INDUSTRIAL CATALOG

OHMITE

RESISTORS
RHEOSTATS
TAP SWITCHES
VARIABLE TRANSFORMERS
TANTALUM CAPACITORS
RELAYS
SEMICONDUCTOR DIODES
R. F. CHOKES

OHMITE MANUFACTURING COMPANY, 3601 HOWARD ST., SKOKIE, ILL. 60076

OHMITE Manufacturing Company

OHMITE
A North American Philips Company

JAN 16 1971

January 11, 1971

Mr. Jack Kornbluh, Chf. Engr.
Magnetic Design Associates
20 Chapel Hill Rd.
Media, Penn. 19063

Dear Mr. Kornbluh:

In regard to your recent note, we are sending the Ohmite Catalogs and Bulletins you requested to bring your Ohmite Industrial Binder up to date. Catalog 501 and Bulletin 753 are not available at this time but will be mailed to you as soon as possible. Your name is on the mailing list to receive all new publications as they are issued.

In answer to your question, the Ohmite News has not been published since 1968.

I am enclosing a copy of the original card that we received from you along with the list of our current catalogs and bulletins, for your future reference.

If I can be of further service, please let me know.

Very truly yours,

OHMITE MANUFACTURING COMPANY

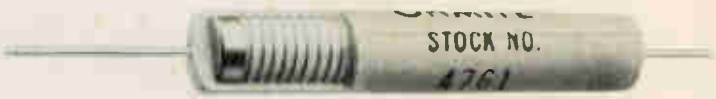
Mrs. Sturgill

Sherril Sturgill (Mrs.)
Secretary, Advertising Dept.

Enc.: Bul. 101B, Cat. 120, Bul. 156D, Cat. 201, Bul 301A
Cat. 300B, Cat. 401, Bul. 751, Bul. 752, Bul. 806,
Bul. 810D, Form 172

the OHMITE® News | MARCH, 1968

SERIES 99 RESISTORS — "TORCH THEM"! THEY'LL ASK NO FAVORS

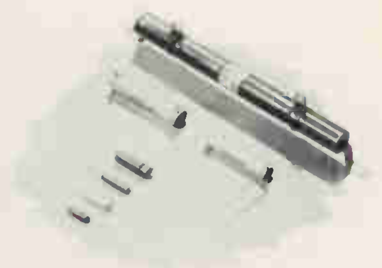


Cutaway View of Series 99 Resistor

We know you don't ordinarily operate a resistor in the flame of a blowtorch. But, this test will prove these wirewound resistors are really "tough". The molded vitreous enamel jacket will withstand 1500°F (red heat) and show no signs of deformation or softening. The vitrified markings stay right there too. Extreme overloads will not obliterate the identifying markings. There are many other outstanding advantages to these axial lead resistors.

The Series 99 resistor meets MIL-R-26E Styles RW67, 68 and 69. Eight sizes are available from 1.5 to 15 watts. Request Bulletin 103 for the entire story and order the sizes you need. Deliveries are excellent in this line.

CATALOG 900B FEATURES RADIO FREQUENCY AND POWER LINE CHOKES



Ohmite Radio Frequency Chokes.

"Radio Frequency Chokes" are used principally within equipment to block r.f. at critical points such as at the plate supply circuits of r.f. amplifiers. They have long been used by radio amateurs everywhere. Noted for their small size, high "Q" and reliable frequency rating, this line of seven chokes encompasses the broad frequency range of 3 to 520 megacycles.

Ohmite "Power Line Chokes" are employed to keep radio frequency waves from entering a power line. They are interposed between the equipment (transmitters, diathermy machines, etc.) and the power line. Ratings to 20 amps are available.

Catalog 900B gives complete information about both lines of chokes including derating curves, suggested circuits for power line applications and newly revised current ratings for the RF chokes. Use coupon to request Catalog 900B.

Ohmite Power Line Chokes.

SCR CIRCUITS ALSO CAN USE THYRATRON PLATE RELAYS

GPR GPRTA GPRTP

GPRTT GPRTS

Because the output of a silicon controlled rectifier (SCR) is half-wave rectified, just as the output of a thyratron rectifier tube, the specially designed Ohmite thyratron relay can be used in SCR circuits with a 115 VAC supply.

Designed to operate without "chatter", Ohmite GPR thyratron relays eliminate the need to fuss with ordinary relays for this specialized application. They are available as both unenclosed and enclosed types up to 4PDT. Enclosed types are the octal type plug-in base (GPRTP); enclosed for above-chassis connection (GPRTA); for below-chassis connection (GPRTT); and enclosed with standard terminal panel (GPRTS) for plugging into the Ohmite SOGPR socket. Complete listings are in Stock Catalog 30.

SEND FOR FURTHER INFORMATION

Bul. Nos. ______

36-page Stock Catalog 30 .... ☒

222-page Industrial Catalog .... ☒

(Attach coupon to Letterhead; give title)

HERE IS
- 10c for Color Coder .... ☐
- Ohm's Law Calculator:
  - 25c for Cardboard Type .... ☐
  - $1.50 for Plastic Type .... ☐
- 25c for Capacitor Calculator .... ☐

Name & Title

Firm Name

Firm Address

City State Zip Code

Printed in U.S.A. March, 1968 O.N.

the OHMITE News

PUBLISHED BY OHMITE MANUFACTURING COMPANY
3603 HOWARD STREET, SKOKIE, ILLINOIS 60076

MARCH, 1968

UNUSUAL ITEMS

Looks like man is not the only tool-making animal. Close observation of chimpanzees in the wild has revealed that they make drinking utensils from leaves, strip leaves from twigs to make rods for extracting termites from their mounds, use leaves to wipe sticky fingers after eating and throw stones. They show other human attributes by dividing food with their wives and young ones also.

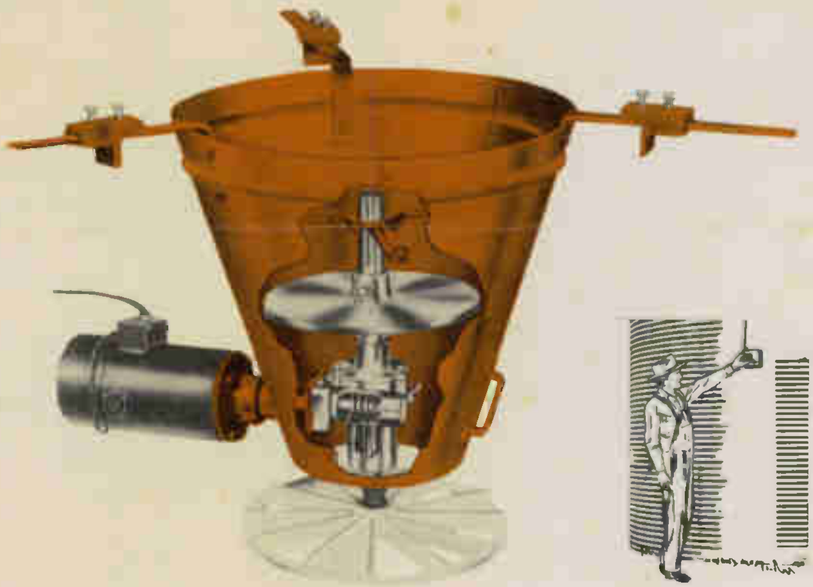
One authority contends that the time is not far off when submarines will be used for vacation trips. Advantages cited are that travel beneath the surface is calm and would also permit viewing of an entirely different world.

Wildlife is prevented from possible death on Dutch highways by an ingenious system of small metal mirrors mounted along the highway. As cars approach, their headlights shine on the mirrors which reflect a moving light into the forest. The light causes the deer to freeze for a few moments and by that time the car is gone. Pretty clever.

Laser beams are being transmitted through fiber bundles in the hopes of treating internal cancers without surgery. Up to now, 70 percent of the laser light has been lost in passing through a six-foot fiber bundle.

And some wives claim it all lands in their houses! Scientists calculate (from recent rocket samplings) that 10,000 tons of dust rain down on the earth each day from space.

PCA 1000 CONTROLS GRAIN SPREADER SPEED — PREVENTS GRAIN SPOILAGE



When grains such as corn, wheat, oats, soy beans, milo or rice are stored in tall bins, problems arise which can cause costly grain spoilage. Grain enters the bin through an opening at the center of the top. This can cause a hard, wet center core to form which prevents complete drying and causes spoilage. Formerly, someone had to go into the bin and walk on the grain scattering it with a shovel to level it properly.

Now, a grain spreader made by Brower Manufacturing Company, Quincy, Illinois, is simply hung across the top opening and leveled. The grain is then made to flow from the auger or elevator into the hopper of the spreader. The motor driven spreader seen at the bottom of the hopper cone then evenly distributes the grain over the entire bin area. An even spread insures fast drying and improves grain quality.

And where does Ohmite enter this picture? The Dial-O-Matic speed control uses an Ohmite Ohmitrol® PCA 1000 solid state power control to vary the spreader motor speed. Varying the speed makes the spreader adaptable to different size bins and insures an even spread throughout the bin. The PCA power control is enclosed in a small box with a circuit breaker and a 30′ extension cord for control from the ground outside the bin.

The Ohmitrol® solid state power control is available both as a component and as a portable unit in a case. The 120 volt input unit is rated as 1000 watts while the 240 volt unit has a 2000 watt rating. Both controls can be supplied in AC output or DC output types. They can be used to control the speed of many types of motors, magnetic clutches and brakes, heaters, soldering irons, incandescent lamps and other resistive loads. For complete information request Bulletin 810. Use coupon on reverse side.

Ohmitrol
PCA 1000
PCD 1000

the OHMITE® News | APRIL-MAY, 1968

MINIATURE MODEL C RHEOSTAT AVAILABLE IN SEVERAL TYPES

Locking Bushing

High Torque Type

Enclosed type, Standard Shaft & Bushing

The exclusive Ohmite Model C rheostat is a rugged power type unit made entirely of ceramic and metal but designed especially for miniaturized equipment. It is offered in two styles — enclosed and unenclosed. The Model C is only 1/2" in diameter and extends 5/8" behind the panel for the enclosed unit; only 15/32" for the unenclosed. Its rating is a full 7-1/2 watts at 40°C (mounted on a metal panel). The resistance range is 10 to 5000 ohms with a tolerance of ±10%.

This miniature rheostat is available with three types of shafts (1) slotted standard shaft for possible knob control (2) locking bushing for permanence of adjustment and (3) high torque shaft which holds settings under relatively rough conditions of vibration and shock.

The enclosed version is available from stock with either a standard shaft or the locking type shaft, in 18 resistance values The unenclosed Model C is available made-to-order. For complete information request Bulletin 203D.

MINIATURE "THIN" SPACE SAVER RESISTORS—STOCK OR SPECIAL

10 Watt

20 Watt

Stacked

Where space is at a premium, Ohmite miniature "thin" resistors can solve your problem quickly and economically. The fixed style is available from stock in the 10 and 20 watt sizes while the 15 watt size is made to order. All three sizes can be made to order with the Dividohm® adjustable tap feature for obtaining intermediate resistance values.

These wirewound vitreous enameled units are only 1/8" thick and 3/8" wide. The core length is 3/4" for the 10 watt size; 1" for 15 watts; 2" for 20 watts. Their wattage rating is based on their being mounted on a minimum size horizontal steel panel, 10" square and .040" thick, which provides a heat sink. The resistor mounting brackets, made of aluminum, extend completely through the core and carry heat to the panel.

The ends of the brackets are equipped with hollow studs through which bolts can pass to mount one or several resistors.

A wide range of resistance values from 1 to 50,000 ohms is stocked in the 10 and 20 watt size units. In addition, three larger "standard" sizes with wattage ratings of 30, 40 and 55 watts are stocked. Request Catalog 30 for stock listings.

A Reminder...

that Ohmite makes metal film resistors with superior characteristics.

Series 66 resistors are made only to the lowest TC (0±25 ppm/°C) specified by MIL-R-10509F. They are designed to exceed the requirements of the specification for Styles RN60E, RN65E, RN70E and RN75E. The film used in the Series 66 surpasses other types of films and results in a unit that can be relied on for accuracy, operation in high ambients, and in high frequency or high gain circuits where low reactance and low noise are imperative.

Four wattage ratings are available — 1/8, 1/4, 1/2 and 1 watt — these ratings being standard at 125°C. Ratings double at 70°C. The standard tolerance is ±1% with tolerances to ±0.1% available. Temperature coefficient is 0±25 ppm/°C ("E" characteristic) over the range of −55°C to +175°C. Units with matched T. C. and tolerance are available.

Use coupon to request Bulletin 110 for complete information.

SEND FOR FURTHER INFORMATION

Bul. Nos ____________

36-page Stock Catalog 30............☐

HERE IS:
- 10c for Color Coder..........☐
- Ohm's Law Calculator:
  - 25c for Cardboard Type..........☐
  - $1.50 for Plastic Type..........☐
- 25c for Capacitor Calculator..........☐

Name & Title ____________

Firm Name ____________

Firm Address ____________

City ____________ State ____________ Zip Code ____________

Printed in U.S.A. April-May, 1968 O.N.

the OHMITE News

PUBLISHED BY OHMITE MANUFACTURING COMPANY
3603 HOWARD STREET, SKOKIE, ILLINOIS 60076

APRIL-MAY, 1968

UNUSUAL ITEMS

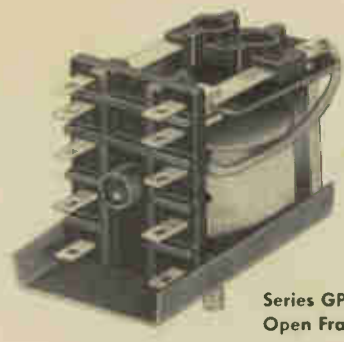
A new electrostatic gyroscope utilizes a beryllium sphere as a rotor. The sphericity tolerance is better than five-millionths of an inch. The rotor spins at 60,000 rpm with a clearance of only a few thousandths of an inch all around. When brought up to speed and the spin power is cut off, the rotor's inertia will keep it rotating for a period of three years.

A new series of alloys called TRIP steels can be stretched from two to five times more than previous ones, yet have high strength, being ductile up to 300,000 pounds per square inch. These new alloys have a built-in self-healing mechanism at the atomic level. When a crack starts, an internal reaction takes place that actually makes the metal stronger.

A piece of glass consisting of thousands of glass fibers twisted about like a twisted hank of hair can be used to scramble and unscramble a page of printed words to insure secrecy. When the glass is held over printed words it breaks them up, visually, into a meaningless jumble. A page photographed through the glass can only be read by viewing through a matching reading glass.

Fire, anathema to most electronic parts may, in itself, become an electronic component. It has been found that a flame from an ordinary welding torch can reproduce sound with high fidelity, can be amplitude-modulated to 100 KC or higher and amplifies in the order of 32 times. By "seeding" the flame with an easily ionized salt, volume of sound is instantly doubled. One use for the discovery is to diagnose rocket engine troubles.

NEW MAGNETIC LATCHING RELAYS EXPAND MODEL GPR LINE



Series GPRM—DPDT
Open Frame

Series GPRMTS—DPDT
Enclosed

Designated the Series GPRM, a new relay using the standard GPR relay frame, performs a latching function magnetically. There are no mechanical latching levers required in the design. This means that a small size latching relay is available for use in the same space that the general purpose GPR relay occupies. Mechanical latching relays generally are double the size of the GPRM because they have latching mechanisms, dual coils and frames. Because the GPRM does not require this design it is more economical in price.

The latching function of the new Series GPRM magnetic latching relay is accomplished by using a magnet structure made from a steel having high "remanence". This means that once the coil has been energized and the relay armature has closed, it will remain in the closed position indefinitely due to retained magnetism even after the coil energizing voltage has been removed.

Coil—Series GPRM relays have one coil with two windings, a "latch" winding and a "release" winding. Five AC coil operating voltages are available from 6 to 230 VAC, 60 Hertz; four DC voltages from 6 to 110 VDC.

Contact Configurations—Up to double-pole, double-throw contact forms are available in the Series GPRM magnetic latching relay as standard. Contact the factory for other contact forms.

Contact Ratings—Relays with fine-silver contacts, gold flashed are rated 5 amps resistive at 115 VAC or 32 VDC. Relays with silver-cadmium oxide gold flashed movable and silver-cad gold flashed fixed contacts are rated 10 amps.

The GPRM relay is available in open frame and four enclosed models each with a different mounting style: through-chassis flange (TT style), above-chassis flange (TA style), socket (TS style, for use with SOGPR-23 socket), and pin-plug base (TP style.)

As with all GPR relays, all connections terminate on one terminal panel. The multi-use terminals can be used in four ways: as solder lug, quick-connect (push-on) which accept Amp series 110 female connectors or to plug into standard Ohmite SOGPR sockets; the pin plug type is designed for plug base sockets.

Series GPRM relays provide long life because they have no mechanical latching levers to wear or go out of adjustment. This feature also makes them able to operate in any position and allows them to tolerate moderate shock and vibration. These relays will not inadvertently unlatch nor can they be locked-in manually. Thus, they guarantee positive action.

For detailed information ask for Bulletin 701-1.

RESISTORS
100

APR 16 1968

RESISTORS

12-70
100 ✓
101B
103E ✓
120 ✓
201 ✓
300B ✓
301A ✓
302 ✓
303 ✓
MS-100 ✓
401 ✓
501 ✓
700C ✓
702B ✓
709 ✓
701-1 ✓
751 ✓
752 ✓
753 ✓
806 ✓
810D ✓
Form 172 ✓
1100 ✓

CATALOG SEQUENCE 100

OHMITE

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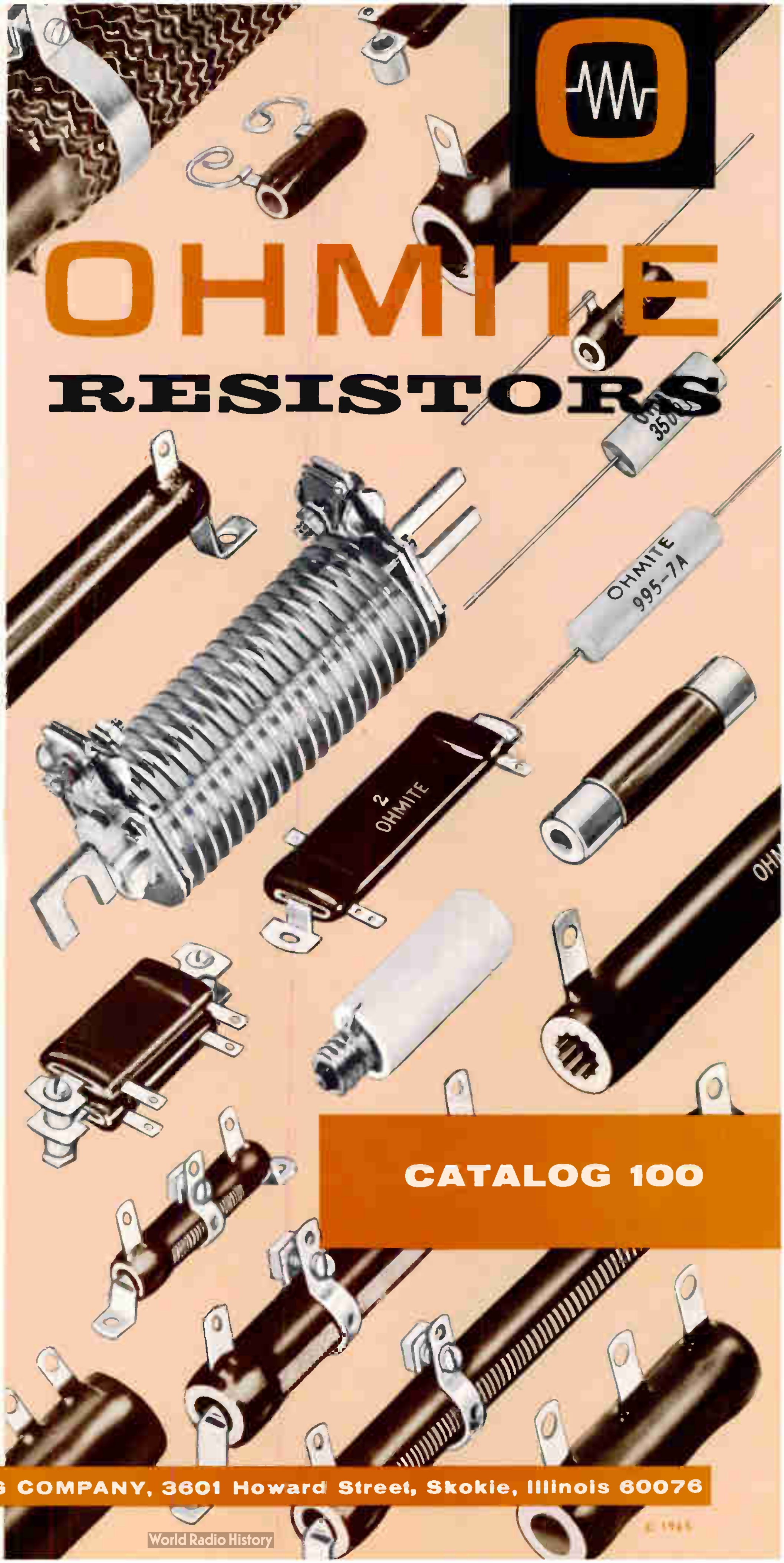
OHMITE RESISTORS



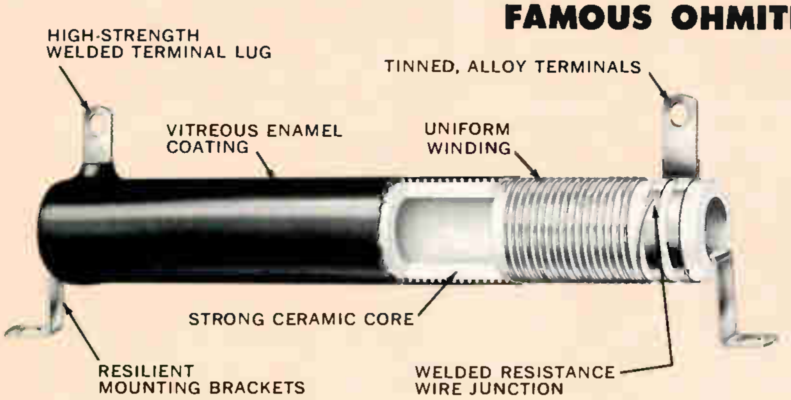
CATALOG 100

OHMITE MANUFACTURING COMPANY, 3601 Howard Street, Skokie, Illinois 60076

OHMITE RESISTOR

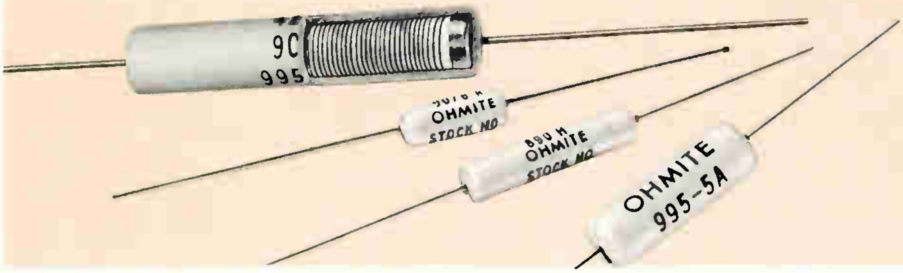
The name Ohmite has long been synonymous with reliability in resistors because of Ohmite's uncompromising control over the quality of materials, construction and workmanship. Unrelenting inspection follows an Ohmite resistor through every phase of its manufacture from the moment the ceramic cores arrive on the receiving dock to the time the completed resistor leaves from the shipping dock. One of the world's most complete resistance laboratories constantly monitors the mechanical and electrical characteristics of the materials used in Ohmite resistors — the coatings, resistance elements, cores and leads. Improvement of these materials and of the overall resistor design is, and will always be a never-ending project at Ohmite. (All resistors shown below are wirewound except for the metal film type.)

FAMOUS OHMITE CONFORMAL VITREOUS ENAMEL



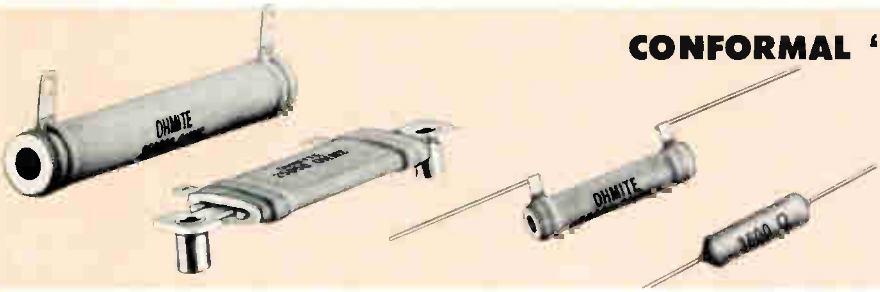
For over 65 years, vitreous enameled, wire-wound resistors have been the most widely used type of power resistor. Even today, with new coatings or methods of application being developed, the conventional vitreous enamel type of construction is still most widely used. The coating is a conformal one, applied as an aqueous suspension to the wirewound core. The entire resistor is then fired at extremely high temperatures to vitrify the coating into a hard, glassy, tough coat that will not shrink or burn, that is unaffected by moisture and which enables the resistor to withstand amazing overloads for a reasonable time. Familiar types of conformal vitreous enamel resistors are shown in the illustration at right. See pages 15, 22, 24, 26, 29, 30, 31, 33, 34, 41, and 54.

EXCLUSIVE! MOLDED VITREOUS ENAMEL



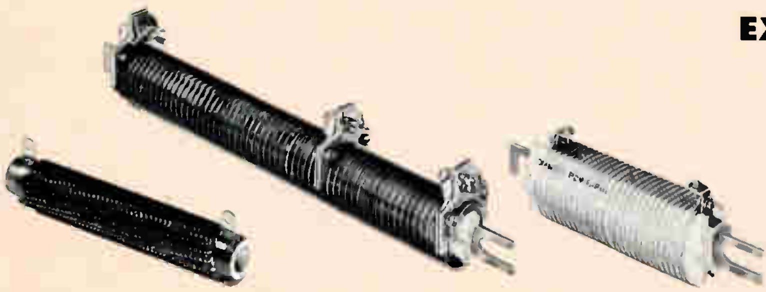
One of the few important innovations in the history of vitreous enameled resistors — a MOLDED vitreous enamel coating. Exclusive Ohmite technique (patents applied for) results in axial-lead resistors which provide (1) 1000-volt insulation, (2) a chip-, heat- (1500°F), moisture- and salt-resistant jacket, and (3) consistent form and dimensions adaptable to automated assembly operations or mounting in clips for significant heat-sink benefits. Markings are vitreous too and as impervious as the coating (page 11).

CONFORMAL "OHMICONE" (SILICONE-CERAMIC)



Any of the resistor styles described and illustrated in this catalog, can be furnished in a conformal, silicone-ceramic ("Ohmicone") coating if so specified. Specifications and requests to quote are invited. Low temperature coefficient, high-stability styles in this type of construction are shown on pages 44, 45.

EXPOSED WINDING CONSTRUCTION



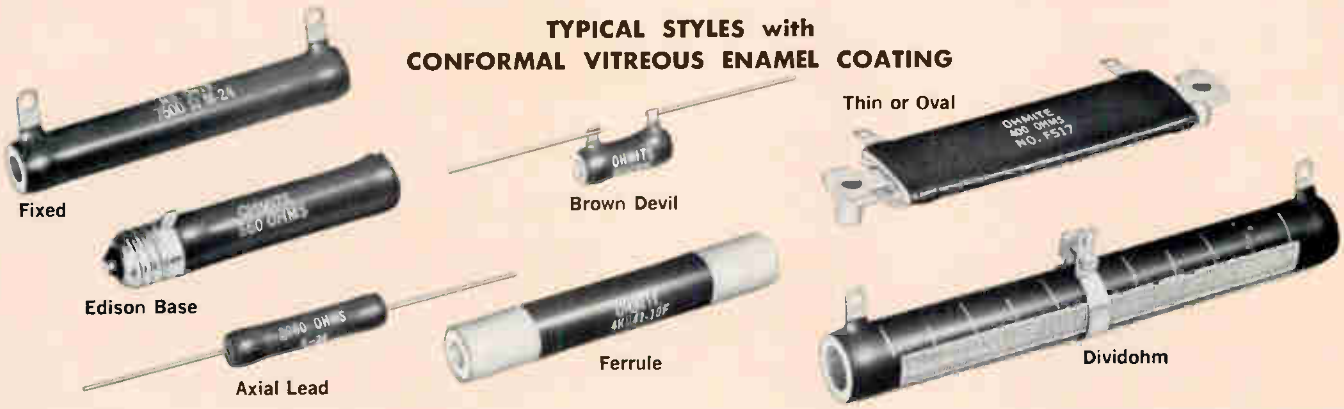
A class of low resistance units intended primarily for very high current during intermittent or continuous duty. This construction category includes (1) popular "Corrib" resistors which employ a corrugated ribbon winding partially coated with vitreous enamel, (2) completely uncoated Corribs in which the corrugated ribbon is wound in a grooved or threaded core (3) "Powr-Rib" resistors in which round or ribbon-type wire is wound on grooved segments which are supported on a metal bar (see pages 34, 35, 46, 47).

CONSTRUCTION & DESIGN

Certain components are produced under a "lot control" procedure to assure unsurpassed quality. Here, identification of individual lots of resistors is maintained through every manufacturing process and recorded for future reference and improvement.

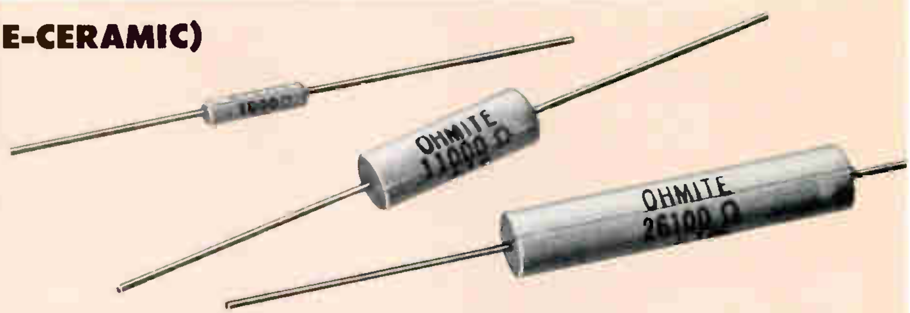
Supplementing this control are such well-known, time-tested Ohmite features as welded terminals, welded connection of resistance wire to terminals and "balanced thermal expansion." This latter feature designates the Ohmite technique of selecting the various materials in a resistor so that their coefficients of thermal expansion are proportioned to prevent crazing or loosening of terminals under wide temperature variations. This attention to detail, this concern with quality is why you can always *be right with OHMITE.*

TYPICAL STYLES with CONFORMAL VITREOUS ENAMEL COATING



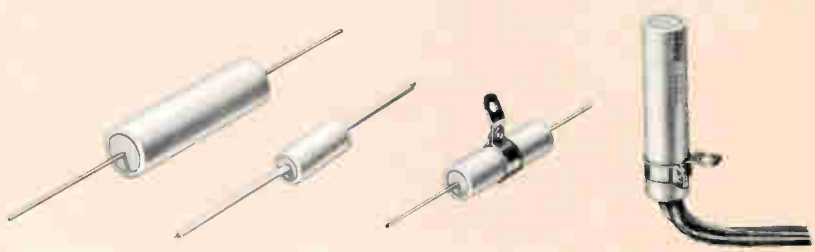
MOLDED "OHMICONE" (SILICONE-CERAMIC)

The molded "Ohmicone," silicone-ceramic type is furnished in the axial-lead style. This tough, resilient, moisture-resistant coating meets a 1000 volt insulation test (500 volts for 1 watt size) and makes possible a standard low temperature coefficient of resistance (0±20ppm/°C) over most of the resistance range. Supplied for commercial applications in 3% tolerances and for close tolerance applications requiring high stability. Meet requirements for insulated axial lead styles of MIL-R-26 (see pages 16-18).



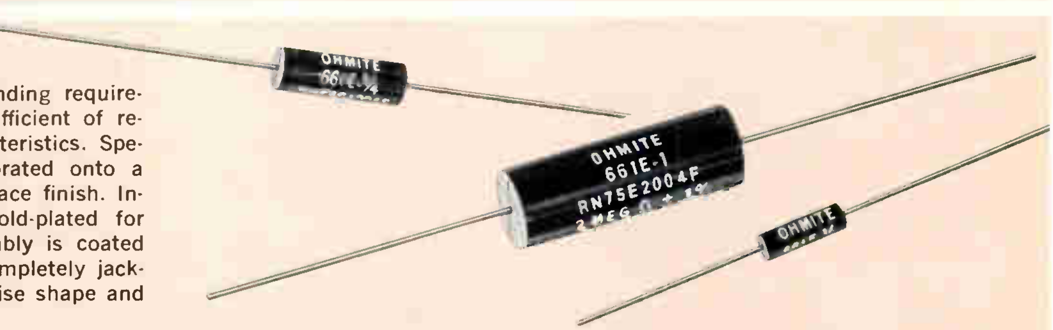
CERAMIC JACKETS

The ceramic jacket or "Tubeohm®" type of construction provides extremely high insulation resistance. In fact, it can withstand breakdown voltages of several thousand volts and, consequently, can be mounted against most live or grounded surfaces with complete assurance. In this type of construction, an "Ohmicone" (silicone-ceramic) coated, axial-lead resistor is sealed in a ceramic tube (see page 19).



PRECISION METAL FILM

Supplied to meet only the most demanding requirements for this type in temperature coefficient of resistance, stability and frequency characteristics. Special non-noble metal is vacuum evaporated onto a special ceramic core of exceptional surface finish. Internal connections to this film are gold-plated for positive permanent contact. The assembly is coated with a special protective resin, then completely jacketed in a tough, molded coating of precise shape and form. Meets MIL-R-10509 (page 20).



RESISTOR FACTS AND FACTORS

A resistor is a device connected into an electrical circuit to introduce a specified resistance. The resistance is measured in ohms. As stated by Ohm's Law, the current through the resistor will be directly proportional to the voltage across it and inversely proportional to the resistance.

The passage of current through the resistance produces heat. The heat produces a rise in temperature of the resistor above the ambient temperature. The physical ability of the resistor to withstand, without deterioration, the temperature attained, limits the operating temperature which can be permitted. Resistors are rated to dissipate a given wattage without exceeding a specified standard "hot spot" temperature and the physical size is made large enough to accomplish this.

Deviations from the standard conditions ("Free Air Watt Rating") affect the temperature rise and therefore affect the wattage at which the resistor may be used in a specific application.

SELECTION REQUIRES 3 STEPS

Simple short-cut graphs and charts in this catalog and in the "Manual of Engineering Information" (abbreviated as "Engineering Manual," Bulletin 1100) permit rapid determination of electrical parameters. Calculation of each parameter is also explained in the Engineering Manual.

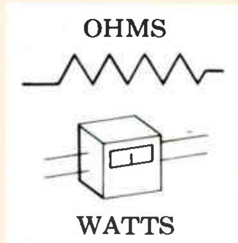
To select a resistor for a specific application, the following basic steps are recommended:

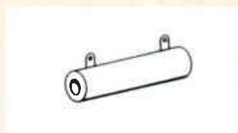
1. **(a)** Determine the Resistance.

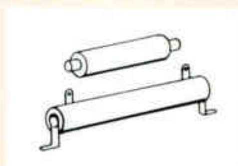
   (b) Determine the Watts to be dissipated by the Resistor.

2. Determine the proper "Watt Size" (physical size) as controlled by watts, volts, permissible temperatures, mounting conditions and circuit conditions.

3. Choose the most suitable kind of unit, including type, terminals and mounting.







STEP 1 DETERMINE RESISTANCE AND WATTS

OHM'S LAW

(a) $R = \frac{E}{I}$ or $I = \frac{E}{R}$ or $E = IR$

Ohm's Law, shown in formula form above, enables determination of the resistance when the required voltage and current are known. When the current and voltage are unknown, or the best values not decided on, at least two of the three terms in Ohm's Law must be measured in a trial circuit (see "Engineering Manual," Bulletin 1100).

(b) $W = I^2R$ or $W = EI$ or $W = \frac{E^2}{R}$

Power, in watts, can be determined from the formulas above, which stem from Ohm's Law. R is measured in ohms, E in volts, I in amperes and W in watts.

Short-Cut Method

Use an Ohmite Ohm's Law Calculator (convenient slide-chart) or use Ohm's Law Chart on page 3 of the "Engineering Manual." Set known values as explained on the Calculator, or Chart, and read the sought for OHMS and WATTS.

Calculation Method

Using the Ohm's Law formulas given above, and explained in greater detail in the Engineering Manual, calculate the unknown values.

How to conduct tests when a trial must be made of the actual apparatus is explained in the Manual.

Why Watts Must Be Accurately Known

Stated non-technically, any change in current or voltage produces a *much larger* change in the wattage (heat to be dissipated by the resistor). Therefore, the effect of apparently *small* increases in current or voltage must be investigated because the increase in wattage may be *large* enough to be significant.

Mathematically, the wattage varies as the square of the current, or voltage, as stated in the formulas (b). For example, an increase of 20% in current or voltage will increase the wattage 44%. Fig. 1 graphically illustrates the square law relation. Hence, the actual current must be used in figuring the wattage, and the increase in wattage due to apparently small changes, then determined in order to select the proper size resistor. Allowance should be made for maximum possible line voltage.

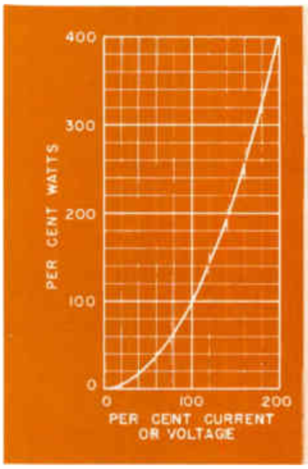


Fig. 1: Rapid increase of wattage with current or voltage.

STEP 2 POWER RATING OR PHYSICAL SIZE OF RESISTOR

A resistor operated at a constant wattage will attain a steady temperature which is determined largely by the ratio between the size (surface area) and the wattage dissipated. The temperature stabilizes when the sum of the heat loss rates (by radiation, convection and conduction) equals the heat input rate (proportional to wattage). The greater the resistor area per watt to be dissipated, the greater the heat loss rate and therefore the lower the temperature rise. The relation between the losses varies for different resistors.

Free Air Watt Rating

The wattage rating of resistors, as established under specified standard conditions, is defined as the "Free Air Rating" ("Full Rating" or "Maximum Power Rating"). Several standard methods of rating are in use based on different service conditions. The method of both the "National Electrical Manufacturers Association" (NEMA) and the "Underwriters' Laboratories, Inc." (UL) can be described as follows:

The relation of the "Free Air Watt Rating" of tubular type, vitreous enameled resistors to the physical size, is to be set at such a figure that . . . *when operated at their rated watts, the temperature rise of the hottest spot shall not exceed 300°C (540°F) as measured by a thermocouple when the temperature of the surrounding air does not exceed 40°C (104°F). The temperature is to be measured at the hottest point of a two-terminal resistor suspended in free still air space with at least one foot of clearance to the nearest object, and with unrestricted circulation of air.*

A slightly different definition of temperature limit used as a basis for wattage rating, and which results in a slightly higher attained temperature, was originally established in military specification MIL-R-26 for wire-wound resistors. In the current version of this specification (revision C), Characteristic V and Y resistors are required to dissipate rated wattage in an ambient of 25°C without exceeding a maximum operating temperature of 350°C at the hottest spot. This corresponds to a temperature rise of 325°C in a 25°C ambient. Although MIL-R-26C permits a 25°C greater temperature *rise* than NEMA or UL, the reference ambient for the latter two is 15° higher. Consequently, the difference in *attained* temperature between the two systems is only 10°C. The curves in Fig. 2 show the relationship between temperature rise and wattage for various specifications. Note the differences in the permissible rise for each specification.

The absolute temperature rise for a specific resistor is roughly related to the area of its radiating surface. It is also dependent upon a number of other factors, however, such as thermal conductivity of the core and coating materials, emissivity factor of the outer surfaces, ratio of length to diameter, heat-sink effect of mountings, and other minor factors.

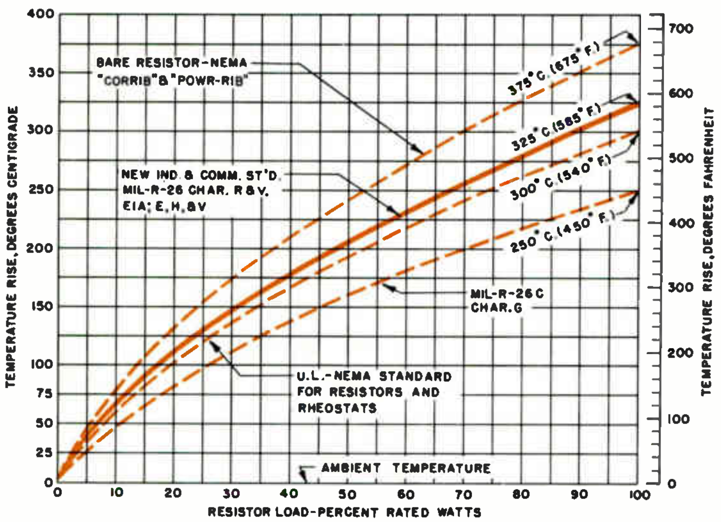
The maximum permissible operating temperature for a given resistor is basically determined by the temperature limitations imposed by the materials used in its construction. Generally speaking, these limits cannot be sharply defined in terms of temperature alone. Other factors such as resistance stability versus time, deterioration rates of insulation and moisture-resistance characteristics, type and size of resistance wire, all enter into consideration of "acceptable service life."

For these reasons, the precise temperature limits corresponding to 100% rated wattage are somewhat arbitrary and serve primarily as design targets. *In the last analysis, once a wattage rating has been assigned on the basis of an empirical hot spot limit, the verification of its correctness must be established through long term load-life tests based on performance and stability standards rather than the measurement of hot spot temperature.*

in both MIL-R-26, EIA and other specifications.

Despite the above variables, figures may be cited in terms of "watts dissipated per square inch of winding surface" for a given temperature rise. For power type resistors operating at 300°C rise above ambient, this figure varies between approximately 6.3 watts per square inch for large resistors (160 watt) to about 9 watts per square inch for smaller resistors (10 watt).

It should also be observed from Fig. 2 that tem-



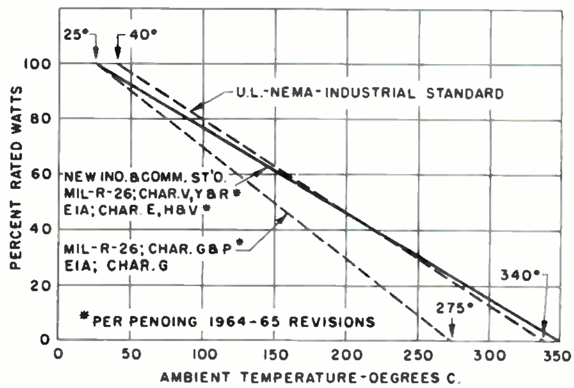


Fig. 3: Derating for ambient temperature.

Fig. 2: Approximate hot spot temperature rise of a resistor in free air for various specifications.

This concept is reflected in the new proposed revisions of both the EIA standard as well as MIL-R-26, in which the previous requirement for measuring hot spot temperature at rated wattage has been effectively abandoned! Instead, maximum limits are stipulated for parameter changes as a result of various tests, including a 2000 hour load-life test.

Another factor in the abandonment of temperature measurements is that physical dimensions and wattage ratings having been correlated and set, the temperature rise has been effectively set! It is also assumed that the temperature rise at a given wattage is independent of the ambient temperature in which this wattage is being dissipated. Therefore, for high ambient temperatures, the operating wattage should be limited in accordance with the curves of Fig. 3. Although the assumption that temperature rise is independent of ambient is not exactly true, the approximation is sufficiently close for all practical purposes and, therefore, has been adopted for derating purposes

perature rise is not directly proportional to wattage dissipated. Note, for example, that at 50% rated wattage, the temperature rise still remains about 70% of that at full rating.

The wattage ratings used in this catalog, unless otherwise stated for certain types, have been revised and in many instances increased (with respect to previous Catalog 58) on the basis of a nominal operating temperature of 350°C at full rating. There are two general categories of power resistors for which the 350°C nominal temperature limit does not apply. One is that class of power-precision resistors where high stability is a salient feature, in which case the operating temperature is nominally limited to 275°C. The other category includes all exposed ribbon wire resistors (see description of CORRIB and POWR-RIB) which are rated for 375°C (675°F) maximum temperature rise when measured on the wire per NEMA standards.

Temperature Distribution on a Resistor

The temperature rise varies (following a curve) along the length of the resistor with the hot spot at the center-top (of a horizontal tube) and the ends at approximately 60% of the maximum temperature rise. The terminals themselves are still cooler. When the resistor is vertical, the hot spot shifts upwards a little and the top end is hotter than the bottom. The standard "Free Air Watt Rating," however, is used regardless of position.

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APPLICATION WATT RATING

To allow for the differences between the actual service conditions and the "Free Air Watt Rating" it is a general engineering practice to operate resistors at ½, ⅓, ¼ or other fraction of nominal rating. The details by which such ratings can be estimated are given in the following pages. Most thermal calculations, however, involve so many factors which are usually not accurately known, that at best they are only approximations.

The most accurate method of determining or checking the rating is to measure the temperature rise in a trial installation. A thermocouple (made of #30 B & S gage wire) is recommended for the measuring element. Even measurements made with a thermocouple will vary slightly with different samples and techniques. On small resistors an infra-red optical pyrometer is recommended.

The factors which affect the temperature rise act independently of each other and are summarized as follows:

1. Ambient Temperature

As the maximum permissible operating temperature is a set amount, any increase in the ambient temperature subtracts from the permissible temperature *rise* and therefore reduces the permissible watt load.

2. Enclosure

Enclosure limits the removal of heat by convection currents in the air and by radiation. The walls of the enclosure also introduce a thermal barrier between the air contacting the resistor and the outside cooling air. Hence, size, shape, orientation, amount of ventilating openings, wall thickness, material and finish all affect the temperature rise of the enclosed resistor.

3. Grouping

When resistors are close to each other they will show an increased hot spot temperature rise for a given wattage because of the heat received by radiation from each other and the increased heat per unit volume of air available for convection cooling.

4. Altitude

The amount of heat which air will absorb varies with the density, and therefore with the altitude above sea level. At altitudes above 100,000 feet, the air is so rare that the resistor loses heat practically only by radiation.

5. Pulse Operation

This is not an environmental condition but a circuit condition. As a pulse of power, when averaged over the total on and off time,results in less heat per unit time than for continuous duty, the temperature rise is affected. This *may* permit higher power during the pulses. The conditions must be expertly considered for conservative rating. The open-wound "Powr-Rib" resistor construction is most suitable.

6. Cooling Air

Forced circulation of air over a resistor removes more heat per unit time than natural convection does and therefore permits an increased watt dissipation. Liquid cooling and special conduction mountings also can increase the rating.

7. Limited Temperature Rise

It is sometimes desirable to operate a resistor at a fraction of the Free Air Watt Rating in order to keep the temperature rise low. This may be to protect adjacent heat sensitive apparatus, to hold the resistance value very precisely both with changing load and over long periods of time and to insure maximum life. Refer to paragraph on Temperature Coefficient of Resistance for additional information.

8. Other Considerations

High Resistance. High resistance units, which require the use of very small diameter wire,generally should operate at reduced temperature for *maximum* reliability.

High Voltage. A maximum voltage gradient of 750 volts R.M.S. (1058 volts peak) per inch of winding length is recommended under normal conditions. For higher gradients in pulse applications or for other special conditions such as oil immersion, consult factory.

High Frequency. Non-inductively wound resistors are generally required for use at radio and supersonic frequencies.

Military and Other Specifications. The special physical operating and test requirements of the applicable industrial or military specification must be considered. Military specification resistors should be ordered by their MIL numbers.

TEMPERATURE COEFFICIENT OF RESISTANCE

The resistance alloys used for all except the lowest ohmic values show such little change with temperature that in most power circuits the resistance is considered constant. Actually there may be changes at full load of −4% to +8% of the initial resistance. The change is attributed in most part to the "temperature coefficient of resistance" (TC) which is the change in resistance expressed as "parts per million per degree centigrade of temperature" (ppm/°C) or previously in "ohms per ohm per degree change of temperature" or "% per °C."

For special applications which require very constant resistance, it may be necessary to specify the maximum permissible TC for the range of temperature involved. This would limit the choice of wire to only certain types of resistance alloys. The commonly known low TC alloys in the 800 ohms per circular-mil-foot class consist largely of nickel and chromium alloyed with small amounts of aluminum and either copper or iron. Other low resistivity alloys, 294 ohms per circular-mil-foot, consist primarily of nickel and copper with only traces of other metals.

Both of these wire classes are rated by the wire manufacturers as having a TC of 0±20ppm/°C (also designated as 0±0.00002 ohm/ohm/°C or 0±0.002%/°C) over designated temperature ranges (ASTM B267-60T: −65°C to +250°C for 800 ohm/cmf wire; −65°C to +150°C for 294 ohm/cmf wire). The expression "0±20ppm/°C" implies that, although the nominal value of the TC is zero, the actual value may lie anywhere within the tolerance range of −20ppm/°C to +20ppm/°C.

For other resistance wires such as the widely used nickel-chromium-iron, for example, a nominal value of +140ppm/°C is given. Actually, however, a tolerance of ±30ppm is applicable so that the TC may range between the limits of +110 to +170ppm/°C.

Unfortunately, the TC of a completed power resistor is generally somewhat different from that of the original wire. This is because the TC may be affected by such factors as heat treatment during processing, and materials and methods of construction. Without special controls and precautions, the TC over the range of 25°C to 300°C rise may increase to as much as 0±80ppm from the original 0±20ppm for certain types of wire on vitreous enameled resistors. Theoretical changes in resistance with temperature are shown in Fig. 4.

The circuit designer should carefully consider the actual needs of the circuit before specifying limits on the TC of a desired resistor. Wherever possible it is best to select a resistor for a critical application so that it operates at a low temperature rise. This will also provide the maximum stability over a long period. For low TC (and other) applications, Ohmite can provide resistors with an "Ohmicone" (silicone-ceramic) coating. "Ohmicone" is processed at much lower temperatures than vitreous enamel and therefore makes control of TC and tolerance easier. Data on the TC and other properties of various alloys is given in the Engineering Manual (Bulletin 1100).

Ballast Resistors: A *very high* TC is required in resistors used to stabilize a circuit against the effects of varying input voltage. To design such "ballast resistors" the following data must be known: Resistance value at a specified reference temperature, change in resistance for a stated temperature or current change, time factors, current and voltage.

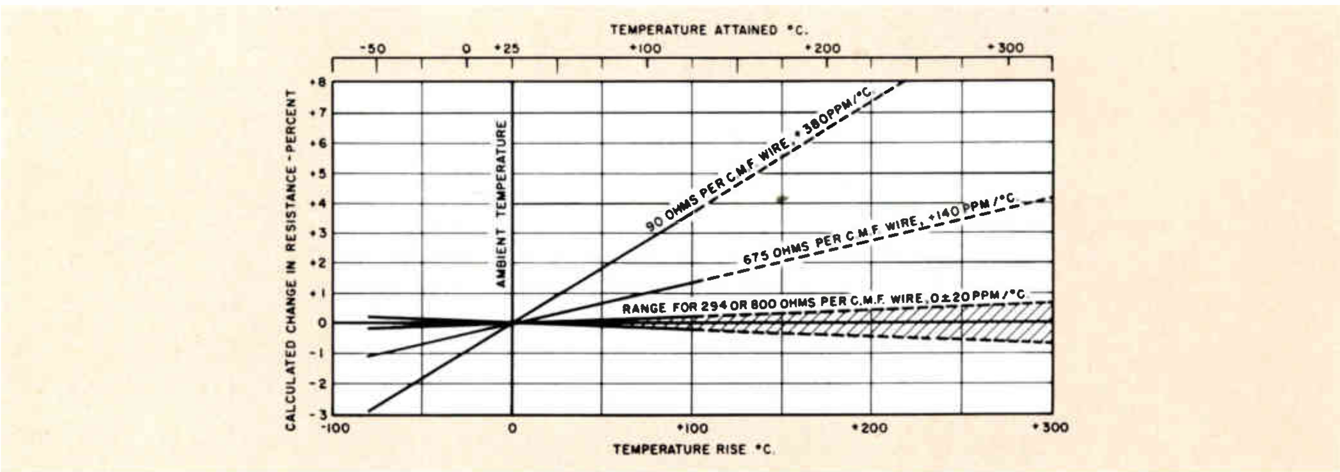

Fig. 4: Calculated change in resistance with nominal TC assumed constant.

PROCEDURES for STEP 2

Calculation Method

Using the graphs given in the Engineering Manual, determine the derating required for each application modification condition. Determine the total derating. Divide the Watts Input by the derating (expressed as a decimal) to obtain the Free Air Watt Size required.

Short-Cut Method

Determine the required Free Air Watt Size by use of the chart on the page opposite. Locate the known application modifications of Free Air conditions, multiply the correction Factors and Watts Input and find Watt Size Required.

STEP 2 Resistor Selection
Short-Cut Chart Method

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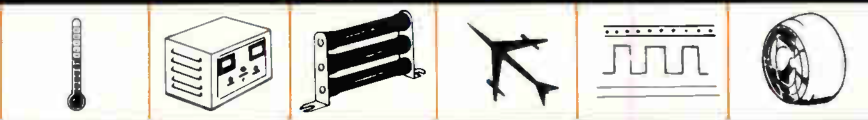
TO FIND REQUIRED SIZE
(As affected by application conditions)

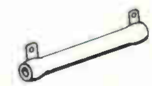
1. For each Condition locate the relevant value on the scales below and record the corresponding Factor (F_1 to F_7).
   Note: The Standard Free Air Condition Factor is always 1.
2. Multiply the Factors together.
3. Multiply the Watts by the product obtained from step 2 above.

WATTS | **APPLICATION CONDITIONS** | **WATT SIZE**



I²R

Ambient Temperature | Enclosure | Grouping | Altitude | Pulse Operation | Cooling Air | Limited Temperature Rise | (Physical size)



From Step 1
Record the Watts to be dissipated as set by your circuit conditions.
See Page 4.

Standard Free Air Conditions

Ambient Temperature — °C / F_1: 300 – 6.6; 5.0; 4.1; 3.2; 2.7; 200 – 2.2; 1.9; 1.6; 1.4; 100 – 1.3; 1.2; 50 – 1.1; 25 – 1.0

Enclosure — % / F_2: 100 – 2.0; 90 – 1.9; 80 – 1.8; 70 – 1.7; 60 – 1.6; 50 – 1.5; 40 – 1.4; 30 – 1.3; 20 – 1.2; 10 – 1.1; NONE – 1.0

Grouping — No. / F_3:
- ON STD. BRACKETS: 3 – 1.4; 2 – 1.3
- 1/2" SPACE: 12 – 1.6; 8 – 1.5; 4 – 1.4; 2 – 1.3
- 1" SPACE: 12 – 1.5; 8 – 1.4; 4 – 1.3; 2 – 1.2
- 2" SPACE: 12 – 1.4; 8 – 1.3; 4 – 1.2; 2 – 1.1
- 1 – 1.0

Altitude — FEET (THOUSANDS OF FEET) / F_4: 100, 90, 80 – 1.5; 70 – 1.5; 60; 50 – 1.4; 40 – 1.3; 30; 20 – 1.2; 10 – 1.1; 5 – 1.0; 0 – 1.0

Pulse Operation — % (PERCENT LOAD) / F_5: 1000 – .10; 900 – .11; .12; 800 – .13; .14; 700 – .15; .16; 600 – .17; .18; .19; 500 – .20; 400 – .25; .30; 300 – .35; .40; 200 – .50; .60; .75; 100 – 1.0

Cooling Air — FPM (AIR VELOCITY-FEET PER MINUTE) / F_6: 1500 – .27; 1400 – .28; 1300 – .29; 1200 – .30; 1100; 1000 – .32; 900 – .35; 800; 700 – .40; 600; 500 – .50; 400; 300 – .60; 200 – .70; .80; 100 – .90; STILL – 1.0

Limited Temperature Rise — °C / F_7: 40; 50 – 13.0; 10.0; 8.0; 7.0; 6.0; 100; 5.0; 4.0; 3.0; 2.5; 2.0; 200; 1.75; 1.5; 1.4; 1.3; 1.2; 1.1; 300 – 1.0

To Step 3
Select standard resistor with equal or larger wattage rating.

See "Contents" (cover) and pages 2-3 for types and ranges.

Refer to Catalog 50 for resistors intended for military applications.

CAUTION
See pages 7-8 if following are concerned:
High resistance
High voltage
Low temperature coefficient
Stability
High frequency

Watts to be Dissipated	x Factor	x Factor	x Factor	x Factor	x Factor	x Factor	x Factor	= Free Air Watt Size Rating
	Temperature at installation includes room temperature plus temperature rise due to adjacent heat sources.	Factors apply approximately for average sheet metal boxes of dimensions such that watts per sq. in. of surface are in the range of .2 to .4.	Factors apply to uniformly spaced banks of parallel resistors with spacing as shown.	Factors apply to altitudes shown. No derating is required for altitudes to 5000 ft. above sea level.	Percent load for pulse operation must first be determined from graphs and data in Manual.	Factors are approximations only. Effectiveness of cooling varies with installation.	Low temperatures may be desired because of adjacent apparatus, increased stability or maximum reliability.	

See Engineering Manual, Bulletin 1100, for detailed explanation of conditions.

EXAMPLE: Four resistors, each dissipating 115 watts, are to be mounted in a group. Spacing is to be 2" surface to surface. Ambient to be 50°C (122°F). Enclosure to be total. Other factors standard. Determine Watt Size required.

Operation (1) On Ambient Temperature scale locate 50°C. Note and record F_1 = 1.1 as shown. Locate and record the other factors.

F_1	F_2	F_3	F_4	F_5	F_6	F_7
50°	100%	4@2"	Standard Conditions			
1.1 x	2.0 x	1.2 x	1 x	1 x	1 x	1

Operation (2) Multiply the factors together = 2.64

Operation (3) 115 watts x 2.64 = 314 Watts Free Air Watt Size Rating required for each resistor.

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STEP 3 HOW TO SELECT & ORDER OHMITE RESISTORS

ASSISTANCE IN SELECTION (See Contents & Pages 2, 3)

Ohmite sales engineers and sales representatives backed by the resources of Ohmite's laboratory and engineering departments, will be pleased to make recommendations on receipt of users' complete requirements. Samples can be supplied, when warranted, for test or use in prototype equipment.

Radio-electronic distributors across the nation and abroad, stock standard Ohmite parts. This service is convenient and economical for small quantities, especially where a minimum billing charge is involved on direct factory orders.

"Little Devil" composition resistors and Type AB and AS composition potentiometers are described in the Ohmite "Stock Catalog." They are sold *only* through Ohmite distributors.

SUGGESTIONS FOR ORDERING RESISTORS

TO ORDER STOCK RESISTORS OF ANY RESISTANCE VALUE

(1) Give catalog number. Also, the information suggested below provides a check against errors.

(a) Style designation; also name, where provided (Style 200-12 "Brown Devil").

(b) Resistance value. Where non-stock value is desired, suffix this value to style designation, e.g., Style 200-12-60.

(c) Core size (e.g., 9/16" x 2")

(2) List mounting brackets or other accessories by catalog number as separate items.

(3) Specify quantity of each item.

(4) Specify "Boxed" if desired in individual or standard package boxes. Manufacturers' orders are normally shipped bulk-packed for ease of handling on assembly lines. A small charge is added for special boxing.

TO ORDER "MADE-TO-ORDER" RESISTORS (See Contents & Pages 2, 3)

Non-stock resistors may be ordered from the tables of core sizes and ranges provided under some specific types of resistors such as Series 99 or Series 88. In this catalog, pages dealing with certain tubular core resistors, list only stock items. Non-stock or made-to-order items for units such as these must be ordered from the "master" table on pages 36 and 37. That table lists the more popular tubular core, vitreous-enameled types of resistors made by Ohmite and, with the terminals listed on the succeeding two pages, permits the buyer to tailor tubular core resistors exactly to his desires.

To order, whether from made-to-order tables under specific resistor types or from the master table on pages 36 and 37, submit the following:

(1) Give the series or type number and name of the resistor (for example, "Type 200, "Brown Devil") if ordering a specific resistor type from the pages devoted to that type. Give the code number, code word, type or style number for the specific size of resistor within that series. (Note: For tubular core, vitreous enameled resistors ordered from the master table on pages 36-37, a code can be assembled, as explained on page 37, based on the physical and electrical characteristics desired for the resistor as enumerated below. Such a code also serves as a specification number which makes future reordering easier.)

(2) Give the physical specifications of the resistor—outside diameter and length of core, terminal type number and whether "fixed" or "adjustable."

(3) State wattage or give current (actual amperes) or voltage to be impressed across the resistor. On tapped resistors, do this for each section.

(4) State resistance value for entire resistor and for each section if tapped.

(5) Specify tolerance where a choice of tolerance is provided or if a tolerance other than the standard is desired.

(6) List mounting brackets, or other accessories by catalog number, as separate items.

(7) On reorder, give the Ohmite *specification number* and resistance. A specification number is assigned to a particular made-to-order item and identifies the item completely. This number is given on Ohmite ackowledgments, invoices, and packing lists and may also appear on the units.

(8) Mention Ohmite *quotation number*, if any.

(9) If you have a drawing covering the part, specify your part and drawing number and supply a copy with order. Including the Ohmite specification number on your drawing will help assure exact duplication on all future orders.

(10) Specify quantity of each item.

(11) Prices will be quoted on request for specific items and quantities, both stock and made-to-order. The quantity shipped at one time of any item ordered, determines the unit price for manufacturers' orders. Prices of stock parts for small quantities are given in Ohmite's "Stock Catalog," available on request.

DIMENSIONS, TOLERANCES, AND PROCUREMENT DRAWINGS

All dimensions are subject to manufacturing tolerances which vary with the type of resistor. To avoid unnecessary delays in inspection, cost, etc., it is recommended that procurement drawings for stock or catalog items be marked, "Commercial part. Dimensions for reference unless otherwise noted." Drawings of special components should carry tolerances on critical dimensions only plus a note such as: "All dimensions not otherwise marked, subject to commercial tolerances." Ohmite standard tolerances on dimensions of stock resistors generally can be found on the pages containing details of construction.

SERIES 99 MOLDED VITREOUS ENAMEL RESISTORS

OHMITE

WIREWOUND, AXIAL LEADS

Fig. 5: Uniformly molded thickness guarantees 1000 VAC breakdown ratings, marked resistance to breakage plus uniform shape and dimension.

Series 99 resistors introduce one of the few important innovations in the long history of vitreous enameled resistors—a MOLDED vitreous enamel coating. This development is the result of a new manufacturing method (patents applied for) which contrasts to the conventional methods that provide conformal-type coatings. Equally remarkable is the creation of a vitrified coating which endures the red heat of manufacture but retains its molded form and dimensions! Series 99 construction offers highly important advantages as follows:

(1) Consistent insulation thickness guarantees 1000 VAC insulation breakdown ratings (500 V for 1w size).

(2) A strong, tough jacket which resists breakage and chipping, that withstands 1500°F without sacrificing its form or dimensions—that endures conditions of high humidity.

(3) Consistent form and dimensions facilitate use of resistors in automated assembly of circuit boards, etc., or mounting in clips (page 15) with heat-sink benefits up to 100% over the original rating. Resistors may be repeatedly inserted and removed from clips without damage.

With all this, THE ACKNOWLEDGED, TIME PROVEN ADVANTAGES OF VITREOUS ENAMEL INSULATION ARE RETAINED. Vitreous enamel anchors the turns of resistance wire in place, distributes heat to minimize hot spots, will not burn or shrink, is unaffected by moisture and imparts to resistors the ability to withstand amazing overloads for a reasonable duration. Beneath this superb insulation, is a single-layer winding of high grade resistance alloy wire on a ceramic core. Axial-type terminal leads and the resistance wire are both welded to metal end caps which fit snugly over the core ends.

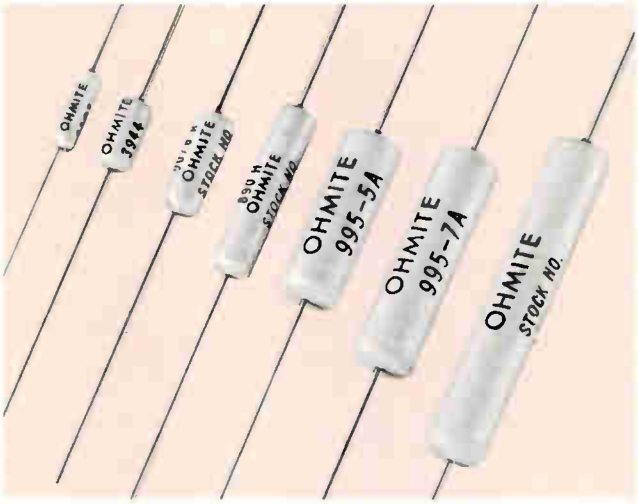

Fig. 6: Series 99 Resistors

Permanent Resistor Markings: Identification markings are vitreous and are applied using an "ink" composed of ceramic compounds. The markings are fired into the molded vitreous enamel coating to become an integral part of the resistor. They resist abrading, standard cleaning solvents, and 1500°F temperatures. *Extreme overloads that may burn out the resistor winding WILL NOT obliterate the markings.*

Ratings: Wattage ratings are based on a maximum hot spot temperature of 350°C.

A MILESTONE IN RESISTOR TECHNOLOGY

Fig. 7: 1500°F — Red Heat! Series 99 resistors show no deformation; vitreous markings remain legible.

Fig. 8: Resists chipping, breaking. Thick, densely molded jacket will not chip even where leads enter body.

Fig. 9: Markings are integral with coatings — are unaffected by abrasion with glass fiber brush.

Fig. 10: Markings, unaffected by degreasing and flux removal solvents, remain legible even after extreme overloads!

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SERIES 99 MOLDED VITREOUS ENAMEL RESISTORS

Low Temperature Coefficient of Resistance (T.C.) as follows:

T.C. in ppm/°C

Resist. Range Ohms	Temp. Range +25°C to +350°C	−55°C to +25°C
less than 1	Consult factory	
1 to 10	0 ± 50	0 ± 80
10 and above	0 ± 30	0 ± 60

Leads: Standard leads are solder dip-coated for soldering; furnished bare for welding or gold-plated on special order.

Outstanding Moisture Resistance: Series 99 resistors which meet all the requirements of MIL-R-26 will also withstand the 10-day MIL-R-26 moisture-resistance test AFTER 2000 hours of cyclic load-life at full wattage.

Non-Inductive versions of Series 99 resistors can be supplied to order. Inquire of factory.

RESISTOR TYPES

TYPE 995 FOR COMMERCIAL POWER APPLICATIONS

Standard tolerance for Type 995 units is ±5% for values 1 ohm and above; ±10% for values below 1 ohm. For tolerances to ±0.25% consult factory.

TYPES 991 AND 991R FOR MILITARY APPLICATIONS

Type 991: This type meets the requirements of MIL-R-26C (as well as proposed MIL-R-26D) Styles RW67V, RW68V, RW69V (350°C max. hot spot). These units meet and exceed the required 1000 VAC V-block dielectric-strength test (500 volts for 1-watt size), the 100 megohm insulation-resistance test, and surpass the stability requirements of ±3%ΔR on the 2000 hour cyclic load-life test. If required, Ohmite can supply these resistors as Styles RW57, RW58 and RW59, Char. G or V. Standard resistance tolerance is ±5% for values 1 ohm and above; for values below 1 ohm, ±10%; other tolerances can be supplied.

Type 991R: Ohmite can supply Series 99 resistors to meet both the "V" and "R" characteristics (350°C hot spot) of proposed MIL-R-26D. The "R" characteristic, which covers resistor Styles RW70R, RW77R, RW78R and RW79R, in addition to meeting the requirements of Characteristic V, also sets more stringent stability requirements (±2% on 2000 hour load-life test), specifies a much lower temperature coefficient of resistance (TC) and offers a choice of either 0.5% or 1.0% resistance tolerance. Type 994 is the commercial equivalent of Type 991R.

For details of these types, see Bulletin 103 or Catalog 50.

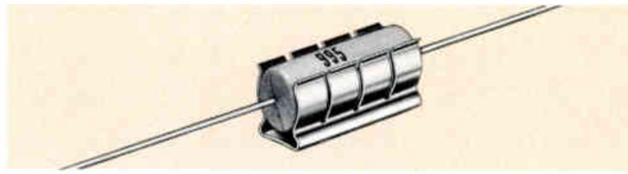


Fig. 11: Uniform shape and size permits mounting in clips. On a metal surface, clips allow as much as a 100% increase in wattage. See page 15.

TYPE 995 COMMERCIAL

5% Tolerance; Closer Tolerances Available

Ohmite Style	Rated Watts @25°C	Dimensions (Inches) Lgth. ±.015	Dia. +.031 −.000	Leads 1½" AWG	Typical Weight (Grams)	Resistance Range (Ohms)	Max. Wkg. Volts RMS
995-1A	1.5	.422*	.125*	24	0.4	0.1 to 6650	
995-2A	2.25	.375	.188	20	0.8	0.1 to 6490	85
995-3A	3.25	.547	.203	20	1.3	0.1 to 22,100	190
995-5A	6.5	.922	.312	20	3.6	0.1 to 80,600	460
995-5B	5	.938	.203	20	2.0	0.1 to 53,600	500
995-7A	9	1.218	.312	20	4.5	0.1 to 118,000	670
995-10A	11	1.781	.312	20	6.9	0.1 to 187,000	1100

*Tolerance +.015, −.005

TYPE 994 HIGH STABILITY

Standard Tolerance 3%;

Tolerances to 0.25% Available

Type 994 units feature long term stability along with the Series 99 low temperature coefficient of resistance.

Stability: Type 994 resistors, on a 2000 hour, cyclic load-life test (1½ hour on, ½ hour off) have less than ±2% change in resistance value.

Standard Tolerance for Type 994 resistors is ±3%. However, tolerances of ±1.0, ±0.5 and ±0.25% are available on order.

TYPE 994 HI-STABILITY

3% Tolerance—Tolerances to 0.25% Available

Ohmite Style	Rated Watts @25°C	Dimensions (Inches) Length ±.015	Dia. +.031 −.000	Leads 1½" AWG	Typical Weight (Grams)	Resistance Range (Ohms)	Max. Wkg. Volts RMS
994-1A	1.5	.422*	.125*	24	0.4	0.1 to 6650	
994-2A	2.25	.375	.188	20	0.8	0.1 to 6490	85
994-3A	3.25	.547	.203	20	1.3	0.1 to 22,100	190
994-5A	6.5	.922	.312	20	3.6	0.1 to 80,600	460
994-5B	5	.938	.203	20	2.0	0.1 to 53,600	500
994-7A	9	1.218	.312	20	4.5	0.1 to 118,000	670
994-10A	11	1.781	.312	20	6.9	0.1 to 187,000	1100

*Tolerance +.015, −.005

STOCK SERIES 99
Molded Vitreous Resistors

OHMITE

Fig. 12:

1½ Watt 2¼ Watt 3¼ Watt

A complete stock of Type 995 molded vitreous enamel, wirewound resistors for commercial power applications, is available in the 1½, 2¼, 3¼, 5 and 11 watt sizes (Styles 995-1A, -2A, -3A, -5B and -10A respectively). The values shown are based on the progression in military standard MS90178 for ±5% values. The stock listings also include popular values not in this progression. The values available are such that any value required by a user, in the range available, is *(Continued on next page)*

1½ WATT — STOCK STYLE 995-1A
.422″ L x .125″ D Overall
Terminal: No. 54

Stock No.	Ohms	Max. Amps.	Stock No.	Ohms	Max. Amps.
4030	1.0	1.24	4087	75	.141
4031	1.1	1.17	4089	82	.135
4032	1.2	1.12	4091	91	.128
4033	1.3	1.08	4092	100	.123
4034	1.5	1.00	4093	110	.117
4035	1.6	.97	4094	120	.112
4036	1.8	.91	4095	130	.108
4037	2.0	.87	4096	150	.100
4038	2.2	.83	4097	160	.097
4039	2.4	.79	4098	180	.091
4041	2.7	.75	4099	200	.087
4042	3.0	.71	4100	220	.083
4043	3.3	.67	4101	240	.079
4044	3.6	.65	4102	250	.077
4045	3.9	.62	4103	270	.075
4046	4.0	.61	4104	300	.071
4047	4.3	.59	4105	330	.067
4048	4.7	.56	4105A	350	.065
4049	5.0	.55	4106	360	.064
4050	5.1	.54	4107	390	.062
4051	5.6	.52	4108	400	.061
4053	6.2	.49	4109	430	.059
4054	6.8	.47	4109A	450	.058
4056	7.5	.45	4110	470	.056
4058	8.2	.43	4111	500	.055
4060	9.1	.41	4112	510	.054
4061	10	.39	4113	560	.052
4062	11	.37	4114	600	.050
4063	12	.35	4115	620	.049
4064	13	.34	4116	680	.047
4065	15	.32	4117	700	.046
4066	16	.31	4118	750	.045
4067	18	.29	4119	800	.043
4068	20	.27	4120	820	.043
4069	22	.26	4121	900	.041
4070	24	.25	4122	910	.041
4071	25	.25	4123	1000	.039
4072	27	.24	4124	1100	.037
4073	30	.22	4125	1200	.035
4074	33	.21	4126	1300	.034
4074A	35	.207	4126A	1400	.033
4075	36	.200	4127	1500	.032
4076	39	.196	4128	1600	.031
4077	40	.193	4129	1800	.029
4078	43	.187	4130	2000	.027
4079	47	.179	4131	2200	.026
4080	50	.173	4132	2400	.025
4081	51	.171	4133	2500	.025
4082	56	.164	4134	2700	.024
4084	62	.156	4135	3000	.022
4085	68	.149			

Avg. Weight .0009 lb.

2¼ WATT — STOCK STYLE 995-2A
.375″ L x .188″ D Overall
Terminal: No. 54

Stock No.	Ohms	Max. Amps.	Stock No.	Ohms	Max. Amps.
3860	1.0	1.50	3916	68	.18
3861	1.1	1.43	3918	75	.17
3862	1.2	1.37	3920	82	.16
3863	1.3	1.31	3922	91	.16
3864	1.5	1.22	3923	100	.15
3865	1.6	1.18	3924	110	.14
3866	1.8	1.11	3925	120	.14
3867	2.0	1.05	3926	130	.13
3868	2.2	1.01	3927	150	.12
3869	2.4	.97	3928	160	.12
3871	2.7	.91	3929	180	.11
3872	3.0	.86	3930	200	.10
3873	3.3	.82	3931	220	.10
3874	3.6	.79	3932	240	.097
3875	3.9	.76	3933	250	.094
3876	4.0	.73	3934	270	.091
3877	4.3	.72	3935	300	.086
3878	4.7	.69	3936	330	.082
3879	5.0	.67	3937	350	.080
3880	5.1	.66	3938	360	.079
3881	5.6	.63	3939	390	.076
3883	6.2	.60	3940	400	.075
3884	6.8	.57	3941	430	.072
3886	7.5	.55	3942	450	.071
3888	8.2	.52	3943	470	.069
3890	9.1	.50	3944	500	.067
3891	10	.47	3945	510	.066
3892	11	.45	3946	560	.063
3893	12	.43	3947	600	.061
3894	13	.41	3948	620	.060
3895	15	.39	3949	680	.057
3896	16	.37	3950	700	.056
3897	18	.35	3951	750	.055
3898	20	.33	3952	800	.053
3899	22	.32	3953	820	.052
3900	24	.31	3954	900	.050
3901	25	.30	3955	910	.050
3902	27	.29	3956	1000	.047
3903	30	.27	3957	1100	.045
3904	33	.26	3958	1200	.043
3905	35	.25	3959	1300	.041
3906	36	.25	3960	1400	.040
3907	39	.24	3961	1500	.039
3908	40	.24	3962	1600	.037
3909	43	.23	3963	1800	.035
3910	47	.22	3964	2000	.033
3911	50	.21	3965	2200	.032
3912	51	.21	3966	2400	.031
3913	56	.20	3967	2500	.030
3915	62	.19	3968	2700	.028
			3969	3000	.027

Avg. Weight .0018 lb.

3¼ WATT — STOCK STYLE 995-3A
.547″ L x .203″ D Overall
Terminal: No. 54

Stock No.	Ohms	Max. Amps.	Stock No.	Ohms	Max. Amps.
4330	1.0	1.80	4399	200	.13
4331	1.1	1.71	4400	220	.12
4332	1.2	1.65	4401	240	.11
4333	1.3	1.58	4402	250	.11
4334	1.5	1.47	4403	270	.109
4335	1.6	1.42	4404	300	.100
4336	1.8	1.34	4405	330	.099
4337	2.0	1.27	4405A	350	.096
4338	2.2	1.22	4406	360	.095
4339	2.4	1.16	4407	390	.091
4341	2.7	1.09	4408	400	.090
4342	3.0	1.04	4409	430	.087
4343	3.3	.99	4409A	450	.084
4344	3.6	.95	4410	470	.083
4345	3.9	.91	4411	500	.081
4346	4.0	.90	4412	510	.080
4347	4.3	.87	4413	560	.076
4348	4.7	.83	4414	600	.073
4349	5.0	.81	4415	620	.072
4350	5.1	.80	4416	680	.069
4351	5.6	.76	4417	700	.068
4353	6.2	.72	4418	750	.065
4354	6.8	.69	4419	800	.064
4356	7.5	.65	4420	820	.063
4358	8.2	.63	4421	900	.060
4360	9.1	.60	4422	910	.060
4361	10	.56	4423	1000	.056
4362	11	.54	4424	1100	.054
4363	12	.52	4425	1200	.052
4364	13	.50	4426	1300	.050
4365	15	.47	4426A	1400	.048
4366	16	.45	4427	1500	.047
4367	18	.42	4428	1600	.045
4368	20	.40	4429	1800	.042
4369	22	.39	4430	2000	.040
4370	24	.36	4431	2200	.039
4371	25	.36	4432	2400	.036
4372	27	.35	4433	2500	.036
4373	30	.30	4434	2700	.035
4374	33	.31	4435	3000	.033
4374A	35	.30	4436	3300	.031
4375	36	.30	4436A	3500	.030
4376	39	.29	4437	3600	.030
4377	40	.28	4438	3900	.029
4378	43	.27	4439	4000	.028
4379	47	.26	4440	4300	.027
4380	50	.25	4440A	4500	.027
4381	51	.25	4441	4700	.026
4382	56	.24	4442	5000	.025
4384	62	.23	4443	5100	.025
4385	68	.22	4444	5600	.024
4387	75	.21	4445	6000	.023
4389	82	.20	4446	6200	.023
4391	91	.19	4447	6800	.022
4392	100	.18	4448	7000	.021
4393	110	.17	4449	7500	.021
4394	120	.16	4450	8000	.020
4395	130	.16	4451	8200	.020
4396	150	.15	4452	9000	.019
4397	160	.14	4453	9100	.019
4398	180	.13	4454	10000	.018

Avg. Weight .003 lb.

STOCK SERIES 99

Molded Vitreous Resistors

5 WATT

STOCK STYLE 995-5B

.938″ L x .203″ D Overall

Terminal: No. 54

Stock No.	Ohms	Max. Amps.	Stock No.	Ohms	Max. Amps.
4530	1.0	2.24	4605	330	.12
4531	1.1	2.13	4605A	350	.12
4532	1.2	2.04	4606	360	.12
4533	1.3	1.96	4607	390	.11
4534	1.5	1.83	4608	400	.11
4535	1.6	1.77	4609	430	.11
4536	1.8	1.67	4609A	450	.11
4537	2.0	1.58	4610	470	.10
4538	2.2	1.51	4611	500	.10
4539	2.4	1.44	4612	510	.10
4541	2.7	1.36	4613	560	.094
4542	3.0	1.29	4614	600	.091
4543	3.3	1.23	4615	620	.090
4544	3.6	1.18	4616	680	.086
4545	3.9	1.13	4617	700	.084
4546	4.0	1.11	4618	750	.082
4547	4.3	1.07	4619	800	.079
4548	4.7	1.03	4620	820	.078
4549	5.0	1.00	4621	900	.074
4550	5.1	.99	4622	910	.074
4551	5.6	.94	4623	1000	.071
4553	6.2	.90	4624	1100	.067
4554	6.8	.86	4625	1200	.065
4556	7.5	.82	4626	1300	.062
4558	8.2	.78	4626A	1400	.059
4560	9.1	.74	4627	1500	.058
4561	10	.71	4628	1600	.056
4562	11	.67	4629	1800	.053
4563	12	.65	4630	2000	.050
4564	13	.62	4631	2200	.048
4565	15	.58	4632	2400	.046
4566	16	.56	4633	2500	.045
4567	18	.53	4634	2700	.043
4568	20	.50	4635	3000	.041
4569	22	.48	4636	3300	.039
4570	24	.46	4636A	3500	.038
4571	25	.45	4637	3600	.037
4572	27	.43	4638	3900	.036
4573	30	.41	4639	4000	.035
4574	33	.39	4640	4300	.034
4574A	35	.38	4640A	4500	.033
4575	36	.37	4641	4700	.033
4576	39	.36	4642	5000	.032
4577	40	.35	4643	5100	.031
4578	43	.34	4644	5600	.030
4579	47	.33	4645	6000	.029
4580	50	.32	4646	6200	.028
4581	51	.31	4647	6800	.027
4582	56	.30	4648	7000	.027
4584	62	.28	4649	7500	.026
4585	68	.27	4650	8000	.025
4587	75	.26	4651	8200	.025
4589	82	.25	4652	9000	.024
4591	91	.23	4653	9100	.023
4592	100	.22	4654	10000	.022
4593	110	.21	4655	11000	.021
4594	120	.20	4656	12000	.020
4595	130	.20	4657	13000	.020
4596	150	.18	4657A	14000	.018
4597	160	.18	4658	15000	.018
4598	180	.17	4659	16000	.018
4599	200	.16	4659B	17000	.017
4600	220	.15	4660	18000	.017
4601	240	.14	4661	20000	.016
4602	250	.14	4662	22000	.015
4603	270	.14	4663	24000	.014
4604	300	.13	4664	25000	.014

Avg. Weight .004 lb.

11 WATT

STOCK STYLE 995-10A

1.781″ L x .312″ D Overall

Terminal: No. 54

Stock No.	Ohms	Max. Amps.	Stock No.	Ohms	Max. Amps.
4730	1.0	3.32	4805	330	.18
4731	1.1	3.16	4805A	350	.18
4732	1.2	3.03	4806	360	.17
4733	1.3	2.91	4807	390	.17
4734	1.5	2.71	4808	400	.16
4735	1.6	2.62	4809	430	.16
4736	1.8	2.42	4809A	450	.16
4737	2.0	2.34	4810	470	.15
4738	2.2	2.24	4811	500	.15
4739	2.4	2.14	4812	510	.15
4741	2.7	2.02	4813	560	.14
4742	3.0	1.92	4814	600	.14
4743	3.3	1.83	4815	620	.13
4744	3.6	1.75	4816	680	.13
4745	3.9	1.67	4817	700	.12
4746	4.0	1.66	4818	750	.12
4747	4.3	1.60	4819	800	.12
4748	4.7	1.53	4820	820	.12
4749	5.0	1.48	4821	900	.11
4750	5.1	1.47	4822	910	.11
4751	5.6	1.40	4823	1000	.11
4753	6.2	1.33	4824	1100	.10
4754	6.8	1.27	4825	1200	.096
4756	7.5	1.21	4826	1300	.092
4758	8.2	1.16	4826A	1400	.089
4760	9.1	1.10	4827	1500	.086
4761	10	1.05	4828	1600	.083
4762	11	1.00	4829	1800	.078
4763	12	.96	4830	2000	.074
4764	13	.92	4831	2200	.071
4765	15	.86	4832	2400	.068
4766	16	.83	4833	2500	.066
4767	18	.78	4834	2700	.064
4768	20	.74	4835	3000	.061
4769	22	.71	4836	3300	.058
4770	24	.68	4836A	3500	.056
4771	25	.66	4837	3600	.055
4772	27	.64	4838	3900	.053
4773	30	.61	4839	4000	.052
4774	33	.58	4840	4300	.050
4774A	35	.56	4840A	4500	.049
4775	36	.55	4841	4700	.048
4776	39	.53	4842	5000	.047
4777	40	.52	4843	5100	.046
4778	43	.50	4844	5600	.044
4779	47	.48	4845	6000	.043
4780	50	.47	4846	6200	.042
4781	51	.46	4847	6800	.040
4782	56	.44	4848	7000	.040
4784	62	.42	4849	7500	.038
4785	68	.40	4850	8000	.037
4787	75	.38	4851	8200	.037
4789	82	.37	4852	9000	.035
4791	91	.35	4853	9100	.035
4792	100	.33	4854	10000	.033
4793	110	.31	4855	11000	.031
4794	120	.30	4856	12000	.030
4795	130	.29	4857	13000	.029
4796	150	.27	4857B	14000	.028
4797	160	.26	4858	15000	.027
4798	180	.24	4859A	16000	.026
4799	200	.23	4859C	17000	.025
4800	220	.22	4860	18000	.024
4801	240	.21	4861	20000	.023
4802	250	.21	4862	22000	.022
4803	270	.20	4863	24000	.021
4804	300	.19	4864	25000	.021

Avg. Weight .015 lb.

Stock No.	Ohms	Max. Amps.	Stock No.	Ohms	Max. Amps.
4865	27000	.020	4870	40000	.016
4866	30000	.019	4871	43000	.016
4867	33000	.018	4871A	45000	.016
4867A	35000	.018	4872	47000	.015
4868	36000	.017	4873	50000	.015
4869	39000	.017	4874	51000	.015

Avg. Weight .015 lb.

(Continued from page 13)

approximately within ±5% of a stock Series 99 resistor. Construction of stock units is the same as described in the made-to-order section on pages 11, 12. Leads are 1½″ long and tinned—24 AWG for the 1½ watt size; 20 AWG for the 2¼, 3¼, 5 and 11 watt sizes. Resistance tolerance is ±5%.

Fig. 13: Five and eleven-watt resistors

OHM'S LAW CALCULATOR

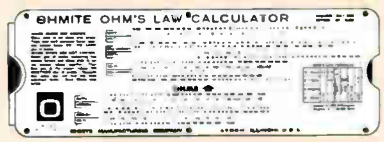


Fig. 14: Ohm's Law Calculator.

Famous Ohmite OHM'S LAW CALCULATOR solves Ohm's Law problems with just one setting of the slide. Handy, pocket-sized (9″ x 3″), it solves problems involving ohms, volts, amperes and watts where any two of these factors are known. Resistance scales range from 0.1 to 100 megohms. Current scales are provided in both amperes and milliamperes. Lists all the formulae variations of Ohm's Law; includes parallel resistance computing scales. Also carries the familar A, B, C, D, slide rule scales for making supplementary calculations. Two types are available — heavy varnished cardboard and a deluxe model of durable Vinylite.

Type	Stock No.
Cardboard	5180
Plastic	5182

Clips for Molded Resistors
Series 22 Axial-Lead Resistors

OHMITE

MOUNTING CLIPS for MOLDED AXIAL LEAD RESISTORS

Molded axial lead resistors (Series 88, "Ohmicone" silcone-ceramic and Series 99, vitreous enamel) are distinguished for their consistent form and dimensions. This characteristic facilitates mounting of such resistors in clips. Thus, while these resistors are conventionally lead mounted, clip mounting may be desirable where immunity to severe vibration or mechanical shock is required. Clip mounting confers another advantage in the form of heat sink benefits. With the clip mounted on a metal surface*, up to a 100% increase in wattage rating is possible. Holes in the base of the clips permit fastening to chassis surface by means of machine screws, eyelets or rivets.

**Equivalent to a minimum of 1½ sq. inches of .040″ aluminum per watt dissipated.*

STOCK CLIPS

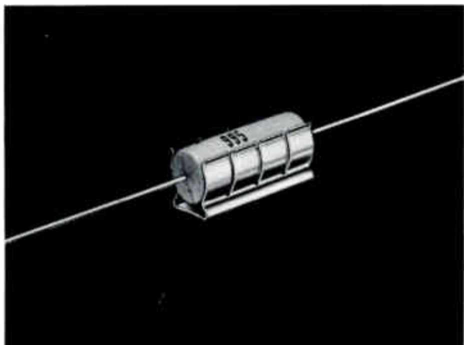


Fig. 15: Series 99 resistor and clip.

Series 88 (Types 881, 882, 884)	Series 99 (Types 991, 994, 995)	CLIP STOCK NO. AND DIMENSIONS						
Style Suffix	Style Suffix	Stock No.	Clip Length	Clip Width	Clip Height	No. of Holes	Hole Ctrs.	Hole Dia.
—1A	—1A	5900	.40″	.150″	.250″	1	....	.071″
—1B	....	5901	.50″	.150″	.250″	2	.300″	.071″
—2	—2A	5902	.35″	.217″	.275″	2	.156″	.071″
—3	—3, —3A	5904	.50″	.257″	.319″	2	.250″	.093″
—5, —6.5	—5A, —6.5	5905	.90″	.333″	.377″	2	.500″	.093″
....	—5B	5906	.90″	.237″	.284″	2	.400″	.103″
—7, —8	—7A	5907	1.20″	.333″	.375″	2	.600″	.103″
....	—10A, —11	5908	1.75″	.333″	.377″	2	.800″	.103″
—10, —11	....	5909	1.75″	.360″	.385″	2	.800″	.103″

SERIES 22 AXIAL-LEAD WIREWOUND RESISTORS with Conformal Vitreous Enamel Coating

MADE-TO-ORDER

Wirewound axial-lead resistors in which a conformal vitreous enamel coating is employed.

Construction: Resistance wire is wound on a steatite tube and is welded to the metal end caps. Terminal leads are also welded to the caps for stable, noise-free connections. The wirewound core is then coated with exclusive, Ohmite vitreous enamel.

Sizes: Four basic diameters available in a variety of lengths provide a wide range of wattage and resistance values (see table).

Wattage Range: From 1 to 10 watts.

Watts	Overall Dimension	Core Size	Max. Ohms†	‡Code
* 1	9/16″ x 1/8″	15/32″ x 1/16″	6,000	15/32-V-54-F
* 3	9/16″ x 1/4″	7/16″ x 5/32″	10,000	7/16-A-54-F
5	15/16″ x 1/4″	3/4″ x 5/32″	15,000	3/4-A-54-F
5	15/16″ x 11/32″	3/4″ x 1/4″	20,000	3/4-C-54-F
* 5	1 1/16″ x 11/32″	7/8″ x 1/4″	25,000	7/8-C-54-F
7.5	1 3/16″ x 11/32″	1″ x 1/4″	30,000	1-D-54-F
7	15/16″ x 13/32″	3/4″ x 5/16″	13,500	3/4-D-54-F
10	1 13/16″ x 13/32″	1 5/8″ x 5/16″	45,500	1 5/8-D-54-F
*10	1 15/16″ x 13/32″	1 3/4″ x 5/16″	50,000	1 3/4-D-54-F

†Min. ohms all sizes = 1 ohm.
‡Order by code and ohms.
*Previous stock size.

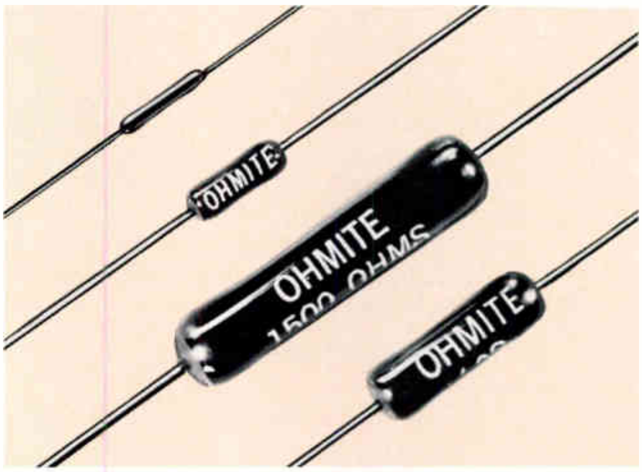


Fig. 16: Series 22 conformal vitreous enamel axial-lead resistors.

Tolerance: Standard tolerance is ±5% for 1 ohm and higher; below 1 ohm tolerance is ±10%. Special tolerances available.

Made-To-Order: Series 22 units are made to order. A new, improved type of vitreous enameled, axial-lead resistor, the Series 99 molded resistor, is now carried in stock and supersedes the Series 22. Unless otherwise specified, Ohmite, at its option, will supply the equivalent in a Series 99 resistor (see pages 11-14).

SERIES 88 Molded Ohmicone Precision Power Resistors

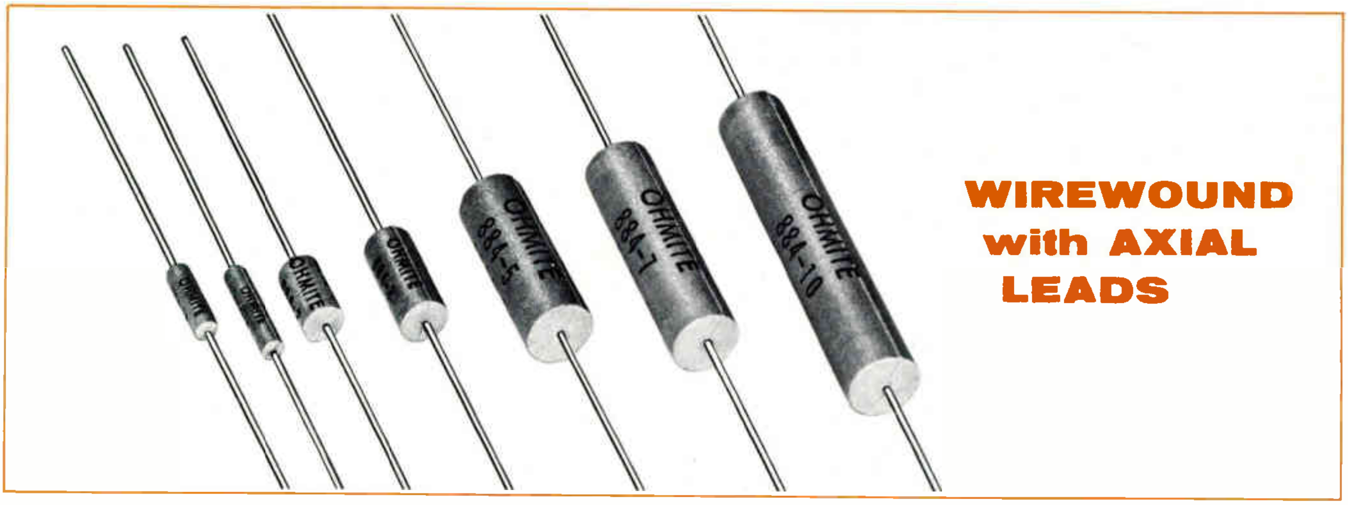


Fig. 17: Series 88 molded Ohmicone resistors.

"Series 88" precision resistors are single-layer wound on a ceramic core. Both the axial-type terminal leads and the resistance wire are welded to metal caps fitted over the core ends. A jacket of patented "OHMICONE," a tough, resilient, moisture-resistant, high-dielectric silicone-ceramic material, is then molded around the resistor to provide a uniformly thick, dense and smooth covering and a unit of thoroughly consistent shape and dimension. Insulation breakdown rating is 1000 VAC; 500 VAC for 1 watt size. Consistent form and size adapts Series 88 resistors to rapid automated assembly of equipment; it also permits mounting in clips for important heat-sink benefits (page 15).

Series 88 resistors are furnished in three basic categories—Types 881 and 881P for military specification MIL-R-26 (and proposed revisions); Type 882 for commercial power applications and Type 884 for high stability, precision-power applications. (Type 884 is the commercial equivalent of Type 881P resistors.) All types feature a low temperature coefficient of resistance (TC) as follows:

TC in ppm/°C	Ohms Range
0±20	10 and above
0±50	1 to 10
Consult factory	below 1

Lower TC's are available, consult factory, Standard leads are solderable; for weldable leads and for non-inductive versions, consult factory.

TYPES 881 & 881P for MILITARY APPLICATIONS

MIL-R-26 and Proposed Revision

Type 881: This type meets the requirements of MIL-R-26C and D, Styles RW67, RW68 and RW69 axial-lead resistors in both G (275°C hot spot) and V (350°C) characteristics. These styles call for ±5% resistance tolerance but Ohmite supplies ±3% at no extra cost. If required, Ohmite can also provide these resistors in Styles RW57, RW58 and RW59, Characteristics G or V.

Type 881P: Both the "V" and "P" characteristics of proposed MIL-R-26D can be supplied. The "P" characteristic which covers resistor Styles RW70, RW77, RW78 and RW79, meets the requirements for Char. V but Char. P also sets more stringent stability, and much closer TC requirements; it also offers a choice of closer resistance tolerances.

Both 881 and 881P types meet the fundamental requirements of MIL-R-26 including the dielectric strength and insulation resistance test. Request Bulletin 101 or Ohmite Military Catalog 50.

TYPE 882 for COMMERCIAL POWER APPLICATIONS

This type is intended for broad commercial use. Standard tolerance is ±3% (for values 1 ohm and higher) which is supplied at no extra cost over ±5% tolerance. Closer tolerances are available. These units derate to zero watts at 350°C ambient (see Fig. 18); TC = 0±20ppm/°C 10 ohms and above; insulation tested at 1000 VAC (see introduction preceding).

TYPE 882, RANGES, DIMENSIONS

Ohmite Style	Nom. Watts 25°C①	Dimensions: Lgth. +.020 −.010	Dimensions: Dia. ±.020	Dimensions: Leads 1½" AWG	Typ. Wt. Grams	Ohms Range Std. 3% Tol.②	Max. Wkg. Volts RMS
882-1A	1.5	0.417	0.105	24	0.3	0.10- 7,500	—
882-1B	1.5	0.542	0.105	24	0.3	0.10- 12,400	—
882-2	2.25	0.375	0.188	20	0.6	0.10- 7,500	85
882-3	3.25	0.542	0.230	20	1.3	0.10- 24,900	200
882-6.5	6.5	0.917	0.323	18	3.3	0.10- 90,900	460
882-8	9	1.218	0.323	18	4.3	0.10-133,000	670
882-11	11	1.823	0.343	18	6.3	0.10-226,000	1100

①See derating graph Fig. 18 for ambients above 25°C.
②Ohmite's standard power tolerance is 3% supplied at no extra charge over 5% for values 1 ohm and higher; 10% for values below 1 ohm. Closer tolerances are available.

SERIES 88 Molded Ohmicone Precision Power Resistors

OHMITE

TYPE 884 HIGH STABILITY, PRECISION-POWER TYPE

Type 884 resistors (formerly referred to as "Riteohm 88") are classified as a "precision-power" type. They are aged and conservatively rated for maximum long term stability and offer superior characteristics. Impressive load-life stability is exhibited by Type 884 resistors. For example, miscellaneous test groups totaling 547 units (including 3, 5 and 10 watt sizes over a resistance range of 1 to 200,000 ohms) displayed an average change in resistance of 0.45% after 10,000 hours of cyclic load-life testing (1½ hours on, ½ hour off).

Type 884 units are available in tolerances from 3% to 0.05% and derate to zero watts at 275°C ambient (Fig. 18); TC = 0±20ppm/°C for 10 ohms and above; insulation tested at 1000 VAC except 500 volts for 1 watt size (see introduction preceding page).

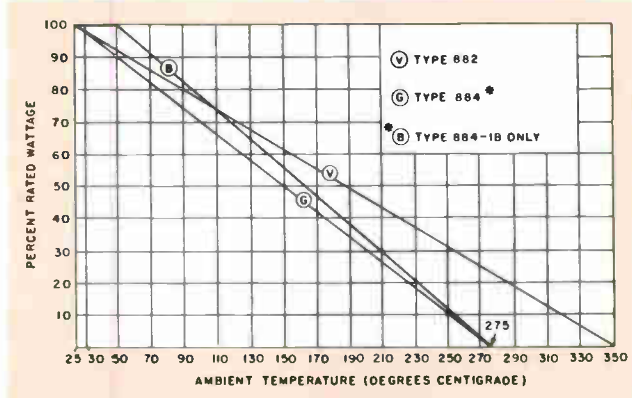


Fig. 18: Derating curves for Types 882 and 884 Resistors.

Ohmite stocks all of the 1% tolerance standard values in the MIL-Bell decade system, up to 200,000 ohms (see table, page 18).

TYPE 884, RANGES, DIMENSIONS

Ohmite Style	[illegible]	Dimensions Lgth. +.020 −.010	Dimensions Dia. ±.020	[illegible]	[illegible]	Resistance Ranges ② Closer Than 0.5% Tol. (Min. Ohms)	Resistance Ranges ② 0.5% & Greater (Min. Ohms)	Resistance Ranges ② Max. Ohms All Tols.	Max. Wkg. Volts RMS
884-1A	1	0.417	0.105	24	0.3	0.499	0.10	7,500	—
884-1B	1	0.542	0.105	24	0.3	0.499	0.10	12,400	—
884-2	2	0.375	0.188	20	0.6	0.499	0.10	7,500	85
884-3③	3	0.542	0.230	20	1.3	0.499	0.10	24,900	200
884-5③	5	0.917	0.323	18	3.3	0.499	0.10	90,900	460
884-7	7	1.218	0.323	18	4.3	0.499	0.10	133,000	670
884-10③	10	1.823	0.343	18	6.3	0.499	0.10	226,000	1100

①See derating graph Fig. 18 for ambients above 25°C.

②Low resistance values (20 Ω and less) are measured at a point on each lead ⅜"±1/16 from body of resistor. Special tolerances to 0.05% can be supplied. For all values 10 ohms and below, it is advisable to use Kelvin bridge technique to eliminate errors due to lead and contact resistance.

③Styles 884-3, 884-5 and 884-10 can be supplied for use as MIL-R-26C Styles RW69G, RW67G and RW68G, respectively. These have better T.C., and stability characteristics than required by MIL-R-26C. The styles supplied under Characteristic P of proposed MIL-R-26D (Bul. 101 or Cat. 50) are furnished under Ohmite Type 881P which is the military equivalent of commercial Type 884.

RESISTORS for MILITARY APPLICATIONS

A complete line of resistors for MIL-R-26, MIL-R-19365 and MIL-R-10509 is described in Ohmite's unique Military Catalog 50. While designated a "catalog," it is, more accurately, a valuable manual of U.S. military specifications on a variety of components made by Ohmite. It simplifies the formidable maze of military specifications and expedites the ordering of components. Write to factory for a copy of Catalog 50. Shock-resistant resistors for MIL-R-15109 are described in Bulletin 104.

STOCK TYPE 884 Precision Molded Ohmicone Resistors

OHMITE

±1% TOLERANCE, TYPE 884 PRECISION RESISTORS (Styles 884-3, -5, -10)

(Values Based on MIL-Bell System of Standard Values For 1% Tolerance—Also See Footnote)

3 Watt		3 Watt		3 Watt		3 Watt		3 Watt		3 Watt	
Ohms	Max. Volts	Ohms	Max. Volts	Ohms	Max. Volts	Ohms	Max. Volts	Ohms	Max. Volts	Ohms	Max. Volts
.100	.547	3.48	3.23	17.8	7.30	90.9	16.5	464	37.3	2370	84.3
.121	.602	3.57	3.27	18.2	7.39	93.1	16.7	475	37.7	2430	85.4
.150	.670	3.65	3.31	18.7	7.49	95.3	16.9	487	38.2	2490	86.4
.182	.739	3.74	3.35	19.1	7.57	97.6	17.1	499	38.7	2550	87.4
.200	.774	3.83	3.39	19.6	7.66	100	17.3	511	39.1	2610	88.4
.221	.814	3.92	3.43	20.0	7.74	102	17.5	523	39.6	2670	89.5
.249	.864	4.02	3.47	20.5	7.84	105	17.7	536	40.1	2740	90.6
.274	.906	4.12	3.51	21.0	7.94	107	17.9	549	40.6	2800	91.6
.332	.998	4.22	3.56	21.5	8.03	110	18.2	562	41.0	2870	92.8
.392	1.08	4.32	3.60	22.1	8.14	113	18.4	576	41.6	2940	93.9
.475	1.19	4.42	3.64	22.6	8.23	115	18.6	590	42.0	3010	95.0
.499	1.22	4.53	3.69	23.2	8.34	118	18.8	604	42.5	3090	96.2
.562	1.30	4.64	3.73	23.7	8.43	121	19.1	619	43.1	3160	97.4
.681	1.43	4.75	3.77	24.3	8.54	124	19.3	634	43.6	3240	98.6
.750	1.50	4.87	3.82	24.9	8.64	127	19.5	649	44.1	3320	99.8
.825	1.57	4.99	3.87	25.5	8.74	130	19.7	665	44.6	3400	101
1.00	1.73	5.11	3.91	26.1	8.84	133	20.0	681	45.2	3480	102
1.02	1.75	5.23	3.96	26.7	8.95	137	20.3	698	45.7	3570	103
1.05	1.77	5.36	4.01	27.4	9.06	140	20.5	715	46.3	3650	105
1.07	1.79	5.49	4.06	28.0	9.16	143	20.7	732	46.8	3740	106
1.10	1.82	5.62	4.10	28.7	9.28	147	21.0	750	47.4	3830	107
1.13	1.84	5.76	4.16	29.4	9.39	150	21.2	768	48.0	3920	108
1.15	1.86	5.90	4.20	30.1	9.50	154	21.5	787	48.6	4020	110
1.18	1.88	6.04	4.25	30.9	9.62	158	21.8	806	49.2	4120	111
1.21	1.91	6.19	4.31	31.6	9.74	162	22.0	825	49.7	4220	112
1.24	1.93	6.34	4.36	32.4	9.86	165	22.2	845	50.4	4320	114
1.27	1.95	6.49	4.41	33.2	9.98	169	22.5	866	51.0	4420	115
1.30	1.97	6.65	4.46	34.0	10.1	174	22.8	887	51.6	4530	117
1.33	2.00	6.81	4.52	34.8	10.2	178	23.1	909	52.2	4640	118
1.37	2.03	6.98	4.57	35.7	10.3	182	23.4	931	52.8	4750	119
1.40	2.05	7.15	4.63	36.5	10.5	187	23.7	953	53.4	4870	121
1.43	2.07	7.32	4.68	37.4	10.6	191	23.9	976	54.1	4990	122
1.47	2.10	7.50	4.74	38.3	10.7	196	24.2	1000	54.7	5110	124
1.50	2.12	7.68	4.80	39.2	10.8	200	24.5	1020	55.3	5230	125
1.54	2.15	7.87	4.86	40.2	11.0	205	24.8	1050	56.1	5360	127
1.58	2.18	8.06	4.92	41.2	11.1	210	25.1	1070	56.6	5490	128
1.62	2.20	8.25	4.97	42.2	11.2	215	25.4	1100	57.4	5620	130
1.65	2.22	8.45	5.04	43.2	11.4	221	25.7	1130	58.2	5760	131
1.69	2.25	8.66	5.10	44.2	11.5	226	26.0	1150	58.7	5900	133
1.74	2.28	8.87	5.16	45.3	11.7	232	26.4	1180	59.5	6040	134
1.78	2.31	9.09	5.22	46.4	11.8	237	26.7	1210	60.2	6190	136
1.82	2.34	9.31	5.28	47.5	11.9	243	27.0	1240	61.0	6340	138
1.87	2.37	9.53	5.34	48.7	12.1	249	27.3	1270	61.7	6490	140
1.91	2.39	9.76	5.41	49.9	12.2	255	27.7	1300	62.4	6650	141
1.96	2.42	10.0	5.47	51.1	12.4	261	28.0	1330	63.2	6810	143
2.00	2.45	10.2	5.53	52.3	12.5	267	28.3	1370	64.1	6980	145
2.05	2.48	10.5	5.61	53.6	12.7	274	28.7	1400	64.8	7150	146
2.10	2.51	10.7	5.66	54.9	12.8	280	29.0	1430	65.5	7320	148
2.15	2.54	11.0	5.74	56.2	13.0	287	29.3	1470	66.4	7500	150
2.21	2.57	11.3	5.82	57.6	13.1	294	29.7	1500	67.0	7680	152
2.26	2.60	11.5	5.87	59.0	13.3	301	30.0	1540	68.0	7870	154
2.32	2.64	11.8	5.95	60.4	13.4	309	30.4	1580	68.8	8060	155
2.37	2.67	12.1	6.02	61.9	13.6	316	30.8	1620	69.7	8250	157
2.43	2.70	12.4	6.10	63.4	13.8	324	31.2	1650	70.3	8450	159
2.49	2.73	12.7	6.17	64.9	13.9	332	31.6	1690	71.2	8660	161
2.55	2.77	13.0	6.24	66.5	14.1	340	31.9	1740	72.2	8870	163
2.61	2.80	13.3	6.32	68.1	14.3	348	32.3	1780	73.0	9090	165
2.67	2.83	13.7	6.41	69.8	14.5	357	32.7	1820	73.9	9310	167
2.74	2.87	14.0	6.48	71.5	14.6	365	33.1	1870	74.9	9530	169
2.80	2.90	14.3	6.55	73.2	14.8	374	33.5	1910	75.7	9760	171
2.87	2.93	14.7	6.64	75.0	15.0	383	33.9	1960	76.6	10K	173
2.94	2.97	15.0	6.70	76.8	15.2	392	34.3	2000	77.4	10.2K	175
3.01	3.00	15.4	6.80	78.7	15.4	402	34.7	2050	78.4	10.5K	178
3.09	3.04	15.8	6.88	80.6	15.5	412	35.1	2100	79.4	10.7K	179
3.16	3.08	16.2	6.97	82.5	15.7	422	35.6	2150	80.3	11K	182
3.24	3.12	16.5	7.03	84.5	15.9	432	36.1	2210	81.4	11.3K	184
3.32	3.16	16.9	7.12	86.6	16.1	442	36.4	2260	82.3	11.5K	186
3.40	3.19	17.4	7.22	88.7	16.3	453	36.9	2320	83.4	11.8K	188

3 Watt	
Ohms	Max. Volts
12.1K	190
12.4K	193
12.7K	195
13K	197
13.3K	200
13.7K	200
14K	200
14.3K	200
14.7K	200
15K	200
15.4K	200
15.8K	200
16.2K	200
16.5K	200
16.9K	200
17.4K	200
17.8K	200
18.2K	200
18.7K	200
19.1K	200
19.6K	200
20K	200
20.5K	200
21K	200
21.5K	200
22.1K	200
5 WATT	
22.6K	337
23.2K	341
23.7K	344
24.3K	347
24.9K	353
25.5K	357
26.1K	361
26.7K	365
27.4K	370
28K	374
28.7K	379
29.4K	383
30.1K	388
30.9K	393
31.6K	397
32.4K	402
33.2K	407
34K	412
34.8K	417
35.7K	422
36.5K	427
37.4K	432
38.3K	437
39.2K	442
40.2K	448
41.2K	454
42.2K	460
43.2K	460
44.2K	460
45.3K	460
46.4K	460
47.5K	460
48.7K	460
49.9K	460
51.1K	460
52.3K	460
53.6K	460
54.9K	460
56.2K	460
57.6K	460

5 Watt	
Ohms	Max. Volts
59K	460
60.4K	460
61.9K	460
63.4K	460
64.9K	460
66.5K	460
68.1K	460
69.8K	460
71.5K	460
73.2K	460
75K	460
76.8K	460
78.7K	460
80.6K	460
10 WATT	
82.5K	908
84.5K	919
86.6K	930
88.7K	942
90.9K	952
93.1K	965
95.3K	976
97.6K	988
100K	1000
102K	1010
105K	1020
107K	1030
110K	1050
113K	1060
115K	1070
118K	1090
121K	1100
124K	1100
127K	1100
130K	1100
133K	1100
137K	1100
140K	1100
143K	1100
147K	1100
150K	1100
154K	1100
158K	1100
162K	1100
165K	1100
169K	1100
174K	1100
178K	1100
182K	1100
187K	1100
191K	1100
196K	1100
200K	1100

Resistance values in tinted areas are derated in wattage because of maximum voltage gradient considerations. Even with these voltage limitations, however, the wattage ratings are still adequate for most precision applications. However, where wattage requirements dictate, the same value shown in a derated area for either the 3 or 5 watt sizes can be made-to-order in the next higher wattage as the case may be.

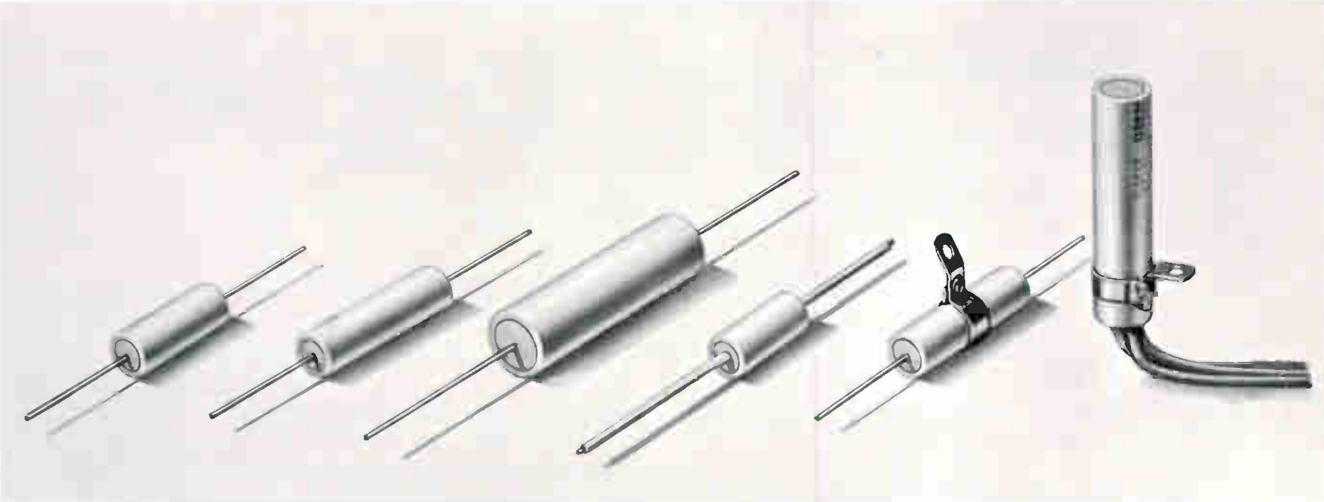


Fig. 19: Typical Tubeohm resistors.

When a resistor with an insulating shell is needed, so that the resistor may be mounted directly against a metal panel, the Ohmite Tubeohm type of resistor provides the answer. It is produced in four basic sizes, rated 5, 10, 20 and 25 watts for commercial purposes and also in two military versions, RW55 and RW56, per specification MIL-R-26 (see page 17).

A unit consists of a wirewound, Series 88, Molded Ohmicone Resistor (Page 16) which is in turn sealed in an outer ceramic shell. Special high temperature cements secure the resistor to the core and plug the ends. The usual terminals are axial, tinned wire leads, which are approximately centered on the ends.

Tubeohms with insulated flexible wire leads can be provided for use where a completely insulated resistor, with no exposed terminals is wanted. Applications occur in such equipment as motion picture apparatus, air conditioning and other equipment. When the equipment is to be approved by the Underwriters' Laboratories, it is necessary that complete details on such requirements be furnished to enable us to recommend the proper unit.

Terminals: Bare wire leads, lugs and insulated wire leads are available. The insulated wire is generally stranded and may have glass braid over plastic insulation, silastic, "Neoprene" or other synthetic "rubber" insulation. Terminals can be brought out at one end. Resistors may have 1 or 2 taps.

Mounting Brackets

Tubeohms are usually mounted by their leads, but they can be mounted by a metal strap which can be supplied fastened around the tube, as illustrated. The vertical type bracket is designed for through-the-chassis mounting, with most of the resistor above the chassis and generally both of the terminals below. Brackets are supplied only when specified on the order.

Watts	Overall Dimen. L	Overall Dimen. D	Max. Ohms
5	1 3/8	1/2	5,000
10	2	1/2	10,000
10	1 1/2	19/32	6,000
20	2 1/2	19/32	12,000
25	2 3/4	23/32	25,000

Bracket, Horizontal type, for 1/2" dia. . . . Cat. No. 15
Bracket, Horizontal type, for 23/32" dia. . . . Cat. No. 23
Bracket, Vertical type, for 19/32" dia. . . . . Cat. No. 19

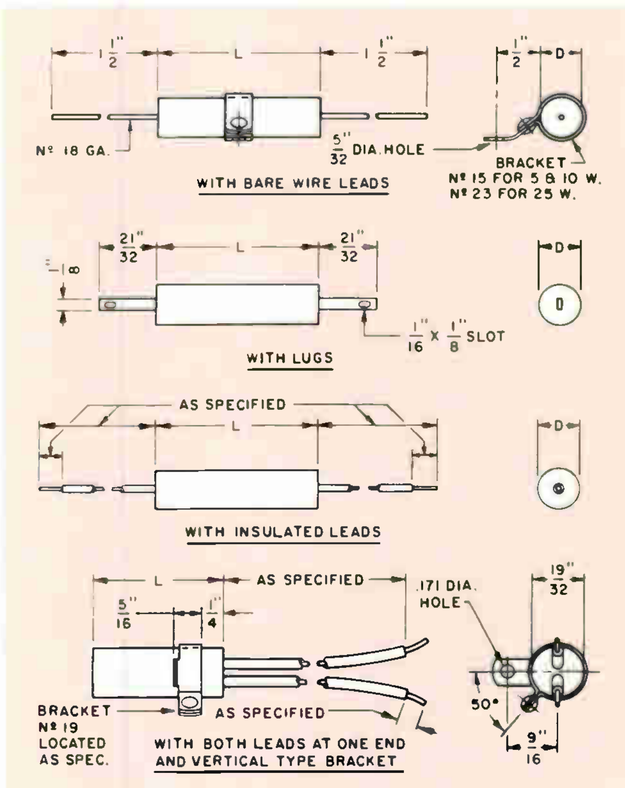


Fig. 20: Tubeohm dimensions.

OHMITE

SERIES 66
METAL FILM RESISTORS

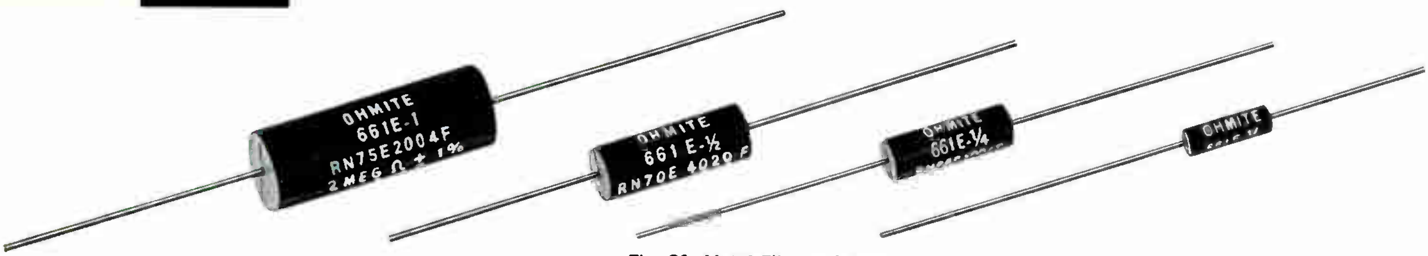


Fig. 21: Metal Film resistors.

Series 66 resistors culminate an intensive program dedicated to the development of the highest quality metal film resistors available to industry! As a result, Series 66 resistors are made only with the lowest specified (per MIL-R-10509E) TC, 0±25ppm/°C, as well as stability and low noise level comparable to precision wirewounds! These units may be confidently relied upon for accuracy, for operation in very high ambients and in high-frequency or high-gain circuits where low reactance and low noise level are mandatory. They are designed to exceed the requirements of MIL-R-10509E.

Construction: The resistance element is a film of special, non-noble metal alloy vacuum-evaporated onto a special ceramic core. Contact to the film is achieved with gold terminal bands fired onto the core ends. Gold-plated end-caps are pressed over the core ends and leads are butt-welded to the caps. The assembly is covered with a special protective resin and completed with a molded coating. Film, core, caps and coating are matched to provide a stable, moisture-resistant component.

Tolerance: Standard tolerance is ±1.0%; tolerances to ±0.1% are available.

Leads: Standard leads are nickel, solder-dip coated for soldering; also furnished bare for welding or gold-plated on special order.

Temperature Coefficient of Resistance (TC): Available only in 0±25ppm/°C ("E" characteristic) over the range of −55°C to +175°C.

TABLE I, TYPE 661 METAL FILM RESISTORS

Ohmite Style	MIL Style	Watts @ 125°C†	Volts (max)	Dimensions: Lgth. ±.015	Dimensions: Dia. ±.010	Leads 1½" AWG*	Min. Ohms	Max. Ohms
661E-⅛	RN60E	⅛	250	.406	.130	22	309	499K
661E-¼	RN65E	¼	300	.594	.203	22	402	1MEG
661E-½	RN70E	½	350	.719	.261	20	402	1MEG
661E-1	RN75E	1	500	1.105	.395	20	365	2MEG

*22 AWG (.025 ±.002) 20 AWG (.032 ±.002) †Double wattage rating at 70°.

TABLE II, TYPICAL TEST DATA FOR SERIES 66 RESISTORS* . . . . . .

TESTS		Ohmite Style/MIL Style		661E-⅛/RN60E				661E-¼/RN65E					
		Watt Rating @ 125°C Amb.		⅛				¼					
		Resistance		309Ω		499KΩ		402Ω		348KΩ		1 MEGΩ	
		MIL Requirements	Avg. of All Tests	Avg.†	Range	Avg.†	Range	Avg.†	Range	Avg.†	Range	Avg.†	Range
T.C. in ppm/°C	@−55°C	25	7.93	9.1	−8.0 to −10.7	8.8	−5.1 to −12.5	5.6	−.5 to −12.0	2.3	+.3 to +5.8	4.4	−.1 to −8.7
T.C. in ppm/°C	@+175°C	25	17.79	15.9	+14.8 to +18.2	19.5	+10.5 to +23.7	23.3	+21.1 to +24.9	20.8	+13.0 to +25.0	18.6	+15.1 to +24.0
125° C Load Life @ 1000 Hrs.	% ΔR	± .5	.107	.097	−.017 to +.250	.080	−.002 to +.407	.145	+.014 to +.404	.088	+.051 to +.149	.062	+.049 to +.069
Temp. Cycling	% ΔR	±.25	.043	.018	0 to +.032	.049	+.040 to +.072	.029	−.003 to +.054	.041	+.022 to +.060	.042	+.024 to +.097
Low Temp. Operation	% ΔR	±.25	.028	.053	+.012 to +.135	.008	0 to +.014	.001	0 to +.004	.002	0 to −.006	.009	0 to −.013
Short Time Overload	% ΔR	±.25	.019	.031	0 to −.104	.009	0 to −.043	.001	0 to −.005	.001	0 to −.003	.006	−.003 to +.010
Terminal Strength	% ΔR	±.25	.003	.003	0 to −.007	.001	0 to +.002	.002	0 to −.005	.002	0 to +.005	.005	0 to +.010
Dielectric Withstand Volts	% ΔR	±.25	.005	.002	0 to −.012	0	0	.004	−.003 to −.005	.002	0 to +.008	.012	+.002 to +.039
Effect of Soldering	% ΔR	±.25	.013	.018	+.003 to +.035	.008	0 to +.022	.002	0 to +.002	.003	0 to −.015	.003	0 to −.006
Moisture Resistance	% ΔR	±.50	.058	.199	+.035 to +.432	.118	+.039 to +.222	.029	+.024 to +.034	.016	+.011 to +.017	.022	+.009 to +.039
Shock	% ΔR	±.25	.006	.008	−.004 to −.010	.002	0 to −.007	.010	+.007 to +.014	.003	0 to +.011	.002	0 to −.005
Hi-Freq. Vibration	% ΔR	±.25	.007	.003	0 to +.009	.006	0 to +.018	.011	−.005 to −.015	.005	0 to −.015	.014	+.002 to −.060

*440 units tested; 40 for each resistance value; 10 each test.
†Plus or minus signs have been disregarded in the computation of average values.

SERIES 66
METAL FILM RESISTORS

OHMITE

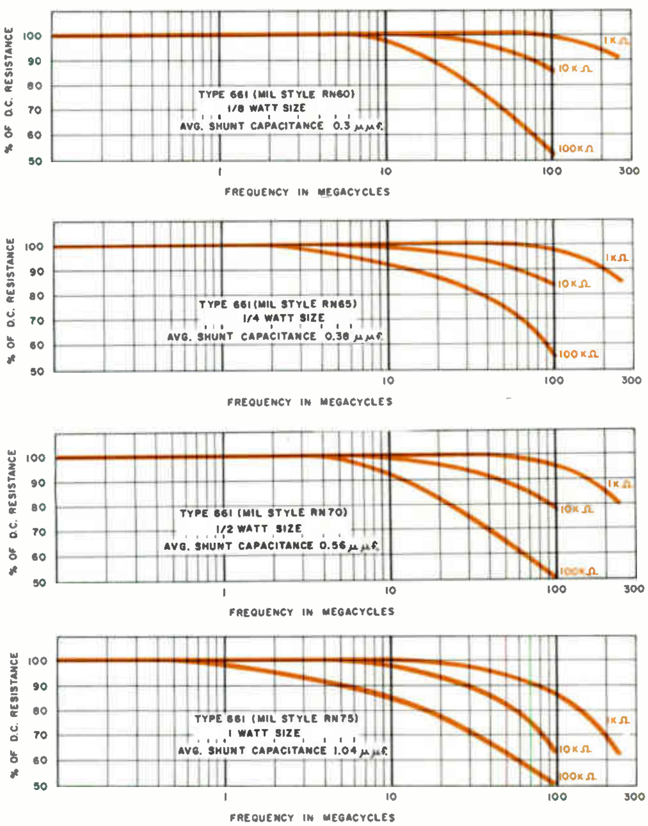


Fig. 22: Typical frequency characteristics.

Wattage Rating: Standard rating at 125°C. Derates linearly to "0" watts at 175°C. *Ratings double at 70°C ambient!*

Frequency, Load-Life and Noise Characteristics: See graphs and tables. The %ΔR values given here, while indicative of the general performance of this line, should not be used as *THE* design or performance limits for specification purposes. See Bulletin 110 for noise characteristics.

TABLE III, CYCLIC LOAD LIFE TEST† SUMMARY for SERIES 66 RESISTORS — ALL STYLES
(Groups Started at Different Times)

Ohmite Style	MIL Style	Total No. of Units	Total Unit-Hours	Failures
661E-⅛	RN60	300	3,000,000	0
661E-¼	RN65	327	3,270,000	0
661E-½	RN70	363	3,630,000	1*
661E-1	RN75	874	8,740,000‡	3**
	Total	1864	18,640,000	4

†Full wattage at 125°C.—1½ hr. on—½ hr. off.
*1 unit opened at 5000 hr.
**1 unit showed 4.5% ΔR at 1000 hr. 1 opened at 6000 hr. 1 opened at 8000 hr.
‡For detailed breakdown of this group, see Table IV.

TABLE IV, ANALYSIS of CYCLIC TEST TIME ON STYLE 661E-1 (RN75) RESISTORS*
(Total Units 874†—Total Unit-Hours 8,740,000)

Elapsed Hours as of 7-16-65	Total No. of Units	Total Unit-Hours	Avg. %ΔR	Max. %ΔR
1,000	874	874,000	0.11	0.58**
2,000	874	1,748,000	0.14	0.53††
5,000	874	4,370,000	0.22	0.61
10,000	874	8,740,000	0.31	1.94

*Various groups of units in the total of 874 went under test at different times.
†See Table III for failures and analysis thereof.
**1 unit exceeded 0.5%.
††2 units exceeded 0.5%.

TABLE V, DISTRIBUTION OF UNITS IN LOAD-LIFE TEST SUMMARY
(For Style 661E-1 (RN75) 1-Watt Resistor)

Resistance Value in Ohms	No. of Units	Resistance Value in Ohms	No. of Units
70	8	3,010	10
200	12	10,000	22
365	82	13,000	16
410	20	20,000	25
552	229	152,000	11
825	13	202,000	17
832	20	*237,000	267
1,000	10	1,000,000	10
2,770	10	2,000,000	82
2,910	10	Total Units	874

*Critical Resistance

. . . (compared to requirements of MIL-R-10509E)

661E-½/RN70E						661E-1/RN75E					
½						1					
402Ω		237KΩ		1 MEGΩ		365Ω		237KΩ		2 MEGΩ	
Avg.†	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range
4.4	+.3 to +10.6	4.9	+1.6 to −10.5	11.5	−7.9 to −13.6	15.7	−7.0 to −25.0	9.9	−1.0 to −19.0	10.6	−.6 to −20.0
20.1	+18.2 to +23.0	19.0	+14.0 to +24.0	14.0	+6.6 to +24.5	12.5	+7.0 to +15.0	12.5	+6.0 to +21.0	19.5	+15.3 to +24.3
.159	+.009 to +.360	.278	+.147 to +.387	.049	0 to +.129	.085	+.057 to +.117	.093	+.025 to +.172	.038	+.004 to +.115
.055	+.002 to +.126	.049	+.004 to +.113	.029	+.009 to +.049	.037	+.005 to −.189	.010	+.004 to +.021	.114	+.064 to +.194
.034	+.019 to +.054	.018	−.009 to −.026	.021	+.009 to −.060	.129	+.079 to +.186	.021	0 to −.089	.010	−.005 to −.015
.015	+.004 to +.069	.011	0 to −.077	.004	0 to −.010	.122	−.088 to −.151	.006	0 to −.009	.004	0 to +.009
.004	0 to −.015	.001	0 to +.008	.003	0 to −.010	.004	0 to +.011	.005	0 to −.009	.003	0 to −.010
.002	0 to −.016	.003	0 to −.002	.001	0 to −.002	.012	0 to +.038	.001	0 to −.005	.013	+.004 to +.024
.031	+.024 to +.034	.011	−.009 to −.022	.023	+.019 to +.029	.012	0 to +.057	.031	+.016 to +.050	.005	0 to −.020
.058	−.030 to −.065	.019	+.008 to +.029	.015	0 to −.050	.024	+.021 to +.032	.068	+.012 to +.337	.066	+.039 to +.084
.004	0 to −.005	0	0 to −.005	.016	0 to −.040	.004	0 to +.010	.004	0 to −.009	.019	+.005 to −.040
.001	0 to −.005	.002	0 to −.005	.003	0 to −.010	.003	0 to −.006	.005	0 to −.009	.022	+.005 to +.045

OHMITE

Type 200, "Brown Devil®" Stock, Vitreous Enameled

"BROWN DEVIL" (Type 200) convenient, vitreous enameled, wire-wound resistors, have been, over many years, an industry byword for small rugged power resistors. Compact, capable of substantial wattages and exhibiting surprising overload capability, these handy units find application in electronic and electrical servicing everywhere as well as in original equipment.

Five sizes (3, 5¼, 8, 12 and 20 watts) are now stocked. These include new, physically smaller sizes to accommodate the trend towards miniaturization. A broad selection of values is carried in these five sizes. Unlisted values can be made to order (see pages 36-39).

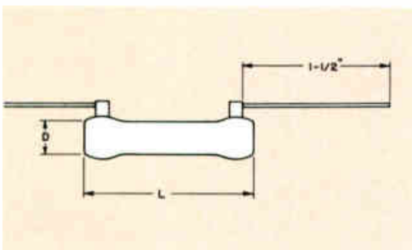


Fig. 23:

Brown Devils are wound with high grade resistance wire on ceramic cores. The terminals are narrow, welded bands of special alloy to which 1½" long, tinned, wire leads are attached (see Fig. 23). Normally they are mounted by these leads, although the 8, 12 and 20-watt units can be mounted with through-bolts or with metal brackets—No. 5 brackets for the 8 and 12-watt units; No. 7 brackets for the 20-watt unit (see page 49).

The winding is covered with famous Ohmite vitreous enamel, the coating which cannot burn or shrink, which anchors the turns in place and provides a smooth, hard coat to distribute heat and minimize hotspots.

Resistance Tolerances: ±5% standard for values 1 ohm or higher; ±10% below 1 ohm. Closer tolerances available on order.

Leads: Solderable. 3 and 5¼ watt sizes, 20 gage; 8, 12 and 20 watt sizes, 18 gage (see Fig. 23).

Fig. 24a:

3 WATT — STOCK STYLE 200-3

Core: 7/16" L x .200" D
Terminal: No. 48
Code: 7/16-AA-48-F

Stock No.	Ohms	Max. Amps.	Stock No.	Ohms	Max. Amps.
2712	1.0	1.73	2760	100	.17
2713	1.1	1.65	2761	110	.16
2714	1.2	1.58	2762	120	.16
2715	1.3	1.52	2763	130	.15
2716	1.5	1.41	2764	150	.14
2717	1.6	1.37	2765	160	.14
2718	1.8	1.29	2766	180	.13
2719	2.0	1.22	2767	200	.12
2720	2.2	1.17	2768	220	.12
2721	2.4	1.12	2769	240	.11
2722	2.7	1.05	2770	270	.11
2723	3.0	1.00	2771	300	.10
2724	3.3	.95	2772	330	.095
2725	3.6	.91	2773	360	.091
2726	3.9	.88	2774	390	.088
2727	4.3	.83	2775	430	.083
2728	4.7	.80	2776	470	.080
2729	5.1	.77	2777	510	.077
2730	5.6	.73	2778	560	.073
2731	6.2	.69	2779	620	.070
2732	6.8	.66	2780	680	.067
2733	7.5	.63	2781	750	.063
2734	8.2	.60	2782	820	.060
2735	9.1	.57	2783	910	.057
2736	10	.55	2784	1,000	.055
2737	11	.52	2785	1,100	.052
2738	12	.50	2786	1,200	.050
2739	13	.48	2787	1,300	.048
2740	15	.45	2788	1,500	.045
2741	16	.43	2789	1,600	.043
2742	18	.42	2790	1,800	.042
2743	20	.39	2791	2,000	.039
2744	22	.37	2792	2,200	.037
2745	24	.35	2793	2,400	.035
2746	27	.33	2794	2,700	.033
2747	30	.32	2795	3,000	.032
2748	33	.30	2796	3,300	.030
2749	36	.29	2797	3,600	.029
2750	39	.28	2798	3,900	.028
2751	43	.26	2799	4,300	.026
2752	47	.25	2800	4,700	.025
2753	51	.24	2801	5,100	.024
2754	56	.23	2802	5,600	.023
2755	62	.22	2803	6,200	.022
2756	68	.21	2804	6,800	.021
2757	75	.20	2805	7,500	.020
2758	82	.19	2806	8,200	.019
2759	91	.18	2807	9,100	.018
			2808	10,000	.017

Avg. Weight .003 Lb.

5¼ WATT — STOCK STYLE 200-5¼

Core: 5/8" L x 1/4" D
Terminal: No. 48
Code: 5/8-CA-48-F

Stock No.	Ohms	Max. Amps.	Stock No.	Ohms	Max. Amps.
2822	1.0	2.29	2874	150	.19
2823	1.1	2.19	2875	160	.18
2824	1.2	2.09	2876	180	.17
2825	1.3	2.01	2877	200	.16
2826	1.5	1.87	2878	220	.16
2827	1.6	1.81	2879	240	.15
2828	1.8	1.71	2880	270	.14
2829	2.0	1.62	2881	300	.13
2830	2.2	1.54	2882	330	.12
2831	2.4	1.48	2883	360	.12
2832	2.7	1.39	2884	390	.12
2833	3.0	1.32	2885	430	.11
2834	3.3	1.24	2886	470	.11
2835	3.6	1.21	2887	510	.10
2836	3.9	1.16	2888	560	.097
2837	4.3	1.10	2889	620	.092
2838	4.7	1.06	2890	680	.088
2839	5.1	1.01	2891	750	.084
2840	5.6	.97	2892	820	.080
2841	6.2	.92	2893	910	.076
2842	6.8	.88	2894	1,000	.072
2843	7.5	.84	2895	1,100	.069
2844	8.2	.80	2896	1,200	.066
2845	9.1	.76	2897	1,300	.064
2846	10	.72	2898	1,500	.059
2847	11	.69	2899	1,600	.057
2848	12	.66	2900	1,800	.054
2849	13	.64	2901	2,000	.051
2850	15	.59	2902	2,200	.049
2851	16	.57	2903	2,400	.047
2852	18	.54	2904	2,700	.044
2853	20	.51	2905	3,000	.042
2854	22	.49	2906	3,300	.040
2855	24	.47	2907	3,600	.038
2856	27	.44	2908	3,900	.037
2857	30	.42	2909	4,300	.035
2858	33	.40	2910	4,700	.033
2859	36	.38	2911	5,100	.032
2860	39	.37	2912	5,600	.031
2861	43	.35	2913	6,200	.029
2862	47	.33	2914	6,800	.028
2863	51	.32	2915	7,500	.027
2864	56	.31	2916	8,200	.025
2865	62	.29	2917	9,100	.024
2866	68	.28	2918	10,000	.023
2867	75	.27	2919	11,000	.022
2868	82	.25	2920	12,000	.021
2869	91	.24	2921	13,000	.020
2870	100	.23	2922	15,000	.019
2871	110	.22	2923	16,000	.018
2872	120	.21	2924	18,000	.017
2873	130	.20	2925	20,000	.016

Avg. Weight .005 Lb.

Type 200, "Brown Devil®" Fixed Resistors

OHMITE

Fig. 24b:

8 WATT — STOCK STYLE 200-8

Core: 1" L x 5/16" D
Terminal: No. 48
Code: 1-D-48-F

Stock No.	Ohms	Max. Amps.	Stock No.	Ohms	Max. Amps.
1500	1.0	2.83	1528	700	.11
1500B	1.5	2.30	1529	750	.10
1501	2.0	2.00	1530	800	.10
1502	3.0	1.63	1531	900	.094
1503	4.0	1.41	1532	1,000	.089
1504	5.0	1.26	1533	1,100	.085
1505	7.5	1.00	1534	1,200	.081
1506	10	.89	1535	1,250	.080
1507	12	.81	1536	1,500	.073
1508	15	.73	1537	1,750	.067
1509	20	.63	1538	2,000	.063
1510	25	.56	1539	2,250	.059
1511	30	.51	1540	2,500	.056
1512	35	.47	1541	3,000	.051
1513	40	.44	1542	3,500	.047
1514	50	.40	1543	4,000	.044
1515	75	.32	1544	4,500	.042
1516	100	.28	1545	5,000	.040
1517	125	.25	1546	6,000	.036
1518	150	.23	1547	7,000	.033
1519	200	.20	1548	7,500	.032
1520	225	.18	1549	8,000	.031
1521	250	.17	1550	9,000	.029
1522	300	.16	1551	10,000	.028
1523	350	.15	1552	12,500	.025
1524	400	.14	1553	15,000	.023
1525	450	.13	1554	17,500	.021
1526	500	.12	1555	20,000	.020
1527	600	.11	1556	22,500	.018
			1557	25,000	.017

Avg. Weight .01 Lb.

12 WATT — STOCK STYLE 200-12

Core: 1¾" L x 5/16" D
Terminal: No. 48
Code: 1¾-D-48-F

Stock No.	Ohms	Max. Amps.	Stock No.	Ohms	Max. Amps.
1700A	0.5	4.90	1737	1,100	.10
1701	1.0	3.46	1738	1,200	.10
1704	1.5	2.82	1739	1,250	.097
1705	2.0	2.45	1740	1,500	.089
1706	3.0	2.00	1741	1,750	.082
1707	4.0	1.73	1742	2,000	.077
1708	5.0	1.54	1743	2,250	.073
1709	7.5	1.26	1744	2,500	.069
1710	10	1.09	1745	3,000	.063
1711	12	1.00	1746	3,500	.058
1712	15	.89	1747	4,000	.054
1713	20	.77	1748	4,500	.051
1714	25	.69	1749	5,000	.049
1715	30	.63	1750	6,000	.044
1716	35	.58	1751	7,000	.041
1717	40	.54	1752	7,500	.040
1718	50	.49	1753	8,000	.038
1719	75	.40	1754	8,500	.037
1720	100	.34	1754A	9,000	.036
1721	125	.31	1755	10,000	.035
1722	150	.28	1756	11,000	.033
1723	200	.24	1757	12,000	.031
1724	225	.23	1758	12,500	.031
1725	250	.22	1759	13,500	.029
1726	300	.20	1761	15,000	.028
1727	350	.18	1762	16,000	.027
1728	400	.17	1763	17,500	.026
1729	450	.16	1764	18,000	.025
1730	500	.15	1765	20,000	.024
1731	600	.14	1766	22,500	.023
1732	700	.13	1767	25,000	.022
1733	750	.12	1768	30,000	.020
1734	800	.12	1769	35,000	.018
1735	900	.11	1770	40,000	.017
1736	1,000	.11	1771	45,000	.016
			1772	50,000	.015

Avg. Weight .015 Lb.

20 WATT — STOCK STYLE 200-20

Core: 2" L x 7/16" D
Terminal: No. 48
Code: 2-H-48-F

Stock No.	Ohms	Max. Amps.	Stock No.	Ohms	Max. Amps.
1800A	0.5	6.32	1831	2,750	.085
1802A	1.0	4.47	1832	3,000	.081
1802B	2.0	3.16	1833	3,500	.075
1802C	3.0	2.58	1834	4,000	.070
1802D	4.0	2.24	1835	4,500	.066
1803	5.0	2.00	1836	5,000	.063
1804	10	1.41	1837	6,000	.057
1805	25	.89	1838	7,000	.053
1806	50	.63	1839	7,500	.051
1807	75	.52	1840	8,000	.050
1808	100	.45	1840A	9,000	.047
1809	150	.36	1841	10,000	.043
1810	200	.32	1842	12,500	.035
1811	250	.28	1843	15,000	.032
1812	300	.26	1844	20,000	.027
1813	350	.24	1845	25,000	.024
1814	400	.22	1846	30,000	.022
1815	500	.20	1847	35,000	.021
1816	650	.18	1848	40,000	.019
1817	700	.17	1849	45,000	.018
1818	750	.16	1850	50,000	.017
1819	800	.15	1851	55,000	.016
1820A	900	.15	1852	60,000	.016
1821	1,000	.14	1853	65,000	.015
1822	1,200	.13	1854	70,000	.014
1823	1,250	.12	1855	75,000	.013
1824	1,500	.12	1856	80,000	.012
1825	1,750	.11	1857	85,000	.012
1827	2,000	.10	1858	90,000	.011
1828	2,250	.094	1859	95,000	.010
1830	2,500	.089	1860	100,000	.010

Avg. Weight .03 Lb.

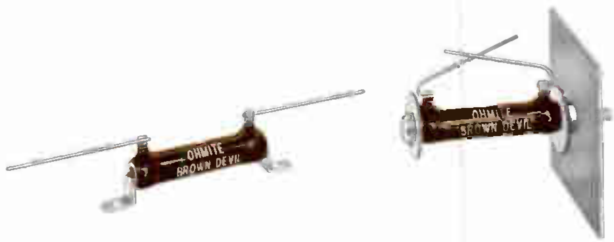


Fig. 25: Brown Devil resistors are normally mounted by means of their terminal wires. Brackets or through-bolts also can be used to mount the 8, 12, and 20-watt resistors as illustrated here.

OHMITE

TYPE 270

Fixed, Radial Lug Type . .

Application: Lug (or tab) terminal type resistors are most widely used for higher power applications.
Description: Wire-wound and vitreous-enameled on tubular ceramic core as described on pages 2 and 3. The best alloy and largest practicable size wire is used for each resistance. The use of such sizes is made feasible by Ohmite's exclusive vitreous enamel which retains the turns, uniformly spaced, just as they were wound and hence permits close spacing.
Stock Range: Six stock sizes, 12 to 225 watts. *Widest resistance range, greatest number of stock values available anywhere!*

Made-to-Order-Range: Intermediate or higher resistances and ratings up to 1000 watts can be made to order. (See pages 36, 37. Also see page 35 for low resistance, high current lug-type "Corrib" resistors.) Intermediate resistance values may also be obtained with Ohmite "Dividohm" adjustable

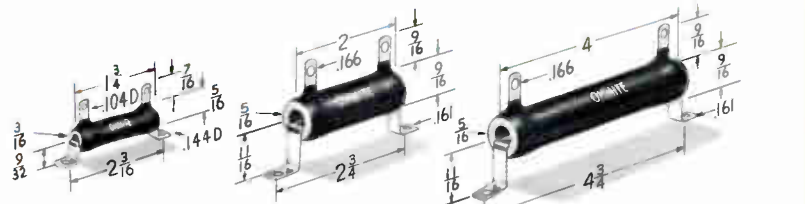


Fig. 26

12 WATT — STOCK STYLE 270-12

Rating: 12 watts in free air for all resistance values
Core: 1¾″ L x 5/16″ D Lug: No. 57
Code: 1¾-D-57-F

Stock No.	Ohms	Maximum Amperes	Maximum Volts
3723	.51	4.86	2.48
3730	1.0	3.46	3.46
3734	1.5	2.83	4.24
3738	2.2	2.34	5.14
3742	3.3	1.91	6.30
3746	4.7	1.60	7.50
3750	6.8	1.33	9.04
3754	10	1.10	11.0
3756	12	1.00	12.0
3758	15	.89	13.4
3760	18	.82	14.8
3762	22	.74	16.3
3764	27	.67	18.0
3766	33	.60	19.9
3768	39	.55	21.6
3770	47	.53	24.8
3772	56	.46	26.0
3774	68	.42	28.6
3776	82	.38	31.4
3778	100	.35	34.7
3780	120	.32	38.0
3782	150	.28	42.5
3784	180	.26	46.5
3786	220	.23	51.3
3788	270	.21	57.1
3790	330	.19	63.0
3792	390	.18	68.5
3794	470	.16	75.1
3796	560	.15	82.0
3798	680	.13	90.4
3800	820	.12	99.3
3802	1,000	.11	110
3804	1,200	.10	120
3806	1,500	.089	134
3808	1,800	.082	147
3810	2,200	.074	163
3812	2,700	.067	180
3814	3,300	.060	199
3816	3,900	.055	216
3818	4,700	.053	248
3820	5,600	.046	259
3822	6,800	.042	286
3824	8,200	.038	314
3826	10,000	.035	346
3828	12,000	.032	380
3830	15,000	.028	424
3832	18,000	.026	464
3834	22,000	.023	514
3836	27,000	.021	570
3838	33,000	.019	630
3840	39,000	.018	685
3842	47,000	.016	751
3843	51,000	.015	784

Standard Mounting Bracket No. 5
Mounting Centers 2 3/16″
Avg. Weight .02 Lb.

25 WATT — STOCK STYLE 270-25

Rating: 25 watts in free air for resistances through 10,000 ohms
Core: 2″ L x 5/16″ D Lug: No. 40
Code: 2-K-40-F

Stock No.	Ohms	Maximum Amperes	Maximum Volts
0200J	1	5.00	5.00
0200K	2	3.54	7.07
0200L	3	2.88	8.65
0200N	4	2.50	10.0
0200A	5	2.24	11.1
0200B	10	1.58	15.8
0200R	15	1.29	19.4
0200C	25	1.00	25.0
0200D	50	.71	35.3
0200E	75	.58	43.2
0200F	100	.50	50.0
0200G	150	.41	61.4
0200H	200	.35	70.7
0201	250	.32	79
0202	500	.22	116
0203	750	.18	137
0204	800	.17	141
0205	1,000	.16	158
0206	1,500	.13	193
0207	2,000	.12	223
0208	2,500	.10	250
0209	3,000	.091	274
0210	3,500	.084	296
0211	4,000	.079	316
0212	5,000	.070	353
0213	6,000	.064	387
0214	7,500	.057	433
0215	10,000	.050	500
0216	12,000	.042	505
0217	15,000	.036	540
0218	20,000	.031	620
0219	25,000	.028	700
0220	30,000	.026	780
0221	35,000	.024	840
0222	40,000	.022	880
0224	50,000	.020	990
0225	60,000	.016	990
0226	70,000	.014	990
0227	80,000	.012	990
0229	100,000	.010	990

Standard Mounting Bracket No. 9
Mounting Centers 2¾″
Avg. Weight .05 Lb.

50 WATT — STOCK STYLE 270-50

Rating: 50 watts in free air for resistances through 25,000 ohms
Core: 4″ L x 5/16″ D Lug: No. 40
Code: 4-K-40-F

Stock No.	Ohms	Maximum Amperes	Maximum Volts
0400J	1	7.07	7.07
0400K	2	5.00	10.0
0400L	3	4.07	12.3
0400N	4	3.53	14.1
0400A	5	3.16	15.8
0400B	10	2.23	22.4
0400C	25	1.41	35.4
0400D	50	1.00	50.0
0400E	75	.82	61.2
0400F	100	.71	70.7
0400G	150	.58	86.6
0400H	200	.50	100
0401	250	.45	112
0402	500	.32	158
0403	750	.26	193
0404	800	.25	200
0405	1,000	.22	224
0406	1,500	.18	274
0407	2,000	.16	316
0408	2,500	.14	354
0409	3,000	.13	387
0410	4,000	.11	447
0411	5,000	.10	500
0412	7,500	.081	612
0413	8,000	.079	632
0414	10,000	.071	707
0415	12,000	.064	774
0416	15,000	.057	866
0417	20,000	.050	1000
0418	25,000	.045	1100
0419	35,000	.032	1120
0420	50,000	.026	1300
0421	75,000	.021	1580
0422	100,000	.018	1800
0423	125,000	.016	1980
0424	150,000	.013	1980
0425	175,000	.011	1980
0426	200,000	.010	1980
0428	250,000	.008	1980

Standard Mounting Bracket No. 9
Mounting Centers 4¾″
Avg. Weight .09 Lb.

TYPE 270
..Vitreous Enameled Resistors

OHMITE

lug-type resistors (page 26).

Tolerance: Standard is ±5%. Also available in tolerances down to ±1% at increased cost.

Ratings: "Free Air Wattage and Derating" are explained on pages 4 to 9. Current and voltage ratings at reduced wattages can be obtained by multiplying the figures in the tables by the factors below, or by direct application of Ohm's Law (up to maximum ohms at Free Air Watts).

Load:	75%	66%	50%	33%	25%
Factor:	.86	.81	.71	.57	.50

Example: Rating of a No. 0402, 500 ohm resistor at 75% of full rating:

.86 × .32 = .275 amps.
.86 × 158 = 136 volts.

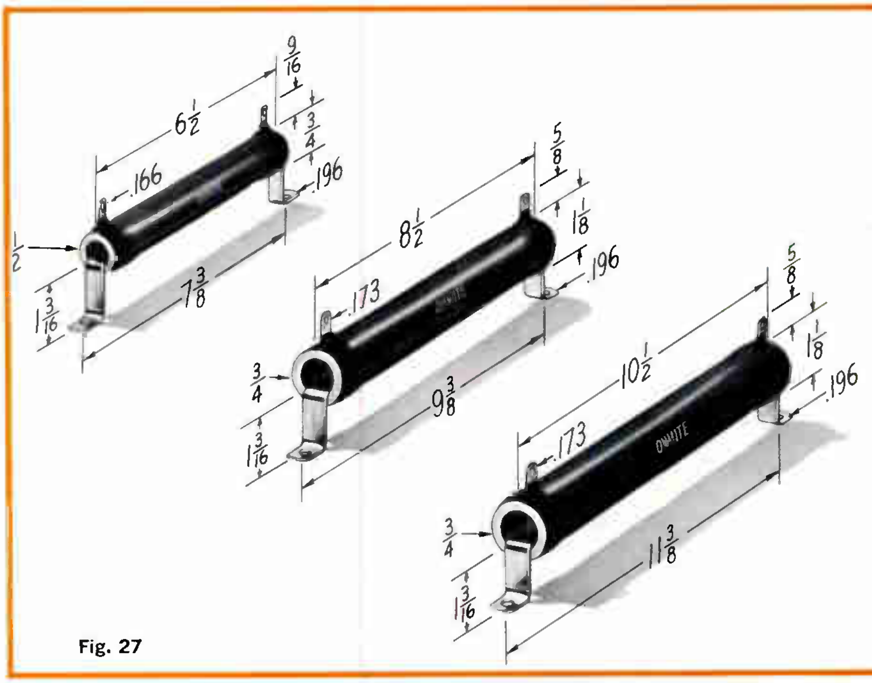


Fig. 27

100 WATT — STOCK STYLE 270-100

Rating: 100 watts in free air for resistances through 60,000 ohms
Core: 6½" L x ¾" D Lug: No. 40
Code: 6½-M-40-F

Stock No.	Ohms	Maximum Amperes	Maximum Volts
0600C	1	10.00	10.0
0600D	2	7.07	14.1
0600E	3	5.77	17.3
0600F	4	5.00	20.0
0600A	5	4.47	22.4
0600B	10	3.16	31.6
0601	25	2.00	50.0
0602	50	1.41	70.7
0603	75	1.15	86.6
0604	100	1.00	100
0604B	125	.90	111
0605	150	.82	123
0606	250	.63	158
0607	500	.45	224
0608	750	.37	274
0609	1,000	.32	316
0610	1,500	.26	387
0611	2,000	.22	447
0612	2,500	.20	500
0613	3,000	.18	548
0614	5,000	.14	707
0615	7,500	.12	866
0616	10,000	.10	1000
0617	15,000	.081	1225
0618	20,000	.071	1414
0619	25,000	.063	1580
0620	30,000	.058	1740
0621	40,000	.050	2000
0622	50,000	.045	2250
0623	60,000	.041	2400
0624	75,000	.032	2400
0625	100,000	.028	2800

Standard Mounting Bracket No. 12
Mounting Centers 7⅜"
Avg. Weight .20 Lb.

175 WATT — STOCK STYLE 270-175

Rating: 175 watts in free air for all stock resistances
Core: 8½" L x 1⅛" D Lug: No. 46
Code: 8½-P-46-F

Stock No.	Ohms	Maximum Amperes	Maximum Volts
0700C	1	13.2	13.2
0700D	2	9.35	18.7
0700E	3	7.63	22.9
0700F	4	6.6	26.4
0700A	5	5.92	29.6
0700B	10	4.18	41.8
0701	25	2.64	66.0
0702	50	1.87	93.5
0703	75	1.52	114
0704	100	1.32	132
0704B	125	1.18	147
0705	150	1.08	162
0706	250	.84	209
0707	500	.59	296
0708	750	.48	362
0709	1,000	.42	419
0710	1,500	.34	512
0711	2,000	.30	592
0712	2,500	.26	662
0713	3,000	.24	725
0714	5,000	.19	936
0715	7,500	.15	1140
0716	10,000	.13	1322
0717	15,000	.11	1620
0718	20,000	.094	1875
0719	25,000	.083	2070
0720	30,000	.076	2290
0721	40,000	.066	2650
0722	50,000	.059	2960
0723	60,000	.054	3240
0724	75,000	.048	3620
0725	100,000	.042	4190

Standard Mounting Bracket No. 18
Mounting Centers 9⅜"
Avg. Weight .50 Lb.

225 WATT — STOCK STYLE 270-225

Rating: 225 watts in free air for all stock resistances
Core: 10½" L x 1⅛" D Lug: No. 46
Code: 10½-P-46-F

Stock No.	Ohms	Maximum Amperes	Maximum Volts
0900C	1	15.00	15.0
0900D	2	10.60	21.2
0900E	3	8.67	26.0
0900F	4	7.50	30.0
0900A	5	6.72	33.6
0900B	10	4.74	47.4
0901	25	3.00	75.0
0902	50	2.12	106
0903	75	1.73	130
0904	100	1.50	150
0905	150	1.25	188
0906	250	.95	238
0907	500	.67	336
0908	750	.55	411
0909	1,000	.47	474
0910	1,500	.39	582
0911	2,000	.34	671
0912	2,500	.30	750
0913	3,000	.27	822
0914	5,000	.21	1062
0915	7,500	.17	1300
0916	10,000	.15	1500
0917	15,000	.13	1875
0918	20,000	.11	2120
0919	25,000	.095	2370
0920	30,000	.087	2600
0921	40,000	.075	3000
0922	50,000	.067	3360
0923	60,000	.061	3670
0924	75,000	.055	4100
0925	100,000	.047	4740

Standard Mounting Bracket No. 18
Mounting Centers 11⅜"
Avg. Weight .62 Lb.

OHMITE

TYPE 210 DIVIDOHM®
Vitreous Adjustable Resistors

Application: Type 210, "DIVIDOHM" resistors are employed where periodic or semi-permanent adjustment of resistance is required. They are also used to obtain odd or non-standard resistances or to make multi-tap resistors or voltage dividers. "Dividohms" provide the flexibility for experimental and design work and for apparatus which must be adjusted to meet different line voltages.

Description: These units are of vitreous enameled construction similar to Ohmite Type 270, Fixed, Lug-Type Resistors (pages 24 and 25) except for a narrow strip along one side left bare of enamel so that the wire is exposed. The strip of exposed turns of wire (every turn securely held against shifting) provides a surface for a contact projection on the adjustable lug. Resistance tolerance is ±10% measured without the adjustable lug. Adjustable resistors *can be made to order on practically any size core (see pages 36-37)*. The wattage ratings given are for operation in free air as discussed on pages 4 to 9. See page 49 for mounting brackets. (Note: Stock units supplied through distributors, include brackets.)

Moving the Adjustable Lugs: Before an adjustable lug is moved, it should be loosened to the point where it will not scrape across the wire. Lugs should not be moved while the circuit is "live," in order to protect the exposed wire from electrical injury and to protect the operator from dangerous voltages. The lugs should be firmly re-tightened but with due regard for the wire size involved. Ohmite adjustable lugs have a superior feature in the flat contact which distributes contact pressure and safeguards the wire much better than conventional, rounded contact points.

Adjustable lugs supplied with stock resistors have a contact embossed out of the band material, but lugs with a separate silver-alloy contact button are available as listed. Adjustable lugs with separate adjustments for fastening and contact pressure are also listed for some sizes.

Watt Rating: When "Dividohm" resistors are used, it must be remembered that the given wattage rating applies only when the entire resistance is in the circuit. When the adjustable lug is set at an intermediate point, the wattage rating is reduced in approximately the same proportion, i.e., if the lug is set at half the resistance, the wattage rating is reduced by one half. A safe rule to follow is simply to make sure that the maximum rated current is not exceeded. This should be carefully checked when several adjustable lugs are used to produce a voltage divider circuit (refer to Catalog 1100, "Engineering Manual").

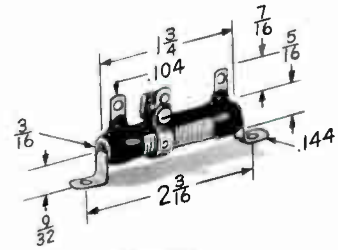


Fig. 28a

12 WATT

STOCK STYLE 210-12
Core: 1¾" L x 5/16" D
Lug: No. 57
Code: 1¾-D-57-D

Stock No.	Ohms	Max. Amps.
1001	1	3.46
1002	2	2.45
1003	3	2.00
1004	5	1.54
1005	7.5	1.26
1006	10	1.09
1007	15	.89
1008	20	.77
1009	25	.69
1010	50	.49
1011	75	.40
1012	100	.34
1013	150	.28
1014	200	.24
1015	250	.22
1016	300	.20
1017	350	.18
1018	400	.17
1019	500	.15
1020	600	.14
1021	750	.13
1022	800	.12
1023	1,000	.11
1024	1,250	.098
1025	1,500	.089
1026	2,000	.077
1027	2,250	.073
1028	2,500	.069
1029	3,000	.063
1030	3,500	.058
1031	4,000	.055
1032	4,500	.052
1033	5,000	.049
1034	6,000	.045
1035	7,000	.042
1036	7,500	.040
1037	8,000	.039
1038	8,500	.037
1039	9,000	.036
1040	10,000	.035

One Adjustable Lug No. 1058 Supplied
Mounting Bracket No. 5 on 2 3/16" Centers
Avg. Weight = .02 lb.

TYPE 210 DIVIDOHM®
Vitreous Adjustable Resistors

OHMITE

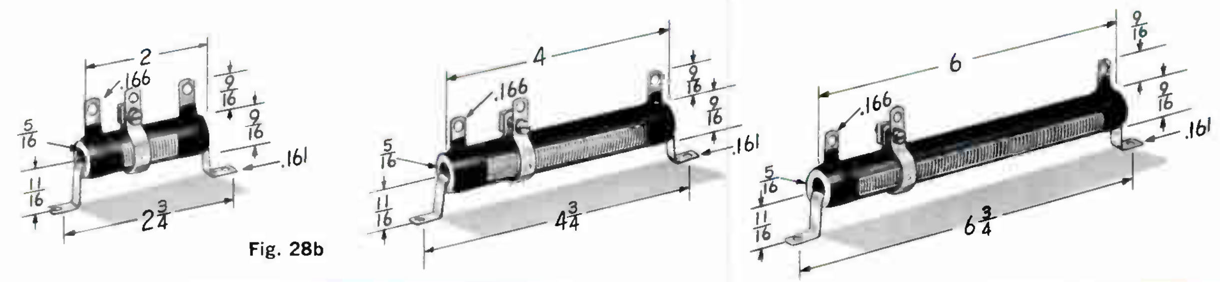


Fig. 28b

25 WATT — STOCK STYLE 210-25

Core: 2″ L x 9/16″ D
Lug: No. 40
Code: 2-K-40-D

Stock No.	Ohms	Max. Amps.
0360	1	5.00
0360B	2	3.54
0361	3	2.88
0362	5	2.24
0362B	7.5	1.82
0363	10	1.58
0364	15	1.29
0364B	20	1.12
0365	25	1.00
0366	50	.71
0367	75	.58
0368	100	.50
0369	150	.41
0370	200	.35
0371	250	.32
0371B	300	.29
0371C	400	.25
0372	500	.22
0373	750	.18
0374	800	.17
0375	1,000	.16
0375B	1,250	.14
0376	1,500	.13
0377	2,000	.12
0377B	2,250	.11
0378	2,500	.10
0379	3,000	.091
0380	3,500	.084
0381	4,000	.079
0381B	4,500	.074
0382	5,000	.070
0383	6,000	.064
0383B	7,000	.060
0384	7,500	.057
0384B	8,000	.055
0384C	9,000	.052
0385	10,000	.050
0386	12,000	.042
0387	15,000	.036
0388	20,000	.031
0389	25,000	.028

One Adjustable Lug No. 0358 Supplied
Mounting Bracket No. 9 on 2¾″ Centers
Avg. Weight = .05 lb.

50 WATT — STOCK STYLE 210-50

Core: 4″ L x 9/16″ D
Lug: No. 40
Code: 4-K-40-D

Stock No.	Ohms	Max. Amps.
0560A	1	7.07
0560B	2	5.00
0560C	3	4.07
0560D	4	3.53
0560	5	3.16
0561	10	2.23
0562	25	1.41
0563	50	1.00
0564	75	.82
0565	100	.71
0566	150	.58
0567	200	.50
0568	250	.45
0568B	300	.41
0568C	400	.35
0569	500	.32
0570	750	.26
0571	800	.25
0572	1,000	.22
0572B	1,250	.20
0573	1,500	.18
0574	2,000	.16
0574B	2,250	.15
0575	2,500	.14
0576	3,000	.13
0576B	3,500	.12
0577	4,000	.11
0577B	4,500	.10
0578	5,000	.10
0578B	6,000	.091
0578C	7,000	.084
0579	7,500	.081
0580	8,000	.079
0580B	9,000	.074
0581	10,000	.071
0582	12,000	.064
0583	15,000	.057
0584	20,000	.050
0585	25,000	.045
0586	30,000	.036
0587	40,000	.029
0588	50,000	.026
0589	60,000	.024
0590	80,000	.021
0591	100,000	.018

One Adjustable Lug No. 0358 Supplied
Mounting Bracket No. 9 on 4¾″ Centers
Avg. Weight = .09 lbs.

75 WATT — STOCK STYLE 210-75

Core: 6″ L x 9/16″ D
Lug: No. 40
Code: 6-K-40-D

Stock No.	Ohms	Max. Amps.
0769A	1	8.66
0769B	2	6.12
0769C	3	5.00
0769D	4	4.33
0769	5	3.87
0770	10	2.74
0771	15	2.24
0772	25	1.73
0773	50	1.22
0774	100	.86
0774B	200	.61
0775	250	.55
0775B	300	.50
0775C	400	.43
0776	500	.39
0777	750	.32
0777B	800	.30
0778	1,000	.27
0778B	1,250	.24
0779	1,500	.22
0780	2,000	.19
0780B	2,250	.18
0781	2,500	.17
0781B	3,000	.16
0782	3,500	.15
0782B	4,000	.14
0782C	4,500	.13
0783	5,000	.12
0783B	6,000	.11
0783C	7,000	.10
0784	7,500	.10
0784B	8,000	.096
0784C	9,000	.091
0785	10,000	.086
0785B	12,000	.079
0786	15,000	.070
0787	20,000	.061
0788	25,000	.054
0789	30,000	.050
0790	35,000	.046
0791	40,000	.043
0792	45,000	.035
0793	50,000	.033
0794	60,000	.030
0795	80,000	.026
0796	100,000	.023

One Adjustable Lug No. 0358 Supplied
Mounting Bracket No. 9 on 6¾″ Centers
Avg. Weight = .15 lb.

TYPE 210 DIVIDOHM®
Vitreous Adjustable Resistors

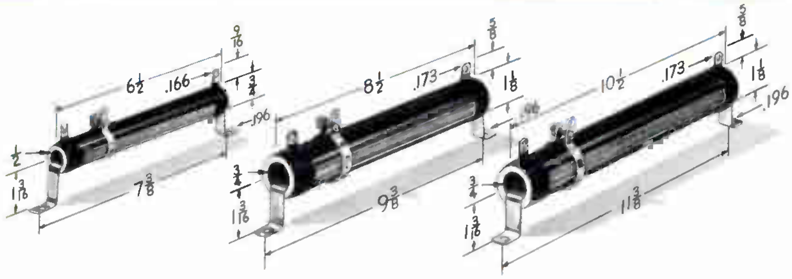


Fig. 29

100 WATT — STOCK—STYLE 210-100
Core: 6½" L x ¾" D
Lug: No. 40
Code: 6½-M-40-D

Stock No.	Ohms	Max. Amps.
0956A	1	10.00
0956B	2	7.07
0956C	3	5.77
0956D	4	5.00
0956	5	4.47
0957	10	3.16
0958	25	2.00
0959	50	1.41
0960	100	1.00
0960B	250	.63
0961	500	.45
0962	1,000	.32
0962B	1,500	.26
0963	2,500	.20
0964	5,000	.14
0965	10,000	.10
0966	15,000	.081
0967	20,000	.071
0968	25,000	.063
0969	30,000	.058
0970	40,000	.050
0971	50,000	.045
0972	75,000	.032
0973	100,000	.028

One Adjustable Lug No. 1958 Supplied
Mounting Bracket No. 12
Mounting Centers 7⅜"
Avg. Weight = .20 lb.

175 WATT — STOCK—STYLE 210-175
Core: 8½" L x 1⅛" D
Lug: No. 46
Code: 8½-P-46-D

Stock No.	Ohms	Max. Amps.
1156A	1	13.2
1156B	2	9.35
1156C	3	7.63
1156D	4	6.60
1156	5	5.92
1157	10	4.18
1158	25	2.64
1159	50	1.87
1160	100	1.32
1160B	250	.84
1161	500	.59
1162	1,000	.42
1162B	1,500	.34
1163	2,500	.26
1164	5,000	.19
1165	10,000	.13
1166	15,000	.11
1167	20,000	.094
1168	25,000	.083
1169	30,000	.076
1170	40,000	.066
1171	50,000	.059
1172	75,000	.048
1173	100,000	.042

One Adjustable Lug No. 2158 Supplied
Mounting Bracket No. 18
Mounting Centers 9⅜"
Avg. Weight = .50 lb.

225 WATT — STOCK—STYLE 210-225
Core: 10½" L x 1⅛" D
Lug: No. 46
Code: 10½-P-46-D

Stock No.	Ohms	Max. Amps.
1356A	1	15.00
1356B	2	10.60
1356C	3	8.67
1356D	4	7.50
1356	5	6.72
1357	10	4.74
1358	25	3.00
1359	50	2.12
1360	100	1.50
1360B	250	.95
1361	500	.67
1362	1,000	.47
1362B	1,500	.39
1363	2,500	.30
1364	5,000	.21
1365	10,000	.15
1366	15,000	.13
1367	20,000	.11
1368	25,000	.095
1369	30,000	.087
1370	40,000	.075
1371	50,000	.067
1372	75,000	.055
1373	100,000	.047

One Adjustable Lug No. 2158 Supplied
Mounting Bracket No. 18
Mounting Centers 11⅜"
Avg. Weight = .62 lb.

ADJUSTABLE LUGS

Fig. 30: Screw driver (left) and bakelite knob types.

Fig. 31: Double thumb screw type

One adjustable lug (screw type) is provided with each "Dividohm." Standard lugs have a contact embossed on the side for making connection with the resistance wire winding.

	Screw Driver Type Cat. No.		Bakelite Knob Type Cat. No.	
Core Dia.	Standard	Silver Contact	Standard	Silver Contact
5/16"	1058	2161	—	—
9/16"	0358	2164	0359	2165
¾"	1958	2166	1959	2167
1⅛"	2158	2170	2159	2171

See Page 48 for dimensions

DOUBLE THUMB SCREW ADJUSTABLE LUGS

These adjustable lugs feature two advantages—ease of adjustment and less chance of damaging the resistance wire while moving lugs.

For 1" dia. cores .... Cat. No. 2157
For 1⅛" dia. cores .... Cat. No. 2160

TYPE 270N Non-Inductive Vitreous Enameled Resistors

OHMITE

Application: These resistors are suitable for radio frequencies extending into the megacycle range depending on resistance and permissible deviation; see graphs on page 31. Non-inductive resistors are used as dummy antennas for radio transmitters, as load resistors in high frequency circuits and as terminating resistors for radio antennas. They are also used in various circuits subject to steep wave-front surges or pulses.

Description: Two resistance windings, opposite in direction and connected in parallel (Ayrton-Perry type) are wound on a tubular ceramic core. Stock sizes have flatted sides; made-to-order units in special sizes, may have a circular cross-section. The wire is covered and protected by Ohmite vitreous enamel. The inductances of the resistors average less than 1% of the inductances of regular resistors of the same size. High resistance units measure capacitive rather than inductive as noted in the tables and explained on page 30. Resistance tolerance is ±5%.

Special Resistors: Non-inductive windings can be provided on practically any type of Ohmite fixed resistor. Inductances different from the stock values can be furnished. "Dividohm" adjustable resistors can be made as non-inductive versions in certain ranges.

Mounting: Non-magnetic mounting brackets are used with these resistors and are ordered separately when desired (see page 49). Through-bolts of steel should not be used.

Limited-Inductance Resistors: Conventional, single-winding resistors may be furnished with inductances lower than usual. This is accomplished by winding the resistors with finer wire and consequently, requiring fewer turns to achieve the equivalent resistance. Consult factory.

12 WATT — Stock—Style 270N-12

Core: 1¾″ L x 5/16″ D
Terminal: No. 57
Code: 1¾-DN-57-N

Stock No.	Ohms	Max. Milli-amps.	Approx.* Induc. (Ls) or Capac. (Cp)	Stock No.	Ohms	Max. Milli-amps.	Approx.* Induc. (Ls) or Capac. (Cp)
2050	5	1,540	.1 µh	2066	600	140	.2 pf
2051	10	1,090	.1 µh	2067	700	130	.5 pf
2052	15	890	.1 µh	2068	800	120	.5 pf
2053	20	770	.1 µh	2069	900	110	.75 pf
2054	25	690	.1 µh	2070	1,000	110	.75 pf
2055	30	630	.1 µh	2071	1,500	89	.75 pf
2056	40	550	.1 µh	2072	2,000	77	.75 pf
2057	50	490	.15 µh	2073	2,500	69	.75 pf
2058	75	400	.15 µh	2074	3,000	63	1.2 pf
2059	100	340	.15 µh	2075	4,000	54	1.2 pf
2060	150	280	.2 µh	2076	5,000	49	1.2 pf
2061	200	240	.2 µh	2077	6,000	44	1.2 pf
2062	250	220	.2 µh	2078	7,500	40	1.2 pf
2063	300	200	.1 µh	2079	8,000	38	1.2 pf
2064	400	170	.1 µh	2080	9,000	36	1.2 pf
2065	500	150	.2 pf	2081	10,000	35	1.2 pf

Mounting Brackets No. 5B Mounting Centers 2 3/16″ Avg. Weight .02 lb.

Fig. 32: Stock Non-Inductive sizes.

50 WATT — Stock—Style 270N-50

Core: 4″ L x 9/16″ D
Terminal: No. 40
Code: 4-KN-40-N

Stock No.	Ohms	Max. Milli-amps.	Approx.* Induc. (Ls) or Capac. (Cp)
2001	5	3,160	.2 µh
2002	10	2,230	.2 µh
2003	25	1,410	.35 µh
2004	50	1,000	.35 µh
2005	100	710	.55 µh
2006	150	580	.55 µh
2007	200	500	.55 µh
2008	250	450	.55 µh
2009	500	320	.05 µh
2010	750	260	.1 pf
2011	1,000	220	.75 pf
2012	1,500	180	.75 pf
2013	2,000	160	.75 pf
2014	2,500	140	.75 pf
2015	3,000	130	1.2 pf
2016	3,500	120	1.2 pf
2017	4,000	110	1.2 pf
2018	5,000	100	1.2 pf

Mounting Brackets No. 9B
Mounting Centers 4¾″
Avg. Weight .09 lb.

100 WATT — Stock—Style 270N-100

Core: 6½″ L x ¾″ D
Terminal: No. 40
Code: 6½-MN-40-N

Stock No.	Ohms	Max. Milli-amps.	Approx.* Induc. (Ls) or Capac. (Cp)
2201	5	4,470	.4 µh
2202	10	3,160	.4 µh
2203	25	2,000	.6 µh
2204	50	1,410	.6 µh
2205	100	1,000	.9 µh
2206	150	816	.9 µh
2207	200	707	.9 µh
2208	250	630	.9 µh
2209	500	450	.7 µh
2210	750	365	.15 µh
2211	1,000	320	.8 pf
2212	1,500	260	1.7 pf
2213	2,000	220	1.7 pf
2214	2,500	200	1.7 pf
2215	3,000	180	1.7 pf
2216	3,500	170	2.3 pf
2217	4,000	160	2.3 pf
2218	5,000	140	2.3 pf

Mounting Brackets No. 12BN
Mounting Centers 7⅜″
Avg. Weight .20 lb.

175 WATT — Stock—Style 270N-175

Core: 8½″ L x 1⅛″ D
Terminal: No. 46
Code: 8½-PN-46-N

Stock No.	Ohms	Max. Milli-amps.	Approx.* Induc. (Ls) or Capac. (Cp)
2401	5	5,920	.65 µh
2402	10	4,180	.65 µh
2403	25	2,640	.9 µh
2404	50	1,870	1.4 µh
2405	100	1,320	1.4 µh
2406	150	1,090	1.4 µh
2407	200	935	1.4 µh
2408	250	840	1.4 µh
2409	500	590	.75 µh
2410	750	480	.15 µh
2411	1,000	420	2.2 pf
2412	1,500	340	3.3 pf
2413	2,000	290	3.3 pf
2414	2,500	260	3.3 pf
2415	3,000	240	3.7 pf
2416	3,500	222	3.7 pf
2417	4,000	208	3.7 pf
2418	5,000	190	3.7 pf

Mounting Brackets No. 18B
Mounting Centers 9⅜″
Avg. Weight .50 lb.

*Effective series inductance (Ls) or effective parallel capacitance (Cp) when measured at 5 megacycles. Capacitance in "picofarads;" 1pf=1µµf

CHARACTERISTICS of RESISTORS at HIGH FREQUENCIES

For most practical purposes, standard Ohmite resistors show no change in impedance or resistance at audio and supersonic frequencies (0 to 25,000 cycles, approximately). For radio-frequency purposes, resistors with non-inductive windings are generally required as explained below.

How Frequency Affects Impedance: Although a resistor is ordinarily represented in a diagram by the symbol for resistance alone, the more detailed analysis required when considering high frequencies, results in the theoretical circuit shown in Fig. 33, that is, any resistor inherently has some inductance and some distributed capacity. As frequency is increased, the reactance due to inductance is proportionately increased:

$$X_L = \omega L = 2\pi f L$$

and the reactance due to capacitance is proportionately decreased:

$$X_C = -\frac{1}{\omega C} = -\frac{1}{2\pi f C}$$

In general, these reactance effects are not large enough to be of importance until frequencies beyond the audio range are reached. At low frequencies or when the inductance and capacitance are small, the impedance is substantially equal to the DC resistance. Since the reactance is added vectorially at 90° to the resistance, it must therefore approach an amount which is a considerable percentage of the resistance before the impedance is appreciably affected.

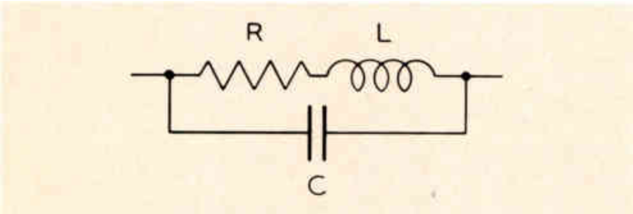


Fig. 33: Theoretical circuit of a resistor.

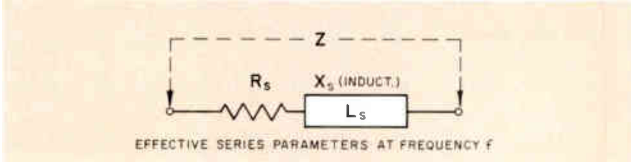


Fig. 34a: Series equivalent circuit.
(Applicable when R_{DC} is less than 500 to 1000 ohms.)

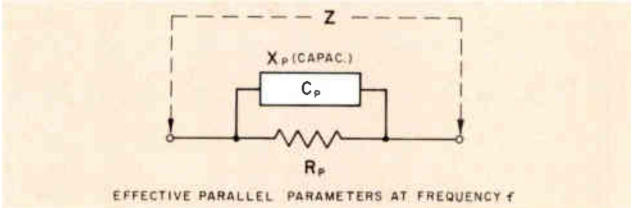


Fig. 34b: Parallel equivalent circuit.
(Applicable when R_{DC} is above 500 to 1000 ohms.)

It should be noted that the circuit shown in Fig. 33 represents the impedance network of a resistor at frequencies sufficiently low such that the assumption of lumped parameters is valid. At any *specific* frequency the impedance of a given resistor may be represented by either a series or parallel equivalent circuit (see Fig. 34).

For low resistances: The reactance due to distributed *shunt* capacitance is negligible in comparison to the resistance. Therefore, the predominating effect is inductive reactance, comparable in magnitude to the resistance, and due to residual inductance despite the Ayrton-Perry winding.

For high resistances: The reactance due to distributed shunt capacitance is comparable in magnitude to the resistance. Therefore the predominating effect is capacitive reactance, which dwarfs the relatively small amount of inductive reactance in an Ayrton-Perry winding.

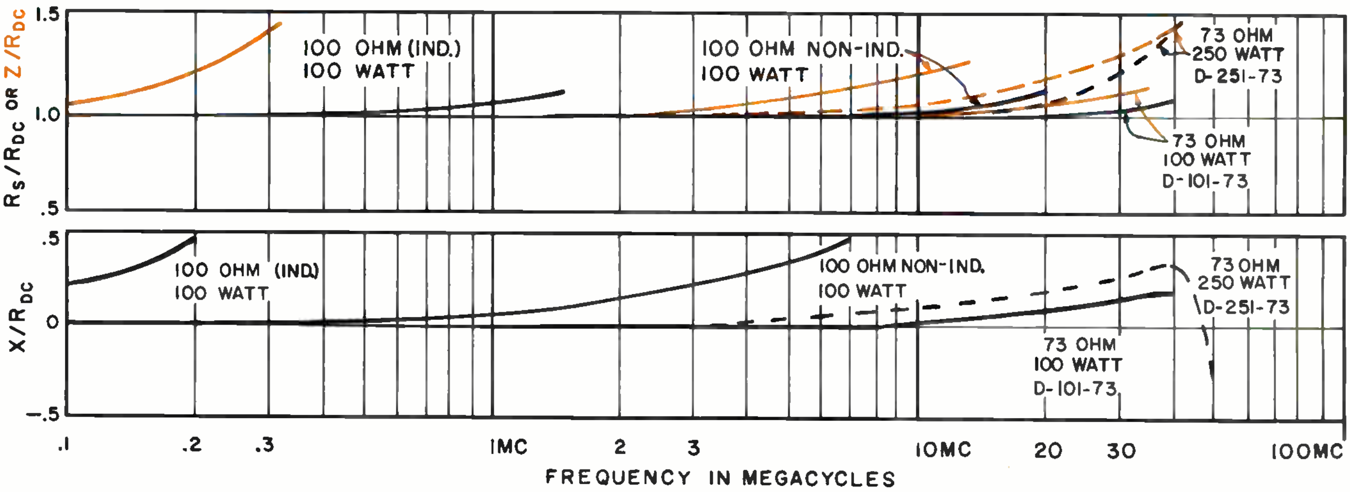


Fig. 35: Normalized resistance, reactance and impedance versus frequency for standard resistors.

In Ohmite non-inductive resistors, residual inductance and distributed capacitance have been kept to a minimum by means of an Ayrton-Perry type of winding (two windings in opposite directions, connected in parallel) thereby making the natural resonant frequency as high as possible. Skin effect is negligible because of the use of small diameter wire of high specific resistance. Consequently, these resistors may be considered appropriately as "Non-Reactive Resistors."

Frequency Characteristics: The effect of frequency on the characteristics of any resistor is a complex function of not only inductance and capacitance, but also resistance. The equivalent values at any specified frequency are influenced by the ratio of the applied frequency to the natural resonant frequency of the resistor. To compare the frequency response characteristics of various resistor types or sizes but having the same resistance value, it is desirable to plot the normalized parameters as given in the graphs of Figs. 35 through 43. Normalized values of Z and R_{AC} are expressed as the ratio of these quantities to the DC resistance.

Fig. 35 offers a comparison between the frequency characteristics of conventional resistors, non-inductive resistors, and Ohmite dummy antenna resistors of comparable resistance. Figs. 36 through 43 show normalized resistance and impedance characteristics for many stock non-inductive resistor sizes and resistance values. For those values not shown, the reader may interpolate on the graphs.

A study of Figs. 36 through 43 indicates that regardless of the physical size of a resistor, there is an optimum resistance range—generally in the order of 500 to 1000 ohms—the frequency response characteristics of which tend to remain essentially flat out to at least 20mc.

For values of resistance less than 500-1000 ohms, depending on size, the residual reactance is generally inductive. Thus, stock resistance values (page 29) below this range are generally shown to be slightly inductive. For resistance values above this range, the residual reactance is generally capacitive and stock values are listed as slightly capacitive.

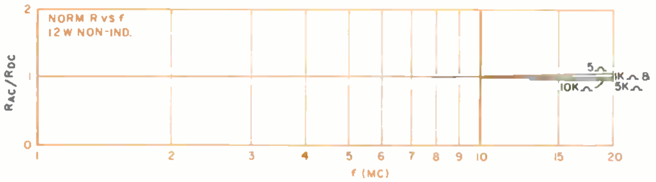


Fig. 36: Normalized resistance vs frequency (12W non-inductive resistor).

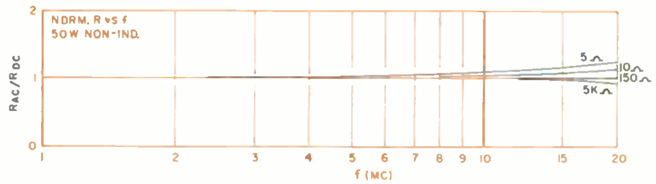


Fig. 38: Normalized resistance vs frequency (50W non-inductive resistor).

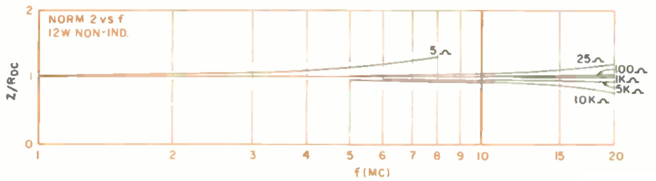


Fig. 37: Normalized impedance vs frequency (12W non-inductive resistor).

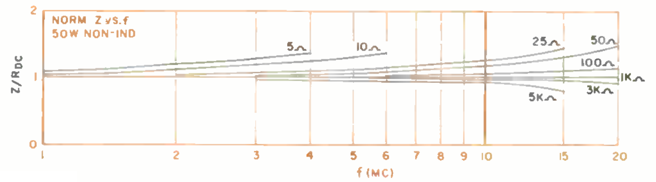


Fig. 39: Normalized impedance vs frequency (50W non-inductive resistor).

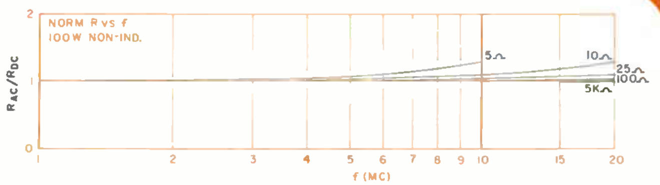


Fig. 40: Normalized resistance vs frequency (100W non-inductive resistor).

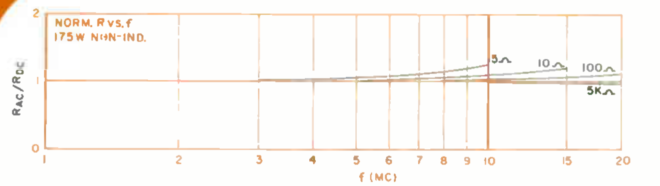


Fig. 42: Normalized resistance vs frequency (175W non-inductive resistor).

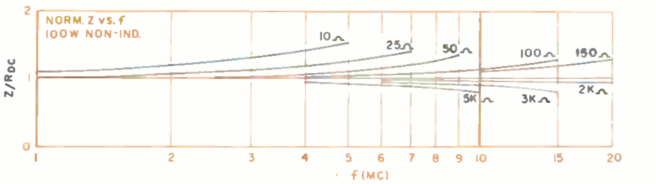


Fig. 41: Normalized impedance vs frequency (100W non-inductive resistor).

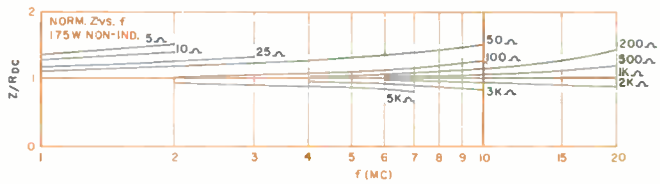


Fig. 43: Normalized impedance vs frequency (175W non-inductive resistor).

NON-INDUCTIVE
Dummy-Antenna Resistors

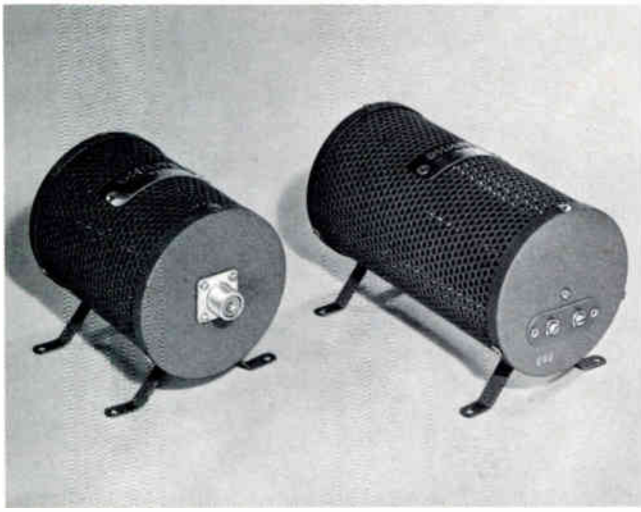


Fig. 44: Dummy antennas with coax and terminal strip connections.

The Dummy Antenna Resistors feature practically constant R.F. resistance (within their recommended frequency range), low reactance, high wattage dissipation, and compactness.

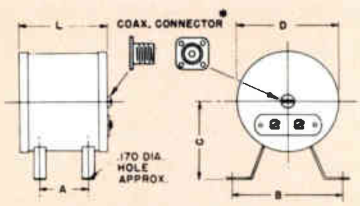
Application: These resistors provide a simple, accurate and direct means of loading a radio-transmitter, diathermy machine or other source of radio-frequency for "tuning-up," i.e., adjusting for best performance, or for the purpose of measuring R.F. power (using an R.F. ammeter). They are suitable for the use of the manufacturer, laboratory technician and amateur, and for the operators of aviation, police, communications and broadcast stations. The power (at any frequency) is simply calculated as I^2R.

Description: The Dummy Antennas consist of a number of special non-inductive vitreous enameled resistors connected in parallel in a cylindrical arrangement and mounted inside a perforated metal cage.

In the design of the component resistors which make up the Dummy Antennas, two important design considerations are responsible for the excellent frequency characteristics obtained. First, the residual inductance and distributed capacitance have been kept to a minimum, thereby making the natural resonant frequency as high as possible. Second, the D.C. resistance, inductance, and distributed capacitance have been proportioned in such a manner as to give the best possible response characteristics. As a result, a resistor has been obtained which has a minimum amount of effective series reactance and an essentially constant effective series resistance up to frequencies shown in the table. This resistor may be considered practically a "Non-Reactive Resistor."

The table below lists the recommended upper limit of frequency at which the various Dummy Antennas may be used and gives other characteristics. These limits allow a ±10% impedance change (of the scalar value). The actual D.C. resistance tolerance is ±5%. For more data and graphs write for D7831.

STOCK DUMMY ANTENNAS



Model D-101 — 100 Watts

Stock No.	Ohms	Amps	A	B	C	D	L
D-101-52*	52	1.38	1 1/2	3 1/2	2 3/8	3 5/32	2 23/32
D-101-73*	73	1.17					
D-101-300	300	0.58	2 3/4	3 1/2	2 3/8	3 5/32	4 7/32
D-101-600	600	0.41					
Model D-251 — 250 Watts							
D-251-52*	52	2.20	3 1/8	3 7/8	2 1/2	3 23/32	4 19/32
D-251-73*	73	1.85					
D-251-300	300	0.92	5 1/8	3 7/8	2 1/2	3 23/32	6 13/16
D-251-600	600	0.64					

*Employs coax connectors

Fig. 45: Stock dummy antennas—dimensions and ratings.

FREQUENCY CHARACTERISTICS OF OHMITE DUMMY ANTENNAS

R_{dc} = D. C. Resistance; R_s = Effective Series Resistance; Z = Scalar Value of Impedance

Model	Model D-101—100 Watts				Model D-251—250 Watts			
Resistance	52 Ohms	73 Ohms	300 Ohms	600 Ohms	52 Ohms	73 Ohms	300 Ohms	600 Ohms
Max. Freq. for $R_s = R_{dc} \pm 10\%$	22 mc	38 mc	22 mc	31 mc	19 mc	21 mc	15 mc	19 mc
R_s at this frequency	1.10 R_{dc}	1.10 R_{dc}	1.10 R_{dc}	.90 R_{dc}	1.10 R_{dc}	1.10 R_{dc}	1.10 R_{dc}	.90 R_{dc}
Z at this frequency	1.18 R_{dc}	1.14 R_{dc}	1.10 R_{dc}	.99 R_{dc}	1.25 R_{dc}	1.13 R_{dc}	1.15 R_{dc}	1.00 R_{dc}
Max. Freq. for $Z = R_{dc} \pm 10\%$	18 mc	32 mc	22 mc	60 mc	13 mc	19 mc	13 mc	30 mc
R_s at this frequency	1.06 R_{dc}	1.07 R_{dc}	1.10 R_{dc}	.60 R_{dc}	1.03 R_{dc}	1.07 R_{dc}	1.08 R_{dc}	.64 R_{dc}
Z at this frequency	1.10 R_{dc}	1.10 R_{dc}	1.10 R_{dc}	.90 R_{dc}	1.10 R_{dc}	1.10 R_{dc}	1.10 R_{dc}	.90 R_{dc}
Avg. Weight	.60 LB.		.65 LB.		1.25 LB.		1.50 LB.	

FERRULE RESISTORS, CLIP-MOUNTED

Ferrule type resistors use the ferrules as the mechanical means of mounting as well as electrical terminals. They are made in four general styles, in sizes from less than 5 watts to 200 watts. Three types mount in fuse clips, or other special clips, while the cap style may mount by a special through-bolt arrangement.

Cup Style Ferrules, Type 140, of all diameters, can be provided on a wide range of resistor tube sizes. The cup shaped ferrules are fastened by plugs cemented into the ends of the cores. Sleeve Style 141, Cartridge Style 145, and Cap Style 147 are available only on certain tube sizes, as the ferrule diameter is related to the core diameter. See page 39 for details.

Sleeve style ferrules consist of brass tubing pressed over the ends of the core. Cartridge style ferrules are tapered alloy metal cups pressed over the ends. Cap style ferrules are pressed on the core and cover the annular ends so contact can be made in the axial direction.

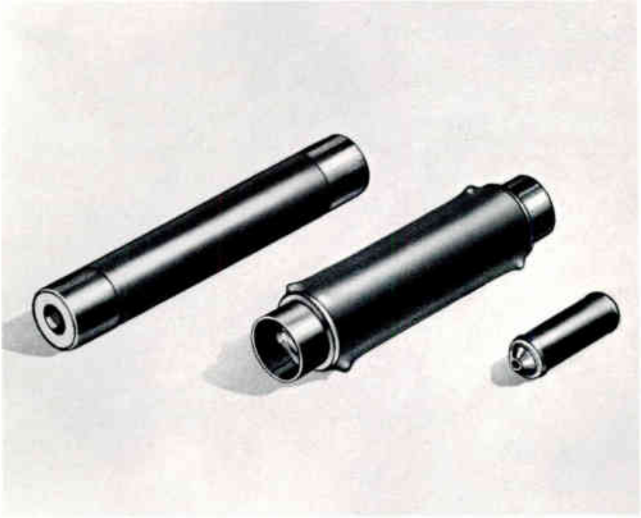


Fig. 46: Ferrule resistors with Type 141, 140 and 145 terminals.

EDISON SCREW-BASE RESISTORS

The Edison Screw Base Resistor is simultaneously mounted and electrically connected with the same ease as an electric light bulb. It is frequently used in battery charging equipment, laboratories, etc. Medium and intermediate (also candelabra and miniature) bases can be supplied. The "medium" size fits the conventional 115 V lamp bulb socket. Resistors with ceramic jackets can be supplied. Resistors with protective enclosures are shown on page 54. The resistor sizes listed in the table are standard.

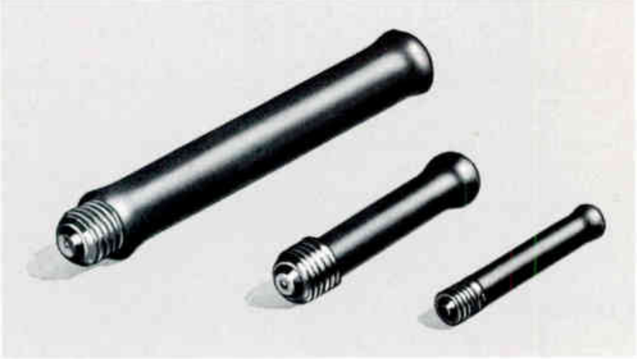


Fig. 47: Typical Edison Base resistors.

Base Size†	Free Air Watts	Maximum Resistance	Overall Length	Core Diameter	Core Length	Code Word
Med.	215	185,000	12¼"	1⅛"	11¼"	EARLE
Med.	*160	135,000	9½"	1⅛"	8½"	EBART
Med.	120	100,000	7½"	1⅛"	6½"	ECOVE
Med.	110	90,000	7"	1⅛"	6"	EDUSA
Med.	*60	50,000	5"	¾"	Spec.	EFRID
Inter.	50	85,000	5¼"	9/16"	4⅞"	EGANT
Inter.	40	65,000	4¼"	9/16"	3⅞"	EILER
Inter.	20	44,000	3¼"	9/16"	2⅞"	ELAIN

†Med. = Medium (same as 115 volt lamp base) Type 146-M, 1 1/32" dia. × 1" long.
Inter. = Intermediate Type 146-I, 21/32" dia. × 13/16" long.
*Most used sizes recommended for standardization.

RESISTORS WITH LUGS AT ONE END ONLY

Vitreous enameled resistors with both terminals at one end can be produced, as shown in the illustration. This requires a specially grooved core and ceramic insulating tubes for the lead which returns from one end of the winding. These units are made only to order, to meet the customer's needs.

Fig. 48: Resistor with terminals at one end.

The starting and speed control circuits for large DC motors such as those used on hoists, cranes, elevators, machine tools, printing presses and other equipment generally require resistance load banks of low ohmic value and high current capacity. The load is most often intermittent. This set of conditions has called for types of construction different from that of the standard round, wire-wound, vitreous enameled resistor, and as a result, many special forms of resistors have evolved. Such resistors are characterized by (1) a resistance element that is either bare or only partly covered (2) a design arrangement which permits ready connection in series and parallel banks and (3) the facility for easy tapping or adjustment of resistance value.

Ohmite covers this field of application with three types of resistors to afford greater flexibility in equipment design:

(1) Conventional "CORRIB" resistor—the resistance element is corrugated ribbon, edgewound on a ceramic tube and partly covered with enamel. Popular ratings are stocked.

(2) "BARE CORRIB" resistor where the corrugated ribbon element is wound in a threaded or grooved tube. Not stocked.

(3) POWR-RIB bare types where round wire or ribbon is wound on ceramic segments carried on a metal bar. Popular ratings are stocked (pages 46, 47).

RATINGS FOR GROUP MOUNTING AND FORCED VENTILATION

Grouping of resistors requires a reduction of wattage rating (derating) or an increase in size or number of resistors. Data for such calculation is given on page 9 and in the "Engineering Manual," Bulletin 1100.

Forced ventilation becomes desirable and economically feasible when the wattage is large enough for savings in resistor size to compensate for the cost of blower operation. It may also be economical when an air blast is being provided for the benefit of adjacent apparatus. See Bulletin 1100 for details.

RATING FOR INTERMITTENT DUTY

When resistors are operated intermittently, they can carry (with normal temperature rise) greater pulse wattage than their continuous duty ratings, provided the duration of the heating and cooling periods falls within certain limits. Wattage ratings for intermittent duty per NEMA classifications, single pulses and multiple pulses, are shown graphically and described in the "Engineering Manual," Bulletin 1100. The graphs enable an estimate to be made of the pulse rating of various sizes and types of resistors for any combination of on-time and off-time within the range of the graphs.

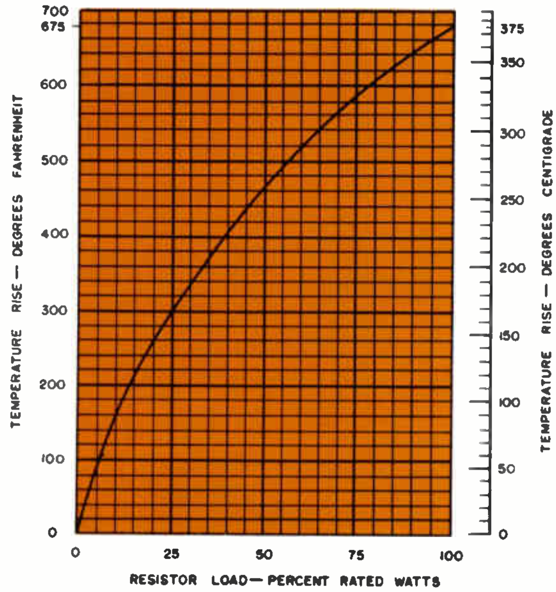


Fig. 49: Approximate temperature rise of Corrib and Powr-Rib resistors on continuous duty.

CORRIB® VITREOUS ENAMELED CORRUGATED RIBBON RESISTORS

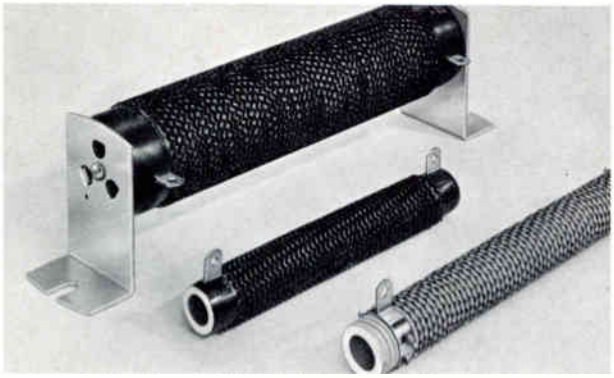


Fig. 50: Typical Corrib resistors including bare threaded-tube type.

Description: A corrugated ribbon of resistance alloy is spacewound edgewise around a ceramic tube. The ribbon is generally ⅛" wide and is terminated on "Heavy Lugs" (Type 45); Type 46 lugs are used on resistors with 9/16" diameter core. Vitreous enamel embeds the inner edge of the ribbon, holding it firmly in place. Taps can be provided. The resistors can also be provided in "Dividohm" style with adjustable lugs. Corribs are made to order and also stocked in certain ratings. Standard resistance tolerance is ±10%. See pages 49 to 51 for mounting brackets.

Application: While used to a large extent in the high wattage circuits described above, Corrib construction also facilitates the manufacture of resistors from a

Stock Corrib® Resistors Types 280 Fixed; 230 Dividohm

fraction of an ohm to several ohms, on cores as small as 9/16" diameter by 2" long—in fact, in the same range of tube sizes (except for the lowest wattage sizes) as used for the regular vitreous enameled resistors (see pages 36-37).

Because these resistors are classified as "bare," (the ribbon is partly exposed) they are permitted a 375°C rise (measured on the ribbon) by the NEMA (National Electrical Manufacturers Association) method of rating as shown in Fig. 49. This temperature rise, plus the effect of the increase in diameter over the tube size due to the height of the ribbon, and the cooling-fin action of the ribbon, allows the Corrib resistor to be rated at a higher wattage for a given core size than the standard round-wire enameled resistor.

Limits on Resistance and Temperature Coefficient: Minimum resistances specified are for resistors wound with 180 ohm/cmf copper-nickel alloy ribbon (#180 alloy) of good nominal temperature coefficient (+180 ppm/°C). Lower resistances than shown can be supplied but generally require other alloys of higher temperature coefficient (two or three times as large).

Maximum resistance can be increased in some cases by use of closely crimped wire. Maximums shown use 1/16" wide ribbon in some cases and may slightly exceed 375°C rise at full load.

When the lowest available temperature coefficient alloy is required (copper-nickel 55%-45%, with nominal 0±20ppm/°C TC) the minimum resistance possible will be approximately 1.64 times the figures shown. The resistor TC may be somewhat greater than the nominal wire TC.

BARE CORRIB, THREADED-TUBE CORRUGATED RIBBON RESISTORS

When it is desired to operate "CORRIB" resistors continuously or intermittently at higher than the normal 375° rise, the uncoated threaded-tube type of "CORRIB" resistor is particularly suited. A typical unit is illustrated in Fig. 50. The corrugated ribbon resistance wire is wound on a ceramic tube which has square threads to keep the turns separated. The ribbon is welded to special Type 44 lugs. Available in 11¼" and 8½" long cores, 1¼" diameter; other sizes can be supplied if quantity warrants.

CORRIB RESISTOR SIZES

[illegible]	Core Size			Resistance Range		New Code (See page 37)
	[illegible]	[illegible]	Length	Min. Ohms	Max. Ohms	
1500	2½"	1¾"	20"	1.00	110.0	20-S-45-C
1000	2½"	1¾"	15"	0.72	79.0	15-S-45-C
750	2½"	1¾"	12"	0.55	61.0	12-S-45-C
375	2½"	1¾"	6"	0.27	30.0	6-S-45-C
550	1⅝"	1⅛"	11¾"	0.37	41.0	11¾-R-45-C
500	1⅝"	1⅛"	10½"	0.32	36.0	10½-R-45-C
400	1⅝"	1⅛"	8½"	0.27	28.0	8½-R-45-C
270	1½"	1⅛"	5"	0.13	13.0	5-Q-45-C
400	1⅛"	¾"	11¼"	0.24	26.0	11¼-P-45-C
375	1⅛"	¾"	10½"	0.22	25.0	10½-P-45-C
300	1⅛"	¾"	8½"	0.17	20.0	8½-P-45-C
220	1⅛"	¾"	6"	0.11	12.5	6-P-45-C
185	1⅛"	¾"	5"	0.09	10.5	5-P-45-C
315	1"	⅝"	10"	0.20	21.0	10-N-45-C
215	1"	⅝"	7"	0.12	13.5	7-N-45-C
190	1"	⅝"	6"	0.10	11.5	6-N-45-C
150	1"	⅝"	5"	0.08	8.5	5-N-45-C
125	1"	⅝"	4"	0.06	6.0	4-N-45-C
180	¾"	½"	6½"	0.08	9.0	6½-M-45-C
160	¾"	½"	6"	0.07	8.3	6-M-45-C
135	¾"	½"	5"	0.06	6.5	5-M-45-C
105	¾"	½"	4"	0.04	4.6	4-M-45-C
100	¾"	½"	3½"	0.03	3.7	3½-M-45-C
135	9/16"	5/16"	6"	0.06	6.5	6-K-46-C
105	9/16"	5/16"	5"	0.05	5.2	5-K-46-C
90	9/16"	5/16"	4"	0.04	3.8	4-K-46-C
36	9/16"	5/16"	2"	0.02	1.8	2-K-40-C*

*Standard for 0.11 ohm or less is 2-K-46-C.

STOCK CORRIBS—300 WATT SIZE

Styles 280-300 Fixed; 230-300 Adjustable

Core: 8½ x 1⅛" Fixed or Adjustable (DIVIDOHM)
Code: (Fixed) 8½-P-45-C; (Dividohm) 8½-P-45-E
Avg. Weight (Fixed) .61 lb.; (Dividohm) .64 lb.

Ohms	Amps.	Fixed Stk. No.	Divid. Stk. No.*	Ohms	Amps.	Fixed Stk. No.	Divid. Stk. No.*
.10	54.7	2501	2601	1.6	13.7	2513	2613
.12	50.0	2502	2602	2.0	12.2	2514	2614
.16	43.3	2503	2603	2.5	10.9	2515	2615
.20	38.7	2504	2604	3.1	9.8	2516	2616
.25	34.6	2505	2605	4.0	8.6	2517	2617
.31	31.1	2506	2606	5.0	7.7	2518	2618
.40	27.4	2507	2607	6.3	6.9	2519	2619
.50	24.5	2508	2608	8.0	6.1	2520	2620
.63	21.8	2509	2609	10.0	5.5	2521	2621
.80	19.3	2510	2610	12.0	5.0	2522	2622
1.0	17.3	2511	2611	16.0	4.3	2523	2623
1.2	15.8	2512	2612	20.0	3.8	2524	2624

*Adjustable Lug Stk. No. 1974 supplied with Dividohm.

Three-hundred watt units are stocked in both fixed (Type 280) and adjustable (Dividohm Type 230) styles. A smooth, adjustable band makes contact almost completely around the entire periphery of the resistor in the Dividohm type. Core size for both types is 8½" long by 1⅛" diameter. Through-bolt bracket hardware is stocked for mounting 1 to 4 units. See below.

Fig. 51: Stock Corribs.

THRU-BOLT MTG. BRACKETS

Incl. bolt, 2 brkts., ctrg. mica & lock wshrs.

No. of Resist.	Stk. No.	No. of Resist.	Stk. No.
1	6126P8½	3	6128P8½
2	6127P8½	4	6129P8½

See page 50 for dimensions & mtg. ctrs.

MADE-TO-ORDER TUBULAR CORE

For Fixed and Dividohm (Adjustable)

Most Used . . .

① Free Air Watt Rating (Watts)	② 2a ③ Nominal Core Dimensions: Length (Inches)	Outside Dia. (Inches)	Inside Dia. (Inches)	④ Minimum Resistance (Ohms)	⑤ Maximum Resistance at Free Air Watts (Ohms)	⑥ Practical Resistance Limits for Vitreous Enamel (Ohms)	⑦ Code for Core Dia.	3/16" W. .104 DIA. 57 Narrow	1/4" W. .166 DIA. 40 General	3/8" W. .173 DIA 46 Medium
*3	7/16	0.20	0.135	0.15	10K	10K	AA			
*5¼	5/8	¼	0.135	0.25	20K	20K	CA			
6½	1	¼	⅛	0.25	35K	35K	CA	○		
*8	1	5/16	3/16	0.3	25K	25K	D	●	●	
*12	1¾	5/16	3/16	0.3	50K	50K	D	◉	●	
7	¾	7/16	5/16	0.4	2.5K	13K	HA	○		
11	1	7/16	5/16	0.5	3.5K	30K	HA	○	●	
15	1½	7/16	¼	0.2	5K	65K	H	●	○	
*20	2	7/16	¼	0.3	9K	100K	H	●	○	
26	3	7/16	¼	0.3	13K	170K	H	●	○	
12	1	9/16	5/16	0.2	3K	31K	K	○	●	
*25	2	9/16	5/16	0.3	10K	100K	K	●	◉	●
35	3	9/16	5/16	0.4	18K	176K	K	●	○	●
*50	4	9/16	5/16	0.5	25K	250K	K	●	◉	●
60	5	9/16	5/16	0.7	33K	320K	K	●	○	●
*75	6	9/16	5/16	1.0	40K	394K	K	●	◉	●
25	1½	¾	½	0.2	6.5K	13K	M	●	○	●
30	2	¾	½	0.3	13K	21K	M	●	○	●
45	3	¾	½	0.5	23K	39K	M	●	○	●
51	3½	¾	½	0.6	28K	47K	M	●	○	●
61	4	¾	½	0.7	33K	56K	M	●	○	●
65	4½	¾	½	0.8	40K	65K	M	●	○	●
76	5	¾	½	0.9	44K	73K	M	●	○	●
90	6	¾	½	1.0	54K	91K	M	●	○	●
*100	6½	¾	½	1.0	60K	100K	M	●	◉	●
52	3	1	⅝	0.3	24K	52K	N		○	●
70	4	1	⅝	0.4	34K	75K	N		○	●
85	5	1	⅝	0.5	45K	99K	N		○	●
105	6	1	⅝	0.6	55K	123K	N		○	●
120	7	1	⅝	0.7	66K	146K	N		○	●
140	8	1	⅝	0.8	76K	170K	N		○	●
176	10	1	⅝	1.0	100K	217K	N		○	●
40	2	1⅛	¾	0.2	10K	11K	P		●	○
80	4	1⅛	¾	0.3	32K	32K	P		●	○
95	5	1⅛	¾	0.4	42K	42K	P		●	○
120	6	1⅛	¾	0.5	53K	53K	P		●	○
130	6½	1⅛	¾	0.6	58K	58K	P		●	○
160	8	1⅛	¾	0.7	74K	74K	P		●	○
*175	8½	1⅛	¾	0.8	100K	100K	P		●	◉
*225	10½	1⅛	¾	1.0	100K	100K	P		●	◉
235	11¼	1⅛	¾	1.0	104K	108K	P		●	○
251	12	1⅛	¾	1.0	115K	115K	P		●	○
150	5½	1½	1⅛	2.0	13K	31K	Q			●
220	8½	1⅝	1⅛	4.0	22K	60K	R			
275	10½	1⅝	1⅛	5.0	29K	77K	R			
300	11¾	1⅝	1⅛	5.5	32K	88K	R			
250	6	2½	1¾	3.5	1K	3.4K	S			
500	12	2½	1¾	8.0	2.5K	8.6K	S			
750	15	2½	1¾	10.0	3.6K	11K	S			
1000	20	2½	1¾	14.5	5K	15K	S			

NOTES for TABLE:

1. Free Air Watt Rating: Refer to page 4 (and following) for limitations due to operating conditions.

2. Tolerance on Nominal Core Dimensions

Length	Tolerance	Length	Tolerance
7/16" to 4"	±1/32"	Over 6½" to 11¼"	+1/64"–3/32"
Over 4" to 6½"	±3/64"	Over 11¼" to 20"	±⅛"

Tolerances do not include effect of longitudinal camber.

I.D.	Tolerance
To ½"	±1/64"
Over ½" to 1⅛"	±1/32"
Over 1⅛" to 1¾"	±1/16"

2a. Maximum Diameter Over Coating; Lug Dimensions: The overall diameter of a finished resistor includes the build-up due to wire diameter, coating and terminal material. This results in a possible maximum increase in diameter of 3/16" for low resistance, 1⅛ O.D. core resistors and larger; 5/32" for resistors with smaller diameter cores. On all high resistance units the increase is generally less than ⅛".

VITREOUS ENAMELED RESISTORS
Ratings, Sizes, Terminals, Codes

OHMITE

. . . Terminals (See pages 38 and 39 for others)

	45 Heavy	48 Wire	53 Quick-connect	54 Axial Lead	126 Flexible Lead	128 Flexible Lead	140 Ferrule	141 Ferrule
		◉						
		◉						
		●						
		◉	●		●	●		
		◉	●		●	●		
		●	●		●	●		
		●	●		●	●	●	
		●	●		●	●	●	
		◉	●		●	●	●	
		●	●		●	●	●	
			●		●	●	●	
		●	●		●	●	●	
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KEY

◉ — Stock Resistor
○ — Standard Terminal
● — Available Terminal
* — Preferred Size

The hot dip tinning on terminals may affect width, thickness or hole size and such dimensional variations are included in the tolerances given on pages 38 and 39 except for occasional irregularities due to tinning.

3. Other Core Sizes: Cores used only for Axial-Lead Resistors, Edison Base Resistors, and special sizes required for Military Specification and EIA Specification resistors, are not listed in the table but are carried in stock. In addition, many other specials are available from stock or on short notice including cores with special inside diameter listed below. All cores listed in previous catalogs can be supplied.

CORES WITH NON-STANDARD I.D. (OR O.D.)

O.D.	I.D.	Code	O.D.	I.D.	Code
5/16″	7/32″	DA	3/4″	35/64″	MA
7/16″	5/16″	HA	15/16″	9/16″	UA
9/16″	25/64″	KA	1 1/8″	7/8″	PA
5/8″	29/64″	LA			

4. Minimum Resistance: Even lower resistances can be provided where TC is not important. Lower resistance can be reached also by using "CORRIB" open construction (see page 34). When ordering low resistances, specify resistance tolerance (generally ±10% or ±15%) and allowable change in resistance with load. Minimums for DIVIDOHM adjustable units are sometimes higher than the values shown for fixed resistors.

5. Maximum Resistance at Free Air Watts: Units having a resistance higher than this value should be operated at less than Free Air Watts. See page 7.

6. Practical Resistance Limits for Vitreous Enamel: Higher resistances than those shown in the column can be provided in vitreous enamel in many cases (consult factory). Still higher limits are possible with Ohmicone silicone-ceramic coatings. See page 44.

Maximum resistance for DIVIDOHM adjustable resistors should be generally limited to the maximums shown for Stock Dividohms or proportional values for the other sizes.

7. Code for Core Diameter: The code letter is used in the "Coded Specification" as explained below.

8. Quick-Connect, Ferrule, Edison Base and Bracket Terminals: The proper suffix indicating size (details on pages 33 and 38) must be added to the terminal number. In some cases, special I.D. tubes must be used.

9. Other Terminals: The terminals listed in the table and additional terminals are described on pages 38 and 39. Special terminals to meet customers requirements can be made when quantity warrants.

Terminal Screws: If desired with terminal screws add suffix A to type number (see page 38-39).

10. Other Features: Most of these resistors can be ordered in DIVIDOHM adjustable style or with non-inductive winding (pages 29-32) or with positive non-turn notch feature "NOTCA" as described on page 49.

11. Axial-lead resistors with vitreous enamel coating are furnished only in certain core sizes not listed for the most part in this table (see pages 11 through 15). In the Series 99 sizes shown on pages 11-14, non-stock resistance values are ordered by specifying the style number followed by the resistance value.

HOW TO ORDER:

Give Code as below for single section resistors:

Core Length	Core Dia. Code	Terminal Number	Type of Winding	Additional Feature	Ohms

Example: 8½—P—46A—F—K—1375

This is an 8½″ lg. x 1⅛″ O.D. x ¾″ I.D. core; with No. 46 lugs equipped with terminal bolts; fixed, round wire construction; with NOTCA 1 non-turn feature; with 1375 ohms resistance.

WINDING CODE

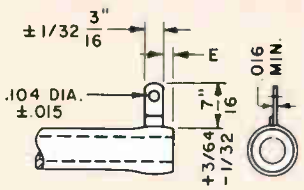
Code	Type	Code	Type
F	Fixed, Round Wire	E	Dividohm, Corrib
D	Dividohm, Round Wire	N	Fixed, Non-Inductive (Stock sizes have flatted sides—page 29)
C	Fixed Corrib		

ADDITIONAL FEATURE CODE

Letter	Type
K	NOTCA 1 (Notched Core—All Sizes)
L	NOTCA 2 (Fluted I.D. Core—Available where Wall Thickness Permits)
OM	Ohmicone (Silicone-Ceramic) Coating

See page 10 for other information on ordering.

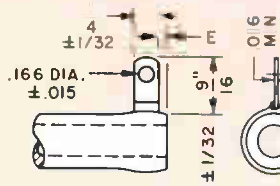
NARROW LUG



TYPE 57

Standard: On 10 Watt Dividohm
For Cores: 1/4" to 3/4" O.D.

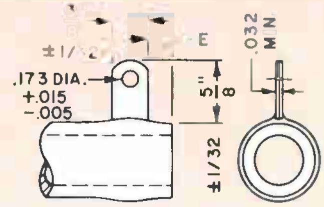
GENERAL PURPOSE LUG



TYPE 40 and 40A

Standard: Type 40 on 5/16" to 1" O.D.
For Cores: 5/16" to 1 1/8" O.D.
Screw Terminal: Type 40A, with No. 6-32x1/2" Fillister Head Screw, 2 Nuts and Washers.

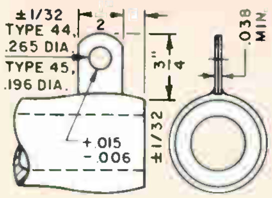
MEDIUM LUG



TYPE 46 and 46A

Standard: Type 46 on 1 1/8" O.D.
For Cores: 9/16" to 1 5/8" O.D.
Screw Terminal: Type 46A, with No. 8-32x5/8" Fillister Head Screw, 2 Nuts and Washers.

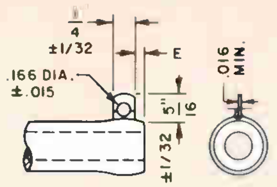
HEAVY LUGS



TYPE 44, 44A and 45, 45A, 45B

For Cores: 3/4" to 2 1/2" O.D.
Holes: Type 44—.265D; Type 45—.196D
Screw Terminals: Filstr. Hd. (2 nuts, wshrs).
44A—1/4-20x5/8; 45A—8-32x5/8;
45B—10-32x5/8"

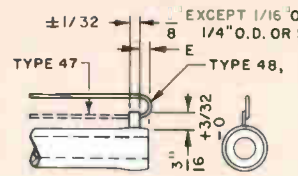
SHORT LUG



TYPE 49

For Cores: 5/16" to 1 1/8" O.D.
A soldering type lug for use where space limits lug height.

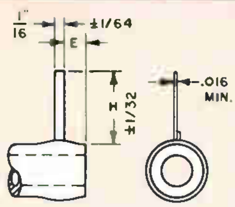
WIRE LEAD



TYPE 47 and 48

For Cores: .20 to 1 1/8" O.D.
Type 47: 2" leads, 20 AWG, all bands
Type 48: 1 1/2" leads, Std. on "Brown Devils"
18 AWG for 1/8" band
20 AWG for 1/16" band

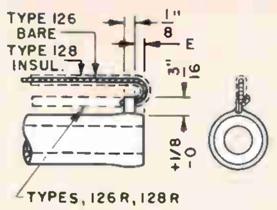
WELDABLE LUG



TYPE 50

For Cores: 5/16" to 9/16" O.D.
An untinned, narrow lug intended for welded connection into a circuit.
Height (H) as specified

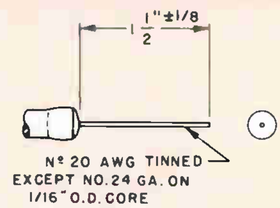
FLEXIBLE LEAD—Standard



TYPE 126 and 128

For Cores: 5/16" to 1 1/8" O.D.
Leads: 18 AWG Stranded, Specify Length.
Type 126, 126R: Phosphor-Bronze, Bare
Type 128, 128R: Copper, Asbestos- Insulated
Type 128F, 128FR: Nickel-Iron, Insulated

AXIAL LEAD



TYPE 54

Special For Core Sizes: 1/16", 3/32", 3/16", 1/4", 5/16", 7/16" O.D.
Description: Solid wire welded to a cap (tinned wire 20 AWG except 24 AWG on 1/16" O.D. core)

EDGE DISTANCE ("E")

Terminals	CORE O.D. .20	1/4	5/16	7/16	9/16	3/4	1	1 1/8	1 1/2	1 5/8	2 1/2
40, 40A, 47, 48, 49, 50, 53, 57, 68, 69, 126, 128	3/32	3/32	3/32	3/32	3/32	1/8	5/32	7/32	—	—	—
44, 44A, 45, 45A, 45B, 46, 46A	—	—	—	—	1/4*	1/4	1/4	1/4	1/4	1/4	1/2

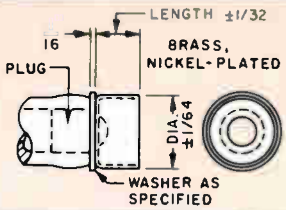
*Applicable to 46 and 46A lug only

Dimension "E" can be varied and is often reduced for cores 2" or less in length or sometimes increased for greater leakage distance to ground. Tolerance on "E" is ±1/32" up to 1/8" and ±1/16" above.

TERMINALS

OHMITE

FERRULES — Cup Style



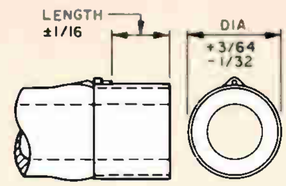
TYPE 140

For Cores: 7/16" to 1 1/8" O.D.

FERRULE		CATALOG NO.	
Dia.	Lgth.	No Washer	With Washer
9/16"	1/2"	140-9*	140-19
11/16"	9/16"	140-11*	140-01
13/16"	1/2"	140-13†	140-03
1 1/8"	1/2"		140-18

*Up thru 9/16" D. core. †Up thru 3/4" core

FERRULES — Sleeve Style

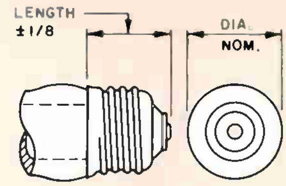


TYPE 141

Ferrule Dia.	Lgth.	Cat. No.	Core O.D.
9/16"	9/16"	141-9	1/2" only
5/8"	5/8"	141-10	9/16" only
13/16"	11/16"	141-13	3/4" only
1 1/16"	11/16"	141-17	1" only
1 3/16"	11/16"	141-19	1 1/8" only

Ferrules are brass, natural finish.

EDISON SCREW BASES



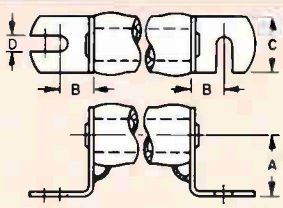
TYPE 146

For Cores: As Required

Cat. No.	Size	Dia.	Length
146-I	Intermediate	21/32"	13/16"
146-M	Medium	1 1/32"	1"

Miniature and Candelabra bases also available.

"LIVE" BRACKETS

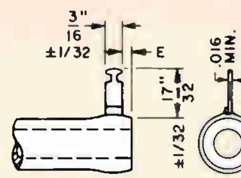


TYPE 63

Cores 9/16" to 3/4" O.D. ....Cat. No. 63-12
Cores 1" to 1 1/8" O.D. ....Cat. No. 63-18

Cat. No.	A ±1/32	B ±1/32	C ±1/32	D (Min)
63-12	25/32"	7/16"	3/4"	1/4"
63-18	7/8"	13/16"	1 1/8"	5/16"

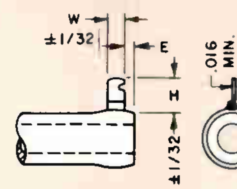
DOUBLE NOTCH LUG



TYPE 68

For Cores: 5/16" to 1 1/8" O.D.
A soldering type lug used by some industries.

SINGLE NOTCH LUG

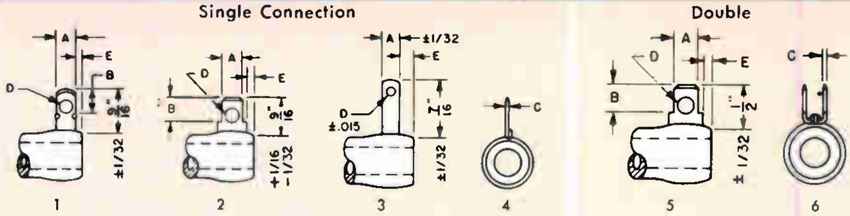


TYPE 69

For Cores: 5/16" to 1 1/8" O.D.

Type No.	W	H
69N	1/8"	3/8"
69L	3/16"	5/8"
69S	3/16"	3/8"

QUICK-CONNECT TERMINALS—TYPE 53

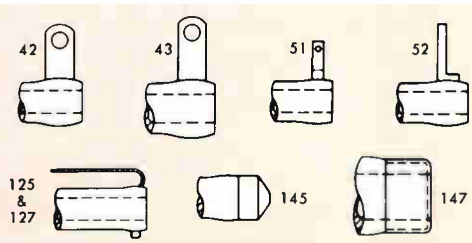


Designed to accept standard quick-connect (push-on) connectors. "Three-Way" terminal (53-25B) accepts connectors, soldering or No. 6 screw. Double terminal style (53-25BT) allows two connections at one point.

Style	Fig.	A ±.005	B ±.020	C +.005 −.001	D ±.015	For Core sizes (diameter):
53-11B	3	‡.125	—	.020	.070	5/16
53-18B†	2	3/16	1/4	.020	1/16	5/16, 7/16, 9/16; also std. "Thin" res.
53-25B*	1	1/4	5/16	.031	.150	5/16 thru 2 1/2; also std. "Thin" Res.
53-25D	2	1/4	5/16	.031	1/16	
53-25BT	5, 6	1/4	5/16	.031	.150	5/16 thru 1 1/8"

*"Three-Way" terminal—Normally supplied on core sizes 5/16" thru 2 1/2" when quick-connect terminal is required.
†Normally supplied on standard "Thin" resistors when quick-connect terminal is required.
‡Normally can be used with female receptacles intended for .110 wide x .020 thick tabs.

OTHER TERMINALS



Type No.	DESCRIPTION
42	Lug 5/16" wide x 5/8" high, .169 dia. hole
43	Lug 5/16" wide x 13/16" high, .169 dia. hole
51	Lug 1/8" wide x height as required, .063 dia. hole
52	Lug for "Wire-Wrap" (Keller, Gardner-Denver T.M.) connection.
125, 127	Lead, 18 AWG stranded, untinned Type 125-2"; Type 127-5 1/2"
145	Ferrules, cap style, for 5/16" and 7/16" dia. cores
147	Ferrules, cap style, for 1/4", 3/4" and 1 1/8" dia. cores (See page 33)

Further data supplied on request.

General. The most frequently used form of resistor terminal is the lug type, which is well adapted to circuit connection by means of soldering. The heavier lugs are also used with terminal bolts. Special shaped lugs are used for receiving push-on connectors or machine-wrapped wire connections. Other special shaped lugs, wire leads of bare, solid or stranded construction, insulated wire leads, ferrules, Edison screw bases and "live" brackets are used as suggested by the requirements of the equipment.

Lugs should be used preferably in accordance with the standards on pages 36 to 39. The bigger lugs are ordinarily used on the larger cores or when the resistance is quite low, as the winding is then made of large size wire or ribbon.

Lug Height. Most of the lugs can be made with the projecting length shorter or longer than standard. Other hole sizes can be supplied also.

Terminal Placement. Terminal lugs can be mounted at any specified distance from the end of the core, but the standard edge distances (see page 38) meet most requirements. Center-line to center-line distances between lugs should not be specified unless essential. Wattage ratings may be reduced when lugs are mounted far in from the ends, or sleeve ferrules are used, particularly on short resistors.

Formal requirements, as well as needs, on electrical leakage distances from resistor terminals to grounded mounting surfaces vary greatly between electronic, industrial and other applications. In addition, the requirements of the Underwriters' Laboratories, Inc., for example, vary with the exact type of equipment, making it desirable for equipment designers to ascertain the pertinent specification. How leakage distances vary with the method of mounting are shown in Fig. 52. Ceramic bushings (listed on page 51) are sometimes used instead of mica and centering washers.

Ohmite stock resistors, or other Ohmite resistors with standard lug spacing, will meet U.L. "Industrial Control Standards" for leakage and air distances for voltages as shown in the table Fig. 53. The U.L. spacings in inches are given in table Fig. 54. The U.L. method of test requires the application of twice the voltage ratings, shown in Fig. 53, plus 1000 volts for the duration of one minute.

Hi-Pot Test—Voltage Breakdown to Ground: All Ohmite resistors with an edge distance of at least 1/16" will withstand *testing* at 1000 VAC between the terminals and mounting.

Use Mounting Brackets. Lug type resistors should not be mounted by the lugs. Resistors should be mounted by the inexpensive brackets or other means as described on pages 49 to 52. Undue strains set up when mounting by means of lugs which were not designed for the purpose, may cause damage to the resistor.

Ferrule Resistor Mounting

Ferrule resistors can be mounted by fuse clips as shown in the table. Fuse clips are available from electrical parts distributors.

Ferrule Dia.	Fuse Clip Size Recommended
9/16", 5/8", 11/16"	0-30 Amp., 250 Volt
13/16"	31-60 Amp., 250 Volt
1 1/16", 1 1/8", 1 3/16"	31-60 Amp., 600 Volt

Type 48 Terminal Used as "Lead and Lug"

When circuit wires are to be connected to a resistor, with Type 48 wire leads, the wires must be soldered to the tinned leads rather than the lug.

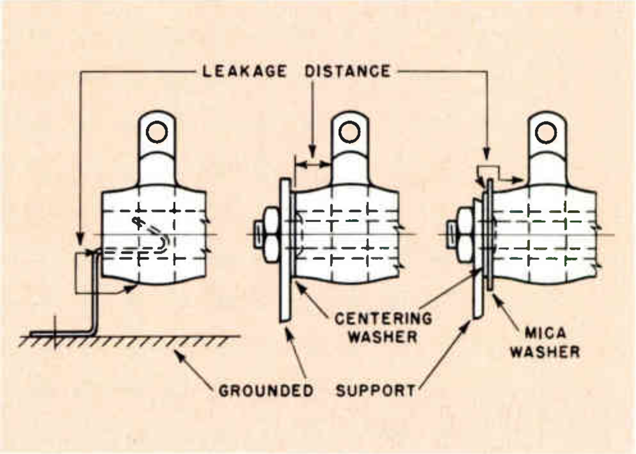


Fig. 52: How surface leakage distance from lug to ground varies with method of mounting.

Stock Watt Sizes or Equivalent		With Spring Grip Brackets	With Through-bolt Brackets and Mica Washers
O.D.	Watts	Voltage Rating	
9/16"	25, 50, 75	—	150 V. Std. 300 V.*
3/4"	100	150 V.	300 V.
1 1/8"	160, 200	300 V.	600 V.

*300 V. with 1" dia. mica washers Cat. No. 6026.

Fig. 53: Voltage rating to ground per UL "Industrial Control Standards."

Circuit Voltage	Insulation Distance (Min.) Over Surface	Insulation Distance (Min.) Through Air
51-150	1/4"	1/8"
151-300	*3/8"	1/4"
301-600	1/2"	3/8"

*1/4" permitted for devices less than 1600 V.A.

Fig. 54: Minimum spacings per UL "Industrial Control Standards."

Series 25 Fixed; 26 Dividohm
"Thin" Resistors

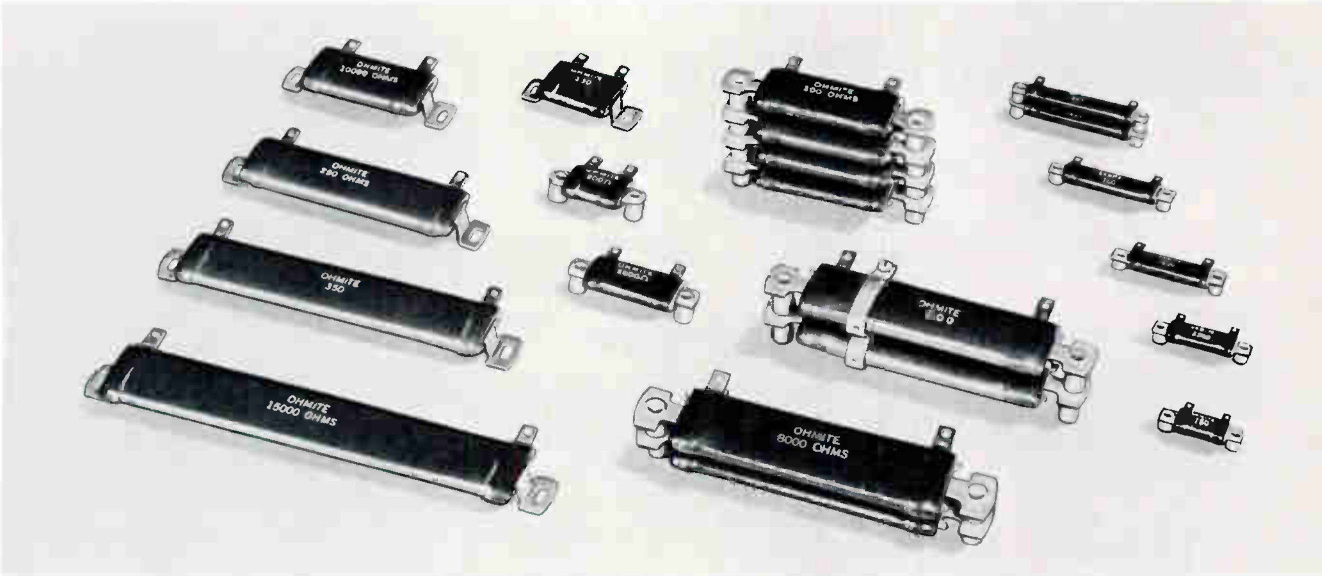


Fig. 55: Typical miniature, intermediate and standard size "Thin" resistors.

Vitreous enameled "Thin" resistors (also known as "Strip," "Flat," or "Oval Core" type) of approximately oval cross-section and mounted by flat brackets of aluminum, are most frequently used where space is limited. Their over-all height above the mounting surface is low and they can be compactly stacked.

Ohmite makes three series of Thin resistors—the "*miniature*" in 10, 15, and 20 watt sizes; the "*intermediate*" in 20 and 30 watt sizes and the "*standard*" in 30, 40, 55, 70 and 95 watt sizes. Mounting brackets, an integral part of these units, extend through the resistor core (two pieces for "unit" type brackets) to equalize heat distribution and to conduct heat directly to the mounting surface. Wattage ratings, therefore, are based on the use of a steel mounting surface of 10″ square x .040″ thick or equivalent.

Fixed resistors Series 25 in the 10, 20, 30, 40 and 55 watt sizes are available from stock as listed on page 43. These and other sizes can be made to order in the fixed, Dividohm adjustable Series 26 or tapped styles. Resistance tolerance for 1 ohm and greater is ±5%; tolerance on lower resistances and all Dividohms is ±10%.

Mountings: "Standard size" (1″ x 1/4″ cross-section) cores can be supplied with either "Stacking" type or "Unit" type mounting brackets assembled, as illustrated. Stacking Type Brackets are available in two heights, "Standard Bracket" (S) of 7/16″ height and "High Bracket" (SH) of 17/32″ height. The "High Bracket" is recommended when Dividohm style (Series 26) resistors are to be stacked as it assures clearance for the adjustable lugs to pass each other.

A spacer washer, Cat. No. 6027, 7/32″ O.D. x 1/8″ I.D. x 3/32″ thick, can be supplied for use with Miniature Thin Dividohms for clearance, as explained above, or for increased wattage (see Derating Table, page 42).

THIN DIVIDOHMS

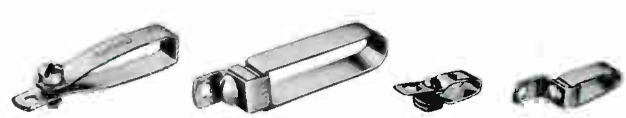
Standard Thin Dividohms have a strip of winding exposed on either the lug edge (L) or the opposite or back (B) edge. On Miniature resistors, the exposed strip may be on either edge or on the top (T). The 1″ long core is the shortest practicable for Dividohm use. Appropriate lugs to suit the location of the exposed area are shown below.

Ordering Code: See page 42.

ADJUSTABLE LUGS

(For Standard & Miniature Sizes)

With "screw at 90°," the screw is perpendicular to the resistor mounting surface. With the screw "parallel" to the mounting surface, it may be adjusted more easily where several Dividohms are stacked.



Cat. No. 1978 | Cat. No. 1979 | Cat. No. 1980 | Cat. No. 1981

Fig. 56: Adjustable lugs for Thin Dividohms.

For Resist. Size	For Contact Area	Screw Location	Cat. No.
Standard	L or B	at 90°	1978
Standard	L or B	parallel	1979
Miniature	T	at 90°	1980
Miniature	L or B	parallel	1981

SERIES 25, 26 "THIN" RESISTORS

DERATING FOR STACKED MOUNTING

Stacked resistors should be derated to prevent excessive temperatures due to proximity. Approximate ratings are given in the table.

No. of Resistors	Percent of Single Unit Rating		
	Std. or Inter.	Miniature	Mini. with 3/32" Sp.
2	70	70	75
3	60	60	69
4	50	50	60

TYPE 250 THIN RESISTORS, MADE-TO-ORDER

*Free Air Watts	†Core Dimensions			Min. Ohms	Practical Resistance Limits for Vitreous Enamel Ohms	Core Code	Fig. No.	A	B	Std. Term.
	L	W	Th.							
Miniature										
10	¾	⅜	⅛	1	15,000	TA	57	1	⅜	51
15	1	⅜	⅛	1	25,000	TA	57	1 ¼	⅜	51
20	2	⅜	⅛	1	50,000	TA	57	2 3/16	⅜	51
12	11/16	19/32	15/64	1	20,000	TB	**	—	—	51
Intermediate										
21	1	13/16	¼	1	8,000	TD	58	1 5/16	19/32	51
25	1 ½	13/16	¼	1	15,000	TD	58	1 13/16	19/32	51
Standard										
30	1 ¼	1	¼	1	10,000	TE	59 60	1 ¾ 2	15/16	57
40	2	1	¼	1	25,000	TE	59 60	2 ½ 2 ¾	15/16	57
55	3 ½	1	¼	1	30,000	TE	59 60	4 4 ¼	15/16	57
70‡	4 ¾	1	¼	1	120,000‡	TE	59 60	5 ¼ 5 ½	15/16	57
95‡	6	1	¼	1	150,000‡	TE	59 60	6 ½ 6 ¾	15/16	57

*Based on mounting on steel panel 10" x 10" x .040".
†Inside dimensions of cores are: ¼" x 3/64" for TA, 13/32" x 3/64" for TB, 7/16" x 1/16" for TD and 43/64" x 1/16" for TE.
‡These sizes are Ohmicone (silicone-ceramic) coated. —Type 450
**User supplies brackets.

Ordering Code: A coded specification number can be written as shown by the example below:

1¼—TE—57—F—SH—100

- Core Length
- Core Code
- Terminal
- Resistor Type
  - F—Fixed
  - Dividohm
  - DL—Lug Edge
  - DB—Back Edge
  - *DT—Top Side
- Bracket
  - S—Stocking Std.
  - †SH—Stocking High
  - U—Unit
- Resistance in Ohms

*Available on "Miniature" style only.
†Available on "Standard" resistors only.

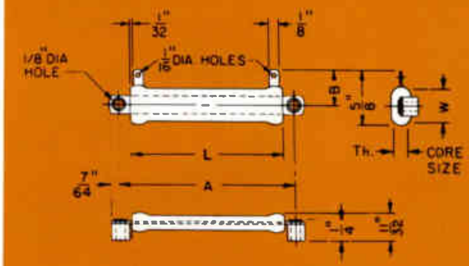


Fig. 57: Miniature Thin resistor.

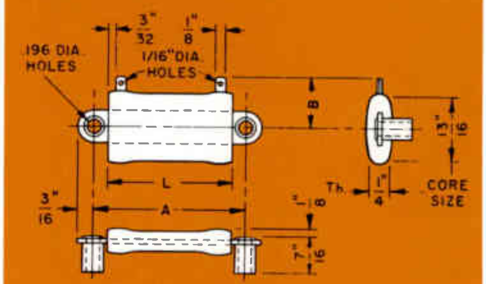


Fig. 58: Intermediate Thin resistor.

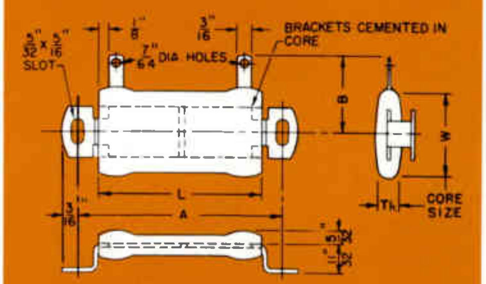


Fig. 59: Standard resistor with unit-type mounting bracket.

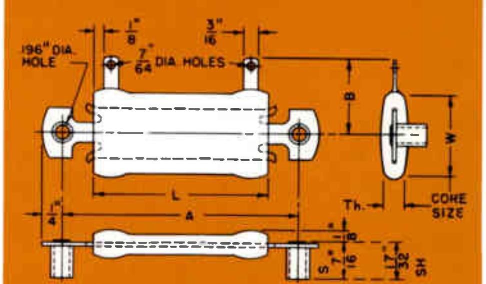


Fig. 60: Standard resistor with stacking-type mounting bracket.

STOCK "THIN" TYPE 250 RESISTORS

OHMITE

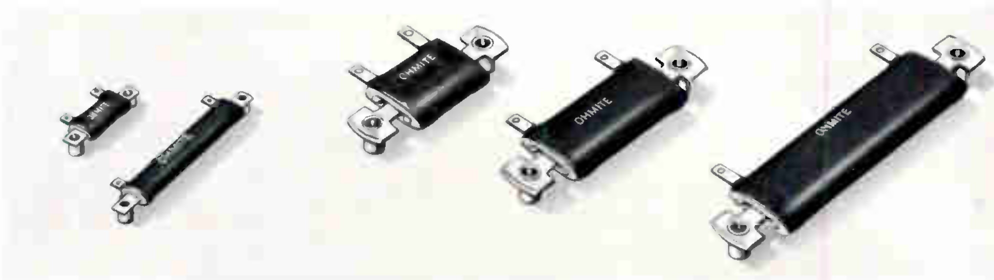
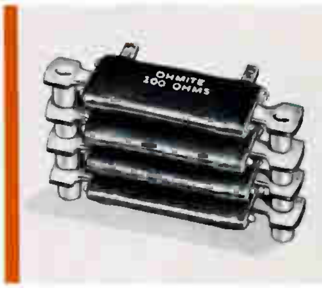


Fig. 61: (A)—Stock 10, 20, 30, 40 and 55 watt Thin resistors.



(B)—Stacked assembly.

Thin resistors, of approximately oval cross-section and mounted by means of flat, stud-equipped brackets fastened to the core, are convenient where space is limited. They can be readily stacked. The resistors, except for shape, are constructed similarly to the tubular resistors and feature all-welded construction and Ohmite vitreous enamel. See complete description in made-to-order section, pages 41-42 for other core sizes and mountings available. Resistance tolerance ±5% for all stock resistances.

STOCK MINIATURE THIN

*10 WATT — Style 250-10

Code: ¾-TA-51-F-S
Terminal: No. 51
Core: ¾" L x ⅜" W x ⅛" Th

Cat. No.	Ohms	Max. Amps
F101	1	3.16
F102	2	2.24
F103	5	1.41
F104	7.5	1.15
F105	10	1.00
F106	15	0.82
F107	20	0.71
F108	25	0.63
F109	30	0.58
F110	40	0.50
F111	50	0.45
F112	75	0.36
F113	100	0.32
F114	125	0.28
F115	150	0.26
F116	200	0.22
F117	250	0.20
F118	300	0.18
F119	400	0.16
F120	500	0.14
F121	600	0.13
F122	750	0.12
F123	1,000	0.10
F124	1,250	0.089
F125	1,500	0.081
F126	1,750	0.075
F127	2,000	0.071
F128	2,500	0.063
F129	3,000	0.057
F130	4,000	0.050
F131	5,000	0.045

Mtg. Centers 1"
Hole Size .125"
Avg. Weight .007 lb.

*20 WATT — Style 250-20

Code: 2-TA-51-F-S
Terminal: No. 51
Core: 2" L x ⅜" W x ⅛" Th

Cat. No.	Ohms	Max. Amps
F201	1	4.47
F202	2	3.16
F203	5	2.00
F204	10	1.41
F205	15	1.16
F206	25	0.89
F207	40	0.71
F208	50	0.63
F209	75	0.52
F210	100	0.45
F211	150	0.36
F212	200	0.32
F213	250	0.28
F214	300	0.26
F215	400	0.22
F216	500	0.20
F217	800	0.16
F218	1,000	0.14
F219	1,250	0.12
F220	1,500	0.12
F221	2,000	0.10
F222	2,500	0.089
F223	3,000	0.081
F224	3,500	0.075
F225	4,000	0.070
F226	5,000	0.063
F227	6,000	0.058
F228	7,500	0.052
F229	10,000	0.045
F230	12,500	0.040
F231	15,000	0.036
F232	20,000	0.032
F233	25,000	0.028
F234	30,000	0.026
F235	35,000	0.024
F236	40,000	0.022
F237	50,000	0.020

Mtg. Centers 2 5/16"
Hole Size .125"
Avg. Weight .015 lb.

STOCK STANDARD THIN RESISTORS

*30 WATT — Style 250-30

Code: 1¼-TE-57-F-S
Terminal: No. 57
Core: 1¼" L x 1" W x ¼" Th

Cat. No.	Ohms	Max. Amps
F301	1	5.47
F302	1.5	4.47
F303	2	3.88
F304	3	3.17
F305	5	2.46
F306	10	1.73
F307	15	1.42
F308	25	1.10
F309	40	0.87
F310	50	0.77
F311	75	0.63
F312	100	0.55
F313	150	0.45
F314	200	0.39
F315	250	0.35
F316	400	0.28
F317	500	0.25
F318	750	0.20
F319	1,000	0.17
F320	1,500	0.14
F321	2,000	0.12
F322	2,500	0.11
F323	3,000	0.10
F324	4,000	0.087
F325	5,000	0.076
F326	7,500	0.057
F327	10,000	0.049

Mtg. Centers 2"
Hole Size .196"
Avg. Weight .037 lb.

*40 WATT — Style 250-40

Code: 2-TE-57-F-S
Terminal: No. 57
Core: 2" L x 1" W x ¼" Th

Cat. No.	Ohms	Max. Amps
F401	1	6.32
F402	1.5	5.16
F403	2	4.47
F404	3	3.65
F405	4	3.16
F406	5	2.83
F407	7.5	2.31
F408	10	2.00
F409	25	1.26
F410	40	1.00
F411	50	0.89
F412	75	0.73
F413	100	0.63
F414	150	0.52
F415	200	0.45
F416	250	0.40
F417	400	0.32
F418	500	0.28
F419	750	0.23
F420	1,000	0.20
F421	1,500	0.16
F422	2,000	0.14
F423	2,500	0.13
F424	3,000	0.12
F425	4,000	0.10
F426	5,000	0.089
F427	7,500	0.073
F428	10,000	0.063
F429	15,000	0.045
F430	20,000	0.039
F431	25,000	0.035

Mtg. Centers 2¾"
Hole Size .196"
Avg. Weight .052 lb.

*55 WATT — Style 250-55

Code: 3½-TE-57-F-S
Terminal: No. 57
Core: 3½" L x 1" W x ¼" Th

Cat. No.	Ohms	Max. Amps
F501	1	7.42
F502	1.5	6.05
F503	2	5.24
F504	3	4.28
F505	4	3.70
F506	5	3.32
F507	7.5	2.72
F508	10	2.34
F509	25	1.48
F510	40	1.17
F511	50	1.05
F512	75	0.86
F513	100	0.74
F514	150	0.61
F515	200	0.52
F516	250	0.47
F517	400	0.37
F518	500	0.33
F519	750	0.27
F520	1,000	0.23
F521	1,500	0.19
F522	2,000	0.17
F523	2,500	0.15
F524	3,000	0.14
F525	4,000	0.12
F526	5,000	0.10
F527	7,500	0.086
F528	10,000	0.074
F529	15,000	0.061
F530	20,000	0.052
F531	25,000	0.047
F532	30,000	0.040

Mtg. Centers 4¼"
Hole Size .196"
Avg. Weight .095 lb.

*Ratings are based on mounting on a steel plate 10" x 10" x .040". Ratings should be reduced for non-metallic mounting surface.

OHMITE

TYPES 404, 444, 454, 474
PRECISION POWER RESISTORS

with "Ohmicone" Coating—Low TC Excellent Stability—Standard Tolerance 3%

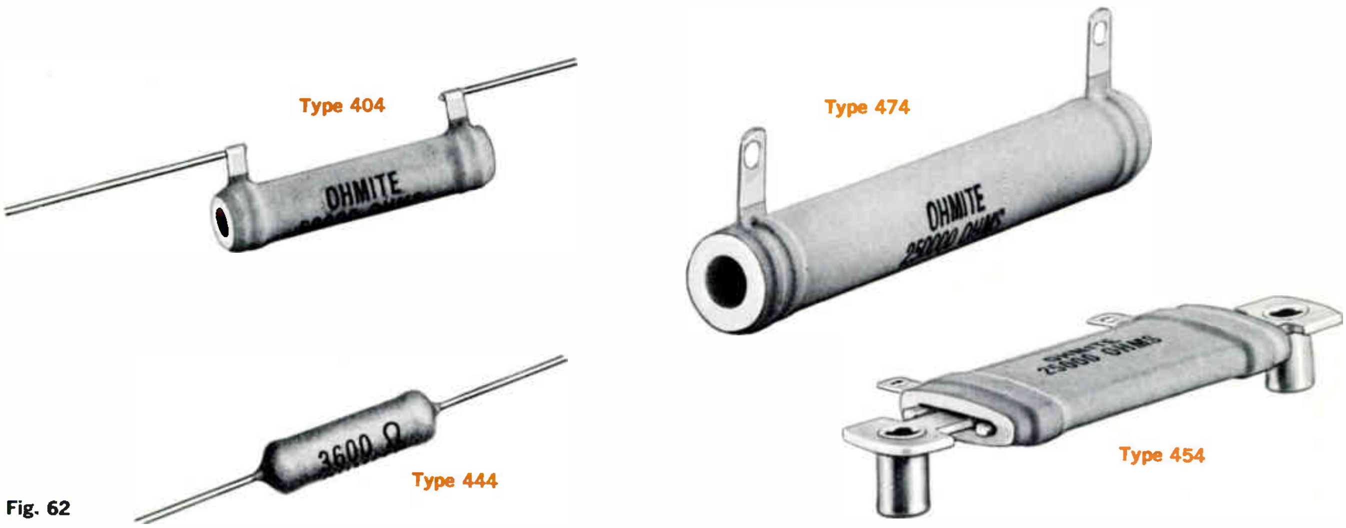


Fig. 62

Types 404, 444, 454, and 474 fixed resistors are Ohmicone-coated wire-wound types which feature a low temperature coefficient of resistance, a tolerance that is closer (3%) than the normal standard of 5% for power resistors, plus excellent stability characteristics. "OHMICONE" is a patented (U.S. 2,647,192) silicone-ceramic compound.

Type 404 resistors are the familiar tubular type with narrow lugs which have tinned leads attached.

Type 444 is the universally popular axial-lead style.

Type 454 resistors are the oval core or "Thin" type with lug terminals and integral brackets which permit stacking.

Type 474 is the popular tubular-core variety with lug terminals. (Terminals other than shown here are available; consult factory.) The

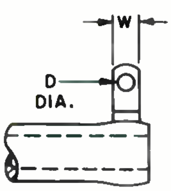


Fig. 63

Lug Terminals for Type 474 Resistors

Style	W	D
40	¼"	.166
45	½"	.196
57	3/16"	.104

TYPE 474 TUBULAR CORE, LUG TYPE RESISTORS

Ohmite Style	Nominal Watts	Core Dimensions			Terminals*	Min. Ohms	Max. Ohms .00175 Wire	Max. Ohms† .001 Wire	Max. Volts††
		L	OD	ID					
474-6.5	6.5	1	¼	⅛	57	0.1	2200	12K	330
474-8	8	1	5/16	3/16	57	0.1	2700	16K	330
474-12	12	1¾	5/16	3/16	57	0.1	7500	43K	890
474-11	11	1	7/16	¼	57	0.1	3900	22K	330
474-15	15	1½	7/16	¼	57	0.1	8200	51K	700
474-20	20	2	7/16	¼	57	0.1	13K	75K	1000
474-26	26	3	7/16	¼	57	0.1	22K	130K	1800
474-25	25	2	9/16	5/16	40	0.1	16K	100K	1000
474-35	35	3	9/16	5/16	40	0.1	27K	160K	1800
474-50	50	4	9/16	5/16	40	0.1	39K	240K	2600
474-60	60	5	9/16	5/16	40	0.1	51K	300K	3300
474-75	75	6	9/16	5/16	40	0.1	62K	360K	4100
474-45	45	3	¾	½	40	0.1	33K	200K	1700
474-51	51	3½	¾	½	40	0.1	43K	270K	2100
474-61	61	4	¾	½	40	0.1	51K	300K	2400
474-65	65	4½	¾	½	40	0.1	56K	330K	2800
474-76	76	5	¾	½	40	0.1	62K	390K	3200
474-90	90	6	¾	½	40	0.1	82K	470K	3900
474-100	100	6½	¾	½	40	0.1	91K	510K	4300
474-70	70	4	1	⅝	40	0.1	62K	390K	2400
474-85	85	5	1	⅝	40	0.1	82K	510K	3100
474-105	105	6	1	⅝	40	0.1	91K	620K	3900
474-140	140	8	1	⅝	40	0.1	150K	910K	5400
474-176	176	10	1	⅝	40	0.1	200K	1.1 MEG	6900
474-80	80	4	1⅛	¾	40	0.1	75K	430K	2300
474-120	120	6	1⅛	¾	40	0.1	120K	670K	3800
474-130	130	6½	1⅛	¾	40	0.1	130K	750K	4200
474-160	160	8	1⅛	¾	40	0.1	160K	1 MEG	5300
474-175	175	8½	1⅛	¾	40	0.1	180K	1.1 MEG	5700
474-225	225	10½	1⅛	¾	40	0.1	220K	1.3 MEG	7200
474-235	235	11¼	1⅛	¾	40	0.1	240K	1.5 MEG	7800
474-251	251	12	1⅛	¾	40	0.1	270K	1.6 MEG	8300
474-150	150	5½	1½	1⅛	45	0.25	130K	300K‡	3000
474-250	250	6	2½	1¾	45	0.5	5.1K‡		—
474-500	500	12	2½	1¾	45	1.0	13K‡	Not Applicable	—
474-750	750	15	2½	1¾	45	1.5	16K‡		—
474-1000	1000	20	2½	1¾	45	2.0	24K‡		—

†For values in excess of those shown here, consult factory

*See terminal diagram

‡Heavier than wire gage indicated

††Where potential to ground exceeds 500 V, supplementary insulation should be used.

TYPES 404, 444, 454, 474
PRECISION POWER RESISTORS

tables list the various standard sizes for each type. Other core sizes can be supplied. All resistors are made to order.

The types described here feature Ohmite's all-welded construction—lugs (where used) are welded around the high quality ceramic cores and the resistance wire is welded to the lug or end-cap for permanent, no-noise connections.

Resistance Tolerance: ±3% for values 1 ohm and above; ±10% for values below 1 ohm. Tolerances to .05% can be supplied depending upon size and resistance value.

Temperature Coefficient of Resistance: For axial-lead Type 444:

TC in ppm/°C	Ohms
0±20	20 and above
0±50	1 to less than 20
Consult factory	below 1

For all other types, 0±30ppm/°C for 10 ohms and above, 0±50ppm/°C below 10 ohms.

Stability: For all types ("V" rating, derating linearly to 0 watts at 350°C) ±3%ΔR after 2000 hours of cyclic load-life at rated wattage; improved stability of ±1%ΔR obtainable from axial lead Type 444 at wattages corresponding to "P" rating (derates linearly to 0 watts at 275°C). See Type 444 table.

Insulation: Meets 1000 volt test except for 1 or 1.5 watt sizes, 500 volts.

Military Specifications: Meets the applicable environmental, mechanical and electrical requirements of MIL-R-26.

Mounting: Type 454 resistors incorporate integral mounting brackets. Type 444 mount by their axial leads. Type 404 mount by their leads but the 5⁄16" and 7⁄16" OD cores of this type also can be mounted with brackets (see page 49). Mounting brackets are available for Type 474 tubular, lug-type resistors. These are slipped inside the resistor core and remain in place by friction. The standard bracket is cadmium-plated steel (see page 49).

TO ORDER:

(1) Specify style number under desired type.

(2) Specify resistance value—note ranges in table.

(3) Specify quantity of resistors.

(4) Specify brackets, if desired, by stock number (see page 49).

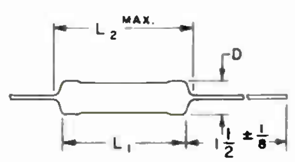


Fig. 64: Dimensions of Type 444 resistor.

TYPE 444 FIXED RESISTORS WITH AXIAL LEADS

Ohmite Style	Watts P Rating†	Watts V Rating†	Resistor Dimensions L1 ±.063	L2 max.††	D ±.031	Leads 1½" AWG	Ohms Range	Max. Volts
444-1A	1	1.5	*.406	.437	.093	24	0.1—7.5K	—
444-3	3	3.25	.500	.563	.218	20	0.1—39.2K	200
444-6.5	5	6.5	.875	1.094	.312	18	0.1—133K	510
444-11	10	11	1.781	1.938	.375	18	0.1—442K	1000

*±.031 †P = derates to 0 watts at 275°C; V = derates to 0 watts at 350°C.
††End of resistor is point at which diameter reduces to .060" for styles 444-3, -6.5 and -11; .050" for 444-1A.

TYPE 404 TUBULAR CORE, LUG-LEAD FIXED RESISTORS

Ohmite Style	Nom. Watts	Core Dimensions [illegible]	OD	[illegible]	Leads 1½" AWG	Ohms Range	Max. Volts
404-3	3	7⁄16	.200	1⁄8	20	1—10K	180
404-5¼	5¼	5⁄8	¼	1⁄8	20	1—20K	320
404-8	8	1	5⁄16	3⁄16	18	1—25K	380
404-12	12	1¾	5⁄16	3⁄16	18	0.5—50K	940
404-20	20	2	7⁄16	¼	18	0.5—100K	1100

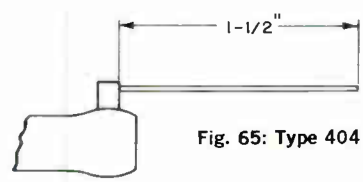


Fig. 65: Type 404 terminal.

Miniature "Thin"

Fig. 66a

Standard "Thin"

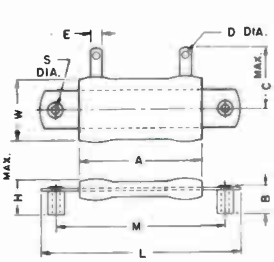


Fig. 66b: Thin Resistor Dimensions

TYPE 454 "THIN," LUG-TERMINAL, FIXED RESISTORS

Ohmite Style	Nom. Watts*	Core, Overall and Mounting Dimensions — Core Dim. A	W	B	C	D	E	H	L	M	S	Min. Ohms	Max. Ohms .00175 Wire	Std. Max. Ohms†	Max. Volts
MINIATURE TYPES															
454-10‡	10	¾	3⁄8	¼	3⁄8	1⁄16	1⁄8	7⁄16	1 7⁄32	1	.125	0.1	2400	15K	330
454-20‡	20	2	3⁄8	¼	3⁄8	1⁄16	1⁄8	7⁄16	2 17⁄32	2 5⁄16	.125	0.1	10K	51K	1300
STANDARD TYPES															
454-30	30	1¼	1	7⁄16	1	.104	3⁄16	21⁄32	2½	2	.196	0.1	9100	18K	470
454-40	40	2	1	7⁄16	1	.104	3⁄16	21⁄32	3¼	2¾	.196	0.15	20K	39K	1000
454-55	55	3½	1	7⁄16	1	.104	3⁄16	21⁄32	4¾	4¼	.196	0.3	43K	82K	2200
454-70	70	4¾	1	7⁄16	1	.104	3⁄16	21⁄32	6	5½	.196	0.4	62K	.12 MEG	3100
454-95	95	6	1	7⁄16	1	.104	3⁄16	21⁄32	7¼	6¾	.196	0.5	82K	.15 MEG	4000

*Wattage ratings are based on resistor being horizontally mounted on a 10" x 10" x .040" plate.
†For values in excess of those shown here, consult factory.
‡For stock mounting, use of 3⁄32" spacer washer (Cat. No. 6027) is recommended.

POWR-RIB® RESISTORS

Types 082 Fixed; 032 Adjustable **Round-Wire**

Ohmite "POWR-RIB" Resistors are uncoated resistors, designed especially for high-current duty in both intermittent and continuous duty applications. They are supplied in two types, the edge-wound ribbon type for the lower resistances and the round-wire type for the higher resistances. Both offer high heat dissipation, resistance to oxidation and ruggedness to withstand shock and vibration.

"POWR-RIBS" are suitable for original equipment or for replacement in existing installations. They are particularly applicable in electric trucks, battery chargers, motor controllers, load banks, plating and welding equipment, as well as motor starting, plugging, field discharge, and dynamic braking in dc controllers.

The edge-wound resistors have a coil made of a heavy ribbon of resistance alloy mounted on ceramic insulators which are supported by a metal bar. Metal parts except for the resistance element, are heavily plated to prevent oxidation at high operating temperatures, to provide good electrical contact and to prevent corrosion.

"POWR-RIB" resistors are rated at 375°C (675°F) temperature rise, measured on the resistance element (NEMA standard). They are made in seven standard lengths, which are 2, 3, 4, 5, 6, 7 or 8 insulator segments long.

ROUND-WIRE "POWR-RIB" RESISTORS

Round-wire wound POWR-RIBS" provide higher resistances than possible with the edge-wound units. As the method of mounting and mounting centers are the same as the edge-wound type, both kinds can be assembled interchangeably in load banks.

The units consist of ceramic insulators assembled on a metal bar and wound with resistance alloy wire. The wire is terminated on clamp type lugs, provided with screw connections.

Due to the reduced radiating surface, the wattage of round-wire "POWR-RIBS" is less than that of the same length edge-wound types. The approximate wattages are 220, 380, 540, 700, 860, 1020 and 1180. Wattages for both round-wire and edge-wound ribbon "POWR-RIB" resistors vary more than ±10% for the same length units in different resistances because of the different heat radiating and conducting properties of the various sizes and types of wire or ribbon necessarily used.

Terminals

Adjustable Terminal (In line mtg.)...Cat. No. 2175
Adjustable Terminal (90° mtg.).....Cat. No. 2176

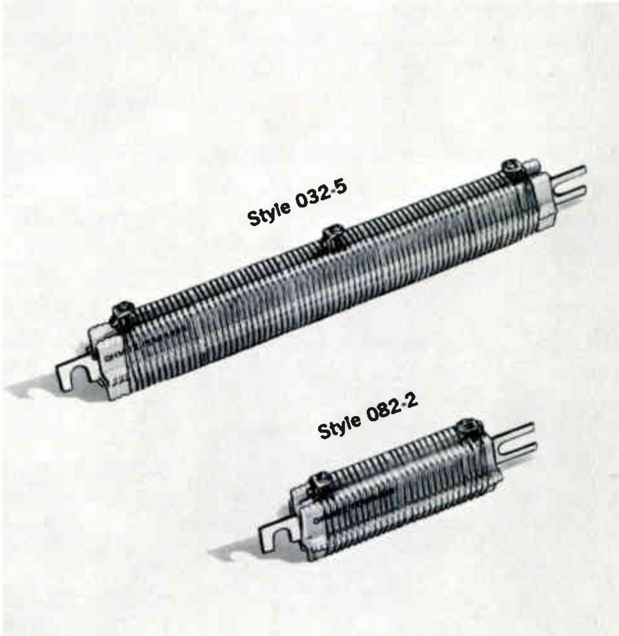


Fig. 67: Typical Round-Wire POWR-RIBS (suffix at end of style no. indicates number of segments)

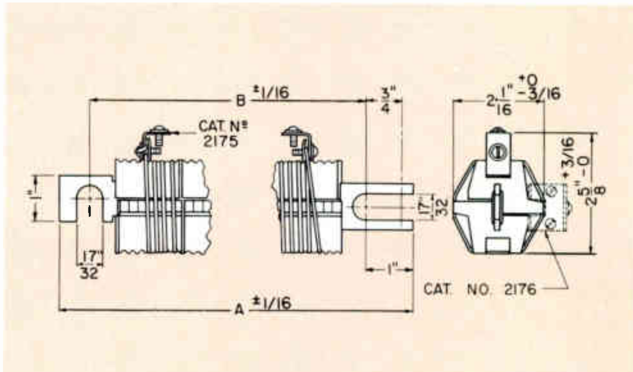


Fig. 68: Dimensions of Round-Wire POWR-RIB

ROUND-WIRE "POWR-RIB" RESISTORS*

Size* (Number of Insulator Segments Long)

2	3	4	5 In Stock		6	7	8	
8⅞" "A"	11⅞" "A"	14⅞" "A"	17⅞" "A"		20⅞" "A"	23⅞" "A"	26⅞" "A"	
7¼" "B"	10¼" "B"	13¼" "B"	16¼" "B"		19¼" "B"	22¼" "B"	25¼" "B"	
Ohms	Ohms	Ohms	Ohms	Stock No.*	Ohms	Ohms	Ohms	Max. Amps.
3.4	5.9	8.5	11.0	2338	13.5	16.0	18.5	8.3
4.1	7.1	10.0	13.0	2339	15.9	18.8	21.7	7.6
5.3	9.2	13.0	17.0	2340	20.8	24.6	28.4	6.6
6.3	10.9	15.4	20.0	2341	24.5	29.0	33.5	5.9
7.9	13.6	19.3	25.0	2342	30.7	36.4	42.1	5.1

*5-section units are stocked and are ordered by stock number.
Order other sizes, or variations, by length and ohms. Two terminals No. 2175 supplied as standard unless otherwise specified.

POWR-RIB® RESISTORS
Edge-Wound Types 080 Fixed; 030 Adjustable

OHMITE

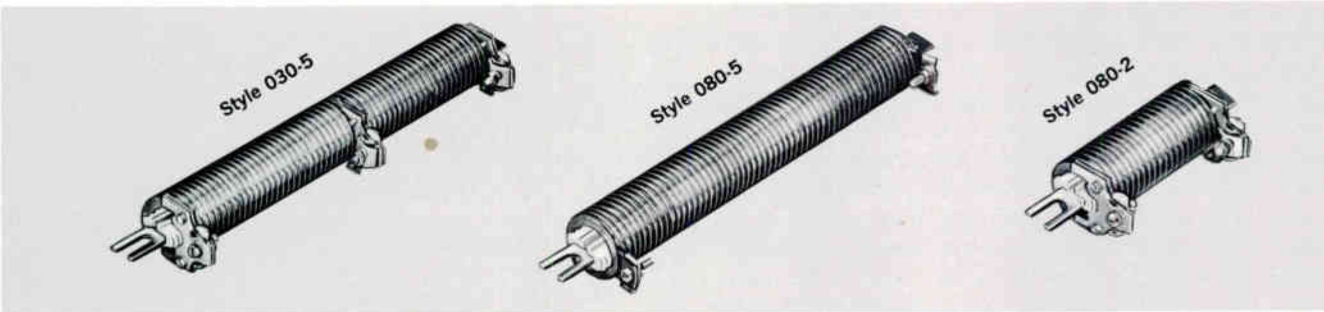


Fig. 69: Typical Edge-Wound POWR-RIBS (suffix at end of style no. indicates number of segments)

Edge-wound Powr-Rib resistors have a coil of heavy resistance alloy ribbon mounted on ceramic insulators which are supported by a metal mounting bar. Higher resistance units, wound with round wire, are described on the preceding page.

Wattage ratings are approximately 400, 600, 800, 1000, 1200, 1400 and 1600 watts respectively for resistances up to 2 ohms, and somewhat less for higher resistances. Available resistance values and current ratings are shown in the table. Intermediate resistance values can be obtained by relocating the terminal clamps. Terminals can be clamped in line with the mounting or at 90° to it. Any combination of clamps can be ordered.

EDGE-WOUND "POWR-RIB" RESISTORS*

Size* (Number of Insulator-Segments Long)

2	3	4	5 In Stock		6	7	8	
8⅞" "A"	11⅞" "A"	14⅞" "A"	17⅞" "A"		20⅞" "A"	23⅞" "A"	26⅞" "A"	
7¼" "B"	10¼" "B"	13¼" "B"	16¼" "B"		19¼" "B"	22¼" "B"	25¼" "B"	
Ohms	Ohms	Ohms	Ohms	*Stock No.	Ohms	Ohms	Ohms	Max. Amps.
.033	.057	.08	.10	2301	.12	.14	.16	100
.040	.070	.10	.12	2302	.14	.16	.18	91
.046	.078	.11	.14	2303A	.17	.20	.23	89
.052	.088	.12	.16	2304A	.19	.22	.25	78
.06	.10	.14	.18	2305A	.21	.25	.30	75
.07	.12	.18	.22	2306A	.26	.30	.34	68
.08	.13	.19	.25	2306	.30	.35	.40	63
.10	.16	.23	.30	2308A	.36	.42	.48	57
.11	.18	.25	.33	2308	.40	.47	.54	54
.12	.20	.28	.37	2309A	.45	.53	.61	50
.17	.28	.38	.50	2310	.60	.70	.80	47
.21	.33	.46	.60	2317	.72	.85	.98	43
.23	.36	.51	.67	2318	.80	.93	1.06	41
.26	.42	.58	.75	2311	.90	1.05	1.2	39
.35	.56	.77	1.00	2312	1.20	1.40	1.6	33
.45	.73	1.00	1.30	2319	1.50	1.75	2.0	29
.56	.90	1.20	1.60	2313	1.90	2.2	2.5	26
.69	1.20	1.70	2.20	2331A	2.70	3.1	3.5	18.4
.88	1.50	2.20	2.80	2332A	3.40	4.0	4.6	16.3
1.10	1.90	2.70	3.50	2333A	4.30	5.1	5.9	14.6
1.40	2.40	3.50	4.50	2334A	5.50	6.5	7.5	12.7
1.70	2.90	4.20	5.40	2335A	6.60	7.8	9.0	11.8
2.10	3.70	5.30	6.80	2336A	8.30	9.8	11.3	10.3
2.70	4.60	6.50	8.50	2337A	10.40	12.3	14.2	9.4

*Stock No.'s are shown only for widely used standard 17⅞" long units. Order other sizes or variations by length and ohms. Two adjustable terminals supplied as standard unless otherwise specified.

An optional slotted sleeve, Cat. No. 2174 (¾" O.D. x ½" I.D. x ⅜" lg.) is available, which permits the mounting bar to expand with complete freedom and without buckling, when the resistor operates at very high temperatures.

Adjustable Terminal ....Cat. No. 2172-B
(For 30 amps. or more)

Adjustable Terminal ....Cat. No. 2172-G
(For 29 amps. or less)

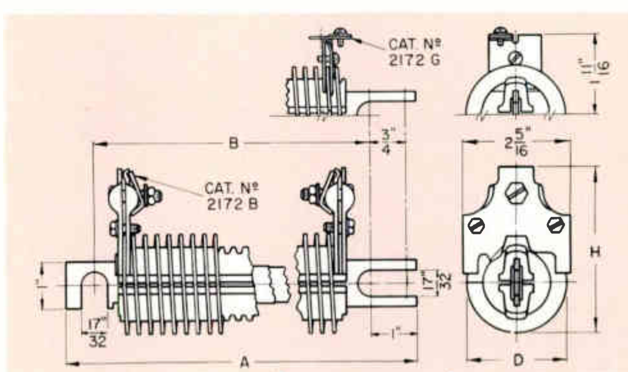
Adjustable Terminal ....Cat. No. 2172-F
(For parallel wound units)

Welded Terminal with ¼" dia. hole.......Type 39
(Cannot be supplied unmounted.
Must be specified on resistor order)

Clamp, with screw, nut and lockwasher. Cat. No. 2173
(For use on welded terminal Type 39)

Welded or brazed terminal Type 39 can be supplied only for edge-wound resistors of 26 ampere rating or greater.

Resistors of 52 amp. rating or greater can be provided with parallel wound coils of lower TC ribbon, when desired.



Amps*	H ±⅛	D +⅛ −0
100-68	3⁵⁄₁₆	2⅛
63-33	3⅛	1⅞
29-26	2⁹⁄₁₆	1⅞
18.4, 16.3, 12.7, 11.8	2½	1¾
14.6, 10.3, 9.4	2⁷⁄₁₆	1⅝

* 100 to 33 amp rating with terminal No. 2172B
29 to 8.5 amp rating with terminal No. 2172G

Fig. 70: Dimensions—Edge-Wound POWR-RIB Resistors

ADJUSTABLE LUGS FOR DIVIDOHM® RESISTORS

Adjustable lugs are clamp terminals used on resistors which have been provided with a bared side or track of exposed wire so the terminal can be located at any desired point and make contact with the wire. The standard lugs are made of cadmium-plated steel. A small embossing provides the contact area. A unique Ohmite feature is the *flat* contact area of the embossing, as contrasted with the conventional ball shape. The flat distributes the pressure and prevents damage to the wire so effectively that special spring mountings are unnecessary. A silver contact can be provided instead of the embossing. Lugs fasten by means of a screw and nut.

Fig. 71: Typical adjustable lugs.

Core Dia.	Dimensions			Screw Driver Type Cat. No.		Bakelite Knob Type Cat. No.	
	W Width	B Proj.	Hole D.	Standard	Silver Contact	Standard	Silver Contact
5/16"	3/16"	13/32"	.125	1058	2161		
7/16"	1/4"	19/32"	.152	0356	2162	0357	2163
9/16"	1/4"	19/32"	.170	0358	2164	0359	2165
3/4"	1/4"	5/8"	.170	1958	2166	1959	2167
1"	5/16"	11/16"	.173	1956	2168	1957	2169
1 1/8"	5/16"	11/16"	.173	2158	2170	2159	2171
1 1/2"	5/16"	11/16"	.169	2180	2182	2181	2183
1 5/8"	3/8"	11/16"	.169	2184	2186	2185	2187
2 1/2"	1/2"	31/32"	.193	2188	2190	2189	2191

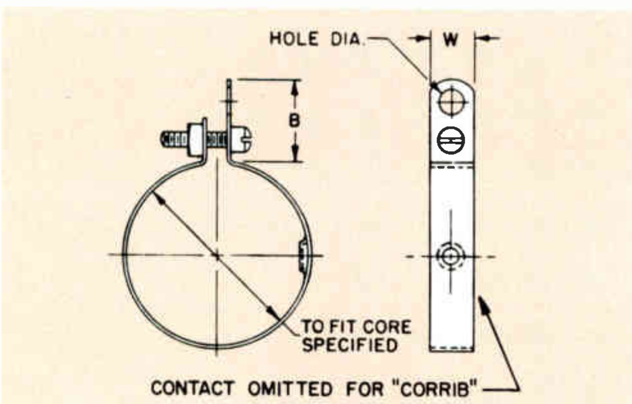


Fig. 72: Dimensions of adjustable lugs.

TAPPED HOLE ADJUSTABLE LUGS

Lugs having a tapped hole, or with a nut welded to the lug, can be provided for added convenience. Dimensions are similar to standard.

Tapped Adjustable Lugs

Core Dia.	Screw Driver Type Cat. No.	
	Standard	Silver Contact
9/16"	2192	2193
3/4"	2194	2195
1 1/8"	2196	2197

ADJUSTABLE LUGS FOR "Corribs"

Adjustable lugs for use on the corrugated ribbon exposed winding "Corrib" resistors are similar to the regular adjustable lugs except for the omission of the embossing.

Corrib Adjustable Lugs

Core Dia.	*Cat. No.	Dimensions		
		Width W	Proj. B	Hole D.
9/16"	1971	5/16"	11/16"	.175
3/4"	1972	5/16"	11/16"	.175
1"	1973	3/8"	11/16"	.175
1 1/8"	1974	3/8"	11/16"	.175
1 1/2"	1975	3/8"	11/16"	.175
1 5/8"	1976	3/8"	11/16"	.175
2 1/2"	1977	1/2"	29/32"	.188

*When ordering Adjustable Lugs separately for "Corrib" resistors, add suffix A to Cat. No. for resistors using 1/16" ribbon; add B to Cat. No. for resistors using 1/8" ribbon. (Consult factory if in doubt.)

DOUBLE THUMB SCREW ADJUSTABLE LUGS

This type of lug has one thumb-nut for fastening the connecting wire and a thumb-screw which presses a phosphor-bronze contact spring against the winding. As the thumb-screw must be loosened before the lug can be moved, this automatically protects the wire against possible damage.

These lugs are available only in the two sizes listed for 1" O.D. and 1 1/8" O.D. cores.

Double Thumb Screw Adjustable Lugs

Core Dia.	Cat. No.
1"	2157
1 1/8"	2160

Fig. 73: Double thumb-screw adjustable lug.

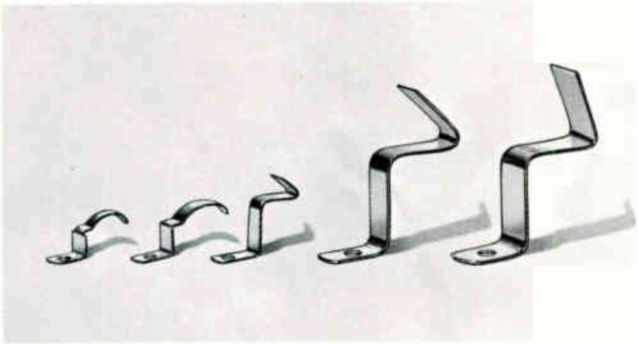


Fig. 74: Spring-grip mounting brackets.

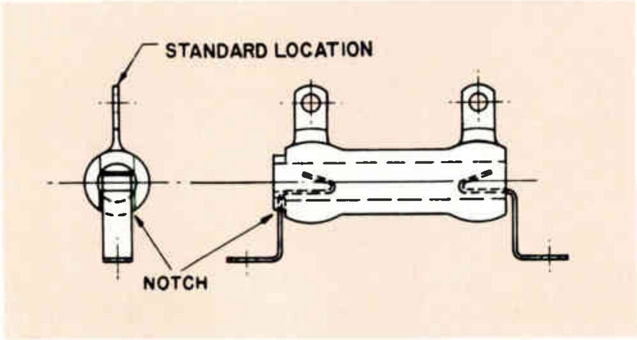


Fig. 76: Notched Core for Notca 1 Feature.

SPRING-GRIP TYPE MOUNTING BRACKETS

These are the standard type of brackets for mounting stock resistors. They will be supplied on bulk shipments to manufacturers only when specifically ordered. They are automatically included with unit boxed stock resistors sold through distributors. The standard brackets are made of cadmium-plated steel. Spring-steel brackets, of greater holding power, can be ordered for increased resistance to vibration and shock. Non-magnetic (brass) brackets should be ordered for use with non-inductive resistors and R. F. Chokes.

NON-TURN FEATURES FOR BRACKETS

When a positive means (not dependent on friction) for preventing the resistor from turning on the bracket is required, resistors can be ordered with special cores which engage the bracket as shown in Fig. 76 and 78.

The code word "NOTCA 1" feature has a notch at one end of the core in line with the terminal and requires the terminal to be set in farther than standard from the end of the core. Special angles can be specified. Code word "NOTCA 2" feature has a novel fluted inside diameter core (patent applied for). The mounting bracket engages the flutes. The resistor may be positioned with the terminals in line with the brackets, at 90°, or at an intermediate angle. "NOTCA 2" is available in certain sizes only, where tube wall thickness permits. When ordering add the complete code word to the resistor designation.

Cat. No.			For Core		Dimensions				Size of Hole	Max. Screw Size
Std.	Spring Steel	Brass	O.D.	I.D.	A	B	C	D		
5	5S	5B	5/16"	3/16"	9/32"	3/16"	3/8"	1/4"	.144	#6
7	7S	7B	7/16"	1/4"	3/8"	1/4"	7/16"	1/4"	.147	#6
9	9S	9B	9/16"	5/16"	11/16"	5/16"	15/32"	1/4"	.161	#6
12	12S	12B*	3/4"	1/2"	1 3/16"	3/8"	3/4"	3/8"*	.196	#10
16	16S	16B	1"	5/8"	1 3/16"	3/8"	3/4"	1/2"	.196	#10
18	18S	18B	1 1/8"	3/4"	1 3/16"	3/8"	3/4"	1/2"	.196	#10

*Cat. No. 12BN (D=5/16") required for flat-sided non-inductive resistors (page 29).

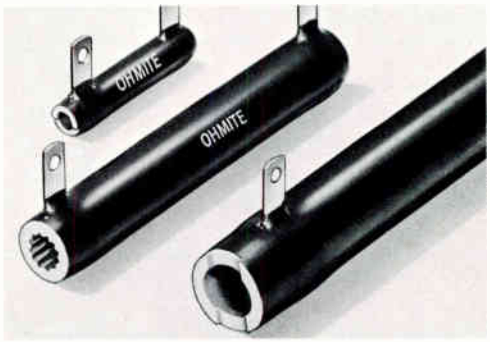


Fig. 77: Resistors with Non-Turn features.

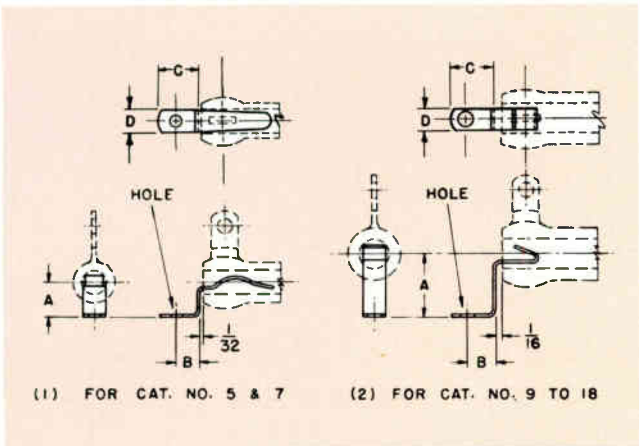


Fig. 75: Mounting bracket dimensions.

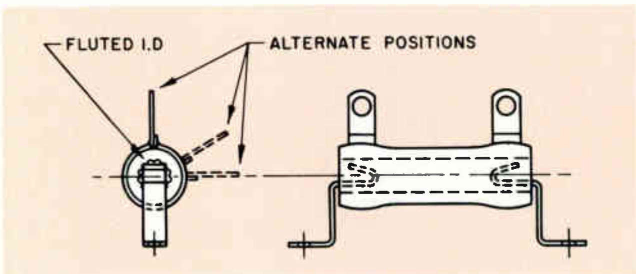


Fig. 78: Fluted I.D. core Notca 2 feature.

THROUGH-BOLT TYPE "DEAD" MOUNTING BRACKETS—SLOTTED

These sturdy, cadmium-plated steel brackets for one, two or three resistors can be supplied mounted on the resistors, by means of through-bolts and centering washers. They are used in pairs, consisting of one "end-slot" and one "side-slot" bracket. The brackets can be ordered unmounted, but if bolts are also wanted, the order must state the length and diameter of resistor. Mica insulating washers are supplied with the brackets, as standard, unless otherwise ordered. Order should state either "assembled" or "unmounted."

Through-bolt Type Mounting Brackets—Slotted

Cat. No. Pair of Brackets Only	Cat. No. Brackets and Bolts	No. of Resistors	Resistor Core O.D.	Dimensions		Standard Core Lengths
6101 6102 6103	Add Resistor Length (Standard or Special) to Cat. No. as a Suffix. Example: Cat. No. 6105-6½.	1 2 3	9/16"	A: 25/32" C: ¾" E: 7/16"	B: 15/16" D: 1/32"* F: ¼"	2", 4", 6"
6104 6105 6106		1 2 3	¾"	A: 25/32" C: ¾" E: 7/16"	B: 1⅛" D: 1/32"* F: ¼"	2", 4", 6½"
6110A 6111A 6112A		1 2 3	1"	A: 1" C: 1⅛" E: 13/16"	B: 1¾" D: 1/16" F: 5/16"	4", 6"
6110 6111 6112		1 2 3	1⅛"	A: 1" C: 1⅛" E: 13/16"	B: 1¾" D: 1/16" F: 5/16"	2", 6", 6½", 8½", 10½"
6113 6113A 6113B		1 1 1	1⅛" 1½" 1⅝"	A: 19/16" C: 1¼" E: 7/16"	B: .... D: 1/16" F: ⅜"	2", 6", 6½", 8½", 10½"
†6114		1	2½"	A: 2¾" C: 2½" E: 1"	B: .... D: 1/16" F: ⅜"	6", 12", 15", 20"

*D = 3/64" on brackets for 2 or 3 resistors.

†Both brackets have end slots and integral centering device, consisting of 3 projections.

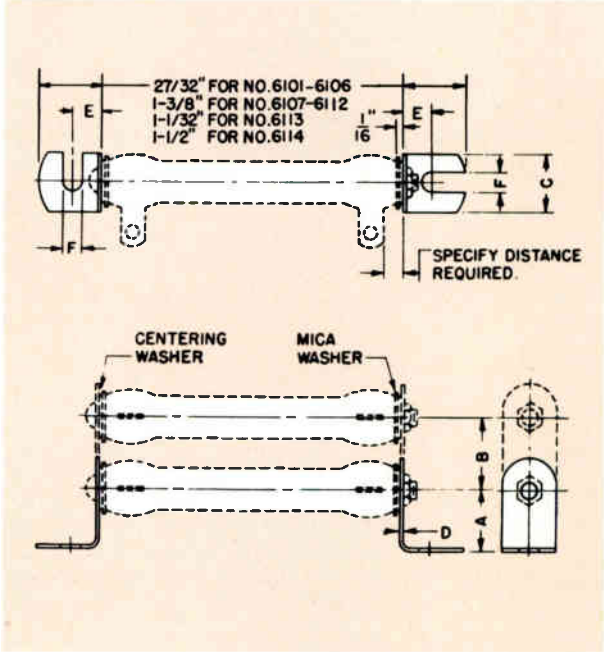


Fig. 79: Slotted brackets

THROUGH-BOLT MOUNTING BRACKETS FOR HIGH SHOCK

Special brackets and centering washers which enenable resistors to meet the Hi-Shock test of MIL-S-901 are available. Refer to Bulletin 104 for details of these resistors and mountings intended for military specification MIL-R-15109.

THROUGH-BOLT TYPE MOUNTING BRACKETS—ELONGATED HOLE

Brackets with elongated holes, instead of open-end slots (at right angles to each other), are available in sizes as listed below. The brackets are made of plated steel. Orders should state "assembled" or "unmounted." Mountings per military standard MS75009 for MIL-R-26 resistors are described in Catalog 50.

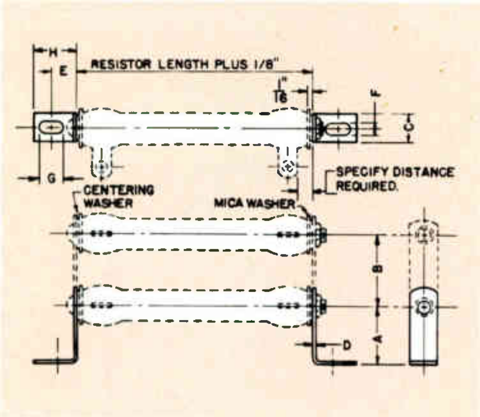


Fig. 80: Elongated-hole brackets

Through-bolt Type Mounting Brackets—Elongated Holes

Cat. No. Pair of Brackets Only	Cat. No. Brackets and Bolts	No. of Resistors	Resistor Core O.D. & Suffix Code	Dimensions		Standard Core Lengths
6120 6121	Add Core Dia. Letter and Resistor Length (Standard or Special) to Cat. No. as a Suffix. Example: Cat. No. 6121-K4	1 2	5/16", 7/16", 9/16" D, H, K	A: 1" C: ½" E: 27/64" G: 7/16"	B: 1⅛" D: 1/32" F: 7/32" H: ¾"	1¾", 2", 4", 6"
6122 6123 6124 6125		1 2 3 4	¾", 1" M, N	A: 1¼" C: ¾" E: 27/64" G: 7/16"	B: 1⅝" D: 1/32" F: 7/32" H: ¾"	2", 4", 6½"
6126 6127 6128 6129		1 2 3 4	1⅛" P	A: 1½" C: 1¼" E: 7/16" G: 9/16"	B: 2" D: 1/16" F: 9/32" H: ⅞"	2", 6", 6½", 8½", 10½"

Fig. 81: Centering washers, mica washers and porcelain bushings.

CENTERING WASHERS

When resistors are to be mounted by through-bolts, "centering washers" are used with all resistors having an inside diameter larger than 1/4", so as to keep the resistor centered on the bolt. The standard washers are made of steel, cadmium plated to resist corrosion.

Cat. No.	O.D. of Core	I.D. of Core	Dia. of Washer	Dia. of Hole	For Max. Screw Size
6007	7/16"	1/4"	7/16"	.173	#8
6000	9/16"	5/16"	9/16"	.190	#10
6006	5/8"	7/16"	5/8"	.190	#10
6001	3/4"	1/2"	3/4"	.190	#10
6002	1"	5/8"	1"	.250	1/4"
6003	1 1/8"	3/4"	1 1/8"	.250	1/4"
6004	1 1/2" or 1 5/8"	1 1/8"	1 5/8"	.250	1/4"
6005	2 1/2"	1 3/4"	2 1/2"	.250	1/4"

MICA WASHERS

Mica washers are used on through-bolt mounted resistors when a larger insulation leakage distance to ground is wanted than that provided by the normal lug edge distance alone. The mica washer fits between the core and the centering washer and the mica washer then requires the same I.D. as the resistor tube. The mica washers are made of "built-up mica" nominally 1/32" thick. As there is often some tendency for the laminations to separate during shipping and handling, it is the usual practice to use one or more laminations together, to obtain 1/32" minimum, when assembling.

Flexibility of mica washers allows No. 10 and 1/4" diameter bolts to pass through nominal 3/16" diameter holes.

	Core		Washer	
Cat. No.	O.D.	I.D.	O.D.	I.D.
*6029	7/16"	1/4"	3/4"	1/4"
6010	9/16"	5/16"	3/4"	3/16"
*6011	9/16"	5/16"	3/4"	5/16"
*6026	9/16"	5/16"	1"	5/16"
6012	3/4"	1/2"	1"	3/16"
*6013	3/4"	1/2"	1"	1/2"
6014	1"	5/8"	1 1/4"	3/16"
*6015	1"	5/8"	1 1/4"	5/8"
6016	1 1/8"	3/4"	1 1/2"	3/16"
*6017	1 1/8"	3/4"	1 1/2"	3/4"
*6019	1 1/2" or 1 5/8"	1 1/8"	2"	1 1/8"
*6018	2 1/2"	1 3/4"	3"	1 3/4"

*To be used with centering washers.

PORCELAIN BUSHINGS FOR THROUGH-BOLT MOUNTING

Porcelain bushings, which act as centering washers and additional end insulation, are available, as listed in the table, for resistors which are to be mounted by through-bolts. The bushings are a convenient means for increasing the leakage distance from the lugs to ground without the necessity of mounting the lugs farther in on the core. The bushings can be furnished cemented into the resistors, when so ordered.

Cat. No.	For Core Size	Recess For Nut Size
6020	1 1/8" O.D. x 3/4" I.D.	—
6022	*1" O.D. x 5/8" I.D.	#10
6023	*1" O.D. x 5/8" I.D.	1/4"
6024	9/16" O.D. x 5/16" I.D.	#8
6025	3/4" O.D. x 1/2" I.D.	#10

*Also used with 1 1/8" O.D. core and special brackets.

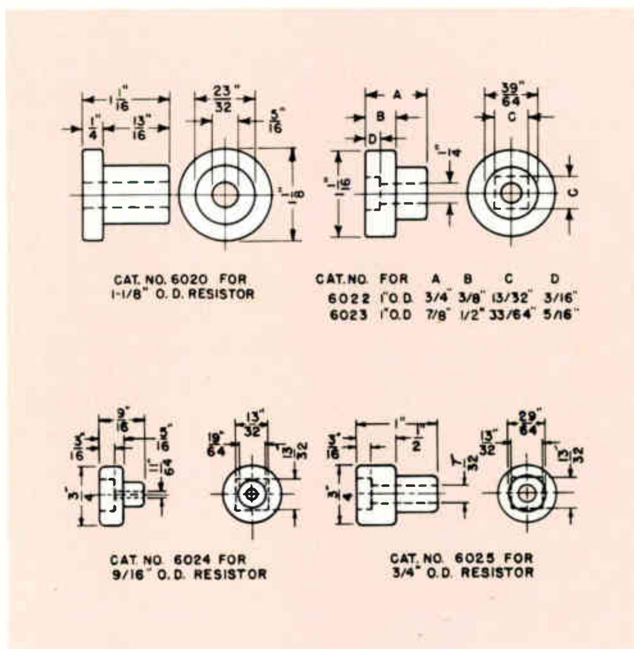


Fig. 82: Porcelain bushings

PERPENDICULAR THROUGH-BOLTS

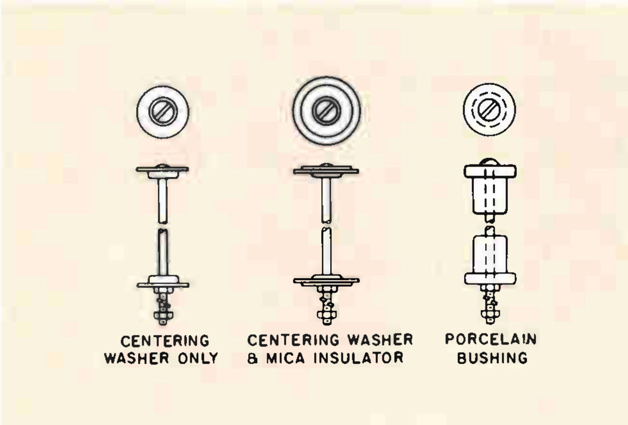


Fig. 83: Through-bolt mountings

Through-bolts, with centering washers, nuts and washers, or with additional mica washers or ceramic bushings can be ordered to mount resistors of various diameters and lengths. Unless otherwise specified, the bolts are long enough to mount the resistor on a ¼" thick panel, maximum. The length of the resistor to be used must be given on the order. Dimensions of the washers, etc., can be taken from the descriptions of those items on page 51.

Through-bolts For Made-to-order Size Resistors

Resistor Core Size	Bolt Size	With Centering Washers	With Centering Washers & Mica Washers	With Porcelain Bushings
O.D.		Cat. No.	Cat. No.	Cat. No.
5/16"	No. 8	*6150	‡6160	—
7/16"	No. 8	*6151	‡6161	—
9/16"	No. 10	6152	6162	§6172
3/4"	No. 10	6153	6163	6173
1"	No. 10#	6154	6164	6174
1 1/8"	1/4"	6155	6165	6175
1 1/2"	1/4"	6156	6166	—
1 5/8"	1/4"	6157	6167	—
2 1/2"	1/4"	6158	6168	—

*Flat washers used.
‡Flat washers are used and mica washers Cat. No. 6010.
#No. 10 used for 7" long max. resistors; ¼" for longer sizes.
§No. 8 bolt size used.

Through-bolts for Stock Resistors

Watts	Size	Bolt Size	Cat. No. with Mica and Centering Washers
5	5/16" x 3/16" x 1"	No. 8 x 1 3/4"	7PA5
12	5/16" x 3/16" x 1 3/4"	No. 8 x 2 1/2"	7PA10
20	7/16" x 1/4" x 2"	No. 8 x 2 3/4"	7PA20
25	9/16" x 5/16" x 2"	No. 10 x 2 3/4"	7PA25
50	9/16" x 5/16" x 4"	No. 10 x 4 3/4"	7PA50
75	9/16" x 5/16" x 6"	No. 10 x 6 3/4"	7PA75
100	3/4" x 1/2" x 6 1/2"	No. 10 x 7 5/16"	7PA100
175	1 1/8" x 3/4" x 8 1/2"	1/4" x 9 1/2"	7PA160
225	1 1/8" x 3/4" x 10 1/2"	1/4" x 11 1/2"	7PA200

HEAT-CONDUCTING STUD MOUNTINGS

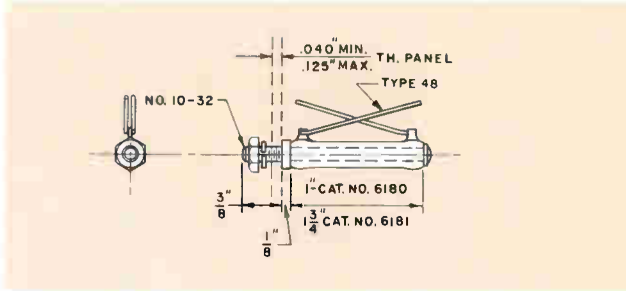


Fig. 84: Typical stud-mounted resistor

For Increased Wattage Ratings
Convenient Mounting—Minimum Space

A substantial part of the heat generated in small tubular type resistors can be conveyed to a metal mounting surface under certain conditions, by means of an aluminum stud fitted snugly into the core. This transfer of heat tends to lower the temperature of the resistor. The size and nature of the mounting panel or chassis, and the permissible panel temperature rise therefore sets limits to the wattage that can be dissipated.

If the temperature rise of the resistor is maintained at the Free Air Watt Rating, the wattage can be more than doubled for small resistors mounted on a chassis of at least 100 square inches area. Ohmite provides special aluminum studs which are supplied riveted into special keyed cores of 8 or 12 watt size (free air rating—see core sizes in table below).

Cat. No. Mtg. Stud	Resistor Size
6180	5/16" x 3/16" x 1"
6181	5/16" x 3/16" x 1 3/4"

Terminals suitable for these cores can be selected from pages 38, 39. The resistors mount conveniently by means of the 10-32 threaded stud extension and a nut. The integral, thick flange assists heat transfer and spaces the lower resistor terminal away from the mounting surface.

To order, specify desired core and stud from table above, terminals (see pages 38, 39), resistance value and whether Dividohm adjustable feature is desired.

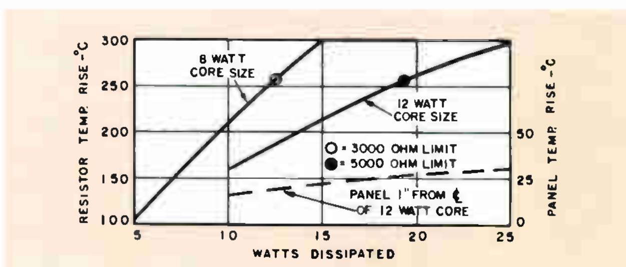


Fig. 85: Wattage dissipation versus temperature rise for stud-mounted resistor.

Fig. 86: (A) Type RC1 (B) Type RC2 (C) Type RC4

INDIVIDUAL TERMINAL TYPE CAGES

These are sturdy perforated metal cages with gray wrinkle enamel finish and porcelain "feed-through" type terminals for each resistor. Mounting slots are 5⁄16" wide. Specify cage type number, number of units, resistance, current and resistor size. Cages with a removable panel for adjustable resistors can be supplied.

Number of Resistors	Resistor Size	Overall Dimensions †Length	Height	Width	Mounting Centers	Fig. No.	% Nom. Watts Each Res.	Cage Type No.
1	1" x 6⅝"	9 9⁄16"	2⅞"	2¼"	8⅜"	86A	100	RC1
	1⅛" x 8½"	11 7⁄16"	2⅞"	2¼"	10¼"	86A	100	RC1A
	As Specified	*	2⅞"	2¼"	‡	86A	100	RCX1
2	1" x 6⅝"	9 9⁄16"	2⅞"	3¾"	8⅜"	86B	66	RC2
	1⅛" x 8½"	11 7⁄16"	2⅞"	3¾"	10¼"	86B	66	RC2A
	As Specified	*	2⅞"	3¾"	‡	86B	66	RCX2
4	1" x 6⅝"	9 9⁄16"	4¼"	3⅝"	8⅜"	86C	52	RC4
	1⅛" x 8½"	11 7⁄16"	4¼"	3⅝"	10¼"	86C	52	RC4A
	As Specified	*	4¼"	3⅝"	‡	86C	52	RCX4

†Length includes terminal. *Dimension is resistor length plus 2 15⁄16". ‡Dimension is resistor length plus 1¾".

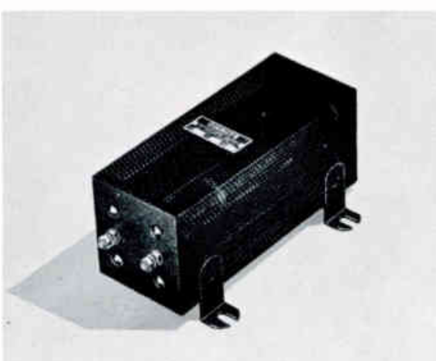


Fig. 87: Typical group terminal cage

GROUP TERMINAL TYPE CAGES

These cages can be made for any required number of resistors which are to be connected together inside the cage with one (or more) pairs of terminals brought out. The ends are of heavy transite and the sides of gray wrinkle enameled perforated sheet metal. Terminal bolts are supplied as standard, but binding posts, conduit connection, or other type of terminal can be supplied. Cages for resistors of other length than those listed below are 1⅜" longer than the resistor length; mounting bracket centers are 2⅞" less than the cage length.

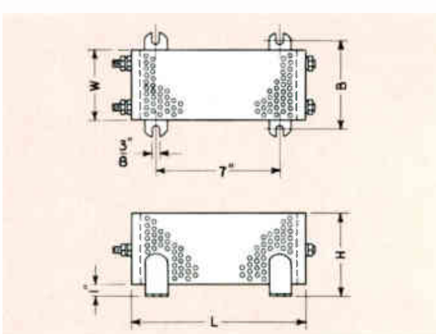


Fig. 88: Group terminal cage dimensions

Type No.	Resistors 1⅛"x8½"	Overall Dimensions Length L is 9⅝" Height H	Width W	B Mtg. Hole Centers	Watts Each Unit††
RCM-1	1	4"	3"	4"	160
RCM-2	2	4"	5½"	6½"	125
RCM-3	3	4"	8"	9"	110
RCM-4	4	6½"	5½"	6½"	105
RCM-6	6	6½"	8"	9"	100
RCM-8	8	6½"	10½"	11½"	96
RCM-9	9	6½"	13"	14"	95
RCM-10	10	6½"	13"	14"	94
RCM-12	12	6½"	15½"	16½"	92

††For continuous duty.

Fig. 89: (A) Code; CUBEN (B) Code; CUBIT (C) Code; CULAC (D) Cat. No. 6050 Plug with Cord

LINE VOLTAGE REDUCER CAGES—ADAPTERS

Three different types: equipped with prongs and receptacle for plug cap; or with Edison screw base and socket; or with line cord and Edison screw receptacle. Generally, the first and second styles are used for the shorter units, and the third style for the longer units.

Cages are perforated metal, gray wrinkle finished. A "Series Plug" Cat. No. 6050, for connecting the resistor in series with the 115 V. line and load can be supplied. Series Plug and 6-ft. heater type cord is identified as Type 607.

Resistor Max. Size	[illegible]	Description of Terminals	[illegible]	[illegible]	[illegible]
1" x ‡	. . .	Two-prong Plug and Two-prong Receptacle	†	46A	CUBEN
1" x 5¼"	85	Edison Screw Plug and Two-prong Receptacle	*8⅛"	. . .	CUBAU
1" x 5¼"	85	Edison Screw Plug and Socket	*8⅛"	46B	CUBIT
1⅛" x 8½"	160	Heater Type Cord Set, 6 ft. long, with Series Plug δ	10¾"	. . .	CULED
1⅛" x 8½"	160	Heater Type Cord Set, 6 ft. long, Plug and Edison Screw Socket δ	11¾"	46C	CULAC

‡Length as specified.
†Length is resistor length plus 1⅝".
*Length is resistor length plus 2⅞".
δBlack rubber covered cord can be supplied. Specify 607R.

SPECIAL CAGES

Ventilated or dustproof enclosures to house any combination of resistors and made according to the customer's specifications can be supplied on order. A sketch or blue print should be submitted.

LIVE BRACKET MOUNTED RESISTORS

Live Bracket Resistors use the brackets as the electrical terminals as well as a means of mounting. They are popular for railway signal work and locomotive circuits. The resistors are made with wire leads which are connected to the plated brass brackets after the brackets are fastened to the core. One type has the brackets cemented to the core per Fig. 90. The other type is assembled by a through-bolt, which is insulated from the brackets by porcelain plugs, as shown in Fig. 91. See page 50 for "Dead" brackets.

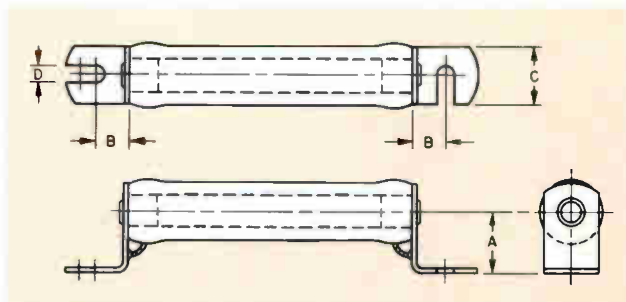


Fig. 90: Type 63, live brackets cemented in place

Type 63 Live Brackets (Cemented in Place)

Cat. No.	For Core Diameters	Dimensions			
		A	B	C	[illegible]
63-12	9/16", ¾"	25/32"	7/16"	¾"	¼"
63-18	1", 1⅛"	⅞"	13/16"	1⅛"	5/16"

Through-bolt Type Live Brackets

Cat. No.	For Core Diameters	Dimensions			
		A	B	C	D
63A-18	1", 1⅛"	⅞"	1 1/16"	1⅛"	⅜"

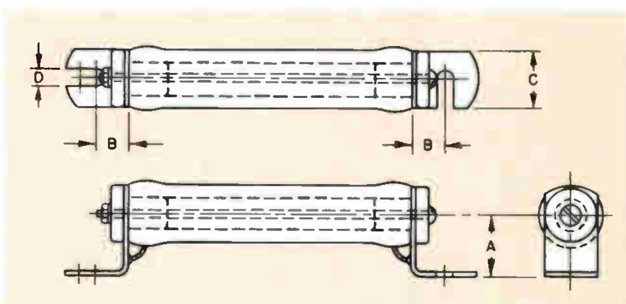


Fig. 91: Type 63A, live brackets bolted in place

SPECIAL RESISTORS

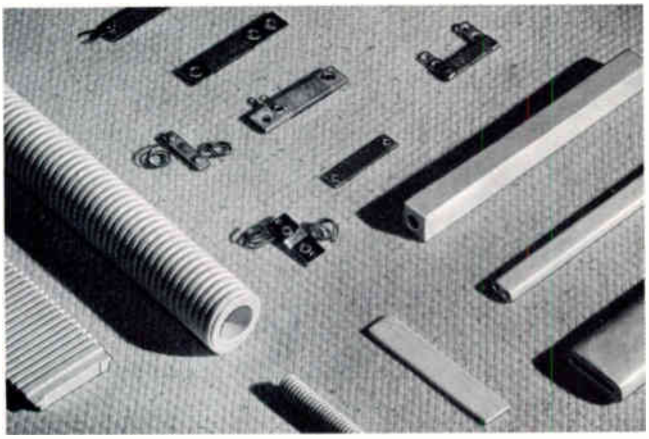


Fig. 92: Special cores and resistors

Ohmite is equipped to make many kinds of special resistors in accordance with the customer's specifications. Flat or special shape resistors can be wound on porcelain, fiber, mica, plastic, or transite. Porcelain cores can be vitreous enameled, and most types may be insulated alternatively with "Ohmicone" coating, cement, lacquer, baking varnish or other materials, or left bare.

Quotations will be sent upon receipt of drawing and complete details of the physical and electrical properties and the number of units involved.

EIA SPECIFICATION POWER RESISTORS

Ohmite can provide resistors to meet the requirements of the Electronic Industries Association "Standard RS-155, Fixed Wirewound Resistors." The proposed revision (1964-65) includes power-type resistors, 1% and 5% tolerance, in tubular, strip and axial-lead styes.

The proposed revision includes major changes. The new standard identifies the resistors by a coded system as shown by the following example:

CRW20	G	1002	F
EIA Style	Characteristic	Resistance (code)	Tolerance

Resistors to meet this standard exactly, should be ordered by EIA coded designation. It should be noted that the standard provides for several different characteristics based on a different ambient and maximum ambient temperature than the NEMA industrial standard. A partial comparison is shown on page 6.

DETERMOHM® RESISTANCE BOX

Application: The Determohm is a resistance box for the use of engineers, technicians, radio servicemen and others in laboratories, factories and schools. It may also be used as a voltmeter multiplier, or with auxiliary apparatus in an ohmmeter, or for other applications.

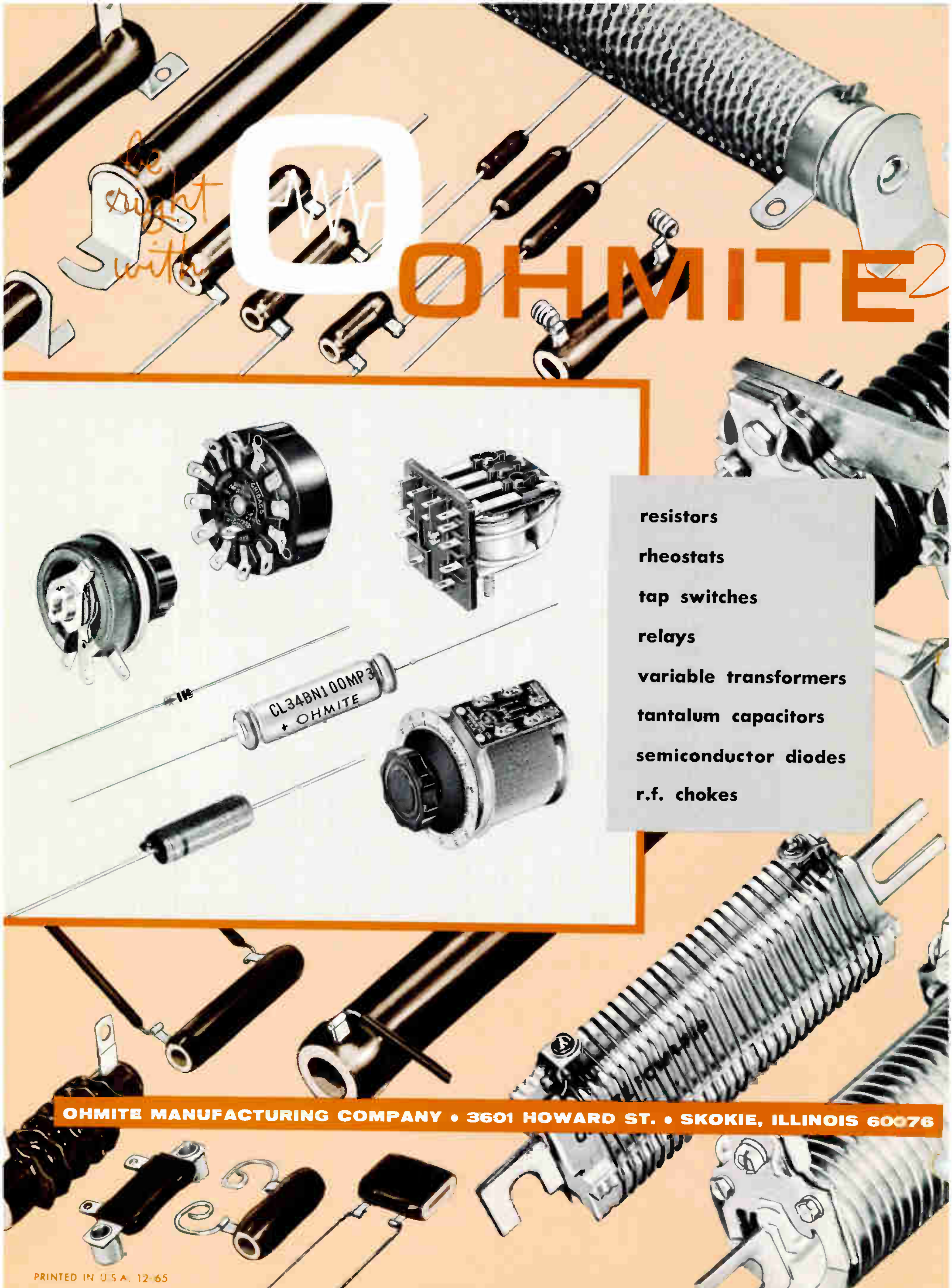
Description: The resistance elements are made up of wirewound resistors (except as noted) which are connected to tap switches. The third and fourth decades (0.1 meg. and 1.0 meg. steps) of Stock No. 3404 use 1 watt "Little Devil" composition resistors. One watt can be dissipated for each switch tap connected in the circuit. Maximum amperes for each decade are stamped on each dial. Binding posts accept banana plugs. Resistance tolerance is ±5% max.

Dimensions: 6$\frac{5}{16}$" x 8$\frac{1}{8}$" x 3$\frac{1}{4}$". Gray wrinkle finish. Weight 3.3 lbs.

Stock DETERMOHM Resistance Boxes

Resistance	Stock No.
1000 to 9,999,000 Ohms	3404
100 to 999,900 Ohms	3401
10 to 99,990 Ohms	3402
1 to 9,999 Ohms	3403

Fig. 93: Determohm resistance box


be right with
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OHMITE

NOV 27 1971

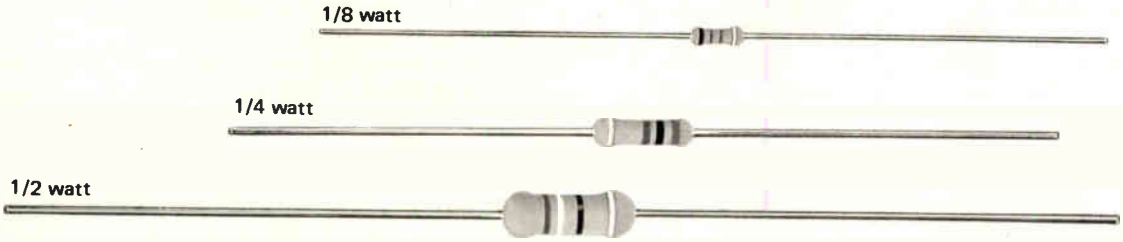
BULLETIN 350

HIGH QUALITY, BETTER SERVICE, AT A COMPARABLE PRICE

high stability • low noise extra long life

Little Rebel T.M. carbon film resistors

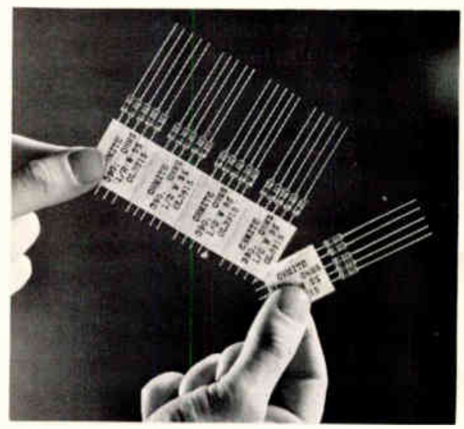
Distrib Stock



High stability, very low noise level, and exceptionally long life make these resistors ideal for applications requiring a steady low power drop. Their accuracy and consistency are relatively unaffected by adverse environmental conditions.

Resistors of 10Ω to 1MΩ have a homogenous film of pure carbon deposited on a high grade ceramic body by cracking a hydrocarbon gas. Resistors having values lower than 10Ω have a nickel film instead of cracked carbon.

Contact caps of special alloy are pressed onto the ends of the resistor body to which the tin coated electrolytic copper connecting wires are welded. Finally the resistors are coated with three or more layers of a special lacquer for electrical, mechanical and environmental protection. This special lacquer will withstand regular industrial cleaning solutions used for cleansing printed circuit boards.



Tally Tape® is Ohmite's exclusive convenient packaging of 1/4 and 1/2 watt Little Rebel resistors that prevents spilling or tangling, simplifies counting, decodes ohmic value for quick identification, and guarantees original, factory-fresh stock. Each perforated segment holds 5 resistors; 10 segments packaged in poly bag 50 pack.

Little Rebel T.M. carbon resistors available from stock on Tally Tape® packaging.*

RESISTANCE (OHMS) ± 5%	CATALOG NUMBER 1/8W.	1/4W.	1/2W.
1		OK10G5	OL10G5
1.2		OK12G5	OL12G5
1.5		OK15G5	OL15G5
1.8		OK18G5	OL18G5
2.2		OK22G5	OL22G5
2.7		OK27G5	OL27G5
3.3		OK33G5	OL33G5
3.9		OK39G5	OL39G5
4.3		OK43G5	OL43G5
4.7		OK47G5	OL47G5
5.1		OK51G5	OL51G5
5.6		OK56G5	OL56G5
6.2		OK62G5	OL62G5
6.8		OK68G5	OL68G5
7.5		OK75G5	OL75G5
8.2		OK82G5	OL82G5
9.1		OK91G5	OL91G5
10.0	OJ1005	OK1005	OL1005
11	OJ1105	OK1105	OL1105
12	OJ1205	OK1205	OL1205
13	OJ1305	OK1305	OL1305
15	OJ1505	OK1505	OL1505
16	OJ1605	OK1605	OL1605
18	OJ1805	OK1805	OL1805
20	OJ2005	OK2005	OL2005
22	OJ2205	OK2205	OL2205
24	OJ2405	OK2405	OL2405
27	OJ2705	OK2705	OL2705
30	OJ3005	OK3005	OL3005
33	OJ3305	OK3305	OL3305
36	OJ3605	OK3605	OL3605
39	OJ3905	OK3905	OL3905
43	OJ4305	OK4305	OL4305
47	OJ4705	OK4705	OL4705
51	OJ5105	OK5105	OL5105

RESISTANCE (OHMS) ± 5%	CATALOG NUMBER 1/8W.	1/4W.	1/2W.
56	OJ5605	OK5605	OL5605
62	OJ6205	OK6205	OL6205
68	OJ6805	OK6805	OL6805
75	OJ7505	OK7505	OL7505
82	OJ8205	OK8205	OL8205
91	OJ9105	OK9105	OL9105
100	OJ1015	OK1015	OL1015
110	OJ1115	OK1115	OL1115
120	OJ1215	OK1215	OL1215
130	OJ1315	OK1315	OL1315
150	OJ1515	OK1515	OL1515
160	OJ1615	OK1615	OL1615
180	OJ1815	OK1815	OL1815
200	OJ2015	OK2015	OL2015
220	OJ2215	OK2215	OL2215
240	OJ2415	OK2415	OL2415
270	OJ2715	OK2715	OL2715
300	OJ3015	OK3015	OL3015
330	OJ3315	OK3315	OL3315
360	OJ3615	OK3615	OL3615
390	OJ3915	OK3915	OL3915
430	OJ4315	OK4315	OL4315
470	OJ4715	OK4715	OL4715
510	OJ5115	OK5115	OL5115
560	OJ5615	OK5615	OL5615
620	OJ6215	OK6215	OL6215
680	OJ6815	OK6815	OL6815
750	OJ7515	OK7515	OL7515
820	OJ8215	OK8215	OL8215
910	OJ9115	OK9115	OL9115
1000	OJ1025	OK1025	OL1025
1100	OJ1125	OK1125	OL1125
1200	OJ1225	OK1225	OL1225
1300	OJ1325	OK1325	OL1325
1500	OJ1525	OK1525	OL1525

RESISTANCE (OHMS) ± 5%	CATALOG NUMBER 1/8W.	1/4W.	1/2W.
1600	OJ1625	OK1625	OL1625
1800	OJ1825	OK1825	OL1825
2000	OJ2025	OK2025	OL2025
2200	OJ2225	OK2225	OL2225
2400	OJ2425	OK2425	OL2425
2700	OJ2725	OK2725	OL2725
3000	OJ3025	OK3025	OL3025
3300	OJ3325	OK3325	OL3325
3600	OJ3625	OK3625	OL3625
3900	OJ3925	OK3925	OL3925
4300	OJ4325	OK4325	OL4325
4700	OJ4725	OK4725	OL4725
5100	OJ5125	OK5125	OL5125
5600	OJ5625	OK5625	OL5625
6200	OJ6225	OK6225	OL6225
6800	OJ6825	OK6825	OL6825
7500	OJ7525	OK7525	OL7525
8200	OJ8225	OK8225	OL8225
9100	OJ9125	OK9125	OL9125
10K	OJ1035	OK1035	OL1035
11K	OJ1135	OK1135	OL1135
12K	OJ1235	OK1235	OL1235
13K	OJ1335	OK1335	OL1335
15K	OJ1535	OK1535	OL1535
16K	OJ1635	OK1635	OL1635
18K	OJ1835	OK1835	OL1835
20K	OJ2035	OK2035	OL2035
22K	OJ2235	OK2235	OL2235
24K	OJ2435	OK2435	OL2435
27K	OJ2735	OK2735	OL2735
30K	OJ3035	OK3035	OL3035
33K	OJ3335	OK3335	OL3335
36K	OJ3635	OK3635	OL3635
39K	OJ3935	OK3935	OL3935
43K	OJ4335	OK4335	OL4335

RESISTANCE (OHMS) ± 5%	CATALOG NUMBER 1/8W.	1/4W.	1/2W.
47K	OJ4735	OK4735	OL4735
51K	OJ5135	OK5135	OL5135
56K	OJ5635	OK5635	OL5635
62K	OJ6235	OK6235	OL6235
68K	OJ6835	OK6835	OL6835
75K	OJ7535	OK7535	OL7535
82K	OJ8235	OK8235	OL8235
91K	OJ9135	OK9135	OL9135
100K	OJ1045	OK1045	OL1045
110K	OJ1145	OK1145	OL1145
120K	OJ1245	OK1245	OL1245
130K	OJ1345	OK1345	OL1345
150K	OJ1545	OK1545	OL1545
160K	OJ1645	OK1645	OL1645
180K	OJ1845	OK1845	OL1845
200K	OJ2045	OK2045	OL2045
220K	OJ2245	OK2245	OL2245
240K		OK2445	OL2445
270K		OK2745	OL2745
300K		OK3045	OL3045
330K		OK3345	OL3345
360K		OK3645	OL3645
390K		OK3945	OL3945
430K		OK4345	OL4345
470K		OK4745	OL4745
510K		OK5145	OL5145
560K		OK5645	OL5645
620K		OK6245	OL6245
680K		OK6845	OL6845
750K		OK7545	OL7545
820K		OK8245	OL8245
910K		OK9145	OL9145
1.0M		OK1055	OL1055

*Tally Tape® for 1/4W. and 1/2W. sizes only; 1/8W packed 50 to plastic box.
End tape reel packaging also available on special order; minimum quantities per value: 5000 pcs for 1/8W., 3000 for 1/4W., 2500 for 1/2W.

▶ specifications shown on reverse side ▶

Ohmite Manufacturing Company a North American Philips company
3601 Howard Street, Skokie, Illinois 60076/Phone (312) 675-2600/TWX: 910-223-0805/Telex 72-4433

SPECIFICATIONS for *Little Rebel*™ carbon film resistors:

Ratings	1/8W	1/4 W	1/2W
Power rating P_{nom} $T_A \lesssim 70°C$	0.125W	0.25W	0.5W
Maximum voltage AC or DC	150V	250V	350V
Voltage (RMS) that may be applied for 1 sec. across insulated coat	300V	500V	700V
Insulation resistance	$10^4 M\Omega$	$10^4 M\Omega$	$10^4 M\Omega$

	ALL TYPES
Ambient temperature	−55 to +155°C
Temperature coefficient	see figure 2
Noise voltage	see figure 1

Voltage Breakdown
2x limiting voltage for 1 min. between terminals of resistor and metal foil .... no breakdown or flashover

Short Term Overload (Room Temperature)
loaded 5 sec. at 6.25 P_{max} at 25°C
(not to exceed 2x maximum voltage)
10 cycles: 5 sec on
10 sec off
ΔR_{max} 1%

Shelf Test
at 25°C_{nom} for 12 months
ΔR_{max} for $R \lesssim 1M\Omega$ 1.5%
$R > 1M\Omega$ 3%

Temperature Cycling
5 cycles: 3 hours −55°C
3 hours +155°C
ΔR_{max} .... 0.5% or 0.5Ω

Humidity Specifications
After long-term exposure to damp heat at 40°C, 5 VDC
RH = 90-95% for 56 days with no drying
5 VDC
ΔR_{max} for R_{nom} = 10Ω to 100 kΩ 1%
R_{nom} = 100 kΩ to 1MΩ 2%
R_{nom} = 1 MΩ or higher 3%

Solder Test (thermal shock)
Terminations immersed for 3 sec. up to .24 inches from end cap in solder bath at 350°C
ΔR_{max} .... 0.5% or 0.5Ω

Lead Test
a. Tensile
diameter .024-.032 inches; load 2.20 lbs; 10 sec.
diameter > .032 inches; load 4.41 lbs;
10 sec. .... no damage
b. Bending
diameter .024-.032 inches; load 1.10 lbs; 4 x 90°
diameter > .032 inches; load 2.20 lbs;
4 x 90° .... no damage
c. Torsion
2 x 360° in opposite directions .... no damage
ΔR_{max} (for all tests) .... 0.5% or 0.5Ω

Shock Test
3 x 1500 shocks in three directions: 50 G;
ΔR_{max} .... 0.5% or 0.5Ω

Vibration
Frequency: 10-500 Hz
Displacement 0.06 in. or acceleration 10G; three directions; total 9 hrs.
ΔR_{max} .... 0.5% or 0.5Ω

Voltage Coefficient 5PPM/Volt (0.0005%/Volt)

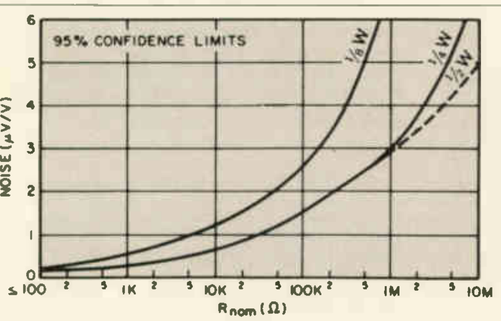


Figure 1. Noise as a function of the resistance value, applicable to all resistor wattages. (as per IEC specifications 195; Method of measurement of current noise generated in fixed resistors).

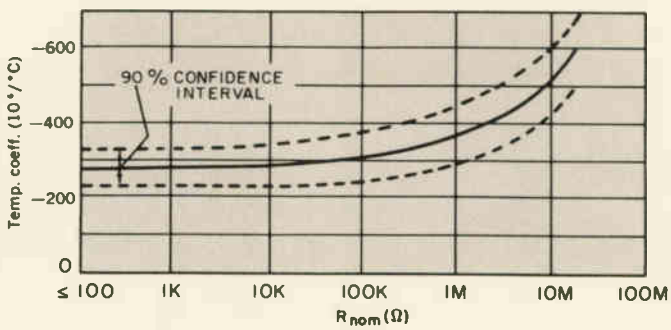
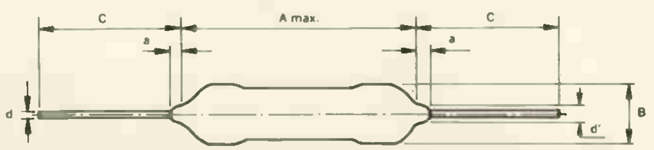


Figure 2. Temperature coefficient as a function of the resistance value, applicable to all resistor wattages.

Type		A max.	B	C	a	d	d'
OJ	1/8W	.161" ± .012"	.059" ± .004"	1-1/8"	max. .020"	.015" ± .002"	.040"
OK	1/4W	.250" ± .015"	.090" ± .008"	1-1/8"	max. .020"	.024" ± .002"	.040"
OL	1/2W	.365" ± .030"	.142" ± .006"	1-1/2"	max. .020"	.028" ± .002"	.040"



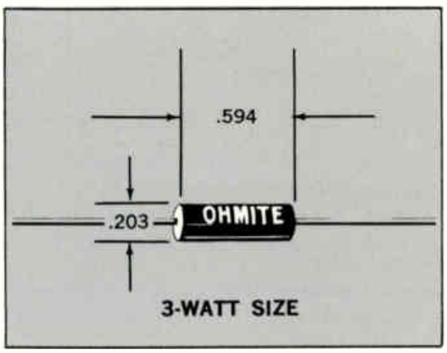
OHMITE has another new answer

DATA SHEET 101-1

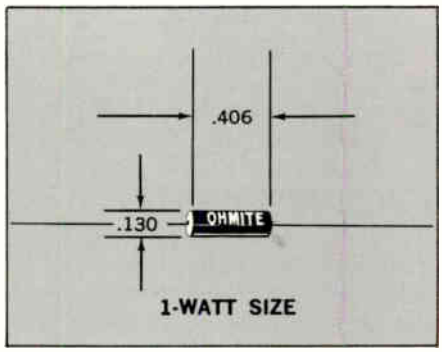
March 25, 1968 / Supplement to Catalog 101

OHMITE Lo-Ohm T.M.

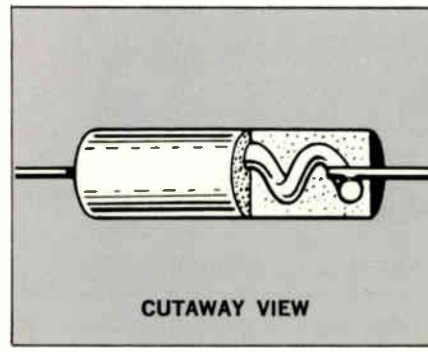
Low resistance wire-wound resistors



3-WATT SIZE



1-WATT SIZE


CUTAWAY VIEW

LESS THAN ONE OHM RESISTANCES, MOLDED SILICONE-CERAMIC BODY, ECONOMICALLY PRICED

Ohmite's new Lo-Ohm T.M. wire-wound resistors are specifically intended for circuits requiring less than one ohm with commercial tolerances and rated at 1 or 3 watts. Molded in a silicone-ceramic material, Lo-Ohm resistors are moisture resistant, are consistent in shape to facilitate automated insertion for circuit board operations, and have a dielectric strength of 1000 VAC.

Ohmic values range from 0.01 to 1.0 ohms, plus or minus 10 percent. For tighter tolerances, contact the factory. Axial leads are welded to the resistance coil and then supported by the tough resilient molded body.

Characteristics

Resistance Range: 0.01 ohms to 1.0 ohms.

Tolerance: Plus or minus 10 percent. Tighter tolerances are available, contact the factory.

Temperature Coefficient: Less than 100 PPM/° C between 0.1 and 1.0 ohms. Less than 500 PPM/°C between 0.01 and 0.1 ohms.

Stability: When subjected to a cyclic load test at rated wattage for 2000 hours, maximum change in resistance shall be less than 3%.

Ambient Temperature: 275°C maximum.

Wattage Derating: Use standard MIL-R-26 derating curve for high ambient temperature.

Configuration:

- *Body* — Cylindrical molded encasement.
- *Leads* — 20 gauge 27 NC axially welded to coil.

Rated Watts @ 25°C	Body Dimension Length ±.015	Body Dimension Dia. +.031 −.000	Leads AWG 20	Resistance Range (Ohms)
1	.406	.130	1½"	0.01 to 1.0
3	.594	.203	1½"	

ORDERING: Specify name Lo-Ohm, wattage size, and Ohmic value required. Example: "Lo-Ohm, 1 watt, .01 ohm"

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a CONELCO company
3601 Howard Street • Skokie, Illinois 60076
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in products for today's & tomorrow's circuitry

Series 99
RESISTORS
molded wire-wound

- Commercial and hi-stability types
- Sizes from 1.5 to 15 watts
- Coating and markings withstand 1500° F
- Consistent shape for automatic insertion equipment

Pat. No. 3,229,237

Series SSA
SOLID STATE RELAYS

- Universal coil accepts AC or DC input
- 10 amp capacity
- 6 milliwatt sensitivity
- Versatile — a few models serve all needs

Ohmitran VT®
VARIABLE TRANSFORMERS
low power series

- Now you can select the exact power rating you need
- Multiple use 3-way terminals
- Instantly replaceable brush contacts
- Adjustable shaft
- Six ratings from 1.0 to 3.0 amp

Model C
WORLDS SMALLEST CERAMIC POWER RHEOSTAT

- The only 7½ watt metal/ceramic rheostat
- Withstands hot spot temperatures to 340°C
- Only ½ inch in diameter

OHMITROL T.M. power control
SOLID STATE CONTROLS

- Provides infinitely smooth control of power over the full voltage range
- Smallest 1 and 2 KW controls
- Integral trimmer adjusts control range
- Component and portable models

Model 711
MINIATURE TAP SWITCHES

Breaks: 7 amps @ 125 VAC
Carries: 15 amps
Smaller: than many low current instrument switches

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in products for today's & tomorrow's circuitry

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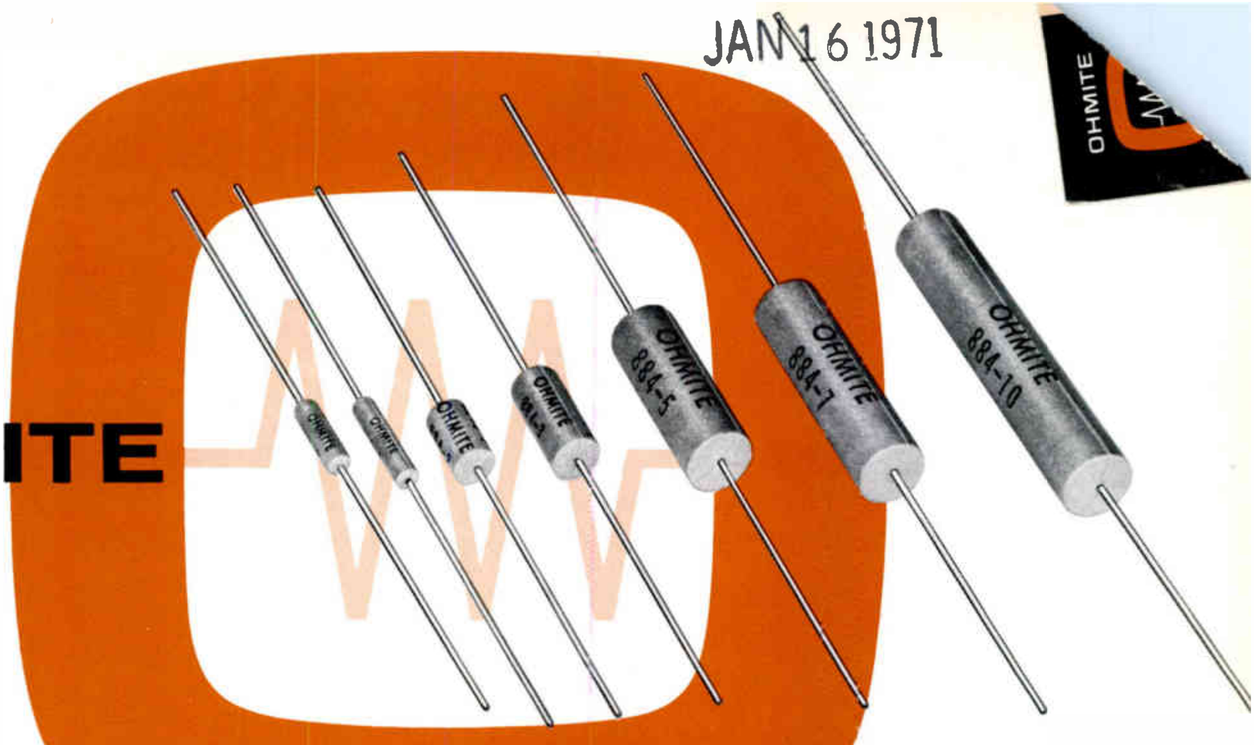


OHMITE SERIES 88

MOLDED OHMICONE
PRECISION, POWER TYPE, WIREWOUND RESISTORS

LOW T.C. – 0 ±10ppm/°C is NEW STANDARD!

3% TOLERANCE INSTEAD OF 5% AT NO EXTRA COST

INSULATED TO MEET 1000 VAC TEST

UNIFORM for AUTOMATED ASSEMBLY
MOUNTS IN CLIPS FOR HEAT-SINK ADVANTAGE

HIGH STABILITY TYPES TO 0.05% TOLERANCE

MEETS MIL-R-26D

BULLETIN 101B

OHMITE MANUFACTURING COMPANY
3601 Howard Street • Skokie, Illinois 60076

SERIES 88 MOLDED OHMICONE PRECISION, POWER TYPE RESISTORS

"Series 88" precision, power-type, wirewound resistors utilize a single-layer winding of high grade resistance alloy wire on a ceramic core. Axial-type terminal leads and the resistance wire are both welded to metal end-caps which fit snugly over the core ends. A jacket of patented "OHMICONE," a tough, resilient, moisture-resistant, high-dielectric* silicone-ceramic material, is then molded around the resistor. The molding technique provides a uniformly thick, dense and smooth covering. Consistent form and size adapts Series 88 resistors to rapid automated assembly of equipment; it also permits mounting in clips for important heat-sink benefits (page 5).

Series 88 resistors are furnished in three basic categories — Type 881U for military (MIL-R-26D) precision-power applications, Type 882 for commercial power applications and Type 884 for high stability, precision-power applications. (Type 884 is functionally the commercial equivalent of Type 881U military units.)

*1000 VAC V-block test (500 volts for 1 watt). For tests on the 1 watt size only, the V-block does not extend beyond the ends of the resistor body due to the impracticality of maintaining the leads straight and concentric.

All types feature low temperature coefficients of resistance equal to or better than that of MIL-R-26D for the applicable resistance ranges.

Resistance (Ohms)	T.C. in ppm/°C
Values equal to or greater than tabulated below	0±10
Values less than tabulated below thru 10	0±20
9.99 thru 1.0	0±50
Below 1.0	0±90

Type	Ohms	Type	Ohms
881U-1A 882-1A 884-1A	31	881U-5 882-5 884-5	353
882-1B 884-1B	49	882-7 884-7	515
882-2 884-2	30	881U-10A 882-10 884-10	874
881U-3A 882-3 884-3	105		

Lower T.C.'s are available; consult factory. Standard leads are solderable; for weldable leads consult factory.

TYPE 881U FOR MILITARY APPLICATIONS (MIL-R-26D)

Type 881U resistors (Table I) meet the requirements of MIL-R-26D, Characteristic U, Styles RW70, RW74, RW78 and RW79 (wirewound, axial-lead insulated, 275°C hot spot). See Table VII for standard resistance values for 1%, 0.5% and 0.1% tolerances. (Styles RW67, RW68, and RW69 can also be supplied in Series 88 resistors, although Series 99 types are normally furnished.)

For Characteristic U, MIL-R-26D (Table I) now specifies a ±0.5% Δ R on 2000 hour cyclic load-life test, and a temperature coefficient of 0±30ppm/°C (for resistances 10 ohms and above). Ohmite, however, supplies considerably closer T.C.'s at no extra cost — see above.

MIL-R-26D specifies resistance tolerances of ±1.0% (MIL symbol F) and ±0.5% (MIL symbol D) for resistance values from 0.1 ohm and up; also specified is 0.1% tolerance (MIL symbol B) for resistance values of 0.499 ohms and up. The choice of tolerances necessitates inclusion of the above appropriate tolerance symbol in the type designation which is added after the resistance code as in "RW74U4991**F**."

Type 881U, of course, meets the stringent test requirements of MIL-R-26D which include the 1000 volt V-block dielectric-strength test (500 volts for 1-watt Style RW70) and the 100 megohm insulation-resistance test. For derating, see Graph I, page 3.

TABLE I — TYPE 881U RESISTORS for MIL-R-26D (CHARACTERISTIC U)

Ohmite Style	MIL Style	Watts[1] Char. U	Dimensions: Length +.020 −.010	Dia. ±.020	Leads 1½" AWG	Weight Grams	Ohms Range: .0008[2,4] Wire	.001[3,4] Wire	MIL Max. Wkg. Volts
881U-1A	RW70	1	0.417	0.105	24	0.3	0.1- 3,160	0.1- 1,210	52
881U-3A	RW79	3	0.600	0.195	20	1.3	0.1-10,500	0.1- 3,570	135
881U-5	RW74	5	0.917	0.323	18	3.3	0.1-38,300	0.1-12,100	300
881U-10A	RW78	10	1.822	0.364	18	6.3	0.1-90,900	0.1-40,200	720

[1] Char. U (275°C max. hot spot temperature).

[2] Minimum wire size except for Navy (See Table VII for standard values for 1.0% to 0.1% tolerances).

[3] Minimum wire size for Navy (See Table VII for standard values for 1.0% to 0.1% tolerances).

[4] Minimum resistance is 0.1 Ω for 1% and 0.5% tolerance resistors; 0.499 Ω for 0.1% tolerances.

TABLE VI
STANDARD RESISTANCE VALUES
per MS90178 (.10 to 10,000 Decades*)
for Tolerances Greater than 1%

OHMS	OHMS	OHMS	OHMS	OHMS
.10†	1.0	10	100	1000
	1.1	11	110	1100
.12†	1.2	12	120	1200
	1.3	13	130	1300
.15†	1.5	15	150	1500
	1.6	16	160	1600
.18†	1.8	18	180	1800
	2.0	20	200	2000
.22†	2.2	22	220	2200
	2.4	24	240	2400
.27†	2.7	27	270	2700
	3.0	30	300	3000
.33†	3.3	33	330	3300
	3.6	36	360	3600
.39†	3.9	39	390	3900
	4.3	43	430	4300
.47†	4.7	47	470	4700
	5.1	51	510	5100
.56†	5.6	56	560	5600
	6.2	62	620	6200
.68†	6.8	68	680	6800
	7.5	75	750	7500
.82†	8.2	82	820	8200
	9.1	91	910	9100

*The table lists values only to 9100 ohms. However, the same progression of numbers continues through successive decades. Ohmite can, of course, supply intermediate resistance values.

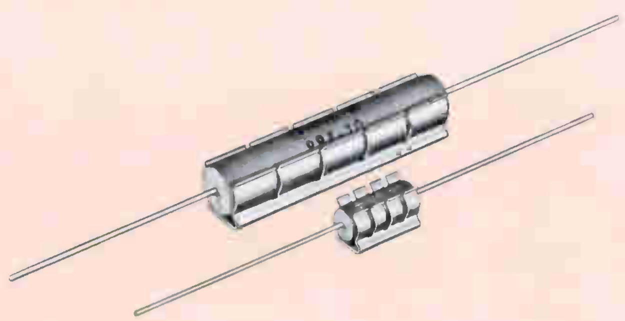
†10% tolerance for these specific values, per MIL-R-26D.

TABLE VII — MIL-BELL SYSTEM OF STANDARD RESISTANCE VALUES (10 to 100 DECADE*) for 1.0%, 0.5%, 0.25% and 0.1% Tolerances (applicable to MIL-R-26D, Styles RW70, 74, 78, & 79 — Ohmite 881U)

OHMS	OHMS	OHMS	OHMS	OHMS	OHMS
10.0	14.7	21.5	31.6	46.4	68.1
10.2	15.0	22.1	32.4	47.5	69.8
10.5	15.4	22.6	33.2	48.7	71.5
10.7	15.8	23.2	34.0	49.9	73.2
11.0	16.2	23.7	34.8	51.1	75.0
11.3	16.5	24.3	35.7	52.3	76.8
11.5	16.9	24.9	36.5	53.6	78.7
11.8	17.4	25.5	37.4	54.9	80.6
12.1	17.8	26.1	38.3	56.2	82.5
12.4	18.2	26.7	39.2	57.6	84.5
12.7	18.7	27.4	40.2	59.0	86.6
13.0	19.1	28.0	41.2	60.4	88.7
13.3	19.6	28.7	42.2	61.9	90.9
13.7	20.0	29.4	43.2	63.4	93.1
14.0	20.5	30.1	44.2	64.9	95.3
14.3	21.0	30.9	45.3	66.5	97.6

*The table lists values only from 10.0 to 97.6 ohms. However, the same progression of numbers continues through successive or preceding decades. Ohmite can, of course, supply intermediate resistance values.

MOUNTING CLIPS



Uniform shape and consistent dimensions of Series 88 resistors permits them to be conveniently mounted in clips. If the clip is on a metal surface (equivalent to 0.040″ aluminum, 1.5 sq. in. per watt) the wattage capability of the resistor can increase by as much as 100%. Holes in clip base permit fastening to chassis by means of machine screws, eyelets or rivets. Clip, hole and mounting center dimensions are given in Table VIII at right.

TABLE VIII
STOCK CLIPS FOR SERIES 88 RESISTORS

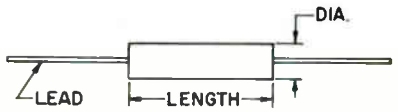
Resistor Style Suffix	Stock No.	Clip Length	Clip Width	Clip Height	No. of Holes	Hole Ctrs.	Hole Dia.
-1A	5900	.40″	.150″	.250″	1	—	.071″
-1B	5901	.50″	.150″	.250″	2	.300″	.071″
-2	5902	.35″	.217″	.275″	2	.156″	.071″
-3	5904	.50″	.257″	.319″	2	.250″	.093″
-5	5905	.90″	.333″	.377″	2	.500″	.093″
-7	5907	1.20″	.333″	.375″	2	.600″	.103″
-10	5909	1.75″	.360″	.385″	2	.800″	.103″

STOCK TYPE 884 RESISTORS 1% TOLERANCE, HIGH STABILITY

TABLE IX (Values Based on MIL-Bell System of Standard Values For 1% Tolerance—Also See Footnote)

Ohms 3 WATT	Max. Volts	Ohms 3 WATT (Cont.)	Max. Volts	Ohms 3 WATT (Cont.)	Max. Volts	Ohms 3 WATT (Cont.)	Max. Volts	Ohms 3 WATT (Cont.)	Max. Volts	Ohms 3 WATT (Cont.)	Max. Volts	Ohms 5 WATT (Cont.)	Max. Volts
.100	.547	4.22	3.56	26.1	8.84	162	22.0	1000	54.7	6,190	136	36,500	427
.121	.602	4.32	3.60	26.7	8.95	165	22.2	1020	55.3	6,340	138	37,400	432
.150	.670	4.42	3.64	27.4	9.06	169	22.5	1050	56.1	6,490	140	38,300	437
.182	.739	4.53	3.69	28.0	9.16	174	22.8	1070	56.6	6,650	141	39,200	442
.200	.774	4.64	3.73	28.7	9.28	178	23.1	1100	57.4	6,810	143	40,200	448
.221	.814	4.75	3.77	29.4	9.39	182	23.4	1130	58.2	6,980	145	41,200	454
.249	.864	4.87	3.82	30.1	9.50	187	23.7	1150	58.7	7,150	146	42,200	460
.274	.906	4.99	3.87	30.9	9.62	191	23.9	1180	59.5	7,320	148	43,200	460
.332	.998	5.11	3.91	31.6	9.74	196	24.2	1210	60.2	7,500	150	44,200	460
.392	1.08	5.23	3.96	32.4	9.86	200	24.5	1240	61.0	7,680	152	45,300	460
.475	1.19	5.36	4.01	33.2	9.98	205	24.8	1270	61.7	7,870	154	46,400	460
.499	1.22	5.49	4.06	34.0	10.1	210	25.1	1300	62.4	8,060	155	47,500	460
.562	1.30	5.62	4.10	34.8	10.2	215	25.4	1330	63.2	8,250	157	48,700	460
.681	1.43	5.76	4.16	35.7	10.3	221	25.7	1370	64.1	8,450	159	49,900	460
.750	1.50	5.90	4.20	36.5	10.5	226	26.0	1400	64.8	8,660	161	51,100	460
.825	1.57	6.04	4.25	37.4	10.6	232	26.4	1430	65.5	8,870	163	52,300	460
1.00	1.73	6.19	4.31	38.3	10.7	237	26.7	1470	66.4	9,090	165	53,600	460
1.02	1.75	6.34	4.36	39.2	10.8	243	27.0	1500	67.0	9,310	167	54,900	460
1.05	1.77	6.49	4.41	40.2	11.0	249	27.3	1540	68.0	9,530	169	56,200	460
1.07	1.79	6.65	4.46	41.2	11.1	255	27.7	1580	68.8	9,760	171	57,600	460
1.10	1.82	6.81	4.52	42.2	11.2	261	28.0	1620	69.7	10,000	173	59,000	460
1.13	1.84	6.98	4.57	43.2	11.4	267	28.3	1650	70.3	10,200	175	60,400	460
1.15	1.86	7.15	4.63	44.2	11.5	274	28.7	1690	71.2	10,500	178	61,900	460
1.18	1.88	7.32	4.68	45.3	11.7	280	29.0	1740	72.2	10,700	179	63,400	460
1.21	1.91	7.50	4.74	46.4	11.8	287	29.3	1780	73.0	11,000	182	64,900	460
1.24	1.93	7.68	4.80	47.5	11.9	294	29.7	1820	73.9	11,300	184	66,500	460
1.27	1.95	7.87	4.86	48.7	12.1	301	30.0	1870	74.9	11,500	186	68,100	460
1.30	1.97	8.06	4.92	49.9	12.2	309	30.4	1910	75.7	11,800	188	69,800	460
1.33	2.00	8.25	4.97	51.1	12.4	316	30.8	1960	76.6	12,100	190	71,500	460
1.37	2.03	8.45	5.04	52.3	12.5	324	31.2	2000	77.4	12,400	193	73,200	460
1.40	2.05	8.66	5.10	53.6	12.7	332	31.6	2050	78.4	12,700	195	75,000	460
1.43	2.07	8.87	5.16	54.9	12.8	340	31.9	2100	79.4	13,000	197	76,800	460
1.47	2.10	9.09	5.22	56.2	13.0	348	32.3	2150	80.3	13,300	200	78,700	460
1.50	2.12	9.31	5.28	57.6	13.1	357	32.7	2210	81.4	13,700	200	80,600	460
1.54	2.15	9.53	5.34	59.0	13.3	365	33.1	2260	82.3	14,000	200	**10 WATT**	
1.58	2.18	9.76	5.41	60.4	13.4	374	33.5	2320	83.4	14,300	200		
1.62	2.20	10.0	5.47	61.9	13.6	383	33.9	2370	84.3	14,700	200	82,500	908
1.65	2.22	10.2	5.53	63.4	13.8	392	34.3	2430	85.4	15,000	200	84,500	919
1.69	2.25	10.5	5.61	64.9	13.9	402	34.7	2490	86.4	15,400	200	86,600	930
1.74	2.28	10.7	5.66	66.5	14.1	412	35.1	2550	87.4	15,800	200	88,700	942
1.78	2.31	11.0	5.74	68.1	14.3	422	35.6	2610	88.4	16,200	200	90,900	952
1.82	2.34	11.3	5.82	69.8	14.5	432	36.1	2670	89.5	16,500	200	93,100	965
1.87	2.37	11.5	5.87	71.5	14.6	442	36.4	2740	90.6	16,900	200	95,300	976
1.91	2.39	11.8	5.95	73.2	14.8	453	36.9	2800	91.6	17,400	200	97,600	988
1.96	2.42	12.1	6.02	75.0	15.0	464	37.3	2870	92.8	17,800	200	100,000	1000
2.00	2.45	12.4	6.10	76.8	15.2	475	37.7	2940	93.9	18,200	200	102,000	1010
2.05	2.48	12.7	6.17	78.7	15.4	487	38.2	3010	95.0	18,700	200	105,000	1020
2.10	2.51	13.0	6.24	80.6	15.5	499	38.7	3090	96.2	19,100	200	107,000	1030
2.15	2.54	13.3	6.32	82.5	15.7	511	39.1	3160	97.4	19,600	200	110,000	1050
2.21	2.57	13.7	6.41	84.5	15.9	523	39.6	3240	98.6	20,000	200	113,000	1060
2.26	2.60	14.0	6.48	86.6	16.1	536	40.1	3320	99.8	20,500	200	115,000	1070
2.32	2.64	14.3	6.55	88.7	16.3	549	40.6	3400	101	21,000	200	118,000	1090
2.37	2.67	14.7	6.64	90.9	16.5	562	41.0	3480	102	21,500	200	121,000	1100
2.43	2.70	15.0	6.70	93.1	16.7	576	41.6	3570	103	22,100	200	124,000	1100
2.49	2.73	15.4	6.80	95.3	16.9	590	42.0	3650	105	**5 WATT**		127,000	1100
2.55	2.77	15.8	6.88	97.6	17.1	604	42.5	3740	106			130,000	1100
2.61	2.80	16.2	6.97	100	17.3	619	43.1	3830	107	22,600	337	133,000	1100
2.67	2.83	16.5	7.03	102	17.5	634	43.6	3920	108	23,200	341	137,000	1100
2.74	2.87	16.9	7.12	105	17.7	649	44.1	4020	110	23,700	344	140,000	1100
2.80	2.90	17.4	7.22	107	17.9	665	44.6	4120	111	24,300	347	143,000	1100
2.87	2.93	17.8	7.30	110	18.2	681	45.2	4220	112	24,900	353	147,000	1100
2.94	2.97	18.2	7.39	113	18.4	698	45.7	4320	114	25,500	357	150,000	1100
3.01	3.00	18.7	7.49	115	18.6	715	46.3	4420	115	26,100	361	154,000	1100
3.09	3.04	19.1	7.57	118	18.8	732	46.8	4530	117	26,700	365	158,000	1100
3.16	3.08	19.6	7.66	121	19.1	750	47.4	4640	118	27,400	370	162,000	1100
3.24	3.12	20.0	7.74	124	19.3	768	48.0	4750	119	28,000	374	165,000	1100
3.32	3.16	20.5	7.84	127	19.5	787	48.6	4870	121	28,700	379	169,000	1100
3.40	3.19	21.0	7.94	130	19.7	806	49.2	4990	122	29,400	383	174,000	1100
3.48	3.23	21.5	8.03	133	20.0	825	49.7	5110	124	30,100	388	178,000	1100
3.57	3.27	22.1	8.14	137	20.3	845	50.4	5230	125	30,900	393	182,000	1100
3.65	3.31	22.6	8.23	140	20.5	866	51.0	5360	127	31,600	397	187,000	1100
3.74	3.35	23.2	8.34	143	20.7	887	51.6	5490	128	32,400	402	191,000	1100
3.83	3.39	23.7	8.43	147	21.0	909	52.2	5620	130	33,200	407	196,000	1100
3.92	3.43	24.3	8.54	150	21.2	931	52.8	5760	131	34,000	412	200,000	1100
4.02	3.47	24.9	8.64	154	21.5	953	53.4	5900	133	34,800	417		
4.12	3.51	25.5	8.74	158	21.8	976	54.1	6040	134	35,700	422		

Resistance values in tinted areas are derated in wattage because of maximum voltage gradient considerations. Even with these voltage limitations, however, the wattage ratings are still adequate for most precision applications. However, where wattage requirements dictate, the same value shown in a derated area for either the 3 or 5 watt sizes can be made-to-order in the next higher wattage as the case may be.



For T. C. Less than 0±10ppm/°C and Non-Inductive Versions, Consult Factory.

TYPE 882 for COMMERCIAL POWER APPLICATIONS

TABLE II — TYPE 882, RANGES, DIMENSIONS

Ohmite Style	Nom. Watts 25°C[1]	Dimensions: Lgth. +.020 −.010	Dimensions: Dia. ±.020	Dimensions: Leads 1½" AWG	Typ. Wt. Grams	Ohms Range Std. 3% Tol.[2]	Max. Wkg. Volts RMS
882-1A	1.5	0.417	0.105	24	0.3	0.10- 10,000	—
882-1B	1.5	0.542	0.105	24	0.3	0.10- 16,500	—
882-2	2.25	0.375	0.188	20	0.6	0.10- 10,000	85
882-3	3.25	0.542	0.230	20	1.3	0.10- 34,000	200
882-5	6.5	0.917	0.323	18	3.3	0.10-124,000	460
882-7	9	1.218	0.323	18	4.3	0.10-178,000	670
882-10	11	1.822	0.343	18	6.3	0.10-301,000	1100

[1] See derating Graph I for ambients above 25°C.

[2] Ohmite's standard power tolerance is 3% supplied at no extra charge over 5% for values 1 ohm and higher; 10% for values below 1 ohm. Closer tolerances are available.

This type (Table II) is intended for commercial power applications. Standard tolerance is ±3% (for values 1.0 ohm and higher) supplied at no extra cost over ±5% tolerances. Closer tolerances are available. These units derate to zero watts at 350°C ambient (Graph I); T.C. = 0±10ppm/°C*; insulation tested at 1000 VAC except 500 volts for 1 watt size (see introduction and footnote, p. 2). Faster delivery is offered on Type 882 values selected from Table VI, "Standard MS90178 Resistance Values for Tolerances Greater Than 1%," on page 5.

*Subject to limitations on page 2.

TYPE 884 HIGH STABILITY, PRECISION-POWER TYPE

Type 884 resistors (Riteohm 88) are classified as high stability, precision-power types (Table III). They are aged and conservatively rated for maximum long term stability and exhibit superior characteristics despite relatively high operating temperature at rated wattage. Impressive stability is displayed in the load-life characteristics tabulated and discussed on the following page (see "Life-Test Proven").

Type 884 units are available in tolerances as close as 0.05% and derate † to zero watts at 275°C ambient (See Graph I); T.C. = 0±10ppm/°C;* insulation tested at 1000 VAC except 500 volts for 1 watt size (see introduction and footnote, p. 2). Ohmite stocks all of the 1% tolerance standard values in the MIL-Bell decade system, up to 200,000 ohms (see Table IX, page 6).

†For applications where maximum stability is of primary importance as may be the case with close tolerance resistors, a derating of 50% is recommended.
*Subject to limitations on page 2.

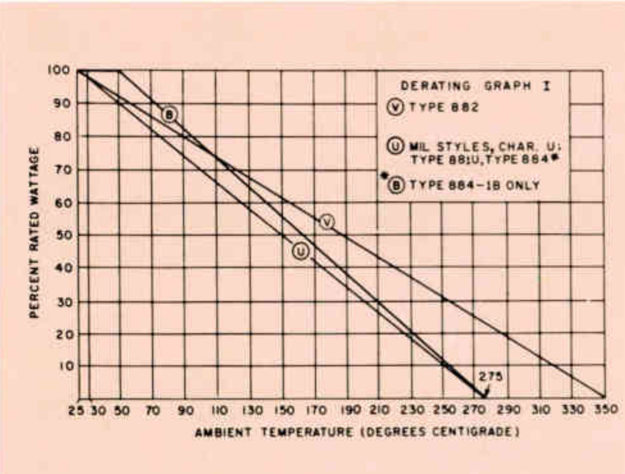


TABLE III — TYPE 884, RANGES, DIMENSIONS

Ohmite Style	Nominal Rated Watts 25°C[1]	Dimensions: Lgth. +.020 −.010	Dimensions: Dia. ±.020	Dimensions: Leads 1½" Long AWG	Typical Weight (Grams)	Resistance Ranges[2]: Closer Than 0.5% Tol. (Min. Ohms)	Resistance Ranges[2]: 0.5% Tol. & Greater (Min. Ohms)	Resistance Ranges[2]: Max. Ohms All Tols.[7]	Max. Wkg. Volts RMS
884-1A[3]	1	0.417	0.105	24	0.3	0.499	0.10	10,000	
884-1B	1	0.542	0.105	24	0.3	0.499	0.10	16,500	
884-2	2	0.375	0.188	20	0.6	0.499	0.10	10,000	85
884-3[4]	3	0.542	0.230	20	1.3	0.499	0.10	34,000	200
884-5[5]	5	0.917	0.323	18	3.3	0.499	0.10	124,000	460
884-7	7	1.218	0.323	18	4.3	0.499	0.10	178,000	670
884-10[6]	10	1.822	0.343	18	6.3	0.499	0.10	301,000	1100

[1] See derating Graph I for ambients above 25°C.

[2] Low resistance values (20 Ω and less) are measured at a point on each lead ⅜" ±1/16 from body of resistor. Special tolerances to 0.05% can be supplied. For all values 10 ohms and below, it is advisable to use Kelvin bridge technique to eliminate errors due to lead and contact resistance.

[3] Commercial equivalent of RW70.

[4] Commercial equivalent of RW79 except for size.

[5] Commercial equivalent of RW74.

[6] Commercial equivalent of RW78 except for size.

[7] Refer to Table VII for preferred values.

"LOT CONTROL" ASSURES QUALITY

Series 88 resistors are manufactured in accordance with a "lot control" technique by which the manufacturing "history" of the resistor is always on record. Identification of individual lots of resistors is maintained throughout all the manufacturing processes. As a result, the details of the materials used, process procedures, quality control checks and testing, can always be associated with a "lot number" which actually appears on the resistor. Thus, the performance of a resistor can be related to the peculiarities of its manufacture and its constituent materials to achieve a program of continuous product improvement!

LOOK FOR THE LOT CONTROL NUMBER ON YOUR SERIES 88 RESISTOR

TABLE IV — CYCLIC LOAD-LIFE TEST SUMMARY ON TYPE 884 RESISTORS‡

Ohmite Style	Total Number of Units†	Total Unit-Hours "On-Time" as of 3-1-67	All Groups 1500 Hrs. "On-Time": No. of Units	All Groups 1500 Hrs. "On-Time": Av. %ΔR	Attained "On-Time" of Different Subgroups as of 3-1-67, 3750 Hrs.: No. of Units	3750 Hrs.: Av. %ΔR	7500 Hrs.: No. of Units	7500 Hrs.: Av. %ΔR
884-1A	245	1,837,500	245	0.022	245	0.031	245	0.028
884-1B	185	1,387,500	185	0.088	185	0.142	185	0.174
884-3	1140	7,780,500	1140	0.268	1068	0.451	978	0.634
884-5	824	4,731,000	824	0.077	645	0.112	545	0.158
884-10	302	2,227,500	302	0.241	302	0.374	292	0.505
All	2696	17,964,000*	2696	0.172	2445	0.287	2245	0.398

*Equal to 23,952,000 total unit-hours of test (cyclic 1½ hours on, ½ hour off).
†See Table V for breakdown of test groups by resistance range.
‡At Full Rated Wattage! See "Life-Test Proven" below.

Life-Test Proven: 23,952,000 unit-hours of testing Type 884 resistors, emphasizes the excellent stability of this Series 88 line. Tables IV and V summarize data accumulated from tests which either have been terminated at 7500 hours of "on-time" or are continuing on test as of Mar. 1, 1967. Testing is being conducted on experimental lots of resistors as well as samples obtained from production lots shipped to users. This test data will be amended from time to time to include additional results from continuing tests on existing test units as well as new units from users' production orders, samples of which are regularly placed under test. The data is characteristic and serves as an excellent guide but should not be used to set design or performance limits. The setting of such limits should be discussed with the factory.

TABLE V — DISTRIBUTION BY RESISTANCE RANGE OF TOTAL NUMBER OF TEST RESISTORS IN EACH STYLE

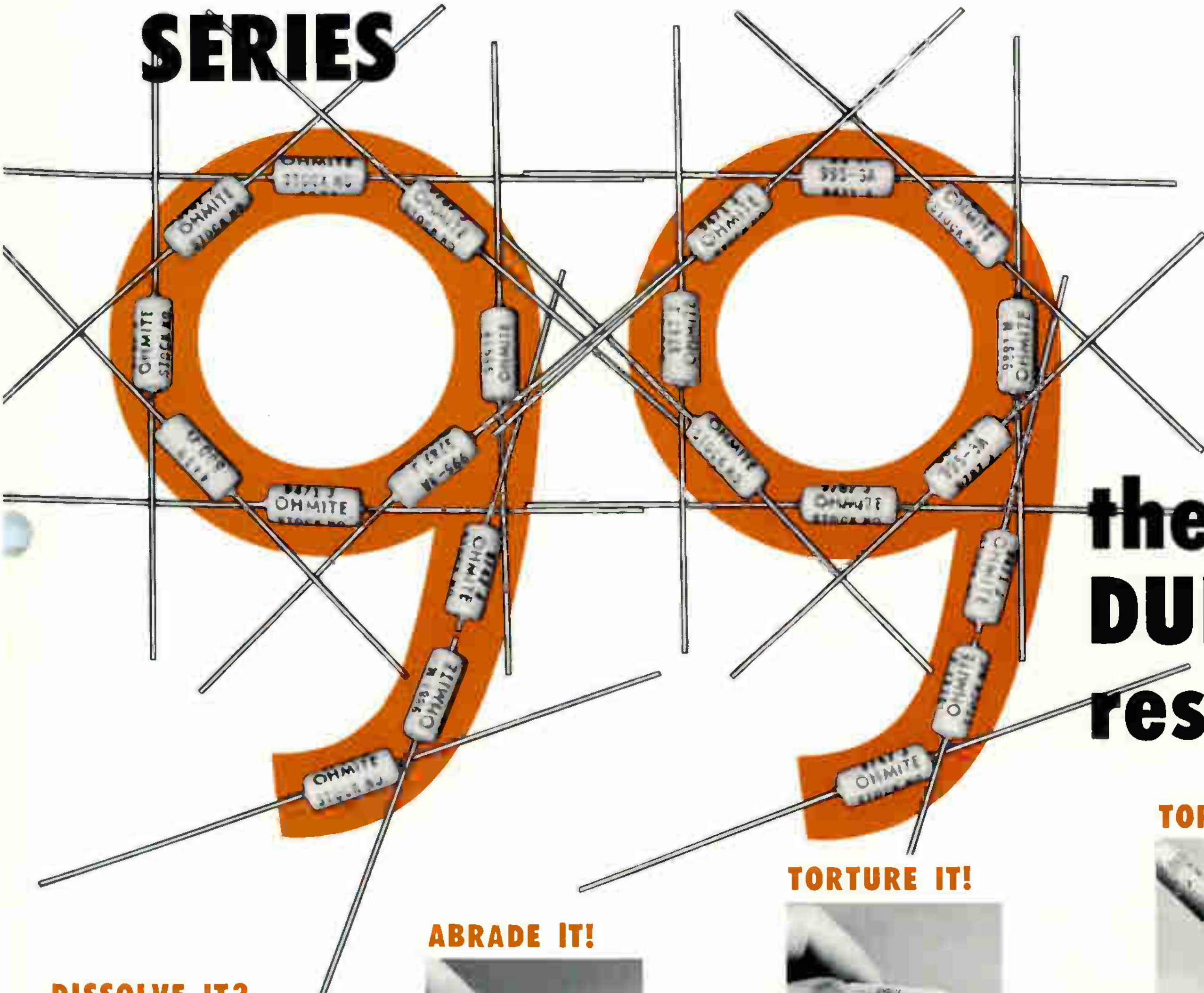
Resistance Range in Ohms	884-1A	884-1B	884-3	884-5	884-10
1 to 100	71		157	120	25
101 to 1,000	20	30	535	139	49
1,001 to 5,000	93	39	310	155	30
5,001 to 10,000	61	69	100	103	20
10,001 to 50,000		47	38	278	43
50,001 to 200,000				29	135

MOLDED!!

Vitreous Enameled Wirewound Resistor

1000 Volt Insulation

SERIES



the DURABLE resistor

DISSOLVE IT?

You can't . . . tough, vitreous
amel coating and markings re-
st the solvents normally used
for degreasing and flux removal.

ABRADE IT!

Glass fiber eraser leaves Series 99 VITRIFIED markings unaffected. Conventional markings would vanish in a few rubs.

TORTURE IT!

Resists chipping, breaking! Thick, densely molded jacket will not chip even where leads enter resistor body.

TORCH IT!

1500°F—RED HEAT! And Series 99 Resistors show no sign of softening or deformation. VITREOUS markings stay right there too!

OHMITE MANUFACTURING COMPANY
3601 Howard Street • Skokie, Illinois 60076

Bulletin 103E

OHMITE

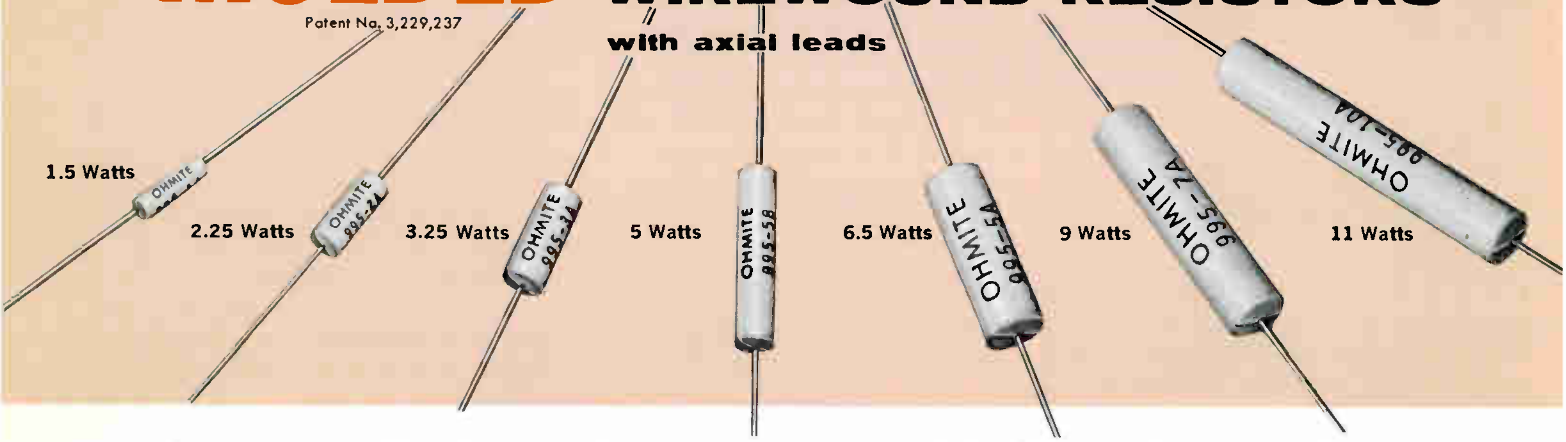
A Milestone in Resistor Technology

OHMITE SERIES 99

MOLDED VITREOUS ENAMELED WIREWOUND RESISTORS

Patent No. 3,229,237

with axial leads



In the long history of vitreous enameled resistors, Ohmite claims the distinction of introducing the first important innovation—a MOLDED vitreous enamel insulating coating. This development, the result of a new manufacturing technique (patent No. 3,229,237) permits the vitreous enamel to be applied by a molding process in contrast to the conventional dip enameling methods. Equally remarkable is the creation of a vitrified coating which endures the red heat of manufacture but retains its molded form and dimensions! The new Series 99 construction offers highly important advantages as follows:

(1) Consistent insulation thickness that guarantees 1000 VAC insulation breakdown ratings. (500 volts for Style 1A, 1½ watt size)*

(2) A strong, tough jacket that resists breakage and chipping—will not chip where leads enter the resistor body—that resists 1500°F without losing its form or dimensions—that withstands conditions of high humidity and immersion in salt solution with unparalleled success.

*For tests on the Style 1A, 1½ watt size only, the V-block does not extend beyond the ends of the resistor body.

(3) Consistent form and dimensions facilitate use of resistors in automated assembly of circuit boards, etc., or mounting in fuse-type clips (page 6) with significant heat-sink benefits which allow a 100% wattage increase when clip is mounted on metal surface. Resistors may be repeatedly inserted and removed from clips without damage.

With all this, THE ACKNOWLEDGED, TIME-PROVEN ADVANTAGES OF VITREOUS ENAMEL INSULATION ARE RETAINED. It anchors the turns of resistance wire in place and provides a hard, glossy material that distributes heat to minimize hotspots, that will not burn or shrink, that is unaffected by moisture and imparts to resistors the ability to withstand amazing overloads for a reasonable duration.

Beneath this superb insulation of Series 99 resistors, is a single layer winding of high grade resistance

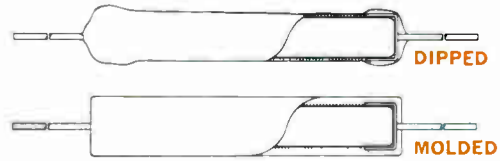
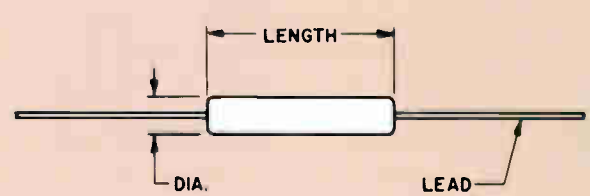


TABLE I—TYPE 995 COMMERCIAL TYPE

5% Tolerance; Closer Tolerances Available

Ohmite Style	Rated Watts @25°C	Dimensions (inches) Lgth. ±.015	Dia. +.031 −.000	Leads 1½″ AWG ‡	Typical Weight (Grams)	Resistance Range† (Ohms)	Max. Wkg. Volts RMS
995-1A	1.5	.422*	.125*	24	0.4	0.1 to 6650	
995-2A	2.25	.375	.188	20	0.8	0.1 to 6490	85
995-3A	3.25	.547	.203	20	1.3	0.1 to 22,100	190
995-5A	6.5	.922	.312	20	3.6	0.1 to 80,600	460
995-5B	5	.938	.203	20	2.0	0.1 to 53,600	500
995-7A	9	1.218	.312	20	4.5	0.1 to 118,000	670
995-10A	11	1.781	.312	20	6.9	0.1 to 187,000	1100

*Tolerance +.015, −.005
†See "Standard Resistance Values," Table VI for 5% tolerances; Table VIII for closer tolerance.
‡AWG 20 = .032″ AWG 24 = .020″



OHMITE

New! 15 WATT SIZE

MOLDED
VITREOUS ENAMEL AXIAL LEAD RESISTOR . . . SERIES 99

Actual Size

TABLE I — COMMERCIAL TYPE 995

5% Tolerance; Closer Tolerances Available

Ohmite Style	Rated Watts @25°C	Dimensions (inches) Lgth. ±.015	Dia. +.031 −.000	Leads 1-1/2" AWG‡	Typical Weight (Grams)	Resistance Range† (Ohms)	Max. Wkg. Volts RMS
995-1A	1.5	.422*	.125*	24	0.4	0.1 to 6650	
995-2A	2.25	.375	.188	20	0.8	0.1 to 6490	85
995-3A	3.25	.547	.203	20	1.3	0.1 to 22,100	190
995-5A	6.5	.922	.312	20	3.6	0.1 to 80,600	460
995-5B	5	.938	.203	20	2.0	0.1 to 53,600	500
995-7A	9	1.218	.312	20	4.5	0.1 to 118,000	670
995-10A	11	1.781	.312	20	6.9	0.1 to 187,000	1100
995-15A	15	2.00	.394	20	13	0.1 to 243,000	1100

*Tolerance +.015, −.005
†For closer tolerances than 1%, minimum value is 1 ohm
‡AWG 20=.032" AWG 24=.020"

Ohmite's new 15 watt Series 99 axial lead resistor, expands the range of sizes available to industry. (Table I). Now you can utilize these tough resistors in even more applications.

For its rating, the 15 watt size is small — 2" long and only 0.394" in diameter. It is expected to find use in many applications where lug type or lug-lead type resistors are presently used.

This new size incorporates the advantages of the Series 99 line — molded vitreous enamel jacket (Patent No. 3,229,237) over the wirewound ceramic core to provide 1000 volt insulation; superior resistance to intense heat, abrasion, solvents and abuse. And, of course, the other well-known advantages of vitreous enamel are provided — its ability to withstand moisture and its unsurpassed overload capability. Molding provides the size uniformity so conducive to the mechanized feeds of automated circuit board operations.

The 15 watt size is provided in the commercial power type (995) and high-stability type (994). It also complies with all requirements for Style RW56 (14 watts) of military specification MIL-R-26 but has a higher wattage rating.

Request Bulletin 103 for complete details of the resistors that have established a milestone in resistor technology — the Series 99.

STYLES RW55, 56 OF MIL-R-26: With the introduction of the 15 watt resistor, two Series 99 resistors are now available for those applications utilizing Styles RW55 and RW 56 of MIL-R-26 as follows:

TABLE II — TYPE 991 for STYLES RW55, 56 of MIL-R-26

5% Tolerance

"V" Char. Ohmite Style	MIL* Style	Rated Watts @25°C	Ohms Range	Dimensions Length ±.015	Dia. +.031 −.000	Leads 1-1/2" AWG†	Typical Weight (grams)
991-15A	RW56V	14	0.1-9.1K	2.00	.394	20	13
991-7A	‡RW55V	7	0.1-5.1K	1.218‡	.312‡	20	4.5

‡Despite the fact that these dimensions are smaller than the minimum limits of the MIL specification, it complies with all functional requirements.
*Other Series 99 sizes meet MIL Styles RW67V, RW68V, RW69V. See Bulletin 103.
†AWG 20=.032"

HI-STABILITY, CLOSE TOLERANCE TYPE 994: The 15 watt Series 99 resistor is also available in the high stability, closer tolerance variety as shown below. See Bulletin 103 for definition of stability, T.C., etc.

TABLE III — TYPE 994, 3% STD. TOLERANCE

Tolerances to 0.25% Available

Ohmite Style	Rated Watts @25°C	Dimensions (inches) Length ±.015	Dia. +.031 −.000	Leads 1-1/2" AWG‡	Typical Weight (Grams)	Resistance Range† (Ohms)	Max. Wkg. Volts RMS
994-15A	14	2.00	.394	20	13	0.1-243K	1100

†For closer tolerances than 1%, minimum value is I ohm.
‡AWG 20=.032"

OHMITE MANUFACTURING COMPANY
3601 Howard Street, Skokie, Illinois 60076

TYPE 994 COMMERCIAL, HIGH STABILITY, (TABLE VII)

Standard Tolerance 3%

Tolerances to 0.25% Available

Type 994 units feature long term stability and the Series 99 low temperature coefficient of resistance (T.C.)—See Table V.

Stability: Type 994 resistors, on a 2000 hour, cyclic, load-life test (1½ hour on, ½ hour off) have less than ±2%△R. **Standard Tolerance** for Type 994 resistors is ±3%. However, tolerances to ±0.25% are available on order.

TABLE V—SERIES 99 T.C. in ppm/°C

Ohmite Types 991, 994, 995			MIL-R-26D	
Resist. Range Ohms	Temp. Range +25°C to +350°C	Temp. Range −55°C to +25°C	Resist. Range Ohms	Temp. Range −55°C to +350°C
less than 1	0±100	0±100		
1 to 10	0±50	0±80	less than 20	0±400
10 and above	0±30	0±60	20 and above	0±260

TABLE VI—STANDARD RESISTANCE VALUES for 3% and 5% Tolerances

See Catalog 100 or 30 for listing of stock values in 1½, 2¼, 3¼, 5 and 11 watt sizes.

Values below are available in accordance with the ranges set forth in the Type 995 (commercial) and Type 991 (MIL-R-26) "Range" tables. Values are standard resistances from military standard MS-90178 except those indicated with an asterisk (*) which are additional commercial standards. Special resistances can be wound to order.

OHMS

.10	1.3	18	200	1300	*9000	68K
.11	1.5	20	220	*1400	9100	75K
.12	1.6	22	240	1500	10K	82K
.13	1.8	24	*250	1600	11K	91K
.15	2.0	*25	270	1800	12K	100K
.16	2.2	27	300	2000	13K	110K
.18	2.4	30	330	2200	*14K	120K
.20	2.7	33	*350	2400	15K	130K
.22	3.0	*35	360	*2500	16K	150K
.24	3.3	36	390	2700	*17K	160K
.27	3.6	39	*400	3000	18K	180K
.30	3.9	*40	430	3300	20K	
.33	*4.0	43	*450	*3500	22K	
.36	4.3	47	470	3600	24K	
.39	4.7	*50	*500	3900	*25K	
.40	*5.0	51	510	*4000	27K	
.43	5.1	56	560	4300	30K	
.47	5.6	62	*600	*4500	33K	
.50	6.2	68	620	4700	*35K	
.51	6.8	75	680	*5000	36K	
.56	7.5	82	*700	5100	39K	
.62	8.2	91	750	5600	*40K	
.68	9.1	100	*800	*6000	43K	
.75	10	110	820	6200	*45K	
.82	11	120	*900	6800	47K	
.91	12	130	910	*7000	*50K	
1.0	13	150	1000	7500	51K	
1.1	15	160	1100	*8000	56K	
1.2	16	180	1200	8200	62K	

TABLE VII—TYPE 994, HI-STABILITY

3% Tolerance—Tolerances to 0.25% Available

Ohmite Style	Rated Watts @25°C	Dimensions (inches) Length ±.015	Dia. +.031 −.000	Leads 1½" AWG ‡	Typical Weight (Grams)	Resistance Range† (Ohms)	Max. Wkg. Volts RMS
994-1A	1.5	.422*	.125*	24	0.4	0.1 to 6650	
994-2A	2.25	.375	.188	20	0.8	0.1 to 6490	85
994-3A	3.25	.547	.203	20	1.3	0.1 to 22,100	190
994-5A	6.5	.922	.312	20	3.6	0.1 to 80,600	460
994-5B	5	.938	.203	20	2.0	0.1 to 53,600	500
994-7A	9	1.218	.312	20	4.5	0.1 to 118,000	670
994-10A	11	1.781	.312	20	6.9	0.1 to 187,000	1100

*Tolerance +.015, −.005

†See "Standard Resistance Values," Table VI for 3% tolerance; Table VIII for closer tolerances.

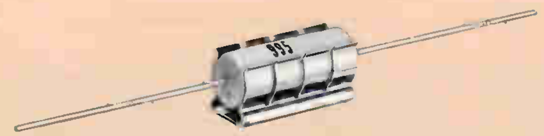
‡AWG 20 = .032" AWG 24 = .020"

TABLE VIII STANDARD RESISTANCE VALUES FOR THE 10 TO 100 DECADE* for 1.0%, 0.5%, 0.25% Tolerances

10.0	14.7	21.5	31.6	46.4	68.1
10.2	15.0	22.1	32.4	47.5	69.8
10.5	15.4	22.6	33.2	48.7	71.5
10.7	15.8	23.2	34.0	49.9	73.2
11.0	16.2	23.7	34.8	51.1	75.0
11.3	16.5	24.3	35.7	52.3	76.8
11.5	16.9	24.9	36.5	53.6	78.7
11.8	17.4	25.5	37.4	54.9	80.6
12.1	17.8	26.1	38.3	56.2	82.5
12.4	18.2	26.7	39.2	57.6	84.5
12.7	18.7	27.4	40.2	59.0	86.6
13.0	19.1	28.0	41.2	60.4	88.7
13.3	19.6	28.7	42.2	61.9	90.9
13.7	20.0	29.4	43.2	63.4	93.1
14.0	20.5	30.1	44.2	64.9	95.3
14.3	21.0	30.9	45.3	66.5	97.6

*The table lists values only from 10.0 to 97.6 ohms. However, the same progression of numbers continues through successive or preceding decades. Ohmite can, of course, supply intermediate resistance values.

MOUNTING CLIPS



Uniform shape and consistent dimension of Series 99 resistors, permits them to be conveniently mounted in clips. If the clip is on a metal surface (equivalent to 0.040" aluminum, 1.5 square inches per watt) the wattage capability of the resistor can increase by as much as 100%. Holes in the clip base permit fastening to chassis by means of machine screws, eyelets or rivets. Clip, hole and mounting center dimensions are given in Table IX at right.

TABLE IX—STOCK CLIPS FOR SERIES 99 RESISTORS

Resistor Style Suffix	Clip Stock No.	Clip Length	Clip Width	Clip Height	No. of Holes	Hole Ctrs.	Hole Dia.
— 1A	5900	.40"	.150"	.250"	1	.....	.071"
— 2A	5902	.35"	.217"	.275"	2	.156"	.071"
— 3A	5904	.50"	.257"	.319"	2	.250"	.093"
— 5A	5905	.90"	.333"	.377"	2	.500"	.093"
— 5B	5906	.90"	.237"	.284"	2	.400"	.103"
— 7A	5907	1.20"	.333"	.375"	2	.600"	.103"
—10A	5908	1.75"	.333"	.377"	2	.800"	.103"

TABLE II—CYCLIC LOAD-LIFE TEST SUMMARY ON TYPE 995 RESISTORS AT ORIGINALLY RATED WATTAGE‡

Ohmite Style	Originally Rated Watts at 25°C	Total Number of Units†	Total Unit Hours "On-Time"	"On-Time" All Groups 2000 Hrs. Av. % ΔR	7500 Hrs. Av. % ΔR
995-1A	1	507	3,802,500	0.603	0.786
995-3A	3	871	6,532,500	0.875	1.317
995-5A	5	407	3,052,500	0.655	0.766
995-5B	5	586	4,395,000	1.744	2.607
995-10A	10	491	3,682,500	0.782	1.048
ALL		2862	21,465,000*	0.958	1.363

*Equal to 28,620,000 total unit-hours of test (cyclic: 1½ hours on, ½ hour off).
†See Table III for breakdown of test groups by resistance value.
‡Important: See paragraph "Life-Test Proven" in narrative below

alloy on a ceramic core. Axial type terminal leads and the resistance wire are both welded to metal end caps which fit snugly over the core ends.

Permanent Resistor Markings: Identification markings are vitreous and are applied using an "ink" composed of ceramic compounds. The markings are fired into the molded vitreous enamel coating and become a permanent and integral part of the resistor. They resist abrading, standard cleaning solvents, 1500°F temperatures (see cover). Extreme overloads that may burn out the resistor winding WILL NOT obliterate the markings which can be conveniently read for reordering.

Ratings: Wattage ratings are based on a maximum hot spot temperature of 350°C at 25°C ambient.

Leads: Standard leads are solder-dip coated for soldering; furnished bare for welding, or gold plated on special order.

Low Resistance Measurements: For values of 20 ohms and less, resistance measurements are made at a point on each lead ⅜″ ± 1⁄16 from body of resistor. For all values of resistance 10 ohms and below, it is advisable to use Kelvin Bridge technique to eliminate errors due to lead and contact resistance.

NON-INDUCTIVE versions of Series 99 resistors can be supplied to order. Inquire of factory.

LIFE-TEST PROVEN: 28,620,000 unit-hours of testing have established the merit of Series 99 construction. Table II summarizes these tests which are still proceeding. Table III provides a breakdown of the resistance values used in each of the test groups listed in Table II. These test results have been obtained from many experimental lots of resistors representing different constructional materials and manufacturing processes. These resistors were produced, tested and evaluated for developmental purposes which ultimately determined our present production practices. Hence, while the % ΔR values given should not be specified as design or performance

TABLE III—PERCENTAGE DISTRIBUTION BY RESISTANCE VALUE OF TOTAL NUMBER OF TEST RESISTORS IN EACH STYLE

Resistance Values in Ohms	995-1A	995-3A	995-5A	995-5B	995-10A
1	25.2		9.8	24.6	
1 & 2.5		22.3			
18				7.6	
1 & 25					27.7
25	8.9		11.1		
100 & 195	16.8				
340		8.2			
390	17.8				
400 & 560		11.3			
610	8.7				
500 & 880				16.5	
800 & 1085		20.9			
1540		4.0			
935 & 1800			23.1		
1870				16.7	
2375	15.2				
2500 & 4600					20.2
3600 & 3700			22.3		
2900				7.4	
4000	7.5		10.6		
7000		21.1			
9000					19.8
10,000 & 11,100		12.3			
11,100				15.6	
12,400					10.0
19,000				4.5	
23,000			18.4		
25,000				6.9	
38,000			4.7		
58,000					16.3
92,000					6.1

limits, they do serve as an excellent guide.

More typical ΔR data is presently being collected as part of another test program in which samples are being taken from standard production lots. Data will be available after sufficient time has elapsed. Based on the information in these tables *all Series 99 resistors will show less than 5% change in resistance over 2,000 hours of cyclic testing* (1½ hours "on", ½ hour "off"). Type 991, however, will display less than 3%ΔR and Type 994, less than 2%ΔR.

Outstanding Moisture Resistance: Series 99 resistors, which meet the requirements of MIL-R-26 will withstand the 10-day MIL-R-26 moisture-resistance test AFTER 2000 hours of cyclic load-life at full rated wattage.

"LOT CONTROL" ASSURES QUALITY

Series 99 resistors are manufactured in accordance with a "lot control" technique by which the manufacturing "history" of the resistor is always on record. Identification of individual lots of resistors is maintained throughout all the manufacturing processes. As a result, the details of the materials used, process procedures, quality control checks and testing, can always be associated with a "lot number" which actually appears on the resistor. Thus, the performance of a resistor can be related to the peculiarities of its manufacture and its constituent materials to achieve a program of continuous product improvement!

RESISTOR TYPES

TYPE 995, COMMERCIAL POWER APPLICATIONS, (TABLE I)

Ratings on this commercial type were increased over those shown in previous bulletins when the impressive capability of the Series 99 line was realized. Table II (page 3) shows the previous ratings which were used to obtain the load-life data in this table and table III.

Standard tolerance for Type 995 units is ±5% for values 1 ohm and above; ±10% for values below 1 ohm. For tolerances to ±0.25%, consult factory. **Low temperature coefficient**—See Table V, page 5.

TYPE 991 FOR MILITARY APPLICATIONS

This type meets the requirements of MIL-R-26D, Styles RW67V, RW68V and RW69V (350°C max. hot spot.) These units meet and exceed the required 1000 VAC V-block dielectric-strength test, the 100 megohm insulation-resistance test, and surpass the stability requirements of ±3%ΔR on the 2000 hour cyclic load-life test. The low TC of Series 99 units far surpasses the requirements of MIL-R-26D (refer to table V on page 5.) Standard resistance tolerance is ±5% for values 1 ohm and above; for values below 1 ohm, ±10%; other tolerances can be supplied. Ohmite can supply these resistors in the now obsolete Char. G (275°C hot spot); also obsolete styles RW57, RW58 and RW59 Char. G or V can be supplied.

TABLE IV—TYPE 991 RESISTORS for MIL-R-26D

"V" Char.				Dimensions			
Ohmite Style	MIL* Style	Rated Watts @25°C	Ohms Range†	Length ± .015	Dia. + .001 − .000	Leads 1½ AWG††	Typical Weight (grams)
991- 3A	RW69V	3	0.1-910	.547	.203	20	1.3
991- 5A	RW67V	6.5	0.1-3600	.922	.312	20	3.6
991-10A	RW68V	11	0.1-8200	1.781	.312	20	6.9

*If required, can be supplied as Char. G (275°C. max. hot spot); also as styles RW59, RW57, and RW58, Characteristics G or V. These styles are not listed in D revision.
†See "Standard Resistance Values," Table VI for "V" Char., 5% tolerance.
††AWG 20 = .032".

obsolete ?
12/70

OHMITE

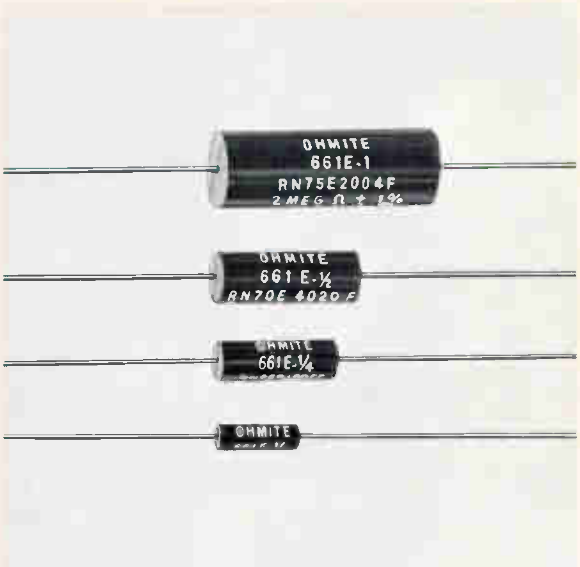
SERIES 66

MAY 6 1968

METAL FILM PRECISION RESISTORS

Available *ONLY* in Lowest MIL Specified T.C.

0±25ppm/°C . . . Over Operating Range of −55°C to +175°C



- ✶ Long Term Load-Life Stability
- ✶ Superior High Frequency Characteristics
- ✶ Negligible Noise Level
- ✶ Molded Protective Coating
- ✶ Standard Rating at 125°C —Double Wattage at 70°C
- ✶ Exceeds Characteristic E of MIL-R-10509E
- ✶ Precision Tolerances to 0.1%
- ✶ Matched TC's and Tolerances

OHMITE MANUFACTURING COMPANY
3601 Howard Street • Skokie, Illinois 60076

BULLETIN 110A

OHMITE

SERIES 66 METAL FILM RESISTORS

Ohmite's new line of metal film resistors—SERIES 66 RESISTORS—culminate an intensive program dedicated to the development *of the highest quality metal film resistors available to industry!* Research on these units has concentrated on goals of a standard low temperature coefficient of resistance, superior load-life stability and outstanding high-frequency characteristics. As a result, Series 66 resistors have only the lowest specified (per MIL-R-10509E) T.C. —0±25ppm/°C—as well as stability and low noise level comparable to precision wirewounds!

In Series 66 resistors, quality and performance are offered which far surpass that of resistors made with other types of film elements. They provide industry with units that may be confidently relied upon for accuracy, for operation in very high ambients and in high-frequency or high-gain circuits where low reactance and low noise level are mandatory. They are designed to exceed the requirements of MIL-R-10509E, Styles RN60E, RN65E, RN70E and RN75E.

TABLE I, TYPE 661 METAL FILM RESISTORS

Ohmite Style	MIL Style	Watts @ 125°C†	Volts (max)	Dimensions: Lgth. ±.015	Dimensions: Dia. ±.010	Leads 1½" AWG*	Min. Ohms	Max. Ohms
661E-⅛	RN60E	⅛	250	.406	.130	22	309	499K
661E-¼	RN65E	¼	300	.594	.203	22	402	1MEG
661E-½	RN70E	½	350	.719	.261	20	402	1MEG
661E-1	RN75E	1	500	1.105	.395	20	365	2MEG

*22 AWG (.025 ±.002) 20 AWG (.032 ±.002) † Double wattage rating at 70°.

Construction: The resistance element is a film of special non-noble metal alloy vacuum-evaporated onto a ceramic core of special composition and exceptional surface finish. Contact to the film is achieved with gold terminal bands fired onto the core ends. Gold-plated end-caps are pressed over the core ends and leads are butt-welded to the caps. The assembly is covered with a special protective resin and completed with a molded coating. Film, core, caps and coating are matched to provide a stable, moisture-resistant component.

Tolerance: Standard tolerance is ±1.0%; tolerances to ±0.1% are available. Consult factory for special requirements.

Leads: Standard leads are nickel, solder-dip coated for soldering; furnished bare for welding or gold-plated on special order.

Temperature Coefficient of Resistance (T.C.): Available only in 0±25ppm/°C ("E" characteristic) over the range of —55°C to +175°C.

Wattage Rating: Standard rating at 125°C. Derates linearly to "0" watts at 175°C. *Ratings double at 70°C ambient!*

Frequency Characteristics, Load Life and Noise Characteristics: See graphs and tables. Note: Load life test results have been obtained from many experi-

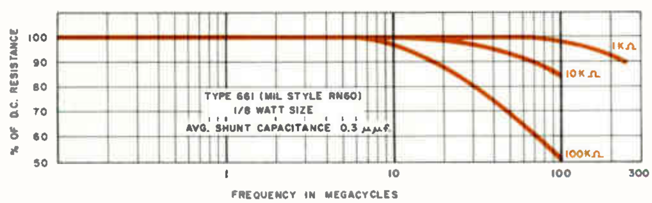
TABLE II, TYPICAL TEST DATA FOR SERIES 66 RESISTORS* . . . . . .

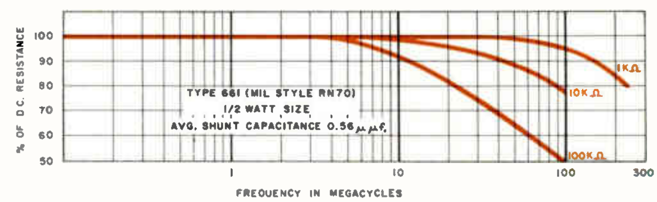
TESTS		MIL Requirements	Avg. of All Tests	661E-⅛/RN60E, ⅛ W, 309Ω Avg.†	309Ω Range	499KΩ Avg.†	499KΩ Range	661E-¼/RN65E, ¼ W, 402Ω Avg.†	402Ω Range	348KΩ Avg.†	348KΩ Range	1 MEGΩ Avg.†	1 MEGΩ Range
T.C. in ppm/°C	@−55°C	25	7.93	9.1	−8.0 to −10.7	8.8	−5.1 to −12.5	5.6	−.5 to −12.0	2.3	+.3 to +5.8	4.4	−.1 to −8.7
T.C. in ppm/°C	@+175°C	25	17.79	15.9	+14.8 to +18.2	19.5	+10.5 to +23.7	23.3	+21.1 to +24.9	20.8	+13.0 to +25.0	18.6	+15.1 to +24.0
125° C Load Life @ 1000 Hrs.	% ΔR	±.5	.107	.097	−.017 to +.250	.080	−.002 to +.407	.145	+.014 to +.404	.088	+.051 to −.149	.062	+.049 to +.069
Temp. Cycling	% ΔR	±.25	.043	.018	0 to +.032	.049	+.040 to +.072	.029	−.003 to +.054	.041	+.022 to +.060	.042	+.024 to +.097
Low Temp. Operation	% ΔR	±.25	.028	.053	+.012 to +.135	.008	0 to +.014	.001	0 to +.004	.002	0 to −.006	.009	0 to −.013
Short Time Overload	% ΔR	±.25	.019	.031	0 to −.104	.009	0 to −.043	.001	0 to −.005	.001	0 to −.003	.006	−.003 to +.010
Terminal Strength	% ΔR	±.25	.003	.003	0 to −.007	.001	0 to +.002	.002	0 to −.005	.002	0 to +.005	.005	0 to +.010
Dielectric Withstand Volts	% ΔR	±.25	.005	.002	0 to −.012	0	0	.004	−.003 to −.005	.002	0 to +.008	.012	+.002 to +.039
Effect of Soldering	% ΔR	±.25	.013	.018	+.003 to +.035	.008	0 to +.022	.002	0 to +.002	.003	0 to −.015	.003	0 to −.006
Moisture Resistance	% ΔR	±.50	.058	.199	+.035 to +.432	.118	+.039 to +.222	.029	+.024 to +.034	.016	+.011 to +.017	.022	+.009 to +.039
Shock	% ΔR	±.25	.006	.008	−.004 to −.010	.002	0 to −.007	.010	+.007 to +.014	.003	0 to +.011	.002	0 to −.005
Hi-Freq. Vibration	% ΔR	±.25	.007	.003	0 to +.009	.006	0 to +.018	.011	−.005 to −.015	.005	0 to −.015	.014	+.002 to −.060

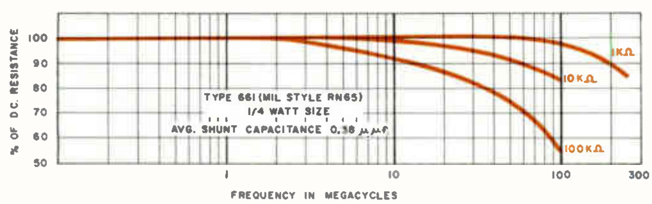
*440 units tested; 40 for each resistance value; 10 each test.
†Plus or minus signs have been disregarded in the computation of average values.

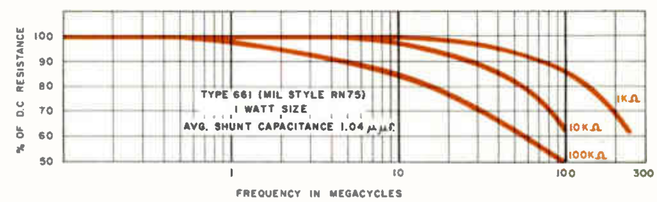
OHMITE MANUFACTURING COMPANY

TYPICAL FREQUENCY CHARACTERISTICS









mental lots of resistors representing different construction materials and manufacturing processes. These resistors were produced, tested and evaluated for development purposes which ultimately determined present production practices. Thus, the% ΔR values given here, while indicative of the general performance of this line, should not be specified as *THE* design or performance limits. However, it is evident that they are well within the limits specified by MIL-R-10509E.

TO ORDER, SPECIFY:

1. Ohmite style or MIL style (see Table I) for which you can compose type designation (see "Military Type Designations" following).

2. Temperature coefficient of resistance.

3. Resistance value in ohms (for military use, a value which conforms to the standard progression of military values—Table III—is preferred.

4. Resistance tolerance.

. . . (compared to requirements of MIL-R-10509E)

661E-½/RN70E						661E-1/RN75E					
½						1					
402Ω		237KΩ		1 MEGΩ		365Ω		237KΩ		2 MEGΩ	
Avg.†	Range	Avg.†	Range	Avg.†	Range	Avg.†	Range	Avg.†	Range	Avg.†	Range
4.4	+.3 to +10.6	4.9	+1.6 to −10.5	11.5	−7.9 to −13.6	15.7	−7.0 to −25.0	9.9	−1.0 to −19.0	10.6	−.6 to −20.0
20.1	+18.2 to +23.0	19.0	+14.0 to +24.0	14.0	+6.6 to +24.5	12.5	+7.0 to +15.0	12.5	+6.0 to +21.0	19.5	+15.3 to +24.3
.159	+.009 to +.360	.278	+.147 to +.387	.049	0 to +.129	.085	+.057 to +.117	.093	+.025 to +.172	.038	+.004 to +.115
.055	+.002 to +.126	.049	+.004 to +.113	.029	+.009 to +.049	.037	+.005 to −.189	.010	+.004 to +.021	.114	+.064 to +.194
.034	+.019 to +.054	.018	−.009 to −.026	.021	+.009 to −.060	.129	+.079 to +.186	.021	0 to −.089	.010	−.005 to −.015
.015	+.004 to +.069	.011	0 to −.077	.004	0 to −.010	.122	−.088 to −.151	.006	0 to −.009	.004	0 to +.009
.004	0 to −.015	.001	0 to +.008	.003	0 to −.010	.004	0 to +.011	.005	0 to −.009	.003	0 to −.010
.002	0 to −.016	.003	0 to −.002	.001	0 to −.002	.012	0 to +.038	.001	0 to −.005	.013	+.004 to +.024
.031	+.024 to +.034	.011	−.009 to −.022	.023	+.019 to +.029	.012	0 to +.057	.031	+.016 to +.050	.005	0 to −.020
.058	−.030 to −.065	.019	+.008 to +.029	.015	0 to −.050	.024	+.021 to +.032	.068	+.012 to +.337	.066	+.039 to +.084
.004	0 to −.005	0	0 to −.005	.016	0 to −.040	.004	0 to +.010	.004	0 to −.009	.019	+.005 to −.040
.001	0 to −.005	.002	0 to −.005	.003	0 to −.010	.003	0 to −.006	.005	0 to −.009	.022	+.005 to +.045

TABLE III.
STANDARD MIL RESISTANCE VALUES FOR THE 10 TO 100 DECADE†

for 1.0%(F), 0.5%(D), 0.25%(C), 0.1%(B)† Tolerances

*10.0	*14.0	*19.6	*27.4	*38.3	*53.6	*75.0
10.1	14.2	19.8	27.7	38.8	54.2	75.9
*10.2	*14.3	*20.0	*28.0	*39.2	*54.9	*76.8
10.4	14.5	20.3	28.4	39.7	55.6	77.7
*10.5	*14.7	*20.5	*28.7	*40.2	*56.2	*78.7
10.6	14.9	20.8	29.1	40.7	56.9	79.6
*10.7	*15.0	*21.0	*29.4	*41.2	*57.6	*80.6
10.9	15.2	21.3	29.8	41.7	58.3	81.6
*11.0	*15.4	*21.5	*30.1	*42.2	*59.0	*82.5
11.1	15.6	21.8	30.5	42.7	59.7	83.5
*11.3	*15.8	*22.1	*30.9	*43.2	*60.4	*84.5
11.4	16.0	22.3	31.2	43.7	61.2	85.6
*11.5	*16.2	*22.6	*31.6	*44.2	*61.9	*86.6
11.7	16.4	22.9	32.0	44.8	62.6	87.6
*11.8	*16.5	*23.2	*32.4	*45.3	*63.4	*88.7
12.0	16.7	23.4	32.8	45.9	64.2	89.8
*12.1	*16.9	*23.7	*33.2	*46.4	*64.9	*90.9
12.3	17.2	24.0	33.6	47.0	65.7	92.0
*12.4	*17.4	*24.3	*34.0	*47.5	*66.5	*93.1
12.6	17.6	24.6	34.4	48.1	67.3	94.2
*12.7	*17.8	*24.9	*34.8	*48.7	*68.1	*95.3
12.9	18.0	25.2	35.2	49.3	69.0	96.5
*13.0	*18.2	*25.5	*35.7	*49.9	*69.8	*97.6
13.2	18.4	25.8	36.1	50.5	70.6	98.8
*13.3	*18.7	*26.1	*36.5	*51.1	*71.5	
13.5	18.9	26.4	37.0	51.7	72.3	
*13.7	*19.1	*26.7	*37.4	*52.3	*73.2	
13.8	19.3	27.1	37.9	53.0	74.1	

†The table lists values only from 10.0 to 98.8 ohms. However, the same progression of numbers continues through successive or preceding decades. Ohmite can, of course, supply intermediate resistance values. The resistances for 0.1% tolerance may be ony value, but values conforming to the progression above, are preferred.

*These listings are 1.0% values. ALL listings are 0.5%, 0.25% and 0.1% values.

OHMITE ®

SERIES 66 METAL FILM RESISTORS

MILITARY TYPE DESIGNATIONS

Metal film precision resistors supplied under MIL-R-10509E carry military type designations such as

R N 6 0 E 2 4 3 1 F

Style (RN60) — Char. (E) — Resist. (2431) — Toler. (F)

The "STYLE" designation "RN60", is obtained from Table I which lists the range of items supplied by Ohmite under MIL-R-10509E. It indicates "high stability, fixed, film resistors" of a specific physical size.

The *CHARACTERISTIC* "E", specifies the temperature coefficient of resistance and other parameters such as maximum ambient temperature and maximum changes in resistance allowed with temperature cycling, moisture, overload, shock, vibration and other tests (see Table II).

The *RESISTANCE* in ohms is indicated by a four-digit symbol—the first three digits represent significant figures—the last specifies the number of zeros to follow. In the example, "2431" equals 2430 ohms. The letter "R" is used to represent a decimal point in which case the figures following the "R" become significant as for example 29.8 ohms is designated by "29R8." The military prefers that values be chosen from a series which follow the general progression of numbers in the table of "Standard Resistance Values" of military specification, MIL-R-10509E shown on page 3. Of course, Ohmite can produce any resistance value within the permissible range of each resistor (see Table I).

The resistance *TOLERANCE* is a single letter in accordance with the following code:

Symbol	Tolerance	Symbol	Tolerance
B	0.10%	D	0.5%
C	0.25%	F	1.0%

For special tolerances, consult factory.

TABLE IV, CYCLIC LOAD LIFE TEST† SUMMARY for SERIES 66 RESISTORS—ALL STYLES

(Groups Started at Different Times)

Ohmite Style	MIL Style	Total No. of Units	Total Unit-Hours	Failures (over ±2%)
661E-⅛	RN60	300	3,000,000	0
661E-¼	RN65	327	3,270,000	0
661E-½	RN70	363	3,630,000	1*
661E-1	RN75	874	8,740,000‡	3**
	Total	1864	18,640,000	4

†Full wattage at 125°C.—1½ hr. on—½ hr. off.
*1 unit opened at 5000 hr.
**1 unit showed 4.5%ΔR at 1000 hr. 1 opened at 6000 hr. 1 opened at 8000 hr.
‡For detailed breakdown of this group, see Table V.

TABLE V, ANALYSIS OF CYCLIC TEST TIME ON STYLE 661E-1 (RN75) RESISTORS*

(Total Units 874†—Total Unit-Hours 8,740,000)

Elapsed Hours as of 7-16-65	Total No. of Units	Total Unit-Hours	Avg. %ΔR	Max. %ΔR
1,000	874	874,000	0.11	0.58**
2,000	874	1,748,000	0.14	0.53††
5,000	874	4,370,000	0.22	0.61
10,000	874	8,740,000	0.31	1.94

*Tests commenced at different times for various groups of units in the total of 874.
†See Table IV for failures and analysis thereof.
**1 unit exceeded 0.5%.
††2 units exceeded 0.5%.

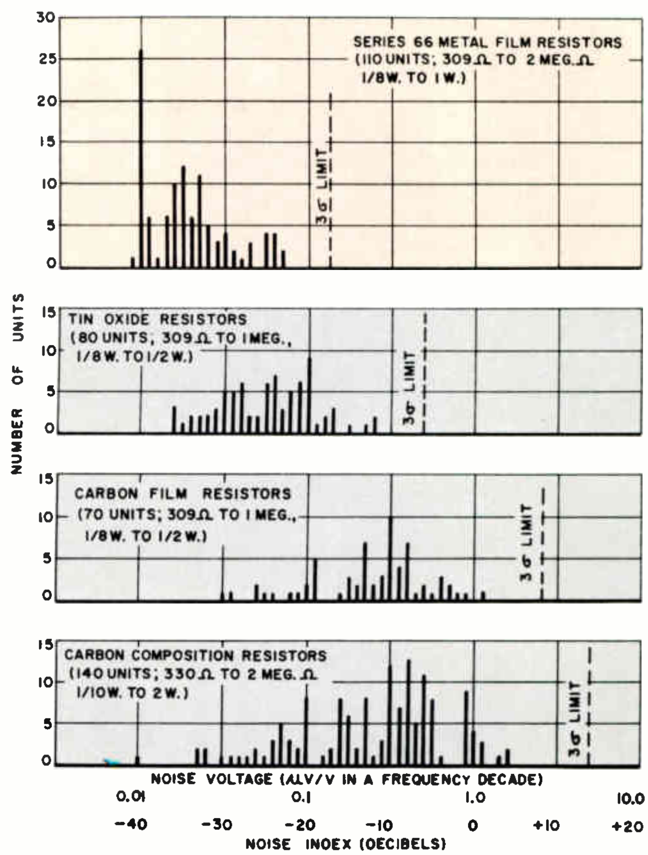
TABLE VI, DISTRIBUTION OF UNITS IN LOAD-LIFE TEST SUMMARY

For Style 661E-1 (RN75) 1-Watt Resistor

Resistance Value in Ohms	No. of Units in Groups Having Elapsed Time of 1000 Hrs.	2000 Hrs.	5000 Hrs.	10,000 Hrs.
70	8	8	8	8
200	12	12	12	12
365	82	82	82	82
410	20	20	20	20
552	229	229	229	229
825	13	13	13	13
832	20	20	20	20
1,000	10	10	10	10
2,770	10	10	10	10
2,910	10	10	10	10
3,010	10	10	10	10
10,000	22	22	22	22
13,000	16	16	16	16
20,000	25	25	25	25
152,000	11	11	11	11
202,000	17	17	17	17
*237,000	267	267	267	267
1,000,000	10	10	10	10
2,000,000	82	82	82	82
Total Units	874	874	874	874

*Critical Resistance

COMPARISON OF NOISE CHARACTERISTICS OF VARIOUS TYPES OF RESISTORS



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RESISTORS • RHEOSTATS • TAP SWITCHES • RELAYS • VARIABLE TRANSFORMERS
TANTALUM CAPACITORS • SOLID STATE CONTROLS • R. F. CHOKES

Printed in U.S.A.

RADIAL LEAD RESISTORS

OHMITE

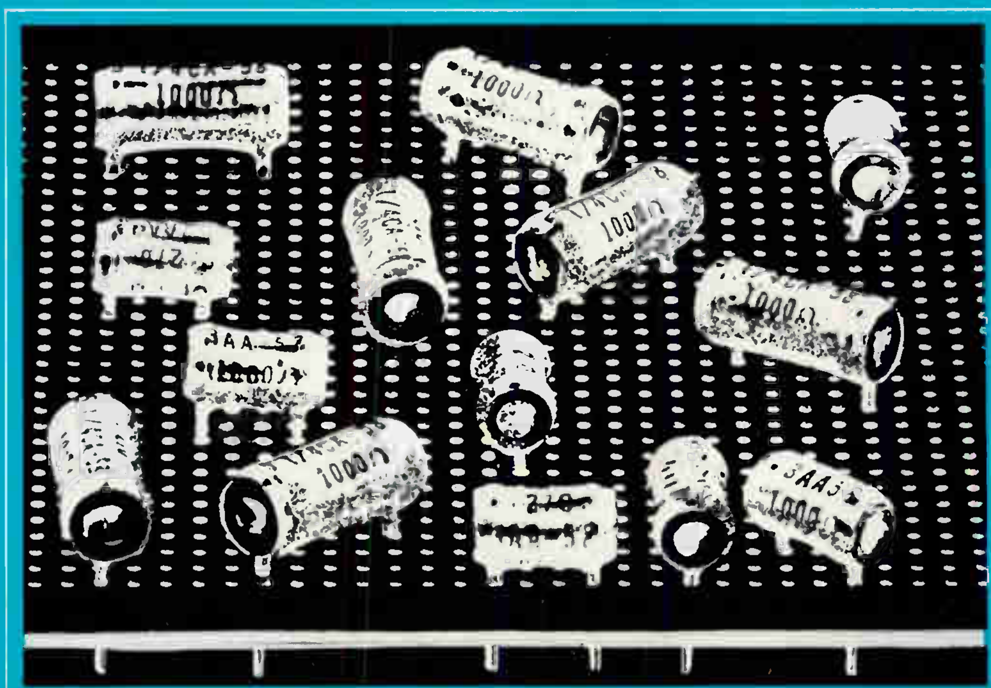
For Printed Circuit Boards

CLASS PC-58

CATALOG 120

January, 1970

Supersedes Data Sheet 100-1



OHMITE

Radial Lead Wirewound Resistors for Printed Circuit Boards

CLASS PC-58

3 WATT

5 WATT

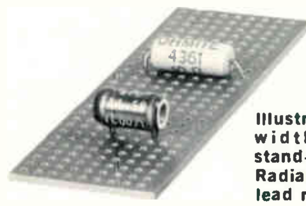


Illustration showing overall width savings and built-in stand-off provided by PC-58 Radial Lead vs. a typical axial lead resistor.

Increases productivity 28.1% Saves circuit board space.

If you are manually inserting axial lead resistors in printed circuit boards, it will pay you to examine the new Ohmite PC-58 Radial Lead wirewound resistor.

ADVANTAGES:

LABOR SAVING: Radial Leads eliminate cutting, bending, and forming of leads. Productivity is increased 28.1%. You achieve a 21.9% savings in labor cost. (Time Study Publication No. 163 available on request.)

SPACE SAVING: Radial leads reduce total length dimension required compared to axial lead types, increases packaging density possibilities.

POSITIVE POSITIONING: Built in stand-off automatically provides correct spacing between resistor and P.C. board.

COST SAVING: PC-58 resistors are priced lower than comparable axial lead types. This is in addition to savings in labor as explained above.

STANDARD SIZE: PC-58 Radial Leads fit standard .1 inch matrix boards with standard .046 inch diameter holes.

MARKINGS ALWAYS VISIBLE: Value and Ohmite code markings are always visible from the top of the PC-58. Eliminates time consuming orientation normally required of axial lead types.

CHOICE OF COATINGS: PC-58 resistors are available in ±5% tolerance with Vitreous Enamel (Type 270) for resistance values to 3300 ohms for 3-watt and to 6800 ohms for 5¼ watt or Ohmicone® silicone-ceramic (Type 470) for values over 3300 ohms and 6800 ohms for 3 and 5¼-watt sizes, respectively. For tolerances of ±3% and closer or for low T.C., specify Ohmicone® Type 474.

AVAILABILITY: Now standard PC-58 resistors are in stock at your local Ohmite authorized stocking distributor.

Made-to-Order PC-58 Resistors—Ordering and Dimensional Information

RATED WATTS @ 25°C.	OHMITE TYPE (Coating)	ORDERING CODE[1]	RESISTANCE RANGE (Ohms)	TOLERANCE (Standard Tolerance)	TEMPERATURE COEFFICIENT ppm/°C.	DIMENSIONS (Inches)				
						A ±.010	B ±1/32	C Max.	E Min.	L ±.006
3	270 (Vitreous Enamel)	270-3AA-58—(Res. Value)	.14 to 3300	±5%, 1Ω & above. ±10%, below 1Ω.	less than 260.	.300	.335	9/32	3/64	7/16
	470 (Ohmicone®)	470-3AA-58—(Res. Value)	.14 to 18K							
	474 (Ohmicone®)	474-3AA-58—(Res. Value)	.16 to 18K	±3%, 1Ω & above.[2] ±10%, below 1Ω.	0±20, 20Ω & above. 0±50, 1Ω up to 20Ω. 0±100, below 1Ω.					
5¼	270 (Vitreous Enamel)	270-5¼ CA-58—(Res. Value)	.20 to 6800	±5%, 1Ω & above. ±10%, below 1Ω.	less than 260.	.500	.375	5/16	1/32	5/8
	470 (Ohmicone®)	470-5¼ CA-58—(Res. Value)	.20 to 36K							
	474 (Ohmicone®)	474-5¼ CA-58—(Res. Value)	.23 to 36K	±3%, 1Ω & above.[2] ±10%, below 1Ω.	0±20, 20Ω & above. 0±50, 1Ω up to 20Ω. 0±100, below 1Ω.					

1. When ordering, add resistance value as a suffix to Ordering Code.
2. Tolerances to ±.05% are available on special order.

OHMITE

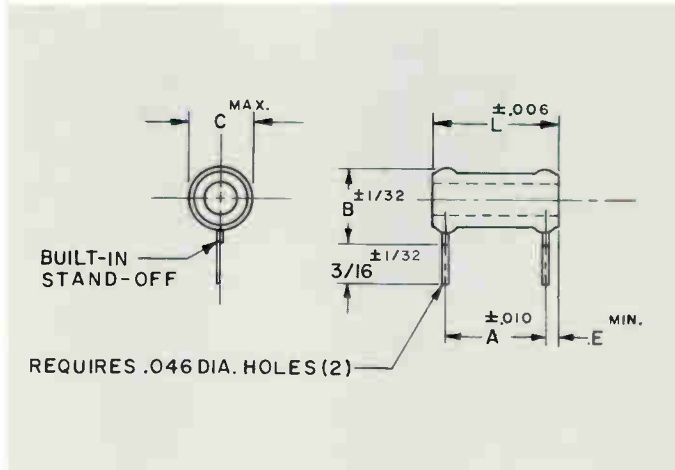
SPECIFICATIONS

MECHANICAL

Coating: Vitreous Enamel or Ohmicone® (silicone-ceramic), depending on Type.
Terminals: Radial, solder-dipped.
Markings: Ohmite Code and Resistance (Ohms) Value.
Weight: 3-Watt: .002 lbs.; 5¼ Watt: .003 lbs.

ELECTRICAL

Tolerance: Types 270 and 470: ±5% for 1 ohm and above; ±10% below 1 ohm.
Type 474: ±3% for 1 ohm and above. ±10%, below 1 ohm.
Tolerances to ±.05% available.
Wattage: 3-Watt, derated to 0 at 350°C
5¼-Watt, derated to 0 at 350°C
Resistance: 3-Watt: .14 to 18K ohms; 5¼-Watt: .20 to 36K ohms, depending on Type.
Types 270 and 470 available in 5% decade values; Type 474 in 1% decades.
Temperature Coefficient: Types 270, 470: less than 260 ppm/°C.
Type 474: 0±20 ppm/°C., 20Ω and above
0±50 ppm/°C., 1Ω up to 20Ω
0±100 ppm/°C., below 1Ω



STANDARD VALUES IN DISTRIBUTORS' STOCK

±5% Tolerance. Type 270 (Vitreous Enamel) and Type 470 (Ohmicone®)
Order using Catalog Number shown in tables below.

3-WATT

Free air rating thru 10K ohms.

Ohms	Catalog No.	Max. Amps	Ohms	Catalog No.	Max. Amps	Ohms	Catalog No.	Max. Amps
1.0	5800	1.73	120	5817	.158	1200	5834	.0500
1.5	5801	1.41	150	5818	.141	1500	5835	.0447
2.0	5802	1.22	200	5819	.122	1800	5836	.0408
2.4	5803	1.12	250	5820	.110	2000	5837	.0387
3.0	5804	1.00	270	5821	.105	2500	5838	.0346
4.0	5805	.866	300	5822	.100	2700	5839	.0333
5.0	5806	.774	330	5823	.0953	3000	5840	.0316
7.5	5807	.632	400	5824	.0866	4000	5841*	.0274
10.0	5808	.548	450	5825	.0816	4700	5842*	.0253
15	5809	.447	500	5826	.0775	5000	5843*	.0245
20	5810	.387	560	5827	.0732	5600	5844*	.0231
30	5811	.316	600	5828	.0707	6200	5845*	.0220
50	5812	.245	620	5829	.0696	7000	5846*	.0209
56	5813	.231	750	5830	.0632	7500	5847*	.0200
68	5814	.210	800	5831	.0612	9000	5848*	.0182
82	5815	.191	900	5832	.0577	10000	5849*	.0173
100	5816	.173	1000	5833	.0548			

*NOTE: These resistors are Ohmicone® Coated, Type 470.

5¼-WATT

Free air rating thru 15K ohms.

Ohms	Catalog No.	Max. Amps	Ohms	Catalog No.	Max. Amps	Ohms	Catalog No.	Max. Amps
1.0	5850	2.29	100	5864	.229	1800	5882	.0540
1.5	5850A	1.87	120	5865	.209	2000	5883	.0512
2.0	5851	1.62	150	5866	.187	2200	5883A	.0488
3.0	5851A	1.32	160	5867	.181	2500	5884	.0458
4.0	5851B	1.15	200	5868	.162	3000	5885	.0418
5.0	5852	1.02	220	5869	.154	3300	5885A	.0399
5.6	5852A	.968	250	5870	.145	3900	5885B	.0367
10.0	5853	.725	270	5870A	.139	4000	5886	.0362
15	5854	.592	300	5871	.132	4500	5887	.0341
18	5855	.540	330	5872	.126	5000	5888	.0324
20	5856	.512	350	5873	.122	5600	5889	.0306
22	5856A	.489	400	5874	.115	6000	5890	.0296
25	5857	.458	500	5875	.102	7500	5891*	.0265
30	5858	.418	510	5875A	.101	8200	5892*	.0253
40	5859	.362	560	5875B	.0968	9000	5893*	.0241
50	5860	.324	600	5876	.0935	9100	5893A*	.0240
51	5860A	.321	750	5877	.0837	10000	5894*	.0229
56	5860B	.306	800	5878	.0810	12000	5895*	.0209
68	5861	.278	1000	5879	.0725	15000	5896*	.0187
75	5862	.265	1200	5880	.0661	20000	5897*	.0152
82	5863	.253	1300	5881	.0635			

*NOTE: These resistors are Ohmicone® Coated, Type 470.

PRICES 3-WATT

Catalog No.	1/9	10/24	25/99	100/249	250/499	500/999
5800 thru 5833	$.54	$.46	$.38	$.32	$.27	$.25
5834 thru 5842	.58	.49	.41	.35	.29	.27
5844 thru 5849	.61	.52	.43	.37	.31	.29

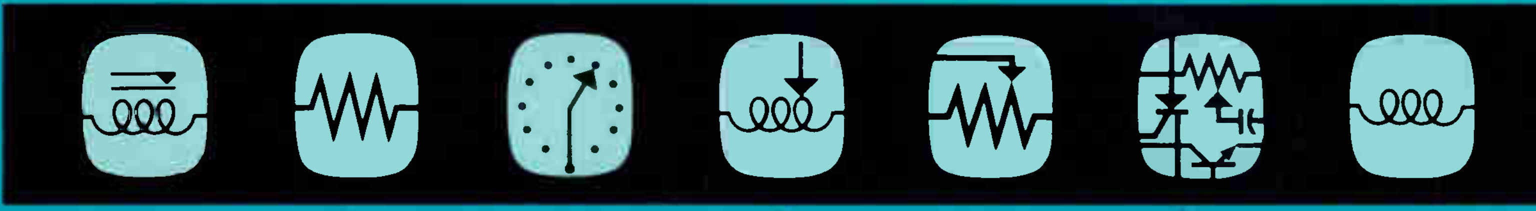
PRICES 5¼-WATT

Catalog No.	1/9	10/24	25/99	100/249	250/499	500/999
5850 thru 5879	$.58	$.49	$.41	$.35	$.29	$.27
5880 thru 5888	.61	.52	.43	.37	.31	.29
5889 thru 5894	.64	.54	.45	.38	.32	.30
5895 thru 5897	.71	.60	.50	.43	.36	.33

OHMITE

has the answer

in products for today's & tomorrow's circuitry



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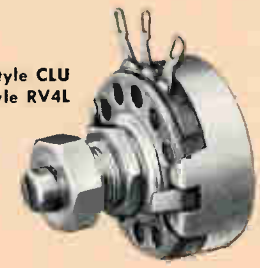
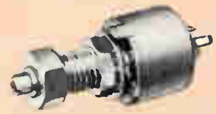
OHMITE

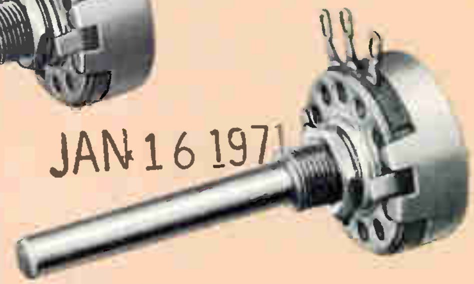


Style CLU
MIL Style RV4L

Style CMU
MIL Style RV4N



Type AS
MIL Style RV6L



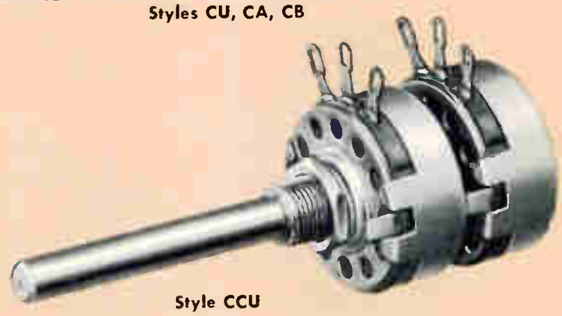
Styles CU, CA, CB

MOLDED COMPOSITION POTENTIOMETERS

INTRODUCING STYLE CMU WITH 7/8″ SHAFT

INCLUDES MIL-R-94 STYLES RV4N, RV4L, RV6L

SOLD ONLY THROUGH OHMITE DISTRIBUTORS



Style CCU

Exceptional reliability along with compactness are provided in Ohmite's molded composition potentiometers. They are available in a number of styles and find universal application as rheostats or potentiometers in high quality industrial or military devices. Type AB controls are nominally rated 2 watts at 70° C and are 1-5/32″ in diameter. Type AS is a miniature potentiometer only 1/2″ in diameter; it is rated 1/2 watt at 70° C.

In contrast to controls featuring thin, sprayed or painted films for the resistance element, the relatively thick, molded elements in Ohmite potentiometers provide smooth operation, long life and a very large safety factor permitting overloads of short duration to be safely absorbed. Noise-free, smoother operation is also enhanced with a molded composition contact. Positive trouble-free connections are assured with terminals that are molded directly into the control elements. For these reasons, Ohmite Type AB potentiometers will give excellent performance in excess of 100,000 cycles of operation and Type AS in excess of 50,000 cycles. Noise level is exceedingly low, actually decreasing with use of the unit.

In manufacture, the various elements are molded together at one time into a single, integral structure with no cracks or crevices to admit moisture. A metal cover sealed to the element, protects and electrically shields the internal parts. The sealing agent is a synthetic resin containing a non-mercurial fungicide helping to assure a dust-tight, splash-proof, fungus-resistant unit. The Type AS unit, in addition, incorporates a water-tight O-ring seal between the shaft and bushing.

The molding method makes it possible to predetermine the resistance-rotation characteristic of the resistance element to such a fine degree that the ideal curves are followed quite closely. *Modified logarithmic tapers furnished in Type AB units, consequently are not obtained with two or three linear sections, but with a single element embodying a smoothly graduated resistance change.*

Terminals of Type AB units are hot solder coated for easy soldering. Because of its smaller size and lower heat dissipation ability, the Type AS Miniature Potentiometer has specially plated terminals to assure easy soldering even after the unit has been in stock for some time.

SPECIFICATIONS

TYPES, SHAFTS AND STYLES — Type AB controls, 1-5/32″ dia., nominally rated 2 watts, are furnished in these styles: (1) Single control with 7/8″ slotted shaft, linear taper, Style CMU, MIL Style RV4N; (2) Single control with 2″ unslotted shaft, linear taper, Style CU; clockwise modified log taper, Style CA; counter-clockwise modified log taper, Style CB; (3) single control with locking-type shaft, linear taper, Style CLU, MIL Style RV4L; (4) dual control with 2″ shaft, linear taper, Style CCU.

Type AS miniature units, MIL Style RV6L, are furnished only in linear taper with locking-type shaft. Locking-type shafts are slotted for screw driver and employ a collet bushing and conical nut. See dimension diagrams reverse side.

WATTAGE RATINGS — Watt determinations are made at +70°C with units mounted on metal panel. Ratings: Single Type AB control, linear taper, full resistance in circuit—2.25 watts; 50% resistance—2.00 watts; 25% resistance—1.3 watts. Type AS Miniature Potentiometer—0.5 watts with full resistance in circuit.

VOLTAGE RATINGS AND INSULATION —Maximum continuous voltage across the resistance element or between current carrying parts and metal parts, under normal atmospheric conditions for Type AB unit—500 volts 60 cycle RMS; for Type AS Miniature unit—350 volts. High potential test for Type AB unit—1000v RMS for 1 second; for Type AS miniature unit—750v RMS for 1 second.

OPERATING TEMPERATURE RANGE—From −55°C to +120°C.

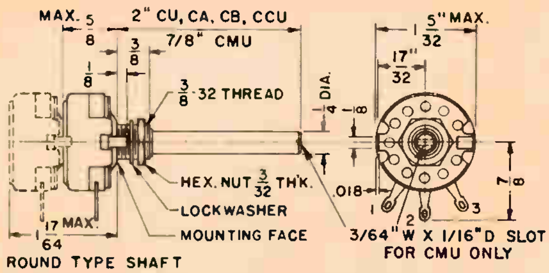
TEMPERATURE DERATING — Derate linearly from full rating at +70°C to "0" at +120°C for linear taper. For

OHMITE MANUFACTURING COMPANY
3601 Howard Street, Skokie, Illinois

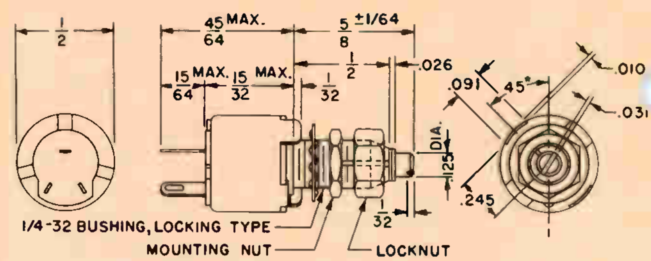
BULLETIN 156D

OHMITE

MOLDED COMPOSITION "POTS"



TYPE AB POTENTIOMETERS



TYPE "AS" 1/2 WATT POTENTIOMETER

STOCK "POTS" — MIL UNITS ARE STAMPED WITH MIL & COMMERCIAL DESIGNATIONS

	TYPE AB (1 5/32" Dia.)								TYPE AS (½" Dia.)	
Resistance Ohms Except As Noted Tol. ±10% except • ±20%	Single Unit 7/8" Shaft		Single Unit 2" Shaft			Locking		Dual	Miniature Locking	
	Style CMU Linear	MIL Designation	Style CU Linear	Style CA CW log	Style CB CCW log	Style CLU Linear	MIL Designation	Style CCU Linear	Linear	MIL Designation
50	CMU5001	RV4NAYSD500A	CU5001			CLU5001	RV4LAYSA500A			
100	CMU1011	RV4NAYSD101A	CU1011			CLU1011	RV4LAYSA101A		AS3601	RV6LAYSA101A
150	CMU1511	RV4NAYSD151A	CU1511			CLU1511	RV4LAYSA151A			
250	CMU2511	RV4NAYSD251A	CU2511			CLU2511	RV4LAYSA251A		AS3602	RV6LAYSA251A
350	CMU3511	RV4NAYSD351A	CU3511			CLU3511	RV4LAYSA351A			
500	CMU5011	RV4NAYSD501A	CU5011			CLU5011	RV4LAYSA501A	Resistance Shown is for Each Unit	AS3603	RV6LAYSA501A
750	CMU7511	RV4NAYSD751A	CU7511			CLU7511	RV4LAYSA751A			
1,000	CMU1021	RV4NAYSD102A	CU1021			CLU1021	RV4LAYSA102A		AS3604	RV6LAYSA102A
1,500	CMU1521	RV4NAYSD152A	CU1521			CLU1521	RV4LAYSA152A			
2,500	CMU2521	RV4NAYSD252A	CU2521			CLU2521	RV4LAYSA252A		AS3605	RV6LAYSA252A
3,500	CMU3521	RV4NAYSD352A	CU3521			CLU3521	RV4LAYSA352A			
5,000	CMU5021	RV4NAYSD502A	CU5021			CLU5021	RV4LAYSA502A		AS3606	RV6LAYSA502A
7,500	CMU7521	RV4NAYSD752A	CU7521			CLU7521	RV4LAYSA752A			
10,000	CMU1031	RV4NAYSD103A	CU1031		CB1031	CLU1031	RV4LAYSA103A	CCU1031	AS3607	RV6LAYSA103A
15,000	CMU1531	RV4NAYSD153A	CU1531			CLU1531	RV4LAYSA153A			
25,000	CMU2531	RV4NAYSD253A	CU2531		CB2531	CLU2531	RV4LAYSA253A	CCU2531	AS3608	RV6LAYSA253A
35,000	CMU3531	RV4NAYSD353A	CU3531			CLU3531	RV4LAYSA353A			
50,000	CMU5031	RV4NAYSD503A	CU5031		CB5031	CLU5031	RV4LAYSA503A	CCU5031	AS3609	RV6LAYSA503A
75,000	CMU7531	RV4NAYSD753A	CU7531			CLU7531	RV4LAYSA753A			
.1 meg.	CMU1041	RV4NAYSD104A	CU1041	CA1041		CLU1041	RV4LAYSA104A	CCU1041	AS3610	RV6LAYSA104A
.15 meg.	CMU1541	RV4NAYSD154A	CU1541			CLU1541	RV4LAYSA154A			
.25 meg.	CMU2541	RV4NAYSD254A	CU2541	CA2541		CLU2541	RV4LAYSA254A	CCU2541	AS3611	RV6LAYSA254A
.35 meg.	CMU3541	RV4NAYSD354A	CU3541			CLU3541	RV4LAYSA354A			
.5 meg.	CMU5041	RV4NAYSD504A	CU5041	CA5041		CLU5041	RV4LAYSA504A	CCU5041	AS3612	RV6LAYSA504A
.75 meg.*	CMU7542	RV4NAYSD754B	CU7542			CLU7542	RV4LAYSA754B			
1.0 meg.*	CMU1052	RV4NAYSD105B	CU1052	CA1052		CLU1052	RV4LAYSA105B	CCU1052	AS3613	RV6LAYSA105B
1.5 meg.*	CMU1552	RV4NAYSD155B	CU1552			CLU1552	RV4LAYSA155B			
2.0 meg.*	CMU2052	RV4NAYSD205B	CU2052			CLU2052	RV4LAYSA205B		AS3684	RV6LAYSA205B
2.5 meg.*	CMU2552	RV4NAYSD255B	CU2552	CA2552		CLU2552	RV4LAYSA255B		AS3614	RV6LAYSA255B
3.5 meg.*	CMU3552	RV4NAYSD355B	CU3552			CLU3552	RV4LAYSA355B			
5.0 meg.*	CMU5052	RV4NAYSD505B	CU5052			CLU5052	RV4LAYSA505B		AS3615	RV6LAYSA505B
Weight	.064 lb.		.084 lb.			.070 lb.		.123 lb.	.017 lb.	
Net Price	**$1.95**		**$1.95**	**$2.25**	**$2.25**	**$2.55**		**$5.85**	**$5.10**	

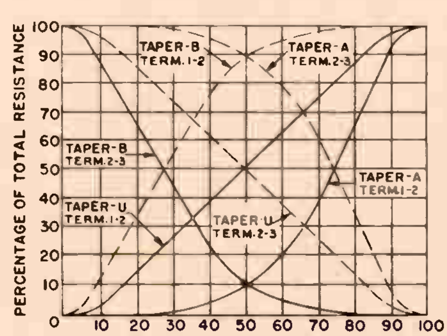
Switch CS-1 (Unmounted) for CMU, CU, CA, CB, CLU .... Net $.66

other tapers, multiply ratings obtained for linear taper by 0.5.

RESISTANCE RANGE — Stock values and styles shown in table. Maximum resistance at minimum resistance settings: for Type AB, 4 ohms or less; for Type AS, 15 ohms or less.

CONNECTIONS AND TAPERS — See "Types, Shafts and Styles" for available tapers. Resistance-rotation characteristics for linear and modified log tapers are shown in the graph. Terminal connections that provide these characteristics are shown for each curve. Note that the taper can be inverted (dotted lines) with respect to the direction of rotation simply by changing the connections.

HUMIDITY AND CORROSION — Temporary changes of resistance are less than 5% after exposure for 100 hours at 40°C to 95% relative humidity.



NOMINAL RESISTANCE-ROTATION CHARACTERISTICS

Meets the 200 hour salt spray corrosion tests of Military Specification QQ-M-151.

SWITCH — A SPST switch rated 2 amps at 125 volts or 10 amps at 10 volts can be supplied for attachment to the back of Type AB controls except Style CCU. The switch is "off" at the extreme c.c.w. shaft position.

ROTATION — Type AB: Without on-off switch 312° ±3°; with switch, 333° ±3°. Effective rotation in either case is 312° ±3°. Type AS: 295° ±5°.

Distributed By

HIGH QUALITY, BETTER SERVICE, AT A COMPARABLE PRICE.

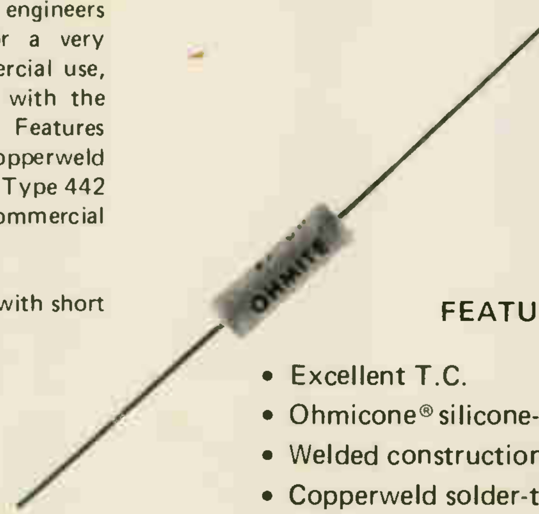
economy axial lead resistors for commercial applications

TYPE 442 wirewound axial lead resistors

~~[illegible]~~
~~[illegible]~~
Factory

New automated methods have enabled Ohmite engineers to design a quality axial lead resistor for a very economical price. Intended for broad commercial use, the Type 442 resistor is conformal coated with the famous Ohmicone® silicone-ceramic formula. Features such as welded construction, solder-coated copperweld leads and precision spaced windings make the Type 442 a true quality resistor at a price to fit commercial applications.

Type 442 resistors are available made-to-order with short lead times required.



FEATURES

- Excellent T.C.
- Ohmicone® silicone-ceramic coated.
- Welded construction for noiseless operation.
- Copperweld solder-tinned leads.
- Economy price.

SPECIFICATIONS

Construction: Resistance wire is wound on a steatite rod and is welded to the metal end caps for stable, noise-free connections. The wirewound unit is then coated with Ohmite's patented Ohmicone® silicone-ceramic coating.

Wattage Sizes: Standard sizes are rated 2, 3, 5 and 7 watts, at 25°C, derated linearly to 0 watts at 275°C. Wattage sizes of 1 and 10 are also available. Consult your local Ohmite office.

Tolerance: Standard tolerance is ±5% for one ohm and above, ±10% below one ohm. Tolerances to ±3% and ±1% are available. Contact your local Ohmite sales office.

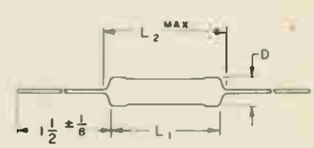
Temperature Coefficient: ±30 ppm/°C for 10 ohms and above; ±50 ppm/°C below 10 ohms. T.C.'s to ±20 ppm/°C are available on special order.

Ordering: Specify type number, resistance value and tolerance.

STANDARD TYPE 442 AXIAL LEAD RESISTORS

Standard tolerance is ±5%, 1 ohm and above; ±10% below 1 ohm.

OHMITE TYPE	RATING @25° (WATTS)	RESISTOR DIMENSIONS			LEADS AWG SIZE	RESISTANCE RANGE	MAX. VOLTS
		L_1 ±.062	L_2 max.	D ±.031			
442-2	2	.343	.406	.142	20	0.1 – 6.5K	85
442-3A	3	.500	.563	.187	20	0.1 – 17.6K★	200
442-5	5	.875	1.090	.312	18	0.1 – 71K	510
442-7	7	1.094	1.309	.312	18	0.1 – 118K	670



Wattage sizes of 1 and 10 available on special order.
★ Resistance to 21.1KΩ available (.218 dia. core) on special order.

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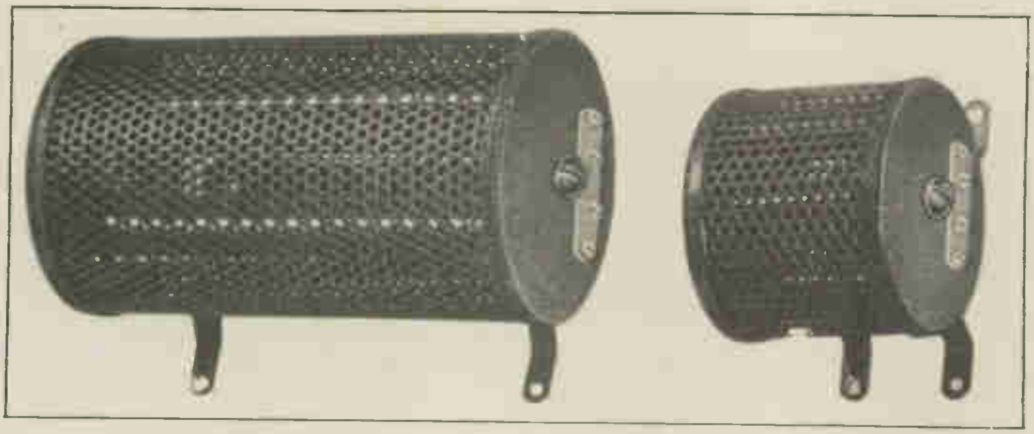
OHMITE DUMMY ANTENNA RESISTORS

MODELS D-101 AND D-251



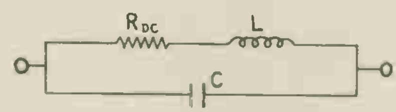
DESCRIPTION

GENERAL -- The Ohmite Model D-101 and D-251 Dummy Antenna Resistors have been designed to replace the D-100 and D-250 glass-enclosed type. The new units consist of a number of special vitreous enameled resistors connected in parallel in a concentric arrangement and mounted inside a perforated metal cage. The dummy antenna resistors feature constant R. F. resistance (within their recommended frequency range), low reactance, high wattage dissipation, and compactness. The actual d.c. resistance tolerance is ± 5%. A simple, accurate, and direct means of measuring R. F. power is thus made available to the radio amateur, experimenter and manufacturer and to operators of aviation, police and broadcast stations.

Although the outward appearance of the new Type D-101 and D-251 Dummy Antennas is radically different from that of the former glass-enclosed units, their frequency characteristics are substantially the same or, in some cases, considerably better than those of the D-100 and D-250 Dummy Antennas. In addition to this, the new D-101 and D-251 Dummy Antennas have the advantage of being composed of wire-wound vitreous enameled resistors which gives them ruggedness and durability and permits the high wattage rating inherent in a vitreous enameled resistor.

The new Type D-101 and D-251 Dummy Antennas represent the results of an extensive investigation and a wide variety of measurements involving all types of resistors to be used at high frequencies. They incorporate certain new design principles which hitherto have not been applied to power type resistors for operation at high frequencies.

PRINCIPLES OF DESIGN -- To have an understanding of the factors which determine the upper limit of frequency at which a wire-wound resistor may be used, it must be kept in mind that such a resistor, because of its physical construction has, in addition to its *desired resistance*, also a certain amount of *undesired residual inductance* and *undesired distributed capacitance*. These three quantities are shown below in the general equivalent circuit of an actual wire-wound resistor.



It should be noted that this circuit represents the actual impedance network of a resistor at any frequency. At a *particular* frequency the impedance of the resistor will, of course, consist of an effective series resistance and an effective series reactance as shown below.

It is quite apparent that the effective series reactance may be either inductive or capacitive depending upon whether the residual inductance or the distributed capacitance of the resistor is the predominating factor.

In the design of the component resistors which make up the new Type D-101 and D-251 Dummy Antennas, two important design considerations are responsible for the excellent frequency characteristics obtained. First, the residual inductance and distributed capacitance have been kept to a minimum, thereby making the natural resonant frequency as high as possible. Secondly, the D.C. resistance, residual inductance, and distributed capacitance have been *proportioned* in such a manner as to give the best possible response characteristics. As a result, a resistor has been obtained which has a minimum amount of effective series reactance and an essentially constant effective series resistance up to frequencies shown in the graphs. This resistor may be considered practically a "Non-Reactive Resistor".

FREQUENCY CHARACTERISTICS -- Graphs No.1 and 2 show the normalized effective series resistance,* the normalized effective series reactance* and the normalized impedance* as functions of frequency.

In evaluating the frequency characteristics shown in those graphs, it should be kept in mind that the effective series reactance is added *vectorially* to the effective series resistance in order to obtain the impedance. Consequently, a relatively large value of effective series reactance may be tolerated without resulting in an impedance which is greatly different from the D.C. resistance of the resistor.

In addition to the two graphs, Table No.I conveniently lists the upper limit of frequency at which the various Dummy Antennas may be used and gives other characteristics. These limits are based on the arbitrary assumption that a ± 10% impedance change (of its scalar value) is permissible.

MEASUREMENT OF R.F. POWER -- At frequencies lower than those indicated by a "†" in Table I both the effective series resistance and the impedance of the Dummy Antenna are within ± 10% of its D.C. resistance. Consequently, the current indicated by an R.F. ammeter in series with the Dummy Antenna is correct within ± 10% of its in-phase component and can, therefore, be used for the purpose of computing the power dissipated by the Dummy Antenna to a corresponding degree of accuracy. This power is then given by the relation $P = I^2 \times R$, where I is the current indicated by the R.F. ammeter and R is the D.C. resistance of the Dummy Antenna.

*These three normalized quantities signify those quantities in terms of the D.C. resistance of the resistor.

The Dummy Antennas can also be used for power measurements at higher frequencies, but certain corrections become necessary then. These corrections are also required in the frequency range mentioned above if a greater degree of precision is desired. The procedure for computing power is then as follows:

A. If it is desired to compute the power dissipated by the Dummy Antenna, this power can be obtained by the relation I^2XR where I is the current indicated by the R.F. ammeter and R is the effective series resistance at the operating frequency. The effective series resistance of the Dummy Antenna is obtained by multiplying the normalized effective series resistance at the operating frequency times the actual D.C. resistance of the Dummy Antenna.

B. If it is desired to dissipate a given amount of power in the Dummy Antenna, the current which should be indicated by the R. F. ammeter is obtained from the same relationship outlined in "A"

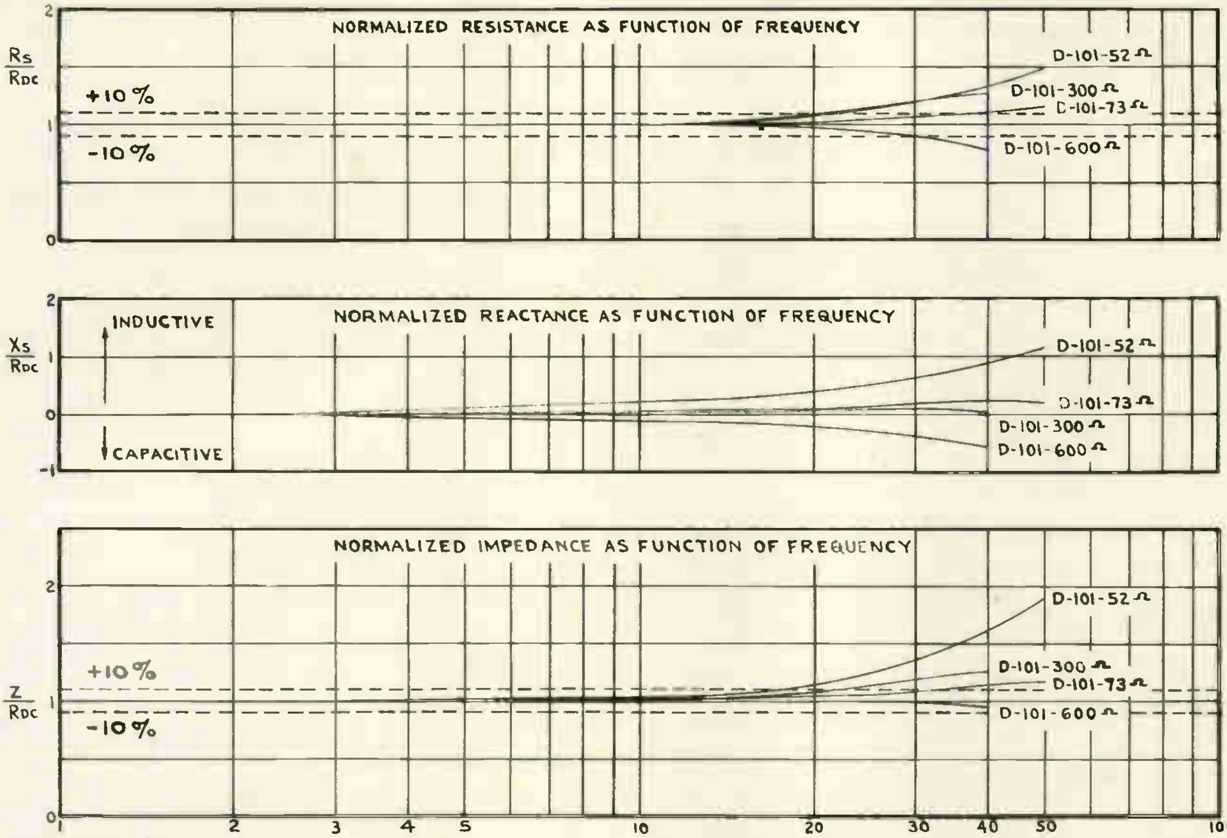
The handy Ohmite Ohm's Law Calculator can be used to find the power being dissipated simply and easily without any mathematical computation. The resistance of the Dummy Antenna is set above the OHMS arrow on the calculator by moving the slide to the proper value. The power in watts is then read directly on the WATTS scale on the calculator, above the R.F. ammeter current as found on the AMPERES scale. The calculator may be obtained by mailing 25¢ in coin or stamps.

TERMINALS -- *Early models* of the D-101 and D-251 were equipped with two types of terminations depending upon whether the unit was intended to be used in conjunction with a coaxial cable or with a parallel transmission line.

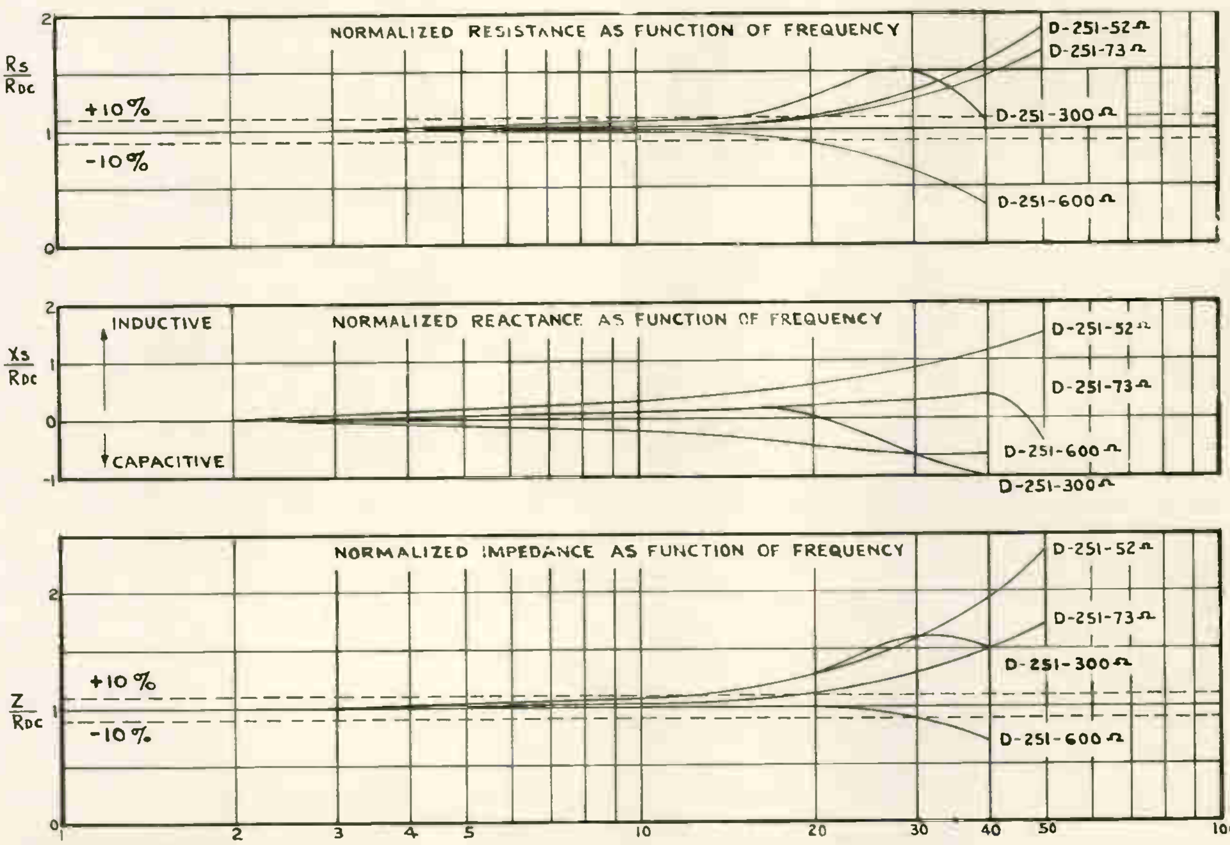
TABLE NO. I - FREQUENCY CHARACTERISTICS OF OHMITE DUMMY ANTENNAS

R_{dc} ------ D. C. Resistance of Dummy Antenna
R_s ------ Effective Series Resistance of Dummy Antenna
Z ------ Scalar Value of Impedance of Dummy Antenna

TYPE	D-101				D-251			
RESISTANCE	52 ohms	73 ohms	300 ohms	600 ohms	52 ohms	73 ohms	300 ohms	600 ohms
Maximum Frequency at which $R_s = R_{dc} \pm 10\%$	22 mc	38 mc	22 mc	† 31 mc	19 mc	21 mc	15 mc	† 19 mc
R_s at this frequency	1.10 R_{dc}	1.10 R_{dc}	1.10 R_{dc}	.90 R_{dc}	1.10 R_{dc}	1.10 R_{dc}	1.10 R_{dc}	.90 R_{dc}
Z at this frequency	1.18 R_{dc}	1.14 R_{dc}	1.10 R_{dc}	.99 R_{dc}	1.25 R_{dc}	1.13 R_{dc}	1.15 R_{dc}	1.00 R_{dc}
Maximum Frequency at which $Z = R_{dc} \pm 10\%$	† 18 mc	† 32 mc	† 22 mc	60 mc	† 13 mc	† 19 mc	† 13 mc	30 mc
R_s at this frequency	1.06 R_{dc}	1.07 R_{dc}	1.10 R_{dc}	.60 R_{dc}	1.03 R_{dc}	1.07 R_{dc}	1.08 R_{dc}	.64 R_{dc}
Z at this frequency	1.10 R_{dc}	1.10 R_{dc}	1.10 R_{dc}	.90 R_{dc}	1.10 R_{dc}	1.10 R_{dc}	1.10 R_{dc}	.90 R_{dc}



GRAPH NO. 1



GRAPH NO. 2

OHMITE MANUFACTURING COMPANY

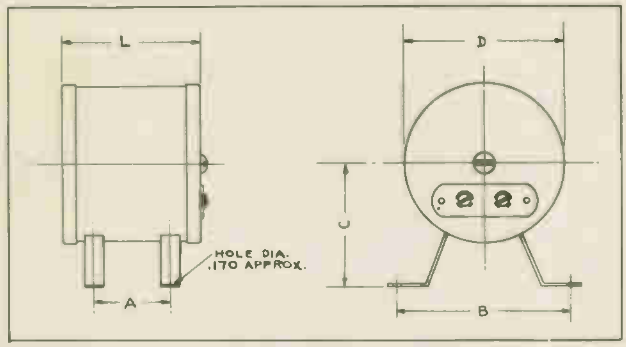
For use with a coaxial cable the unit was provided with an Amphenol Type 80 CT coaxial female chassis connector. The coaxial cable may be connected by means of the corresponding male cable connector. If, for some reason, the male is connector is not used, a soldering lug is provided, to which the coaxial cable shield may be connected. The center conductor of the cable may be terminated with a phone tip which can be inserted in the female cable connector. For use with a parallel transmission line the unit was provided with stand-off terminals on opposite ends of the cage.

Present models of the dummy antennas are equipped with a two-screw terminal strip made from high grade bakelite suitable for operation at high frequencies. On 600 ohm dummy antennas the cage is left floating. On dummy antennas of all other resistance values, the cage is connected to the left screw terminal. The use of a plain terminal strip was found desirable since a great variety of coaxial and other connectors are in use and it is impossible to have any other type of termination suitable for direct connections to all the various kinds and types of connectors.

DUMMY ANTENNAS FOR HIGHER WATTAGE APPLICATIONS (500 WATTS TO 5000 WATTS)

Ohmite Manufacturing Company is prepared to make specific recommendations for the construction of Dummy Antennas, in sizes ranging from 500 to 5000 watts, by means of parallel combinations of Non-Reactive Resistors to give the desired resistance in combination with the desired wattage rating. These recommendations, unless otherwise specified, are intended for use at Medium Frequencies (up to 3 Mc). It should be kept in mind that the selection of component resistors for such special Dummy Antennas is not merely a matter of calculating the ***combined resistance*** and ***combined wattage rating*** but involves consideration of the ***frequency characteristics*** of the component resistors as well.

In Table No. II a number of such recommended constructions are listed for special Dummy Antennas having various resistance values and possessing wattage ratings from 500 watts to 5000 watts. This table, of course, is intended to present only a few typical examples of a wide variety of such special Dummy Antennas. Upon receipt of the necessary technical information, recommendations will be made for the construction of a Dummy Antenna of the above type which will have the most favorable frequency characteristics, in combination with the specified resistance and power requirements.



NOTE: STOCK UNITS
D-101-52 & D-101-73
D-251-52 & D-251-73
ARE FURNISHED WITH
COAX CONNECTOR

STOCK NUMBER	DIMENSIONS (INCHES) A	B	C	D	L
D-101-52, D-101-73	1-1/2	3-1/2	2-3/8	3-5/32	2-23/32
D-101-300, D-101-600	2-3/4	3-1/2	2-3/8	3-5/32	4-7/32
D-251-52, D-251-73	3-1/8	3-7/8	2-1/2	3-23/32	4-19/32
D-251-300, D-251-600	5-1/8	3-7/8	2-1/2	3-23/32	6-13/16

STOCK NO.	WATTS	OHMS (± 5%)	NET PRICE
D-101-52	100	52	$12.00
D-101-73	100	73	12.00
D-101-300	100	300	8.00
D-101-600	100	600	8.00
D-251-52	250	52	16.00
D-251-73	250	73	16.00
D-251-300	250	300	16.00
D-251-600	250	600	16.00

Prices subject to change without notice.

TABLE NO. II

DUMMY ANTENNAS FOR MEDIUM FREQUENCIES

This table shows the quantity, the resistance, and the wattage rating of the component Non-Reactive Resistors which, when connected in parallel, will provide a dummy antenna of the desired resistance and wattage rating.

WATTAGE OF DUMMY ANTENNA	RESISTANCE OF DUMMY ANTENNA 50 OHMS	75 OHMS	100 OHMS
500	10 500 Ω 50 W	10 750 Ω 50 W	10 1000 Ω 50 W
1000	10 500 Ω 100 W	10 750 Ω 100 W	10 1000 Ω 100 W
1500	10 500 Ω 160 W	10 750 Ω 160 W	10 1000 Ω 160 W
3000	20 1000 Ω 160 W	20 1500 Ω 160 W	20 2000 Ω 160 W
5000	32 1600 Ω 160 W	32 2400 Ω 160 W	32 3200 Ω 160 W

RHEOSTATS 200

RHEOSTATS

CATALOG SEQUENCE 200

OHMITE

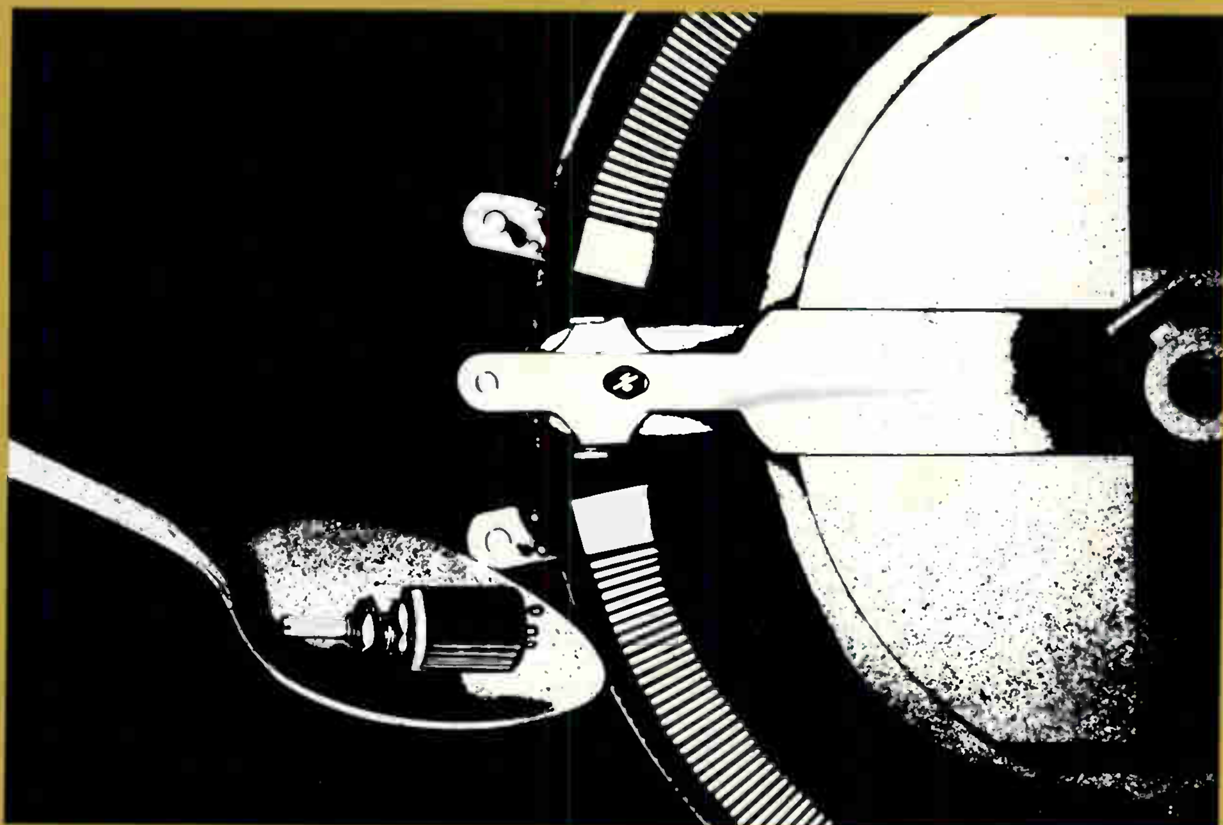
OHMITE

RHEOSTATS
POTENTIOMETERS

CATALOG 201

NOVEMBER, 1970

Supersedes Catalog 200,
Bulletins 201, 202, 203D, 204 & 205.



OHMITE

RHEOSTATS

ALL CERAMIC
CLOSE CONTROL
SMOOTH ACTION

When you turn the knob of an Ohmite Rheostat you experience an unmatched smoothness of action. This smooth action means much more than just good operating characteristics. It means smooth electrical control, the kind of control associated only with special laboratory type rheostats until the original Ohmite design was produced in 1930.

It means, too, that your Ohmite Rheostat is engineered for long life. This has been time-proved in performance in the products and laboratories of leading electrical manufacturers.

Ohmite rheostats have been in use in all parts of the world, in locations from lunar explorations to the depths of the oceans, testifying to their basic sound design. The all-porcelain vitreous-enameled construction originated by Ohmite has set the standard for such rheostats.

Ohmite rheostats are widely used for motor speed control — generator field control — arc-welding generator control — electronic tube control — lamp dimming — heater and oven control — variation of current and voltage — potentiometer applications — test apparatus — communications equipment — actually hundreds of different uses.

Ohmite manufactures the most widely used and extensive series of close control power rheostats available. There are twelve sizes ranging from 7.5 watts to 1000 watts, in fourteen models, in a wide range of resistances to provide the exact, most economical unit for every control need.

OHMITE

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OHMITE

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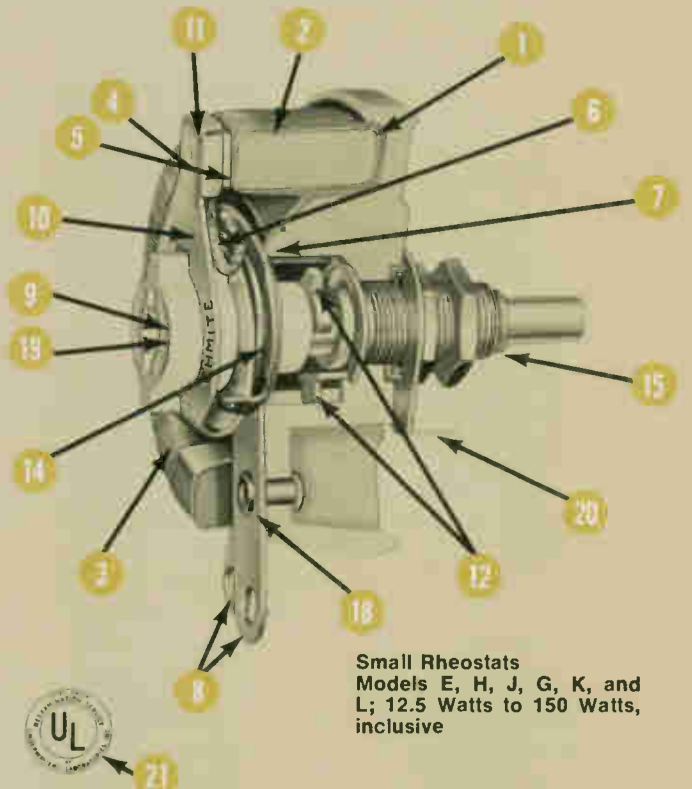
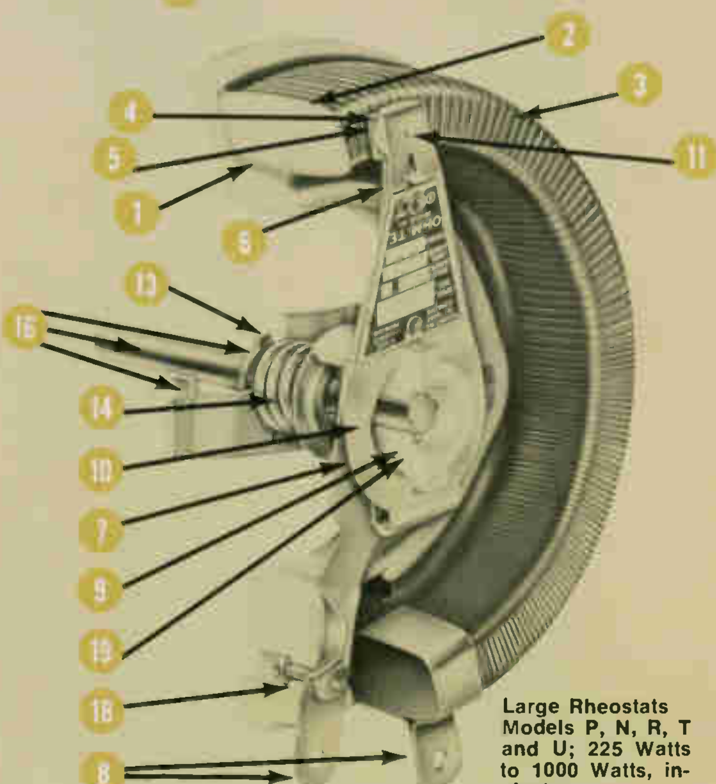


Small Rheostats
Models E, H, J, G, K, and L; 12.5 Watts to 150 Watts, inclusive



Large Rheostats
Models P, N, R, T and U; 225 Watts to 1000 Watts, inclusive

1. Vitreous enamel bonds the core and base together into one integral unit.
2. The wire is wound over a solid porcelain core and each turn is locked against shifting by vitreous enamel. Uniform or tapered winding.
3. Close graduation of control. Each turn of wire is a separate resistance step.
4. Large, flat surface upon which the contact brush rides.
5. Metal-graphite contact brush (varied to fit current and resistance) insures good contact with negligible wear on the wire.
6. Shunt pigtail of ample size carries the current directly to the slip-ring.
7. Large slip-ring of high current carrying ability minimizes mechanical wear and provides connection from the moving contact to the terminal.
8. Potentiometer Use. The rheostats are provided with three terminals so they can be used as potentiometers or voltage dividers.
9. High strength ceramic hub insulates the shaft and bushing from all live parts. Rheostats from 25 to 150 watts in size, have the live parts insulated to ground to meet the Underwriters' Laboratories 300 volt rating; 225 to 1000 watts to meet the 600 volt rating. These sizes will stand a 3000 volt AC breakdown test to ground. Breakdown test for 12½ watt model, 1000 volts AC; for 7½ watt model, 500 volts.
10. The contact arm is a long tempered steel spring which assures uniform contact pressure at all times. Cadmium plated for corrosion resistance.
11. Rounded pivot holds contact brush in flush-floating contact with wire.
12. **Models E, H, J, G, K and L.** Stops which are fastened to the shaft and keyed to the base, limit the rotation. Thus, no torsional strain is imposed on the contact arm on stopping.
13. **Models P, N, R, T and U.** Stop on shaft and stop nib on steel mounting plate limit the rotation. No torsional strain on contact arm on stopping.
14. Compression spring maintains uniform pressure and electrical contact between the slip-ring and centerlead at all times. Pressure here is independent of that at the contact brush.
15. **Models H, J, G, K and L.** Phosphor-bronze retaining ring takes end-thrust; ¼″ diameter steel shaft in brass bushing provides a wear-resistant, wobble-free bearing. Rheostats mount by ⅜″-32 threaded bushing and nut. Standard shaft has a flat (opposite to the contact) for set screw of knob.
    Models C and E have ⅛″ diameter shaft and ¼″-32 mounting bushing.
16. **Models P, N, R, T and U.** "Large" rheostats have ⅜″ diameter steel shafts, standard with flat for set screw of knob. Stop washer takes end thrust. Rheostats mount by means of two screws and tapped holes in mounting plate.
18. Center lead is securely fastened to the base.
19. Ohmite Rheostats have a ceramic core, base and driving hub. There is only ceramic and metal in the construction of Ohmite rheostats except for the Model C which includes a Teflon liner and Ohmicone coating.
20. **Models, C, E, H, J, G, K and L.** Non-turn washer has a projecting lug which fits into a hole in the panel and prevents the rheostat from turning out of position.
21. Ohmite Rheostat **Models H, J, G, K, L, P and N,** with uniform or tapered winding, when made without other additional features, are listed under the Underwriters' Laboratories Reexamination Service and are marked "Series A." Write for further information when special applications are involved.
22. Ohmite rheostats meet requirements of NEMA and EIA.
23. Complete series of military rheostats supplied per MIL-R-22, aircraft power rheostats per MIL-R-6749 and rheostats per other military specifications.
24. Rheostat temperature rise 300°C (540°F) maximum, above 40°C (104°F) ambient for all U.L. listed rheostats.

OHMITE

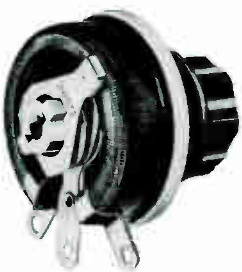
GUIDE TO CLOSE CONTROL RHEOSTATS

STANDARD — Popular values of all standard models are carried in stock as indicated on pages 9 through 13.

MADE-TO-ORDER — Intermediate, higher and lower resistance values than are listed as "standard" and assemblies with any number of additional features are available made-to-order. Contact your local Ohmite sales office for assistance.

Model	Watts	Diameter	Depth behind Panel	Standard Rheostats: Max. Panel Thickness	Standard Rheostats: Min. Total Ohms	Standard Rheostats: Max. Total Ohms	Special Resistance Range: Min. Total Ohms	Special Resistance Range: Max. Total Ohms	Page
C	7.5	.515"	7/8"	1/8"	10.0	5,000	10.0	5,000	9
E	12.5	7/8"	11/16"	1/8"	1.0	15,000	0.25	15,000	9
H	25	1 9/16"	1 3/8"	1/4"	1.0	25,000	0.21	25,000	10
J	50	2 5/16"	1 3/8"	1/4"	0.5	50,000	0.10	50,000	10
G	75	2 3/4"	1 3/4"	1/4"	0.5	10,000	0.15	50,000	10
K	100	3 1/8"	1 3/4"	1/4"	0.5	10,000	0.16	50,000	10
L	150	4"	2"	1/4"	0.5	10,000	0.25	50,000	10
P	225	5"	2 1/8"	1 1/4"	1.0	2,500	0.10	30,000	12
N	300	6"	2 3/8"	1 1/4"	1.0	2,500	0.15	50,000	12
R	500	8"	2 1/8"	1 1/4"	1.0	2,500	0.20	20,000	12
T	750	10"	3"	1 1/4"	1.0	2,500	0.25	15,000	12
U	1000	12"	3"	1 1/4"	1.0	2,500	0.32	20,000	12

WINDINGS



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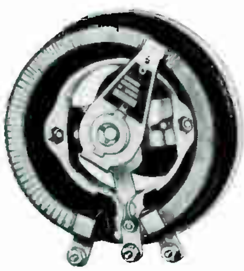

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OHMITE

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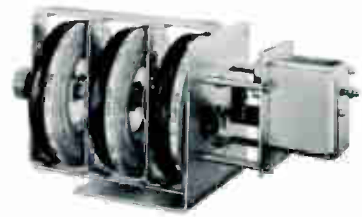

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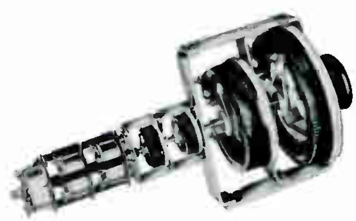

Tandem with
Tap Switches
As Required

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Adjustable Tap
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SELECTING A RHEOSTAT

OHMITE

STEP 1 DETERMINE RESISTANCE AND WATTS

OHM'S LAW

(a) $R = \frac{E}{I}$ or $I = \frac{E}{R}$ or $E = RI$

Ohm's Law, shown in formula form above, enables determination of the resistance when the required voltage and current are known. When the current and voltage are unknown, or the best values not decided on, at least two of the three terms in Ohm's Law must be measured in a trial circuit (see Engineering Manual Bulletin 1100).

Note that the maximum current to be determined is the current of the load before the rheostat resistance is inserted. On the other hand, the maximum resistance occurs with the minimum current.

(b) $W = I^2R$ or $W = EI$ or $W = \frac{E^2}{R}$

Power, in watts, can be determined from the formulas above, which stem from Ohm's Law.

Note that the rated wattage of a uniform wound rheostat is calculated using the maximum current and the total rheostat resistance. The Summation Watts are calculated instead for a taper wound rheostat as explained under "Tapered Rheostats", page 14.

SHORT-CUT METHOD

Use an Ohmite Ohm's Law Calculator (convenient slide-chart) or use Ohm's Law Chart in the Engineering Manual, Bulletin 1100. Set known values as explained on the Calculator, or Chart, and read the sought for OHMS, WATTS (or other terms).

CALCULATION METHOD

Using the Ohm's Law formulas given above, and explained in greater detail in the Engineering Manual, calculate the unknown values. How to conduct tests when a trial must be made of the actual apparatus is explained in the Manual.

STEP 2 POWER RATING OR PHYSICAL SIZE OF RHEOSTAT

General: Rheostat watt ratings are based on the condition that the moving contact is set so that all of the winding is in the circuit. This makes the condition the same as that of a fixed resistor (assuming a uniform rheostat winding) and we may then say that a rheostat operated at a constant wattage will attain a steady temperature which is determined largely by the ratio between the size (surface area) and the wattage dissipated. The temperature stabilizes when the sum of the heat loss rates (by radiation, convection and conduction) equals the heat input rate (proportional to wattage). The greater the rheostat area per watt to be dissipated, the greater the heat loss rate and therefore the lower the temperature rise.

FREE AIR WATT RATING

In general, for commercial rheostats, the relation of the "Free Air Watt Rating" of vitreous enameled rheostats to the physical size has been set at such a figure that: "When operated at their rated watts the temperature rise of the hottest spot shall not exceed 300°C (540°F) as measured by a thermo-couple, when the temperature of the surrounding air does not exceed 40°C (104°F). The temperature is to be measured at the hottest point on the embedding material of a rheostat mounted on a vertical metal panel in free, still air space with at least one foot of clearance to the nearest object, and with unrestricted circulation of air". This is in accordance with standards of the "National Electrical Manufacturers Association" (NEMA) and the "Underwriters' Laboratories".

Electronic Industries Association (formerly RETMA) standards provide for a maximum attained hot spot temperature of 340°C for rheostats of 100 watts or less and 390°C for rheostats of greater wattage. The reference ambient is 25°C.

Military Rheostat Specification MIL-R-22 provides for a maximum hot spot temperature attained (on the exposed winding) of 340°C for rheostats of 100 watts or less and 390°C for larger rheostats. The reference ambient is 25°C.

The temperature rise, with all resistance in the circuit, is not directly proportional to the wattage but follows the curves as shown in Fig. 1 and Fig. 2.

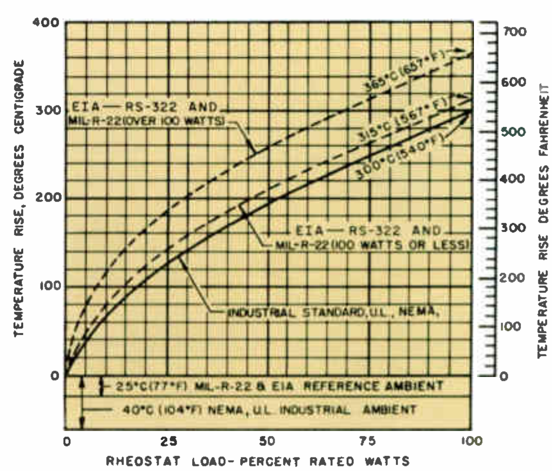


Fig. 1: Hot spot temperature rise of a rheostat for various specifications.

The temperature rise on a tapered rheostat does not exceed the rated maximum, but the location of the hot spot, for each position of the contact, depends on the taper design.

In the usual rheostat application, the current is reduced as the resistance is inserted in the circuit and so the operating temperature is much less than the maximum rated temperature. If the maximum current is actually carried as a constant value, the hot spot temperature builds up as the resistance is added and levels off at the maximum rated temperature starting at approximately 30% rotation.

CURRENT RATING

When selecting a rheostat for a particular application, it is the current rating, rather than the wattage rating, which directly indicates the usability. For any given wattage size and resistance, the maximum current to be carried through any part of a uniform winding is determined from Ohm's Law, $I=\sqrt{W/R}$. The current values for all stock rheostat resistances are given in the stock tables.

The minimum current (occurring at maximum resistance) is a factor influencing the rheostat watt size required, as explained under "Tapered Rheostats".

When a rheostat is connected as a potentiometer, i.e., bridged across the line with the load connected between one end and the moving contact, the minimum current is the "bleeder" current (through the entire winding). The maximum potentiometer current is the sum of the bleeder current and the maximum load current.

TAPERED WINDINGS

A "tapered winding" consists of two or more smoothly joined sections wound with larger wire for the higher current sections. Characteristics of tapered windings are explained fully starting on page 14.

APPLICATION MODIFICATIONS OF POWER RATINGS

To allow for the differences between the actual service conditions and the "Free Air Watt Rating" it is sound engineering practice to operate the rheostats at modifications of nominal rating. The details by which such ratings can be estimated are given hereafter. Most thermal calculations, however, involve so many factors which are usually not accurately known, that at best they are only approximations.

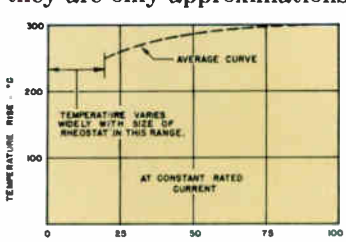


Fig. 2: Hot spot temperature rise of a typical rheostat versus percentage of winding in circuit.

The factors which affect the temperature rise act nearly independently of each other and are summarized as follows:

1. Ambient Temperature: As the maximum permissible operating temperature is a set amount, any increase in the ambient temperature subtracts from the permissible temperature *rise* and therefore reduces the permissible watt load.

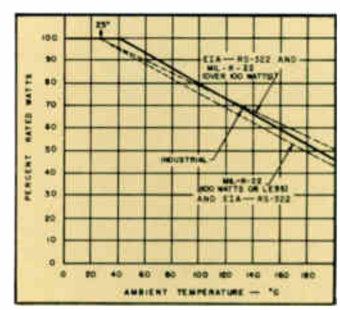
2. Enclosure: Enclosure limits the removal of heat by convection currents in the air and by radiation. The walls of the enclosure also introduce a thermal barrier between the air contacting the rheostat and the outside cooling air. Hence, size, shape, orientation, amount of ventilating openings, wall thickness, material and finish, all affect the temperature rise of the enclosed rheostat. Reduction of rating is generally necessary only if the housing is only slightly larger than the rheostat, totally enclosed and where the ratio of $I_{max.}$ to $I_{min.}$ is less than two.

3. Grouping: Rheostats mounted in standard tandem frames do not require derating. Other conditions should be studied for possible effects.

4. Altitude: The amount of heat which air will absorb varies with the density, and therefore with the altitude above sea level. At altitudes above 100,000 feet, the air is so rare that the rheostat loses heat practically only by radiation (and conduction).

5. Pulse or Rotating Operation: This is not an environmental condition but a circuit condition. As a pulse of power (or the varying power in the rheostat as the contact is rotated) when averaged over the total on and off time results in less heat per unit time than for continuous duty, the temperature rise is affected. This *may* permit higher pulse power. The conditions must be expertly considered for conservative rating.

Fig. 3: Rheostat derating for ambient temperature for various specifications.



6. Cooling Air: Forced circulation of air over a rheostat removes more heat per unit time than natural convection does and therefore permits an increased watt dissipation. Liquid cooling also can increase the rating.

7. Limited Temperature Rise: It is sometimes desirable to operate a rheostat at a fraction of the Free Air Watt Rating in order to keep the temperature rise low. This may be to protect adjacent heat sensitive apparatus; to hold the resistance value very precisely both with changing load and over long periods of time and to insure maximum life.

8. Other Considerations: HIGH RESISTANCE. High resistance units, which require the use of very small diameter wire, generally should operate at reduced temperature and voltage for *maximum* reliability.

HIGH VOLTAGE. The total volts must be limited to a reasonable ratio with respect to the insulation breakdown values, etc.

SELECTING A RHEOSTAT

OHMITE

HIGH FREQUENCY. Special, non-inductively wound rheostats are required for use at radio and super-sonic frequencies.

MILITARY AND OTHER SPECIFICATIONS. The special physical operating and test requirements of the applicable industrial or military specification must be considered. Military specification rheostats should be ordered by their MIL numbers.

TEMPERATURE COEFFICIENT OF RESISTANCE

The resistance alloys used for all except the lowest ohmic values show such little change with temperature that in most power circuits the resistance is considered constant with load.

For special applications which require very constant resistance, it may be desirable to specify the maximum permissible TC (temperature coefficient of resistance), and the range of temperature, and consequently to use only certain types of resistance alloys.

For low TC (and other) applications, Ohmite can provide rheostats with an "Ohmicone"(silicone-ceramic) coating. "Ohmicone" is processed at much lower temperatures than vitreous enamel and therefore makes control of TC and tolerance easier.

Data on the TC of various alloys is given in the Engineering Manual.

DETERMINING THE POWER RATING

Short-Cut Method: Appropriate scales on the "Step 2 Short Cut Chart" in the Resistor Catalog can also be used for rheostats. Locate the known application modifications of Free Air Conditions, multiply the correction factors for ambient, altitude, etc., together with the rheostat Watts ($I^2_{max.} \times R_{Rheo.}$) to obtain the minimum Watt Size Required.

Calculation Method: Obtain derating factors from graphs in this catalog and the Engineering Manual and calculate necessary allowances.

STEP 3 SELECTING THE RHEOSTAT MODEL AND MECHANICAL FEATURES

A uniformly wound rheostat can be chosen quite easily from the many models and resistances listed on pages 9 to 13. It is only necessary to select one with the desired resistance which has a current value not less than the maximum current of the circuit.

When the desired resistance falls between the standard values listed, use coded specification number to order.

Taper wound rheostats of the required resistance and with both maximum and minimum current ratings not less than those of your application may be selected from listings on pages 35 through 38.

Ohmite will be pleased to design a tapered rheostat for your application based on the required resistance, maximum and minimum current and nature of the load.

The minimum size model for a three-section taper can be determined with fair accuracy by the method given on page 15.

Additional Features—Mechanical and Electrical:

The Rheostat Guide, pages 4 and 5, indicates the more commonly used additional features and the pages on which detailed information will be found. Mechanical features include such typical items as special mounting bushings and shafts, tandem mountings, and auxiliary switches. Electrical features include special winding angles, and tapers.

Special attention may be required for extra long rotation life, unusual vibration, resolution, linearity, etc. The possible combinations of additional features are great. In addition, special designs to meet customer requests can be created.

SUGGESTIONS FOR ORDERING

FOR STANDARD RHEOSTATS

1. Quantity.
2. Resistance.
3. Catalog Number.
4. Model and Watt Rating.
5. Itemize knobs and all other accessories separately.

FOR MADE-TO-ORDER RHEOSTATS

1. Quantity.
2. Resistance.
3. (a) Coded Specification Number and Resistance. (For Uniform Wound Rheostats where applicable.)
   (b) Ohmite Specification Number and Resistance. On re-orders of special rheostats, the use of this number will assure exact duplication.
   (c) Catalog Number of standard Tapered Rheostats.
4. Model, Watt Rating and whether Tapered Winding is desired.
5. Maximum current.
6. Minimum current (for Tapered Winding).
7. Resistance Tolerance if other than standard ±10%.
8. Give Catalog Number, Type Number or Code Word for all Additional Features plus description of special shafts, etc.
9. Itemize knobs and all other accessories separately.
10. MIL Rheostats should be ordered by MIL number.

CODED SPECIFICATION NUMBER

Model — Ohms — Shaft Type — Max.* Panel — Additional Feature

Model	Ohms	Shaft Type	Max.* Panel	Additional Feature
E, H, J, G, K, L, P, N, R, T, or U	As Required. Letter R used for decimal point	F=Flatted R=Round S=Screwdriver or/and LO=Locking "SHALO" LA=Locking "SHALA" LE=Locking "SHALE"	Number of Eighths	352, etc., Off Pos. 375, etc., Toggle Sw. T2=Two in Tandem T3=Three in Tandem

*Substitute the shaft Type No. from pages 16 or 18 instead of max. panel thickness when one of these shafts is to be used.

Example 1: H-7R5-S-2-T2
This is a Model H rheostat, 7.5 ohms, with screwdriver slotted shaft for ¼" panel and mounted two in tandem.

Example 2: J-500-502B-352
This is a Model J rheostat, 500 ohms, with a catalog item special shaft (from table page 16) — and with Type 352 Off Position.

Rheostats with following features may be specified using code formula described above:

- Standard or Special resistances
- Off position or auxiliary switches
- Standard, round, screwdriver and locking shafts
- Standard cages
- Catalogued special panel length bushing or shaft
- Tandem assemblies

Rheostats with following features may not be coded but are assigned a serial specification number at the factory:

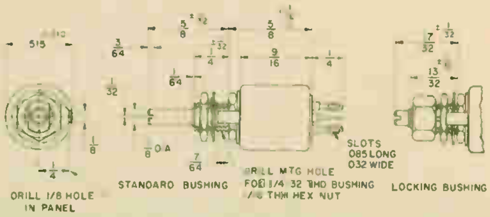
- Tapered or special winding
- Combination of more than 2 "additional features"
- Customer designed special shafts and features

STANDARD VITREOUS ENAMELED RHEOSTATS

OHMITE

Fig. 4: Model C with standard bushing (left), locking bushing (right).

Fig. 5: Model C



MODEL C

7.5 Watts▲

Diameter: .515″ max.
Shaft: ⅛″ dia.
Resistance Tolerance: ±10%
Torque: 0.25 to 3 oz.-inch **Weight:** 0.27 oz.
Standard Mounting: For panels up to ⅛″ by ¼-32 bushing with non-turn projection.
Rotation: 300° ±5°.
Standard Knob: No. 5151. Specify separately on order when desired.

Made-to-Order Code:
(For non-standard values)
Standard Shaft: C— ____ —S-1
Ohms
Locking Shaft: C— ____ —LO-1
Ohms

▲Rating on metal panel—Unit is silicone-ceramic coated

MODEL C RHEOSTATS

Ohms	Amps	Standard Shaft Cat. No. *	Locking Shaft Cat. No. *	Ohms	Amps	Standard Shaft Cat. No. *	Locking Shaft Cat. No. *
10	.86	4908	4948	250	.17	4917	4957
15	.71	4909	4949	350	.15	4918	4958
25	.55	4910	4950	500	.12	4919	4959
35	.46	4911	4951	750	.10	4920	4960
50	.39	4912	4952	1000	.086	4921	4961
75	.32	4913	4953	1500	.071	4922	4962
100	.27	4914	4954	2500	.055	4923	4963
150	.22	4915	4955	3500	.046	4924	4964
200	.19	4916	4956	5000	.039	4925	4965

* Some items are classified "non-stock standard" due to limited usage and therefore are not stocked. Consult latest issue of catalog 300 series for availability.

Fig. 6: Model E unenclosed (left) and enclosed in 6584 can.

OHMITE

MODEL E

12.5 Watts▲

Diameter: ⅞″ Unenclosed.
1$\frac{3}{64}$″ in aluminum enclosure (See p. 29)

Shaft: ⅛″ Diameter.

Resistance Tolerance: ±10%.
Torque: 1 to 6 oz.-inch
Weight: 0.6 oz.; enclosed 0.85 oz.
Standard Mounting: For panels up to ⅛″ by ¼″-32 bushing, with non-turn projection.
Rotation: 300° ±5°. **Standard Knob:** No. 5151. Specify separately on order when desired.
Made-to-Order Code:
(For non-standard values)
Unenclosed: E— ____ —R-1
Ohms
Enclosed: EW— ____ —R-1
Ohms

▲Rating on metal panel.

MODEL E RHEOSTATS

Total Ohms	Max. Amps	Steps Appr.	Unenclosed Cat. No. *	Enclosed Cat. No. *	Total Ohms	Max. Amps	Steps Appr.	Unenclosed Cat. No. *	Enclosed Cat. No. *
1	3.53	28	0101	W0101	175	.27	155	0114	W0114
2	2.50	29	0102	W0102	200	.25	135	0114A	W0114A
2.5	2.24	29	0102A	W0102A	250	.22	170	0115	W0115
3	2.04	38	0103	W0103	350	.19	190	0116	W0116
5	1.58	51	0103A	W0103A	500	.16	210	0117	W0117
6	1.44	35	0104	W0104	750	.13	200	0118	W0118
8	1.25	53	0105	W0105	1,000	.11	260	0119	W0119
10	1.12	50	0106	W0106	1,500	.091	209	0120	W0120
15	.91	70	0107	W0107	2,500	.071	323	0121	W0121
25	.71	72	0108	W0108	3,500	.060	400	0122†	W0122†
35	.60	82	0109	W0109	5,000	.050	340	0123†	W0123†
50	.50	92	0110	W0110	7,500	.041‡	420	4190†	W4190†
75	.41	105	0111	W0111	10,000	.035‡	560	4191†	W4191†
100	.35	102	0112	W0112	12,500	.031‡	480	4192†	W4192†
125	.32	110	0113	W0113	15,000	.029‡	490	4193†	W4193†
150	.29	130	0113A	W0113A					

†Silicone-ceramic coating. ‡Max. volts for 7500Ω = 305V; 10K, 12.5K & 15KΩ = 350V.
* Some items are classified "non-stock standard" due to limited usage and therefore are not stocked. Consult latest issue of catalog 300 series for availability.

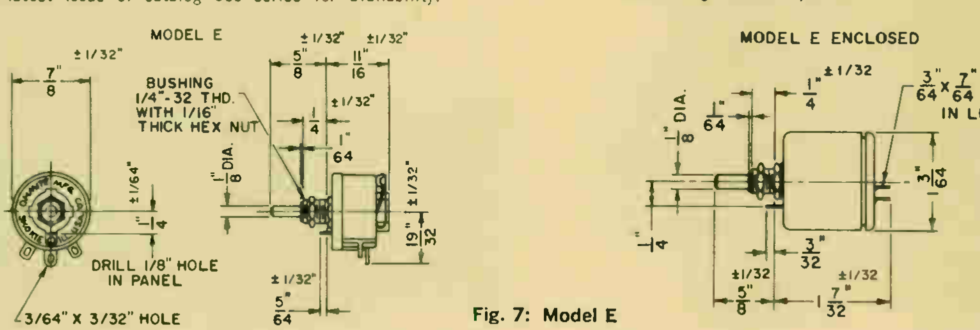


Fig. 7: Model E

OHMITE

MODEL H

25 Watts

Fig. 8

Diameter: 1 9/16″

Shaft: 1/4″ diameter. **Resistance Tolerance:** ±10%.
Torque: 0.25 to 0.5 pound-inch. **Weight:** 0.19 lb.
Standard Mounting: For panels up to 1/4″, by 3/8″-32 bushing with No. 5050 non-turn washer.
Rotation: 300° ± 5°. **Standard Knob:** No. 5150. Specify separately on order when desired.

Made-to-Order Code: H— ____ —F-2 (Ohms)
(For non-standard values)

OHMITE

MODEL J

50 Watts

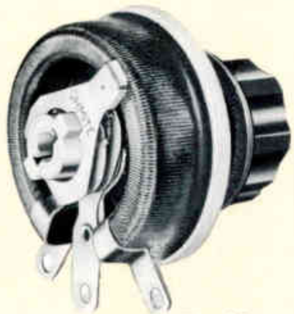


Fig. 10

Diameter: 2 5/16″

Shaft: 1/4″ diameter. **Resistance Tolerance:** ±10%.
Torque: 0.25 to 2.0 pound-inches. **Weight:** 0.32 lb.
Standard Mounting: For panels up to 1/4″, by 3/8″-32 bushing with No. 5050 non-turn washer.
Rotation: 300° ± 5°. **Standard Knob:** No. 5150. Specify separately on order when desired.

Made-to-Order Code: J — ____ —F-2 (Ohms)
(For non-standard values)

OHMITE

MODEL G

75 Watts

Fig. 12

Diameter: 2 3/4″

Shaft: 1/4″ diameter. **Resistance Tolerance:** ±10%
Torque: 0.5 to 2.0 pound-inches. **Weight:** 0.52 lb.
Standard Mounting: For panels up to 1/4″, by 3/8″-32 bushing with No. 5050 non-turn washer.
Rotation: 300° ± 5°. **Standard Knob:** No. 5150. Specify separately on order when desired.

Made-to-Order Code: G— ____ —F-2 (Ohms)
(For non-standard values)

OHMITE

MODEL K

100 Watts

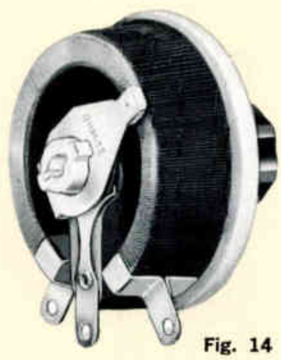


Fig. 14

Diameter: 3 1/8″

Shaft: 1/4″ diameter. **Resistance Tolerance:** ±10%
Torque: 0.5 to 2.0 pound-inches. **Weight:** 0.64 lb.
Standard Mounting: For panels up to 1/4″, by 3/8″-32 bushing with No. 5050 non-turn washer.
Rotation: 300° ± 5°. **Standard Knob:** No. 5150. Specify separately on order when desired.

Made-to-Order Code: K— ____ —F-2 (Ohms)
(For non-standard values)

OHMITE

MODEL L

150 Watts

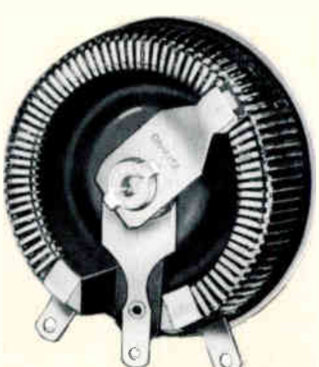


Fig. 16

Diameter: 4″

Shaft: 1/4″ diameter. **Resistance Tolerance:** ± 10%.
Torque: 0.5 to 3.0 pound-inches. **Weight:** 1.1 lb.
Standard Mounting: For panels up to 1/4″, by means of 3/8″-32 bushing or by two No. 10-32x3/4″ F. H. screws.
Rotation: 300° ± 5°. **Standard Knob:** No. 5150. Specify separately on order when desired.

Made-to-Order Code: L— ____ —F-2 (Ohms)
(For non-standard values)

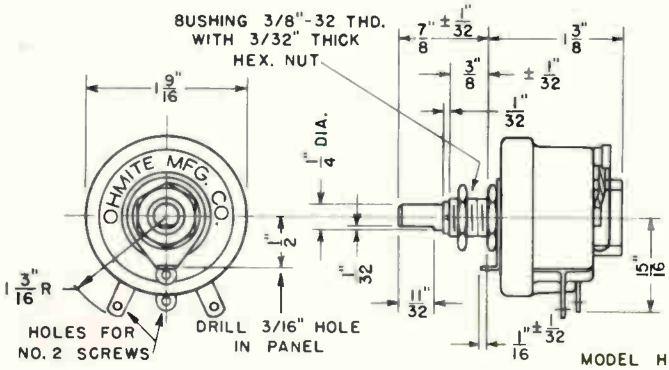


Fig. 9

Cat. No. *	Total Ohms	Max. Amps.	Steps Approx.	Cat. No. *	Total Ohms	Max. Amps.	Steps Approx.	Cat. No. *	Total Ohms	Max. Amps.	Steps Approx.
0140	1	5.000	30	0152	125	.445	155	4201†	10,000	.050	525
0141	2	3.540	29	0153	175	.375	171	4202†	15,000	.041	750
0142	3	2.880	51	0154	250	.316	195	4203†	20,000	.035	750
0143	6	2.040	50	0155	350	.267	210	4204†	25,000	.032	700
0144	8	1.770	52	0156	500	.222	245				
0145	10	1.580	52	0157	750	.182	286				
0146	15	1.290	74	0158	1,000	.155	305				
0147	25	1.000	95	0159	1,500	.129	380				
0148	35	.845	107	0160	2,500	.100	300				
0149	50	.707	97	0161	3,500	.084	335				
0150	75	.575	117	0162	5,000	.070	380				
0151	100	.500	123	4200†	7,500	.058	590				

STANDARD RESISTANCES

† Silicone-ceramic coating, 500V max. Not listed UL Ser. A.

* Some items are classified "non-stock standard" due to limited usage. Consult 300 series catalog for availability.

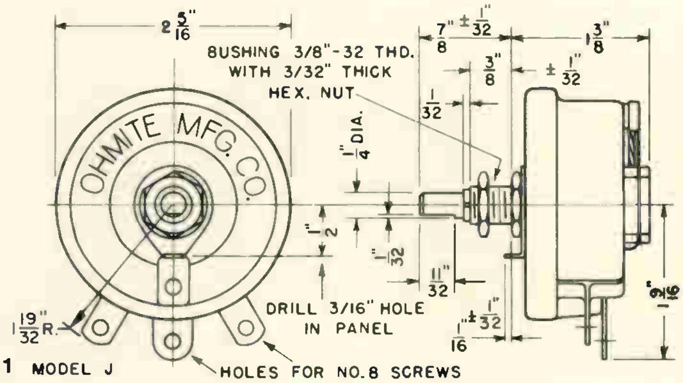


Fig. 11 MODEL J

STANDARD RESISTANCES

Cat. No. *	Total Ohms	Max. Amps.	Steps Approx.	Cat. No. *	Total Ohms	Max. Amps.	Steps Approx.	Cat. No. *	Total Ohms	Max. Amps.	Steps Approx.
0308	0.5	10.000	25	0320	125	.630	177	0332	10,000	.070	567
0309	1	7.070	44	0321	150	.575	175	4210†	15,000	.058	700
0310	2	5.000	44	0322	225	.470	203	4211†	20,000	.050	850
0311	4	3.530	44	0323	300	.408	215	4212†	25,000	.045	950
0312	6	2.880	74	0324	500	.316	286	4213†	30,000	.041	900
0313	8	2.500	82	0325	800	.250	286	4214†	40,000	.035	950
0314	12	2.040	85	0326	1,000	.224	360	4215†	50,000	.032	1130
0315	16	1.760	89	0327	1,600	.176	368				
0316	22	1.500	98	0328	2,500	.141	463				
0317	35	1.190	126	0329	3,500	.119	510				
0318	50	1.000	111	0330	5,000	.100	442				
0319	80	.790	143	0331	8,000	.079	560				

† Silicone-ceramic coating, 750V max. Not listed UL Ser. A.

* Some items are classified "non-stock standard" due to limited usage. Consult 300 series catalog for availability.

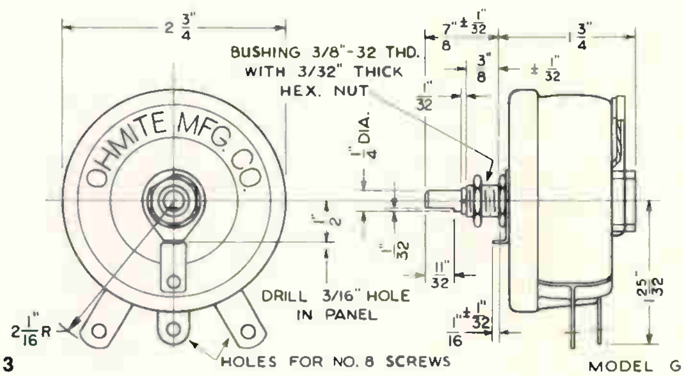


Fig. 13

STANDARD RESISTANCES

Cat. No. *	Total Ohms	Max. Amps.	Steps Approx.	Cat. No. *	Total Ohms	Max. Amps.	Steps Approx.
1100	0.5	12.300	28	1112	200	.612	186
1101	1	8.660	27	1113	300	.500	217
1102	2	6.120	28	1114	400	.433	230
1103	3	5.000	53	1115	500	.388	291
1104	5	3.880	54	1116	750	.316	345
1105	7.5	3.160	51	1117	1,000	.274	351
1106	10	2.740	55	1118	1,500	.224	434
1107	16	2.170	131	1119	2,000	.194	450
1108	25	1.730	113	1120	2,500	.173	448
1109	50	1.230	143	1121	5,000	.123	590
1110	75	1.000	134	1122	7,500	.100	544
1111	100	.866	180	1123	10,000	.087	568

HIGH RESISTANCES (Made to Order)

Cat. No.	Ohms	Amps
4220	15,000	.071
4221	20,000	.061
4222	30,000	.050
4223	40,000	.043
4224	50,000	.039

(All silicone ceramic coated)

MAX. VOLTS 900

* Some items are classified "non-stock standard" due to limited usage. Consult 300 series catalog for availability.

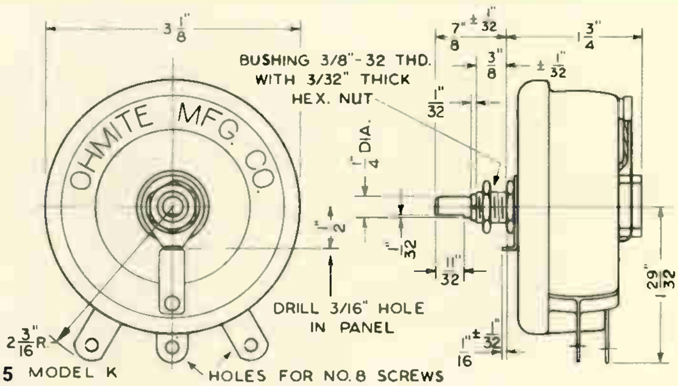


Fig. 15 MODEL K

STANDARD RESISTANCES

Cat. No. *	Total Ohms	Max. Amps.	Steps Approx.	Cat. No. *	Total Ohms	Max. Amps.	Steps Approx.
0440	0.5	14.100	33	0452	200	.707	213
0441	1	10.000	33	0453	300	.575	259
0442	2	7.070	33	0454	400	.500	270
0443	3	5.750	30	0455	500	.447	269
0444	5	4.470	57	0456	750	.365	319
0445	7.5	3.650	60	0457	1,000	.316	330
0446	10	3.160	57	0458	1,500	.258	402
0447	16	2.500	124	0459	2,000	.224	417
0448	25	2.000	107	0460	2,500	.200	515
0449	50	1.410	135	0461	5,000	.141	560
0450	75	1.150	158	0462	7,500	.115	495
0451	100	1.000	168	0463	10,000	.100	673

HIGH RESISTANCES (Made to Order)

Cat. No.	Ohms	Amps
4230	15,000	.082
4231	20,000	.070
4232	25,000	.063
4233	30,000	.058
4234	40,000	.050
4235	50,000	.045

(All silicone-ceramic coated)

MAX. VOLTS 1000

* Some items are classified "non-stock standard" due to limited usage. Consult 300 series catalog for availability.

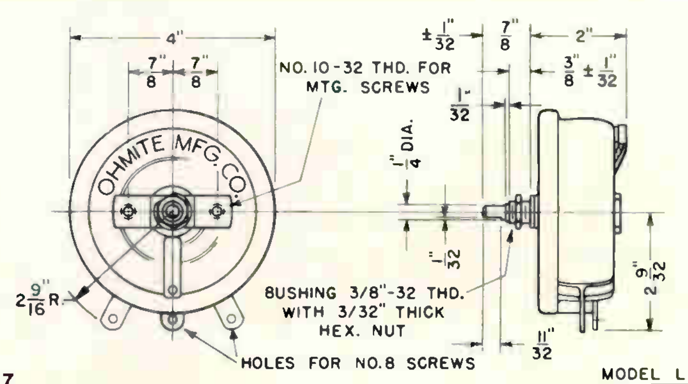


Fig. 17

STANDARD RESISTANCES

Cat. No. *	Total Ohms	Max. Amps.	Steps Approx.	Cat. No. *	Total Ohms	Max. Amps.	Steps Approx.
0524	0.5	17.300	28	0537	150	1.000	215
0525	1	12.300	44	0538	200	.865	229
0526	2	8.650	43	0539	250	.775	285
0527	3	7.070	74	0540	350	.655	315
0528	5	5.480	78	0541	500	.548	366
0529	7.5	4.470	81	0542	750	.447	335
0530	10	3.880	77	0543	1,250	.346	453
0531	15	3.163	130	0544	1,800	.288	497
0532	25	2.450	114	0545	2,250	.259	511
0533	35	2.070	125	0546	3,000	.224	526
0534	50	1.735	142	0547	4,500	.182	630
0535	75	1.415	170	0548	7,500	.141	894
0536	100	1.225	177	0549	10,000	.122	929

HIGH RESISTANCES (Made to Order)

Cat. No.	Ohms	Amps
4240	15,000	.100
4241	20,000	.087
4242	25,000	.077
4243	30,000	.071
4244	40,000	.061
4245	50,000	.055

(All silicone-ceramic coated)

MAX. VOLTS 1200

* Some items are classified "non-stock standard" due to limited usage. Consult 300 series catalog for availability.

OHMITE

MODEL P

225 Watts

Fig. 18

Diameter: 5″

Shaft: 3/8″ diameter. **Resistance Tolerance:** ±10%.
Torque: 2.5 to 4.0 pound-inches. **Weight:** 2 lb.
Standard Mounting: For panels up to 1¼″ thick. Use two ¼″-20 by 1½″ flat head screws.
Rotation: 310° ± 5°. **Standard Knob:** No. 5105. Specify separately on order when desired.

Made-to-Order Code: P— _____ —F-10
(For non-standard values) Ohms

OHMITE

MODEL N

300 Watts

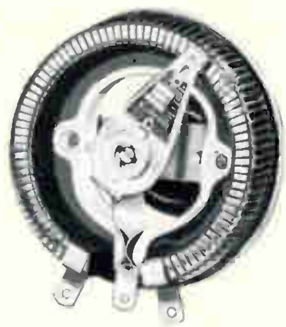


Fig. 20

Diameter: 6″

Shaft: 3/8″ diameter. **Resistance Tolerance:** ±10%.
Torque: 2.5 to 5.0 pound-inches. **Weight:** 2.6 lb.
Standard Mounting: For panels up to 1¼″ thick. Use two ¼″-20 by 1½″ flat head screws.
Rotation: 320° ± 5°. **Standard Knob:** No. 5105. Specify separately on order when desired.

Made-to-Order Code: N— _____ —F-10
(For non-standard values) Ohms

OHMITE

MODEL R

500 Watts

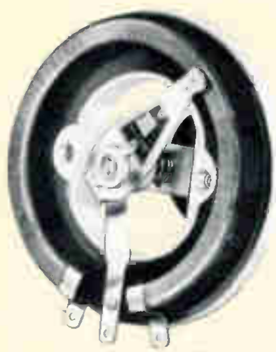


Fig. 22

Diameter: 8″

Shaft: 3/8″ diameter. **Resistance Tolerance:** ±10%.
Torque: 4.5 to 7.0 pound-inches. **Weight:** 4 lb.
Standard Mounting: For panels up to 1¼″ thick. Use two ¼″-20 by 1½″ flat head screws.
Rotation: 325° ± 3°. **Standard Knob:** No. 5105. Specify separately on order when desired.

Made-to-Order Code: R— _____ —F-10
(For non-standard values) Ohms

OHMITE

MODEL T

750 Watts

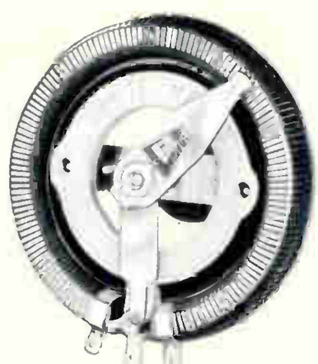


Fig. 24

Diameter: 10″

Shaft: 3/8″ Diameter. **Resistance Tolerance:** ±10%.
Torque: 3.5 to 7.0 pound-inches. **Weight:** 7.6 lb.
Standard Mounting: For panels up to 1¼″ thick. Use two ¼″-20 by 1½″ flat head screws.
Rotation: 330° ± 3°. **Standard Knob:** No. 5105. Specify separately on order when desired.

Made-to-Order Code: T— _____ —F-10
(For non-standard values) Ohms

OHMITE

MODEL U

1000 Watts

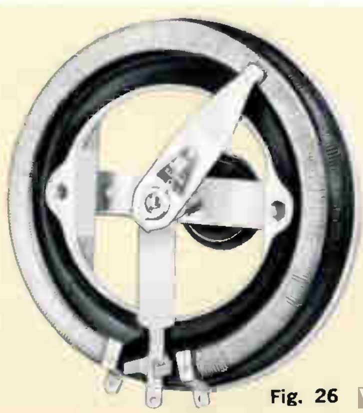


Fig. 26

Diameter: 12″

Shaft: 3/8″ diameter. **Resistance Tolerance:** ±10%
Torque: 3.5 to 7.0 pound-inches. **Weight:** 10 lb.
Standard Mounting: For panels up to 1¼″ thick. Use two ¼″-20 x 1½″ flat head screws.
Rotation: 335° ± 3°. **Standard Knob:** No. 5105. Specify separately on order when desired.

Made-to-Order Code: U— _____ —F-10
(For non-standard values) Ohms

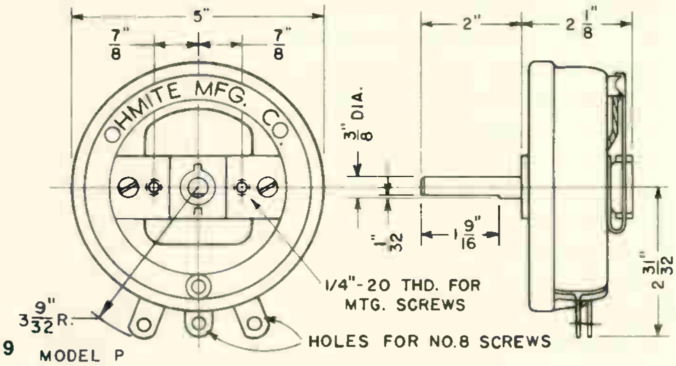


Fig. 19 MODEL P

STANDARD RESISTANCES							
Cat. No.*	Total Ohms	Max. Amps.	Steps Approx.	Cat. No.*	Total Ohms	Max. Amps.	Steps Approx.
1250	1.0	15.000	42	1262	150	1.220	256
1251	2.0	10.600	42	1263	200	1.060	337
1252	3.0	8.660	43	1264	300	.866	323
1253	4.0	7.500	57	1265	400	.750	343
1254	5.0	6.710	57	1266	700	.567	484
1255	7.5	5.490	61	1267	900	.500	493
1256	10.0	4.740	103	1268	1,200	.433	520
1257	15.0	3.870	109	1269	1,500	.387	647
1258	25.0	3.000	115	1270	1,750	.358	603
1259	50.0	2.120	183				
1260	75.0	1.730	192	1270A	2,000	.336	650
1261	100	1.500	268	1271	2,500	.300	652

HIGH RESISTANCES (Made to Order)		
Cat No.	Ohms	Amps
4250	5,000	.212
4251	7,500	.172
4252	10,000	.150
4253	15,000	.122
4254	20,000	.106
4255	25,000	.095
4256	30,000	.087

(All silicone-ceramic coated)

MAX. VOLTS 1300

Except No. 4250 = 1060 volts.

* Some items are classified "non-stock standard" due to limited usage. Consult 300 series catalog for availability.

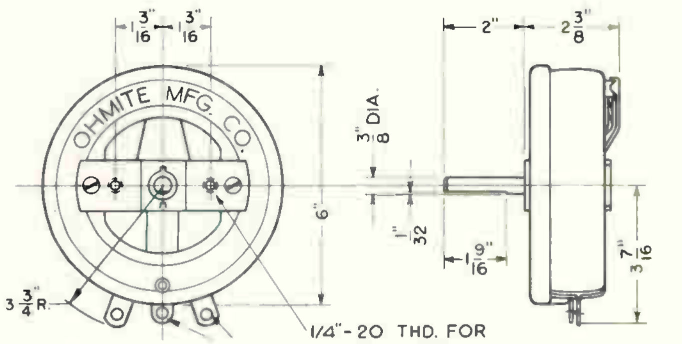


Fig. 21 HOLES FOR NO. 8 SCREWS MODEL N

STANDARD RESISTANCES							
Cat. No.*	Total Ohms	Max. Amps.	Steps Approx.	Cat. No.*	Total Ohms	Max. Amps.	Steps Approx.
0650	1.0	17.320	50	0662	150	1.410	342
0651	2.0	12.240	52	0663	200	1.220	363
0652	3.0	10.000	52	0664	300	1.000	424
0653	4.0	8.660	78	0665	400	.866	454
0654	5.0	7.750	78	0666	700	.655	504
0655	7.5	6.320	72	0667	900	.578	528
0656	10.0	5.480	78	0668	1,200	.500	546
0657	15.0	4.470	144	0669	1,500	.447	678
0658	25.0	3.460	135	0670	1,750	414	626
0659	50.0	2.450	218	0670A	2,000	.387	700
0660	75.0	2.000	225	0671	2,500	.346	708
0661	100	1.730	285				

HIGH RESISTANCES (Made to Order)		
Cat. No.	Ohms	Amps
4260	5,000	.245
4261	7,500	.200
4262	10,000	.173
4263	15,000	.141
4264	20,000	.122
4265	25,000	.110
4266	30,000	.100
4267	40,000	.086
4268	50,000	.077

(All silicone-ceramic coated)

MAX. VOLTS 1375

Except No. 4260 = 1225 volts.

* Some items are classified "non-stock standard" due to limited usage. Consult 300 series catalog for availability.

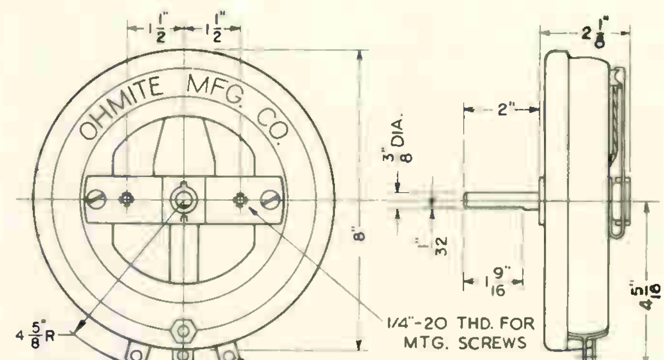


Fig. 23 MODEL R HOLES FOR NO.8 SCREWS

STANDARD RESISTANCES							
Cat. No.*	Total Ohms	Max. Amps.	Steps Approx.	Cat. No.*	Total Ohms	Max. Amps.	Steps Approx.
0849	1.0	22.300	69	0872	50	3.160	206
0850	1.5	18.200	79	0861	80	2.520	327
0851	2.0	15.800	75	0862	125	2.000	327
0852	2.5	14.100	76	0863	175	1.690	423
0853	3.0	12.900	78	0864	250	1.410	488
0854	4.0	11.200	73	0865	325	1.240	500
0855	5.0	10.000	103	0866	500	1.000	609
0856	8.0	7.900	103	0867	750	.817	727
0857	12.5	6.300	103	0868	1,000	.707	771
0858	16.0	5.600	188	0869	1,500	.577	925
0859	25.0	4.470	204	0870	2,000	.500	980
0860	40.0	3.540	206	0871	2,500	.447	968

HIGH RESISTANCES (Made to Order)		
Cat. No.	Ohms	Amps
4270	5,000	.315
4271	7,500	.260
4272	10,000	.225
4273	15,000	.185
4274	20,000	.150

(All silicone-ceramic coated)

MAX. VOLTS 1450

* Some items are classified "non-stock standard" due to limited usage. Consult 300 series catalog for availability.

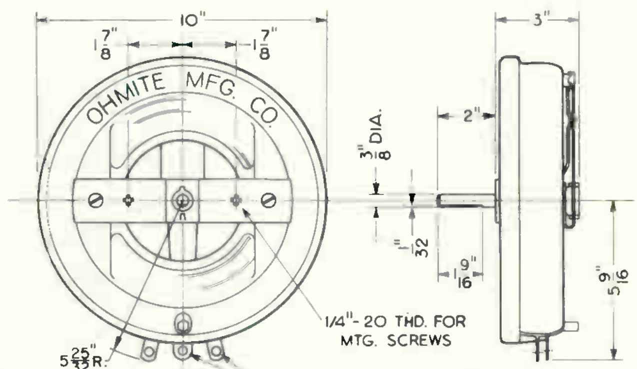


Fig. 25 MODEL T HOLES FOR NO. 8 SCREWS

STANDARD RESISTANCES							
Cat. No.*	Total Ohms	Max. Amps.	Steps Approx.	Cat. No.*	Total Ohms	Max. Amps.	Steps Approx.
1300	1.0	27.400	71	1312	50	3.870	248
1301	1.5	22.300	91	1313	80	3.060	250
1302	2.0	19.400	103	1314	100	2.740	248
1303	2.5	17.300	99	1315	160	2.170	446
1304	3.0	15.800	94	1316	200	1.940	442
1305	4.0	13.600	91	1317	300	1.580	540
1306	5.0	12.200	102	1318	400	1.370	583
1307	8.0	9.650	98	1319	600	1.117	684
1308	10.0	8.650	138	1320	750	1.000	686
				1321	1,200	.791	870
1309	12.5	7.750	138	1322	1,800	.646	1,042
1310	16.0	6.820	140	1322A	2,000	.610	900
1311	25.0	5.470	138	1323	2,500	.547	1,170

HIGH RESISTANCES (Made to Order)		
Cat. No.	Ohms	Amps
4280	5,000	.390
4281	7,500	.315
4282	10,000	.273
4283	15,000	.225

(All silicone-ceramic coated)

MAX. VOLTS 1525

* Some items are classified "non-stock standard" due to limited usage. Consult 300 series catalog for availability.

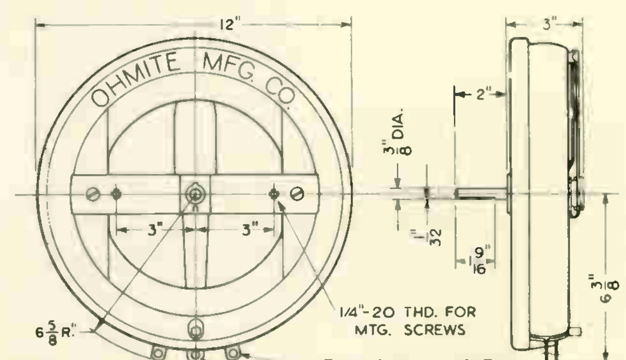


Fig. 27 MODEL U HOLES FOR NO. 8 SCREWS

STANDARD RESISTANCES							
Cat. No.*	Total Ohms	Max. Amps.	Steps Approx.	Cat. No.*	Total Ohms	Max. Amps.	Steps Approx.
1450	1.0	31.600	86	1462	50	4.470	321
1451	1.5	25.800	89	1463	75	3.650	301
1452	2.0	22.400	115	1464	100	3.160	321
1453	2.5	20.000	122	1465	175	2.390	520
1454	3.0	18.300	125	1466	225	2.110	608
1455	4.0	15.800	118	1467	300	1.830	640
1456	5.0	14.100	122	1468	400	1.580	685
1457	8.0	11.200	116	1469	500	1.410	687
1458	10.0	10.000	114	1470	750	1.150	806
1459	12.5	8.950	181	1471	1,000	1.000	855
1460	16.0	7.900	164	1472	1,500	.816	1,026
1461	25.0	6.330	181	1473	2,500	.633	1,097

HIGH RESISTANCES (Made to Order)		
Cat. No.	Ohms	Amps
4290	5,000	.450
4291	7,500	.365
4292	10,000	.316
4293	15,000	.260
4294	20,000	.224

(All silicone-ceramic coated)

MAX. VOLTS 1600

* Some items are classified "non-stock standard" due to limited usage. Consult 300 series catalog for availability.

TAPER WOUND RHEOSTATS

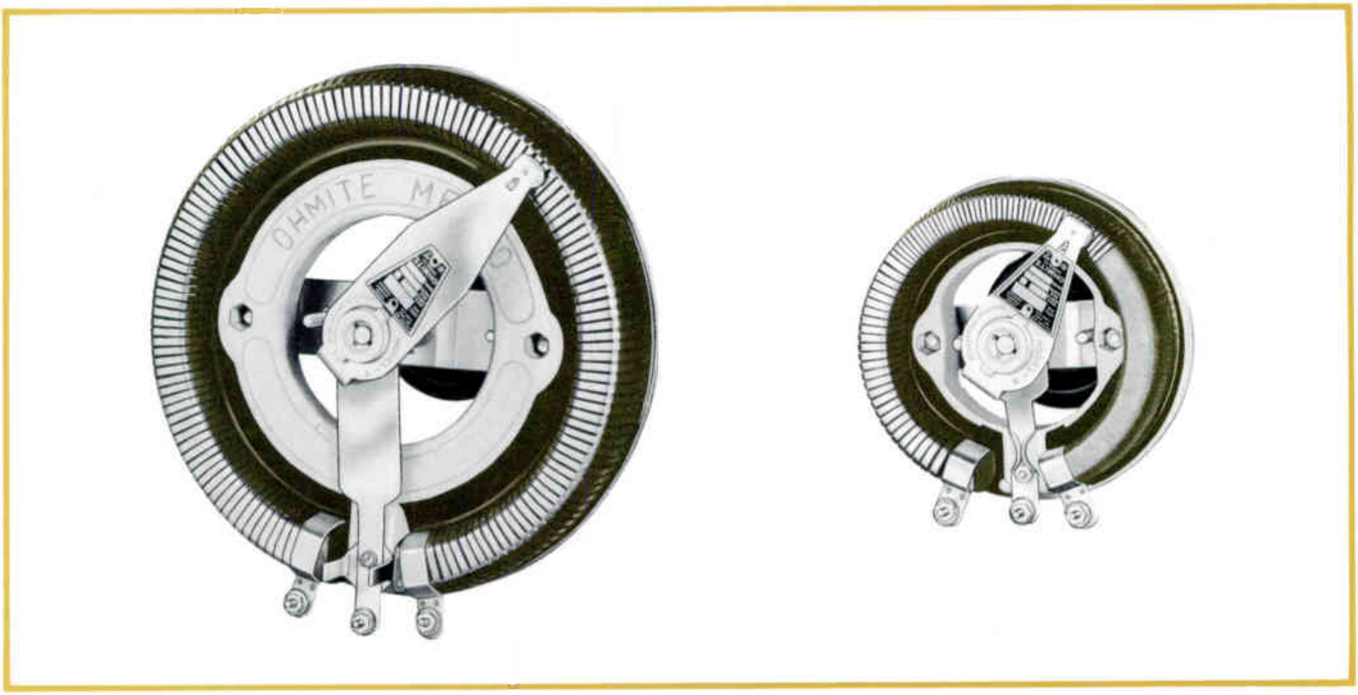


Fig. 28: Size comparison of uniform and tapered rheostats for a specific application.

Rheostat windings are sometimes tapered, i.e., wound in two to five (or more) sections of diminishing wire or ribbon sizes. These sections are so smoothly joined that only the change in wire size tells where the sections connect (see Fig. 28).

For a given application, the taper may accomplish one or more of the following:

1. Make possible the use of a smaller rheostat.
2. Provide more uniform control (i.e., more nearly linear control) at all positions of the contact arm.
3. Make possible special curves of resistance (or of the controlled effect) versus rotation.
4. Make possible the winding of higher resistance on a given size rheostat, for a given maximum amperes.

Because tapered windings involve extra manufacturing operations, tapered rheostats when ordered singly or in small quantities generally cost more than uniformly wound rheostats of the next larger size. Tapers are generally not suitable unless the ratio of maximum to minimum current is 1.5 or greater. When large quantities are involved (the necessary quantity depending upon the rheostat model and number of sections) the tapered unit generally becomes the more economical one. For convenience and economy in making preliminary tests to determine the resistance and current rating, a stock (linear) rheostat is frequently used.

HOW SIZE IS REDUCED

When the moving contact of a rheostat is on the first turn of wire or ribbon, this turn must carry the maximum current. But as the resistance is put into the circuit, the succeeding turns never have to carry more than a certain fraction of the maximum current, because the current tapers off from the maximum to some minimum value.

Hence, in a uniform, or linear winding, the latter portions of the winding operate at lower wattages (I^2R) per square inch than the rated values. The tapered winding, using smaller size wire for each section, proportioned for the current to be carried, increases the ohms per inch of winding in successive sections. This makes the watts dissipated per square inch of winding section more nearly approach the rated wattage value. As the core area required for a given wattage dissipation is less when operated at higher watts per square inch than for lower watts per square inch, the total core size is reduced.

Ohmite taper designs use the largest wire practicable for each section so that great durability is maintained.

HOW BETTER CONTROL IS PRODUCED

Fig. 29 shows how the current varies (in a typical case) with the per cent rotation of the rheostat contact. Because a uniformly wound rheostat adds a constant number of ohms per degree of rotation to a constantly increasing number of ohms, the current changes ever more slowly as the resistance is increased (curve "A" Fig. 29). A tapered winding (curves "B" and "C") by increasing the number of ohms per degree of rotation as the total ohms in circuit increases, makes the current curve more nearly linear.

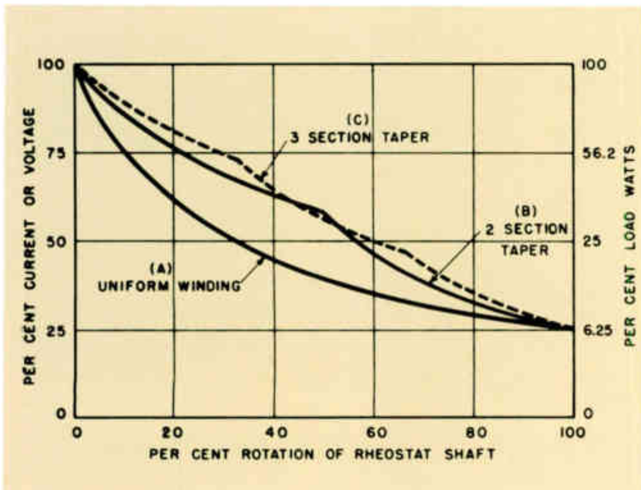


Fig. 29: Typical curves of load variation with shaft rotation for uniform and taper-wound rheostats.

SELECTING A TAPERED RHEOSTAT

Tapers depend, among other factors, on the ratio of the maximum to the minimum current and upon the way in which the current varies between these end points. Tapers, therefore, are designed for specific circuits.

For any given set of rheostat conditions (resistance, maximum and minimum current) it is generally possible to design more than one size of tapered rheostat. That is, any of the various Ohmite rheostats can be used the wattage rating of which is sufficiently greater than the required Summation Watts ($\Sigma W = I_{max.} \times I_{min.} \times R_{rheo.}$) —the smaller rheostat generally having more sections than the larger. The choice between the models will depend upon the space requirements, mounting conditions, and upon the quantity ordered. In small quantities the larger rheostat of fewer sections sometimes costs less than the smaller rheostat of greater number of sections.

APPROXIMATE SIZE OF TAPERED RHEOSTAT

Method I. The approximate size of a tapered rheostat, for specified conditions, having an average number of sections (3) can be determined as follows:

1. Determine Summation Watts— $\Sigma W = I_{max.} \times I_{min.} \times R$
2. Determine $K = \dfrac{I_{max.}}{I_{min.}}$ Round off the figure to the next highest number in Col. K, Fig. 30.
3. Select Factor F from Table Fig. 30. (Note: For greater accuracy, the exact value of K can be used and F found by interpolation in the Table.)
4. Determine Rheostat Model (Watt Size). Multiply ΣW by F and choose smallest rheostat having a watt rating equal to or greater than this product.

Example:

Rheostat Ohms = 20 $I_{max.} = 12.6$ amps.
$I_{min.} = 1.27$ amps.

1. $\Sigma W = 12.6 \times 1.27 \times 20 = 321$ watts
2. $K = \dfrac{12.6}{1.27} = 9.9$ Round off to 10.
3. $F = 2.13$ (from table Fig. 30)
4. $\Sigma W x F = 321 \times 2.13 = 684$ Model T = 750 which is greater than product 684 and therefore 3 section Model T can be used.

K	F	K	F
1.5	1.15	5	1.70
2	1.26	7.5	1.93
3	1.45	10	2.13
4	1.60		

Fig. 30: Table of factor F for tapered rheostat selection (three sections)

The Ohmite Engineering Department will be glad to recommend the most economical unit and to design the taper upon receipt of full information (see page 8 "How To Order").

Standard Taper Rheostats The rheostats listed on pages 35 to 39 include taper-wound units which can be used for field control or other purposes, such as the control of heating elements or other loads of constant resistance.

Method II. An alternate design method sometimes can be used which results in a rheostat of smaller size and/or fewer number of taper sections than that provided by the Method I design. Method II specifies a rheostat, the wattage size of which is equal to (or sometimes less than) the calculated Summation Watts. Such designs operate at *higher* hot spot temperatures than the Method I designs.

Direction of Taper To indicate the direction of taper, a sketch, similar to Fig. 31 or a statement, should be included when ordering. The direction of taper shown is standard and will be supplied unless otherwise ordered. It is described as "counterclockwise increase in resistance when viewed from the knob side."

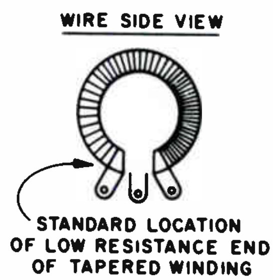


Fig. 31: Standard direction of taper

BUSHINGS AND SHAFTS FOR SMALL RHEOSTATS (Models C, E, H, J, G, K, L)

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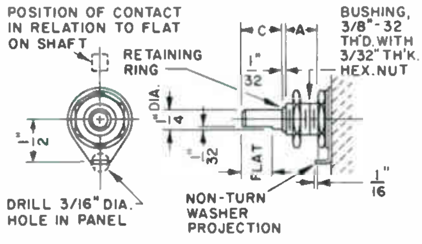


Fig. 32: Flatted shaft for 1/4" diameter

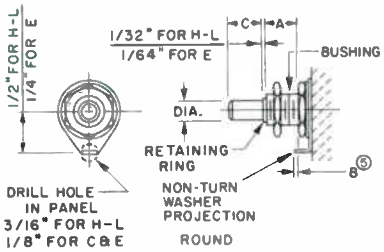


Fig. 33: Round shaft for 1/8" and 1/4" diameter

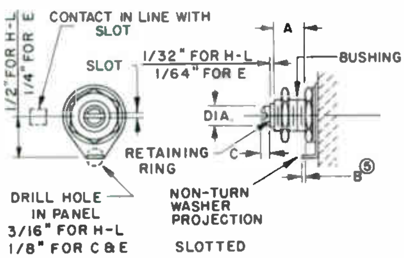


Fig. 34: Slotted (Screwdriver) shaft for 1/8" and 1/4" diameter

STANDARD SHAFT VARIATIONS FOR MODEL C(4) and E (1/8" Dia. Shaft)

MAX. PANEL	BUSHING PROJ. "A"		(1) SHAFT PROJECTION (C) FROM RETAINING RING — TYPE NUMBERS											
			(3) FLATTED	ROUND		SCREWDRIVER SLOT					LOCKING — SCREWDRIVER SLOT		
	REG.	LOCK.		STD.	LONG	STD.	LONG				STD.	SPECIAL	
			23/64	23/64	1 15/64	7/64	23/64	1 15/64	1 23/64	2 15/64	7/64	7/64	23/64
1/16	3/16	11/32	F 1/2	R 1/2	572A	S 1/2	573A	573B	573C	573D	*1/2	—	—
‡ 1/8	1/4	13/32	F 1	R 1	576A	S 1	577A	577B	577C	577D	*1	—	†578C
		1/2	—	—	—	—	—	—	—	—	—	†579B	†579C
1/4	3/8	17/32	F 2	R 2	581A	S 2	582A	582B	582C	582D	*2	†583B	†583C
(2) 1/8"	Proj. From Mtg. Surface to end of shaft		5/8"	5/8"	1 1/2"	3/8"	5/8"	1 1/2"	2"	2 1/2"	17/32"	5/8"	7/8"

(1) Add 1/64" to obtain projection from front of bushing to end of shaft.
(2) For PFMS (projection from mounting surface) for panels other than 1/8" add difference between the chosen bushing projection and 1/4" to projection shown.
(3) Flat length 5/32"
(4) Model C limited at present to 577A, 578C, 579B, and 579C. No. 577A is standard on Model C and used instead of S1.
(5) B=7/64" for Model C; 5/64" for Model E
*Prefix "S" for "screwdriver" and code for type of locknut must be added as in SLO1, SLA1 or SLE1.
†Prefix consisting of code for type of locknut must be added as in LE579B (LA is not applicable)
‡Standard

Standard shafts for Models C and E rheostats are round with a 1/4"-32 bushing for mounting on panels to 1/8" thick; for Models H, J, G, K and L rheostats, standard shafts have a flat and a 3/8"-32 threaded bushing long enough for mounting on panels up to 1/4" thick. Shafts without a flat, with a screwdriver slot, or with screwdriver slot and slotted bushing for a locking device are also available with bushings to accommodate various panel thicknesses. They can be obtained with different projections beyond the retaining ring to accommodate special knobs, or auxiliary devices, etc.

Where appearance requires that the knob be close to the panel or space is limited, and the panel is thin, the 1/8" panel bushing is used. Bushings for 1/16" panel can be made also.

SHAFTS WITH FLAT

The standard flat is always located so that a perpendicular to the flat is in line with the rheostat contact and on the opposite side of the shaft. This agrees with the normal location of a set screw on a knob and results in the arrow-head or pointer, if any, pointing to the location of the contact. Symbol "F" describes this type of shaft in the rheostat coded designation (for standard front projection only).

SHAFTS WITHOUT FLAT (ROUND)

A plain round end is sometimes preferred when it is desired to be able to line up the knob with certain panel calibration marks, to fit a coupling gear, etc. Rheostat code symbol is "R" (for standard front projection only).

STANDARD SHAFT VARIATIONS FOR MODELS H, J, G, K AND L (1/4" Dia. Shaft)

Max. Panel	Bushing Proj. A"	(1) Shaft Projection (C) from Retaining Ring—Type Nos.								
		Flatted (3)				Round				
	Regular Type	Std.	Long			Std.	Long			Short
		15/32"	1 3/32"	1 19/32"	2 3/32"	15/32"	1 3/32"	1 19/32"	2 3/32"	1/4"
1/8"	1/4"	F1	502A	502B	502C	R1	512A	512B	512C	512D
‡1/4"	3/8"	F2	503A	503B	503C	R2	513A	513B	513C	513D
1/2"	5/8"	F4	504A	504B	504C	R4	514A	514B	514C	514D
3/4"	7/8"	F6	505A	505B	505C	R6	515A	515B	515C	515D
1"	1 1/8"	F8	506A	506B	506C	R8	516A	516B	516C	516D
1 1/2"	1 5/8"	F12	507A	507B	507C	R12	517A	517B	517C	517D
2"	2 1/8"	F16	508A	508B	508C	R16	518A	518B	518C	518D
(2) 1/4"	Proj. from Mtg. Surface to end of Shaft	7/8"	1 1/2"	2"	2 1/2"	7/8"	1 1/2"	2"	2 1/2"	21/32"

Max. Panel	Bushing Proj. A"		(1) Shaft Projection (C) from Retaining Ring—Type Nos.							
			Screw Driver Slot					Locking—Screw Driver Slot		
	Regular Type	Locking	Std.	Med.	Long			Std.	Long	
			3/32"	15/32"	1 3/32"	1 19/32"	2 3/32"	3/32"	1/4"	15/32"
1/8"	1/4"	1/2"	S1	552E	552A	552B	552C	*1	†562F	†562E
‡1/4"	3/8"	5/8"	S2	553E	553A	553B	553C	*2	†563F	†563E
1/2"	5/8"	7/8"	S4	554E	554A	554B	554C	*4	†564F	†564E
3/4"	7/8"	1 1/8"	S6	555E	555A	555B	555C	*6	†565F	†565E
1"	1 1/8"	1 3/8"	S8	556E	556A	556B	556C	*8	†566F	†566E
1 1/2"	1 5/8"	1 7/8"	S12	557E	557A	557B	557C	*12	†567F	†567E
2"	2 1/8"	2 3/8"	S16	558E	558A	558B	558C	*16	†568F	†568E
(2) 1/4"	Proj. from Mtg. Surface to end of Shaft		1/2"	7/8"	1 1/2"	2"	2 1/2"	3/4"	29/32"	1 1/8"

(1) Add 1/32" to obtain projection from front of bushing to end of shaft.
(2) For PFMS (projection from mounting surface) for panels other than 1/4" add difference between the chosen bushing projection and 3/8" to projections shown.
(3) Flat length; 11/32" for Std.; 5/8" for Long.
(5) B=1/16" for Models H, J, G, K and L.

*Prefix "S" for "screwdriver" and code for type of locknut must be added as in SLO1, SLA1 or SLE1 (see page 17).
†Prefix consisting of code for type of locknut must be added as in LO562F or LE562F (LA is not applicable—see page 17).
‡Standard

SHAFTS WITH SCREW-DRIVER SLOT

This type of shaft is used to permit operation by a screw-driver instead of a knob when the rheostat is to be adjusted infrequently or when possibility of tampering with the setting must be minimized. Symbol "S" is used in the code (for standard front projection only).

LOCKING TYPE SCREW DRIVER SHAFTS

A slotted bushing for use with special nuts as described below can be supplied. Rheostat code shaft and bushing symbols are "LO," "LA," or "LE" depending on the type of locking nut.

SPECIAL SHAFTS

Commercial shafts for Models E, H, J, G, K and L are ordinarily of cadmium-plated steel. Stainless steel is standard on Model C. Bushings are unplated brass, but can be supplied cadmium or nickel-plated at extra cost. All shafts listed in military specification MIL-R-22 are available also.

For special shafts made to order, supply drawing or complete dimensions. Specify dimension "A", which is the projection of the bushing beyond the rheostat assembly nut. The retaining ring is not included in this dimension. Dimension "A" is (nominally) the sum of the given maximum panel thickness plus the thickness of the mounting nut and an allowance for manufacturing tolerance. The bushing should be another 1/16" longer if a lock-washer (see page 26) is to be used. See page 26 for "Shoulder Nuts" which are used with screwdriver shafts (3/8"-32 bushing) when it is desired to keep the end of the shaft protected in a recess. Use shoulder nut No. 6057 for bushing lengths over 1/4".

HEAVY DUTY STOP AND 3/8" DIA. SHAFT

Rheostat Models H, J, G, K and L can be provided with a 3/8" diameter shaft sleeve with a special heavy duty stop for use on industrial applications, especially where large diameter knobs are used. The stop can safely withstand stopping torques of 80 pound-inches. As the stationary stop is a part of the special mounting bracket and the moving stop is a part of the 3/8" diameter sleeve, the stopping torque is not transmitted into the rheostat.

Shaft projection, special drilling, etc., can be varied.

	Code Word
Heavy Duty Stop, 3/8" Dia. Shaft and Tapped Mounting Bracket..............	SHABS

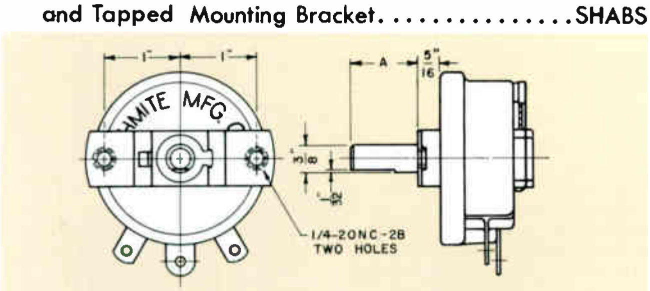


Fig. 35: Heavy duty stop for small rheostats.

SHAFTS WITH REAR EXTENSION

Special shafts with an extension on the rheostat wire side can be provided, so that other apparatus can be coupled to enable operation by the rheostat knob. Valves and switches are examples of items frequently coupled.

	Code Word
Shaft Extended on Wire Side, 1/4" Dia.............	SHEFE

Distance from mounting surface to end of shaft must be given. Provide a sketch for special drilling, etc.

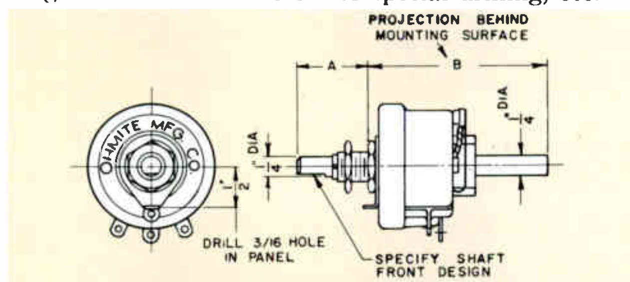
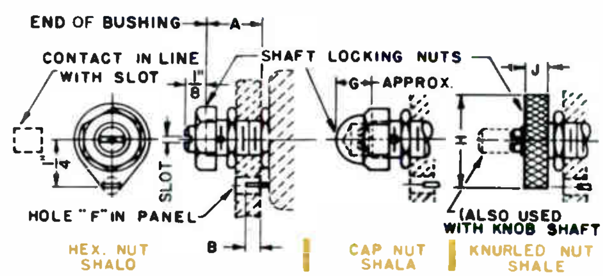


Fig. 36: Shaft with rear extension.

SHAFT LOCKING DEVICES for Models C, E, H, J, G, K, L



Shaft Dia.	Max. Panel	A	B	Slot	F	G	H	J
1/8	See p. 16	See p. 16	5/64 (E) 7/64 (C)	1/32 W 3/64 D	1/8	9/32	5/8	5/32
1/4	See p. 16	See p. 16	1/16	3/64 W 1/16 D	3/16	11/32	1	1/4

Fig. 37: Shaft locking devices.

Shaft clamping or "locking" devices which discourage or prevent tampering with a rheostat setting, consist of a special nut on a split and tapered bushing (Fig. 37). The lock nut has a matching internal taper which forces the segments of the bushing against the shaft. Several types of nuts are available as shown. The knurled edge disc type is for tightening with the fingers and is sometimes employed with a knob-type shaft. The standard shaft end is normally slotted for screwdriver unless otherwise ordered. To order the shaft-lock feature, state panel thickness and proper code word shown below and/or specify bushing and shaft assembly when possible by the type numbers shown on page 16.

	Code Word*
Hexagon Nut Locking Device..............................	SHALO
Cap Nut Locking Device..................................	SHALA
Knurled Round Nut Locking Device.........................	SHALE

* "LO, LA or LE" are used in coded specification.

OHMITE

SHAFTS FOR LARGE RHEOSTATS (Models P, N, R, T, U)

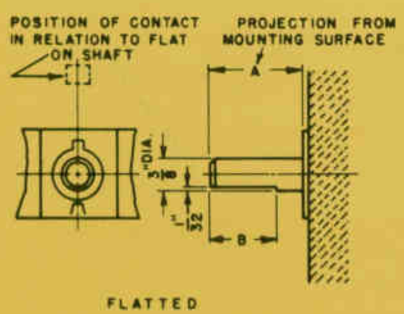


Fig. 38: Flatted shaft.

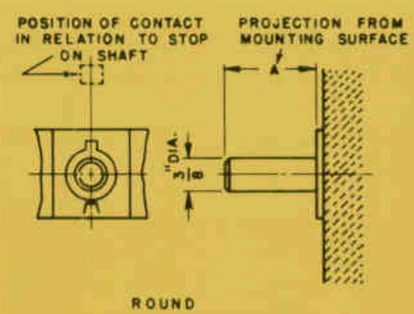


Fig. 39: Round shaft.

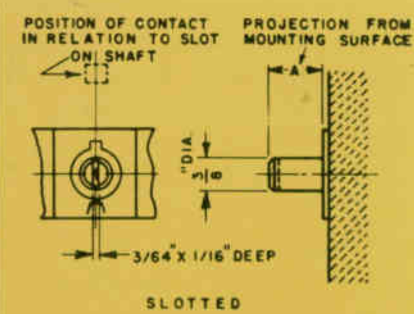


Fig. 40: Slotted (screwdriver) shaft.

SPECIAL SHAFTS

Standard rheostat shaft assemblies, as illustrated on stock units, have a shaft with a flat for the set screw of a knob, and are long enough for mounting on panels up to 1¼" thick (when used with knob Cat. No. 5104 or 5105). Shafts without a flat, or with a screw-driver slot are also available. While the standard shaft is generally used on thin panels as well as on panels up to the maximum, shorter shafts are available and are frequently used when it is desired to have the knob and pointer close to the dial, or panel. Standard shafts are cadmium plated steel. Stainless steel, Type 416 or 303, is available at extra cost.

Shafts in all lengths per MIL-R-22 are also available. Special length shafts or shafts with special drilling, etc., can be supplied. Please submit drawing.

PANEL THICKNESS	FLATTED			ROUND		SCREW-DRIVER SLOT	
	A Proj. from Mtg. Surface	B Lgth. of Flat	Code Symbol	Proj. from Mtg. Surface	Code Symbol	Proj. from Mtg. Surface	Code Symbol
1/16" to 3/8"*	1 11/32"	1"	F3	1 11/32"	R3	¾"	S6
½" to 1¼"	2"	1 9/16"	F10 STD.	2"	R10	1¼"	S10
1½" to 2¼"*	3"	1 9/16"	F18	3"	R18	2"	S16

*¾" Panel max. for S6 and 2" for S16.

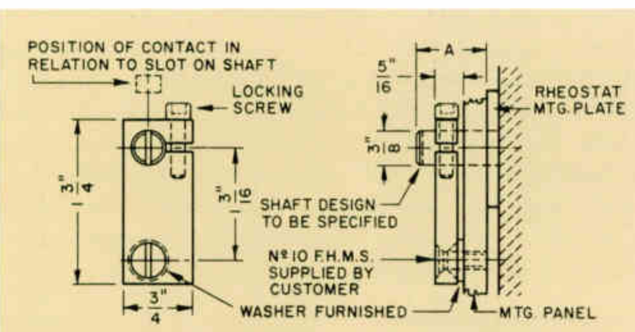


Fig. 41: Shaft locking device.

SHAFTS WITH REAR EXTENSION

Special shafts with an extension on the rheostat wire-side can be provided. Rheostats can also be made with the normal front end cut off and the rear extended for operation from the wire side only.

Code Word

Shaft Extended on Wire Side, 11/32" Dia. . . . . SHOFO

Distance from mounting surface to end of shaft must be given. Provide a sketch if any special drilling, etc., is required.

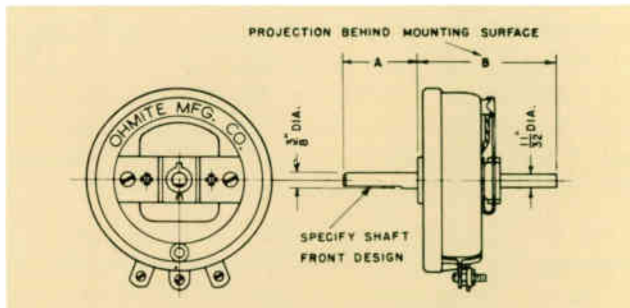


Fig. 42: Shaft with rear extension.

SCREW CLAMP LOCKS

The locking device for large rheostats takes the form of a split arm fastened to the mounting panel as shown in Fig. 41. When the hex socket cap screw is tightened, the split arm is clamped to the shaft, preventing rotation. The shaft is slotted for screw-driver operation.

Screw Clamp Locking Device. . . . . . Code Word: SHALL

Specify shaft selected from following table or give projection from mounting surface for other panels.

Panel Thickness	Shaft Projection From Mounting Surface	Shaft Type No.
1/16" to 3/8" incl.	¾"	S6
½" to 1 5/16" incl.	1¼"	S10

STANDARD TANDEM ASSEMBLIES

OHMITE

Fig. 43: Standard assembly of two Model J rheostats

STANDARD TANDEM ASSEMBLIES

Ohmite rheostats can be supplied mounted two, three, or more in tandem for simultaneous control of several circuits, or phases of a circuit, by means of a single knob, as shown in Figs. 43 to 50. The rheostats are spaced to permit their operation at the same ratings as when individually mounted. Tandem rheostats are frequently connected in series (and sometimes in parallel) to obtain increased wattage dissipation over that of a single rheostat for a given panel space, or because the wattage required exceeds that of a single rheostat.

Frames consist of plated steel strip, as illustrated, with mounting holes for panel or shelf mounting. Two, 3, or 4 rheostats are generally connected by Ohmite-made universal joints which provide smooth action with a minimum of backlash. Greater numbers of rheostats are connected by a single through-shaft, which may be supplied also for 2 to 4 rheostats at the option of Ohmite or the customer. As many as ten rheostats can be arranged in tandem on special frames; details supplied on request.

Mixed Models: Tandem assemblies of different model rheostats can be ordered, but such rheostats are specially made to make the angle of rotation of all of the rheostats the same as that of the smallest rheostat. The largest rheostat is mounted next to the panel and mounting dimensions for that size apply to the mixed assembly.

Ordering Information: Give Tandem Mounting Catalog Number and specify rheostats completely. When the rheostats are not identical, their location with respect to the panel should be given. Shaft lengths are as indicated in Figs. 44 to 46. Specify panel thickness or shaft length if other than standard is desired.

Shaft Diameter P, N, R, T & U: Model P, N, R, T, and U tandem assemblies can be supplied with ½″ diameter through-shafts instead of ⅜″ diameter. All large tandems of more than 4 rheostats in tandem are supplied with ½″ diameter shafts as standard.

Location of Flat on Tandem Shafts: The standard location of the flat on a tandem shaft has been selected so that when the tandem frame is mounted on a panel with the frame vertical, the pointer on a knob will rotate symmetrically about the vertical center-line. Note that both the rheostat and the flat have been rotated 90° from the normal mounting position with the center-lead vertical and down. If the user intends to mount the rheostats per this latter method, the tandem assembly can be ordered with the flat on the shaft the same as on an individual rheostat, i.e., the perpendicular to the flat is 180° from the contact. Specify on order: "Flat on shaft to be 180° from contact."

FACTORY ASSEMBLED TANDEM RHEOSTAT ASSEMBLIES MODEL E

OHMITE

Model E-T3 Tandem

Rheostat Model	Watts Each	2-in-tandem Cat. No.	2-in-tandem Weight (lbs.)	3-in-tandem Cat. No.	3-in-tandem Weight (lbs.)
E	12½	6640	.080	6641	.164

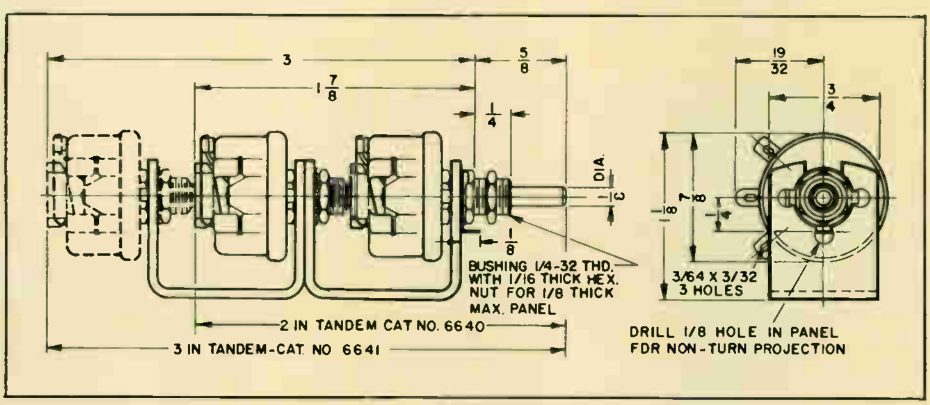


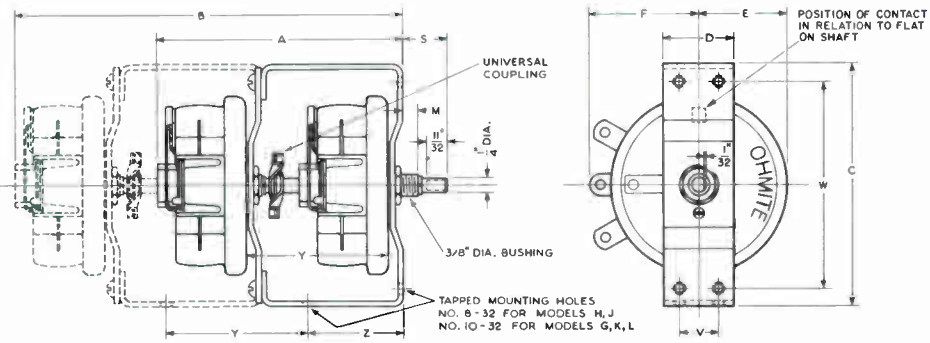
Fig. 44: Dimensions for Model E tandem assemblies

OHMITE

FACTORY ASSEMBLED TANDEM RHEOSTAT ASSEMBLIES

Model J-T3 Tandem

Models H, J, G, K, L



Max. Panel	M	S
*Std.	9/32	25/32
½	⅝	1⅛
¾	⅞	1⅜
1	1⅛	1⅝
1½	1⅝	2⅛
2	2⅛	2⅝

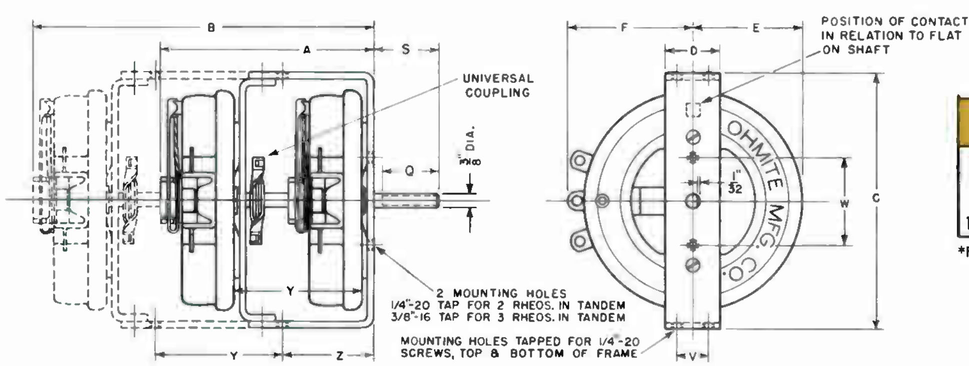
*Fits ¼" thick panel max. without a panel nut; 3/16" max. with panel nut. All others allow for panel nut.

Fig. 45: Dimensions for Model H, J, G, K or L tandem assemblies.

RHEOSTAT		TANDEM ASSEMBLY CATALOG NUMBER				DIMENSIONS									
		FOR 2 RHEO.		FOR 3 RHEO.											
Model	Watts Each	Cat. No.	Weight Incl. Rheo. Lbs.	Cat. No.	Weight Incl. Rheo. Lbs.	A	B	C	D	E	F	V	W	Y	Z
H	25	6600	.53	6610	.72	3½"	5½"	2⅜"	1"	25/32"	15/16"	11/16"	1⅞"	2"	1 11/16"
J	50	6601	.82	6611	1.2	3½"	5½"	3"	1"	1 5/32"	1 9/16"	11/16"	2½"	2"	1 11/16"
G	75	6602	1.5	6612	2.0	4⅜"	6⅞"	4¼"	1¼"	1⅜"	1 25/32"	11/16"	3⅝"	2½"	1 11/16"
K	100	6603	1.7	6613	2.4	4⅜"	6⅞"	4¼"	1¼"	1 9/16"	1 29/32"	11/16"	3⅝"	2½"	1 11/16"
L	150	6604	2.7	6614	3.8	4¾"	7¼"	5"	1¼"	2"	2 9/32"	11/16"	4¼"	2½"	1 15/16"

NOTE: Catalog Numbers for 4 rheostats in Tandem are: H = 6620, J = 6621, G = 6622, K = 6623, L = 6624

Models P, N, R, T, U



Max. Panel	S	Q*
Std.		
½ to 1¼	2"	1 9/16
1/16 to ⅜	1 15/32	1 7/16
1½ to 2¼	3	1 9/16

*Flat length.

Fig. 46: Dimensions for Model P, N, R, T or U tandem assemblies

RHEOSTAT		TANDEM ASSEMBLY CATALOG NUMBER				DIMENSIONS									
		FOR 2 RHEO.		FOR 3 RHEO.											
Model	Watts Each	Cat. No.	Weight Incl. Rheo. Lbs.	Cat. No.	Weight Incl. Rheo. Lbs.	A	B	C	D	E	F	V	W	Y	Z
P	225	6605	5.6	6615	7.6	5 13/16"	9 5/16"	7"	1½"	2½"	2 31/32"	⅞"	1¾"	3½"	2½"
N	300	6606	6.8	6616	9.4	6 1/16"	9 9/16"	7"	1½"	3"	3 7/16"	⅞"	2⅜"	3½"	2½"
R	500	6607	9.8	6617	13.8	5 13/16"	9 5/16"	8¾"	1½"	4"	4 5/16"	⅞"	3"	3½"	2½"
T	750	6608	17.9	6618	25.5	7 3/16"	11 3/16"	13"	1½"	5"	5 9/16"	⅞"	3¾"	4"	3"
U	1000	6609	22.7	6619	32.7	7 3/16"	11 3/16"	13"	1½"	6"	6⅜"	⅞"	6"	4"	3"

NOTE: Catalog Numbers for 4 rheostats in Tandem are: P = 6625, N = 6626, R = 6627, T = 6628, U = 6629

TANDEM COUPLING KITS

OHMITE

Tandem coupling kit consists of steel "U" frame, coupling with set screws, mica washer, hex key and instructions. The kit is intended for field assembly, coupling two standard rheostats. The coupling fastens to the shaft of the back unit—projections on the coupling engage the recesses in the driving hub of the front unit.

Fig. 47: Typical assembly and tandem kit

ORDERING INFORMATION

Coupling Kit for two Model E Rheostats . . Stock No. 6591
Coupling Kit for Model H or J . . . . Cat. No. 6532
Coupling Kit for Model G, K or L . . . . Cat. No. 6533

Cat. No.	Rheo. Model	A	B	C	D
6532	H	25/32	1 3/8	2 5/32	15/16
	J	1 5/32	1 3/8	2 5/32	1 9/16
6533	G	1 3/8	1 3/4	2 9/16	1 25/32
	K	1 9/16	1 3/4	2 9/16	1 29/32
	L	2	2	2 9/16	2 9/32

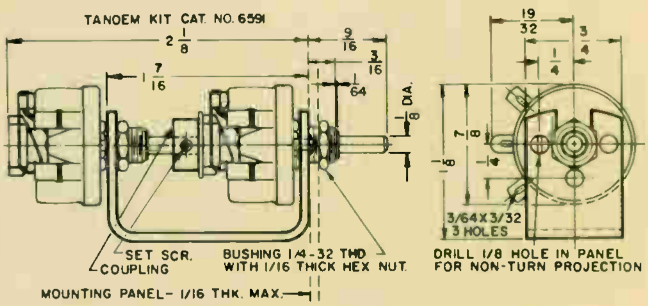


Fig. 48: Dimensions, Model E tandem kit

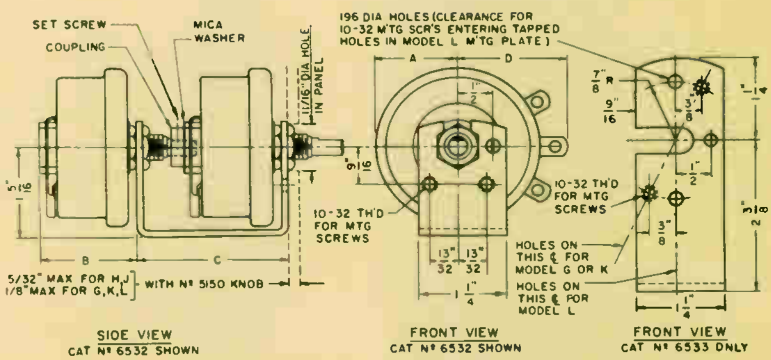


Fig. 49: Dimensions, tandem kit for Models H, J, G, K, L

BACK-TO-BACK TANDEM ASSEMBLIES

OHMITE

Fig. 50: Back-to-back assembly of Model J rheostats

When the depth behind a panel is too limited for a standard type tandem assembly, a "Back-to-Back" Tandem Assembly may fit as it is somewhat shorter. As illustrated, the rear rheostat is mounted inside the frame, back-to-back with the first rheostat. "Back-to-back" tandem frame dimensions are the same as the standard frames, except for the depth. When mounting Models H, J, G, K, or L on these frames, a hole 3/4" in diameter is required in the panel to clear the assembly nut.

Two in Tandem

Model	Depth Behind Panel	B-to-B Tandem Frame Cat. No.	Model	Depth Behind Panel	B-to-B Tandem Frame Cat. No.
H	2 15/16"	6630	P	5 3/16"	6635
J	2 15/16"	6631	N	5 11/16"	6636
G	3 5/8"	6632	R	5 3/16"	6637
K	3 5/8"	6633	T	6 1/2"	6638
L	4 1/4"	6634	U	6 1/2"	6639

SEQUENCE COUPLED RHEOSTATS

OHMITE

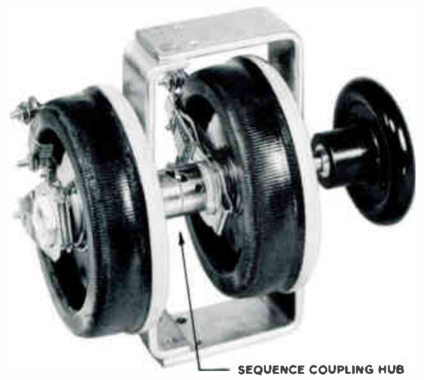


Fig. 51: Sequence-coupled rheostats

"Sequence Coupling" is a method (Pat. No. 3,127,582) of coupling two rheostats in tandem so that they can be rotated by a single knob, in succession (or "sequence") rather than together as in conventional ganged devices. Either the "front" or "back" rheostat can be arranged to rotate first. Sequence coupling is obtained by means of a special hub which links the two rheostats.

Advantages of this feature are:

(1) *The physical size of tandem rheostat assemblies used for motor speed control can be reduced considerably.* Where conventional tandem rheostats are used in combined motor-armature, motor-field or combined motor-field, generator-field control, opposite halves of the two rheostats must be "zero" resistance to permit full current to be maintained in one circuit while the current is varied in the other circuit (Fig. 52). With sequence-coupled rheostats, however, each rheostat controls its circuit in turn while the other remains fixed at the maximum current position. Hence, the zero resistance halves are not required (Fig 53) and rheostat size may be approximately halved.

(2) *Resolution of adjustment is significantly increased* because control is possible over approximately 650 degrees of rotation.

(3) *Sequence-coupled rheostats can be wound to provide, in combination, a taper, which permits a higher ratio of maximum to minimum current combined with high total resistance,* than is otherwise feasible.

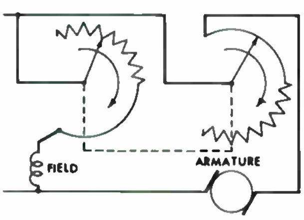


Fig. 52: Conventional tandem rheostat in field and armature circuit of motor.

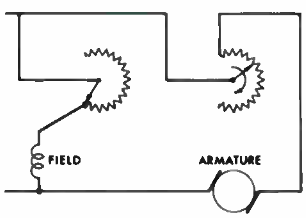


Fig. 53: Sequence-coupled rheostat in field and armature circuit of motor.

Rheostat Sizes: Sequence-coupled rheostats can be supplied in the following sizes:

Front Position (Adjacent to Knob End)—Models P, N, R, T, U (respectively 225, 300, 500, 750, 1000 watts).

Back Position — Models J, G, K, L, P, N, R, T, U (50, 75, 100, 150, 225, 300, 500, 750 and 1000 watts).

Note: The "front" or "back" rheostat actually can consist of more than one rheostat, conventionally ganged, so that one group of rheostats is, in effect, sequence-coupled to another group.

Sequence: One of the following sequences of operation should be specified:

Sequence "A" Operation (Code Word: Secoa): When the knob is turned clockwise from the extreme counter-clockwise position, the "front" rheostat (closest to the knob) turns through its full rotation before the "back" one does. When the knob is turned in a CCW direction from the extreme CW position, then the back rheostat turns first.

Sequence "B" Operation (Code Word: Secob): When the knob is rotated clockwise from the extreme CCW position, the back rheostat turns first.

Panel Thickness: Standard assembly accommodates up to 11/16" panel; specify greater thicknesses.

Mounting Considerations: Tandem frame is normally arranged to mount on a panel in horizontal position. If the Sequence Coupling Dial is desired, and the frame must be mounted vertically on the panel, then the rheostat mounting screws must be countersunk in the panel.

Dimensions of sequence-coupled tandem assemblies are approximately the same as shown on page 20.* However, the frames are tapped for 1/4-20 mounting screws only, even where there are three or more rheostats in tandem. An end support may therefore be required.

Motor Drives can be supplied. Submit requirements.

**The "W" dimension for Model U rheostat changes to 3¾" and the "A" dimension to 7 9/16" in a sequence coupling arrangement.*

SEQUENCE COUPLING DIALS

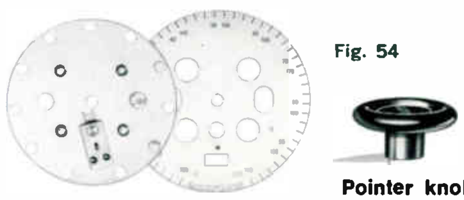


Fig. 54

Cover Plate. Calibrated plate Pointer knob

A "sequence-coupling" dial and knob are available which provide a specific reading for every setting of the knob throughout its double (approximately 650 degree) rotation. Between the points where one rheostat stops and the other begins its rotation, the movable (calibrated) plate is tripped by a pin on the knob pointer. This plate shifts to expose one of two sets of numbers (0-100, or 100-200) through holes in the cover plate.

The sequence coupling dial assembly is held on the panel by four-self-tapping screws. A choice of dials is available to accommodate the screws used in mounting the rheostat.

SEQUENCE COUPLING DIAL and KNOB KITS

Front Rheostat*	Rheostat Mounting Screws	Dial-Knob Kit Cat. No.	Requires Rheostat †Frame
P to U	Flat Hd.	5020	Hor. or Vert.
P	Round Head	5021	Horiz. Only
N		5022	
R		5023	
T or U		5024	

*Next to panel. †See "Mounting Considerations" above.

Fig. 56: Model J with toggle switch and extra lug

Fig. 55: Model J with toggle switch

Fig. 57: Model P with dwell operation toggle switch

TOGGLE SWITCHES

OHMITE

Description: The toggle switch is operated with a positive snap after the rheostat arm has been rotated through from 30° (Model H) to 5° (Model U) approximately. The operation takes place while the rheostat contact is on the end lug only on Model P rheostats or larger. Depth of rheostat is increased approximately ½″, except on Model R, it is ⅝″. Two switches can be mounted on the same rheostat, to operate at opposite ends of rotation.

Standard Lugs: Toggle switch opens the rheostat circuit or switches an independent circuit. Recommended for 115V service on all models.

Extra Lug: Enables switching of rheostat and an independent circuit. Also used on Models H, J, G, K and L when the operation of the switch must occur outside the limits of resistance change. For all models.

Dwell Operation: Switch is operated at either end of rotation and remains in same state when direction of shaft rotation is reversed, until the other end of the rotation, where the switch is re-set. Action accomplished by double-pronged operating lever which pushes, but cannot pull, the toggle-switch lever at both ends of rotation. Used to extend range of rheostat by alternately adding or removing a series resistor; also for motor reversal. Available on any model rheostat.

Toggle Switch Rating 125V. AC or DC	Type Numbers					
	With Std. Lugs		With Extra Lug		Dwell Oper.	
	*C.C. End	*C. End	*C.C. End	*C. End	*C.C. End	*C. End
SPST-N.O.† 6A	355	455	357	457	355D	375D
SPST-N.C.‡ 6A	375	475	377	477	375D	355D
DPDT, 6A	360	460	363	463	360D	360D
SPDT, 3A	346	446	348	448	346D	346D
SPDT, 12A	346A	446A	348A	448A	346AD	346AD
DPDT, 15A,AC	360A	460A	363A	463A	360AD	360AD

*Rotation observed from knob end of shaft, clockwise or counter-clockwise.
†Switch position when rheostat arm is on lug.

SENSITIVE SWITCHES

OHMITE

Application: When an auxiliary switch must be operated with a minimum amount of rheostat shaft rotation, or operation of the switch must occur at a closely specified angular location, regardless of direction of rotation, a sensitive, snap action switch (such as a "Micro-Switch") is required. Functions are otherwise the same as for a toggle-switch. These switches are also used when certain MIL specifications must be met. Depth of rheostat behind panel is increased ¾″ approximately.

Fig. 58: Rheostat with sensitive switch

Description: A basic size, or a small size, sensitive switch and actuator are mounted by means of a bracket and operated by a lever or cam attached to the rheostat shaft or contact arm. Available on any model. As listed in the table, the mechanism can be arranged to operate the switch at either end of rotation, or at any intermediate point. When ordering the latter type, the point of operation (and tolerance on location) must be specified in degrees, as well as the type of switch.

Switch Rating Notes: For tungsten filament lamp loads the size B switch rating is 30A. inrush and normal 3A. A size BA switch is also available rated at 20A. and lamp load of 75A. inrush, 10A. normal; ordered by adding A to the Type No. Special SPDT switches for 125V. DC with rating of 10A., non-inductive circuit, can be specified by adding MT to Type No. 381 or 481.

Sensitive Switch				Type Number	
Contact Form	Rating	Size	Rheostat Model	Counter-clockwise End*	Clockwise End*
SPDT	15A. 125/250 VAC	V	E, H, J, G, K, L	380	480
SPDT	15A. 125/250/480 VAC	B	P, N, R, T, U	381	481
SPDT	5A. 125/250 VAC	SM	E	379	479
DPDT	10A. 125/250 VAC	DT	P, N, R, T, U	385	485
DPDT	10A. 125/250 VAC	D	H to U	386	486

*Rotation observed from knob end of shaft.

Switch Description			
Size	Dimensions	Terminals	Trade Name or Equiv.
B	1 15/16″ x 27/32″ x 11/16″	Solder lugs, std.	Micro Switch Basic
V	1 3/32″ x 5/8″ x 13/32″	Screws, std.	Micro Switch V-3
DT	1 15/16″ x 1 1/4″ x 11/16″	Screws, std.	Micro Switch DT-2R
D	1 1/4″ x 7/8″ x 1/2″	Solder lugs, std.	Licon 22-104
SM	25/32″ x 23/64″ x 1/4″	Solder lugs, std.	Micro Switch 1SM1

RHEOSTAT ADDITIONAL FEATURES

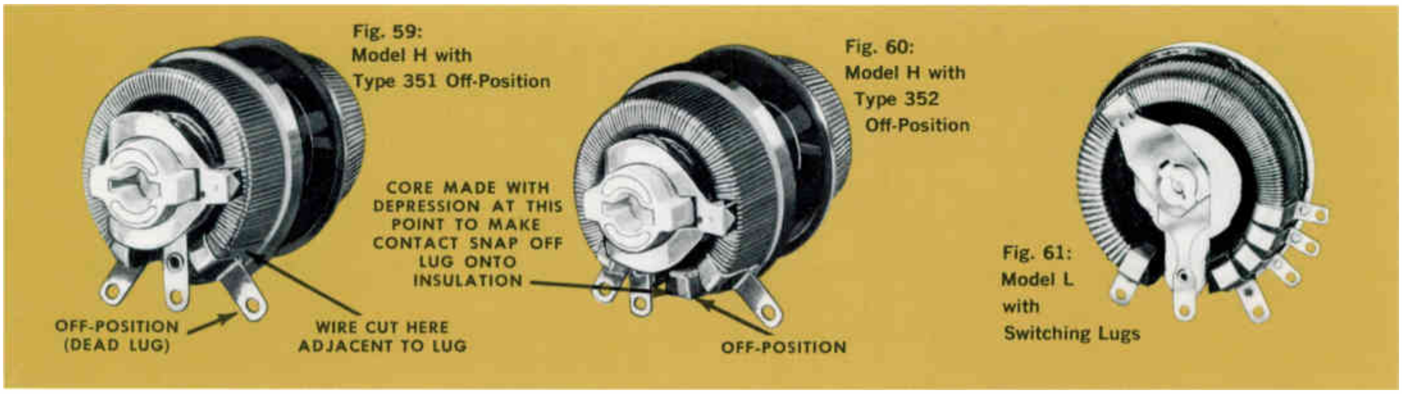


Fig. 59: Model H with Type 351 Off-Position

Fig. 60: Model H with Type 352 Off-Position

Fig. 61: Model L with Switching Lugs

DEAD-LUG OFF-POSITION

Application: To open the rheostat circuit at the high resistance position. For light-duty and medium resistance values.

Description: The resistance winding is disconnected at one lug so that the circuit is opened as the contact passes onto the lug. This is the simplest construction. For fine wire rheostats, or units for heavy current or frequent adjustment, Type 353 (this page) is recommended.

Clockwise End Position (as illustrated) ...... Type No. 351
Counterclockwise End Position............. Type No. 451

SNAP-ACTION OFF-POSITION

Application: The most popular form for general service. Opens the rheostat circuit at either the high or low resistance end.

Description: The circuit is opened as the contact brush snaps into an insulated notch next to the lug. Provides definite indexing action.

Additional Detent: The lug at the off-position end of the winding can be provided with an embossed ridge which provides a detent effect on the rotation to signal the operator (by sense of feel) the approach to the off-position.

Cut-Off Lug: The projecting part of the lug at the off-position can be omitted on any style off-position when specified on order. Add "COL" suffix to Type Number.

Location (From Wire Side View)	Std. Type No.	With Detent
Clockwise End	352	352A
Counter-clockwise End	452	452A

DEAD-SECTION OFF-POSITION

Application: To open the rheostat circuit at either the high or low resistance position. Used mostly for medium duty apparatus type applications where no indicated off-position is desired.

Description: The circuit is opened as the contact brush passes off the lug onto an insulated section at the same level—otherwise similar to Fig. 60.

Position at Right (Standard)............. Type No. 353
Position at Left (Opposite).............. Type No. 453

OFF-POSITION RATINGS

Toggle switches should be used generally for line voltage applications and direct current use above 20 volts. The exact current and voltage rating of an off-position depends on the specific circuit in which it is used. The use of a condenser for spark suppression is generally helpful on direct current.

SWITCHING LUGS

Application: The addition of switching lugs to a rheostat is not for the purpose of an off-position but rather to add a tap switch action at the end of the rheostat winding so as to achieve the effect of a special tapered winding of a type not otherwise possible.

Description: As shown in Fig. 61, several insulated lugs, to the number desired, are located near the end of the rheostat rotation. They are to be connected to external resistances which are switched into the circuit by the rheostat contact brush.

Switching Lugs.................... Code Word: ZAPIN

BRIDGED GAP AND 360° WINDINGS FOR UNLIMITED ROTATION

Fig. 62: Model N with bridge for unlimited rotation

Rheostats can be constructed without stops and with a track between the ends of the winding to provide for unlimited rotation. Rheostats can also be made with 360° cores and continuous winding, with taps as required.

Bridged Gap Feature .... Code Word: BRIGA
360° Winding Feature .... Code Word: CIRWI

NON-STANDARD ROTATION

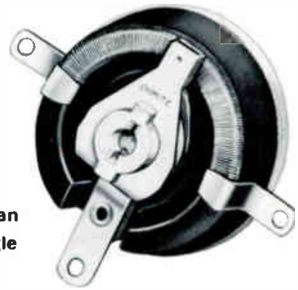


Fig. 63: Rheostat with less than standard winding angle

Rheostats can be supplied with winding space and angle of rotation less than standard. The wattage rating of such rheostats is reduced approximately in proportion. For example, a Model J rheostat, 50 watts rating, when provided with a winding of 180° from center of lug to center of lug, would be reduced to 180/300 x 50, or 30 watts rating. The rotation specified is from stop to stop, which is approximately 15° more (varying with the model) than the degrees occupied by the winding alone, because of the width of the terminal lugs.

Less than Standard Rotation and Winding Feature . . . . Code Word: LESWI

SPECIAL STOPS

Rheostats can be supplied with a fixed or an adjustable stop limiting the angle of rotation to any desired part of the total possible rotation. Generally, such rheostats are used where it is desired to leave a certain amount of resistance in the circuit at all times. However, a standard rheostat and separate resistor are often to be recommended. An adjustable stop increases the projection behind the panel by approximately ½".

Code Word:

Fixed Minimum Stop Feature, All Models . . . . SPECO

Adjustable Stop Feature, Back of Panel—All Models . . . . Code Word: SPACA

Adjustable Stop Feature, Front of Panel—Models P to U only . . . . Code Word: SPICE

TAPPED WINDINGS

Rheostats can be supplied with taps at any point or points on the winding. The tap is usually a lug of the same dimensions as the regular terminals. An adjustable tap can be provided, also.

LOW TORQUE

Rheostats with lower than normal torque are sometimes wanted when they are to be remotely controlled and operated by very small motors. Low torque is accomplished by eliminating friction at the center-lead by omitting the compression spring and using a flexible shunt connection to the contact (see Flexible Shunt). The torque for any given rheostat model will be somewhat greater on low resistance units than on high resistance units.

Low Torque Feature . . . . Code Word: LOTOR

REDUCED TORQUE RHEOSTATS

Rheostat Model	Approx. Torque	Rheostat Model	Approx. Torque
H	1.5—3 oz. in.	P	1.25—2.5 lb. in.
J	2—3.5 oz. in.	N	1.25—2.5 lb. in.
G	2—4 oz. in.	R	1.25—2.5 lb. in.
K	3—5 oz. in.	T	1.25—2.5 lb. in.
L	3—6 oz. in.	U	1.25—2.5 lb. in.

FLEXIBLE SHUNTS

Fig. 64: Rheostat with flexible shunt and low torque

Rheostats can be equipped with a flexible shunt directly connecting the moving contact and the center-lead. This is sometimes called for when the circuit requires that even minute variations in slip-ring to center-lead resistance be eliminated.

	Type No.
Flexible Shunt (5 Amps. Max.) For H, J, G, K, L	204
Flexible Shunt (Over 5 Amps.) J, G, K, L, P, N, R, T, U	203

QUICK-CONNECT TERMINALS

Fig. 65: Typical rheostat with terminals for push-on connection

Terminals to receive standard female "quick-connectors" or "push-on" connectors can be provided on most rheostats. In addition to single terminations, a double or twin terminal permitting two connections at one terminus is also available.

Terminal†		For Rheostats
Width	Number	
3/16"	53-18B	H
¼"	53-25D *	H, J, G, K, L, P, N, R, T, U
¼" (Twin)	53-25DT	H, J, G, K, L, P, N, R, T, U

*53-25B and 53-25BT also available. Three-way type — accepts standard ¼" female quick connector, 6-32 screw and nut or soldering.
†Provided at all three rheostat connections unless otherwise specified.

OTHER TERMINALS

Model H rheostats can be provided with special size terminals with .156" diameter holes to receive No. 6 screws, maximum.

Terminals for No. 6 Screw on Model H . . . . Type 56

Welded Nuts on Terminals

Rheostats can be provided with nuts welded to the terminals to permit screwdriver fastening of connections. Screws are not provided unless specified. Positions are specified from wire-side view. Nuts are No. 6-32 on Model H and No. 8-32 on larger models.

Clockwise lug and center lead . . . . Type 55A
Counter-clockwise lug and center lead . . . . Type 55B
All three terminals . . . . Type 55C

Terminal Bolts

Description	Cat. No.
For Model H—3 sets each consisting of: 1 No. 2-56 x ½" screw, 2 hex. nuts and 1 lockwasher	5075
For Models J, G, K or L—3 sets each consisting of: 1 No. 8-32 x ½" screw, 2 hex. nuts, 1 each flat, cup and lock washers	5077
For Models P, N, R, T, U—3 sets each consisting of: 1 No. 8-32 x ⅝" screw, 2 hex nuts, 1 each flat, cup and lock washers	5079

RHEOSTAT KNOBS, DIALS, BRACKETS

OHMITE

RHEOSTAT KNOBS

Fig. 66

Knobs are made of black bakelite and fasten by means of two screwdriver slotted set screws (except No. 5102, 5103, 5150 and 5151 which have one screw). Knobs can be ordered with hexagon socket set screws by adding suffix -A to catalog number. Indicating lines are white filled; pointers are bright plated. Any knob can be used with any model of rheostat having the corresponding shaft diameter. Knob No. 5116 is recommended for general use where a small bar type knob is wanted. Knobs must be specified on order, when desired.

Description	Knob Dia.	Hole Dia.	Pointer Radius	Cat. No.
Bar Knob, 2¼" long	—	¼"	1⅛"	5102
Bar Knob, 1¼" long	—	¼"	⅝"	5103
Handwheel with Pointer	3¼"	⅜"	2⁹⁄₃₂"	5104
Handwheel without Pointer	3¼"	⅜"	—	5105
Handwheel with Pointer	3¼"	¼"	2⁹⁄₃₂"	5106
Handwheel without Pointer	3¼"	¼"	—	5107
Finger-Grip with Pointer	1⅝"	¼"	1⁵⁄₃₂"	5109
Finger-Grip without Pointer	1⅝"	¼"	—	5110
Finger-Grip with Pointer	2⅜"	¼"	1¹⁷⁄₃₂"	5111
Finger-Grip without Pointer	2⅜"	¼"	—	5112
Bar Knob, 4¾" long—Requires cross-pin and tapped hole in shaft	—	⅜"	1⁵⁄₁₆"	5115
Bar Knob, 1½" long	—	¼"	¾"	5116
Finger-Grip without Pointer	2⅜"	⅜"	—	5124
Finger-Grip with Pointer	2⅜"	⅜"	1¹⁷⁄₃₂"	5130
Bar Knob, 1½" long, AN-3220-3 Military Style—Dull Finish	—	*¼"	¾"	5136
Finger-Grip	1½"	¼"	—	5150
Finger-Grip	¾"	⅛"	—	5151

*"D"-Shaped hole to fit ¹⁄₃₂" deep flat.

RHEOSTAT DIALS

Fig. 67: Typical rheostat dial

Standard Dials For Rheostat	Dial Diam.	Catalog No.
H, J, G, K, L	2³⁄₁₆"	5000
P, N, R, T, U	5½"	5001
C, E,	1¼"	5007

Dials are made of aluminum with the figures and lines natural aluminum on an etched black background. Dials are calibrated to indicate the approximate percentage of resistance in the circuit (clockwise increase). Dials No. 5000 and 5007 are secured by the rheostat mounting nut. Dial No. 5001 is separately fastened by means of No. 6 screws, or it can be held by the rheostat mounting screws.

MOUNTING NUTS

Standard Nut: ⅜"-32 thread hexagonal ⁹⁄₁₆" across flats by ³⁄₃₂" thick, cadmium plated steel. . . . . Cat. No. 6500

RHEOSTAT MOUNTING BRACKETS

Fig. 68: Rheostat mounting brackets and insulating washer No. 6028

Mounting brackets are made of cadmium-plated steel. They furnish a convenient mounting for units located and controlled on the rear of a panel, in an enclosure or for "breadboard" construction.

HORIZONTAL TYPE

For Models	Mtg. Hole Centers	Mtg. Hole Dia.	Mtg. Hole For Max. Screw	Width	Height	Cat. No.
H, J	3"	³⁄₁₆"	No. 8	2⁷⁄₁₆"	1¹¹⁄₁₆"	6520
G, K, L	5"	³⁄₁₆"	No. 8	4³⁄₁₆"	2⁹⁄₁₆"	6521

VERTICAL TYPE

For Models	Mtg. Hole Centers	MTG. HOLE Dia.	MTG. HOLE For Max. Screw	Height to Shaft Center	Hole Size	Cat. No.
H, J, G	1⁵⁄₃₂"	⁵⁄₃₂"	No. 6	1⅝"	½"	6522*
H, J, G	1⁵⁄₃₂"	⁵⁄₃₂"	No. 6	1⅝"	⅜"†	6523

*Supplied with insulating fibre bushing, Cat. No. 6028, as illustrated, for ⅜" dia. bushing of rheostats, to provide additional insulation to ground.
†Includes ³⁄₁₆" dia. hole at ½ center for standard non-turn washer.

SHOULDER TYPE MOUNTING NUTS

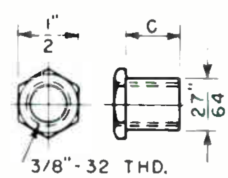


Fig. 69

Shoulder nuts are used when it is desired to have the end of a screw-driver slotted shaft below the top of the mounting nut. The nuts are tapped ⅜"-32 and require a ⁷⁄₁₆" diameter hole in the panel. Refer to page 17 for more information on use.

Shoulder Nut, "C" = ⁷⁄₃₂". . . . . Cat. No. 6056
Shoulder Nut, "C" = ¹⁵⁄₃₂". . . . . Cat. No. 6057

NON-TURN WASHERS

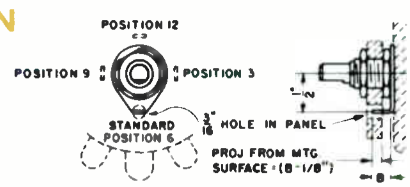


Fig. 70: How non-turn washer is used.

To prevent rheostats which are mounted by a single bushing, such as the Models H, J, G, K, (and sometimes L) from turning on the panel, they are provided with a washer which has a projecting lug to fit into an additional hole in the panel. The lug can be ordered located at any 90° position, and it can be bent down if not wanted. Supplied in "6 o'clock" position unless otherwise specified.

Standard Non-Turn Washer—"B" = ⁵⁄₃₂". . . Cat. No. 5050
Long Tip Non-Turn Washer—"B" = ¼". . . . Cat. No. 5051
Narrow Tip Non-Turn Washer—
"B" = ⁵⁄₃₂" x ⅛". . . . . Cat. No. 5052

Fig. 71: Table-mounted cage for Model J with Series Plug Terminal No. 607

Fig. 72: Table mounted cage for Model R with Terminal No. 604

Fig. 73: Typical cages for back-of-panel mounting.

Application: A ventilated enclosure should be used when a rheostat is to be mounted where there is possibility of mechanical injury or likelihood of human contact with electrically "live" parts. Cages also provide a convenient means of table top mounting and are a necessity for portable applications. Classifications of cages per NEMA definitions are given under that heading. Dustproof cages are frequently used where there are unusual amounts of dust or particles in the air.

Cage Wattage Ratings: Rheostats in ventilated enclosures can be used at full wattage, but rheostats in dustproof enclosures must generally be operated at reduced wattage to avoid overheating caused by the absence of ventilation. Rheostats in circuits where the ratio of maximum to minimum current exceeds 2 can be operated at full rating, but rheostats where the current ratio is less, should be operated at not over 50% of the free air wattage.

Cage Types: A variety of cages are available to meet different requirements. Standard cages are the General Purpose Ventilated Type GPV or Dustproof Type GPD. Lightweight Sealed Type LWD, Explosion-proof EXP, Weather-proof or Watertight Type WP, Drip-proof Type DP, Gastight Type GT, 'Hermetically' Sealed (Gas or Air Filled) Type HSG and Fluid Filled HSF are also available in some sizes.

STANDARD GENERAL PURPOSE CAGES

Description: Ventilated cages have perforated metal sides and are gray wrinkle finished. Dustproof cages are similar but without ventilating holes.

TERMINAL TYPES
Cages can be supplied with terminals as listed below

Terminal	Available On	Type No.
Binding Posts—2 Terminals	L,P,N,R,T,U	601
Binding Posts—3 Terminals	L,P,N,R,T,U	602
Wire Leads—2 Asbestos Insulated Wires, 6 inches long	All	603
Wire Leads—3 Asbestos Insulated Wires, 6 inches long	All	622
BX Cable—2 Conductor, 6 inches long	P,N,R,T,U	604
BX Clamp and 6" Wire Leads	P,N,R,T,U	605
Pipe Flange for ½" Conduit, with 2 Wire Leads, 6 inches long	L,P,N,R,T,U	606
Line Cord—6 ft., Heater (Type HPD) with Series Plug	All	607*
Line Cord—6 ft., Heater Type with Rubber Covered Cord (Type HSJ and Series Plug)	All	607R*
Line Cord—6 ft., Heavy Duty Rubber Covered with Heavy Duty Plug	All	628
Line Cord—6 ft., Heavy Duty Rubber Covered with Grounding Terminal Plug	All	623
90° Elbow "Condulet" fitting with 3-wire leads	P,N,R,T,U	624
Outlet Box 4" x 4" with 3 Terminal Strip	P,N,R,T,U	625
Outlet Box 4" x 4" with 6 Terminal Strip	P,N,R,T,U	626
Screw and Nut Terminals—3, with Cover-plate and 27/32" dia. hole for BX fitting, etc.	P,N,R,T,U	627

**Specify No. 607G or 607GR if grounding plug is required.*

STANDARD VENTILATED AND DUSTPROOF RHEOSTAT CAGES

For Rheostat Model †	H	J	G	K	L	P	N	R	T	U
Cage Diameter	2⅜"	3⅛"	3¾"	3¾"	4½"	7½"	7½"	9½"	13 9/16"	13 9/16"
Height or Depth Behind Panel	2"	2"	2⅜"	2⅜"	2⅝"	3¼"	3¼"	4¼"	4 13/16"	4 13/16"
Mounting Bolt Radius	1 9/16"	1 15/16"	2¼"	2¼"	2⅝"	4¼"	4¼"	5 11/32"	7⅜"	7⅜"
Mounting Bolt Slots (120° Apart) for Screw Size	No. 10	No. 10	No. 10	No. 10	No. 10	¼"	¼"	¼"	¼"	¼"
Approximate Weight, Pounds (without rheostat)	0.18	0.26	0.41	0.41	0.53	1.25	1.25	2.0	6.8	6.8
Table Mounted Ventilated Cage Cat. No.	6550	6551	6552	6553	6554	6555	6556	6557	6558	6559
Table Mounted Dustproof Cage Cat. No.	6570	6571	6572	6573	6574	6575	6576	6577	6578	6579
Equipment	A	A	A	A	A	C	C	C	C	C
* Back-of-Panel Ventilated Cage Cat. No.	6560	6561	6562	6563	6564	6565	6566	6567	6568	6569
* Back-of-Panel Dustproof Cage Cat. No.	6540	6541	6542	6543	6544	6545	6546	6547	6548	6549
Equipment	B	B	B	B	B	C	C	C	C	C

*Models H, J, G, K, L mount by means of rheostat bushing on panels up to 5/16" thick. Models P, N, R, T, U mount by means of 3 screws on panels up to ½" thick except 1" on Models P and N.

†For Model E rheostat cages, see pages 9 and 29.

Equipment A: Terminal No. 603, Knob No. 5116, Dial No. 5000.
Equipment B: Terminal No. 603, Knob No. 5150.
Equipment C: Terminal No. 604, Knob No. 5105.

OHMITE

RHEOSTAT CAGES

NEMA-NEC ENCLOSURE CLASSIFICATIONS

The "National Electrical Manufacturers Association" (NEMA) Industrial Standards IC-2-128 provides for a variety of enclosures to meet different ambient conditions. Listed below are the principal types, the corresponding National Electrical Code designations (from Article 500) and the equivalent Ohmite type designations.

NEMA (National Electrical Mfg. Association)		NEC (National Electrical Code)		DESCRIPTION PER STANDARDS	OHMITE TYPE DESIGNATIONS	
TYPE	CLASS	CLASS	GROUP		TYPE	DESCRIPTION
I				General Purpose Ventilated or Closed (Dustproof)	GPV (or GPD)	Sheet Metal Enclosure with Perforated Metal Sides
IA				Semi Dust-Tight	GPD	Sheet Metal Enclosure
V		III & IV		Dust-Tight	EXP	Heavy Walled Cast Enclosure with Threaded Cover Fastening (or Ground Joints) "Explosion-Proof"
VII	I	I	C, D	Hazardous Locations (Gas)		
IX	II, F&G	II	E, F&G	Hazardous Locations (Dust)		
III				Weather-Resistant	WR	Cast Enclosure with Gasketed Cover and Shaft
IV				Watertight		
XII				Industrial Enclosure—Dirt and Oilproof		Same as Type GPD

Note: As size, weight, delivery time, and cost vary greatly with the type of enclosure, the exact type required should be carefully considered before making a selection.

SERIES PLUG TERMINAL

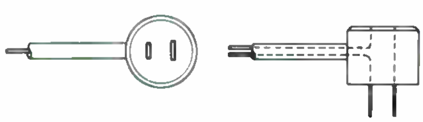


Fig. 74: Series Plug No. 6050 for Terminals No. 607 and No. 607R

Application: For connecting a rheostat (or resistor) in series with a load and the line by simply plugging the load attachment plug into the series plug which itself is plugged into the power receptacle. Also available with grounding terminal.

Description: The series plug consists of a bakelite body with a receptacle in the top and prongs on the bottom. The series plug is connected to the rheostat by means of a line cord.

Series Plug only.......................Cat.No. 6050
Series Plug with Grounding Pin....Cat. No. 6050G
Series Plug with 6 ft. Heater Cord......Type No. 607*
Series Plug with 6 ft. Rubber Cord....Type No. 607R*

******Specify No. 607G or 607GR if grounding plug is required.*

HEAT OR OTHER CONTROL RHEOSTATS

Wattage of Device To Be Controlled		Rheostat Control	Cage	Dimensions	Net Weight
Watts	Volts	Cat. No.	Dia.	Height	lbs.
40—65	115	SRC65	3⅛"	2"	.58
85—100	115	SRC100	3⅛"	2"	.58
120—150	115	SRC150	3¾"	2⅜"	.93
175—220	115	SRC220	3¾"	2⅜"	1.05
300—350	115	SRC350	4½"	2⅜"	1.63
430—500	115	SRC500	7½"	3¼"	2.25

Application: To control the temperature involved in heat-sealing, wax and solder pots, soldering irons, furnaces and for other uses within the specified current range.

Description: The rheostats listed are mounted in perforated, gray wrinkle finished metal cages with knob and dial, Series Plug and six-foot heater type cord as described above. Designed to reduce power in load by approximately 50% maximum, for 115V, use.

AUDIO T AND L PAD ATTENUATORS

T-PAD ATTENUATORS		L-PAD ATTENUATORS	
25 WATT Avg. Wt. 1.44 lbs.		25 WATT Avg. Wt. 1 lb.	
Catalog No.	Line Impedance In Ohms	Catalog No.	Line Impedance In Ohms
3001	15	3201	15
3002	50	3202	50
3003	200	3203	200
3004	500	3204	500
50 WATT Avg. Wt. 1.88 lbs.		50 WATT Avg. Wt. 1.25 lbs.	
3101	15	3301	15
3102	50	3302	50
3103	200	3303	200
3104	500	3304	500

Fig. 75: Attentuator

Application: Smooth, stepless control of loud-speaker volume in high-power public address systems. Varies volume without changing the impedance of the total load connected to the amplifier, thus avoiding distortion and power changes. No insertion loss in full volume position.

Standard or Special: 15, 50, 200 and 500 ohm pads of 25 and 50 watt rating are available from stock. Pads for special line impedance, wattages, or with other circuits are made to order.

OHMITE

Fig. 76: A special explosion-proof rheostat enclosure

EXPLOSION-PROOF ENCLOSURES

Ohmite explosion-proof enclosures are primarily for use in hazardous locations where the atmosphere may carry explosive gases or dust.

These enclosures meet the requirements of NEMA Type VII, Class I, Hazardous Locations (gas), (NEC Class 1, Group C and D); and NEMA Type IX, Class II, Groups F and G, Hazardous Locations (dust), (NEC Class II, Groups E, F and G). They also meet the requirements of NEMA Type V, Dust-tight, (NEC Class III and IV). The enclosures are made of thick-walled castings with accurately machined, tight fitting covers and tight fitting shaft. If explosive mixtures penetrate the enclosure and are ignited by a spark or heat, the flame will be extinguished by cooling as the products of combustion go through the small clearance openings, thus preventing ignition of the explosive mixture on the outside of the enclosure. Enclosures for surface mounting or back of panel, can be supplied for Models H to U single or two in tandem. Further information will be supplied for specific requests.

'HERMETICALLY' SEALED RHEOSTATS

To completely isolate rheostats from the ambient atmosphere, rheostats can be supplied in 'hermetically' sealed enclosures. Terminals are brought out through glass seals. The shaft is sealed by a special O-ring. The enclosures may be filled with dry gases or various liquids. Recommendations will be made for specific cases.

SEALED LIGHTWEIGHT ENCLOSURES FOR RHEOSTAT *MODELS E, H, J, G, OR K

Fig. 77

Compact enclosures, made from lightweight drawn cups, and equipped with two or three screw terminals (or 3 solder lugs), as required, are available for the Model E, H, J, G, and K rheostats. They are dust-tight, but not hermetically sealed. The enclosures are permanently closed by a rolled double seam. The Model E, H and J enclosures correspond to the sizes called for in Military Specifications MIL-R-22 and Models H and J as included in MIL-R-6749. When units are desired to meet the MIL specifications, they should be ordered by the code designation of the pertinent specification. Commercial types are listed in the table.

**Model C normally enclosed; Model E stocked enclosed and unenclosed* — *see page 9.*

Model	Description			Avg. Wt. With Rheo.	Cat. No.
	Terminals	Dia.	Length	Pounds	
E	2	1 3/64"	1 7/32"	.06	6584A
E	3	1 3/64"	1 7/32"	.06	6584B
H	2	1 3/4"	1 3/4"	.30	6580A
H	3	1 3/4"	1 3/4"	.30	6580B
J	2	2 1/2"	1 3/4"	.45	6581A
J	3	2 1/2"	1 3/4"	.45	6581B
G	2	3 7/16"	2 1/4"	.75	6582A
G	3	3 7/16"	2 1/4"	.75	6582B
K	2	3 7/16"	2 1/4"	.90	6583A
K	3	3 7/16"	2 1/4"	.90	6583B

Note: Bushings for 1/4" thick panel, max., (1/8" for Model E) supplied as standard. Two terminals will be connected for counter-clockwise increase of resistance, as viewed from knob, unless otherwise ordered. When soldering lugs are wanted, they must be specified; add suffix L to Cat. No. Rheostat ohms, current, etc., must be specified.

LABORATORY TYPE STANDS

Fig. 78

A convenient semi-enclosed table top rheostat mounting for laboratory and similar use, consists of an angular stand, grey wrinkle finished, equipped with dial, pointer type knob, and suction feet as illustrated. Stands are equipped with 3 multi-purpose binding posts with jack-type heads for receiving banana plugs.

Specify rheostat separately; rheostat is shipped not assembled to stand, unless ordered assembled.

Model	Approx. Weight Pounds	Dimensions			Cat. No.
		Width	Depth	Height	
P	3	6 1/4"	7"	6 3/4"	6534
N	3	6 1/4"	7"	6 3/4"	6525
R	4.5	8 1/4"	8 1/2"	7 3/4"	6526
T	10	11 1/2"	9 7/8"	10 1/2"	6529
U	12	13 1/2"	11 7/8"	12"	6530

MOTOR SPEED CONTROL

OHMITE

Application: Rheostat control of the speed of fractional and integral horsepower motors is the most widely applicable method, is generally the simplest and is easily added to existing installations. Ohmite rheostats provide close, smooth, compact, convenient motor-speed control in countless industrial and appliance uses, such as:

Arc Lamps	Respirators
Blue-Printers	Dental and Medical Equipment
Film Printers	Flame Cutters
Motion Picture Projectors	Machine Tools
Fans	Portable Tools
Blowers	Laboratory Mixers
Pumps	Model Trains
Unit Heaters	

Advantages of Ohmite Rheostats: Smooth, close, continuously variable control, permanently good performance, freedom from deterioration, and compactness make Ohmite rheostats ideal for this service.

All Motors Not Speed Controllable: While all types of direct current motors can be speed-controlled, only a few kinds of alternating current motors are controllable, hence it is essential to obtain the correct type of A.C. motor when speed control is required. Speed controllable motors are listed in the table on page 31.

The following alternating current motors are not speed controllable: Split Phase, Repulsion Start-Induction Run, Repulsion-Induction, Capacitor Start and Run (except for special fan duty motors), Capacitor Start-Induction Run, Synchronous, and Squirrel Cage. No type of speed control is generally available for standard models of these motors because of the use of centrifugal starting switches, inherent constant speed or other design details.

Choice of Motor Depends on the Load: Only the universal motor (a form of series-wound motor) is available for service on both alternating and direct current. It is a high-speed type of motor (3000 to 15,000 R.P.M.) with strong starting torque. The speed varies widely with changes in the load. Generally, the rheostat setting for a given speed will be slightly different on A.C. than D.C. because the characteristics of a series motor change with the type of current. Resistors are often connected in the circuit on D.C. to make the characteristics more nearly identical with the A.C. characteristics. The shunt wound direct current motor has a very slight change of speed with load.

Motor manufacturers find it necessary to change the inherent characteristics such as starting torque, running torque, etc., to suit different applications of the same motor and therefore rheostats, too, must be designed to suit each particular application. In general, motors of similar rating made by different manufacturers require somewhat different rheostats for best control.

Fig. 79: An application of a rheostat in a special cage for motor speed control

Speed Control Laws for D. C. Motors:

Speed is proportional to the voltage across the armature and inversely proportional to the field flux.

Torque (turning moment expressed in pound-feet or ounce-inches) is proportional to the product of the armature current and the field strength.

These laws apply to all forms of direct current motor speed control and help explain the principles underlying the different control circuits.

Different Types of Control: Several different types of control are shown in the table on page 31. A study of this table will help to show that the choice of control depends on:

1. Whether A.C. or D.C. or universal operation is required.
2. The type of motor.
3. The type and amount of load.
4. The exactness of speed control desired.
5. The speed range to be covered.

Another circuit, not shown, uses two rheostats connected in tandem, one in series with the armature and one in parallel with it. This circuit is used to produce very slow speed control of shunt wound motors.

In addition to the circuits shown, Ohmite rheostats are utilized on the motor-generator systems of speed control which are used on A.C. motors of integral horsepower size. There are also multi-speed variations of the circuits shown which utilize Ohmite Power Tap Switches and Ohmite Fixed Resistors; also governor-controlled motors which utilize Ohmite Fixed Resistors. Ohmite VT Variable Transformers can also be used on AC applications, or on DC in conjunction with a rectifier.

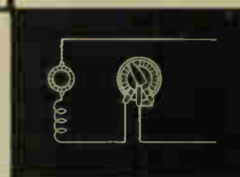
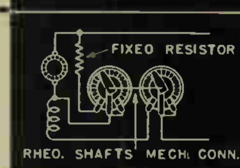
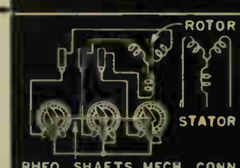
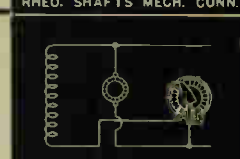
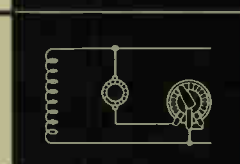
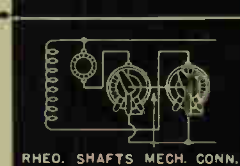
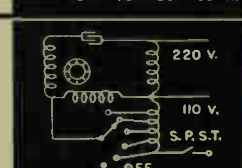
Rheostats with Reversing Switch: Rheostats with two separate windings and a toggle switch can be supplied for single knob speed control and reversing of D.C. motors. One winding controls forward speed, the other reverse.

Fig. 80: A reversing-type, speed control rheostat

Rheostats Individually Designed:

Loads have been classified for general calculation as (a) Machine Duty, where the current is assumed 80% at 50% speed, and (b) Fan Duty, where the load current is assumed as reduced to 40% of maximum at 50% of full load speed.

While loads have been grouped arbitrarily in the above two classifications, each application varies from these theoretical values to such an extent that for the best control, the rheostats must be designed for the particular application. This means that the actual currents and resistances under load must be obtained to permit proper design; the nameplate data from the motor is generally insufficient.

Type of Control	Type of Motor	General Characteristics of Control	Circuit Diagram
I. SERIES RHEOSTAT	D.C. Series or Shunt D.C. Permanent Magnet Universal A.C Series A.C. Repulsion A.C. Shaded Pole	Most used for fractional H.P. appliances, A.C. or Universal, where the load is constant or variations in speed with load are unimportant. Speed will vary widely with the load. 50% reduction of full load speed is maximum used on larger motors—more on smaller motors—depends on type of load.	
II. ARMATURE SHUNT RHEOSTAT	D.C. Series A.C. Series Universal	Reduces speed but maintains torque. Speed will vary less widely with the load than with Series Control. 50% reduction of full load speed is maximum used on larger motors—more on smaller motors—depends on type of load.	
III. COMBINED ARMATURE SHUNT AND SERIES RHEOSTATS	D.C. Series A.C. Series Universal	Widest speed range—maintains torque—useful where load varies. Speed will remain fairly constant regardless of load. Range of 5 to 1 or more is possible depending on type of load.	
IV. ROTOR SERIES RHEOSTATS	A.C. Polyphase Wound Rotor	Standard method for wound rotor motors—also used on single-phase type. Speed will vary with the load. 50% reduction in speed is the maximum generally used. Greater reduction is possible.	
V. FIELD RHEOSTAT	D.C. Shunt	Most used type for integral H.P. industrial applications. Speed remains fairly constant at any load. Speed *increases* with added resistance. Range depends on motor design. Field must *never* be opened.	
VI. ARMATURE SERIES RHEOSTAT	D.C. Shunt	Used to lower speed. Speed will vary with load. Speed decreases as resistance is added. 50% maximum on larger motors.	
VII. COMBINED FIELD AND ARMATURE SERIES RHEOSTATS	D.C. Shunt	Used for widest speed range. Speed variation with load depending on position of control. Speed range depends on motor design.	
VIII. AUTO- TRANSFORMER WITH TAP SWITCH	Special A.C. Capacitor Motor	Used for fan type duty or other low starting torque, constant type of loads. will vary with load. Speed range depends on motor design.	

OHMITE

MOTOR DRIVEN RHEOSTATS

Fig. 81: Typical Ohmite motor-driven rheostat assembly

Ohmite rheostats, either single or in tandem, can be motor operated under remote control. While customers can adapt drives of their own to the rheostats, Ohmite offers standard reversible motor drives assembled to the rheostat of your choice. These standard drives encompass a selection of traverse speeds designed to meet the most frequent requirements and faster delivery can be provided on these. The standard drives are available with 115-volt DC or AC motors in traverse speeds as follows:

TRAVERSE SPEED

DC Motor (Seconds)	AC Motor (Seconds)
3-4	4
10-12	8
40-50	16
100-120	30
	45

The standard arrangement includes the necessary limit switches and cams to stop traverse at the end of the rotational arc. Reversal is accomplished by moving a 3-position control switch to the "reverse" position. Users may also specify additional switches for programming associated equipment during the traverse of the rheostat. Request Bulletin 206 for complete ordering data on standard motor driven rheostats.

Non-Standard Drives: Ohmite can adapt motor drives to meet applications where the requirements are so special that the standard motor driven assemblies are not suitable. Such requirements could include special speeds, 360 degree rotation using "bridged-gap" rheostats (page 24), self-reversing rotation, special auxiliary programming switches, slip clutches, combinations of rheostats and other controls such as transformers or composition potentiometers and other variations. Complete specifications in such cases must be submitted to Ohmite for engineering evaluation and quote.

OHMITE

CONCENTRIC CONTROL RHEOSTAT ASSEMBLIES

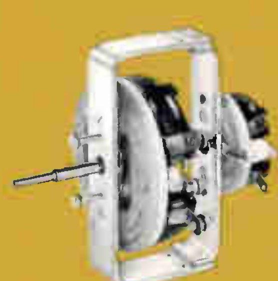


Fig. 82: Tandem assembly with rheostats independently controlled

Two rheostats can be separately controlled by means of concentrically located knobs. This may be done for convenience in operation, to conserve panel space, or where it may be desired to use one rheostat as a vernier for another.

The two rheostats are mounted on a tandem assembly frame with the shaft of the rear unit extending through the hollow shaft of the first. A hand-wheel, or knob, controls the rheostat closest to the mounting panel and a smaller knob controls the other rheostat.

Any combination of models of rheostats can be mounted for concentric control, with the larger rheostat preferably next to the panel. When the largest rheostat is no larger than a Model L, the hollow shaft is $\frac{1}{4}$" diameter and the through-shaft is $\frac{3}{16}$" diameter. When the larger rheostat is a Model P, N, R, T, or U, the standard hollow shaft is $\frac{3}{8}$" diameter and the through shaft is $\frac{1}{4}$" diameter. A hollow shaft of $\frac{1}{2}$" diameter and through-shaft of $\frac{3}{8}$" diameter can be supplied also. The tandem assembly can consist of more than two rheostats with the additional rheostats turning with either shaft. Mounting dimensions are similar to an equivalent standard tandem assembly. Write for further information for specific applications. Panel thickness must be given.

Combinations with Other Controls: Tap switches, low power wafer-type switches, composition potentiometers or variable transformers can be combined with rheostats in concentric control assemblies, with the auxiliary device operated by the through-shaft.

Concentric Control Tandem Mtg. . . . . Code Word: CONCO

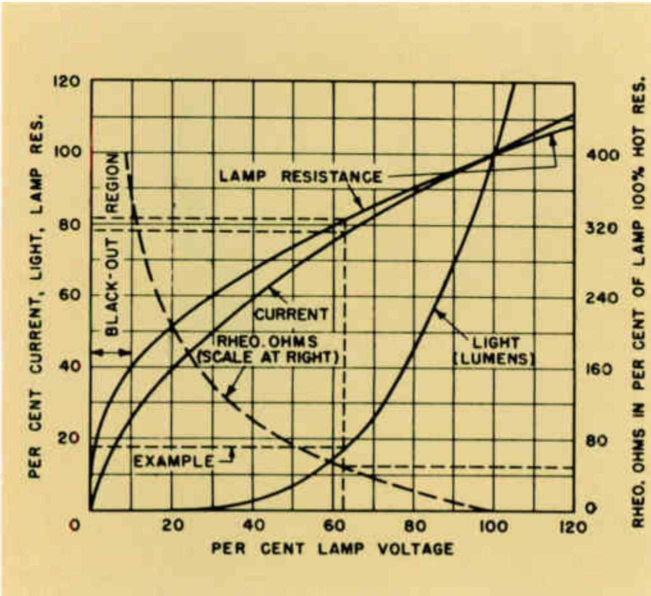


Fig. 83: Average curves for tungsten filament lamps

An Ohmite Rheostat, when connected in series with an incandescent lamp, provides ideally smooth, gradual control of light output from full intensity to any desired degree of dimming. Such control is utilized in photography (lighting of subjects, projection and contact printers, and safe lights); in medicine and dentistry (examination lights); in aviation (instrument lights); in advertising displays, theater stage lighting, and in other applications.

The size and resistance of the rheostat is determined by the lamp to be controlled and the amount of dimming desired. Because a larger rheostat or a tapered winding of more sections is needed for blackout than for 1% light, important economies can often be made if it is permissible to open the circuit before blackout. It is strongly recommended that the minimum amount of light desired be determined by a substitution trial or by measurement with a photo-electric light meter, as visual estimates generally are not sufficiently accurate.

The curves in Fig. 83 show the per cent lamp current, voltage, and resistance, and the per cent required rheostat ohms for any percentage of dimming. The curves apply to 115 volt standard tungsten filament lamps and, in general, to any other lower voltage tungsten filament lamp. Rheostats listed in the table cover the most common applications. They are unmounted units, taper wound as required. The second letter of the Catalog Number corresponds to the model, details of which will be found on pages 9 to 13. A knob, as listed on page 26, should be ordered if one is desired.

Our Engineering Department will be glad to recommend the proper rheostat for any special application on receipt of the following information:

Lamp type, volts and rated current, minimum light (in per cent of maximum), and off-position if wanted. For uncommon types of lamps, supply a sample for test or a curve of light and current versus volts.

LAMP DIMMING RHEOSTATS

Lamp Watts	Minimum Brilliance of Light as Percentage of Full Intensity			
	10%	1%	‡⅛% & Off	Blackout.
25	LHA25	LJB25	LJC25	LJD25
40	LHA40	LJB40	LGC40	LKD40
50	LJA50	LGB50	LKC50	LKD50
60	LJA60	LKB60	LKC60	LKD60
75	LJA75	LKB75	LKC75	LLD75
100	LKA100	LKB100	LKC100	LPD100
120	LKA120	LLB120	LPC120	LND120
150	LKA150	LLB150	LNC150	LND150
180	LKA180	LNB180	LNC180	LND180
200	LLA200	LNB200	LNC200	LND200
§No. 1	*LGA1	LNB1	LRC1	LRD1
§No. 2	*LLA2	LRB2	LTC2	LUD2
§No. 4	*LNA4	LUB4	†LTTC4	†LUUD4

*50% light instead of 10%. †Two rheostats in tandem.

‡Light is reduced to ⅛% and then the circuit is opened by a No. 352 Off-Position.

§Numbers 1, 2 and 4 are photoflood lamps which operate at 250, 500 and 1000 watts respectively.

MOTOR DRIVEN LAMP DIMMERS

Ohmite rheostats arranged for motor drive are often used as faders in advertising displays. Such rheostats are of the bridged gap type (page 24) for continuous rotation. Fig. 84 (A) shows a method of using one rheostat to fade between two lamp banks (both going out as the arm passes the center lead). Figure 84 (B) shows a method for gradually bringing a lamp from out to full on and back to out once every revolution.

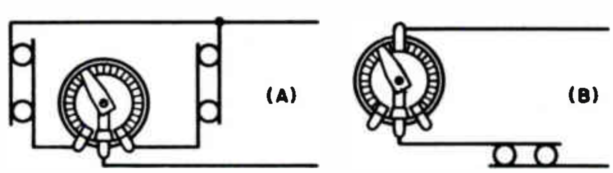


Fig. 84: Fader circuits arranged for continuous rotation

RHEOSTATS FOR MILITARY SPECIFICATIONS

OHMITE

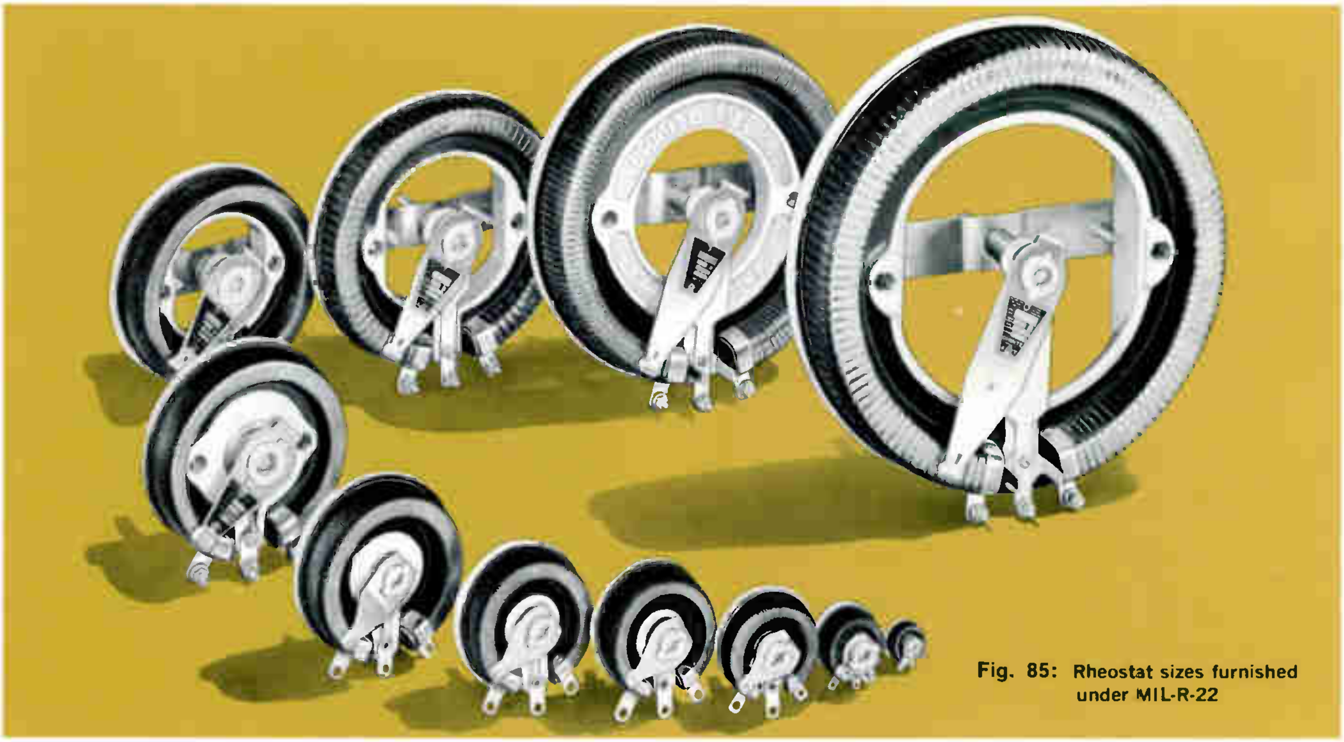


Fig. 85: Rheostat sizes furnished under MIL-R-22

Ohmite power rheostats have seen service in military applications for many years. They have established their noted dependability in widely dispersed areas subject to the extremes of environment from the tropics to the arctic. Ohmite's inert, all ceramic and metal construction is the reason for the durability and ruggedness required to meet the exhaustive tests of the military specifications.

All of the styles (sizes) required by the fundamental rheostat specification, MIL-R-22 (Resistors, Variable, Wirewound, Power Type) from the tiny 5 watt Style RP05 (Model C) to the 1000-watt RP55 (Model U) are supplied by Ohmite with the various options required by the military—options such as enclosures, locking shafts with slots or flats, off-positions, etc.

Ohmite also supplies rheostats to meet military specification MIL-R-6749 for Aircraft Rheostats. This specification covers 25 and 50-watt enclosed rheostats used in aircraft, primarily for light dimming purposes. The physical sizes correspond to Styles RP11 and RP16 of MIL-R-22 with a few differences. The entire specified range of winding tapers is provided under this specification.

TO Order: When a QPL item is required always order by Military Designation, not by Ohmite Type number.

Slotted with locking bushing

Flatted with locking bushing

Enclosed with locking bushing

Fig. 86: Typical locking-type rheostats supplied under MIL-R-22

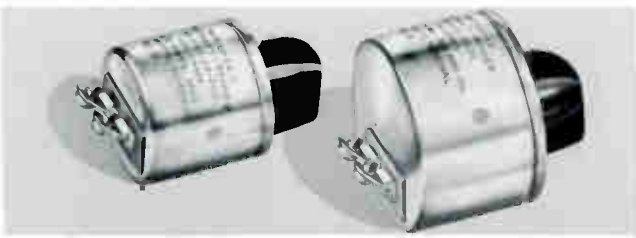


Fig. 87: Aircraft Power Rheostats for MIL-R-6749

MIL-R-22 RHEOSTATS, WIREWOUND

Military Designation	Watt Size	Ohmite Type	Military Designation	Watt Size	Ohmite Type
RP05 ①	5	Model C, enclosed	RP16	25	Model J, enclosed
RP06	12.5	Model E	RP20	75	Model G
RP07	6.25	Model E, enclosed	RP25	100	Model K
			RP30	150	Model L
RP10	25.0	Model H	RP351 ②	225	Model P
RP11	12.5	Model H, enclosed	RP401 ②	300	Model N
			RP451 ②	500	Model R
RP15	50	Model J	RP501 ②	750	Model T
			RP551 ②	1000	Model U

MIL-R-6749 RHEOSTATS: ② AN (Enclosed)

AN3155 25 and 50 Watt

MIL-R-15109 RHEOSTATS: HI-SHOCK

Models E ③, H ③, J, G, K

Notes: ① 1,000 ohms, max.
② Not applicable to CAMESA (Canadian equiv. to DESC-E)
③ Also enclosed

Application: Ohmite Vitreous Enameled Rheostats provide smooth, close, gradual control of generator voltage. The permanence of their characteristics, smoothness of operation, exactness of control, and compactness have made them first choice among generator and switchboard designers. By providing practically continuous variation of resistance in even the smallest sizes, they have made possible great savings in control-panel space. This makes them particularly useful on portable equipment, such as welding generators and power supplies.

Range of Sizes: With a series of ten wattage sizes, there is an Ohmite rheostat, or tandem rheostat assembly, suitable for every size generator in the range from the smallest to units of several hundred kilowatts.

Individually Designed: Ohmite field rheostats will be individually designed by our Engineering Department to fit each generator field condition upon receipt of the following information: State whether self or separately excited, give field resistance (hot), maximum field current (state at what volts for self-excited machines), minimum field current, rheostat resistance (if known). For self-excited machines it is desirable to supply a field magnetization curve.

Standard Designs: The rheostats listed on the following pages are tapered or uniformly wound, as required, designed to provide control for separately or self-excited generators. A number of models with differently tapered windings are listed for each resistance value. Current values depend on both the maximum voltage and the field resistance. Maximum design volts used were 32, 40, 64, 80, 100, 125, 160, 200, 250, 320 and 400. Ratios of rheostat resistance to field resistance were set at equal, 1.6 times, 2.5 times or 4 times.

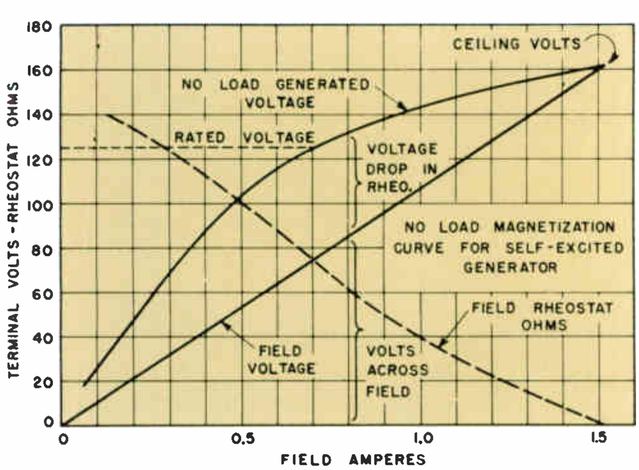


Fig. 88: Design curve for field rheostat

Fig. 89: Typical field control rheostat, wire side view.

DESIGN OF FIELD RHEOSTAT FOR SELF-EXCITED GENERATOR

A magnetization curve (such as Fig. 88) for the particular machine should be obtained from the generator manufacturer. The no load curve is used for machines which may be operated without load or with a light load; a full load curve may be used for a generator which is permanently connected to a load.

The first step is to locate the "ceiling volts"—the highest voltage up to which the generated voltage will build when there is no resistance in series with the field. At this point $E_G = R_{field} \times I_{field}$. A straight line drawn through zero and "ceiling volts" represents the voltage necessary to produce the field current at any intervening point. The vertical distance between this line and the curve of generated voltage represents the voltage drop which must be taken up by the field rheostat.

The second step is to draw the curve of field rheostat ohms versus field current. This is obtained by Ohms' Law:

Rheostat Ohms = Volts Drop in Rheostat ÷ Field Amps.

The total resistance required will depend upon how low it is desired to bring the terminal voltage.

Knowing the maximum voltage, the resistance and maximum and minimum currents, a rheostat may be selected from the tables or Ohmite engineers will design a special unit for the job.

OHMITE

GENERATOR FIELD CONTROL AND GENERAL PURPOSE TAPERED RHEOSTATS

The rheostats in the following table are arranged in the following way: *First*, by increasing order of resistance, from low to high; *second*, for any specific resistance by decreasing maximum current; and *third*, by decreasing order of minimum current. The specific resistance values listed are those which have been used for many years for field control of generators where the voltage may range from approximately 24 volts to 400 and the resistance of the rheostat may vary from equal to the field resistance to four times as much.

All the rheostats have tapered windings except those marked with a dagger sign. In addition to their use for field control, they may be used to control any load of stable resistance, where the maximum and minimum currents are not exceeded; for example, heater loads. The uniform wound rheostats can, of course, be used for any type of load within their maximum current rating.

The rheostats are the same in construction as the stock units listed on pages 10 to 13, inclusive, except that they are taper-wound where indicated. When a field control unit is made up of several rheostats (indicated thus: 2-T, 3-U, etc.), the rheostats are supplied assembled in tandem as described on page 19 and are wired in series by Ohmite Mfg. Co. Standard taper-windings provide a decrease in resistance (increase in generated voltage) with clockwise rotation of the knob. Ohmite rheostats, Models H, J, G, K, L, P, and N are listed under the heading, "Industrial Control Equipment — Miscellaneous Apparatus" in the "List of Inspected Electrical Equipment" published by the Underwriters' Laboratories, Inc.

Total Rheo. Ohms	Current		Model and Dia.	Cat. No. SE—
	Max. Amps	Min. Amps		
1.25	25	12.5	R,8"	15024
1.6	25	12.5	T,10"	15223
1.6	20	10	R,8"	15023
2	25.6	9.85	T,10"	15073
2	20	10	R,8"	15222
2	16	8	R,8"	†15022
2.5	25.6	12.8	U,12"	15422
2.5	16	8	R,8"	15221
2.5	12.8	6.4	N,6"	15021
2.56	25	9.6	U,12"	15271
2.56	20	7.7	T,10"	15072
3.2	25.6	7.2	U,12"	15123
3.2	25	12.5	2-T,10"	15620
3.2	20	10	U,12"	15421
3.2	20	7.7	T,10"	15270
3.2	16	6.15	R,8"	15071
3.2	12.5	6.25	N,6"	15220
3.2	10	5	P,5"	15020
4	25.6	9.9	2-T,10"	15471
4	25	12.5	2-T,10"	15817
4	25	7.15	U,12"	15319
4	20	10	U,12"	15619
4	20	5.71	T,10"	15122
4	16	8	T,10"	15420
4	16	6.16	T,10"	15269
4	12.8	4.92	R,8"	15070
4	10	5	N,6"	15219
4	8	4	P,5"	15018
4	8	4	N,6"	*15019
5	25	12.5	2-U,12"	16018
5	25	9.75	2-U,12"	15670
5	20	10	2-T,10"	15816
5	20	7.8	U,12"	15470
5	20	5.7	U,12"	15318
5	16	8	U,12"	15618
5	16	4.57	T,10"	15121
5	12.8	6.4	R,8"	15419
5	12.5	4.88	R,8"	15268
5	10	3.85	N,6"	15069
5	8	4	P,5"	15218
5	6.4	3.2	L,4"	15017
6.4	25.6	7.2	2-U,12"	15518
6.4	25	12.5	3-U,12"	16229
6.4	25	9.6	2-U,12"	15866
6.4	20	7.7	2-T,10"	15669

Total Rheo. Ohms	Current		Model and Dia.	Cat. No. SE—
	Max. Amps	Min. Amps		
6.4	19.5	9.7	2-T,10"	16017
6.4	16	6.15	U,12"	15469
6.4	16	4.5	T,10"	15317
6.4	15.6	7.8	U,12"	15815
6.4	12.8	3.6	R,8"	15120
6.4	12.5	6.3	T,10"	15617
6.4	10	5	R,8"	15418
6.4	10	3.85	R,8"	15267
6.4	8	3.08	N,6"	15068
6.4	6.25	3.12	P,5"	15216
6.4	6.25	3.12	N,6"	*15217
6.4	5	2.5	K,3⅛"	15015
6.4	5	2.5	L,4"	*15016
8	25	12.5	3-U,12"	16428
8	25	9.6	3-U,12"	16067
8	25	7.14	2-U,12"	15717
8	20	10	2-U,12"	16228
8	20	7.7	2-U,12"	15865
8	20	5.71	2-T,10"	15517
8	16	6.15	U,12"	15668
8	15.6	7.8	2-T,10"	16016
8	12.8	4.92	T,10"	15468
8	12.5	6.25	T,10"	15814
8	12.5	3.57	T,10"	15316
8	10	5	R,8"	15616
8	10	2.86	R,8"	15119
8	8	4	R,8"	15417
8	8	3.08	N,6"	15266
8	6.4	2.46	P,5"	15067
8	5	2.5	L,4"	15215
8	4	2	K,3⅛"	15014
10	25	12.5	4-U,12"	16626
10	25	9.75	3-U,12"	16265
10	25	7.15	3-U,12"	15916
10	20	10	3-U,12"	16427
10	20	5.7	2-T,10"	15716
10	19.5	7.6	2-U,12"	16066
10	16	8	2-U,12"	16227
10	16	4.56	U,12"	15516
10	15.6	6.1	2-T,10"	15864
10	12.5	6.25	U,12"	16015
10	12.5	4.87	U,12"	15667
10	10	5	T,10"	15813
10	10	3.9	T,10"	15467
10	10	2.86	R,8"	15315
10	8	4	R,8"	15615

Total Rheo. Ohms	Current		Model and Dia.	Cat. No. SE—
	Max. Amps	Min. Amps		
10	8	2.28	N,6"	15118
10	6.4	3.2	N,6"	15416
10	6.25	2.44	P,5"	15264
10	6.25	2.44	N,6"	*15265
10	5	1.92	L,4"	15066
10	4	2	K,3⅛"	15213
10	4	2	L,4"	*15214
10	3.2	1.6	G,2¾"	15013
12.5	25	9.75	4-U,12"	16465
12.5	25	7.15	3-U,12"	16115
12.5	20	10	3-U,12"	16625
12.5	20	7.8	3-U,12"	16264
12.5	20	5.7	2-U,12"	15915
12.5	16	8	2-U,12"	16426
12.5	16	4.56	2-T,10"	15715
12.5	15.6	6.1	2-U,12"	16065
12.5	12.8	6.4	2-T,10"	16226
12.5	12.8	3.66	U,12"	15515
12.5	12.5	4.88	U,12"	15863
12.5	10	5	T,10"	16014
12.5	10	3.9	T,10"	15666
12.5	8	4	R,8"	15812
12.5	8	3.12	R,8"	15466
12.5	8	2.28	R,8"	15314
12.5	6.4	3.2	R,8"	15614
12.5	6.4	1.83	P,5"	15116
12.5	6.4	1.83	N,6"	*15117
12.5	5.1	2.55	P,5"	15414
12.5	5.1	2.55	N,6"	*15415
12.5	5	1.95	P,5"	15263
12.5	4	1.54	K,3⅛"	15064
12.5	4	1.54	L,4"	*15065
12.5	3.2	1.6	K,3⅛"	15212
12.5	2.56	1.28	J,2 5/16"	15010
12.5	2.56	1.28	G,2¾"	15011
12.5	2.56	1.28	K,3⅛"	*†15012
16	20	10	4-U,12"	16820
16	20	7.7	3-U,12"	16464
16	19.5	5.6	3-U,12"	16114
16	16	6.15	2-U,12"	16263
16	15.6	7.8	3-U,12"	16624
16	15.6	4.46	2-T,10"	15914
16	12.5	6.25	2-T,10"	16425
16	12.5	4.8	2-T,10"	16064
16	12.5	3.57	U,12"	15714

Total Rheo. Ohms	Current		Model and Dia.	Cat. No. SE—
	Max. Amps	Min. Amps		
16	10	5	U,12"	16225
16	10	3.85	U,12"	15862
16	10	2.86	T,10"	15514
16	8	3.07	T,10"	15665
16	7.8	3.9	T,10"	16013
16	6.4	2.46	R,8"	15465
16	6.25	3.12	R,8"	15811
16	6.25	1.78	N,6"	15313
16	5	2.5	N,6"	15613
16	5	1.43	P,5"	15115
16	4	2	P,5"	15412
16	4	2	N,6"	*†15413
16	4	1.54	L,4"	15262
16	3.2	1.23	K,3⅛"	15063
16	2.5	1.25	G,2¾"	15211
16	2	1	J,2 5/16"	15008
16	2	1	G,2¾"	*†15009
20	20	7.7	4-U,12"	16662
20	20	5.7	3-U,12"	16311
20	16	8	3-U,12"	16819
20	16	6.15	3-U,12"	16463
20	15.6	4.45	3-T,10"	16113
20	12.8	4.92	2-U,12"	16262
20	12.5	6.25	2-U,12"	16623
20	12.5	3.57	2-T,10"	15913
20	10	5	2-T,10"	16424
20	10	3.9	U,12"	16063
20	10	2.86	U,12"	15713
20	8	4	U,12"	16224
20	8	3.08	T,10"	15861
20	8	2.28	T,10"	15513
20	6.25	3.13	R,8"	16012
20	6.4	2.46	R,8"	15664
20	5.1	1.97	N,6"	15464
20	5	2.5	R,8"	15810
20	5	1.43	P,5"	15311
20	5	1.43	N,6"	*15312
20	4	2	P,5"	15612
20	4	1.14	L,4"	15114
20	3.2	1.6	L,4"	15411
20	3.2	1.23	K,3⅛"	15260
20	3.2	1.23	L,4"	*15261
20	2.56	0.99	G,2¾"	15061
20	2.56	0.99	K,3⅛"	*15062
20	2	1	J,2 5/16"	15208

**Where several rheostats are listed for a given resistance and rating and when the quantity to be purchased is only one, the unit indicated by the asterisk costs the least of the two or three sizes given. The smaller rheostat (taper-wound with more sections) is generally cheaper in large quantities. Further information on request.*

†These rheostats have a uniform winding (i.e., not tapered).

GENERATOR FIELD CONTROL AND GENERAL PURPOSE TAPERED RHEOSTATS

OHMITE

Total Rheo. Ohms	Current		Model and Dia.	Cat. No. SE—
	Max. Amps	Min. Amps		
20	2	1	G,2¾"	15209
20	2	1	K,3⅛"	*†15210
20	1.6	0.8	J,2 5/16"	†15007
25	20	5.7	4-U,12"	16511
25	16	4.57	3-U,12"	16310
25	15.6	6.1	3-U,12"	16661
25	12.8	6.4	3-U,12"	16818
25	12.5	4.87	2-U,12"	16462
25	12.5	3.57	2-U,12"	16112
25	10	5	2-T,10"	16622
25	10	3.9	2-T,10"	16261
25	10	2.86	U,12"	15912
25	8	4	U,12"	16423
25	8	2.28	T,10"	15712
25	7.8	3.1	U,12"	16062
25	6.25	2.44	T,10"	15860
25	6.4	3.2	T,10"	16223
25	6.4	1.83	R,8"	15512
25	5	2.5	R,8"	16011
25	5	1.95	R,8"	15663
25	4	1.56	P,5"	15462
25	4	1.56	N,6"	*15463
25	4	1.14	P,5"	15310
25	4	2	N,6"	15809
25	3.2	1.6	P,5"	15610
25	3.2	1.6	N,6"	*†15611
25	3.2	0.92	L,4"	15113
25	2.56	1.28	K,3⅛"	15409
25	2.56	1.28	L,4"	*15410
25	2.5	0.98	K,3⅛"	15259
25	2	0.77	J,2 5/16"	15059
25	2	0.77	G,2¾"	*15060
25	1.6	0.8	J,2 5/16"	15206
25	1.6	0.8	G,2¾"	†*15207
25	1.28	0.64	H,1 9/16"	15005
25	1.28	0.64	J,2 5/16"	†*15006
32	20	4	4-U,12"	16367
32	16	6.15	4-U,12"	16860
32	16	4.5	4-U,12"	16510
32	12.8	3.6	3-T,10"	16309
32	12.5	4.8	3-U,12"	16660
32	10	5	2-U,12"	16817
32	10	3.85	2-U,12"	16461
32	10	2.8	2-T,10"	16111
32	8	3.1	U,12"	16260
32	8	2.25	U,12"	15911
32	7.8	3.9	2-T,10"	16621
32	6.25	3.13	T,10"	16422
32	6.25	2.4	T,10"	16061
32	6.4	1.8	T,10"	15711
32	5.11	1.44	R,8"	15511
32	5	2.5	R,8"	16222
32	5	1.92	R,8"	15859
32	4	1.54	N,6"	15662
32	3.9	1.95	R,8"	†16010
32	3.2	1.23	P,5"	15461
32	3.2	0.9	L,4"	15309
32	3.12	1.56	P,5"	15807
32	3.12	1.56	N,6"	*15808
32	2.56	0.72	K,3⅛"	15112

Total Rheo. Ohms	Current		Model and Dia.	Cat. No. SE—
	Max. Amps	Min. Amps		
32	2.5	1.25	L,4"	15609
32	2	1	K,3⅛"	15408
32	2	0.77	G,2¾"	15257
32	2	0.77	K,3⅛"	*15258
32	1.6	0.62	J,2 5/16"	15056
32	1.6	0.62	G,2¾"	15057
32	1.6	0.62	K,3⅛"	†*15058
32	1.25	0.63	J,2 5/16"	15204
32	1.25	0.63	G,2¾"	†*15205
32	1	0.5	H,1 9/16"	15003
32	1	0.5	J,2 5/16"	†*15004
40	16	3.2	3-U,12"	16366
40	12.8	4.93	4-U,12"	16859
40	12.5	3.57	3-U,12"	16509
40	10	5	3-U,12"	17017
40	10	3.85	2-U,12"	16659
40	10	2.86	2-U,12"	16308
40	8	4	2-U,12"	16816
40	8	3.08	2-T,10"	16460
40	7.8	2.24	U,12"	16110
40	6.4	2.46	U,12"	16259
40	6.25	3.13	U,12"	16620
40	6.25	1.79	T,10"	15910
40	5	2.5	T,10"	16421
40	5	1.92	T,10"	16060
40	5	1.43	R,8"	15710
40	4	2	R,8"	16221
40	4	1.54	R,8"	15858
40	4	1.14	N,6"	15510
40	3.13	1.56	N,6"	16009
40	3.2	1.23	P,5"	15660
40	3.2	1.23	N,6"	*15661
40	2.56	0.99	L,4"	15460
40	2.5	1.25	P,5"	15805
40	2.5	1.25	N,6"	†*15806
40	2.5	0.72	L,4"	15308
40	2	1	K,3⅛"	15607
40	2	1	L,4"	*15608
40	2	0.57	G,2¾"	15110
40	2	0.57	K,3⅛"	*15111
40	1.6	0.62	J,2 5/16"	15255
40	1.6	0.62	G,2¾"	*15256
40	1.28	0.49	J,2 5/16"	15055
40	1.6	0.8	G,2¾"	15407
40	1	0.5	H,1 9/16"	15202
40	1	0.5	J,2 5/16"	†*15203
40	0.8	0.4	H,1 9/16"	15001
40	0.8	0.4	J,2 5/16"	†*15002
50	16	3.2	4-U,12"	16564
50	12.8	2.56	3-U,12"	16365
50	12.5	3.57	4-U,12"	16708
50	10	3.9	3-U,12"	16858
50	10	2.86	2-U,12"	16508
50	8	4	2-U,12"	17016
50	8	2.29	2-T,10"	16307
50	7.8	3.05	2-U,12"	16658
50	6.4	3.2	2-T,10"	16815
50	6.25	2.44	U,12"	16459
50	6.25	1.79	U,12"	16109
50	5	2.5	T,10"	16619

Total Rheo. Ohms	Current		Model and Dia.	Cat. No. SE—
	Max. Amps	Min. Amps		
50	5	1.95	T,10"	16258
50	5	1.43	T,10"	15909
50	4	1.15	R,8"	15709
50	4	2	R,8"	16420
50	3.9	1.52	R,8"	16059
50	3.2	1.6	N,6"	16220
50	3.2	0.92	P,5"	15508
50	3.2	0.92	N,6"	*15509
50	3.12	1.22	N,6"	15857
50	2.5	1.25	N,6"	16008
50	2.5	0.98	P,5"	15659
50	2	1	L,4"	15804
50	2	0.78	K,3⅛"	15458
50	2	0.78	L,4"	*15459
50	2	0.57	K,3⅛"	15307
50	1.6	0.8	K,3⅛"	15606
50	1.6	0.46	J,2 5/16"	15108
50	1.6	0.46	G,2¾"	*15109
50	1.28	0.64	J,2 5/16"	15404
50	1.28	0.64	G,2¾"	15405
50	1.28	0.64	K,3⅛"	†*15406
50	1.25	0.49	J,2 5/16"	15252
50	1.25	0.49	G,2¾"	15253
50	1.25	0.49	K,3⅛"	†*15254
50	1	0.39	J,2 5/16"	†15054
50	0.8	0.4	H,1 9/16"	15200
50	0.8	0.4	J,2 5/16"	†*15201
50	0.64	0.32	H,1 9/16"	†15000
64	12.8	3.6	4-U,12"	16906
64	12.5	2.5	3-U,12"	16563
64	10	2.81	3-U,12"	16707
64	10	2	2-U,12"	16364
64	8	3.08	2-U,12"	16857
64	8	2.25	2-U,12"	16507
64	6.4	1.8	U,12"	16306
64	6.25	3.13	2-T,10"	17015
64	6.25	2.4	2-T,10"	16657
64	5	2.5	U,12"	16814
64	5	1.92	U,12"	16458
64	5	1.4	T,10"	16108
64	4	1.54	T,10"	16257
64	4	1.12	R,8"	15908
64	3.9	1.95	T,10"	16618
64	3.2	0.9	N,6"	15708
64	3.13	1.2	R,8"	16058
64	3.12	1.56	R,8"	16419
64	2.56	0.72	P,5"	15507
64	2.5	1.25	N,6"	16219
64	2.5	0.96	P,5"	15855
64	2.5	0.96	N,6"	*15856
64	2	0.77	L,4"	15658
64	1.96	0.976	P,5"	16006
64	1.96	0.976	N,6"	†*16007
64	1.56	0.78	K,3⅛"	15802
64	1.56	0.78	L,4"	*15803
64	1.28	0.36	J,2 5/16"	15106
64	1.28	0.36	G,2¾"	*15107
64	1.25	0.63	G,2¾"	15605
64	1.6	0.62	K,3⅛"	15457
64	1.6	0.45	G,2¾"	15305

Total Rheo. Ohms	Current		Model and Dia.	Cat. No. SE—
	Max. Amps	Min. Amps		
64	1.6	0.45	K,3⅛"	*15306
64	1	0.5	J,2 5/16"	15402
64	1	0.5	G,2¾"	†*15403
64	1	0.39	J,2 5/16"	15251
64	0.8	0.31	H,1 9/16"	15052
64	0.8	0.31	J,2 5/16"	†*15053
80	12.5	2.5	4-U,12"	16761
80	10	2.86	3-U,12"	16905
80	10	2	3-U,12"	16562
80	8	1.6	2-U,12"	16363
80	7.8	2.23	2-U,12"	16706
80	6.4	2.46	2-U,12"	16856
80	6.25	1.79	2-T,10"	16506
80	5	2.5	2-T,10"	17014
80	5	1.92	U,12"	16656
80	5	1.42	T,10"	16305
80	4	2	U,12"	16813
80	4	1.54	T,10"	16457
80	3.9	1.1	T,10"	16107
80	3.2	1.23	R,8"	16256
80	3.13	1.56	R,8"	16617
80	3.1	0.89	R,8"	15907
80	2.5	1.25	N,6"	16418
80	2.5	0.96	N,6"	16057
80	2.5	0.71	P,5"	15706
80	2.5	0.71	N,6"	*15707
80	2	1	P,5"	16218
80	2	0.77	P,5"	15854
80	2	0.57	L,4"	15506
80	1.6	0.62	K,3⅛"	15656
80	1.6	0.62	L,4"	*15657
80	1.56	0.78	L,4"	16005
80	1.28	0.49	G,2¾"	15455
80	1.28	0.49	K,3⅛"	*15456
80	1.25	0.63	K,3⅛"	15801
80	1.25	0.36	J,2 5/16"	15303
80	1.25	0.36	G,2¾"	*15304
80	1	0.5	J,2 5/16"	15602
80	1	0.5	G,2¾"	15603
80	1	0.5	K,3⅛"	†*15604
80	1	0.29	J,2 5/16"	15105
80	0.8	0.4	J,2 5/16"	15400
80	0.8	0.4	G,2¾"	†*15401
80	0.8	0.31	J,2 5/16"	15250
80	0.64	0.25	H,1 9/16"	15050
80	0.64	0.25	J,2 5/16"	†*15051
100	10	2	3-U,12"	16760
100	8	2.28	3-U,12"	16904
100	8	1.6	2-U,12"	16561
100	6.4	1.28	2-T,10"	16362
100	6.25	1.78	2-U,12"	16705
100	5	1.95	2-T,10"	16855
100	5	1.43	U,12"	16505
100	4	1.14	T,10"	16304
100	4	2	U,12"	17013
100	3.9	1.52	U,12"	16655
100	3.2	1.6	T,10"	16812
100	3.13	0.9	R,8"	16106
100	3.12	1.22	T,10"	16456
100	2.5	1.25	R,8"	16616

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OHMITE

GENERATOR FIELD CONTROL AND GENERAL PURPOSE TAPERED RHEOSTATS

Total Rheo. Ohms	Current Max. Amps	Current Min. Amps	Model and Dia.	Cat. No. SE—
100	2.5	0.98	R,8"	16255
100	2.5	0.71	N,6"	15906
100	2	1	N,6"	16417
100	2	0.57	P,5"	15705
100	1.95	0.76	P,5"	16055
100	1.95	0.76	N,6"	*16056
100	1.6	0.8	P,5"	16216
100	1.6	0.8	N,6"	†*16217
100	1.6	0.46	L,4"	15505
100	1.56	0.61	L,4"	15853
100	1.25	0.625	K,3⅛"	16003
100	1.25	0.625	L,4"	*16004
100	1.25	0.49	G,2¾"	15654
100	1.25	0.49	K,3⅛"	*15655
100	1	0.5	G,2¾"	15800
100	1	0.39	J,2 5/16"	15453
100	1	0.39	G,2¾"	*15454
100	1	0.29	J,2 5/16"	15301
100	1	0.29	G,2¾"	*15302
100	0.8	0.4	J,2 5/16"	15600
100	0.8	0.4	G,2¾"	†*15601
100	0.8	0.23	J,2 5/16"	15103
100	0.8	0.23	G,2¾"	†*15104
125	10	2.04	4-U,12"	16959
125	7.8	1.59	3-U,12"	16759
125	6.4	1.83	3-T,10"	16903
125	6.25	1.28	2-U,12"	16560
125	5	1.43	2-T,10"	16704
125	5	1	U,12"	16361
125	4	1.56	U,12"	16854
125	4	1.14	U,12"	16504
125	3.2	1.6	T,10"	17012
125	3.2	.91	T,10"	16303
125	3.12	1.22	T,10"	16654
125	2.56	1.28	R,8"	16811
125	2.5	0.98	R,8"	16455
125	2.5	0.71	R,8"	16105
125	2	1	N,6"	16615
125	2	0.78	N,6"	16254
125	2	0.57	P,5"	15904
125	2	0.57	N,6"	*15905
125	1.6	0.8	P,5"	16416
125	1.6	0.45	L,4"	15704
125	1.56	0.61	P,5"	16054
125	1.28	0.64	L,4"	16215
125	1.28	0.37	K,3⅛"	15504
125	1.25	0.49	K,3⅛"	15851
125	1.25	0.49	L,4"	*15852
125	1	0.5	G,2¾"	16001
125	1	0.5	K,3⅛"	*16002
125	0.8	0.31	J,2 5/16"	15450
125	0.8	0.31	G,2¾"	15451
125	0.8	0.31	K,3⅛"	†*15452
125	0.8	0.23	J,2 5/16"	15300
125	0.64	0.18	H,1 9/16"	15100
125	0.64	0.18	J,2 5/16"	15101
125	0.64	0.18	G,2¾"	†*15102
128	1	0.38	G,2¾"	15652
128	1	0.38	K,3⅛"	*15653
160	8	1.6	3-U,12"	16958

Total Rheo. Ohms	Current Max. Amps	Current Min. Amps	Model and Dia.	Cat. No. SE—
160	6.25	1.25	2-U,12"	16758
160	5	1.43	2-U,12"	16902
160	5	1	2-T,10"	16559
160	4	0.8	U,12"	16360
160	3.9	1.12	U,12"	16703
160	3.2	1.23	U,12"	16853
160	3.12	0.89	T,10"	16503
160	2.5	1.25	T,10"	17011
160	2.5	.96	T,10"	16653
160	2.5	.71	R,8"	16302
160	2	1	R,8"	16810
160	2	0.77	R,8"	16454
160	1.95	0.56	N,6"	16104
160	1.6	0.62	P,5"	16252
160	1.6	0.62	N,6"	*16253
160	1.56	0.78	N,6"	16614
160	1.56	0.45	P,5"	15903
160	1.25	0.625	P,5"	16414
160	1.25	0.625	N,6"	†*16415
160	1.25	0.48	L,4"	16053
160	1.25	0.36	L,4"	15703
160	1	0.5	K,3⅛"	16213
160	1	0.5	L,4"	*16214
160	1	0.39	K,3⅛"	15850
160	1	0.29	G,2¾"	15502
160	1	0.29	K,3⅛"	*15503
160	0.8	0.31	J,2 5/16"	15650
160	0.8	0.31	G,2¾"	*15651
160	0.78	0.39	G,2¾"	16000
200	6.4	1.28	3-U,12"	16957
200	5	1	2-T,10"	16757
200	4	1.14	2-T,10"	16901
200	4	0.8	U,12"	16558
200	3.2	0.64	T,10"	16359
200	3.12	0.89	U,12"	16702
200	2.56	0.99	T,10"	16852
200	2.5	0.72	T,10"	16502
200	2	1	R,8"	17010
200	2	0.77	R,8"	16652
200	2	0.57	R,8"	16301
200	1.6	.8	N,6"	16809
200	1.6	0.615	N,6"	16453
200	1.56	0.45	P,5"	16103
200	1.28	0.49	P,5"	16251
200	1.25	0.625	P,5"	16612
200	1.25	0.625	N,6"	*16613
200	1.25	0.36	L,4"	15901
200	1.25	0.36	P,5"	*15902
200	1	0.5	L,4"	16413
200	1	0.39	K,3⅛"	16051
200	1	0.39	L,4"	*16052
200	1	0.28	K,3⅛"	15702
200	0.8	0.4	K,3⅛"	16211
200	0.8	0.4	L,4"	†*16212
200	0.8	0.23	J,2 5/16"	15500
200	0.8	0.23	G,2¾"	*15501
250	5	1	2-U,12"	16956
250	3.9	0.8	2-T,10"	16756
250	3.2	0.91	U,12"	16900
250	3.12	0.64	U,12"	16557

Total Rheo. Ohms	Current Max. Amps	Current Min. Amps	Model and Dia.	Cat. No. SE—
250	2.5	0.715	T,10"	16701
250	2.5	0.51	R,8"	16358
250	2	0.78	R,8"	*16850
250	2	0.78	T,10"	16851
250	2	0.57	R,8"	16501
250	1.6	0.8	R,8"	17009
250	1.6	0.46	N,6"	16300
250	1.56	0.61	R,8"	16651
250	1.28	0.64	N,6"	16808
250	1.25	0.49	P,5"	16451
250	1.25	0.49	N,6"	*16452
250	1.25	0.36	N,6"	16102
250	1	0.5	P,5"	16610
250	1	0.5	N,6"	*16611
250	1	0.39	L,4"	16250
250	1	0.28	L,4"	15900
250	0.8	0.4	K,3⅛"	16411
250	0.8	0.4	L,4"	*16412
250	0.8	0.23	G,2¾"	15700
250	0.8	0.23	K,3⅛"	*15701
250	0.78	0.3	K,3⅛"	16050
250	0.64	0.32	G,2¾"	16210
320	4	0.8	2-U,12"	16955
320	3.1	0.63	U,12"	16755
320	2.5	0.5	T,10"	16556
320	2	0.56	T,10"	16700
320	2	0.4	R,8"	16357
320	1.6	0.45	R,8"	16500
320	1.25	0.625	N,6"	17008
320	1.25	0.48	N,6"	16650
320	1	0.5	P,5"	16807
320	1	0.385	P,5"	16450
320	1	0.28	L,4"	16101
320	0.78	0.39	L,4"	16609
320	0.625	0.313	G,2¾"	16408
320	0.625	0.313	K,3⅛"	16409
320	0.625	0.313	L,4"	†*16410
320	0.5	0.25	J,2 5/16"	16207
320	0.5	0.25	G,2¾"	16208
320	0.5	0.25	K,3⅛"	†*16209
400	3.2	0.64	2-T,10"	16954
400	2.5	0.5	T,10"	16754
400	2	0.4	R,8"	16555
400	1.6	0.32	R,8"	16356
400	1	0.5	N,6"	17007
400	0.8	0.4	P,5"	16805
400	0.8	0.4	N,6"	†*16806
400	0.78	0.22	L,4"	16100
400	0.625	0.313	K,3⅛"	16607
400	0.625	0.313	L,4"	*16608
400	0.5	0.25	G,2¾"	16407
400	0.4	0.2	J,2 5/16"	16205
400	0.4	0.2	G,2¾"	†*16206
500	2.56	0.51	U,12"	16953
500	2	0.4	T,10"	16753
500	1.6	0.32	R,8"	16554
500	1.28	0.26	N,6"	16355
500	0.8	0.4	P,5"	17006
500	0.64	0.32	L,4"	16804
500	0.5	0.25	G,2¾"	16605
500	0.5	0.25	K,3⅛"	*16606
500	0.4	0.2	J,2 5/16"	16404
500	0.4	0.2	G,2¾"	16405
500	0.4	0.2	K,3⅛"	†*16406
500	0.32	0.16	J,2 5/16"	16204
640	2	0.4	U,12"	16952
640	1.56	0.31	R,8"	16752

Total Rheo. Ohms	Current Max. Amps	Current Min. Amps	Model and Dia.	Cat. No. SE—
640	1.25	0.25	R,8"	16553
640	1	0.2	P,5"	16353
640	1	0.2	N,6"	*16354
640	0.625	0.313	P,5"	17004
640	0.625	0.313	N,6"	†*17005
640	0.5	0.25	K,3⅛"	16802
640	0.5	0.25	L,4"	*16803
640	0.39	0.195	G,2¾"	16604
640	0.312	0.156	J,2 5/16"	16403
640	0.25	0.125	H,1 9/16"	16202
640	0.25	0.125	J,2 5/16"	†*16203
800	1.6	0.32	T,10"	16951
800	1.25	0.25	R,8"	16751
800	1	0.2	N,6"	16552
800	0.8	0.16	P,5"	16351
800	0.8	0.16	N,6"	*16352
800	0.5	0.25	L,4"	17003
800	0.4	0.2	K,3⅛"	16801
800	0.312	0.156	J,2 5/16"	16601
800	0.312	0.156	G,2¾"	16602
800	0.312	0.156	K,3⅛"	†16603
800	0.25	0.125	J,2 5/16"	†16402
800	0.2	0.1	H,1 9/16"	16200
800	0.2	0.1	J,2 5/16"	†*16201
1000	1.28	0.256	R,8"	16950
1000	1	0.2	R,8"	16750
1000	0.8	0.16	P,5"	16550
1000	0.8	0.16	N,6"	*16551
1000	0.64	0.128	L,4"	16350
1000	0.4	0.2	K,3⅛"	17001
1000	0.4	0.2	L,4"	*17002
1000	0.32	0.16	G,2¾"	16800
1000	0.25	0.125	J,2 5/16"	16600
1000	0.2	0.1	H,1 9/16"	16400
1000	0.2	0.1	J,2 5/16"	†*16401
1250	0.32	0.16	K,3⅛"	17000

**Where several rheostats are listed for a given resistance and rating and when the quantity to be purchased is only one, the unit indicated by the asterisk costs the least of the two or three sizes given. The smaller rheostat (taper-wound with more sections) is generally cheaper in large quantities. Further information on request.*

†These rheostats have a uniform winding (i.e., not tapered).

INDEX OF TAPERED RHEOSTATS BY CATALOG NUMBER

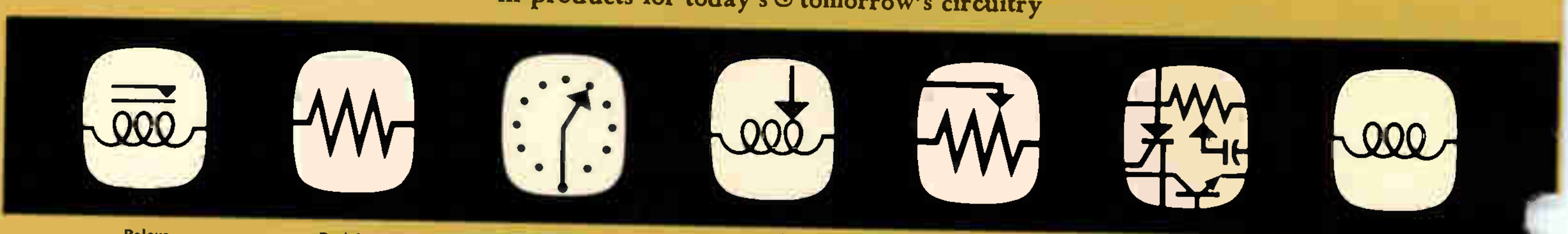
OHMITE

Cat. No. SE—	Total Rheo. Ohms	Cat. No. SE—	Total Rheo. Ohms	Cat. No. SE—	Total Rheo. Ohms	Cat. No. SE—	Total Rheo. Ohms	Cat. No. SE—	Total Rheo. Ohms	Cat. No. SE—	Total Rheo. Ohms	Cat. No. SE—	Total Rheo. Ohms	Cat. No. SE—	Total Rheo. Ohms
15000	50	15211	16	15456	80	15706	80	16051	200	16302	160	16510	32	16806	400
15001	40	15212	12.5	15457	64	15707	80	16052	200	16303	125	16511	25	16807	320
15002	40	15213	10	15458	50	15708	64	16053	160	16304	100	16550	1000	16808	250
15003	32	15214	10	15459	50	15709	50	16054	125	16305	80	16551	1000	16809	200
15004	32	15215	8	15460	40	15710	40	16055	100	16306	64	16552	800	16810	160
15005	25	15216	6.4	15461	32	15711	32	16056	100	16307	50	16553	640	16811	125
15006	25	15217	6.4	15462	25	15712	25	16057	80	16308	40	16554	500	16812	100
15007	20	15218	5	15463	25	15713	20	16058	64	16309	32	16555	400	16813	80
15008	16	15219	4	15464	20	15714	16	16059	50	16310	25	16556	320	16814	64
15009	16	15220	3.2			15715	12.5			16311	20	16557	250	16815	50
15010	12.5	15221	2.5	15465	16	15716	10	16060	40	16350	1000	16558	200	16816	40
15011	12.5	15222	2	15466	12.5	15717	8	16061	32	16351	800	16559	160	16817	32
15012	12.5	15223	1.6	15467	10	15800	100	16062	25	16352	800	16560	125	16818	25
15013	10	15250	80	15468	8	15801	80	16063	20	16353	640	16561	100	16819	20
15014	8	15251	64	15469	6.4	15802	64			16354	640	16562	80		
15015	6.4	15252	50	15470	5	15803	64	16064	16	16355	500	16563	64	16820	16
15016	6.4	15253	50	15471	4	15804	50	16065	12.5	16356	400	16564	50	16850	250
15017	5	15254	50	15500	200	15805	40	16066	10	16357	320	16600	1000	16851	250
15018	4	15255	40	15501	200	15806	40	16067	8	16358	250	16601	800	16852	200
15019	4	15256	40	15502	160	15807	32			16359	200	16602	800	16853	160
15020	3.2	15257	32	15503	160	15808	32	16100	400	16360	160	16603	800	16854	125
15021	2.5	15258	32	15504	125	15809	25	16101	320	16361	125	16604	640	16855	100
15022	2	15259	25	15505	100	15810	20	16102	250	16362	100	16605	500	16856	80
15023	1.6	15260	20	15506	80	15811	16	16103	200	16363	80	16606	500	16857	64
15024	1.25	15261	20	15507	64	15812	12.5	16104	160	16364	64	16607	400	16858	50
15050	80	15262	16	15508	50	15813	10	16105	125	16365	50	16608	400	16859	40
15051	80	15263	12.5	15509	50	15814	8	16106	100	16366	40	16609	320	16860	32
15052	64	15264	10	15510	40	15815	6.4	16107	80	16367	32	16610	250	16900	250
15053	64	15265	10	15511	32	15816	5	16108	64	16400	1000	16611	250	16901	200
15054	50	15266	8	15512	25	15817	4	16109	50	16401	1000	16612	200	16902	160
15055	40	15267	6.4	15513	20	15850	160	16110	40	16402	800	16613	200	16903	125
15056	32	15268	5	15514	16	15851	125	16111	32	16403	640	16614	160	16904	100
15057	32	15269	4	15515	12.5	15852	125	16112	25	16404	500	16615	125	16905	80
15058	32	15270	3.2	15516	10	15853	100	16113	20	16405	500	16616	100	16906	64
15059	25			15517	8	15854	80	16114	16			16617	80	16950	1000
15060	25	15271	2.56	15518	6.4	15855	64	16115	12.5	16406	500	16618	64	16951	800
15061	20	15300	125	15600	100	15856	64	16200	800	16407	400	16619	50	16952	640
15062	20	15301	100	15601	100	15857	50	16201	800	16408	320	16620	40	16953	500
15063	16	15302	100	15602	80	15858	40	16202	640	16409	320	16621	32	16954	400
15064	12.5	15303	80	15603	80	15859	32	16203	640	16410	320	16622	25	16955	320
15065	12.5	15304	80	15604	80	15860	25	16204	500	16411	250	16623	20	16956	250
15066	10	15305	64	15605	64	15861	20	16205	400	16412	250	16624	16	16957	200
15067	8	15306	64	15606	50	15862	16	16206	400	16413	200	16625	12.5	16958	160
15068	6.4	15307	50	15607	40	15863	12.5	16207	320	16414	160	16626	10	16959	125
15069	5	15308	40	15608	40			16208	320	16415	160	16650	320	17000	1250
15070	4	15309	32	15609	32	15864	10	16209	320	16416	125	16651	250	17001	1000
15071	3.2	15310	25	15610	25	15865	8	16210	250	16417	100	16652	200	17002	1000
15072	2.56	15311	20	15611	25	15866	6.4	16211	200	16418	80	16653	160	17003	800
15073	2	15312	20	15612	20	15900	250	16212	200	16419	64	16654	125	17004	640
15100	125	15313	16	15613	16	15901	200	16213	160	16420	50			17005	640
15101	125	15314	12.5	15614	12.5	15902	200	16214	160	16421	40	16655	100	17006	500
15102	125	15315	10	15615	10	15903	160	16215	125	16422	32	16656	80	17007	400
15103	100	15316	8	15616	8	15904	125	16216	100	16423	25	16657	64	17008	320
15104	100	15317	6.4	15617	6.4	15905	125	16217	100	16424	20	16658	50	17009	250
15105	80	15318	5	15618	5	15906	100	16218	80	16425	16	16659	40	17010	200
15106	64	15319	4	15619	4	15907	80	16219	64	16426	12.5	16660	32	17011	160
15107	64	15400	80	15620	3.2	15908	64	16220	50	16427	10	16661	25	17012	125
15108	50	15401	80	15650	160	15909	50	16221	40	16428	8	16662	20	17013	100
15109	50	15402	64	15651	160	15910	40	16222	32	16450	320	16700	320	17014	80
		15403	64	15652	128	15911	32	16223	25	16451	250	16701	250	17015	64
15110	40	15404	50	15653	128	15912	25	16224	20	16452	250	16702	200	17016	50
15111	40	15405	50	15654	100	15913	20	16225	16	16453	200	16703	160	17017	40
15112	32	15406	50	15655	100	15914	16	16226	12.5	16454	160	16704	125		
15113	25	15407	40	15656	80	15915	12.5	16227	10	16455	125	16705	100		
15114	20	15408	32	15657	80	15916	10	16228	8	16456	100	16706	80		
15115	16	15409	25	15658	64	16000	160	16229	6.4	16457	80	16707	64		
15116	12.5	15410	25	15659	50	16001	125	16250	250	16458	64	16708	50		
15117	12.5	15411	20	15660	40	16002	125	16251	200	16459	50	16750	1000		
15118	10	15412	16	15661	40	16003	100	16252	160	16460	40	16751	800		
15119	8	15413	16			16004	100			16461	32	16752	640		
15120	6.4	15414	12.5	15662	32	16005	80	16253	160	16462	25	16753	500		
15121	5	15415	12.5	15663	25	16606	64	16254	125	16463	20	16754	400		
15122	4	15416	10	15664	20	16007	64	16255	100	16464	16	16755	320		
15123	3.2	15417	8	15665	16	16008	50	16256	80	16465	12.5	16756	250		
15200	50	15418	6.4	15666	12.5	16009	40	16257	64	16500	320	16757	200		
15201	50	15419	5	15667	10	16010	32	16258	50	16501	250	16758	160		
15202	40	15420	4	15668	8	16011	25	16259	40	16502	200	16759	125		
15203	40	15421	3.2	15669	6.4	16012	20	16260	32	16503	160	16760	100		
15204	32	15422	2.5	15670	5	16013	16	16261	25	16504	125	16761	80		
15205	32	15450	125	15700	250	16014	12.5	16262	20	16505	100	16800	1000		
15206	25	15451	125	15701	250	16015	10	16263	16	16506	80	16801	800		
15207	25	15452	125	15702	200	16016	8	16264	12.5	16507	64	16802	640		
15208	20	15453	100	15703	160	16017	6.4	16265	10	16508	50	16803	640		
15209	20	15454	100	15704	125	16018	2.5	16300	250	16509	40	16804	500		
15210	20	15455	80	15705	100	16050	250	16301	200			16805	400		

OHMITE

has the answer

in products for today's & tomorrow's circuitry



Relays | Resistors | Tap Switches | Variable Transformers | Rheostats | Solid-State Controls | RF Chokes

Ohmite Manufacturing Company, a North American Philips Company
3601 Howard Street, Skokie, Illinois 60076 / Phone: (312) 675-2600 / TWX: 910-223-0805 / Telex: 72-4433

Printed in USA

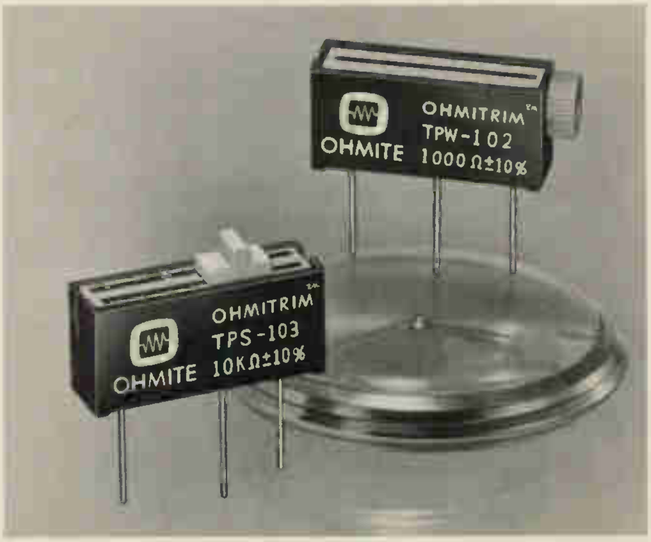
PUBLICATION 265

OHMITE NOV 27 1971 BULLETIN 250

HIGH QUALITY, BETTER SERVICE, AT A COMPARABLE PRICE.

economy trimmer for commercial applications

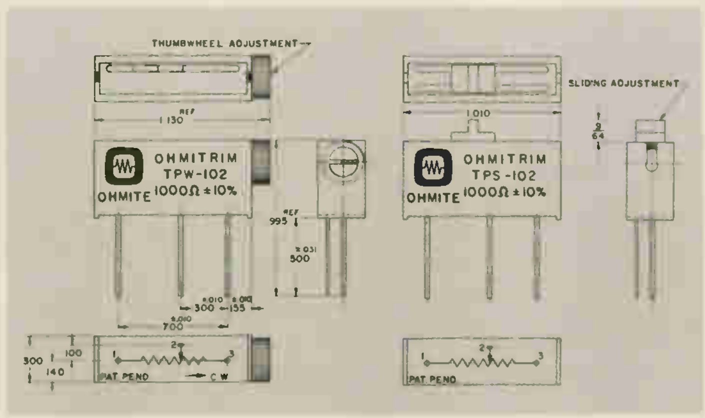
OHMITRIM™ wirewound rectilinear multiturn resistance trimmer



FEATURES

Ohmitrim™ trimmers offer four features, especially important in view of their economical price:

1. *Gold plated* leads for excellent solderability.
2. *Gold plated* contact for excellent oxidation-free long life service.
3. Resistance wire is welded to leads for noiseless connection.
4. Choice of thumbwheel or slider for easy adjustment without tools.



TPW and TPS series, Ohmitrim™ wirewound trimmers have a nominal 1 watt rating and are offered in resistance values ranging from 10 to 20K ohms. Leads are printed circuit type, spaced for standard 0.1 inch matrix hole pattern. They are available in screwdriver/thumbwheel (TPW series) and slider (TPS series) actuator styles.

Model TPW is lead-screw operated (approximately 35 turns) and provides clutching action at either end of the winding. Trimming is accomplished by either screwdriver or hand via a thumbwheel.

Model TPS is slide operated. It permits fast approximate placement of the slide actuator to a predetermined position and subsequent fine adjustment by an additional small movement. This model is especially useful where a number of trimmers, stacked side by side, can be quickly positioned to their approximate location by using a single template.

Both models are of a new "open" design and are not "sealed." A number of openings in the enclosure permit cleaning solvents to enter and readily leave. Thorough testing has assured that when the cleaning process is properly performed in a vapor degreaser, there is no danger of contamination of either the winding or the contact.

Both models meet the requirements outlined in EIA Standard RS-345 "Resistors, Variable, Wirewound" for characteristic "A." They both have the exact lead spacing of style CRT 11 of the EIA Standard. While they deviate slightly in dimensions, both models conform closest in this respect to style CRT 13.

CHARACTERISTICS

Temperature Rating	40°C max. ambient. (for full wattage rating)
Power Rating	1 watt.
Resistance Tolerance	± 10%.
Temperature co-efficient	0 ± .010% per degree C.
Dielectric Strength	500 Volts A.C.
Insulation Resistance	100 megohms.
Torque	0.1 to 8.0 oz.-inches.
End Resistance	2% maximum.
No. of Turns	35, approximately.
Leads	Gold Plated, 0.1 grid spacing.
Contacts	Gold Plated.
For Δ R = ±10%:	
Thermal shock	−55 to ±85°C.
Rotational life	200 cycles.
Electrical life	1000 hours.

ORDERING

STD. RES. VALUES	CATALOG NUMBER	
	THUMB–WHEEL TYPE	SLIDE TYPE
10Ω	TPW-100	TPS-100
20Ω	TPW-200	TPS-200
50Ω	TPW-500	TPS-500
100Ω	TPW-101	TPS-101
200Ω	TPW-201	TPS-201
500Ω	TPW-501	TPS-501

STD. RES. VALUES	CATALOG NUMBER	
	THUMB–WHEEL TYPE	SLIDE TYPE
1,000Ω	TPW-102	TPS-102
2,000Ω	TPW-202	TPS-202
5,000Ω	TPW-502	TPS-502
10KΩ	TPW-103	TPS-103
20KΩ	TPW-203	TPS-203

Ohmite Manufacturing Company a North American Philips company

3601 Howard Street, Skokie, Illinois 60076/Phone (312) 675-2600/TWX: 910-223-0805/Telex 72-4433

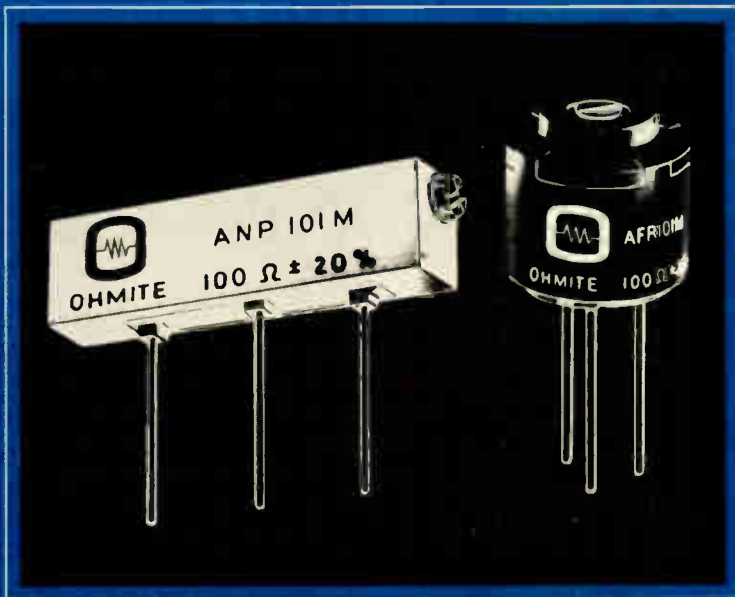
OHMITE

TRIMMERS

DATA SHEET 30M-1

June, 1968 Supplement to Catalog 30M

Obsolete?
12/70



OHMITE
has another
new answer

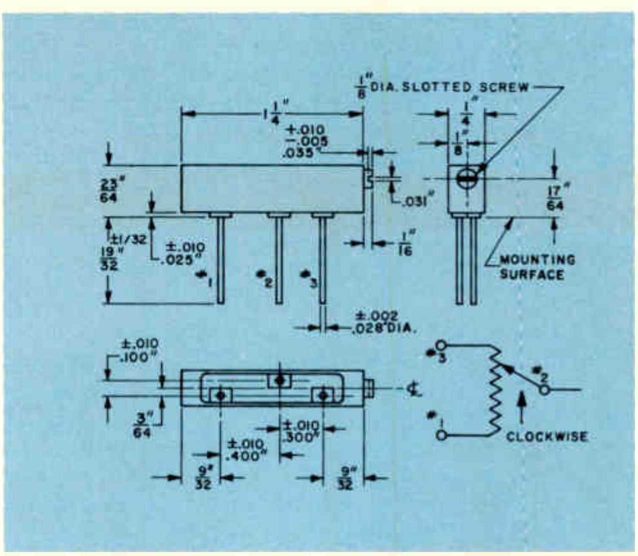
OHMITE

HOT MOLDED 25-TURN TRIMMERS

Type ANP

Ohmite type ANP Hot-Molded Trimmers are continuously adjustable 25-turn variable resistors intended primarily for trimmer applications. Designed for use on printed circuit boards, these dependable three-terminal devices can be applied as either rheostats or potentiometers with equally satisfactory results. Stepless and relatively non-inductive regardless of resistance value. Unexcelled stability of setting in normal environmental conditions.

The type ANP Trimmer is produced by a hot-molding process using a high insulation material together with a hot molded resistance track, low resistance collector track and terminal pins — all combined into a single, solid, integral structure. The type ANP is splash-proof, dust-tight and can be mounted by its own rugged terminals.



CHARACTERISTICS

Power Rating: 1/3 watt @ 50° C ambient temperature. Derate power linearly to zero at 100 °C.

Resistance Range: 100 ohms to 0.1 megohms. Resistance change is nominally linear with shaft rotation.

Tolerance: Standard resistance tolerance is ±20%.

Temperature Range: −55° C to +100° C.

Working Voltage: 350 volts RMS, maximum at sea level.

Dielectric Strength: 700 volts RMS, at sea level.

Insulation Resistance: 1000 megohms minimum.

Adjustment: 25 ± 3 turns for continuous resistance change. Mechanical release at end positions. Turning torque is 0.10 to 8 inch-ounces. Slotted for screwdriver adjustment.

Leads: Pin type terminals, spaced in accordance with 0.1″ printed wiring board grid system.

Stock OHMITE Type ANP Trimmers

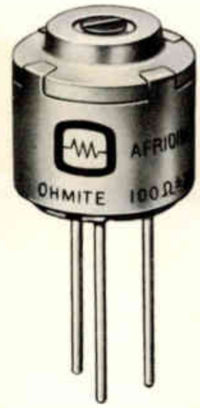
Ohms ±20%	Stock Number	Ohms ±20%	Stock Number
100	ANP-101M	5,000	ANP-502M
250	ANP-251M	10,000	ANP-103M
500	ANP-501M	25,000	ANP-253M
1,000	ANP-102M	50,000	ANP-503M
2,500	ANP-252M	.1 meg	ANP-104M

Net Price 1-9 pcs.: $3.30

Available only through au

OHMITE

HOT MOLDED SINGLE-TURN TRIMMERS

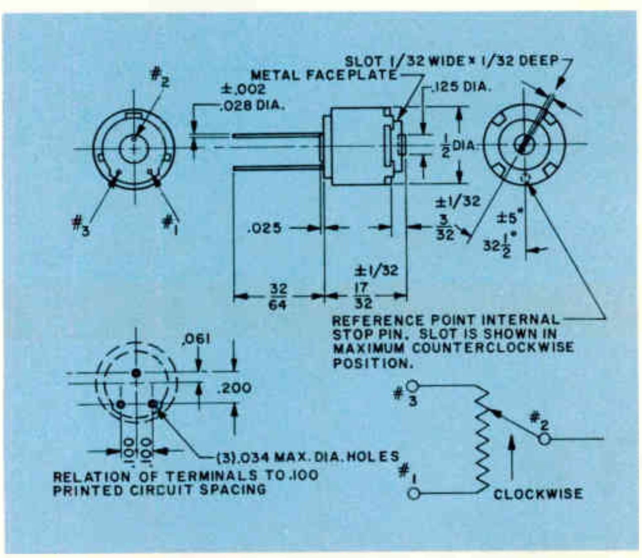


Type AFR

OHMITE type AFR Trimmers are single-turn controls built to withstand severe environmental conditions. Their unique design includes a hot-molded resistor track bridged by a single moving molded contact brush. Resistance material, collector track material, insulation material and metal terminals are all molded together at one time into a single, solid, integral structure. There are no cracks or crevices to admit moisture.

Enclosure of the Ohmite type AFR is non-magnetic, corrosion resistant, and splash-proof. Type AFR Trimmers are designed for screwdriver adjustment. Fixed stops withstand a maximum shaft torque of 2 inch-pounds.

In excess of 50,000 operational cycles with low "noise" level initially — decreasing with use — can be expected in conventional applications.



CHARACTERISTICS

Power Rating: ¼ watt @ +70° C ambient temperature. Derate power linearly to zero at +120° C ambient for resistance values to 0.5 megohms. Additional derating required for resistance values over 0.1 megohms at ambients higher than 70° C.

Resistance Range: 100 ohms to 5.0 megohms. Resistance change is nominally linear with shaft rotation.

Tolerance: ±20% standard.

Temperature Range: —55° C to +120° C.

Working Voltage: 350 volts, RMS, maximum.

Dielectric Strength: 750 VAC, RMS, at sea level.

Adjustment: Single turn, 295 ±5 degrees.

Torque: 0.25 to 3.0 inch-ounces.

Leads: Designed for mounting directly on printed wiring boards using the terminal leads which are spaced to fit the 0.1" printed wiring board standard spacing.

Stock OHMITE Type AFR Trimmers

Ohms ±20%	Stock Number	Ohms ±20%	Stock Number
100	AFR 101M	25,000	AFR 253M
250	AFR 251M	50,000	AFR 503M
500	AFR 501M	.1 meg	AFR 104M
1000	AFR 102M	.25 meg	AFR 254M
2500	AFR 252M	.5 meg	AFR 504M
5000	AFR 502M	1.0 meg	AFR 105M
10,000	AFR 103M	2.5 meg	AFR 255M
		5.0 meg	AFR 505M

Net Price 1-9 pcs.: $3.00

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in products for today's & tomorrow's circuitry

Series 99
RESISTORS
molded wire-wound

- Commercial and hi-stability types
- Sizes from 1.5 to 15 watts
- Coating and markings withstand 1500° F
- Consistent shape for automatic insertion equipment

Pat. No. 3,229,237

Series SSA
SOLID STATE RELAYS

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- 6 milliwatt sensitivity
- Versatile — a few models serve all needs

Ohmitran VT®
VARIABLE TRANSFORMERS
low power series

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- Multiple use 3-way terminals
- Instantly replaceable brush contacts
- Adjustable shaft
- Six ratings from 1.0 to 3.0 amp

Model C
WORLDS SMALLEST CERAMIC POWER RHEOSTAT

- The only 7½ watt metal/ceramic rheostat
- Withstands hot spot temperatures to 340° C
- Only ½ inch in diameter

OHMITROL T.M. power control
SOLID STATE CONTROLS

- Provides infinitely smooth control of power over the full voltage range
- Smallest 1 and 2 KW controls
- Integral trimmer adjusts control range
- Component and portable models

Model 711
MINIATURE TAP SWITCHES

Breaks: 7 amps @ 125 VAC
Carries: 15 amps
Smaller: than many low current instrument switches

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Form No. 111 Printed in U.S.A.

WORLD'S *SMALLEST* CERAMIC POWER RHEOSTAT

OHMITE

Obsolete? 12/70

Model C Standard Bushing
Actual Size

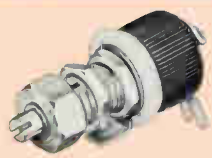
MODEL C MINIATURE RHEOSTAT

7½ Watts
(at 40°C Ambient)

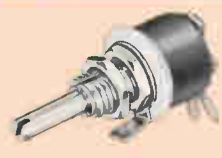
The Model C (unenclosed) rheostat is a ceramic and metal unit just like the other sizes of the famous Ohmite rheostat family up to 1000 watts. It represents a triumph of miniaturization from the difficult toroidal winding of the tiny core to the assembly of parts into a miniature working rheostat.

The Model C unit is only 1/2″ in diameter and extends 15/32″ behind the panel. Yet it dissipates an amazing 7-1/2 watts at 40°C (mounted on metal panel). It is available in three types (1) slotted standard shaft for possible knob control (2) locking bushing for fool-proof permanence of adjustment and (3) high torque shaft which holds settings under relatively rough conditions of vibration and shock.

In this era of miniaturization, the Model C enlarges the horizons of designers by providing greater design flexibility. The Model C is available in enclosed versions — see reverse side.



Locking Bushing



High Torque Type

Winding Side

Resistance Tolerance: ± 10%.

Torque: 0.25 to 3 oz. inch;
for high torque unit — 6 to 15 oz. inch.

Standard Mounting: For panels to ⅛″ thick by means of ¼″-32 flatted threaded bushing.

Shafts and Bushings: ⅛″ diameter, round with screwdriver slot for standard or locking bushing. High torque type also available for secure setting under conditions of vibration and shock. Standard shaft accommodates knob.

Weight: 0.176 oz. (5 grams).

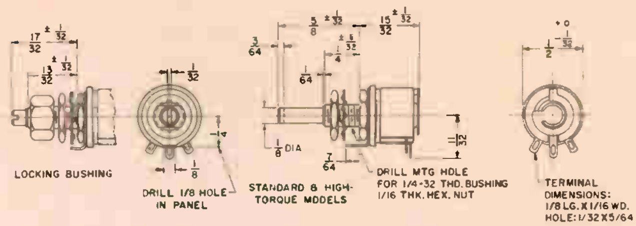
Rotation: 300° ± 5°.

Recommended Knob: No. 5151 for standard shaft.

SPECIFICATIONS — MODEL C — UNENCLOSED

Power Rating: 7.5 watts on steel panel (4″ x 4″ x .040″) at 40°C ambient. Non-metallic panel rating — 5 watts.

Resistance Range: 10 to 5000 ohms.



STANDARD VALUES (STANDARD SHAFT)

Ohms	Amps	Cat. No.	Ohms	Amps	Cat. No.
10	.86	4982	250	.17	4991
15	.71	4983	350	.15	4992
25	.55	4984	500	.12	4993
35	.46	4985	750	.10	4994
50	.39	4986	1000	.086	4995
75	.32	4987	1500	.071	4996
100	.27	4988	2500	.055	4997
150	.22	4989	3500	.046	4998
200	.19	4990	5000	.039	4999

LOCKING BUSHING and HIGH TORQUE SHAFT

	Code Word
Locking Bushing	SHALO
High Torque Shaft	HITOR

OHMITE MANUFACTURING COMPANY
3601 Howard Street, Skokie, Illinois 60076

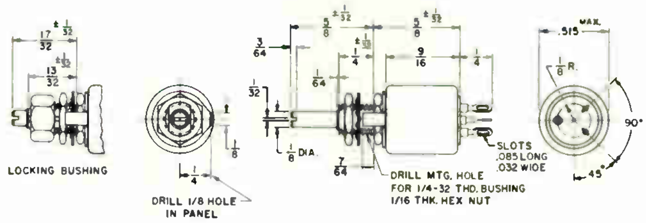
ENCLOSED Model C

Miniature Rheostats

OHMITE

With Standard Bushing

With Locking Bushing



Enclosed or "cased" Model C rheostats employ the same tiny ceramic and metal rheostat described on the reverse side. The case is stainless steel and increases the body size very little so that these units remain in the "miniature" category. (Body size is .515″ diameter, max. x 9/16″ long exclusive of terminals.) Enclosed Model C rheostats retain the same wattage ratings since dissipation is based primarily on conduction through the shaft to the metal panel. Versatile terminals fit popular transistor sockets and also accept soldering. The enclosed Model C unit, is stocked in both standard and locking-type bushings. A high torque shaft which holds settings under relatively rough conditions of vibration and shock is available on special order (code word HITOR).

STOCK MODEL C ENCLOSED RHEOSTATS*

Ohms	Amps.	Standard Shaft Stock No.	Locking Shaft Stock No.
10	.86	4908	4948
15	.71	4909	4949
25	.55	4910	4950
35	.46	4911	4951
50	.39	4912	4952
75	.32	4913	4953
100	.27	4914	4954
150	.22	4915	4955
200	.19	4916	4956
250	.17	4917	4957
350	.15	4918	4958
500	.12	4919	4959
750	.1	4920	4960
1000	.086	4921	4961
1500	.071	4922	4962
2500	.055	4923	4963
3500	.046	4924	4964
5000	.039	4925	4965

*Lower or special resistance values can be supplied —submit specifications

SPECIFICATIONS, MODEL C ENCLOSED

Power Rating: 7.5 watts on steel panel 4″ x 4″ x .040″ thick at 40°C ambient. Non-metallic panel rating or in transistor socket or printed circuit board—5 watts.

Resistance Range: 10 to 5000 ohms.

Resistance Tolerance: ± 10%.

Torque: 0.25 to 3 oz. inch; for high torque unit — 6 to 15 oz. inch.

Standard Mountings: For panels up to ⅛″ thick by means of ¼ -32 flatted threaded bushing.

Shafts and Bushings: ⅛″ diameter, round with screwdriver slot for standard or locking bushing. High torque type also available for secure setting under conditions of vibration and shock. Standard shaft accommodates knob.

Weight: 0.27 ounce (7.5 grams).

Rotation: 300° ± 5°.

Recommended Knob: No. 5151.

Terminals: Rheostat terminals accept 22 ga. solid or 24 ga. stranded wire for soldering; will also fit an EIA Type TS—E3R100 transistor socket or similar hole configuration in printed circuit boards. Taper pin terminals to receive special quick-connect (push-on) connectors or spade type solder lugs can be furnished to order.

Fits Transistor Sockets

OHMITE MANUFACTURING COMPANY • 3601 HOWARD ST. • SKOKIE, ILLINOIS 60076

RESISTORS • RHEOSTATS • TAP SWITCHES • RELAYS • VARIABLE TRANSFORMERS
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CATALOG 300D

SEPTEMBER 1972/SUPERSEDES CATALOG 300C

ITEMS IN THIS CATALOG ARE AVAILABLE FROM AUTHORIZED OHMITE STOCKING DISTRIBUTORS

CATALOG 300C

PRODUCT LOCATOR

Catalog No.	Page	Description
AFR101M-AFR505M	25	Single Turn Trimmer—1/4 W.
ANP101M-ANP503M	25	25-Turn Trimmer—1/3 W.
AS3601-AS3684	24	Type AS Locking Pot.
ASM6661-ASM6676	24	Type AS 7/8" Shaft Pot.
CA1041-CA5041	24	Type AB Potentiometer
CB1031-CB5031	24	Type AB Potentiometer
CAB2-CAB48	18	Little Devil® Assortments
CAB5F-CAB44F	15	Little Rebel™ Assortments
CAB91-CAB99	5	Type 995 Assortments
CCU1031-CCU5041	24	Type AB Pot. Dual
CLU1011-CLU7542	24	Type AB Pot. Locking
CMU1011-CMU7542	24	Type AB Pot. Locking
CU1011-CU7542	24	Type AB Pot. Locking
DOXXXXX	30	Relays
D101-52 to D251-600	13	Dummy Antenna
F101-F532	10	Type 250 Resistor
GPRXXXX	28-29	GPR Relays
L0101-L0123	20	Model E Rheo, Lock'g Shaft
L0140-L0162	21	Model H Rheo, Lock'g Shaft
L4190-L4193	20	Model E Rheo, Lock'g Shaft
L4200-L4204	21	Model H Rheo, Lock'g Shaft
OMC-7111	19	Meter Saver
OB1001-OB9175	16-17	Little Devil® Resistors, 1/8 W.
OC1001-OC9175	16-17	Little Devil® Resistors, 1/4 W.
OE1001-OE9175	16-17	Little Devil® Resistors, 1/2 W.
OG1001-OG9175	16-17	Little Devil® Resistors, 1 W.
OH1001-OH9175	16-17	Little Devil® Resistors, 2 W.
OJ1005-OJ9135	14	Little Rebel Carb. Film, 1/8 W.
OK1005-OK9145	14	Little Rebel Carb. Film, 1/4 W.
OL1005-OL9145	14	Little Rebel Carb. Film, 1/2 W.
PCA1000-PCA1021	23	Ohmitrol® Power Controls
PCD1000-PCD1021	23	Ohmitrol® Power Controls
P-300	19	Parasitic Suppressor
SOGPR	28	Relay Sockets
SRC65-SRC500	22	Heat Control Rheostat
SSA-	35	Solid State Relay
SSB-	35	Solid State Relay
SSC-	35	Solid State Relay
SSH-	35	Hybrid Relay
SSS-	35	Solid State Switch
TPS-100 to TPS-502	25	Ohmitrim® Wirewound Trimmer, Slide Operated
TPW-100 to TPW-502	25	Ohmitrim® Wirewound Trimmer, Lead Wheel Operated
T503-T10012-S	27	Ceramic Tap Switch
VTXXX	32-34	Ohmitran® V.T.
W0101-W0123	20	Model "E" Rheostat, Encl.
W4190-W4193	20	Model "E" Rheostat, Encl.
Z7 to Z460	19	Chokes
5 to 18S	11	Mounting Brackets
0101-0123	20	Model "E" Rheostats
0140-0162	21	Model "H" Rheostats
0200-0229	8	Type 270 Resistors, 25 W.
0308-0332	21	Model "J" Rheostats
0358-0359	9	Adj. Lug—Type 210
0360-0389	9	Dividohm—25 Watt
0400-0428	8	Type 270 Resistor, 50 W.
0440-0463	21	Model "K" Rheostat
0524-0549	21	Model "L" Rheostat
0560-0591	9	Dividohm—50 Watt
0600-0625	8	Type 270 Resistor, 100 W.
0650-0671	21	Model "N" Rheostat
0700-0725	8	Type 270 Resistor, 175 W.
0769-0796	9	Dividohm—75 Watt
0849-0872	21	Model "R" Rheostat
0900-0925	8	Type 270 Resistor, 225 W.
0956-0973	9	Type 210 Resistor, 100 W.
1001-1040	9	Type 210 Resistor, 12 W.

Catalog No.	Page	Description
1058	9	Adj. Lug—Type 210
1100-1123	21	Model "G" Rheostat
111-XXX	26	Model 111 Tap Switch
1156-1173	9	Type 210 Resistor, 175 W.
1250-1271	21	Model "P" Rheostat
1300-1323	21	Model "T" Rheostat
1356-1373	9	Type 210 Resistor, 225 W.
1450-1473	21	Model "U" Rheostat
1500-1557	7	Type 200 Resistor, 8 W.
1700-1772	7	Type 200 Resistor, 12 W.
1800-1860	7	Type 200 Resistor, 20 W.
1958-1959	9	Adjustable Lugs—Type 210
1974	12	Adjustable Lugs—Corrib®
2001-2018	11	Type 270N, 50 W.
2050-2081	11	Type 270N, 12 W.
212-3 to 212-12-T3	26	Model 212 Tap Switch
2115-2171	9	Adjustable Lugs
2172-2176	12	Extra Term. Powr-Rib®
2201-2218	11	Type 270N, 100 W.
2301-2342	12	Type 080.5—Powr-Rib®
2401-2418	11	Type 270N, 175 W.
2501-2524	12	Type 280 Corrib®
2601-2624	12	Type 230 Corrib®
2712-2808	7	Type 200 Resistor, 3 W.
2822-2925	7	Type 200 Resistor, 5 1/4 W.
3001-3004	22	"T" Pad Attenuators
3101-3104	22	"T" Pad Attenuators
312-3 to 312-12-T3	26	Model 312 Tap Switches
3201-3204	22	"L" Pad Attenuators
3301-3304	22	"L" Pad Attenuators
3405-3410	13	Determ-ohm Box
3723-3843	8	Type 270, 12 W.
3860-3969	4	Style 995-2A, 2 1/4 W.
4030-4119	4	Style 995-1A, 1 1/2 W.
412-3 to 412-12-T3	27	Model 412 Tap Switch
4120-4135	4	Style 995-1A, 1 1/2 W.
4190-4193	20	Model "E" Rheostat
4200-4204	21	Model "H" Rheostat
4210-4215	21	Model "J" Rheostat
4330-4454	4	Style 995-3A, 3 1/4 W.
4530-4664	4	Style 995-5B, 5 W.
4730-4874	4	Style 995-10A, 11 W.
4908-4925	20	Model "C" Std. Shaft
4948-4965	20	Model "C" Lock. Shaft
5000-5001	22	Rheostat Dials
5002-5004	27	Tap Switch Dials
5005-5006	33	V.T. Dials
5007	22	Rheostat Dials
5008-5010	33	V.T. Dials
5011-5019	33	V.T. Dials
5102-5152	22	Bakelite Knobs
5155-5158	33	V.T. Knobs
5180-5182	5	Ohm's Law Calculator
5190	16	Little Devil® Color Coder
5800-5897	3	PC-58 Radial Lead Resistor
5900-5909	5	Clips for Types 995 and 884
608-3 to 608-8-T3	27	Model 608 Tap Switch
6101-2 to 6120-K-4	11	Thru-Bolt Type Brackets
6126P8½ to 6129P½	12	Thru-Bolt Type Brackets
6507-6519	33	V.T. Brush Contact Assm.
6532-6533	22	Rheostat Tandem Kits
6536-6538	33	V.T. Adjustable Stop
6591	22	Rheostat Tandem Kit
6594, 6596	33	V.T. Brush Contact Assm.
7PA5-7PA200	11	Thru-Bolts
7070-7074	22	Rheostat Repair Kits
7090-7091	22	Mounting Hardware
711-3 to 711-11	26	Model 711 Tap Switch
80013-85260	6	Type 884 Riteohm® Resistor

ORDERING INFORMATION

For your convenience, we recommend that you place your orders with your local authorized OHMITE stocking distributor for standard OHMITE components listed in this catalog. Authorized OHMITE distributors stock factory-fresh OHMITE components in-depth and therefore are able to offer same-day or overnight service.

QUICK-DELIVERY COMPONENTS (Bold Print Cat. No.)
You are assured of immediate delivery of those items listed in this catalog that appear in **bold** print. **Bold** listings indicate that these items have, over the years, become the most popular components on a national basis.

Items appearing in light face type are available from authorized OHMITE distributors but normally are not stocked in-depth because they are not as popular as **bold** print items.

Items appearing in parentheses are non-stock standard items and are subject to a minimum handling charge per item.

STANDARD PACKAGES
Most products are packaged in multiple packs. Orders for less-than-standard quantities will be automatically increased to the next standard package. Consult price schedule for standard package information.

FACTORY TERMS
Standard payment terms for components ordered from the factory by firms with established credit is 1%, 10th and 25th, net 30 days. F.O.B. Skokie, Illinois.

WARRANTY
Specific written permission to return goods must be obtained from your local OHMITE sales office. No warrants expressed or implied other than those published in Ohmite Policies.

OHMITE® radial lead resistors for P.C. boards

CLASS PC-58

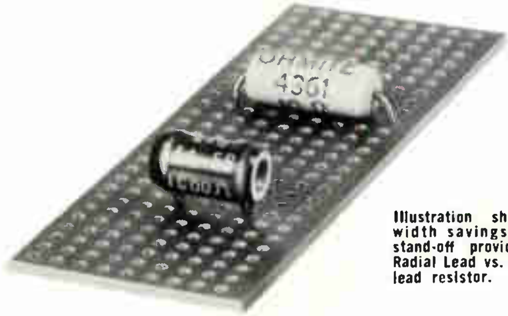


Illustration showing overall width savings and built-in stand-off provided by PC-58 Radial Lead vs. a typical axial lead resistor.

Increases productivity 28.1% — Saves circuit board space

If you are manually inserting axial lead resistors in printed circuit boards, it will pay you to examine the new Ohmite PC-58 resistor.

ADVANTAGES:

LABOR SAVING: Radial Leads eliminate cutting, bending, and forming of leads. Productivity is increased 28.1%. You achieve a 21.9% savings in labor cost. (Time Study Publication No. 163 available on request.)

SPACE SAVING: Radial leads reduce total length dimension required compared to axial lead types, increases packaging density possibilities.

POSITIVE POSITIONING: Built in stand-off automatically provides correct spacing between resistor and P.C. board.

COST SAVING: PC-58 resistors are priced lower than comparable axial lead types. This is in addition to savings in labor as explained above.

STANDARD SIZE: PC-58 Radial Leads fit standard .1 inch matrix boards with standard .046 inch diameter holes.

MARKINGS ALWAYS VISIBLE: Value and Ohmite code markings are always visible from the top of the PC-58. Eliminates time consuming orientation normally required of axial lead types.

CHOICE OF COATINGS: PC-58 resistors are available in ±5% tolerance with Vitreous Enamel (Type 270) for resistance values to 3020 ohms for 3-watt and to 6800 ohms for 5¼-watt or Ohmicone® silicone-ceramic (Type 470) for values over 3020 ohms and 6800 ohms for 3 and 5¼-watt sizes, respectively. For tolerances of ±3% and closer or for low T.C., specify Ohmicone® Type 474.

AVAILABILITY: Now standard PC-58 resistors are in stock at your local Ohmite authorized stocking distributor.

SPECIFICATIONS:

MECHANICAL

Coating: Vitreous Enamel or Ohmicone® (silicone-ceramic), depending on Type.

Terminals: Radial, solder-dipped.

Markings: Ohmite Code and Resistance (Ohms) Value.

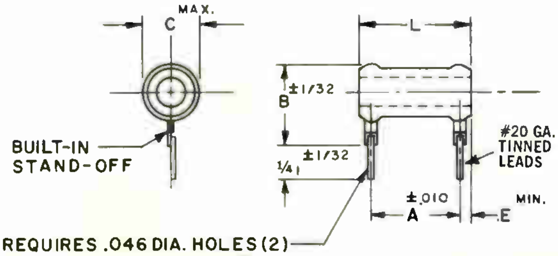
Weight: 3-Watt: .002 lbs.; 5¼ Watt: .003 lbs.

ELECTRICAL

Tolerance: ±5% for 1 ohm and above; ±10% below 1 ohm.

Wattage: 3-Watt, derated to 0 at 350°C—5¼-Watt, derated to 0 at 350°C

Temperature Coefficient: Less than 260 ppm/°C.



Rated Watts @ 25°C	DIMENSIONS (Inches)				
	A ±.010	B ±1/32	C Max.	E Min.	L ±1/32
3	.300	.429	9/32	1/32	7/16
5¼	.500	.469	5/16	1/32	5/8

3-WATT

Free air rating thru 10K ohms.

Ohms	Catalog No.¹	Max. Amps	Ohms	Catalog No.¹	Max. Amps	Ohms	Catalog No.¹	Max. Amps
1.0	5800	1.73	120	5817	.158	1200	5834	.0500
1.5	5801	1.41	150	5818	.141	1500	5835	.0447
2.0	5802	1.22	200	5819	.122	1800	5836	.0408
2.4	5803	1.12	250	5820	.110	2000	5837	.0387
3.0	5804	1.00	270	5821	.105	2500	5838	.0346
4.0	5805	.866	300	5822	.100	2700	5839	.0333
5.0	5806	.774	330	5823	.0953	3000	5840	.0316
7.5	5807	.632	400	5824	.0866	4000	5841*	.0274
10.0	5808	.548	450	5825	.0816	4700	5842*	.0253
15	5809	.447	500	5826	.0775	5000	5843*	.0245
20	5810	.387	560	5827	.0732	5600	5844*	.0231
30	5811	.316	600	5828	.0707	6200	5845*	.0220
50	5812	.245	620	5829	.0696	7000	5846*	.0209
56	5813	.231	750	5830	.0632	7500	5847*	.0200
68	5814	.210	800	5831	.0612	9000	5848*	.0182
82	5815	.191	900	5832	.0577	10000	5849*	.0173
100	5816	.173	1000	5833	.0548			

*NOTE: These resistors are Ohmicone® Coated, Type 470.

5¼-WATT

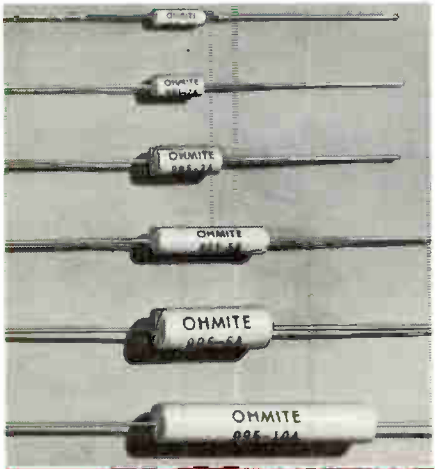
Free air rating thru 15K ohms.

Ohms	Catalog No.¹	Max. Amps	Ohms	Catalog No.¹	Max. Amps	Ohms	Catalog No.¹	Max. Amps
1.0	5850	2.29	100	5864	.229	1800	5882	.0540
1.5	5850A	1.87	120	5865	.209	2000	5883	.0512
2.0	5851	1.62	150	5866	.187	2200	5883A	.0488
3.0	5851A	1.32	160	5867	.181	2500	5884	.0458
4.0	5851B	1.15	200	5868	.162	3000	5885	.0418
5.0	5852	1.02	220	5869	.154	3300	5885A	.0399
5.6	5852A	.968	250	5870	.145	3900	5885B	.0367
10.0	5853	.725	270	5870A	.139	4000	5886	.0362
15	5854	.592	300	5871	.132	4500	5887	.0341
18	5855	.540	330	5872	.126	5000	5888	.0324
20	5856	.512	350	5873	.122	5600	5889	.0306
22	5856A	.489	400	5874	.115	6000	5890	.0296
25	5857	.458	500	5875	.102	7500	5891*	.0265
30	5858	.418	510	5875A	.101	8200	5892*	.0253
40	5859	.362	560	5875B	.0968	9000	5893*	.0241
50	5860	.324	600	5876	.0935	9100	5893A*	.0240
51	5860A	.321	750	5877	.0837	10000	5894*	.0229
56	5860B	.306	800	5878	.0810	12000	5895*	.0209
68	5861	.278	1000	5879	.0725	15000	5896*	.0187
75	5862	.265	1200	5880	.0661	20000	5897*	.0152
82	5863	.253	1300	5881	.0635			

*NOTE: These resistors are Ohmicone® Coated, Type 470.

¹ All standard values shown above are popular values and are stocked by authorized OHMITE stocking distributors.

OHMITE® type 995 MOLDED axial lead vitreous enameled resistors



- FIRST MOLDED WIREWOUND, VITREOUS ENAMEL RESISTOR
- INSULATED! MEETS 1000 VAC TEST
- WITHSTANDS 1500°F TEMPERATURES WITHOUT DISTORTION
- RESISTS CHIPPING, BREAKING
- UNIFORM SIZE PERMITS CLIP-MOUNTING WITH SIGNIFICANT HEAT SINK BENEFITS
- HIGH OVERLOAD CAPABILITY

An exclusive technique (U. S. Patent No.'s 3,229,237 and 3,489,828) permits application of the vitreous enamel coating by **molding** instead of the conventional "dip" process. The dimensionally consistent and thicker coating that results, guarantees a 1000 VAC insulation rating plus unparalleled capability for withstanding very high temperatures, high humidity and immersion in salt solution.

These resistors are normally mounted by their axial leads. However, their consistent form also permits mounting in clips with heat sink benefits up to 100%. (See "Mounting Clips" on page 5.) Resistance tolerance is ±5%. Series 99 resistors meet the requirements of MIL-R-26 for "insulated" resistors.

	1½ WATT .425" x .115" Dia. Style 995-1A Avg. Wt. .0009 lb.		2½ WATT .575" x .160" Dia. Style 995-2A Avg. Wt. .0016 lb.		3¼ WATT .547" x .203" Dia. Style 995-3A Avg. Wt. .003 lb.		5 WATT .538" x .203" Dia. Style 995-5B Avg. Wt. .004 lb.		11 WATT 1.731" x .312" Dia. Style 995-10A Avg. Wt. .015 lb.	
Ohms	Cat. No.[1]	Max. Amps	Cat. No.[1]	Max. Amps	Cat. No.[1]	Max. Amps	Cat. No.[1]	Max. Amps	Cat. No.[1]	Max. Amps
1.0	4030	1.24	3860	1.50	4330	1.80	4530	2.24	4730	3.32
1.1	(4031)	1.17	(3861)	1.43	(4331)	1.71	(4531)	2.13	4731	3.16
1.2	4032	1.12	(3862)	1.37	4332	1.65	4532	2.04	4732	3.03
1.3	(4033)	1.08	(3863)	1.31	4333	1.58	(4533)	1.96	(4733)	2.91
1.5	4034	1.00	(3864)	1.22	4334	1.47	4534	1.83	4734	2.71
1.6	(4035)	.97	(3865)	1.18	(4335)	1.42	4535	1.77	(4735)	2.62
1.8	4036	.91	3866	1.11	4336	1.34	4536	1.67	4736	2.42
2.0	4037	.87	3867	1.05	4337	1.27	4537	1.58	4737	2.34
2.2	4038	.83	3868	1.01	4338	1.22	4538	1.51	4738	2.24
2.4	4039	.79	(3869)	.97	4339	1.16	4539	1.44	4739	2.14
2.7	4041	.75	(3871)	.91	4341	1.09	4541	1.36	(4741)	2.02
3.0	4042	.71	3872	.86	4342	1.04	4542	1.29	4742	1.92
3.3	4043	.67	3873	.82	4343	.99	4543	1.23	4743	1.83
3.6	(4044)	.65	(3874)	.79	4344	.95	4544	1.18	(4744)	1.75
3.9	4045	.62	(3875)	.76	(4345)	.91	4545	1.13	(4745)	1.67
4.0	4046	.61	3876	.73	4346	.90	4546	1.11	4746	1.66
4.3	(4047)	.59	(3877)	.72	4347	.87	(4547)	1.07	4747	1.60
4.7	4048	.56	3878	.69	4348	.83	4548	1.03	4748	1.53
5.0	4049	.55	3879	.67	4349	.81	4549	1.00	4749	1.48
5.1	(4050)	.54	(3880)	.66	4350	.80	4550	.99	(4750)	1.47
5.6	4051	.52	(3881)	.63	4351	.76	4551	.94	4751	1.40
6.2	4053	.49	3883	.60	4353	.72	4553	.90	4753	1.33
6.8	4054	.47	(3884)	.57	4354	.69	4554	.86	4754	1.27
7.5	4056	.45	3886	.55	4356	.65	4556	.82	4756	1.21
8.2	(4058)	.43	3888	.52	4358	.63	4558	.78	4758	1.16
9.1	(4060)	.41	(3890)	.50	4360	.60	(4560)	.74	(4760)	1.10
10	4061	.39	3891	.47	4361	.56	4561	.71	4761	1.05
11	(4062)	.37	(3892)	.45	4362	.54	(4562)	.67	4762	1.00
12	4063	.35	3893	.43	4363	.52	4563	.65	4763	.96
13	(4064)	.34	(3894)	.41	4364	.50	4564	.62	4764	.92
15	4065	.32	3895	.39	4365	.47	4565	.58	4765	.86
16	4066	.31	(3896)	.37	4366	.45	4566	.56	4766	.83
18	4067	.29	(3897)	.35	4367	.42	4567	.53	4767	.78
20	4068	.27	3898	.33	4368	.40	4568	.50	4768	.74
22	4069	.26	3899	.32	4369	.39	4569	.48	4769	.71
24	(4070)	.25	3900	.31	4370	.36	4570	.46	4770	.68
25	(4071)	.25	3901	.30	4371	.36	4571	.45	4771	.66
27	(4072)	.24	3902	.29	4372	.35	4572	.43	4772	.64
30	4073	.22	3903	.27	4373	.30	4573	.41	4773	.61
33	4074	.21	(3904)	.26	4374	.31	4574	.39	4774	.58
35	(4074A)	.207	(3905)	.25	4374A	.30	4574A	.38	4774A	.56
36	(4075)	.200	(3906)	.25	4375	.30	4575	.37	4775	.55
39	(4076)	.196	3907	.24	4376	.29	4576	.36	4776	.53
40	(4077)	.193	(3908)	.24	4377	.28	4577	.35	4777	.52
43	(4078)	.187	(3909)	.23	4378	.27	4578	.34	4778	.50
47	(4079)	.179	3910	.22	4379	.26	4579	.33	4779	.48
50	4080	.173	(3911)	.21	4380	.25	4580	.32	4780	.47
51	(4081)	.171	(3912)	.21	4381	.25	4581	.31	(4781)	.46
56	4082	.164	(3913)	.20	4382	.24	4582	.30	4782	.44
62	4084	.156	3915	.19	4384	.23	4584	.28	4784	.42
68	4085	.149	3916	.18	4385	.22	4585	.27	4785	.40
75	4087	.141	(3918)	.17	4387	.21	4587	.26	4787	.38
82	4089	.135	(3920)	.16	4389	.20	4589	.25	4789	.37
91	4091	.128	(3922)	.16	4391	.19	4591	.23	4791	.35
100	4092	.123	3923	.15	4392	.18	4592	.22	4792	.33
110	4093	.117	3924	.14	4393	.17	4593	.21	(4793)	.31
120	4094	.112	3925	.14	4394	.16	4594	.20	4794	.30
130	4095	.108	3926	.13	4395	.16	4595	.20	4795	.29
150	4096	.100	3927	.12	4396	.15	4596	.18	4796	.27
160	(4097)	.097	3928	.12	4397	.14	4597	.18	4797	.26
180	4098	.091	3929	.11	4398	.13	4598	.17	4798	.24
200	4099	.087	3930	.10	4399	.13	4599	.16	4799	.23
220	4100	.083	3931	.10	4400	.12	4600	.15	4800	.22
240	(4101)	.079	(3932)	.097	4401	.11	4601	.14	4801	.21
250	4102	.077	3933	.094	4402	.11	4602	.14	4802	.21
270	4103	.075	3934	.091	4403	.109	4603	.14	4803	.20
300	4104	.071	3935	.086	4404	.100	4604	.13	4804	.19
330	4105	.067	3936	.082	4405	.099	4605	.12	4805	.18
350	4105A	.065	3937	.080	4405A	.096	4605A	.12	4805A	.18
360	4106	.064	(3938)	.079	4406	.095	(4606)	.12	(4806)	.17
390	4107	.062	(3939)	.076	4407	.091	4607	.11	4807	.17
400	(4108)	.061	(3940)	.075	4408	.090	4608	.11	4808	.16
430	(4109)	.059	(3941)	.072	4409	.087	4609	.11	4809	.16

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Ohms	Cat. No.[1]	Max. Amps	Cat. No.[1]	Max. Amps	Cat. No.[1]	Max. Amps	Cat. No.[1]	Max. Amps	Cat. No.[1]	Max. Amps
450	(4109A)	.058	(3942)	.071	4409A	.084	4609A	.11	4809A	.16
470	4110	.056	3943	.069	4410	.083	4610	.10	4810	.15
500	4111	.055	3944	.067	4411	.081	4611	.10	4811	.15
510	4112	.054	(3945)	.066	4412	.080	4612	.10	(4812)	.15
560	4113	.052	(3946)	.063	4413	.076	4613	.094	(4813)	.14
600	4114	.050	(3947)	.061	4414	.073	4614	.091	4814	.14
620	4115	.049	(3948)	.060	4415	.072	4615	.090	(4815)	.13
680	(4116)	.047	(3949)	.057	4416	.069	4616	.086	4816	.13
700	4117	.046	3950	.056	4417	.068	4617	.084	4817	.12
750	4118	.045	(3951)	.055	4418	.065	4618	.082	4818	.12
800	4119	.043	(3952)	.053	4419	.064	4619	.079	4819	.12
820	4120	.043	3953	.052	4420	.063	4620	.078	4820	.12
900	(4121)	.041	(3954)	.050	4421	.060	4621	.074	4821	.11
910	(4122)	.041	(3955)	.050	4422	.060	(4622)	.074	(4822)	.11
1000	4123	.039	3956	.047	4423	.056	4623	.071	4823	.11
1100	(4124)	.037	(3957)	.045	4424	.054	4624	.067	4824	.10
1200	4125	.035	3958	.043	4425	.052	4625	.065	4825	.096
1300	4126	.034	(3959)	.041	4426	.050	4626	.062	(4826)	.092
1400	(4126A)	.033	(3960)	.040	(4426A)	.048	4626A	.059	4826A	.089
1500	4127	.032	3961	.039	4427	.047	4627	.058	4827	.086
1600	4128	.031	(3962)	.037	4428	.045	4628	.056	(4828)	.083
1800	(4129)	.029	(3963)	.035	4429	.042	4629	.053	4829	.078
2000	4130	.027	3964	.033	4430	.040	4630	.050	4830	.074
2200	4131	.026	3965	.032	4431	.039	4631	.048	4831	.071
2400	(4132)	.025	(3966)	.031	4432	.036	4632	.046	(4832)	.068
2500	4133	.025	(3967)	.030	4433	.036	4633	.045	4833	.066
2700	4134	.024	(3968)	.028	4434	.035	4634	.043	4834	.064
3000	4135	.022	(3969)	.027	4435	.033	4635	.041	4835	.061
3300					4436	.031	4636	.039	4836	.058
3500					4436A	.030	4636A	.038	4836A	.056
3600					(4437)	.030	(4637)	.037	4837	.055
3900					4438	.029	4638	.036	(4838)	.053
4000					4439	.028	4639	.035	4839	.052
4300					(4440)	.027	4640	.034	4840	.050
4500					4440A	.027	4640A	.033	4840A	.049
4700					4441	.026	4641	.033	4841	.048
5000					4442	.025	4642	.032	4842	.047
5100					(4443)	.025	4643	.031	(4843)	.046
5600					4444	.024	4644	.030	4844	.044
6000					4445	.023	4645	.029	4845	.043
6200					(4446)	.023	(4646)	.028	4846	.042
6800					4447	.022	4647	.027	4847	.040
7000					4448	.021	4648	.027	4848	.040
7500					4449	.021	4649	.026	4849	.038
8000					4450	.020	4650	.025	4850	.037
8200					4451	.020	4651	.025	4851	.037
9000					4452	.019	4652	.024	(4852)	.035
9100					(4453)	.019	4653	.023	(4853)	.035
10000					4454	.018	4654	.022	4854	.033
11000							(4655)	.021	(4855)	.031
12000							4656	.020	4856	.030
13000							(4657)	.020	(4857)	.029
14000							(4657A)	.018	(4857B)	.028
15000							4658	.018	4858	.027
16000							4659	.018	(4859A)	.026
17000							(4659B)	.017	(4859C)	.025
18000							4660	.017	4860	.024
20000							4661	.016	4861	.023
22000							4662	.015	4862	.022
24000							(4663)	.014	(4863)	.021
25000							4664	.014	4864	.021
27000									4865	.020
30000									4866	.019
33000									(4867)	.018
35000									(4867A)	.018
36000									4868	.017
39000									4869	.017
40000									4870	.016
43000									4871	.016
45000									(4871A)	.016
47000									4872	.015
50000									4873	.015
51000									4874	.015

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.

OHMITE®

type 991 mil-approved and type 995 resistor assortment

MIL-R-26 AXIAL LEAD RESISTORS

Ohmite maintains stocks of molded vitreous enameled resistors to MIL-R-26 specifications. These Type 991 units meet or exceed required 1000 VAC V-block dielectric, 100 megohm insulation and ±3% △R on 2000 hr. cyclic load-life test.

MIL-R-26 RESISTORS IN STOCK

Mil. Type	Char V Watts	Char G Watts	Resistance Range*
RW67	6.5	5.0	0.10-3600Ω
RW68	11.0	8.0	0.10-8200Ω
RW69	3.0	2.5	0.10-2000Ω

To order, specify using this formula:

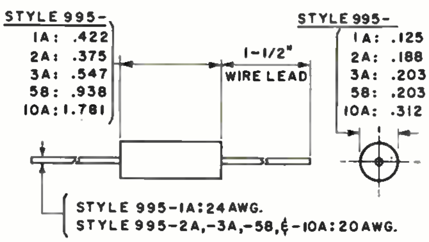
RW67	V	R10
Mil Type	Charact.	Ohmic Symbol

Example: RW67VR10 = 6.5W, 0.10Ω

STANDARD VALUES* IN STOCK

Ohms	Symbol	Ohms	Symbol	Ohms	Symbol	Ohms	Symbol	Ohms	Symbol
.10	R10	1.0	1R0	10	100	100	101	1000	102
		1.1	1R1	11	110	110	111	1100	112
.12	R12	1.2	1R2	12	120	120	121	1200	122
		1.3	1R3	13	130	130	131	1300	132
.15	R15	1.5	1R5	15	150	150	151	1500	152
		1.6	1R6	16	160	160	161	1600	162
.18	R18	1.8	1R8	18	180	180	181	1800	182
		2.0	2R0	20	200	200	201	2000	202
.22	R22	2.2	2R2	22	220	220	221	2200	222
		2.4	2R4	24	240	240	241	2400	242
.27	R27	2.7	2R7	27	270	270	271	2700	272
		3.0	3R0	30	300	300	301	3000	302
.33	R33	3.3	3R3	33	330	330	331	3300	332
		3.6	3R6	36	360	360	361	3600	362
.39	R39	3.9	3R9	39	390	390	391	3900	392
		4.3	4R3	43	430	430	431	4300	432
.47	R47	4.7	4R7	47	470	470	471	4700	472
		5.1	5R1	51	510	510	511	5100	512
.56	R56	5.6	5R6	56	560	560	561	5600	562
		6.2	6R2	62	620	620	621	6200	622
.68	R68	6.8	6R8	68	680	680	681	6800	682
		7.5	7R5	75	750	750	751	7500	752
.82	R82	8.2	8R2	82	820	820	821	8200	822
		9.1	9R1	91	910	910	911		

* ±5% 1 ohm and above; ±10% below 1 ohm.



WIRE-WOUND/AXIAL LEAD MOLDED VITREOUS ENAMEL

- Perfect for R & D and Prototype Labs.
- All popular values included.
- Resistors and handy cabinet for the price of the resistors alone.
- 4 Wattage sizes to choose from.
- Contents clearly marked on front of each drawer segment.

Select the wire-wound resistor you need, right on the job. All the popular resistance values, as determined by national usage, are contained in these handy, compact assortments.

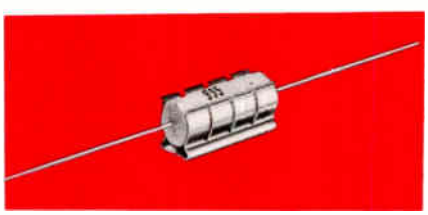
The attractive plastic cabinet is furnished at no extra cost with each assortment. Cabinets are factory packed in accordance with the table (shown at right) which states the quantities of each resistance value per assortment. Each drawer segment is individually labeled. Dovetail tops and bottoms of cabinets facilitate stacking. Dimensions for single cabinets are 9" long x 4¾" high x 5¼" deep; double cabinets are 10" high, including wall hanging brackets.

±5% Resistance Values	Quantities and Resistance for Each Assortment: 1½ Watt CAB-91	3¼ Watt CAB-93	5 Watt CAB-95	11 Watt CAB-99	±5% Resistance Values	Quantities and Resistance for Each Assortment: 1½ Watt CAB-91	3¼ Watt CAB-93	5 Watt CAB-95	11 Watt CAB-99
1.0	10	7	7	5	470	5	7	4	4
1.2	—	—	4	—	500	5	7	7	5
1.5	5	4	4	—	510	5	—	4	—
2.0	5	4	4	5	560	—	4	4	—
2.2	5	—	—	—	600	5	7	4	—
2.7	—	4	—	—	620	—	4	—	—
3.0	5	4	4	5	680	2	7	—	—
4.0	3	4	4	5	700	—	4	—	—
5.0	5	7	7	5	750	2	7	7	5
5.6	—	1	4	—	800	2	4	4	—
6.8	—	4	—	—	820	—	—	4	—
7.5	3	4	1	5	900	—	4	—	—
10.0	10	4	7	5	1000	5	7	7	5
12	—	1	4	—	1200	2	4	4	—
15	5	7	7	5	1300	—	7	7	—
18	—	1	4	—	1500	5	7	4	4
20	3	4	7	5	1800	2	4	4	—
22	2	7	4	5	2000	5	7	7	4
25	—	4	7	5	2200	2	4	4	—
30	3	4	4	5	2500	2	4	4	4
33	—	4	—	—	2700	—	4	1	—
39	—	4	4	5	3000	5	4	7	4
40	3	4	4	5	3300	—	4	4	—
47	—	4	4	—	3900	—	1	1	—
50	5	7	7	5	4000	—	4	4	4
51	—	—	7	—	4300	—	—	4	—
56	2	4	4	—	4500	—	—	—	—
68	2	4	4	5	4700	—	4	4	—
75	2	7	4	4	5000	—	4	7	4
82	—	4	4	5	5600	—	1	4	—
91	5	—	—	—	6000	—	—	4	—
100	5	7	7	5	6800	—	1	5	4
110	5	—	—	—	7000	—	4	—	—
120	—	7	4	—	7500	—	3	—	—
150	—	4	4	5	8000	—	—	4	—
160	—	1	4	—	8200	—	4	4	—
200	5	7	7	5	9000	—	—	4	—
220	5	7	7	—	9100	—	—	—	—
250	—	4	7	5	10,000	—	7	7	4
270	—	4	4	—	12,000	—	—	4	—
300	5	7	7	5	15,000	—	—	4	4
330	5	4	4	—	20,000	—	—	4	—
350	—	—	4	4	22,000	—	—	4	—
390	—	4	4	—	25,000	—	—	4	4
400	—	4	4	—	40,000	—	—	—	4
450	—	4	—	—	50,000	—	—	—	4

SPECIFICATIONS

Nominal Wattage Size	Catalog Number	No. of Res. Values	Quantity of Resistors
1½ W.	CAB-91	40	167
3½ W.	CAB-93	71	325
5 W.	CAB-95	75	355
11 W.	CAB-99	40	185

MOUNTING CLIPS



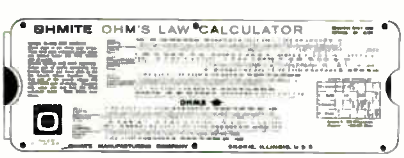
Uniform shape and consistent dimensions of Series 99 and 88 (page 6) resistors, permits them to be conveniently mounted in clips. If the clip is on a metal surface, the wattage capability of the resistor can increase by as much as 100%. Holes in clip base permit fastening to chassis by means of machine screws, eyelets or rivets.

CLIPS FOR TYPE 995 AND 884* RESISTORS

Resistor Watts	Resistor Series	Clip Stock No.
1½	99	5900
2¼	99	5902
3	88	5904
3¼	99	5904
5	88	5905
5	99	5906
10	88	5909
11	99	5908

*See page 6 for Type 884 resistors.

OHM'S LAW CALCULATOR . . .



Solve Ohm's Law/Parallel Resistance problems with Ohmite's pocketsized calculator. Also convenient A, B, C, and D slide rule scales for supplementary calculations. Resistance scales from 0.01 ohm to 100 megohms. Varnished cardboard or deluxe plastic model.

Type	Stock No.
Cardboard	5180
Plastic	5182

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.

OHMITE® type 884 Riteohm® Resistors—1% tolerance

molded for uniform shape and size

- OHMICONE® silicone-ceramic
- low T.C.
- insulated for 1000 volts
- aged for stability

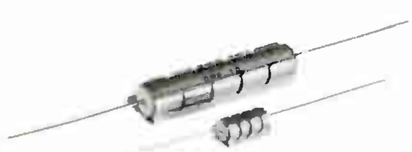
Type 884 Riteohm® Resistors are stocked in power ratings of 3, 5 and 10 watts. Single layer wound on ceramic cores, Riteohm resistors feature a pressure-molded coating of tough, resilient Ohmicone® silicone-ceramic material which meets the MIL-R-26, 1000 VAC insulation test. Riteohms are aged for long term stability and exhibit negligible inductance at audio frequencies. Temperature coefficient of resistance is 0 ±10ppm/°C[1] for most values. Values shown are available from stock. For non-standard values. closer tolerances. etc. contact your local Ohmite office.

Resistance Ohms	3 WATTS Style 884-3		5 WATTS Style 884-5		10 WATTS Style 884-10	
	Cat. No.[2]	Max. Amps	Cat. No.[2]	Max. Amps	Cat. No.[2]	Max. Amps
.100	80013	5.48	80015	7.07	80010	10.0
.121	80023	4.98	80025	6.43	80020	9.09
.150	80033	4.47	80035	5.77	80030	8.16
.200	80053	3.87	80055	5.00	80050	7.07
.221	80063	3.68	80065	4.76	80060	6.73
.249	80073	3.47	80075	4.48	80070	6.34
.274	80083	3.31	80085	4.27	80080	6.04
.392	80103	2.77	80105	3.57	80100	5.05
.475	80113	2.51	80115	3.24	80110	4.59
.499	80123	2.45	80125	3.17	80120	4.48
.681	80143	2.10	80145	2.71	80140	3.83
.750	80153	2.00	80155	2.58	80150	3.65
.825	80163	1.91	80165	2.46	80160	3.48
1.00	80173	1.73	80175	2.24	80170	3.16
1.10	80213	1.65	80215	2.13	80210	3.02
1.21	(80253)	1.57	80255	2.03	80250	2.87
1.43	80323	1.45	80325	1.87	80320	2.64
1.50	(80343)	1.41	80345	1.83	80340	2.58
1.58	(80363)	1.38	80365	1.78	80360	2.52
1.82	80423	1.28	80425	1.66	80420	2.34
2.00	80463	1.22	80465	1.58	80460	2.24
2.21	(80503)	1.17	80505	1.50	80500	2.13
2.49	80553	1.10	80555	1.42	80550	2.00
2.74	(80593)	1.05	80595	1.35	80590	1.91
3.01	(80633)	.998	80635	1.29	80630	1.82
3.32	(80673)	.951	80675	1.23	80670	1.74
4.02	(80753)	.864	80755	1.12	80750	1.58
4.42	80793	.824	80795	1.06	80790	1.50
4.53	80803	.814	80805	1.05	80800	1.49
4.99	80843	.775	80845	1.00	80840	1.42
5.11	(80853)	.766	80855	.989	80850	1.40
6.19	(80933)	.696	80935	.899	80930	1.27
6.81	(80973)	.664	80975	.857	80970	1.21
7.50	81013	.632	81015	.816	81010	1.15
8.06	81043	.610	81045	.788	81040	1.11
9.09	81093	.574	81095	.742	81090	1.05
10.0	81133	.548	81135	.707	81130	1.00
11.0	81173	.522	81175	.674	81170	.953
12.1	81213	.498	81215	.643	81210	.909
13.0	81243	.480	81245	.620	81240	.877
14.0	81273	.463	81275	.598	81270	.845
15.0	81303	.447	81305	.577	81300	.816
18.2	(81383)	.406	81385	.524	81380	.741
20.0	81423	.387	81425	.500	81420	.707
22.1	81463	.368	81465	.476	81460	.673
24.3	81503	.351	81505	.454	81500	.642
24.9	81513	.347	81515	.448	81510	.634
27.4	81553	.331	81555	.427	81550	.604
30.1	81593	.316	81595	.408	81590	.576
33.2	81633	.301	81635	.388	81630	.549
34.8	(81653)	.294	81655	.379	81650	.536
38.3	81693	.280	81695	.361	81690	.511
39.2	81703	.277	81705	.357	81700	.505
40.2	81713	.273	81715	.353	81710	.499
43.2	81743	.264	81745	.340	81740	.481
47.5	81783	.251	81785	.324	81780	.459
49.9	81803	.245	81805	.317	81800	.448
51.1	81813	.242	81815	.313	81810	.442

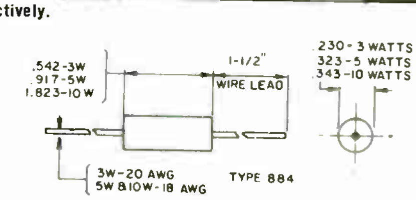
Resistance Ohms	3 WATTS Style 884-3		5 WATTS Style 884-5		10 WATTS Style 884-10	
	Cat. No.[2]	Max. Amps	Cat. No.[2]	Max. Amps	Cat. No.[2]	Max. Amps
56.2	(81853)	.231	81855	.298	81850	.422
59.0	81873	.225	81875	.291	81870	.412
60.4	81883	.223	81885	.288	81880	.407
61.9	81893	.220	81895	.284	81890	.402
68.1	81933	.210	81935	.271	81930	.383
75.0	81973	.200	81975	.258	81970	.365
82.5	82013	.191	82015	.246	82010	.348
88.7	82043	.184	82045	.237	82040	.336
90.9	82053	.182	82055	.235	82050	.332
100	82093	.173	82095	.224	82090	.316
115	82153	.162	82155	.209	82150	.295
121	82173	.157	82175	.203	82170	.287
130	82203	.152	82205	.196	82200	.277
150	82263	.141	82265	.183	82260	.258
162	82293	.136	82295	.176	82290	.248
169	82313	.133	82315	.172	82310	.243
174	82323	.131	82325	.170	82320	.240
178	82333	.130	82335	.168	82330	.237
182	82343	.128	82345	.166	82340	.234
200	82383	.122	82385	.158	82380	.224
205	82393	.121	82395	.156	82390	.221
215	82413	.118	82415	.152	82410	.216
221	82423	.117	82425	.150	82420	.213
249	82473	.110	82475	.142	82470	.200
255	82483	.108	82485	.140	82480	.198
274	82513	.105	82515	.135	82510	.191
301	82553	.0998	82555	.129	82550	.182
332	82593	.0951	82595	.123	82590	.174
340	82603	.0939	82605	.121	82600	.171
365	(82633)	.0907	82635	.117	82630	.166
374	82643	.0896	82645	.116	82640	.164
383	82653	.0885	82655	.114	82650	.162
392	82663	.0875	82665	.113	82660	.160
402	82673	.0864	82675	.112	82670	.158
432	(82703)	.0833	82705	.108	82700	.152
453	82723	.0814	82725	.105	82720	.149
475	82743	.0795	82745	.103	82740	.145
499	82763	.0775	82765	.100	82760	.142
511	82773	.0766	82775	.0989	82770	.140
562	82813	.0731	82815	.0943	82810	.133
604	82843	.0705	82845	.0910	82840	.129
619	82853	.0696	82855	.0899	82850	.127
681	82893	.0664	82895	.0857	82890	.121
715	82913	.0648	82915	.0836	82910	.118
750	82933	.0632	82935	.0816	82930	.115
806	82963	.0610	82965	.0788	82960	.111
825	82973	.0603	82975	.0778	82970	.110
909	83013	.0574	83015	.0742	83010	.105
953	83033	.0561	83035	.0724	83030	.102
1000	83053	.0548	83055	.0707	83050	.100
1100	83093	.0522	83095	.0674	83090	.0953
1180	83123	.0504	83125	.0651	83120	.0921
1300	83163	.0480	83165	.0620	83160	.0877
1470	83213	.0452	83215	.0583	83210	.0825
1500	83223	.0447	83225	.0577	83220	.0816
1620	83253	.0430	83255	.0556	83250	.0786
1780	83293	.0411	83295	.0530	83290	.0750
1820	83303	.0406	83305	.0524	83300	.0741

Resistance Ohms	3 WATTS Style 884-3		5 WATTS Style 884-5		10 WATTS Style 884-10	
	Cat. No.[2]	Max. Amps	Cat. No.[2]	Max. Amps	Cat. No.[2]	Max. Amps
2000	83343	.0387	83345	.0500	83340	.0707
2150	83373	.0374	83375	.0482	83370	.0682
2210	83383	.0368	83385	.0476	83380	.0673
2260	83393	.0364	83395	.0470	83390	.0665
2430	83423	.0351	83425	.0454	83420	.0641
2490	83433	.0347	83435	.0448	83430	.0634
2740	83473	.0331	83475	.0427	83470	.0604
2940	83503	.0319	83505	.0412	83500	.0583
3010	83513	.0316	83515	.0408	83510	.0576
3090	83523	.0312	83525	.0402	83520	.0569
3160	83533	.0308	83535	.0398	83530	.0563
3240	83543	.0304	83545	.0393	83540	.0556
3320	83553	.0301	83555	.0388	83550	.0549
3480	83573	.0294	83575	.0379	83570	.0536
3920	83623	.0277	83625	.0357	83620	.0505
4020	83633	.0273	83635	.0353	83630	.0499
4750	83703	.0251	83705	.0324	83700	.0459
4870	83713	.0248	83715	.0320	83710	.0453
4990	83723	.0245	83725	.0317	83720	.0448
5110	83733	.0242	83735	.0313	83730	.0442
5490	83763	.0234	83765	.0302	83760	.0427
5620	83773	.0231	83775	.0298	83770	.0422
6040	83803	.0223	83805	.0288	83800	.0407
6190	83813	.0220	83815	.0284	83810	.0402
6650	83843	.0212	83845	.0274	83840	.0388
6810	83853	.0210	83855	.0271	83850	.0383
6980	83863	.0207	83865	.0268	83860	.0379
7500	83893	.0200	83895	.0258	83890	.0365
8060	83923	.0193	83925	.0249	83920	.0352
8250	83933	.0191	83935	.0246	83930	.0348
8870	83963	.0184	83965	.0237	83960	.0336
10,000	84013	.0173	84015	.0224	84010	.0316
15,000	84183	.0133*	84185	.0183	84180	.0258
20,000	84303	.0100*	84305	.0158	84300	.0224
20,500	84313	.00976*	84315	.0156	84310	.0221
22,100	84343	.00905*	84345	.0150	84340	.0213
23,700			84375	.0145	84370	.0205
24,900			84395	.0142	84390	.0200
25,500			84405	.0140	84400	.0198
27,400			84435	.0135	84430	.0191
30,100			84475	.0129	84470	.0182
34,000			84525	.0121	84520	.0171
36,500			84555	.0117	84550	.0166
40,200			84595	.0112	84590	.0158
43,200			84625	.0106*	84620	.0152
45,300			84645	.0102*	84640	.0149
47,500			84665	.00968*	84660	.0145
49,900			84685	.0922*	84680	.0142
51,100			84695	.00900*	84690	.0140
80,600			84885	.00571*	84880	.0111
82,500					84890	.0110
90,900					84930	.0105
100,000					84970	.0100
150,000					85140	.00733*
174,000					85200	.00632*
200,000					85260	.00550*

*These values correspond to limiting maximum voltages of 200, 460 and 1100 for the 3, 5 and 10W sizes respectively.



Uniform shape of Riteohms permits clip mounting for extra heat dissipation. The wattage capability can be increased by as much as 100% when clip is mounted to a metal surface. See page 5 for clip ordering information.



[1] T.C. of values in 3 Watt size under 97.6 ohms is as follows: From 97.6 thru 10 ohms, 0±20ppm/°C; from 9.76 thru 1.0 ohms, 0±50ppm/°C; below 1 ohm, 0±90ppm/°C.

[2] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.

OHMITE® type 200 *brown devil*® fixed resistors

BROWN DEVIL® (Type 200) resistors, are vitreous enameled, wirewound units long famous for ruggedness and durability in small power resistors. With the emphasis towards miniaturization and the current industry trend towards higher operating temperatures, Ohmite has been able to increase the ratings on two Brown Devil sizes. The 5 watt size is now rated 8 watts and the 10 watt size is now rated 12 watts. The 20 watt unit retains the same rating. The higher ratings may be confidently applied to any 5 or 10 watt unit now in the possession of users or distributors. At this time also, to meet the demand for lower wattage units, Ohmite introduces two, new, small stock sizes — 3 and 5¼ watts.

Standard resistance tolerance is ±5% for values 1 ohm or higher; ±10% for values below 1 ohm. Tinned leads 1½" long: 3 and 5¼ watt, 20 AWG; 8, 12 and 20 watt, 18 AWG.

DIMENSIONS & WEIGHTS

Rating	3W	5¼W	8W	12W	20W
Core Dimen.	7/16x.21D	5/8x1/4D	1x5/16D	1¾x5/16D	2x7/16D
Weight (lbs.)	.003	.005	.01	.015	.03

Ohms	3 WATT Cat. No.[1]	3 WATT Amps.	5¼ WATT Cat. No.[1]	5¼ WATT Amps.	8 WATT Cat. No.[1]	8 WATT Amps.	12 WATT Cat. No.[1]	12 WATT Amps.	20 WATT Cat. No.[1]	20 WATT Amps.
0.5							**1700A**	4.90	**1800A**	6.32
1.0	**2712**	1.73	**2822**	2.29	**1500**	2.83	**1701**	3.46	**1802A**	4.47
1.1	(2713)	1.65	(2823)	2.19						
1.2	(2714)	1.58	(2824)	2.09						
1.3	(2715)	1.52	(2825)	2.01						
1.5	(2716)	1.41	2826	1.87	**1500B**	2.30	1704	2.82		
1.6	(2717)	1.37	(2827)	1.81						
1.8	2718	1.29	(2828)	1.71						
2.0	2719	1.22	**2829**	1.62	**1501**	2.00	**1705**	2.45	**1802B**	3.16
2.2	(2720)	1.17	(2830)	1.54						
2.4	(2721)	1.12	2831	1.48						
2.7	2722	1.05	2832	1.39						
3.0	2723	1.00	2833	1.32	1502	1.63	**1706**	2.00	**1802C**	2.58
3.3	2724	.95	2834	1.24						
3.6	2725	.91	2835	1.21						
3.9	(2726)	.88	2836	1.16						
4.0					**1503**	1.41	**1707**	1.73	1802D	2.24
4.3	2727	.83	2837	1.10						
4.7	(2728)	.80	2838	1.06						
5.0					**1504**	1.26	**1708**	1.54	**1803**	2.00
5.1	2729	.77	**2839**	1.01						
5.6	(2730)	.73	2840	.97						
6.2	2731	.69	2841	.92						
6.8	(2732)	.66	(2842)	.88						
7.5	2733	.63	2843	.84	**1505**	1.00	**1709**	1.26		
8.2	2734	.60	2844	.80						
9.1	(2735)	.57	(2845)	.76						
10	2736	.55	**2846**	.72	**1506**	.89	**1710**	1.09	**1804**	1.41
11	(2737)	.52	(2847)	.69						
12	(2738)	.50	2848	.66	1507	.81	1711	1.00		
13	(2739)	.48	(2849)	.64						
15	2740	.45	**2850**	.59	**1508**	.73	**1712**	.89		
16	(2741)	.43	2851	.57						
18	2742	.42	(2852)	.54						
20	2743	.39	2853	.51	**1509**	.63	**1713**	.77		
22	2744	.37	2854	.49						
24	2745	.35	2855	.47						
25					**1510**	.56	**1714**	.69	**1805**	.89
27	(2746)	.33	2856	.44						
30	2747	.32	**2857**	.42	1511	.51	**1715**	.63		
33	(2748)	.30	2858	.40						
35					**1512**	.47	1716	.58		
36	(2749)	.29	2859	.38						
39	2750	.28	2860	.37						
40					**1513**	.44	**1717**	.54		
43	(2751)	.26	2861	.35						
47	2752	.25	2862	.33						
50					**1514**	.40	**1718**	.49	**1806**	.63
51	2753	.24	2863	.32						
56	2754	.23	2864	.31						
62	2755	.22	2865	.29						
68	2756	.21	2866	.28						
75	2757	.20	2867	.27	**1515**	.32	**1719**	.40	**1807**	.52
82	(2758)	.19	2868	.25						
91	(2759)	.18	2869	.24						
100	2760	.17	**2870**	.23	**1516**	.28	**1720**	.34	**1808**	.45
110	(2761)	.16	2871	.22						
120	2762	.16	2872	.21						
125					**1517**	.25	**1721**	.31		
130	(2763)	.15	(2873)	.20						
150	2764	.14	**2874**	.19	**1518**	.23	**1722**	.28	**1809**	.36
160	(2765)	.14	2875	.18						
180	2766	.13	**2876**	.17						
200	**2767**	.12	**2877**	.16	**1519**	.20	**1723**	.24	**1810**	.32
220	2768	.12	2878	.16						
225					1520	.18	1724	.23		
240	2769	.11	2879	.15						
250					**1521**	.17	**1725**	.22	**1811**	.28
270	2770	.11	2880	.14						
300	2771	.10	**2881**	.13	**1522**	.16	**1726**	.20	**1812**	.26
330	2772	.095	**2882**	.12						
350					1523	.15	1727	.18	1813	.24
360	2773	.091	2883	.12						
390	(2774)	.088	2884	.12						
400					**1524**	.14	1728	.17	1814	.22
430	(2775)	.083	2885	.11						
450					1525	.13	1729	.16		
470	2776	.080	2886	.11						
500					**1526**	.12	**1730**	.15	**1815**	.20
510	2777	.077	**2887**	.10						
560	2778	.073	2888	.097						
600					**1527**	.11	**1731**	.14		
620	(2779)	.070	2889	.092						
650									**1816**	.18
680	2780	.067	2890	.088						
700					1528	.11	1732	.13	1817	.17
750	2781	.063	2891	.084	1529	.10	**1733**	.12	**1818**	.16
800					1530	.10	1734	.12	1819	.15
820	2782	.060	2892	.080						
900					1531	.094	**1735**	.11	1820A	.15
910	**2783**	.057	2893	.076						
1000	2784	.055	**2894**	.072	**1532**	.089	**1736**	.11	**1821**	.14
1100	(2785)	.052	2895	.069	1533	.085	(1737)	.10		
1200	2786	.050	2896	.066	1534	.081	**1738**	.10	**1822**	.13
1250					1535	.080	1739	.097	1823	.12
1300	(2787)	.048	2897	.063						
1500	2788	.045	**2898**	.059	**1536**	.073	**1740**	.089	**1824**	.12
1600	(2789)	.043	(2899)	.057						
1750					1537	.067	1741	.082	1825	.11
1800	(2790)	.042	2900	.050						
2000	2791	.039	2901	.047	**1538**	.063	**1742**	.077	**1827**	.10
2200	2792	.037	2902	.045						
2250					**1539**	.059	**1743**	.073	1828	.094
2400	(2793)	.035	2903	.043						
2500					**1540**	.056	**1744**	.069	**1830**	.089
2700	2794	.033	2904	.041						
2750									1831	.085
3000	2795	.032	**2905**	.039	**1541**	.046	**1745**	.063	**1832**	.081
3300	2796	.030	2906	.037						
3500					1542	.043	**1746**	.058	1833	.075
3600	(2797)	.029	2907	.035						
3900	2798	.028	2908	.034						
4000					**1543**	.040	**1747**	.054	**1834**	.070
4300	(2799)	.026	(2909)	.032						
4500					1544	.038	**1748**	.051	1835	.066
4700	2800	.025	2910	.031						
5000					**1545**	.036	**1749**	.049	**1836**	.063
5100	(2801)	.024	**2911**	.030						
5600	(2802)	.023	2912	.028						
6000					**1546**	.033	**1750**	.044	**1837**	.057
6200	(2803)	.022	2913	.027						
6800	(2804)	.021	2914	.026						
7000					**1547**	.030	1751	.041	1838	.053
7500	(2805)	.020	2915	.025	1548	.029	**1752**	.036	1839	.051
8000					1549	.029	**1753**	.035	1840	.050
8200	2806	.019	2916	.023						
8500							(1754)	.034		
9000					1550	.027	1754A	.033	(1840A)	.047
9100	(2807)	.018	(2917)	.022						
10K	**2808**	.016	**2918**	.021	**1551**	.026	**1755**	.032	**1841**	.043
11K			(2919)	.020			(1756)	.030		
12K			2920	.019			1757	.029		
12.5K					1552	.023	1758	.028	1842	.032
13K			2921	.019						
13.5K							1759	.027		
15K			2922	.017	**1553**	.021	**1761**	.026	1843	.029
16K			2923	.017			1762	.025		
17.5K					1554	.019	1763	.024		
18K			2924	.016			1764	.024		
20K			**2925**	.014	1555	.018	**1765**	.022	1844	.026
22.5K					1556	.017	1766	.021		
25K					1557	.015	**1767**	.020	1845	.023
30K							**1768**	.018	1846	.021
35K							**1769**	.017	1847	.019
40K							**1770**	.016	1848	.018
45K							1771	.015	(1849)	.017
50K							**1772**	.014	1850	.016
55K									(1851)	.015
60K									1852	.015
65K									1853	.014
70K									(1854)	.014
75K									(1855)	.013
80K									(1856)	.013
85K									(1857)	.012
90K									(1858)	.012
95K									(1859)	.012
100K									**1860**	.011

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.

OHMITE® type 270 vitreous enameled fixed resistors

These lug type resistors are wire-wound on high quality ceramic cores, protected and insulated by Ohmite vitreous enamel — the time-proved standard covering that is the best conductor of heat for a material which must also be a good electrical insulator.

Resistance tolerance is ±5% for values 1 ohm or higher; ±10% below 1 ohm.

Wattage ratings are for use in free air. When resistors are mounted in closed spaces or where the circulation of air is restricted, they should not be used at more than one-half rating. Currents and voltages for reduced ratings can be obtained by multiplying full rating by the following factors: 75% load = .86, 66% = .81, 50% = .71, 33% = .57, 25% = .50.

Mounting brackets are automatically supplied in individual unit packs; supplied only when specified in bulk pack orders. See page 18, "Mounting Brackets for Tubular Resistors" to specify other brackets.

12 WATT [illegible]		
Resist. Ohms.	Cat. No.[1]	Max. Amps.
.51	3723	4.86
1.0	3730	3.46
1.5	3734	2.83
2.2	3738	2.34
3.3	3742	1.91
4.7	3746	1.60
6.8	3750	1.33
10	3754	1.10
12	3756	1.00
15	3758	.89
18	3760	.82
22	3762	.74
27	3764	.67
33	3766	.60
39	3768	.55
47	3770	.53
56	3772	.46
68	3774	.42
82	3776	.38
100	3778	.35
120	3780	.32
150	3782	.28
180	3784	.26
220	3786	.23
270	3788	.21
330	3790	.19
390	3792	.18
470	3794	.16
560	3796	.15
680	3798	.13
820	3800	.12
1,000	3802	.11
1,200	3804	.10
1,500	3806	.089
1,800	3808	.082
2,200	3810	.074
2,700	3812	.067
3,300	3814	.060
3,900	3816	.055
4,700	3818	.051
5,600	3820	.046
6,800	3822	.038
8,200	3824	.035
10,000	3826	.032
12,000	3828	.029
15,000	3830	.026
18,000	(3832)	.024
22,000	3834	.021
27,000	3836	.019
33,000	(3838)	.017
39,000	(3840)	.016
47,000	(3842)	.015
51,000	3843	.014

	25 WATT [illegible]		50 WATT [illegible]		100 WATT [illegible]		175 WATT [illegible]		225 WATT [illegible]	
Ohms Res.	Catalog No.[1]	Max. Amps.	Catalog No.[1]	Max. Amps.	Catalog No.[1]	Max. Amps.	Catalog No.[1]	Max. Amps.	Catalog No.[1]	Max. Amps.
1	0200J	5.00	0400J	7.07	0600C	10.00	0700C	13.2	0900C	15.00
2	0200K	3.54	0400K	5.00	0600D	7.07	0700D	9.35	0900D	10.60
3	0200L	2.88	0400L	4.07	0600E	5.77	0700E	7.63	0900E	8.67
4	0200N	2.50	0400N	3.53	0600F	5.00	(0700F)	6.6	0900F	7.50
5	0200A	2.24	0400A	3.16	0600A	4.47	0700A	5.92	0900A	6.72
10	0200B	1.58	0400B	2.23	0600B	3.16	0700B	4.18	0900B	4.74
15	0200R	1.29								
25	0200C	1.00	0400C	1.41	0601	2.00	0701	2.64	0901	3.00
50	0200D	.71	0400D	1.00	0602	1.41	0702	1.87	0902	2.12
75	0200E	.58	0400E	.82	0603	1.15	0703	1.52	0903	1.73
100	0200F	.50	0400F	.71	0604	1.00	0704	1.32	0904	1.50
125					0604B	.90	0704B	1.18		
150	0200G	.41	0400G	.58	0605	.82	0705	1.08	0905	1.25
200	0200H	.35	0400H	.50						
250	0201	.32	0401	.45	0606	.63	0706	.84	0906	.95
500	0202	.22	0402	.32	0607	.45	0707	.59	0907	.67
750	0203	.18	0403	.26	0608	.37	0708	.48	0908	.55
800	0204	.17	0404	.25						
1,000	0205	.16	0405	.22	0609	.32	0709	.42	0909	.47
1,500	0206	.13	0406	.18	0610	.26	(0710)	.34	0910	.39
2,000	0207	.12	0407	.16	0611	.22	0711	.30	0911	.34
2,500	0208	.10	0408	.14	0612	.20	(0712)	.26	0912	.30
3,000	0209	.091	0409	.13	0613	.18	(0713)	.24	0913	.27
3,500	0210	.084								
4,000	0211	.079	0410	.11						
5,000	0212	.070	0411	.10	0614	.14	0714	.19	0914	.21
6,000	0213	.064								
7,500	0214	.057	0412	.081	0615	.12	(0715)	.15	0915	.17
8,000			0413	.079						
10,000	0215	.050	0414	.071	0616	.10	0716	.13	0916	.15
12,000	0216	.045	0415	.064						
15,000	0217	.036	0416	.057	0617	.081	(0717)	.11	0917	.13
20,000	0218	.031	0417	.050	0618	.071	0718	.094	0918	.11
25,000	0219	.028	0418	.045	0619	.063	0719	.083	0919	.095
30,000	0220	.026			0620	.058	(0720)	.076	0920	.087
35,000	(0221)	.024	0419	.032						
40,000	0222	.022			0621	.050	0721	.066	0921	.075
50,000	0224	.019	0420	.026	0622	.045	(0722)	.059	0922	.067
60,000	0225	.016			0623	.041	(0723)	.054	0923	.061
70,000	0226	.013								
75,000			0421	.021	0624	.032	(0724)	.048	0924	.055
80,000	0227	.012								
100,000	0229	.0094	0422	.018	0625	.028	0725	.042	0925	.047
125,000			0423	.017						
150,000			0424	.015						
175,000			(0425)	.014						
200,000			0426	.012						
250,000			0428	.010						

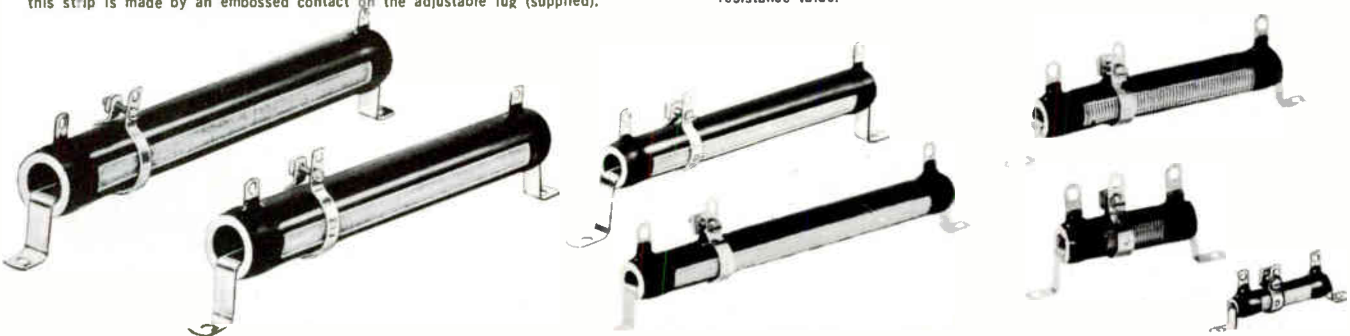
[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.

OHMITE® dividohm® type 210 adjustable vitreous enameled resistors

"Dividohm" resistors make ideal voltage dividers for original equipment and replacement in transmitters, rectifiers and other apparatus. Such tapped "bleeders" are made by using one or more adjustable lugs, as required. "Dividohms" are also handy for obtaining odd resistance values, for adjusting circuits, and for use on equipment which must be set to meet various line voltages.

"Dividohm" resistors are vitreous enameled resistors on which a narrow strip has been left uncovered to expose a portion of each turn. Contact to any wire in this strip is made by an embossed contact on the adjustable lug (supplied).

WATT RATING: **The stated wattage rating applies only when the entire resistance is in the circuit.** When the adjustable lug is set at an intermediate point, the wattage rating is reduced in approximately the same proportion, i.e., if the lug is set at half the resistance, the wattage is reduced by one-half. A safe rule to follow is to make sure that the maximum rated current is not exceeded. This should be carefully checked particularly if the resistor will be used as a voltage divider with several adjustable lugs. Resistance tolerance is ±10% for the total resistance value.



Resist. Ohms	12 WATT Core: 1¾"x5/16"D. Mtg. Ctr: 2⅜"— Av. Wt. .02 lb. Std. Mtg. Brkt.* No. 5		25 WATT Core: 2"x9/16"D. Mtg. Ctr: 2¾"— Av. Wt. .05 lb. Std. Mtg. Brkt.* No. 9		50 WATT Core: 4"x9/16"D. Mtg. Ctr: 4¾"— Av. Wt. .09 lb. Std. Mtg. Brkt.* No. 9		75 WATT Core: 6"x9/16"D. Mtg. Ctr: 6¾"— Av. Wt. .15 lb. Std. Mtg. Brkt.* No. 9		100 WATT Core: 6½"x¾"D. Mtg. Ctr: 7¾"— Av. Wt. .20 lb. Std. Mtg. Brkt.* No. 12		175 WATT Core: 8½"x1⅛"D. Mtg. Ctr: 9¾"— Av. Wt. .50 lb. Std. Mtg. Brkt.* No. 18		225 WATT Core: 10½"x1⅛"D. Mtg. Ctr: 11¾"— Av. Wt. .62 lb. Std. Mtg. Brkt.* No. 18	
	Catalog No.¹	Max. Amps.	Catalog No.¹	Max. Amps.	Catalog No.¹	Max. Amps.	Catalog No.¹	Max. Amps.	Catalog No.¹	Max. Amps.	Catalog No.¹	Max. Amps.	Catalog No.¹	Max. Amps.
1	**1001**	3.46	**0360**	5.00	**0560A**	7.07	0769A	8.66	**0956A**	10.0	1156A	13.2	**1356A**	15.00
2	1002	2.45	**0360B**	3.54	**0560B**	5.00	0769B	6.12	**0956B**	7.07	1156B	9.35	**1356B**	10.60
3	1003	2.00	0361	2.88	0560C	4.07	0769C	5.00	**0956C**	5.77	1156C	7.63	**1356C**	8.67
4					0560D	3.53	0769D	4.33	**0956D**	5.00	1156D	6.60	**1356D**	7.50
5	**1004**	1.54	**0362**	2.24	**0560**	3.16	0769	3.87	**0956**	4.47	1156	5.92	**1356**	6.72
7.5	1005	1.26	0362B	1.82										
10	**1006**	1.09	**0363**	1.58	**0561**	2.23	0770	2.74	**0957**	3.16	**1157**	4.18	**1357**	4.74
15	1007	.89	0364	1.29			0771	2.24						
20	1008	.77	**0364B**	1.12										
25	**1009**	.69	**0365**	1.00	**0562**	1.41	0772	1.73	**0958**	2.00	**1158**	2.64	**1358**	3.00
50	**1010**	.49	**0366**	.71	**0563**	1.00	0773	1.22	**0959**	1.41	1159	1.87	**1359**	2.12
75	**1011**	.40	**0367**	.58	**0564**	.82								
100	**1012**	.34	**0368**	.50	**0565**	.71	0774	.86	**0960**	1.00	**1160**	1.32	**1360**	1.50
150	**1013**	.28	0369	.41	**0566**	.58								
200	**1014**	.24	0370	.35	**0567**	.50	0774B	.61						
250	1015	.22	**0371**	.32	**0568**	.45	0775	.55	**0960B**	.63	1160B	.84	**1360B**	.95
300	1016	.20	**0371B**	.29	0568B	.41	**0775B**	.50						
350	1017	.18												
400	1018	.17	0371C	.25	0568C	.35	0775C	.43						
500	**1019**	.15	**0372**	.22	**0569**	.32	0776	.39	**0961**	.45	1161	.59	**1361**	.67
600	1020	.14												
750	1021	.13	0373	.18	0570	.26	0777	.32						
800	1022	.12	0374	.17	0571	.25	(0777B)	.30						
1000	**1023**	.11	**0375**	.16	**0572**	.22	0778	.27	**0962**	.32	1162	.42	**1362**	.47
1250	1024	.098	0375B	.14	0572B	.20	0778B	.24						
1500	**1025**	.089	0376	.13	0573	.18	0779	.22	0962B	.26	1162B	.34	**1362B**	.39
2000	**1026**	.077	**0377**	.12	0574	.16	0780	.19						
2250	1027	.073	0377B	.11	(0574B)	.15	(0780B)	.18						
2500	**1028**	.069	**0378**	.10	0575	.14	(0781)	.17	**0963**	.20	1163	.26	**1363**	.30
3000	1029	.063	0379	.091	0576	.13	(0781B)	.16						
3500	1030	.058	0380	.084	0576B	.12	(0782)	.15						
4000	1031	.055	0381	.079	0577	.11	0782B	.14						
4500	1032	.052	0381B	.074	0577B	.10	(0782C)	.13						
5000	**1033**	.049	**0382**	.070	0578	.10	0783	.12	0964	.14	1164	.19	**1364**	.21
6000	1034	.045	0383	.064	0578B	.091	(0783B)	.11						
7000	1035	.042	0383B	.060	0578C	.084	(0783C)	.10						
7500	1036	.040	0384	.057	0579	.081	(0784)	.10						
8000	1037	.039	0384B	.055	0580	.079	(0784B)	.096						
8500	(1038)	.037												
9000	1039	.036	0384C	.052	(0580B)	.074	(0784C)	.091						
10000	**1040**	.035	0385	.050	0581	.071	0785	.086	0965	.10	1165	.13	**1365**	.15
12000			0386	.042	0582	.064	(0785B)	.079						
15000			0387	.036	0583	.057	(0786)	.070	0966	.081	(1166)	.11	1366	.13
20000			0388	.031	0584	.050	(0787)	.061	0967	.071	(1167)	.094	1367	.11
25000			0389	.028	0585	.045	0788	.054	0968	.063	(1168)	.083	1368	.095
30000					0586	.036	(0789)	.050	(0969)	.058	(1169)	.076	(1369)	.087
35000							(0790)	.046						
40000					0587	.029	(0791)	.043	0970	.050	(1170)	.066	1370	.075
45000							(0792)	.035						
50000					0588	.026	(0793)	.033	0971	.045	(1171)	.059	1371	.067
60000					(0589)	.024	(0794)	.030						
75000									(0972)	.032	(1172)	.048	1372	.055
80000					0590	.021	(0795)	.026						
100000					0591	.018	(0796)	.023	0973	.028	1173	.042	1373	.047

¹ Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.

* Mounting brackets are automatically supplied in individual unit packs; supplied only when specified in bulk packs.

adjustable lugs

One "Screw Driver Type Adjustable Lug" is supplied with each unit. Lugs with a silver contact button can be ordered from the table shown below.

MOVING THE LUGS: Lugs always should be loosened completely before moving and not moved except while the current is off, in order to protect the exposed wire from mechanical or electrical injury and to protect the operator from dangerous voltages.

STANDARD

Core Diam. Inches	Screw Driver Type New Cat. No.	Screw Driver Type Old Cat. No.	Bakelite Knob Type New Cat. No.	Bakelite Knob Type Old Cat. No.
5/16	2115	1058	—	—
9/16	2121	0358	2122	0359
¾	2125	1958	2126	1959
1⅛	2133	2158	2134	2159

With SILVER CONTACT BUTTONS

Core Diam. Inches	Screw Driver Type New Cat. No.	Screw Driver Type Old Cat. No.	Bakelite Knob Type New Cat. No.	Bakelite Knob Type Old Cat. No.
5/16	2116	2161	—	—
9/16	2123	2164	2124	2165
¾	2127	2166	2128	2167
1⅛	2135	2170	2136	2171

DOUBLE THUMB SCREW ADJUSTABLE LUG

This adjustable lug, which is illustrated at left, features two advantages — ease of adjustment and less chance of damaging the resistance wire while moving lugs. Available for 1⅛" cores. Catalog No. 2160

OHMITE® type 250 "THIN" vitreous enameled resistors

Ohmite "Thin" Resistors are intended for use in equipment where space is at a premium. They are wound on flat, oval shaped ceramic cores, and covered with Ohmite's exclusive vitreous enamel coating. Resistance tolerance, ±5%.

Integral mounting brackets extend through the resistor core to equalize heat distribution and to conduct heat directly to the mounting surface — provides equivalent wattage with less bulk and in less space. Wattage ratings assume the use of a metal mounting surface. Reduce ratings 15% for non-metallic surfaces.

"Thin" resistors are mounted or compactly stacked by means of spacing brackets which are perforated to receive assembly bolts. The load should be reduced for each unit when resistors are stacked or used in confined, poorly ventilated spaces. Total height from mounting surface to top of resistor is approximately 9/16" for the Standard units and 11/32" for the Miniature units.

For other sizes, closer tolerances, non-stacking brackets, Dividohm adjustable or other features, consult factory.

	MINIATURE SIZES						STANDARD SIZES								
	10 WATT* Core: 3/4"x3/8"x1/8" — Mtg. Ctr. 1" Mtg. Hole .125" — Av. Wt. .007 lb.			20 WATT* Core: 2"x3/8"x1/8" — Mtg. Ctr. 2⅜" Mtg. Hole .125" — Av. Wt. .015 lb.			30 WATT* Core: 1⅛"x1"x⅛" — Mtg. Ctr. 2" Mtg. Hole .196" — Av. Wt. .037 lb.			40 WATT* Core: 2"x1"x⅛" — Mtg. Ctr. 2¾" Mtg. Hole .196" — Av. Wt. .052 lb.			55 WATT* Core: 3½"x1"x¼" — Mtg. Ctr. 4¼" Mtg. Hole .196" — Av. Wt. .095 lb.		
Resist. Ohms	Cat. No.[1]	Max. Volts	Max. Amps	Cat. No.[1]	Max. Volts	Max. Amps	Cat. No.[1]	Max. Volts	Max. Amps	Cat. No.[1]	Max. Volts	Max. Amps	Cat. No.[1]	Max. Volts	Max. Amps
1	F101	3.16	3.16	F201	4.47	4.47	F301	5.47	5.47	F401	6.32	6.32	F501	7.42	7.42
1.5							(F302)	6.70	4.47	(F402)	7.74	5.16	F502	8.25	6.05
2	F102	4.47	2.24	F202	6.32	3.16	(F303)	7.74	3.88	F403	8.94	4.47	F503	10.4	5.24
3							F304	9.45	3.17	F404	10.9	3.65	F504	12.8	4.28
4										(F405)	12.6	3.16	F505	14.8	3.70
5	F103	7.07	1.41	F203	10.0	2.00	F305	12.2	2.46	F406	14.1	2.83	F506	16.6	3.32
7.5	F104	8.66	1.15							F407	17.3	2.31	F507	20.6	2.72
10	F105	10.0	1.00	F204	14.1	1.41	F306	17.3	1.73	F408	20.0	2.00	F508	23.4	2.34
15	F106	12.2	0.82	F205	17.3	1.16	F307	21.2	1.42						
20	F107	14.1	0.71												
25	F108	15.8	0.63	F206	22.3	0.89	F308	27.4	1.10	F409	31.6	1.26	F509	37.1	1.48
30	(F109)	17.3	0.58												
40	(F110)	20.0	0.50	F207	28.3	0.71	F309	34.6	0.87	F410	40.0	1.00	F510	46.9	1.17
50	F111	22.3	0.45	F208	31.6	0.63	F310	38.7	0.77	F411	44.7	0.89	F511	52.4	1.05
75	F112	27.4	0.36	(F209)	38.7	0.52	F311	47.4	0.63	(F412)	54.8	0.73	F512	64.2	0.86
100	F113	31.6	0.32	F210	44.7	0.45	F312	54.8	0.55	(F413)	63.2	0.63	F513	74.1	0.74
125	F114	35.3	0.28												
150	F115	38.7	0.26	F211	54.8	0.36	(F313)	67.0	0.45	(F414)	77.4	0.52	F514	82.5	0.61
200	F116	44.7	0.22	F212	63.2	0.32	(F314)	77.4	0.39	(F415)	89.4	0.45	F515	104.0	0.52
250	F117	50.0	0.20	F213	70.7	0.28	F315	86.6	0.35	(F416)	100.0	0.40	F516	117.0	0.47
300	F118	54.8	0.18	F214	77.4	0.26									
400	F119	63.2	0.16	F215	89.4	0.22	(F316)	108.0	0.28	(F417)	126.0	0.32	F517	148.0	0.37
500	F120	70.7	0.14	F216	100.0	0.20	F317	122.0	0.25	F418	141.0	0.28	F518	166.0	0.33
600	(F121)	77.4	0.13												
750	F122	86.6	0.12				F318	150.0	0.20	F419	173.0	0.23	(F519)	206.0	0.27
800				(F217)	126.0	0.16									
1000	F123	100.0	0.10	F218	141.0	0.14	F319	173.0	0.17	(F420)	200.0	0.20	F520	234.0	0.23
1250	(F124)	111.0	0.089	F219	158.0	0.12									
1500	F125	122.0	0.081	F220	173.0	0.12	F320	212.0	0.14	(F421)	245.0	0.16	(F521)	287.0	0.19
1750	F126	132.0	0.075												
2000	F127	141.0	0.071	(F221)	200.0	0.10	(F321)	245.0	0.12	F422	283.0	0.14	(F522)	332.0	0.17
2500	F128	158.0	0.063	(F222)	223.0	0.089	F322	274.0	0.11	(F423)	316.0	0.13	(F523)	371.0	0.15
3000	F129	173.0	0.057	(F223)	245.0	0.081	(F323)	300.0	0.10	(F424)	345.0	0.12	(F524)	406.0	0.14
3500				(F224)	264.0	0.075									
4000	(F130)	200.0	0.050	(F225)	283.0	0.070	F324	346.0	0.087	(F425)	400.0	0.10	(F525)	469.0	0.12
5000	(F131)	223.0	0.045	F226	316.0	0.063	(F325)	387.0	0.076	(F426)	447.0	0.089	(F526)	524.0	0.10
6000				(F227)	346.0	0.058									
7500				(F228)	387.0	0.052	(F326)	424.0	0.057	(F427)	548.0	0.073	(F527)	642.0	0.086
10000				F229	445.0	0.045	(F327)	490.0	0.049	F428	632.0	0.063	(F528)	741.0	0.074
12500				(F230)	500.0	0.040									
15000				F231	555.0	0.036				(F429)	670.0	0.045	(F529)	825.0	0.061
20000				(F232)	625.0	0.032				(F430)	774.0	0.039	F530	1040.0	0.052
25000				(F233)	715.0	0.028				(F431)	866.0	0.035	(F531)	1170.0	0.047
30000				(F234)	770.0	0.026							(F532)	1210.0	0.040
35000				(F235)	835.0	0.024									
40000				(F236)	910.0	0.022									
50000				F237	990.0	0.020									

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.

*Ratings are based on use of steel panel mounting and should be reduced on non-metallic mounting surface because of reduced thermal conductivity.

OHMITE® non-inductive
type 270N vitreous enameled fixed resistors

These non-inductively wound power resistors are widely used at radio frequencies for such purposes as dummy antennas, terminating resistors for antennas, and in diathermy apparatus. Their properly proportioned Ayrton-Perry type windings, reduce the inductance to low proportions (less than 1% of regular solenoid type resistors) while the distributed capacity is small. R.F. resistance is the same as the D.C. resistance over the useful range of frequencies.

Change of impedance with frequency is so slight that the resistors can be used throughout the broadcast band and at even higher frequencies, depending on the particular resistance to be used. All the resistors are lug-type tubular units which mount by means of mounting brackets (furnished). Ohmite's high grade ceramic construction and exclusive vitreous enamel coating assure long, reliable performance under full rated load. Resistance tolerance is ±5%.

12 WATT — Core: 1¾"x5/16" — Mtg. Ctr: 2 5/16"—Av. Wt. .02 lb. — Std. Mtg. Brkt.* No. 5B					
Ohms	Cat. No.¹	Max. Milli-Amps	Ohms	Cat. No.¹	Max. Milli-Amps
5	2050	1,540	600	(2066)	140
10	2051	1,090	700	(2067)	130
15	(2052)	890	800	(2068)	120
20	2053	770	900	(2069)	110
25	2054	690	1,000	(2070)	110
30	(2055)	630	1,500	(2071)	89
40	2056	550	2,000	(2072)	77
50	2057	490	2,500	(2073)	69
75	2058	400	3,000	(2074)	63
100	2059	340	4,000	(2075)	54
150	(2060)	280	5,000	(2076)	49
200	(2061)	240	6,000	(2077)	44
250	2062	220	7,500	(2078)	40
300	(2063)	200	8,000	(2079)	38
400	(2064)	170	9,000	(2080)	36
500	(2065)	150	10,000	(2081)	35

	50 WATT — Core: 4"x9/16" — Mtg. Ctr: 4¾" — Av. Wt. .09 lb. — Std. Mtg. Brkt.* No. 9B		100 WATT — Core: 6½"x¾" — Mtg. Ctr: 7⅜" — Av. Wt. .20 lb. — Std. Mtg. Brkt.* No. 12B		175 WATT — Core: 8½"x1⅛" — Mtg. Ctr: 9⅝" — Av. Wt. .50 lb. — Std. Mtg. Brkt.* No. 18B	
Resist. Ohms	Cat. No.¹	Max. Milliamps	Cat. No.¹	Max. Milliamps	Cat. No.¹	Max. Milliamps
5	(2001)	3,160	**2201**	4,470	**2401**	5,920
10	2002	2,230	**2202**	3,160	**2402**	4,180
25	2003	1,410	2203	2,000	**2403**	2,640
50	**2004**	1,000	**2204**	1,410	**2404**	1,870
100	(2005)	710	2205	1,000	**2405**	1,320
150	2006	580	(2206)	816	2406	1,090
200	(2007)	500	(2207)	707	(2407)	935
250	(2008)	450	(2208)	630	2408	840
500	2009	320	(2209)	450	2409	590
750	2010	260	2210	365	2410	480
1000	2011	220	(2211)	320	2411	420
1500	2012	180	2212	260	(2412)	340
2000	(2013)	160	(2213)	224	(2413)	290
2500	(2014)	140	(2214)	200	2414	260
3000	(2015)	130	2215	180	2415	240
3500	(2016)	119	(2216)	169	(2416)	222
4000	(2017)	110	(2217)	158	(2417)	208
5000	2018	100	(2218)	140	(2418)	190

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*** Mounting brackets are automatically supplied in individual unit packs; supplied only when specified in bulk packs.**

thru-bolts

Thru-bolts with centering and mica insulating washers are used to mount tubular resistors perpendicularly to a panel, up to ¼" thick.

For Watt Size	Core Size O.D.xI.D.xL (Inches)	Bolt Size No.	Bolt Size Length (Inches)	Cat. No.
5	5/16x3/16x1	No. 8	1¾	7PA5
12	5/16x3/16x1¾	No. 8	2½	7PA10
20	7/16x¼x2	No. 8	2¾	7PA20
25	9/16x5/16x2	No. 10	2¾	7PA25
50	9/16x5/16x4	No. 10	4¾	7PA50
75	9/16x5/16x6	No. 10	6¾	7PA75
100	¾x½x6½	No. 10	7 5/16	7PA100
175	1⅛x¾x8½	¼"	9½	7PA160
225	1⅛x¾x10½	¼"	11½	7PA200

METAL CENTERING WASHERS

Cat No.	O.D. of Core	I.D. of Core	Dia. of Washer	Dia. of Hole	For Max. Screw Size
6000	9/16"	5/16"	9/16"	.190	#10
6001	¾"	½"	¾"	.190	#10
6003	1⅛"	¾"	1⅛"	.250	¼"

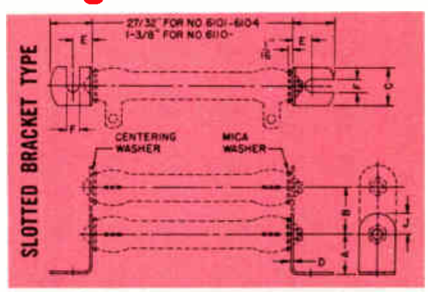
MICA INSULATING WASHERS

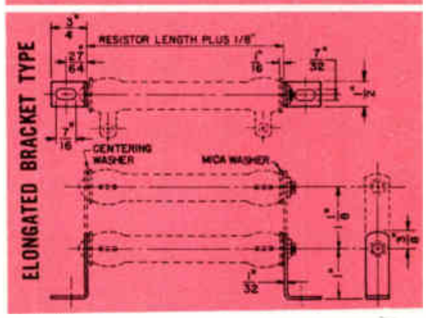
Cat. No.	Core O.D.	Core I.D.	Washer O.D.	Washer I.D.
6010	9/16"	5/16"	¾"	3/16"
*6011	9/16"	5/16"	¾"	5/16"
6012	¾"	½"	1"	3/16"
*6013	¾"	½"	1"	½"
6016	1⅛"	¾"	1½"	5/16"
*6017	1⅛"	¾"	1½"	¾"

* To be used with centering washers

thru-bolt and mounting brackets

These sturdy cadmium-plated steel brackets mount tubular resistors type 270 (fixed) and type 210 (adjustable Dividohm®) via thru-bolts and centering washers with mica insulating washers. Slotted, consisting of one end-slot and one side-slot bracket, and elongated styles are offered.





Thru-Bolt Bracket Cat. No. Slotted Style	Thru-Bolt Bracket Cat. No. Elongated Style	Watt Size	For Tubular Resistor Fixed Type Cat. No.	For Tubular Resistor Dividohm Cat. No.
—	6120-D-1¾	12	3723-3843	1001-1040
6101-2	6120-K-2	25	0200A-0229	0360-0389
6101-4	6120-K-4	50	0400A-0428	0560-0591
6101-6	—	75	—	0769-0796
6104-6½	—	100	0600A-0625	0956-0973
6110-8½	—	175	0700A-0725	1156-1173
6110-10½	—	225	0900A-0925	1356-1373

DIMENSIONS FOR SLOTTED BRACKET

Cat. No. Type	A	B	C	D	E	F	J
6101	25/32	15/16	¾	1/32	7/16	¼	13/32
6104	25/32	1⅛	¾	1/32	7/16	¼	13/32
6110	1	1¾	1⅛	1/16	13/16	5/16	9/16

mounting brackets for tubular resistors

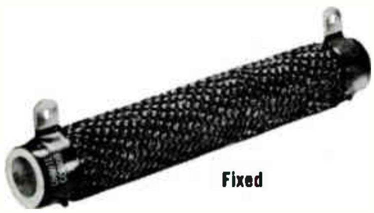
Brackets fit inside the cores of tubular resistors and remain in place by friction. The standard bracket (indicated by catalog number without suffix) is cadmium plated steel. An "S" suffix on the catalog number indicates spring steel; a "B" suffix indicates brass; a "BN" suffix indicates brass bracket for 100 Watt type 270N non-inductive resistor with flat sided core.

Spring steel brackets are excellent where vibration is involved; brass brackets are used with non-inductive resistors or for corrosion resistance. A pair of standard brackets is supplied with each individually boxed resistor sold through distributors. Brackets are not automatically supplied for bulk resistor orders. Brackets are sold in lots of 100 pieces (50 pair).

Catalog No.	Mtg. Screw Max.	Fits these Resistors	Weight Lbs. 100 pcs.
5, 5S, 5B	6	12 W Brown Devil or Divid.	.17
7, 7S, 7B	6	20W Brown Devil	.24
9, 9S, 9B	6	25, 50W Fixed; 25, 50, 75W Dividohm	.30
12, 12S, 12B	10	100W Fixed or Dividohm	1.30
18, 18S, 18B	10	175, 225W Fixed or Divid.	1.50

*100 pieces per pkg. — Minimum Order

OHMITE® corrib® HIGH CURRENT LOW OHMS resistors



Fixed

Dividohm® Adjustable

STOCK CORRIBS — 300 WATT SIZE
Type 280 Fixed; 230 Dividohm®

Core: 8½x1⅛" Fixed or Adjustable (DIVIDOHM)
Avg. Weight (Fixed) .61 lb.; (Dividohm) .64 lb.

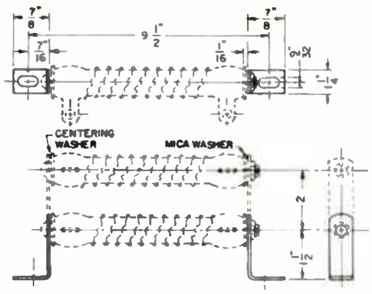
Ohms	Amps.	Fixed[1] Catalog No.	Dividohm*[1] Catalog No.
.10	54.7	**2501**	**2601**
.12	50.0	**2502**	(2602)
.16	43.3	2503	2603
.20	38.7	2504	2604
.25	34.6	**2505**	**2605**
.31	31.1	**2506**	**2606**
.40	27.4	2507	2607
.50	24.5	**2508**	**2608**
.63	21.8	2509	2609
.80	19.3	2510	2610
1.0	17.3	**2511**	**2611**
1.2	15.8	**2512**	(2612)
1.6	13.7	2513	2613
2.0	12.2	**2514**	**2614**
2.5	10.9	2515	2615
3.1	9.8	**2516**	2616
4.0	8.6	2517	**2617**
5.0	7.7	**2518**	**2618**
6.3	6.9	**2519**	**2619**
8.0	6.1	**2520**	2620
10.0	5.5	**2521**	2621
12.0	5.0	**2522**	**2622**
16.0	4.3	**2523**	**2623**
20.0	3.8	**2524**	**2624**

*Adjustable Lug Stk. No. 1974 supplied with Dividohm.

THRU-BOLT MOUNTING BRACKETS FOR CORRIBS

Includes 2 brackets; bolt; centering, mica, and lock washers; nuts. Diagram below.

No. of Resistors	Catalog No.
1	6126P8½
2	6127P8½
3	6128P8½
4	6129P8½



High current, low resistance, heavy duty units used in motor starting, dynamic braking, etc. "Corrib" type units employ a corrugated ribbon of resistance alloy. This is space-wound edge-wise around a ceramic tube. Vitreous enamel is fused around the alloy ribbon to lock the turns securely in place. Heavy lug terminals. Resistance tolerance is ±10%.

Available in fixed or Dividohm® adjustable types. Dividohm® type is similar to fixed and includes one adjustable lug. Rating of Fixed or Dividohm® stock units—300 watts—reduce unit load for stack-mounted resistors; core size (bare) 8½" long x1⅛" diameter. Other sizes made to order.

EXTRA ADJUSTABLE LUGS FOR CORRIBS

For Dividohm	Lug Catalog No.
2601-2606 2610; 2619	1974-B
2607-2609 2611-2618 2620-2624	1974-A

powr-rib® HIGH CURRENT LOW OHMS resistors

Even higher power handling capability—approximately 700 to 1000 watts—is available in stock, "Powr-Rib" resistors. These are UNCOATED types and are wound either edgewise with ribbon ("Edgewound" type) or with round wire (Round-Wire type).

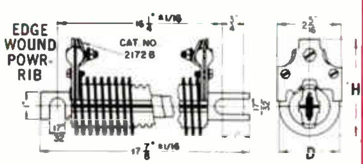
The core of these units consists of ceramic segments on a metal bar which is slotted on both ends for rapid installation. Standard resistance tolerance is ±10%. Terminals clamp onto the resistor wire and may be moved in from the ends for intermediate resistance values. Extra terminals available for use as taps. See diagrams for terminals. Terminal Stk. No. 2172G (not shown) has screw connections.

Edgewound Ribbon Type

Round-Wire Type with extra terminal

STYLE 080-5 EDGEWOUND POWR-RIBS

Ohms*	H ±⅛	D +⅛ —0
.10-.22	3 5/16	2⅛
.25-1.00	3⅛	1⅞
1.30-1.60	2 11/16	1⅞
2.2, 2.8, 4.5, 5.4	2½	1¾
3.5, 6.8, 8.5	2 7/16	1⅝

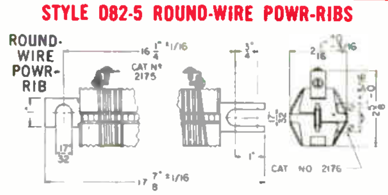


*.10 to 1.00 Ω with terminal No. 2172B
1.3 to 8.5 Ω with terminal No. 2172G

Avg. Weight .18Ω or less, 4 lbs.; .22Ω and up, 2 lbs.

Catalog No.[1]	Ohms	Max. Amps.	Catalog No.[1]	Ohms	Max. Amps.
2301	.10	100	2318	.67	41
2302	.12	91	**2311**	.75	39
2303A	.14	89	**2312**	1.00	33
2304A	.16	78	**2319**	1.30	29
2305A	.18	75	**2313**	1.60	26
2306A	.22	68	**2331A**	2.20	18.4
2306	.25	63	**2332A**	2.80	16.3
2308A	.30	57	**2333A**	3.50	14.6
2308	.33	54	**2334A**	4.50	12.7
2309A	.37	50	**2335A**	5.40	11.8
2310	.50	47	2336A	6.80	10.3
2317	.60	43	**2337A**	8.50	9.4

STYLE 082-5 ROUND-WIRE POWR-RIBS



Avg. Weight 3¼ lbs.

Catalog No.[1]	Ohms	Max. Amps.
2338	11.0	8.3
2339	13.0	7.6
2340	17.0	6.6
2341	20.0	5.9
2342	25.0	5.1

EXTRA TERMINALS

For Round Wire Powr-Rib		For Edgewound Powr-Rib	
Descrip	Catalog No.	Descrip	Catalog No.
In-Line Mtg. 90° Mtg.	2175 2176	30 Amps & more 29 Amps & less	2172B 2172G

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.

OHMITE® 0.1% precision Determ-Ohm® resistance box

The new Ohmite Precision Determ-ohm® is a resistance decade box with an accuracy of ±0.1%. Four models cover the resistance range from 1 ohm to 1 megohm in a choice of three-4 decade and one-6 decade models.

Simplified selection of resistance values is accomplished by operation of rocker-type thumbwheel switches. Resistance setting is indicated by a direct in-line numeric readout. Unique switch feature (pat. pend.) allows advancing or decreasing of values directly from 9 thru 0 to 1 or vice versa, without retracing all the other values.

The housing is a functional sloping panel metal case equipped with universal binding posts and a grounded metallic binding post for effective shielding.

SPECIFICATIONS

Accuracy: 0.1% (plus .01Ω max. contact and circuit resistance per decade).

Selection: Rocker-type thumbwheel switches, continuous rotation in either direction.

Switch Life: In excess of 50,000 operations.

Power: ¼ Watt per resistor.

Operating Temperature: +15 to +35°C.

T.C. of Resistors: ±10 ppm/°C, max. 20 ppm/°C.

MAXIMUM CURRENT RATINGS

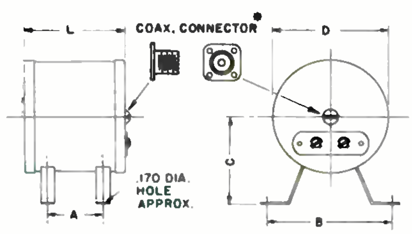
(Do not exceed 500 Volts.)

Resistance Range (Ohms)	Maximum Current (Milliamps)
1-9	710
10-99	220
100-999	71
1000-9999	22
10,000-99,999	7.1
100,000-999,999	1.1

SELECTION

Resistance Range (Ohms)	Ohms Per Step	Number of Decades	Catalog Number
0 to 9.999K	1	4	3405
0 to 99.99K	10	4	3406
0 to 999.9K	100	4	3407
0 to 999.999K	1	6	3410

dummy-antenna resistors NON-INDUCTIVE



Ohmite Models D-101 and D-251 Dummy Antenna Resistors provide a simple, accurate, and direct means of measuring R.F. power for the radio amateur, experimenter and manufacturer and for operators of aviation, police and broadcast stations. These units consist of a number of special, vitreous enameled resistors connected in parallel in a concentric arrangement and mounted inside a perforated metal cage. The dummy antenna resistors feature constant R.F. resistance (within their recommended frequency range), low reactance, high wattage dissipation, and compactness. Actual D.C. resistance tolerance is ±5%.

The residual inductance and distributed capacitance have been kept to a minimum, thereby making the natural resonant frequency as high as possible. These factors and the D.C. resistance have been proportioned in such a manner as to give the best possible response characteristics. This resistor may be considered practically a "Non-Reactive Resistor."

Catalog Number	Dimensions (Inches) A	B	C	D	L
D-101-52*, (D-101-73*)	$1\frac{1}{2}$	$3\frac{1}{2}$	$2\frac{3}{8}$	$3\frac{5}{32}$	$2\frac{23}{32}$
(D-101-300), (D-101-600)	$2\frac{3}{4}$	$3\frac{1}{2}$	$2\frac{3}{8}$	$3\frac{5}{32}$	$4\frac{7}{32}$
D-251-52*, (D-251-73*)	$3\frac{1}{8}$	$3\frac{7}{8}$	$2\frac{1}{2}$	$3\frac{23}{32}$	$4\frac{19}{32}$
D-251-300, (D-251-600)	$5\frac{1}{8}$	$3\frac{7}{8}$	$2\frac{1}{2}$	$3\frac{23}{32}$	$6\frac{13}{16}$

*Employs coax connector.

FREQUENCY CHARACTERISTICS OF OHMITE DUMMY ANTENNAS

Type	D-101				D-251			
Resistance	52 Ohms	73 Ohms	300 Ohms	600 Ohms	52 Ohms	73 Ohms	300 Ohms	600 Ohms
Maximum frequency at which Rs = Rdc ± 10%	22 mc	38 mc	22 mc	31 mc	19 mc	21 mc	15 mc	19 mc
Rs at this frequency	1.10 R dc	1.10 R dc	1.10 R dc	.90 R dc	1.10 R dc	1.10 R dc	1.10 R dc	.90 R dc
Z at this frequency	1.18 R dc	1.14 R dc	1.10 R dc	.99 R dc	1.25 R dc	1.13 R dc	1.15 R dc	1.00 R dc
Maximum frequency at which Z = Rdc ± 10%	18 mc	32 mc	22 mc	60 mc	13 mc	19 mc	13 mc	30 mc
Rs at this frequency	1.06 R dc	1.07 R dc	1.10 R dc	.60 R dc	1.03 R dc	1.07 R dc	1.08 R dc	.64 R dc
Z at this frequency	1.10 R dc	1.10 R dc	1.10 R dc	.90 R dc	1.10 R dc	1.10 R dc	1.10 R dc	.90 R dc

Cat. No.[1]	Watts	*±5% Ohms*	Net Lbs.
D-101-52	100	52	.60
(D-101-73)	100	73	.60
(D-101-300)	100	300	.65
(D-101-600)	100	600	.65
D-251-52	250	52	1.25
(D-251-73)	250	73	1.25
(D-251-300)	250	300	1.50
D-251-600	250	600	1.50

Rdc D.C. Resistance of Dummy Antenna
Rs Effective Series Resistance of Dummy Antenna
Z Scalar Value of Impedance of Dummy Antenna

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.

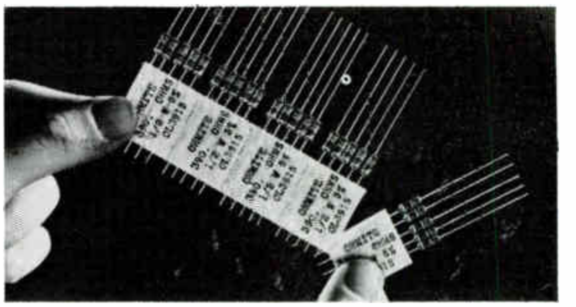
OHMITE® *Little Rebel*™ carbon film resistors

high stability • low noise • extra long life

High stability, very low noise level, and exceptionally long life make these resistors ideal for applications requiring a steady low power drop. Their accuracy and consistency are relatively unaffected by adverse environmental conditions.

Resistors of 10Ω to 1MΩ have a homogenous film of pure carbon deposited on a high grade ceramic body by cracking a hydrocarbon gas. Resistors having values lower than 10Ω have a nickel film instead of cracked carbon.

Contact caps of special alloy are pressed onto the ends of the resistor body to which the tin coated electrolytic copper connecting wires are welded. Finally the resistors are coated with three or more layers of a special lacquer for electrical, mechanical and environmental protection. This special lacquer will withstand regular industrial cleaning solutions used for cleansing printed circuit boards.



Tally Tape® is Ohmite's exclusive convenient packaging of ¼ and ½ watt Little Rebel resistors that prevents spilling or tangling, simplifies counting, decodes ohmic value for quick identification, and guarantees original, factory-fresh stock. Each perforated segment holds 5 resistors; 10 segments packaged in poly bag 50 pack.

SPECIFICATIONS

Ratings

	⅛W	¼W	½W
Power rating P_{nom} $T_A \leqq 70°C$	0.125W	0.25W	0.5W
Maximum voltage AC or DC	150V	250V	350V
Voltage (RMS) that may be applied for 1 sec. across insulated coat	300V	500V	700V
Insulation resistance	10^4MΩ	10^4MΩ	10^4MΩ

	ALL TYPES
Ambient temperature	−55°C to +155°C
Temperature coefficient	see figure 2
Noise voltage	see figure 1

Voltage Breakdown
2x limiting voltage for 1 min. between terminals of resistor and metal foil .... no breakdown or flashover

Short Term Overload (Room Temperature)
Loaded 5 sec. at 6.25 P_{max} at 25°C (not to exceed 2x maximum voltage)
10 cycles: 5 sec. on
10 sec. off
ΔR_{max} 1%

Shelf Test
At 25°C_{nom} for 12 months
ΔR_{max} for $R \leqq 1M\Omega$ 1.5%
$R > 1M\Omega$ 3%

Temperature Cycling
5 cycles: 3 hours −55°C
3 hours +155°C
ΔR_{max} .... 0.5% or 0.5Ω

Humidity Specifications
After long-term exposure to damp heat at 40°C, 5 VDC
RH = 90-95% for 56 days with no drying
5 VDC
ΔR_{max} for R_{nom} = 10Ω to 100 kΩ 1%
R_{nom} = 100 kΩ to 1 MΩ 2%
R_{nom} = 1 MΩ or higher 3%

Solder Test (thermal shock)
Terminations immersed for 3 sec. up to .24 inches from end cap in solder bath at 350°C
ΔR_{max} .... 0.5% or 0.5Ω

Lead Test
a. Tensile
diameter .024-.032 inches; load 2.20 lbs.; 10 sec.
diameter >.032 inches; load 4.41 lbs;
10 sec. .... no damage
b. Bending
diameter .024-.032 inches; load 1.10 lbs; 4 x 90°
diameter >.032 inches; load 2.20 lbs.;
4 x 90° .... no damage
c. Torsion
2 x 360° in opposite directions .... no damage
ΔR_{max} (for all tests) .... 0.5% or 0.5Ω

Shock Test
3 x 1500 shocks in three directions: 50 G:
ΔR_{max} .... 0.5% or 0.5Ω

Vibration
Frequency: 10-500 Hz
Displacement 0.06 inches or acceleration 10 G; three directions; total 9 hrs.
ΔR_{max} .... 0.5% or 0.5Ω

Voltage Coefficient 5PPM/Volt (0.0005%/Volt)

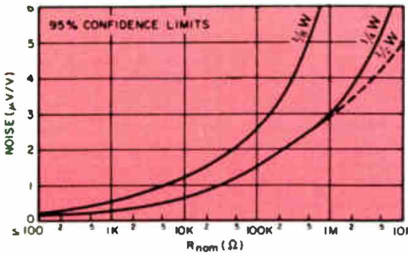


Figure 1. Noise as a function of the resistance value, applicable to all resistor wattages (as per IEC specifications 195; Method of measurement of current noise generated in fixed resistors).

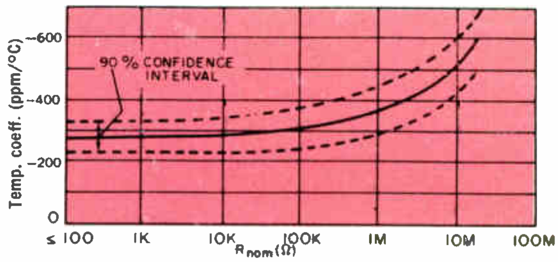
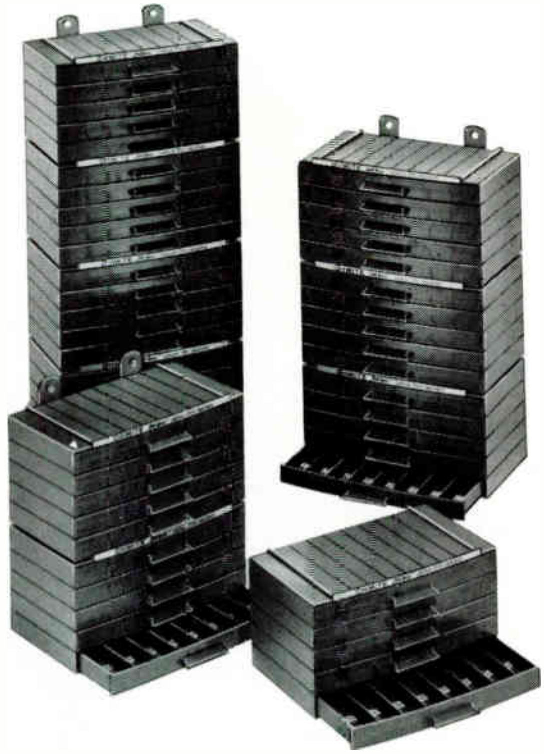


Figure 2. Temperature coefficient as a function of the resistance value, applicable to all resistor wattages.

	Size: .161"L x .059"D Leads: .015"D x 1⅛"L	Size: .250"L x .090"D Leads: .024"D x 1⅛"L	Size: .365"L x .142"D Leads: .028"D x 1½"L		Size: .161"L x .059"D Leads: .015"D x 1⅛"L	Size: .250"L x .090"D Leads: .024"D x 1⅛"L	Size: .365"L x .142"D Leads: .028"D x 1½"L		Size: .161"L x .059"D Leads: .015"D x 1⅛"L	Size: .250"L x .090"D Leads: .024"D x 1⅛"L	Size: .365"L x .142"D Leads: .028"D x 1½"L		Size: .161"L x .059"D Leads: .015"D x 1⅛"L	Size: .250"L x .090"D Leads: .024"D x 1⅛"L	Size: .365"L x .142"D Leads: .028"D x 1½"L
	Catalog Number				Catalog Number				Catalog Number				Catalog Number		
Resistance (Ohms) ±5%	⅛ Watt Type OJ	¼ Watt Type OK	½ Watt Type OL	Resistance (Ohms) ±5%	⅛ Watt Type OJ	¼ Watt Type OK	½ Watt Type OL	Resistance (Ohms) ±5%	⅛ Watt Type OJ	¼ Watt Type OK	½ Watt Type OL	Resistance (Ohms) ±5%	⅛ Watt Type OJ	¼ Watt Type OK	½ Watt Type OL
1		OK10G5	OL10G5	56	OJ5605	OK5605	OL5605	1600	OJ1625	OK1625	OL1625	47K	OJ4735	OK4735	OL4735
1.2		OK12G5	OL12G5	62	OJ6205	OK6205	OL6205	1800	OJ1825	OK1825	OL1825	51K	OJ5135	OK5135	OL5135
1.5		OK15G5	OL15G5	68	OJ6805	OK6805	OL6805	2000	OJ2025	OK2025	OL2025	56K	OJ5635	OK5635	OL5635
1.8		OK18G5	OL18G5	75	OJ7505	OK7505	OL7505	2200	OJ2225	OK2225	OL2225	62K	OJ6235	OK6235	OL6235
2.2		OK22G5	OL22G5	82	OJ8205	OK8205	OL8205	2400	OJ2425	OK2425	OL2425	68K	OJ6835	OK6835	OL6835
2.7		OK27G5	OL27G5	91	OJ9105	OK9105	OL9105	2700	OJ2725	OK2725	OL2725	75K	OJ7535	OK7535	OL7535
3.3		OK33G5	OL33G5	100	OJ1015	OK1015	OL1015	3000	OJ3025	OK3025	OL3025	82K	OJ8235	OK8235	OL8235
3.9		OK39G5	OL39G5	110	OJ1115	OK1115	OL1115	3300	OJ3325	OK3325	OL3325	91K	OJ9135	OK9135	OL9135
4.3		OK43G5	OL43G5	120	OJ1215	OK1215	OL1215	3600	OJ3625	OK3625	OL3625	100K	OJ1045	OK1045	OL1045
4.7		OK47G5	OL47G5	130	OJ1315	OK1315	OL1315	3900	OJ3925	OK3925	OL3925	110K	OJ1145	OK1145	OL1145
5.1		OK51G5	OL51G5	150	OJ1515	OK1515	OL1515	4300	OJ4325	OK4325	OL4325	120K	OJ1245	OK1245	OL1245
5.6		OK56G5	OL56G5	160	OJ1615	OK1615	OL1615	4700	OJ4725	OK4725	OL4725	130K	OJ1345	OK1345	OL1345
6.2		OK62G5	OL62G5	180	OJ1815	OK1815	OL1815	5100	OJ5125	OK5125	OL5125	150K	OJ1545	OK1545	OL1545
6.8		OK68G5	OL68G5	200	OJ2015	OK2015	OL2015	5600	OJ5625	OK5625	OL5625	160K	OJ1645	OK1645	OL1645
7.5		OK75G5	OL75G5	220	OJ2215	OK2215	OL2215	6200	OJ6225	OK6225	OL6225	180K	OJ1845	OK1845	OL1845
8.2		OK82G5	OL82G5	240	OJ2415	OK2415	OL2415	6800	OJ6825	OK6825	OL6825	200K	OJ2045	OK2045	OL2045
9.1		OK91G5	OL91G5	270	OJ2715	OK2715	OL2715	7500	OJ7525	OK7525	OL7525	220K	OJ2245	OK2245	OL2245
10.0	OJ1005	OK1005	OL1005	300	OJ3015	OK3015	OL3015	8200	OJ8225	OK8225	OL8225	240K		OK2445	OL2445
11	OJ1105	OK1105	OL1105	330	OJ3315	OK3315	OL3315	9100	OJ9125	OK9125	OL9125	270K		OK2745	OL2745
12	OJ1205	OK1205	OL1205	360	OJ3615	OK3615	OL3615	10K	OJ1035	OK1035	OL1035	300K		OK3045	OL3045
13	OJ1305	OK1305	OL1305	390	OJ3915	OK3915	OL3915	11K	OJ1135	OK1135	OL1135	330K		OK3345	OL3345
15	OJ1505	OK1505	OL1505	430	OJ4315	OK4315	OL4315	12K	OJ1235	OK1235	OL1235	360K		OK3645	OL3645
16	OJ1605	OK1605	OL1605	470	OJ4715	OK4715	OL4715	13K	OJ1335	OK1335	OL1335	390K		OK3945	OL3945
18	OJ1805	OK1805	OL1805	510	OJ5115	OK5115	OL5115	15K	OJ1535	OK1535	OL1535	430K		OK4345	OL4345
20	OJ2005	OK2005	OL2005	560	OJ5615	OK5615	OL5615	16K	OJ1635	OK1635	OL1635	470K		OK4745	OL4745
22	OJ2205	OK2205	OL2205	620	OJ6215	OK6215	OL6215	18K	OJ1835	OK1835	OL1835	510K		OK5145	OL5145
24	OJ2405	OK2405	OL2405	680	OJ6815	OK6815	OL6815	20K	OJ2035	OK2035	OL2035	560K		OK5645	OL5645
27	OJ2705	OK2705	OL2705	750	OJ7515	OK7515	OL7515	22K	OJ2235	OK2235	OL2235	620K		OK6245	OL6245
30	OJ3005	OK3005	OL3005	820	OJ8215	OK8215	OL8215	24K	OJ2435	OK2435	OL2435	680K		OK6845	OL6845
33	OJ3305	OK3305	OL3305	910	OJ9115	OK9115	OL9115	27K	OJ2735	OK2735	OL2735	750K		OK7545	OL7545
36	OJ3605	OK3605	OL3605	1000	OJ1025	OK1025	OL1025	30K	OJ3035	OK3035	OL3035	820K		OK8245	OL8245
39	OJ3905	OK3905	OL3905	1100	OJ1125	OK1125	OL1125	33K	OJ3335	OK3335	OL3335	910K		OK9145	OL9145
43	OJ4305	OK4305	OL4035	1200	OJ1225	OK1225	OL1225	36K	OJ3635	OK3635	OL3635	1.0M		OK1055	OL1055
47	OJ4705	OK4705	OL4705	1300	OJ1325	OK1325	OL1325	39K	OJ3935	OK3935	OL3935				
51	OJ5105	OK5105	OL5105	1500	OJ1525	OK1525	OL1525	43K	OJ4335	OK4335	OL4335				

OHMITE® *Little Rebel*™ carbon film resistor assortments

and cabinets for price of resistors alone



Always have the right resistor on hand and thwart Murphy's Law which states: "The resistance value needed will not be available." Ohmite Assortments of Little Rebel carbon film resistors come in Nine assortments and offer a wide selection of values in ⅛, ¼ and ½ watt sizes. All values have been selected by popularity.

The attractive gray and blue cabinet is furnished at no extra cost. Each cabinet has five drawers and each drawer has eight compartments, all individually labeled.

Dimensions of the single cabinet are 9" long, 4¾" high, 5¼" deep. Dovetail tops and bottoms facilitate stacking. Assemblies of 2, 3 and 4 cabinets are riveted to metal strips for wall hanging.

Assortments are factory packed per the schedule shown below.

NINE ASSORTMENTS

	Res. Quant.	No. of Values	No. of Cabinets	Cat. No.
⅛ Watt ±5%	150	31	1	CAB-5F
	500	52	2	CAB-22F
	1000	103	3	CAB-34F
¼ Watt ±5%	150	36	1	CAB-6F
	1000	75	2	CAB-23F
	1500	136	4	CAB-43F
½ Watt ±5%	150	36	1	CAB-7F
	1000	75	2	CAB-24F
	1500	136	4	CAB-44F

Resistance Values	⅛ WATT			¼ WATT			½ WATT		
	CAB-5F	CAB-22F	CAB-34F	CAB-6F	CAB-23F	CAB-43F	CAB-7F	CAB-24F	CAB-44F
1				5	10	30	5	10	30
1.2					5	10		5	10
1.5					5	15		5	15
1.8					5	10		5	10
2.2					5	15		5	15
2.7					5	10		5	10
3.3				1	15	15	1	15	15
3.9					5	10		5	10
4.3					5	5		5	5
4.7					5	15		5	15
5.1				1	10	15	1	10	15
5.6					5	5		5	5
6.2						10			10
6.8					5	5		5	5
7.5						5			5
8.2				1	5	10	1	5	10
9.1						5			5
10	5	20	20	5	20	30	5	20	30
11			5			5			5
12		5	5		5	5		5	5
15		5	5	1	5	5	1	5	5
16			5			5			5
18		5	5		5	5		5	5
20			5			5			5
22		5	5		5	5		5	5
24			5			5			5
27		5	10	1	5	5	1	5	5
30			5			5			5
33		5	10		5	5		5	5
36			5			5			5
39		5	10		5	5		5	5
43			5			5			5
47	5	20	20	3	20	10	3	20	5
51			5			10			15
56		5	10		5	5		5	5
62			5			5			5
68		5	10		5	5		5	5
75	1		5	1		5	1		20
82		5	10		5	5		5	5
91			5			5			5
100	5	30	30	10	30	30	10	30	30
110			5			5			5
120		5	5		5	5		5	5
130			5			5			5
150	5	10	20	3	20	10	3	15	15
160			5			5			5
180		10	10		5	5		5	5
200			5	5		5	5		15
220		5	5		20	30		20	15
240			5			5			5
270	5	5	10	3	30	10	3	15	15
300			5			5			5
330		10	10		20	20		15	15
360			5			5			5
390		5	5		5	5		5	15
430	1		5			5			5
470	5	10	20	3	20	30	3	30	20
510			5			10			15
560		5	5		5	5		15	15
620			5			5			15
680	5	5	5	3	20	10	3	15	5
750			5			5			5
820		5	10		5	5		5	5
910			5			5			5
1000	10	20	30	10	10	30	10	30	30
1100			5			5			5
1200		5	5		5	20		5	15
1300			5			5			5
1500	5	10	20	3	20	10	3	20	20
1600			5			5			5
1800		5	5		5	30		15	15
2000			5			20			30
2200		5	10		30	30		30	30
2400	1		5			5			5
2700	5	10	10	3	20	30	3	15	15
3000	1		5			10			15
3300		30	30		30	30		20	30
3600	1		5			5			5
3900		5	10		20	20		5	15
4300			5			5			5
4700	10	20	30	10	30	30	10	30	30
5100			5			20			15
5600		5	10		5	30		20	15
6200			5			10			5
6800	5	10	10	1	30	20	1	15	20
7500	1		5			5			5
8200		5	10		20	30		10	15
9100			5			5			5
10,000	10	20	30	10	30	30	10	30	30
11,000			5			5			5
12,000		5	10		20	30		15	20
13,000			5			5			5
15,000	5	10	20	5	30	30	5	30	30
16,000			5			5			5
18,000	3		5		20	10		10	15
20,000		10	20			30			15
22,000	5		10	5	30	30	5	30	30
24,000			5			5			15
27,000	3	5	10	3	20	10	3	20	15
30,000			5			10			15
33,000	5	20	30	3	20	30	3	20	20
36,000			5			5			5
39,000	3	5	10	3	5	10	3	15	15
43,000			5			5			5
47,000	5	20	30	5	30	30	5	30	20
51,000			5			10			15
56,000		5	10		20	5		15	15
62,000			5			5			5
68,000	5	10	20	3	20	10	3	20	15
75,000			5			5			5
82,000	5	5	10		5	10		15	5
91,000			5			5			5
0.10 meg	10	20	30	10	30	30	10	30	30
0.11 meg			5			5			5
0.12 meg		5	10		5	5		5	5
0.13 meg			5			5			5
0.15 meg	5	10	20	5	5	10	5	15	15
0.16 meg			5			5			5
0.18 meg		5	10		5	5		5	5
0.20 meg			5			10			5
0.22 meg	10	20	30	3	20	5	3	20	15
0.24 meg						5			5
0.27 meg				3	5	5	3	20	5
0.30 meg						5			5
0.33 meg				3	20	5	3	15	5
0.36 meg						5			5
0.39 meg					5	5		5	5
0.43 meg						5			5
0.47 meg				5	20	10	5	20	20
0.51 meg						5			5
0.56 meg					5	5		5	5
0.62 meg						5			5
0.68 meg				1	5	5	1	5	5
0.75 meg						5			5
0.82 meg					5	5		5	5
0.91 meg						5			5
1.0 meg				10	30	30	10	30	20

OHMITE® *Little Devil*® molded composition resistors on "Tally Tape"®

"Tally Tape," Ohmite's wonderfully convenient packaging presently provides for 1/4, 1/2, 1 and 2-watt resistors. Each perforated segment holds 5 resistors — prevents spilling or tangling — simplifies counting — is printed for quick identification — guarantees original, factory-fresh stock.

Now Includes MIL-R-II Types

Also available per MIL-R-39008 for 1/4, 1/2 and 1 Watt, ±5% Tol.

Little Devils, Ohmite's famous molded composition resistors, find broad use in commercial and military applications. The 1/4, 1/2, 1 and 2-watt sizes, which conform respectively to Styles RC07, RC20, RC32 and RC42 of MIL-R-11, meet all the stringent requirements of this military specification. All sizes available satisfy a wide range of design and service needs.

Little Devils have molded insulation for high dielectric strength. Noted advantages of these units are great stability, low noise level, low voltage coefficient, high insulation breakdown voltage and rapid heat dissipation. They may be used at full rated wattage at 70°C (158°F) ambient temperature.

Little Devils are available from stock in standard EIA resistance values in the tolerances and resistance ranges shown in the price table. Ratings for maximum continuous RMS voltage drop are high: 150 volts for 1/8 watt units, 250 volts for 1/4 watt, 350 volts for 1/2 watt, 500 volts for 1 watt, and 750 volts for 2 watt units. See "Little Devil" Resistor Assortments, next page.

Color Coder

CATALOG NO. 5190

1/8 WATT Size: .145"L. x .062"D. Leads: .015" D. x 1" L.

Resistance	Catalog Number ±5%	±10%	Resistance	Catalog Number ±5%	±10%	Resistance	Catalog Number ±5%	±10%	Resistance	Catalog Number ±5%	±10%	Resistance	Catalog Number ±5%	±10%
2.7 ohms	OB27G5	OB27G1	62. ohms	OB6205		1,500. ohms	OB1525	OB1521	36,000. ohms	OB3635		0.82 megs	OB8245	OB8241
3.0 ohms	OB30G5		68. ohms	OB6805	OB6801	1,600. ohms	OB1625		39,000. ohms	OB3935	OB3931	0.91 megs	OB9145	
3.3 ohms	OB33G5	OB33G1	75. ohms	OB7505		1,800. ohms	OB1825	OB1821	43,000. ohms	OB4335		1. megs	OB1055	OB1051
3.6 ohms	OB36G5		82. ohms	OB8205	OB8201	2,000. ohms	OB2025		47,000. ohms	OB4735	OB4731	1.1 megs	OB1155	
3.9 ohms	OB39G5	OB39G1	91. ohms	OB9105		2,200. ohms	OB2225	OB2221	51,000. ohms	OB5135		1.2 megs	OB1255	OB1251
4.3 ohms	OB43G5		100. ohms	OB1015	OB1011	2,400. ohms	OB2425		56,000. ohms	OB5635	OB5631	1.3 megs	OB1355	
4.7 ohms	OB47G5	OB47G1	110. ohms	OB1115		2,700. ohms	OB2725	OB2721	62,000. ohms	OB6235		1.5 megs	OB1555	OB1551
5.1 ohms	OB51G5		120. ohms	OB1215	OB1211	3,000. ohms	OB3025		68,000. ohms	OB6835	OB6831	1.6 megs	OB1655	
5.6 ohms	OB56G5	OB56G1	130. ohms	OB1315		3,300. ohms	OB3325	OB3321	75,000. ohms	OB7535		1.8 megs	OB1855	OB1851
6.2 ohms	OB62G5		150. ohms	OB1515	OB1511	3,600. ohms	OB3625		82,000. ohms	OB8235	OB8231	2.0 megs	OB2055	
6.8 ohms	OB68G5	OB68G1	160. ohms	OB1615		3,900. ohms	OB3925	OB3921	91,000. ohms	OB9135		2.2 megs	OB2255	OB2251
7.5 ohms	OB75G5		180. ohms	OB1815	OB1811	4,300. ohms	OB4325		0.1 megs	OB1045	OB1041	2.4 megs	OB2455	
8.2 ohms	OB82G5	OB82G1	200. ohms	OB2015		4,700. ohms	OB4725	OB4721	0.11 megs	OB1145		2.7 megs	OB2755	OB2751
9.1 ohms	OB91G5		220. ohms	OB2215	OB2211	5,100. ohms	OB5125		0.12 megs	OB1245	OB1241	3.0 megs	OB3055	
10. ohms	OB1005	OB1001	240. ohms	OB2415		5,600. ohms	OB5625	OB5621	0.13 megs	OB1345		3.3 megs	OB3355	OB3351
11. ohms	OB1105		270. ohms	OB2715	OB2711	6,200. ohms	OB6225		0.15 megs	OB1545	OB1541	3.6 megs	OB3655	
12. ohms	OB1205	OB1201	300. ohms	OB3015		6,800. ohms	OB6825	OB6821	0.16 megs	OB1645		3.9 megs	OB3955	OB3951
13. ohms	OB1305		330. ohms	OB3315	OB3311	7,500. ohms	OB7525		0.18 megs	OB1845	OB1841	4.3 megs	OB4355	
15. ohms	OB1505	OB1501	360. ohms	OB3615		8,200. ohms	OB8225	OB8221	0.20 megs	OB2045		4.7 megs	OB4755	OB4751
16. ohms	OB1605		390. ohms	OB3915	OB3911	9,100. ohms	OB9125		0.22 megs	OB2245	OB2241	5.1 megs	OB5155	
18. ohms	OB1805	OB1801	430. ohms	OB4315		10,000. ohms	OB1035	OB1031	0.24 megs	OB2445		5.6 megs	OB5655	OB5651
20. ohms	OB2005		470. ohms	OB4715	OB4711	11,000. ohms	OB1135		0.27 megs	OB2745	OB2741	6.2 megs	OB6255	
22. ohms	OB2205	OB2201	510. ohms	OB5115		12,000. ohms	OB1235	OB1231	0.30 megs	OB3045		6.8 megs	OB6855	OB6851
24. ohms	OB2405		560. ohms	OB5615	OB5611	13,000. ohms	OB1335		0.33 megs	OB3345	OB3341	7.5 megs	OB7555	
27. ohms	OB2705	OB2701	620. ohms	OB6215		15,000. ohms	OB1535	OB1531	0.36 megs	OB3645		8.2 megs	OB8255	OB8251
30. ohms	OB3005		680. ohms	OB6815	OB6811	16,000. ohms	OB1635		0.39 megs	OB3945	OB3941	9.1 megs	OB9155	
33. ohms	OB3305	OB3301	750. ohms	OB7515		18,000. ohms	OB1835	OB1831	0.43 megs	OB4345		10. megs	OB1065	OB1061
36. ohms	OB3605		820. ohms	OB8215	OB8211	20,000. ohms	OB2035		0.47 megs	OB4745	OB4741	11. megs	OB1165	
39. ohms	OB3905	OB3901	910. ohms	OB9115		22,000. ohms	OB2235	OB2231	0.51 megs	OB5145		12. megs	OB1265	OB1261
43. ohms	OB4305		1,000. ohms	OB1025	OB1021	24,000. ohms	OB2435		0.56 megs	OB5645	OB5641	13. megs	OB1365	
47. ohms	OB4705	OB4701	1,100. ohms	OB1125		27,000. ohms	OB2735	OB2731	0.62 megs	OB6245		15. megs	OB1565	OB1561
51. ohms	OB5105		1,200. ohms	OB1225	OB1221	30,000. ohms	OB3035		0.68 megs	OB6845	OB6841	16. megs	OB1665	
56. ohms	OB5605	OB5601	1,300. ohms	OB1325		33,000. ohms	OB3335	OB3331	0.75 megs	OB7545		18. megs	OB1865	OB1861
												20. megs	OB2065	
												22. megs	OB2265	OB2261

1/4 WATT MIL Type: RC 07 Size: 1/2"L. x .090"D. Leads: .025"D. x 1 1/2"L.

Resistance	Catalog Number ±5%	±10%	Resistance	Catalog Number ±5%	±10%	Resistance	Catalog Number ±5%	±10%	Resistance	Catalog Number ±5%	±10%	Resistance	Catalog Number ±5%	±10%
2.7 ohms	OC27G5	OC27G1	68. ohms	OC6805	OC6801	1,800. ohms	OC1825	OC1821	47,000. ohms	OC4735	OC4731	1.2 megs	OC1255	OC1251
3.0 ohms	OC30G5		75. ohms	OC7505		2,000. ohms	OC2025		51,000. ohms	OC5135		1.3 megs	OC1355	
3.3 ohms	OC33G5	OC33G1	82. ohms	OC8205	OC8201	2,200. ohms	OC2225	OC2221	56,000. ohms	OC5635	OC5631	1.5 megs	OC1555	OC1551
3.6 ohms	OC36G5		91. ohms	OC9105		2,400. ohms	OC2425		62,000. ohms	OC6235		1.6 megs	OC1655	
3.9 ohms	OC39G5	OC39G1	100. ohms	OC1015	OC1011	2,700. ohms	OC2725	OC2721	68,000. ohms	OC6835	OC6831	1.8 megs	OC1855	OC1851
4.3 ohms	OC43G5		110. ohms	OC1115		3,000. ohms	OC3025		75,000. ohms	OC7535		2.0 megs	OC2055	
4.7 ohms	OC47G5	OC47G1	120. ohms	OC1215	OC1211	3,300. ohms	OC3325	OC3321	82,000. ohms	OC8235	OC8231	2.2 megs	OC2255	OC2251
5.1 ohms	OC51G5		130. ohms	OC1315		3,600. ohms	OC3625		91,000. ohms	OC9135		2.4 megs	OC2455	
5.6 ohms	OC56G5	OC56G1	150. ohms	OC1515	OC1511	3,900. ohms	OC3925	OC3921	0.1 megs	OC1045	OC1041	2.7 megs	OC2755	OC2751
6.2 ohms	OC62G5		160. ohms	OC1615		4,300. ohms	OC4325		0.11 megs	OC1145		3.0 megs	OC3055	
6.8 ohms	OC68G5	OC68G1	180. ohms	OC1815	OC1811	4,700. ohms	OC4725	OC4721	0.12 megs	OC1245	OC1241	3.3 megs	OC3355	OC3351
7.5 ohms	OC75G5		200. ohms	OC2015		5,100. ohms	OC5125		0.13 megs	OC1345		3.6 megs	OC3655	
8.2 ohms	OC82G5	OC82G1	220. ohms	OC2215	OC2211	5,600. ohms	OC5625	OC5621	0.15 megs	OC1545	OC1541	3.9 megs	OC3955	OC3951
9.1 ohms	OC91G5		240. ohms	OC2415		6,200. ohms	OC6225		0.16 megs	OC1645		4.3 megs	OC4355	
10. ohms	OC1005	OC1001	270. ohms	OC2715	OC2711	6,800. ohms	OC6825	OC6821	0.18 megs	OC1845	OC1841	4.7 megs	OC4755	OC4751
11. ohms	OC1105		300. ohms	OC3015		7,500. ohms	OC7525		0.20 megs	OC2045		5.1 megs	OC5155	
12. ohms	OC1205	OC1201	330. ohms	OC3315	OC3311	8,200. ohms	OC8225	OC8221	0.22 megs	OC2245	OC2241	5.6 megs	OC5655	OC5651
13. ohms	OC1305		360. ohms	OC3615		9,100. ohms	OC9125		0.24 megs	OC2445		6.2 megs	OC6255	
15. ohms	OC1505	OC1501	390. ohms	OC3915	OC3911	10,000. ohms	OC1035	OC1031	0.27 megs	OC2745	OC2741	6.8 megs	OC6855	OC6851
16. ohms	OC1605		430. ohms	OC4315		11,000. ohms	OC1135		0.30 megs	OC3045		7.5 megs	OC7555	
18. ohms	OC1805	OC1801	470. ohms	OC4715	OC4711	12,000. ohms	OC1235	OC1231	0.33 megs	OC3345	OC3341	8.2 megs	OC8255	OC8251
20. ohms	OC2005		510. ohms	OC5115		13,000. ohms	OC1335		0.36 megs	OC3645		9.1 megs	OC9155	
22. ohms	OC2205	OC2201	560. ohms	OC5615	OC5611	15,000. ohms	OC1535	OC1531	0.39 megs	OC3945	OC3941	10. megs	OC1065	OC1061
24. ohms	OC2405		620. ohms	OC6215		16,000. ohms	OC1635		0.43 megs	OC4345		11. megs	OC1165	
27. ohms	OC2705	OC2701	680. ohms	OC6815	OC6811	18,000. ohms	OC1835	OC1831	0.47 megs	OC4745	OC4741	12. megs	OC1265	OC1261
30. ohms	OC3005		750. ohms	OC7515		20,000. ohms	OC2035		0.51 megs	OC5145		13. megs	OC1365	
33. ohms	OC3305	OC3301	820. ohms	OC8215	OC8211	22,000. ohms	OC2235	OC2231	0.56 megs	OC5645	OC5641	15. megs	OC1565	OC1561
36. ohms	OC3605		910. ohms	OC9115		24,000. ohms	OC2435		0.62 megs	OC6245		16. megs	OC1665	
39. ohms	OC3905	OC3901	1,000. ohms	OC1025	OC1021	27,000. ohms	OC2735	OC2731	0.68 megs	OC6845	OC6841	18. megs	OC1865	OC1861
43. ohms	OC4305		1,100. ohms	OC1125		30,000. ohms	OC3035		0.75 megs	OC7545		20. megs	OC2065	
47. ohms	OC4705	OC4701	1,200. ohms	OC1225	OC1221	33,000. ohms	OC3335	OC3331	0.82 megs	OC8245	OC8241	22. megs	OC2265	OC2261
51. ohms	OC5105		1,300. ohms	OC1325		36,000. ohms	OC3635		0.91 megs	OC9145				
56. ohms	OC5605	OC5601	1,500. ohms	OC1525	OC1521	39,000. ohms	OC3935	OC3931	1. megs	OC1055	OC1051			
62. ohms	OC6205		1,600. ohms	OC1625		43,000. ohms	OC4335		1.1 megs	OC1155				

[1] Items appearing in BOLD print are popular values and are usually stocked by authorized OHMITE distributors. Items appearing in LIGHT FACE print are available from stocking distributors but normally are not stocked in depth.

½ WATT — Mil. Type: RC 20 — Size: [illegible] — Leads: [illegible]

Resistance	Catalog Number ±5%	±10%
1. ohms	OE10G5	OE10G1
1.1 ohms	OE11G5	
1.2 ohms	OE12G5	OE12G1
1.3 ohms	OE13G5	
1.5 ohms	OE15G5	OE15G1
1.6 ohms	OE16G5	
1.8 ohms	OE18G5	OE18G1
2. ohms	OE20G5	
2.2 ohms	OE22G5	OE22G1
2.4 ohms	OE24G5	
2.7 ohms	OE27G5	OE27G1
3.0 ohms	OE30G5	
3.3 ohms	OE33G5	OE33G1
3.6 ohms	OE36G5	
3.9 ohms	OE39G5	OE39G1
4.3 ohms	OE43G5	
4.7 ohms	OE47G5	OE47G1
5.1 ohms	OE51G5	
5.6 ohms	OE56G5	OE56G1
6.2 ohms	OE62G5	
6.8 ohms	OE68G5	OS68G1
7.5 ohms	OE75G5	
8.2 ohms	OE82G5	OE82G1
9.1 ohms	OE91G5	
10. ohms	OE1005	OE1001
11. ohms	OE1105	
12. ohms	OE1205	OE1201
13. ohms	OE1305	
15. ohms	OE1505	OE1501
16. ohms	OE1605	
18. ohms	OE1805	OE1801
20. ohms	OE2005	
22. ohms	OE2205	OE2201
24. ohms	OE2405	
27. ohms	OE2705	OE2701
30. ohms	OE3005	

Resistance	Catalog Number ±5%	±10%
33. ohms	OE3305	OE3301
36. ohms	OE3605	
39. ohms	OE3905	OE3901
43. ohms	OE4305	
47. ohms	OE4705	OE4701
51. ohms	OE5105	
56. ohms	OE5605	OE5601
62. ohms	OE6205	
68. ohms	OE6805	OE6801
75. ohms	OE7505	
82. ohms	OE8205	OE8201
91. ohms	OE9105	
100. ohms	OE1015	OE1011
110. ohms	OE1115	
120. ohms	OE1215	OE1211
130. ohms	OE1315	
150. ohms	OE1515	OE1511
160. ohms	OE1615	
180. ohms	OE1815	OE1811
200. ohms	OE2015	
220. ohms	OE2215	OE2211
240. ohms	OE2415	
270. ohms	OE2715	OE2711
300. ohms	OE3015	
330. ohms	OE3315	OE3311
360. ohms	OE3615	
390. ohms	OE3915	OE3911
430. ohms	OE4315	
470. ohms	OE4715	OE4711
510. ohms	OE5115	
560. ohms	OE5615	OE5611
620. ohms	OE6215	
680. ohms	OE6815	OE6811
750. ohms	OE7515	
820. ohms	OE8215	OE8211
910. ohms	OE9115	

Resistance	Catalog Number ±5%	±10%
1,000. ohms	OE1025	OE1021
1,100. ohms	OE1125	
1,200. ohms	OE1225	OE1221
1,300. ohms	OE1325	
1,500. ohms	OE1525	OE1521
1,600. ohms	OE1625	
1,800. ohms	OE1825	OE1821
2,000. ohms	OE2025	
2,200. ohms	OE2225	OE2221
2,400. ohms	OE2425	
2,700. ohms	OE2725	OE2721
3,000. ohms	OE3025	
3,300. ohms	OE3325	OE3321
3,600. ohms	OE3625	
3,900. ohms	OE3925	OE3921
4,300. ohms	OE4325	
4,700. ohms	OE4725	OE4721
5,100. ohms	OE5125	
5,600. ohms	OE5625	OE5621
6,200. ohms	OE6225	
6,800. ohms	OE6825	OE6821
7,500. ohms	OE7525	
8,200. ohms	OE8225	OE8221
9,100. ohms	OE9125	
10,000. ohms	OE1035	OE1031
11,000. ohms	OE1135	
12,000. ohms	OE1235	OE1231
13,000. ohms	OE1335	
15,000. ohms	OE1535	OE1531
16,000. ohms	OE1635	
18,000. ohms	OE1835	OE1831
20,000. ohms	OE2035	
22,000. ohms	OE2235	OE2231
24,000. ohms	OE2435	
27,000. ohms	OE2735	OE2731
30,000. ohms	OE3035	

Resistance	Catalog Number ±5%	±10%
33,000. ohms	OE3335	OE3331
36,000. ohms	OE3635	
39,000. ohms	OE3935	OE3931
43,000. ohms	OE4334	
47,000. ohms	OE4735	OE4731
51,000. ohms	OE5135	
56,000. ohms	OE5635	OE5631
62,000. ohms	OE6235	
68,000. ohms	OE6835	OE6831
75,000. ohms	OE7535	
82,000. ohms	OE8235	OE8231
91,000. ohms	OE9135	
0.1 megs	OE1045	OE1041
0.11 megs	OE1145	
0.12 megs	OE1245	OE1241
0.13 megs	OE1345	
0.15 megs	OE1545	OE1541
0.16 megs	OE1645	
0.18 megs	OE1845	OE1841
0.20 megs	OE2045	
0.22 megs	OE2245	OE2241
0.24 megs	OE2445	
0.27 megs	OE2745	OE2741
0.30 megs	OE3045	
0.33 megs	OE3345	OE3341
0.36 megs	OE3645	
0.39 megs	OE3945	OE3941
0.43 megs	OE4345	
0.47 megs	OE4745	OE4741
0.51 megs	OE5145	
0.56 megs	OE5645	OE5641
0.62 megs	OE6245	
0.68 megs	OE6845	OE6841
0.75 megs	OE7545	
0.82 megs	OE8245	OE8241
0.91 megs	OE9145	

Resistance	Catalog Number ±5%	±10%
1. megs	OE1055	OE1051
1.1 megs	OE1155	
1.2 megs	OE1255	OE1251
1.3 megs	OE1355	
1.5 megs	OE1555	OE1551
1.6 megs	OE1655	
1.8 megs	OE1855	OE1851
2.0 megs	OE2055	
2.2 megs	OE2255	OE2251
2.4 megs	OE2455	
2.7 megs	OE2755	OE2751
3.0 megs	OE3055	
3.3 megs	OE3355	OE3351
3.6 megs	OE3655	
3.9 megs	OE3955	OE3951
4.3 megs	OE4355	
4.7 megs	OE4755	OE4751
5.1 megs	OE5155	
5.6 megs	OE5655	OE5651
6.2 megs	OE6255	
6.8 megs	OE6855	OE6851
7.5 megs	OE7555	
8.2 megs	OE8255	OE8251
9.1 megs	OE9155	
10. megs	OE1065	OE1061
11. megs	OE1165	
12. megs	OE1265	OE1261
13. megs	OE1365	
15. megs	OE1565	OE1561
16. megs	OE1665	
18. megs	OE1865	OE1861
20. megs	OE2065	
22. megs	OE2265	OE2261

1 WATT — Mil. Type: RC [illegible] — Size: [illegible] — Leads: [illegible]

Resistance	Catalog Number ±5%	±10%
2.7 ohms	OG27G5	OG27G1
3.0 ohms	OG30G5	
3.3 ohms	OG33G5	OG33G1
3.6 ohms	OG36G5	
3.9 ohms	OG39G5	OG39G1
4.3 ohms	OG43G5	
4.7 ohms	OG47G5	OG47G1
5.1 ohms	OG51G5	
5.6 ohms	OG56G5	OG56G1
6.2 ohms	OG62G5	
6.8 ohms	OG68G5	OG68G1
7.5 ohms	OG75G5	
8.2 ohms	OG82G5	OG82G1
9.1 ohms	OG91G5	
10. ohms	OG1005	OG1001
11. ohms	OG1105	
12. ohms	OG1205	OG1201
13. ohms	OG1305	
15. ohms	OG1505	OG1501
16. ohms	OG1605	
18. ohms	OG1805	OG1801
20. ohms	OG2005	
22. ohms	OG2205	OG2201
24. ohms	OG2405	
27. ohms	OG2705	OG2701
30. ohms	OG3005	
33. ohms	OG3305	OG3301
36. ohms	OG3605	
39. ohms	OG3905	OG3901
43. ohms	OG4305	
47. ohms	OG4705	OG4701
51. ohms	OG5105	
56. ohms	OG5605	OG5601
62. ohms	OG6205	

Resistance	Catalog Number ±5%	±10%
68. ohms	OG6805	OG6801
75. ohms	OG7505	
82. ohms	OG8205	OG8201
91. ohms	OG9105	
100. ohms	OG1015	OG1011
110. ohms	OG1115	
120. ohms	OG1215	OG1211
130. ohms	OG1315	
150. ohms	OG1515	OG1511
160. ohms	OG1615	
180. ohms	OG1815	OG1811
200. ohms	OG2015	
220. ohms	OG2215	OG2211
240. ohms	OG2415	
270. ohms	OG2715	OG2711
300. ohms	OG3015	
330. ohms	OG3315	OG3311
360. ohms	OG3615	
390. ohms	OG3915	OG3911
430. ohms	OG4315	
470. ohms	OG4715	OG4711
510. ohms	OG5115	
560. ohms	OG5615	OG5611
620. ohms	OG6215	
680. ohms	OG6815	OG6811
750. ohms	OG7515	
820. ohms	OG3215	OG8211
910. ohms	OG9115	
1,000. ohms	OG1025	OG1021
1,100. ohms	OG1125	
1,200. ohms	OG1225	OG1221
1,300. ohms	OG1325	
1,500. ohms	OG1525	OG1521
1,600. ohms	OG1625	

Resistance	Catalog Number ±5%	±10%
1,800. ohms	OG1825	OG1821
2,000. ohms	OG2025	
2,200. ohms	OG2225	OG2221
2,400. ohms	OG2425	
2,700. ohms	OG2725	OG2721
3,000. ohms	OG3025	
3,300. ohms	OG3325	OG3321
3,600. ohms	OG3625	
3,900. ohms	OG3925	OG3921
4,300. ohms	OG4325	
4,700. ohms	OG4725	OG4721
5,100. ohms	OG5125	
5,600. ohms	OG5625	OG5621
6,200. ohms	OG6225	
6,800. ohms	OG6825	OG6821
7,500. ohms	OG7525	
8,200. ohms	OG8225	OG8221
9,100. ohms	OG9125	
10,000. ohms	OG1035	OG1031
11,000. ohms	OG1135	
12,000. ohms	OG1235	OG1231
13,000. ohms	OG1335	
15,000. ohms	OG1535	OG1531
16,000. ohms	OG1635	
18,000. ohms	OG1835	OG1831
20,000. ohms	OG2035	
22,000. ohms	OG2235	OG2231
24,000. ohms	OG2435	
27,000. ohms	OG2735	OG2731
30,000. ohms	OG3035	
33,000. ohms	OG3335	OG3331
36,000. ohms	OG3635	
39,000. ohms	OG3935	OG3931
43,000. ohms	OG4335	

Resistance	Catalog Number ±5%	±10%
47,000. ohms	OG4735	OG4731
51,000. ohms	OG5135	
56,000. ohms	OG5635	OG5631
62,000. ohms	OG6235	
68,000. ohms	OG6835	OG6831
75,000. ohms	OG7535	
82,000. ohms	OG8235	OG8231
91,000. ohms	OG9135	
0.1 megs	OG1045	OG1041
0.11 megs	OG1145	
0.12 megs	OG1245	OG1241
0.13 megs	OG1345	
0.15 megs	OG1545	OG1541
0.16 megs	OG1645	
0.18 megs	OG1845	OG1841
0.20 megs	OG2045	
0.22 megs	OG2245	OG2241
0.24 megs	OG2445	
0.27 megs	OG2745	OG2741
0.30 megs	OG3045	
0.33 megs	OG3345	OG3341
0.36 megs	OG3645	
0.39 megs	OG3945	OG3941
0.43 megs	OG4345	
0.47 megs	OG4745	OG4741
0.51 megs	OG5145	
0.56 megs	OG5645	OG5641
0.62 megs	OG6245	
0.68 megs	OG6845	OG6841
0.75 megs	OG7545	
0.82 megs	OG8245	OG8241
0.91 megs	OG9145	
1. megs	OG1055	OG1051
1.1 megs	OG1155	

Resistance	Catalog Number ±5%	±10%
1.2 megs	OG1255	OG1251
1.3 megs	OG1355	
1.5 megs	OG1555	OG1551
1.6 megs	OG1655	
1.8 megs	OG1855	OG1851
2.0 megs	OG2055	
2.2 megs	OG2255	OG2251
2.4 megs	OG2455	
2.7 megs	OG2755	OG2751
3.0 megs	OG3055	
3.3 megs	OG3355	OG3351
3.6 megs	OG3655	
3.9 megs	OG3955	OG3951
4.3 megs	OG4355	
4.7 megs	OG4755	OG4751
5.1 megs	OG5155	
5.6 megs	OG5655	OG5651
6.2 megs	OG6255	
6.8 megs	OG6855	OG6851
7.5 megs	OG7555	
8.2 megs	OG8255	OG8251
9.1 megs	OG9155	
10. megs	OG1065	OG1061
11. megs	OG1165	
12. megs	OG1265	OG1261
13. megs	OG1365	
15. megs	OG1565	OG1561
16. megs	OG1665	
18. megs	OG1865	OG1861
20. megs	OG2065	
22. megs	OG2265	OG2261

2 WATT — Mil. Type: RC [illegible] — Size: [illegible] — Leads: [illegible]

Resistance	Catalog Number ±5%	±10%
10. ohms	OH1005	OH1001
11. ohms	OH1105	
12. ohms	OH1205	OH1201
13. ohms	OH1305	
15. ohms	OH1505	OH1501
16. ohms	OH1605	
18. ohms	OH1805	OH1801
20. ohms	OH2005	
22. ohms	OH2205	OH2201
24. ohms	OH2405	
27. ohms	OH2705	OH2701
30. ohms	OH3005	
33. ohms	OH3305	OH3301
36. ohms	OH3605	
39. ohms	OH3905	OH3901
43. ohms	OH4305	
47. ohms	OH4705	OH4701
51. ohms	OH5105	
56. ohms	OH5605	OH5601
62. ohms	OH6205	
68. ohms	OH6805	OH6801
75. ohms	OH7505	
82. ohms	OH8205	OH8201
91. ohms	OH9105	
100. ohms	OH1015	OH1011
110. ohms	OH1115	
120. ohms	OH1215	OH1211
130. ohms	OH1315	
150. ohms	OH1515	OH1511
160. ohms	OH1615	
180. ohms	OH1815	OH1811

Resistance	Catalog Number ±5%	±10%
200. ohms	OH2015	
220. ohms	OH2215	OH2211
240. ohms	OH2415	
270. ohms	OH2715	OH2711
300. ohms	OH3015	
330. ohms	OH3315	OH3311
360. ohms	OH3615	
390. ohms	OH3915	OH3911
430. ohms	OH4315	
470. ohms	OH4715	OH4711
510. ohms	OH5115	
560. ohms	OH5615	OH5611
620. ohms	OH6215	
680. ohms	OH6815	OH6811
750. ohms	OH7515	
820. ohms	OH8215	OH8211
910. ohms	OH9115	
1,000. ohms	OH1025	OH1021
1,100. ohms	OH1125	
1,200. ohms	OH1225	OH1221
1,300. ohms	OH1325	
1,500. ohms	OH1525	OH1521
1,600. ohms	OH1625	
1,800. ohms	OH1825	OH1821
2,000. ohms	OH2025	
2,200. ohms	OH2225	OH2221
2,400. ohms	OH2425	
2,700. ohms	OH2725	OH2721
3,000. ohms	OH3025	
3,300. ohms	OH3325	OH3321
3,600. ohms	OH3625	

Resistance	Catalog Number ±5%	±10%
3,900. ohms	OH3925	OH3921
4,300. ohms	OH4325	
4,700. ohms	OH4725	OH4721
5,100. ohms	OH5125	
5,600. ohms	OH5625	OH5621
6,200. ohms	OH6225	
6,800. ohms	OH6825	OH6821
7,500. ohms	OH7525	
8,200. ohms	OH8225	OH8221
9,100. ohms	OH9125	
10,000. ohms	OH1035	OH1031
11,000. ohms	OH1135	
12 000. ohms	OH1235	OH1231
13,000. ohms	OH1335	
15,000. ohms	OH1535	OH1531
16,000. ohms	OH1635	
18,000. ohms	OH1835	OH1831
20,000. ohms	OH2035	
22,000. ohms	OH2235	OH2231
24,000. ohms	OH2435	
27,000. ohms	OH2735	OH2731
30,000. ohms	OH3035	
33,000. ohms	OH3335	OH3331
36,000. ohms	OH3635	
39 000. ohms	OH3935	OH3931
43,000. ohms	OH4335	
47,000. ohms	OH4735	OH4731
51,000. ohms	OH5135	
56,000. ohms	OH5635	OH5631
62,000. ohms	OH6235	
68,000. ohms	OH6835	OH6831

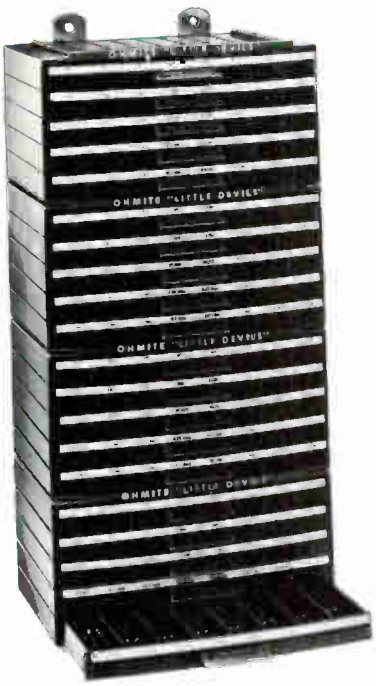
Resistance	Catalog Number ±5%	±10%
75,000. ohms	OH7535	
82,000. ohms	OH8235	OH8231
91,000. ohms	OH9135	
0.1 megs	OH1045	OH1041
0.11 megs	OH1145	
0.12 megs	OH1245	OH1241
0.13 megs	OH1345	
0.15 megs	OH1545	OH1541
0.16 megs	OH1645	
0.18 megs	OH1845	OH1841
0.20 megs	OH2045	
0.22 megs	OH2245	OH2241
0.24 megs	OH2445	
0.27 megs	OH2745	OH2741
0.30 megs	OH3045	
0.33 megs	OH3345	OH3341
0.36 megs	OH3645	
0.39 megs	OH3945	OH3941
0.43 megs	OH4345	
0.47 megs	OH4745	OH4741
0.51 megs	OH5145	
0.56 megs	OH5645	OH5641
0.62 megs	OH6245	
0.68 megs	OH6845	OH6841
0.75 megs	OH7545	
0.82 megs	OH8245	OH8241
0.91 megs	OH9145	
1. megs	OH1055	OH1051
1.1 megs	OH1155	
1.2 megs	OH1255	OH1251
1.3 megs	OH1355	

Resistance	Catalog Number ±5%	±10%
1.5 megs	OH1555	OH1551
1.6 megs	OH1655	
1.8 megs	OH1855	OH1851
2.0 megs	OH2055	
2.2 megs	OH2255	OH2251
2.4 megs	OH2455	
2.7 megs	OH2755	OH2751
3.0 ohms	OH3055	
3.3 megs	OH3355	OH3351
3.6 megs	OH3655	
3.9 megs	OH3955	OH3951
4.3 megs	OH4355	
4.7 megs	OH4755	OH4751
5.1 megs	OH5155	
5.6 megs	OH5655	OH5651
6.2 megs	OH6255	
6.8 megs	OH6855	OH6851
7.5 megs	OH7555	
8.2 megs	OH8255	OH8251
9.1 megs	OH9155	
10. megs	OH1065	OH1061
11. megs	OH1165	
12. megs	OH1265	OH1261
13. megs	OH1365	
15. megs	OH1565	OH1561
16. megs	OH1665	
18. megs		OH1861
22. megs		OH2261

‡Min. Resistance under MIL-R-11 is 2.7 ohms.

[1] Items appearing in BOLD print are popular values and are usually stocked by authorized OHMITE distributors. Items appearing in LIGHT FACE print are available from stocking distributors but normally are not stocked in depth.

OHMITE® *Little Devil*® industrial and service resistor assortments



RESISTORS AND HANDY CABINET FOR THE PRICE OF THE RESISTORS ALONE

Select the composition resistor you need, right on the job from time-saving Little Devil® Assortments. Ohmite now offers **seven industrial** assortments in addition to the four service assortments that have been so popular for many years. In this complete line, there is an assortment to fill every industrial and service need. An attractive plastic cabinet or cabinet assembly is furnished at no extra cost with each assortment. Each drawer of a single 5-drawer cabinet has eight compartments, all individually labeled. Dimensions of the single cabinet are 9" long, 4¾" high, 5¼" deep. Dovetail tops and bottoms facilitate stacking. Cabinet assemblies for industrial assortments are riveted to metal strips which afford rigidity and permit hanging of the unit on the wall.

Of the seven industrial assortments, there are three ±10% tolerance assortments of ¼, ½ or 1 watt sizes each containing 80 values. A two-cabinet assembly is furnished for these assortments. Four 5% tolerance assortments provide 160 values each of resistors in the ⅛, ¼, ½, or 1 watt sizes. A four-cabinet assembly is furnished for each of these assortments.

The four popular **service** assortments provide ±10% tolerance resistors in a single cabinet in ¼, ½, 1 or 2 watt sizes.

Cabinets are factory packed in accordance with the tables shown below.

11 ASSORTMENTS

Assortment	Catalog No.	Quantity of Resistors	Wattage Size
INDUSTRIAL ±10% Tolerance 80 Resistance Values 2 Cabinets	CAB-25	1000	¼
	CAB-26	1000	½
	CAB-27	600	1
INDUSTRIAL ±5% Tolerance 160 Resistance Values 4 Cabinets	CAB-45	1000	⅛
	CAB-46	1500	¼
	CAB-47	1500	½
	CAB-48	900	1
RADIO & TV SERVICE KITS ±10% Tolerance 37 Values—CAB-4 40 Values—Others 1 Cabinet	CAB-4	150	¼
	CAB-10	150	½
	CAB-2	125	1
	CAB-3	125	2

10% TOLERANCE ASSORTMENTS

10% Resistance Values[1]	Quantities in Each Assortment: Service Assortments CAB-4, ¼ W	CAB-10, ½ W	CAB-2, 1 W	CAB-3, 2 W	Industrial Assortments CAB-25, ¼ W	CAB-26, ½ W	CAB-27, 1 W
2.7					5	5	10
3.3					5	5	5
3.9					5	5	5
4.7					5	5	10
5.6					5	5	5
6.8					5	5	10
10		1	1	1	20	20	10
12					5	5	5
15		1	1	1	5	5	10
18					5	5	5
22					5	5	10
27		1	1	1	5	5	10
33					5	5	10
39					5	5	5
47	5	1	1	1	20	20	10
56					5	5	5
68					5	5	5
82					5	5	5
100	5	5	1	1	30	30	10
120					5	5	5
150	1	1	1	1	20	15	10
180					5	5	5
220					20	20	10
270	3	3	1	1	30	15	10
330	1	1	1	1	20	15	10
390					5	5	10
470	3	3	1	1	20	30	10
560					5	15	10
680	1	1	1	1	20	15	10
820					5	5	5
1,000	10	5	3	3	5	30	10
1,200					5	5	10
1,500	5	1	1	1	20	20	10
1,800					5	15	5
2.200	10	1	1	1	30	30	10
2,700	5	3	3	3	20	15	10
3,300					30	20	10
3,900					20	5	10
4,700	10	10	5	5	30	30	10
5.600					5	20	5
6,800	5	1	1	1	30	15	10
8,200					20	5	5
10,000	10	10	10	10	30	30	10
12,000					20	15	5
15,000	5	3	3	3	30	5	10
18,000					20	5	5
22,000	5	5	5	5	30	30	10
27,000	5	10	10	10	20	20	10
33,000	3	3	1	1	20	20	10
39,000	3	5	5	5	5	15	10
47,000	5	10	10	10	30	30	10
56,000					20	15	5
68,000	3	3	1	1	20	20	5
82,000	2	1	1	1	5	15	5
0.10 meg.	10	10	10	10	30	30	10
0.12 meg.					5	5	5
0.15 meg.	3	5	5	5	5	15	10
0.18 meg.					5	5	5
0.22 meg.	3	3	1	1	20	20	10
0.27 meg.	3	10	10	10	5	20	10
0.33 meg.	3	3	1	1	20	15	5
0.39 meg.					5	5	5
0.47 meg.	5	10	10	10	20	30	10
0.56 meg.					5	5	5
0.68 meg.	1	1	1	1	5	5	5
0.82 meg.					5	5	5
1.0 meg.	10	10	10	10	30	30	10
1.2 meg.					5	5	5
1.5 meg.	1	1	1	1	5	5	5
1.8 meg.					5	5	5
2.2 meg.	1	1	1	1	5	15	5
2.7 meg.	1	3	1	1	5	5	5
3.3 meg.					5	15	5
3.9 meg.	1	1	1	1	5	5	5
4.7 meg.	1	1	1	1	5	5	5
5.6 meg.					5	5	5
6.8 meg.	1	1	1	1	5	5	5
10.0 meg.	1	1	1	1	5	5	5
15.0 meg.					5	5	5
22.0 meg.					5	5	5

5% TOLERANCE ASSORTMENTS

5% Resistance Values	Quantities in Each Assortment, Industrial Assortments: CAB-45, ⅛ W	CAB-46, ¼ W	CAB-47, ½ W	CAB-48, 1 W
2.7	5	5	5	5
3.0	5	5	5	5
3.3	5	5	5	5
3.6	5	5	5	5
3.9	5	5	5	5
4.7	5	5	5	5
5.1	5	5	5	5
5.6	5	5	5	5
6.8	5	5	5	5
7.5	5	5	5	5
8.2	5	5	5	5
9.1	5	5	5	5
10	20	25	30	10
11	5	5	5	5
12	5	5	5	5
15	5	5	5	5
16	5	5	5	5
18	5	5	5	5
20	5	5	5	5
22	5	5	5	5
24	5	5	5	5
27	5	5	15	5
30	5	5	5	5
33	5	5	5	5
36	5	5	5	5
39	5	5	5	5
43	5	5	5	5
47	10	10	5	5
51	10	10	15	10
56	5	5	5	5
62	5	5	5	5
68	5	5	5	5
75	5	5	20	5
82	5	5	5	5
91	5	5	5	5
100	20	30	30	10
110	5	5	5	5
120	5	5	5	5
130	5	5	5	5
150	5	10	15	10

5% Resistance Values	CAB-45, ⅛ W	CAB-46, ¼ W	CAB-47, ½ W	CAB-48, 1 W
160	5	5	5	5
180	20	5	5	5
200	5	5	15	10
220	10	25	15	10
240	5	5	5	5
270	5	10	15	10
300	5	5	5	5
330	5	25	15	10
360	5	5	5	5
390	5	10	15	5
430	5	5	5	5
470	10	25	20	10
510	5	10	15	10
560	5	10	15	5
620	5	5	15	5
680	5	10	5	10
750	5	5	5	5
820	5	10	5	5
910	5	5	5	5
1,000	20	30	30	10
1,100	5	5	5	5
1,200	10	25	15	10
1,300	5	5	5	5
1,500	20	10	20	5
1,600	5	5	5	5
1,800	5	25	15	5
2,000	20	25	30	10
2,200	20	30	30	10
2,400	5	10	5	5
2,700	10	25	15	5
3,000	5	10	15	5
3,300	5	25	30	5
3,600	5	5	5	5
3,900	10	25	15	5
4,300	5	5	5	5
4,700	20	30	30	10
5,100	10	25	15	5
5,600	5	25	15	5
6.200	5	10	5	5
6,800	5	30	20	5

5% Resistance Values	CAB-45, ⅛ W	CAB-46, ¼ W	CAB-47, ½ W	CAB-48, 1 W
7,500	5	5	5	5
8,200	5	25	15	5
9,100	5	5	5	5
10,000	20	30	30	10
11,000	5	5	5	5
12,000	10	25	20	5
13,000	5	5	5	5
15,000	5	30	30	5
16,000	5	5	5	5
18,000	5	10	15	5
20,000	5	25	15	5
22,000	5	25	30	10
24,000	5	5	15	5
27,000	5	10	15	5
30,000	5	10	5	5
33,000	5	25	20	5
36,000	5	5	5	5
39,000	5	10	15	5
43,000	5	5	5	5
47,000	10	25	20	10
51,000	5	10	15	5
56,000	5	5	15	5
62,000	5	5	5	5
68,000	5	10	15	5
75,000	5	5	5	5
82,000	5	10	5	5
91,000	5	5	5	5
0.10 meg.	20	30	30	10
0.11 meg.	5	5	5	5
0.12 meg.	5	5	5	5
0.13 meg.	5	5	5	5
0.15 meg.	5	10	15	5
0.16 meg.	5	5	5	5
0.18 meg.	5	5	5	5
0.20 meg.	5	10	5	5
0.22 meg.	5	5	15	5
0.24 meg.	5	5	5	5
0.27 meg.	5	5	5	5
0.30 meg.	5	5	5	5
0.33 meg.	5	5	5	5

5% Resistance Values	CAB-45, ⅛ W	CAB-46, ¼ W	CAB-47, ½ W	CAB-48, 1 W
0.36 meg.	5	5	5	5
0.39 meg.	5	5	5	5
0.43 meg.	5	5	5	5
0.47 meg.	5	10	20	5
0.51 meg.	5	5	5	5
0.56 meg.	5	5	5	5
0.62 meg.	5	5	5	5
0.68 meg.	5	5	5	5
0.75 meg.	5	5	5	5
0.82 meg.	5	5	5	5
0.91 meg.	5	5	5	5
1.0 meg.	5	25	20	5
1.1 meg.	5	5	5	5
1.2 meg.	5	5	5	5
1.3 meg.	5	5	5	5
1.5 meg.	5	10	5	5
1.6 meg.	5	5	5	5
1.8 meg.	5	5	5	5
2.0 meg.	5	5	5	5
2.2 meg.	5	5	5	5
2.4 meg.	5	5	5	5
2.7 meg.	5	5	5	5
3.0 meg.	5	5	5	5
3.3 meg.	5	5	5	5
3.6 meg.	5	5	5	5
3.9 meg.	5	5	5	5
4.3 meg.	5	5	5	5
4.7 meg.	5	5	5	5
5.1 meg.	5	5	5	5
5.6 meg.	5	5	5	5
6.2 meg.	5	5	5	5
6.8 meg.	5	5	5	5
7.5 meg.	5	5	5	5
8.2 meg.	5	5	5	5
10.0 meg.	5	5	5	5
12.0 meg.	5	5	5	5
15.0 meg.	5	5	5	5
18.0 meg.	5	5	5	5
20.0 meg.	5	5	5	5
22.0 meg.	5	5	5	5

[1] ITEMS APPEARING IN BOLD PRINT ARE POPULAR VALUES AND ARE USUALLY STOCKED BY AUTHORIZED OHMITE DISTRIBUTORS.

OHMITE®

power line chokes

Catalog No.[1]	Inductance Micro-henries	Amps.	Total D.C. Ohms	Core	Weight lbs.
Z-20	14	5	0.15	4" x 9/16"	.11
Z-21	15	10	0.07	6½" x ¾"	.31
Z-22	18	20	0.045	8½" x 1⅛"	.73
*Z-30	110	20	0.085	8½" x 1⅛"	1.45

*One section is wound as a second layer over the other.
Non-magnetic brackets furnished with each choke.

Prevents high-frequency currents of radio transmitters, diathermy and therapeutic equipment from going out over the power lines and interfering with nearby radio receiving sets. They are used as filters in conjunction with two grounding capacitors of 0.1 microfarad capacity each. The Z-20 Choke is also used at radio receivers to keep out interference. All chokes consist of two, single-layer windings on a single ceramic core, insulated and protected by moisture-proof coating.

radio frequency plate chokes

This series of seven, single-layer-wound, solenoid type radio frequency plate chokes, covers the entire frequency range of 3 to 520 megacycles. The stock number corresponds to the approximate frequency at which maximum efficiency will be obtained, but the chokes may be used at any other frequencies within their operating ranges, as listed in the table.

Chokes of the four highest frequencies are wound on low power factor plastic cores while the other three units are wound on steatite tubes. Windings are insulated and protected by a moisture-proof coating. The single

Catalog No.[1]	Operating Range	Inductance Micro-henries	D.C. Res. Ohms*	Rated Current Amps	Resonant Freq. Mc	Core	Wt. Lbs.
Z-7	3 to 20 Mc.	84.0	4.70	1.00	13	6" x 9/16"	.106
Z-14	7 to 35 Mc.	44.0	2.60	0.68	23	2" x 7/16"	.026
Z-28	20 to 60 Mc.	21.0	2.70	0.60	41	1¾" x 5/16"	.011
Z-50	35 to 110 Mc.	7.0	0.98	1.00	79	1" x 7/32"	.005
Z-144	80 to 200 Mc.	1.8	0.33	1.10	168	¾" x 3/16"	.002
Z-235	160 to 350 Mc.	0.84	0.14	1.70	300	¾" x 3/16"	.002
Z-460	320 to 520 Mc.	0.20	0.034	4.00	500	½" x 5/32"	.001

Non-magnetic Brackets Furnished with Z-7.
* At 100 ma, 25°C ambient.

layer winding is designed to avoid adverse harmonic effects and also prevents breakdown from high r.f. potentials. Non-magnetic mounting brackets are furnished with the largest size, Z-7. The Z-14 and Z-28 have wire leads welded to lug type terminals; the Z-50, Z-144, Z-235 and Z-460 have axial-type wire leads.

Any one of these chokes may be selected for a particular frequency within its recommended operating range with the assurance that it will give excellent performance. Selection should be made, however, subject to the following qualification. It is generally advisable to select a choke with a resonant frequency (see chart) slightly higher than the desired operating frequency since any additional capacity to ground will tend to shift the resonant frequency closer to the operating frequency. Also, for this reason, the frequency designated by the catalog number of a choke is lower than its natural resonant frequency.

parasitic suppressor

The P-300 Suppressor is designed to prevent unwanted ultra-high-frequency parasitic oscillations which occur in the plate and grid leads of push-pull and parallel tube circuits. The P-300 is a non-inductive, 50 ohm, vitreous enameled resistor combined with a choke (in parallel) of .3 microhenries inductance and .003 ohms D.C. resistance. The two form a small integral unit only 1¾" long overall and 21/32" diameter. The unit may be mounted directly in the grid lead without extra support.

Model P-300 Wt. .04 lb.

diode metersaver protects meters

Designed to protect sensitive (high internal resistance) meters against burnout due to overload even where potential is reversed. Introduces negligible error. Consists of 2 silicon diodes in compact case with leads and lugs. Connects across meter terminals without regard for polarity. Shunts excess current around meters — for example, can convert 200 times overload to 3 times overload. Allows use of less expensive meter fuses. Can be used with meters of low internal resistance but use of series resistor is then recommended.

Catalog No. OMC7111

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.

OHMITE® vitreous enameled rheostats (potentiometers)

Now, Ohmite offers TWELVE sizes in its line of famous rheostats ranging from 7.5 to 1000 watts. Nothing to shrink or burn, all models are metal and ceramic construction and coated with Ohmite's exclusive vitreous enamel or Ohmicone® silicone ceramic. The revolutionary Model C, 7½ watt miniature unit, the smallest rheostat of its rating available, employs this same construction! All Model C stock units and the enclosed Model E unit, are normally supplied in a corrosion-resistant dust-proof case. Models C, E and H are stocked with both standard and locking shafts.

In all Ohmite rheostats, the resistance wire is wound on a solid ceramic core. The turns are locked in place with tough, protective vitreous enamel or Ohmicone® silicone ceramic. Pivoted, universal action mounting of the brush, assures perfect contact. Metal-graphite contact brushes, varied to fit current and resistance, insure good contact with negligible wear of the wire. Terminals at each end of the winding permit connection of the unit as a potentiometer.

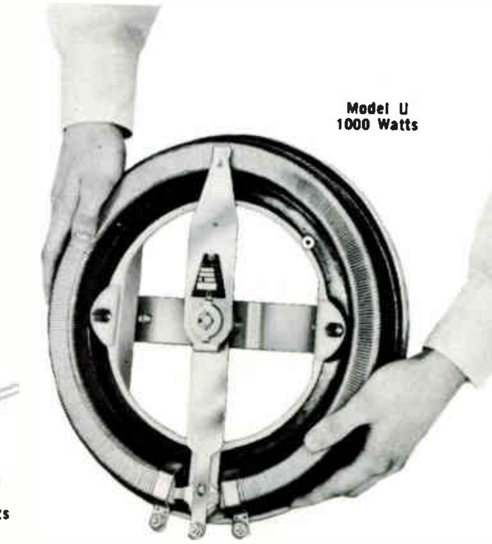
Models H, J, G, K, L, P, and N, are listed under the Underwriter's Laboratories Reexamination Service. RHEOSTAT KNOBS are listed on page 22. Rheostats can be supplied to meet military specification MIL-R-22.

RATINGS: Current ratings shown, assume use in free air. If units are enclosed, wattage should be reduced to as much as 50% depending upon ventilation. The rated current causes the rheostat to dissipate its rated wattage when its full resistance is in the circuit.

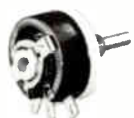
SPECIAL RHEOSTAT FEATURES: Hundreds of features to meet your special rheostat requirements can be furnished. Submit your specifications.

Model C
7½ Watts

NOW, FOR ITS RATING, INDUSTRY'S SMALLEST RHEOSTAT!



Model U
1000 Watts



Unenclosed
Model E
12½ Watts

Enclosed
Model E
12½ Watts

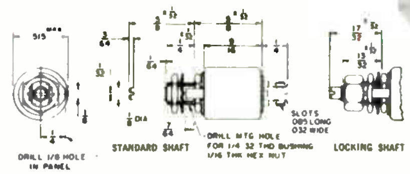
MODEL "C" — 7½ WATT* — STANDARD & LOCKING SHAFT

Diameter .515" max. — Depth behind panel ⅞" — Shaft ⅛" diameter, slotted for both types; Std. shaft accommodates knob — Rotation 300° — Mounting for panels up to ⅛" by means of ¼"-32 bushing and hex. nut — Non-turn lug requires ⅛" hole ¼" below center of shaft — No. 5151 knob recommended — Solder terminals also fit EIA type TS-E3R100 transistor socket — Wt. 0.27 oz.

Ohms	Amps	Standard Shaft Catalog No.[1]	Locking Shaft Catalog No.[1]	Ohms	Amps	Standard Shaft Catalog No.[1]	Locking Shaft Catalog No.[1]
10	.86	4908	4948	250	.17	4917	(4957)
15	.71	4909	(4949)	350	.15	4918	4958
25	.55	4910	(4950)	500	.12	4919	(4959)
35	.46	(4911)	(4951)	750	.10	(4920)	(4960)
50	.39	4912	(4952)	1000	.086	4921	4961
75	.32	(4913)	(4953)	1500	.071	(4922)	(4962)
100	.27	4914	4954	2500	.055	(4923)	4963
150	.22	(4915)	(4955)	3500	.046	(4924)	(4964)
200	.19	4916	(4956)	5000	.039	4925	4965

*Rating on metal panel — unit is silicone-ceramic coated.

Locking-type Model C mounted in socket on panel. Solder terminals fit transistor socket.

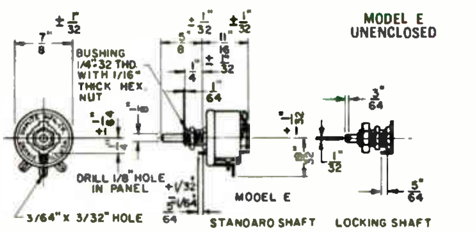


MODEL "E" — 12½ WATT* — UNENCLOSED & ENCLOSED

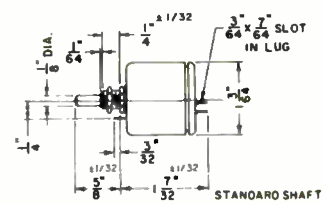
Diameter ⅞"; Diameter with dust-tight aluminum enclosure 1³⁄₆₄" — Depth behind panel ¹¹⁄₁₆"; for enclosed, 1⁷⁄₃₂" — Rotation 300° — Mounts on panels up to ⅛" by means of ¼"-32 bushing and hex nut — Non-turn lug requires ⅛" hole ¼" below center of shaft. No. 5151 knob recommended—Wt. 0.6 oz.; enclosed 0.85 oz.

Total Ohms	Max. Amps	Steps Appr.	Unenclosed Standard Shaft Cat. No.[1]	Unenclosed Locking Shaft Cat. No.[1]	Enclosed Std. Shaft Cat. No.	Total Ohms	Max. Amps	Steps Appr.	Unenclosed Standard Shaft Cat. No.[1]	Unenclosed Locking Shaft Cat. No.[1]	Enclosed Std. Shaft Cat. No.
1	3.53	32	0101	L0101	(W0101)	175	.27	146	0114	L0114	(W0114)
2	2.50	28	0102	L0102	(W0102	200	.25	132	0114A	L0114A	(W0114A)
2.5	2.24	31	(0102A)	(L0102A)	(W0102A)	250	.22	128	0115	L0115	(W0115)
3	2.04	33	0103	L0103	(W0103)	350	.19	149	0116	L0116	(W0116)
5	1.58	61	0103A	L0103A	(W0103A)	500	.16	213	0117	L0117	(W0117)
6	1.44	58	0104	L0104	(W0104)	750	.13	193	0118	L0118	(W0118)
8	1.25	61	0105	L0105	(W0105)	1,000	.11	257	0119	L0119	(W0119)
10	1.12	76	0106	L0106	(W0106)	1,500	.091	255	0120	L0120	(W0120)
15	.91	64	0107	L0107	(W0107)	2,500	.071	277	0121	L0121	(W0121)
25	.71	67	0108	L0108	(W0108)	3,500	.060	313	0122†	L0122†	(W0122)†
35	.60	73	0109	L0109	(W0109)	5,000	.050	355	0123†	L0123†	(W0123)†
50	.50	83	0110	L0110	(W0110)	7,500	.041‡	299	4190†	L4190†	(W4190)†
75	.41	101	0111	L0111	(W0111)	10,000	.035‡	398	4191†	L4191†	(W4191)†
100	.35	106	0112	L0112	(W0112)	12,500	.031‡	434	(4192)†	(L4192)†	(W4192)†
125	.32	132	0113	L0113	(W0113)	15,000	.029‡	521	4193†	L4193†	(W4193)†
150	.29	125	0113A	L0113A	(W0113A)						

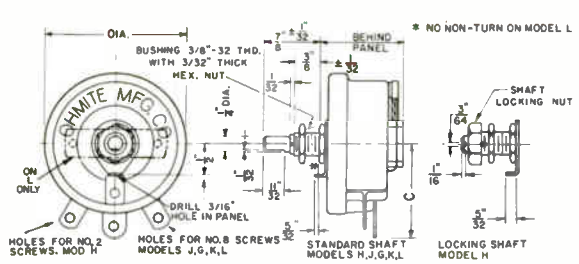
*Rating on metal panel. †Silicone-ceramic coating. ‡7.5KΩ = 305V. max; 10KΩ, 12.5KΩ, and 15KΩ = 350V. max.



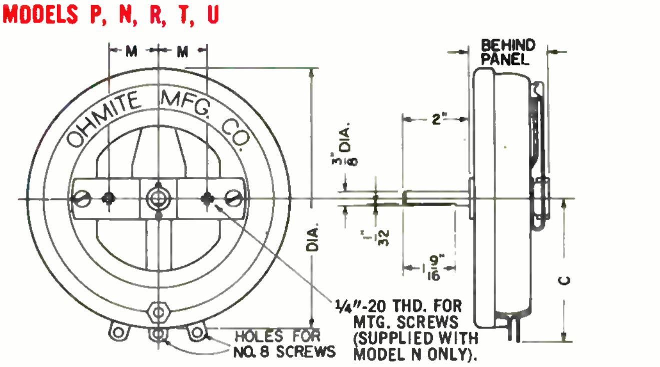
MODEL E ENCLOSED



dimensions: MODELS H, J, G, K, L*



MODELS P, N, R, T, U



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OHMITE® vitreous enameled rheostats (potentiometers)

25 WATT

MODEL "H"; UL Listed

Dia. 1 9/16" — Depth behind panel 1 3/8" — Shaft 1/4" dia. Rotation 300° — Mounts on panels up to 1/4" by means of 3/8"-32 Bushing and Hex. Nut — Non-turn lug requires 3/16" hole 1/2" below ctr. of shaft — No. 5150 knob recom. — C dimension is 15/16" — Weight 0.19 lb.

Locking Shaft	Std. Shaft	Total Ohms	Max. Amps	Steps Approx.
L0140	0140	1	5.000	30
L0141	0141	2	3.540	30
L0142	0142	3	2.880	31
L0143	0143	6	2.040	50
L0144	0144	8	1.770	53
L0145	0145	10	1.580	52
L0146	0146	15	1.290	67
L0147	0147	25	1.000	89
L0148	0148	35	.845	98
L0149	0149	50	.707	80
L0150	0150	75	.575	107
L0151	0151	100	.500	142
L0152	0152	125	.445	139
L0153	0153	175	.375	154
L0154	0154	250	.316	177
L0155	0155	350	.267	197
L0156	0156	500	.222	220
L0157	0157	750	.182	261
L0158	0158	1,000	.155	278
L0159	0159	1,500	.129	267
L0160	0160	2,500	.100	341
L0161	0161	3,500	.084	315
L0162	0162	5,000	.070	355
L4200	4200†	7,500	.058	439
L4201†	4201†	10,000	.050	476
L4202†	4202†	15,000	.041	431
L4203†	4203†	20,000	.035	422
L4204†	4204†	25,000	.032	527

† Silicone-ceramic coating, 500V max. for 10KΩ and above. Not UL listed.

50 WATT

MODEL "J"; UL Listed

Dia. 2 5/16" — Depth behind panel 1 3/8" — Shaft 1/4" dia. Rotation 300° — Mounts on panels up to 1/4" by means of 3/8"-32 Bushing and Hex. Nut — Non-turn lug requires 3/16" hole 1/2" below ctr. of shaft — No. 5150 knob recom. — C dimension is 1 1/16" — Weight 0.32 lb.

Catalog No.*	Total Ohms	Max. Amps	Steps Approx.
0308	0.5	10.000	24
0309	1	7.070	44
0310	2	5.000	43
0311	4	3.530	42
0312	6	2.880	45
0313	8	2.500	43
0314	12	2.040	86
0315	16	1.760	91
0316	22	1.500	100
0317	35	1.190	125
0318	50	1.000	112
0319	80	.790	143
0320	125	.630	176
0321	150	.575	170
0322	225	.470	199
0323	300	.408	211
0324	500	.316	284
0325	800	.250	282
0326	1,000	.224	352
0327	1,600	.176	355
0328	2,500	.141	449
0329	3,500	.119	496
0330	5,000	.100	459
0331	8,000	.079	576
0332	10,000	.070	565
4210†	15,000	.058	568
4211†	20,000	.050	599
4212†	25,000	.045	573
4213†	30,000	.041	688
(4214†)	40,000	.035	673
4215†	50,000	.032	842

† Silicone-ceramic coating. 750V max. for 15KΩ and above. Not UL listed.

75 WATT

MODEL "G"; UL Listed

Dia. 2 3/4" — Depth behind panel 1 3/4" — Shaft 1/4" dia. Rotation 300° — Mounts on panels up to 1/4" by means of 3/8"-32 Bushing and Hex. Nut — Non-turn lug requires 3/16" hole 1/2" below ctr. of shaft — No. 5150 knob recom. — C dimension is 1 23/32" — Weight 0.52 lb.

Catalog No.*	Total Ohms	Max. Amps	Steps Approx.
1100	0.5	12.300	27
(1101)	1	8.660	27
1102	2	6.120	30
1103	3	5.000	28
1104	5	3.880	53
1105	7.5	3.160	50
1106	10	2.740	53
1107	16	2.170	91
1108	25	1.730	113
1109	50	1.230	142
1110	75	1.000	134
1111	100	.866	178
1112	200	.612	180
1113	300	.500	211
1114	400	.433	223
1115	500	.388	279
(1116)	750	.316	338
1117	1,000	.274	356
(1118)	1,500	.224	420
1119	2,000	.194	443
(1120)	2,500	.173	441
(1121)	5,000	.123	564
(1122)	7,500	.100	547
1123	10,000	.087	572

100 WATT

MODEL "K"; UL Listed

Dia. 3 1/8" — Depth behind panel 1 3/4" — Shaft 1/4" dia. Rotation 300° — Mounts on panels up to 1/4" by means of 3/8"-32 Bushing and Hex. Nut — Non-turn lug requires 3/16" hole 1/2" below ctr. of shaft — No. 5150 knob recom. — C dimension is 1 29/32" — Weight 0.64 lb.

Catalog No.*	Total Ohms	Max. Amps	Steps Approx.
0440	0.5	14.100	33
0441	1	10.000	33
0442	2	7.070	32
0443	3	5.750	39
0444	5	4.470	57
0445	7.5	3.650	60
0446	10	3.160	57
0447	16	2.500	88
0448	25	2.000	109
0449	50	1.410	137
0450	75	1.150	163
0451	100	1.000	172
0452	200	.707	216
0453	300	.575	261
0454	400	.500	272
0455	500	.447	269
0456	750	.365	326
0457	1,000	.316	343
0458	1,500	.258	404
0459	2,000	.224	426
0460	2,500	.200	426
0461	5,000	.141	543
0462	7,500	.115	528
0463	10,000	.100	704

150 WATT

MODEL "L"; UL Listed

Dia. 4" — Depth behind panel 2" — Shaft 1/4" diameter. Rotation 300° — Mounting for panels up to 1/4", 3/8"-32 Bushing and Hex. Nut or two 10-32 flat head screws, mounting centers 7/8" each side of center of shaft on line perpendicular to center terminal. — Stock No. 5150 knob recom. — C dimension is 2 3/32" — Weight 1.1 lbs.

Catalog No.*	Total Ohms	Max. Amps	Steps Approx.
0524	0.5	17.300	29
0525	1	12.300	41
0526	2	8.650	40
0527	3	7.070	42
0528	5	5.480	44
0529	7.5	4.470	75
0530	10	3.880	79
0531	15	3.163	75
0532	25	2.450	120
0533	35	2.070	133
0534	50	1.735	151
0535	75	1.415	179
0536	100	1.225	190
0537	150	1.000	225
0538	200	.865	239
0539	250	.775	236
0540	350	.655	265
0541	500	.548	296
0542	750	.447	352
0543	1,250	.346	473
0544	1,800	.288	537
0545	2,250	.259	529
0546	3,000	.224	558
0547	4,500	.182	667
0548	7,500	.141	714
0549	10,000	.122	952

225 WATT

MODEL "P"; UL Listed

Dia. 5" — Depth behind panel 2 1/8" — Shaft 3/8" dia. Rotation 310° — Mounting for panels up to 1 1/4" by two 1/4"-20 screws, mounting centers (M) 7/8" each side of center of shaft on center line of cross-bar. — Stock No. 5105 Knob Recommended — C dimension is 2 31/32" — Weight 2 lbs.

Catalog No.*	Total Ohms	Max. Amps	Steps Approx.
(1250)	1.0	15.000	42
1251	2.0	10.600	41
1252	3.0	8.660	61
(1253)	4.0	7.500	58
1254	5.0	6.710	57
(1255)	7.5	5.490	60
1256	10.0	4.740	115
1257	15.0	3.870	108
1258	25.0	3.000	114
1259	50.0	2.120	218
1260	75.0	1.730	206
1261	100	1.500	275
1262	150	1.220	259
1263	200	1.060	345
1264	300	.866	326
1265	400	.750	342
1266	700	.567	483
1267	900	.500	484
1268	1,200	.433	513
1269	1,500	.387	641
(1270)	1,750	.358	603
(1270A)	2,000	.336	690
1271	2,500	.300	679

300 WATT

MODEL "N"; UL Listed

Dia. 6" — Depth behind panel 2 3/8" — Shaft 3/8" dia. Rotation 320° — Mounting for panels up to 1 1/4" by two 1/4"-20 screws, (supplied) mounting centers (M) 1 3/16" each side of center of shaft on center line of cross-bar. — Stock No. 5105 Knob Recommended — C dimension is 3 7/16" Weight — 2.6 lbs.

Catalog No.*	Total Ohms	Max. Amps	Steps Approx.
0650	1.0	17.320	56
0651	2.0	12.240	51
0652	3.0	10.000	51
0653	4.0	8.660	77
0654	5.0	7.750	76
0655	7.5	6.320	72
0656	10.0	5.480	76
0657	15.0	4.470	144
0658	25.0	3.460	134
0659	50.0	2.450	230
0660	75.0	2.000	275
0661	100	1.730	288
0662	150	1.410	345
0663	200	1.220	364
0664	300	1.000	433
0665	400	.866	456
0666	700	.655	500
0667	900	.578	517
0668	1,200	.500	541
0669	1,500	.447	676
(0670)	1,750	.414	625
(0670A)	2,000	.387	714
0671	2,500	.346	720

500 WATT

MODEL "R"

Dia. 8" — Depth behind panel 2 1/8" — Shaft 3/8" dia. Rotation 325° — Mounting for panels up to 1 1/4" by two 1/4"-20 screws, mounting centers (M) 1 1/2" each side of center of shaft on center line of cross-bar. — Stock No. 5105 Knob Recommended — C dimension is 4 5/16" — Weight 4 lbs.

Catalog No.*	Total Ohms	Max. Amps	Steps Approx.
0849	1.0	22.300	56
0850	1.5	18.200	71
(0851)	2.0	15.800	75
(0852)	2.5	14.100	78
0853	3.0	12.900	79
0854	4.0	11.200	74
0855	5.0	10.000	104
0856	8.0	7.900	104
0857	12.5	6.300	115
0858	16.0	5.600	186
0859	25.0	4.470	205
0860	40.0	3.540	206
0872	50.0	3.160	205
0861	80.0	2.520	316
0862	125	2.000	388
0863	175	1.690	434
0864	250	1.410	490
0865	325	1.240	505
0866	500	1.000	614
0867	750	.817	735
0868	1,000	.707	769
0869	1,500	.577	932
(0870)	2,000	.500	971
0871	2,500	.447	962

750 WATT

MODEL "T"

Dia. 10" — Depth behind panel 3" — Shaft 3/8" dia. Rotation 330° — Mounting for panels up to 1 1/4" by two 1/4"-20 screws, mounting centers (M) 1 7/8" each side of center of shaft on center line of cross-bar. — Stock No. 5105 Knob Recommended — is 5 5/16" — Weight 7.6 lbs.

Catalog No.*	Total Ohms	Max. Amps	Steps Approx.
1300	1.0	27.400	72
(1301)	1.5	22.300	72
(1302)	2.0	19.400	96
(1303)	2.5	17.300	101
(1304)	3.0	15.800	96
(1305)	4.0	13.600	94
1306	5.0	12.200	104
1307	8.0	9.650	100
(1308)	10.0	8.650	139
(1309)	12.5	7.750	138
1310	16.0	6.820	139
1311	25.0	5.470	137
1312	50.0	3.870	246
(1313)	80.0	3.060	381
1314	100	2.740	376
1315	160	2.170	476
1316	200	1.940	469
1317	300	1.580	562
1318	400	1.370	593
1319	600	1.117	705
1320	750	1.000	694
1321	1,200	.791	889
(1322)	1,800	.646	1,050
(1322A)	2,000	.610	935
(1323)	2,500	.547	1,170

1000 WATT

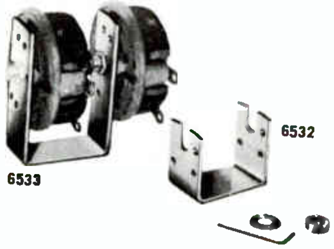
MODEL "U"

Dia. 12" — Depth behind panel 3" — Shaft 3/8" dia. Rotation 335° — Mounting for panels up to 1 1/4" by two 1/4"-20 screws, mounting centers (M) 3" each side of center of shaft on center line of cross-bar. — Stock No. 5105 Knob Recommended — C dimension is 6 3/8" — Weight 10 lbs.

Catalog No.*	Total Ohms	Max. Amps	Steps Approx.
1450	1.0	31.600	91
1451	1.5	25.800	90
1452	2.0	22.400	90
1453	2.5	20.000	127
1454	3.0	18.300	114
1455	4.0	15.800	120
1456	5.0	14.100	124
1457	8.0	11.200	118
1458	10.0	10.000	117
(1459)	12.5	8.950	163
1460	16.0	7.900	166
1461	25.0	6.330	162
1462	50.0	4.470	327
1463	75.0	3.650	307
1464	100	3.160	446
1465	175	2.390	490
1466	225	2.110	630
1467	300	1.830	661
1468	400	1.580	704
1469	500	1.410	695
1470	750	1.150	828
1471	1,000	1.000	870
1472	1,500	.816	1,040
1473	2,500	.633	1,100

* Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.

OHMITE® rheostat tandem coupling kits



Tandem rheostat assemblies can be ordered from the factory or assembled by the user with these kits which permit assembly of two units. Each kit consists of a steel "U" frame, a coupling with set screw, mica washer, Allen wrench and instructions.

Rheostat shafts are joined by the coupling which is fastened to the shaft of the rear unit. Projections on the coupling fit a recess on the rear of the hub of the front unit.

Three kits are available as follows:

Cat. No. 6532—Mounts Models H or J in either front or rear position. Models G, K or L in rear position when panel-mounted.

Cat. No. 6533—Mounts G, K or L units, also accommodates Models H, J, G, K or L in rear position.

Cat. No. 6591—Mounts Model E units only.

Catalog No.	Max. Panel	Weight
6532	5/32"*	.17 lb.
6533	1/8"*	.41
6591	1/16"	.044

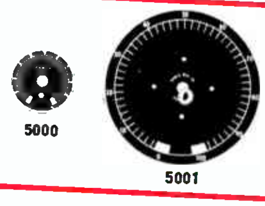
*Using No. 5150 Knob.

black bakelite knobs

Catalog No.[1] Standard	Catalog No.[1] Hex-Socket	Description	Knob Dia.	Hole Dia.
5102		Bar Knob, 2¼" long		¼"
5103	5103A	Bar Knob, 1¼" long		¼"
5104	5104A	Handwheel with Pointer	3¼"	⅜"
5105		Handwheel without Pointer	3¼"	⅜"
5106	5106A	Handwheel with Pointer	3¼"	¼"
5107		Handwheel without Pointer	3¼"	¼"
5109	5109A	Finger-Grip with Pointer	1⅝"	¼"
5110	5110A	Finger-Grip without Pointer	1⅝"	¼"
5111	5111A	Finger-Grip with Pointer	2⅜"	¼"
5112	5112A	Finger-Grip without Pointer	2⅜"	¼"
*5115		Bar Knob, 4¾" long		¼"
5116	5116A	Bar Knob, 1½" long		⅜"
5150	5150A	Finger-Grip	1½"	¼"
5151		Finger-Grip	¾"	⅛"
5152A		Like 5104 but shorter pointer	3¼"	¼"

* Requires pin and tapped hole in shaft. Standard knobs have slotted set-screw(s); knobs ordered with "A" suffix have hex socket set-screw(s).

rheostat dials



Cat. No.	For Rheostat	Dial Dia.	Recom'd. Knobs*
5007	C, E	1¼"	5151
5000	H, J, G, K, L	2⅞"	5150, 5116, 5103
5001	P, N, R, T, U	5½"	5104, 5106

*See Bakelite Knobs above

Handsomely finished dials for Ohmite rheostats and other apparatus, feature bright figures and lines on etched black background. Divisions marked from 0 to 100 indicate approximate percentage of rheostat resistance in circuit.

heat control rheostats

A convenient control for regulating the temperature of soldering irons, melting pots (such as those used for solder, wax, potting material) or other heater loads. With soldering irons, it permits quick adjustment of operating heat for the type of job and grade of solder.

Consists of vitreous enameled rheostat housed in a perforated metal cage, with knob and dial. Supplied with series plug and six feet of heater type cord. The cord from the heater load is plugged into the series plug which is then plugged into a receptacle. Order in accordance with expected maximum wattage load.

Rating of Device To Be Controlled: Watts	Volts	Rheostat Control Catalog No.	Cage Dimensions: Dia.	Height	Net Weight lbs.
40—65	115	(SRC65)	3⅛"	2"	.58
85—100	115	SRC100	3⅛"	2"	.58
120—150	115	(SRC150)	3¾"	2⅜"	.93
175—220	115	(SRC220)	3¾"	2⅜"	1.05
300—350	115	(SRC350)	4½"	2⅜"	1.63
430—500	115	(SRC500)	7½"	3¼"	2.25

T-pad and L-pad attenuators

Stepless control of speaker volume with essentially constant impedance is provided by Ohmite attenuators. In use, these units are interposed between high power amplifiers and speaker or speakers.

Housed in gray, perforated metal cage 3⅛" high, 2⅝" wide and extending 4¼" behind panel for L-pads; 6¼" for T-pads. Shaft ¼" and bushing ⅜" diameter; bushing length is for ¼" maximum panel (specify greater thicknesses). Mounted with two 10/32 screws (supplied) on 2⅝" vertical centers.

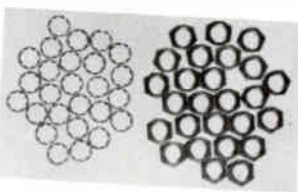
Line Impedance In Ohms	T-Pads: 25 WATTS Avg. Wt. 1.44 lbs. Cat. No.	T-Pads: 50 WATTS Avg. Wt. 1.88 lbs. Cat. No.	L-Pads: 25 WATTS Avg. Wt. 1 lb. Cat. No.	L-Pads: 50 WATTS Avg. Wt. 1.25 lbs. Cat. No.
15	(3001)	(3101)	(3201)	(3301)
20	(3002)	(3102)	(3202)	(3302)
200	(3003)	(3103)	(3203)	(3303)
500	(3004)	(3104)	(3204)	(3304)

rheostat repair kits

For replacing contact. Kits include contact/slip ring assemblies for round and ribbon wire rheostats, copper graphite washer, spring arm and hub. Instructions included.

For Model	P	N	R	T	U
Catalog No.	7070	7071	7072	7073	7074

extra mounting hardware



Handy kit of 25 nuts and lock washers for panel mounting rheostats, tap switches and variable transformers. Nuts are nickel plated brass.

Used for	Cat. No.
E Rheostat	Cat. No. 7090
H, J, G, K, L Rheostat 111, 212, 711 Tap Switch VT1, VT2, VTO2, VT3, Var. Trans	Cat. No. 7091

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OHMITE® OHMITROL solid state power and motor speed controls

FEATURES
- CONSERVES SPACE & POWER
- SMALLEST 1 & 2 KW CONTROL
- AC & DC OUTPUT TYPES
- BUILT-IN ON-OFF SWITCH
- ADJUSTABLE CONTROL RANGE
- CHOICE OF COMPONENT & PORTABLE STYLES
- LONG LIFE

USE IT TO CONTROL

POWER
MODEL PCA: AC Output

Shaded pole motors
Permanent split capacitor motors
Universal motors
Heaters—both resistive and infra-red

MOTOR SPEED
MODEL PCD: DC Output

Shunt wound motors
Series wound motors
Permanent magnet motors
Magnetic clutches and brakes

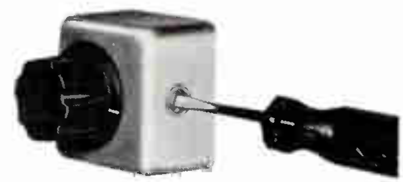
Now, for the first time, a Solid State Power Control is available which is adaptable to a wide variety of applications by a simple turn of a screwdriver!
An internal trimmer allows the starting point of the control voltage of the Ohmitrol to be set anywhere within the stated trimmer voltage range. (This adjustment can be preset at the factory at small additional cost).
From the starting point to full line voltage, infinitely smooth control is obtained by means of the control knob. An "on-off" line switch actuated at the counterclockwise end of the control knob rotator is provided on all models.
Ohmite solid state power controls are the smallest 1 or 2 KW controls available and offer the advantages not only of convenient size, but also of power savings, long life and low initial cost.
Two styles are available: the component style for panel mounting in equipment, and the lightweight, self-contained portable style. Portable units are completely self contained with grounded line cord and standard grounded AC receptacle.
Ohmitrol Controls are available with AC output and with two DC output delivered simultaneously. One output is rectified DC, at approximately full line voltage; the other is the variable or controlled DC. This double output is useful, for example, for controlling shunt wound motors. Terminals at the rear of the controls accept quick-connectors.

Component Style*
PCA series

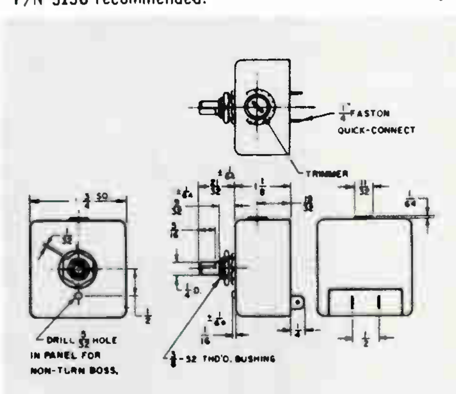
* Knob not included. Ohmite P/N 5150 recommended.

Component Style
PCD series

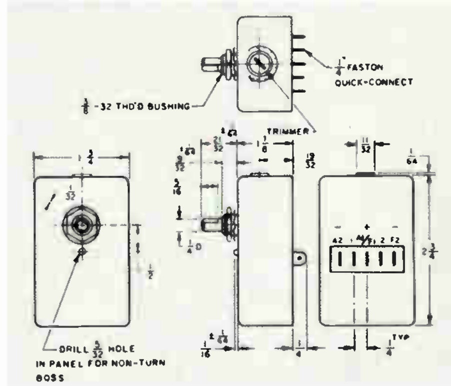
Portable Style
PCA and PCD series



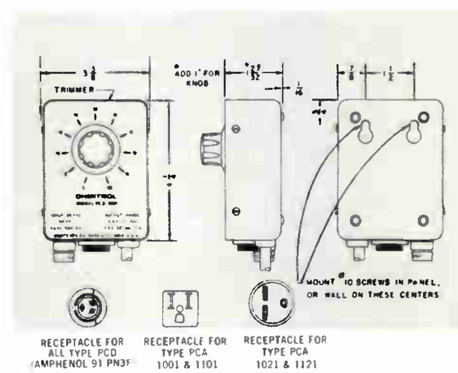
Adjustment of the integral trimmer sets the starting point of the control voltage within the stated trimmer voltage adjust range.



Model PCA-Component Style



Model PCD-Component Style



Models PCA and PCD-Portable

Catalog No. Component Style	Catalog No. Portable Style	Input Volts	Freq.	Output Range (Nominal)	Load Capacity Rating (Maximum)	Trimmer Range (Minimum)
PCA-1000	PCA-1001	120 VAC	60 Hz	0-120 VAC	1 KW, 8.3 Amps AC	0-50 Volts
PCA-1050	—				15 Amps AC	
PCA-1100	PCA-1101		50 Hz		1 KW, 8.3 Amps AC	
PCA-1020	PCA-1021	240 VAC	60 Hz	0-240 VAC	2 KW, 8.3 Amps AC	0-100 Volts
PCA-1120	PCA-1121		50 Hz			
PCD-1000	PCD-1001	120 VAC	60 Hz	0-120 VDC and Full 120 VDC	6.0 Amp DC — Resistive 3.5 Amp DC — Motor Load	10-50 Volts
PCD-1100	PCD-1101		50 Hz			
PCD-1020	PCD-1021	240 VAC	60 Hz	0-240 VDC and Full 240 VDC		20-100 Volts
PCD-1120	PCD-1121		50 Hz			

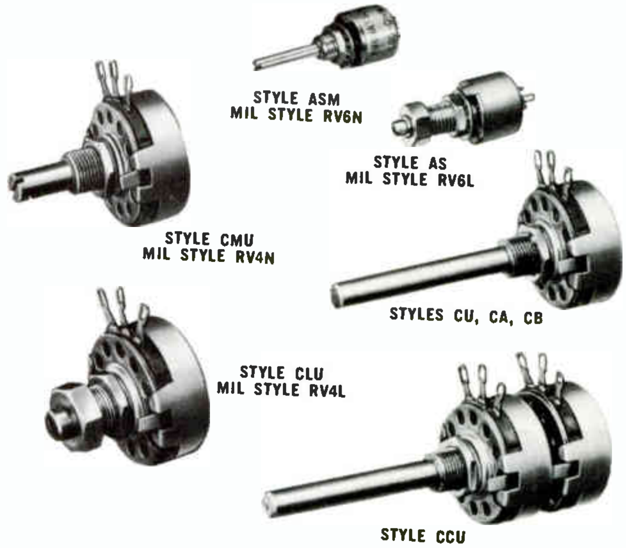
Note: Controls are available for voltages to 480 VAC and currents to 40 A in both single and three-phase configurations. Consult the factory for details.

OHMITE® molded composition potentiometers

Ohmite molded composition potentiometers are used in commercial and military electronic applications where high quality and dependable performance are important. Type AB is rated 2 watts at 70°C ambient and is available with ⅞" slotted shaft (CMU), 2" unslotted shaft (CU, CA, CB, CCU) and locking type bushing with slotted shaft (CLU). Type AS is a miniature unit rated ½ watt. It is available with locking type bushing and slotted shaft (Style AS) and standard bushing with longer (slotted) shaft for knob control (Style ASM).

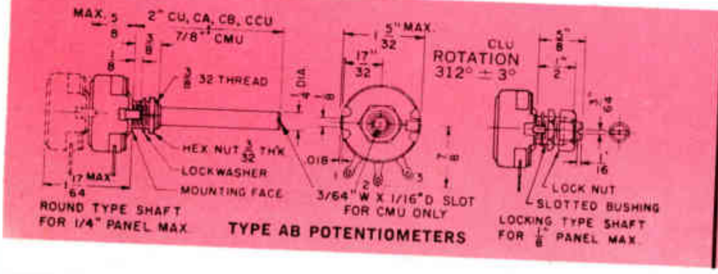
Because the resistance element is a thick, solid-molded ring — not a sprayed film or paint-type resistor — longer life and smoother operation are obtained. This is due also to the molded composition contact. Units are dust and splash proof, fungus and corrosion resistant and meet the requirements of military specification MIL-R-94. Styles CMU, CLU, AS and ASM conform respectively to MIL-R-94, Styles RV4N, RV4L, RV6L and RV6N.

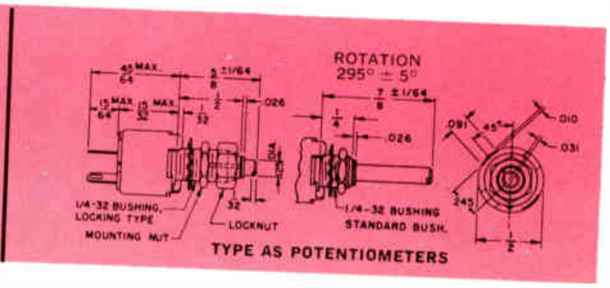
Styles and tapers are listed in table. Dimensions of all stock units are shown below.



STOCK "POTS"— MIL Units are stamped with MIL and Commercial Designations.

Resistance Ohms Except As Noted Tol. ±10% except * ±20%	TYPE AB (1$\frac{5}{32}$" Dia.) Rated 2 Watts[1] — Single Unit ⅞" Shaft: Style CMU Linear	MIL Designation (Cat. No. Prefix RV4N-AYSD-)	Single Unit 2" Shaft: Style CU Linear	Style CA CW log	Style CB CCW log	Locking: Style CLU Linear	MIL Designation (Cat. No. Prefix RV4L-AYSA-)	Dual: Style CCU Linear (Resistance Shown is for Each Unit)	TYPE AS (½" Dia.) Rated ½ Watt[1] — Miniature Locking: Style AS Linear	MIL Designation (Cat. No. Prefix RV6L-AYSA-)	Miniature ⅞" Shaft: Style ASM Linear	MIL Designation (Cat. No. Prefix RV6N-AYSD-)
50	**CMU5001**	500A	**CU5001**			**CLU5001**	500A					
100	**CMU1011**	101A	**CU1011**			**CLU1011**	101A		**AS3601**	101A	ASM6661	101A
150	CMU1511	151A	CU1511			CLU1511	151A					
250	**CMU2511**	251A	**CU2511**			**CLU2511**	251A		AS3602	251A	ASM6662	251A
350	CMU3511	351A	CU3511			CLU3511	351A					
500	**CMU5011**	501A	**CU5011**			**CLU5011**	501A		**AS3603**	501A	**ASM6663**	501A
750	CMU7511	751A	CU7511			CLU7511	751A					
1,000	**CMU1021**	102A	**CU1021**			**CLU1021**	102A		**AS3604**	102A	**ASM6664**	102A
1,500	CMU1521	152A	**CU1521**			**CLU1521**	152A					
2,500	**CMU2521**	252A	**CU2521**			**CLU2521**	252A		**AS3605**	252A	**ASM6665**	252A
3,500	CMU3521	352A	CU3521			CLU3521	352A					
5,000	**CMU5021**	502A	**CU5021**			**CLU5021**	502A		**AS3606**	502A	**ASM6666**	502A
7,500	CMU7521	752A	CU7521			CLU7521	752A					
10,000	**CMU1031**	103A	**CU1031**		CB1031	**CLU1031**	103A	**CCU1031**	**AS3607**	103A	**ASM6667**	103A
15,000	**CMU1531**	153A	CU1531			CLU1531	153A					
25,000	**CMU2531**	253A	**CU2531**		CB2531	**CLU2531**	253A	**CCU2531**	**AS3608**	253A	ASM6668	253A
35,000	CMU3531	353A	CU3531			CLU3531	353A					
50,000	**CMU5031**	503A	**CU5031**		**CB5031**	**CLU5031**	503A	**CCU5031**	**AS3609**	503A	**ASM6669**	503A
75,000	CMU7531	753A	**CU7531**			CLU7531	753A					
.1 meg.	**CMU1041**	104A	**CU1041**	**CA1041**		**CLU1041**	104A	**CCU1041**	**AS3610**	104A	ASM6670	104A
.15 meg.	CMU1541	154A	**CU1541**			CLU1541	154A					
.25 meg.	**CMU2541**	254A	**CU2541**	**CA2541**		**CLU2541**	254A	CCU2541	**AS3611**	254A	ASM6671	254A
.35 meg.	CMU3541	354A	CU3541			CLU3541	354A					
.5 meg.	**CMU5041**	504A	**CU5041**	**CA5041**		**CLU5041**	504A	CCU5041	AS3612	504A	ASM6672	504A
.75 meg.*	CMU7542	754B	CU7542			CLU7542	754B					
1.0 meg.*	**CMU1052**	105B	**CU1052**	**CA1052**		**CLU1052**	105B	CCU1052	AS3613	105B	ASM6673	105B
1.5 meg.*	CMU1552	155B	CU1552			CLU1552	155B					
2.0 meg.*	CMU2052	205B	CU2052			CLU2052	205B		AS3684	205B	ASM6674	205B
2.5 meg.*	CMU2552	255B	**CU2552**	CA2552		CLU2552	255B		AS3614	255B	ASM6675	255B
3.5 meg.*	CMU3552	355B	CU3552			CLU3552	355B					
5.0 meg.*	CMU5052	505B	CU5052			CLU5052	505B		AS3615	505B	ASM6676	505B
Weight	.064 lb.		.084 lb.			.070 lb.		.123 lb.	.017 lb.		.017 lb.	





[1] Items appearing in BOLD print are popular values and are usually stocked by authorized OHMITE distributors. Items appearing in LIGHT FACE print are available from stocking distributors but normally are not stocked in depth.

OHMITE® Resistance Trimmers

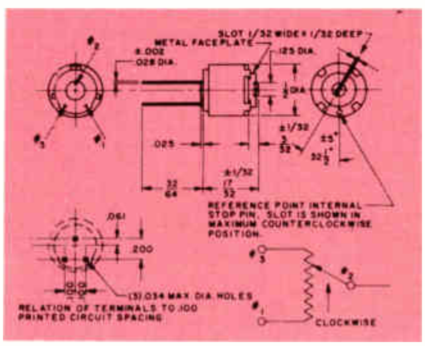
hot molded single-turn trimmers

TYPE AFR
SINGLE TURN

OHMITE type AFR Trimmers are single-turn controls built to withstand severe environmental conditions. Their unique design includes a hot-molded resistor track bridged by a single moving molded contact brush. Resistance material, collector track material, insulation material and metal terminals are all molded together at one time into a single, solid, integral structure. There are no cracks or crevices to admit moisture.

Enclosure of the Ohmite type AFR is non-magnetic, corrosion resistant, and splash-proof. Type AFR Trimmers are designed for screwdriver adjustment. Fixed stops withstand a maximum shaft torque of 2 inch-pounds.

In excess of 50,000 operational cycles with low "noise" level initially — decreasing with use — can be expected in conventional applications.



CHARACTERISTICS

Power Rating: ¼ watt @ +70°C ambient temperature. Derate power linearly to zero at +120°C ambient for resistance values to 0.5 megohms. Additional derating required for resistance values over 0.1 megohms at ambients higher than 70°C.

Resistance Range: 100 ohms to 5.0 megohms. Resistance change is nominally linear with shaft rotation.

Tolerance: ±20% standard.

Temperature Range: −55°C to +120°C.

Working Voltage: 350 volts ,RMS, maximum.

Dielectric Strength: 750 VAC, RMS, at sea level.

Adjustment: Single turn, 295 ±5°.

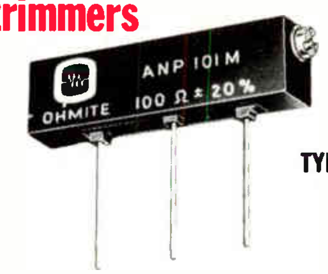
Torque: 0.25 to 3.0 inch-ounces.

Leads: Designed for mounting directly on printed wiring boards using the terminal leads which are spaced to fit the 0.1" printed wiring board standard spacing.

TYPE AFR TRIMMERS

Ohms ±20%	Catalog Number	Ohms ±20%	Catalog Number
100	AFR-101M	25,000	AFR-253M
250	AFR-251M	50,000	AFR-503M
500	AFR-501M	.1 meg	AFR-104M
1,000	AFR-102M	.25 meg	AFR-254M
2,500	AFR-252M	.5 meg	AFR-504M
5,000	AFR-502M	1.0 meg	AFR-105M
10,000	AFR-103M	2.5 meg	AFR-255M
		5.0 meg	AFR-505M

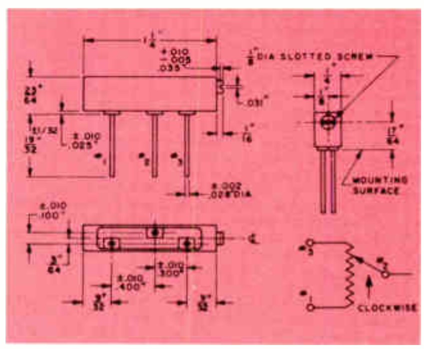
Cermet 25-turn trimmers



TYPE ANP

Ohmite type ANP Cermet Trimmers are continuously adjustable variable resistors intended primarily for trimmer applications. Designed for use on printed circuit boards, these dependable three-terminal devices can be applied as either rheostats or potentiometers with equally satisfactory results. They are stepless and relatively non-inductive regardless of resistance value and have unexcelled stability of setting in normal environmental conditions.

The type ANP Trimmer features a low resistance collector track and terminal pins — all combined into a single, solid, integral structure. It is splash-proof, dust-tight and can be mounted by its own rugged terminals.



CHARACTERISTICS

Power Rating: ⅓ watt @ 50°C ambient temperature. Derate power linearly to zero at 100°C.

Resistance Range: 100 ohms to 0.1 megohms. Resistance change is nominally linear with shaft rotation.

Tolerance: Standard resistance tolerance is ±20%.

Temperature Range: −55°C to +100°C.

Working Voltage: 350 volts RMS, maximum at sea level.

Dielectric Strength: 700 volts RMS maximum, at sea level.

Insulation Resistance: 1000 megohms minimum.

Adjustment: 25 ±3 turns for continuous resistance change. Mechanical release at end positions. Turning torque is 0.10 to 8 inches-ounce. Slotted for screwdriver adjustment.

Leads: Pin type terminals, spaced in accordance with 0.1" printed wiring board grid system.

TYPE ANP TRIMMERS

Ohms ±20%	Catalog Number	Ohms ±20%	Catalog Number
100	ANP-101M	5,000	ANP-502M
250	ANP-251M	10,000	ANP-103M
500	ANP-501M	25,000	ANP-253M
1,000	ANP-102M	50,000	ANP-503M
2,500	ANP-252M	.1 meg	ANP-104M

Ohmitrim™ wirewound trimmers

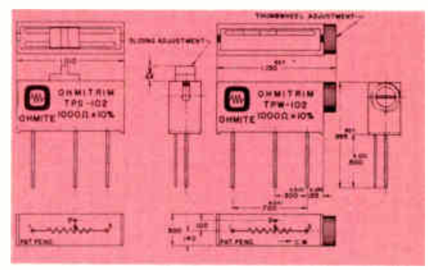
TPW and TPS series, Ohmitrim™ wirewound trimmers have a nominal 1 watt rating and are offered in resistance values ranging from 10 to 20K ohms. Leads are printed circuit type, spaced for standard 0.1 inch matrix hole pattern. They are available in screwdriver / thumbwheel (TPW series) and slider (TPS series) actuator styles.

Model TPW is lead-screw operated (approximately 35 turns) and provides clutching action at either end of the winding. Trimming is accomplished by either screwdriver or hand via a thumbwheel.

Model TPS is slide operated. It permits fast approximate placement of the slide actuator to a predetermined position and subsequent fine adjustment by an additional small movement. This model is especially useful where a number of trimmers, stacked side by side, can be quickly positioned to their approximate location by using a single template.

Both models are of a new "open" design and are not "sealed." A number of openings in the enclosure permit cleaning solvents to enter and readily leave. Thorough testing has assured that when the cleaning process is properly performed in a vapor degreaser, there is no danger of contamination of either the winding or the contact.

Both models meet the requirements outlined in EIA Standard RS-345 "Resistors, Variable, Wirewound" for characteristic "A." They both have the exact lead spacing of style CRT 11 of the EIA Standard. While they deviate slightly in dimensions, both models conform closest in this respect to style CRT 11.



FEATURES

Ohmitrim™ trimmers offer four features, especially important in view of their economical price:

1. **Gold plated** leads for excellent solderability.
2. **Gold plated** contact for excellent oxidation-free long life service.
3. Resistance wire is welded to leads for noiseless connection.
4. Choice of thumbwheel or slider for easy adjustment without tools.

CHARACTERISTICS

Temperature Rating: 40°C maximum ambient. (For full wattage rating.)
Power Rating: 1 watt.
Resistance Tolerance: ±10%.
Temperature Coefficient: 0 ±.010% per °C.
Dielectric Strength: 500 Volts AC.
Insulation Resistance: 100 megohms.
Torque: 0.1 to 0.8 oz.-inches.
End Resistance: 2% maximum.
Number of Turns: 35, approximately.
Leads: Gold Plated, 0.1 grid spacing.
Contacts: Gold Plated.
For △ R = ±10%: Thermal Shock: −55 to ±85°C.
Rotational Life: 200 cycles.
Electrical Life: 1000 hours.

TYPES TPW AND TPS TRIMMERS

Ohms ±10%	Catalog Number	
	Thumbwheel Type	Slide Type
10	TPW-100	TPS-100
20	TPW-200	TPS-200
50	TPW-500	TPS-500
100	TPW-101	TPS-101
200	TPW-201	TPS-201
500	TPW-501	TPS-501
1,000	TPW-102	TPS-102
2,000	TPW-202	TPS-202
5,000	TPW-502	TPS-502
10K	TPW-103	TPS-103
20K	(TPW-203)	(TPS-203)

OHMITE® power tap switches, high current, non-shorting type

Introducing

MODEL 711
Smallest Switch for Its Rating
7 Amps, 125 Volts

Ohmite single pole, rotary, multi-position switches have proven their durability over many years in demanding applications. Such applications are found in switchboards, arc welders, spot welders, battery chargers, motor controls, tapped transformers, X-ray equipment, diathermy equipment, radio transmitters, electrical machine tools and many other products. Six sizes, including the new, miniature Model 711, provide a choice of ratings from 7 amperes at 125 volts to 100 amperes at 300 volts AC. A choice of the number of taps is provided up to the maximums indicated. All switches are enclosed except for the Models 711 and 111. All switches feature the slow-break, quick-make action deemed so desirable for switching of AC current.

The five sizes offering ratings from 15 amperes to 100 amperes (Models 111, 212, 312, 412 and 608) feature all ceramic, arc-proof bodies and solid silver alloy, fixed and movable contacts. The large, thick, silver-alloy fixed contact disks are permanently welded to copper studs. These, in turn, are riveted and soldered to sturdy terminal lugs, assuring a permanent mechanical and electrical joint. The rotor (moving) contact, also of solid silver-alloy, is riveted and soldered to the contact arm. Face of the rotor contact is slightly rounded assuring a perfect seating of the contacts with a slight rubbing, self-cleaning motion on every operation.

The new Model 711 tap switch was designed to achieve high current capability with small size. It is actually smaller than many low current instrument switches. It interrupts 7 amperes at 125 VAC and can carry 15 amperes AC or DC. The Model 711 features a melamine phenolic body with solid silver alloy fixed and movable contacts. Dual-purpose terminals allow connection by soldering or by means of 3⁄16" quick-connectors. This switch is stocked as a single, unenclosed unit, but is available made-to-order in enclosed tandem assemblies up to 10 units or as a single enclosed unit.

The following Ohmite Tap Switches are listed by the Underwriters' Laboratories, Inc., Reexamination Service for use where the acceptability of combination (with other apparatus) has been determined by them: Models 111, 212, 312 and 412. Variations from the basic switch design, identified by suffixes A, B, C, or X are also Underwriters' approved. When the switches are not factory installed, screw terminals are specified by the Underwriters' Laboratories for Model 312 and soldering lugs for Model 412. Further information on terminal fittings is available on request. When an Underwriters' approved unit is required, specify this on the order.

MODEL 711 TAP SWITCH

Alternating Current Rating 7 Amps. 125 Volts — Diameter 1⅛" — Shaft Diameter ¼" — Standard Mounting: For ⅛" panel maximum, by means of ⅜"-32 threaded bushing and hex. nut. See mounting illustration "A." Weight, single unit: .047 lb. approximately. Dual-purpose terminals accept 3⁄16" quick-connectors as well as soldering. Non-turn lug can be positioned at "12. 3, 6. and 9 o'clock."

Depth Behind Panel		Single Unit	2-in-Tandem	3-in-Tandem
		1⅜"	1²⁹⁄₃₂"	2²⁵⁄₃₂"
No. of Taps	Total Rotation	Catalog No.¹	Catalog No.	Catalog No.
3	60°	711-3	711-3-T2	711-3-T3
4	90°	711-4	711-4-T2	711-4-T3
5	120°	711-5	711-5-T2	711-5-T3
6	150°	711-6	711-6-T2	711-6-T3
7	180°	(711-7)	711-7-T2	711-7-T3
8	210°	711-8	711-8-T2	711-8-T3
9	240°	(711-9)	711-9-T2	711-9-T3
10	270°	711-10	711-10-T2	711-10-T3
11	300°	**711-11**	711-11-T2	711-11-T3
Recommended Knobs— (See p. 10 for description)		Catalog No. 5103A	Catalog No. 5103A	Catalog No. 5116A

MODEL 111 TAP SWITCH

Alternating Current Rating 15 Amps. 125 Volts — Diameter 1¾" — Shaft Diameter ¼" — Standard Mounting: For ¼" panel maximum, by means of ⅜"-32 threaded bushing and hex. nut. See mounting illustration "A." For Tandem Mounting see illustration "B." Weight, single unit: .16 lb. approximately.

Depth Behind Panel		Single Unit	2 in Tandem
		1⅝"	2¾"
No. of Taps	Total Rotation	Catalog No.¹	Catalog No.¹
3	60°	**111-3**	**111-3 -T2**
4	90°	**111-4**	**111-4 -T2**
5	120°	**111-5**	111-5 -T2
6	150°	**111-6**	111-6 -T2
7	180°	**111-7**	(111-7 -T2)
8	210°	**111-8**	**111-8 -T2**
9	240°	111-9	(111-9 -T2)
10	270°	**111-10**	(111-10-T2)
11	300°	**111-11**	111-11-T2
Recommended Knobs— (See p. 22 for description)		Catalog No. 5150A to 5116A	Catalog No. 5109A or 5110A

MODEL 212 TAP SWITCH

Alternating Current Rating 20 Amps. 150 Volts — Diameter 2¼" — Shaft Diameter ¼" — Standard Mounting: For ¼" panel maximum, by means of ⅜"-32 threaded bushing and hex. nut — See mounting illustration "C." Tandem Mounting for ¼" panel maximum, three No. 10-32 flat-head machine screws ⅜" long — See mounting illustration "D." Weight, single unit: .4 lb. approximately.

Depth Behind Panel		Single Unit	2 in Tandem	3 in Tandem
		1¾"	4⁵⁄₁₆"	6⁵⁄₁₆"
No. of Taps	Total Rotation	Catalog No.¹	Catalog No.¹	Catalog No.¹
3	60°	**212-3**	**212- 3-T2**	212- 3-T3
4	90°	**212-4**	(212- 4-T2)	(212- 4-T3)
5	120°	**212-5**	212- 5-T2	(212- 5-T3)
6	150°	**212-6**	212- 6-T2	212- 6-T3
7	180°	212-7	(212- 7-T2)	(212- 7-T3)
8	210°	212-8	(212- 8-T2)	(212- 8-T3)
9	240°	**212-9**	(212- 9-T2)	(212- 9-T3)
10	270°	**212-10**	(212-10-T2)	(212-10-T3)
11	300°	**212-11**	(212-11-T2)	(212-11-T3)
12	330°	**212-12**	212-12-T2	(212-12-T3)
Recommended Knobs (See p. 22 for description)		Catalog No. 5150A or 5116A	Catalog No. 5111A or 5112A	Catalog No. 5111A or 5112A

MODEL 312 TAP SWITCH

Alternating Current Rating 30 Amps. 300 Volts — 150V A.C. between taps — Diameter 3¹¹⁄₁₆" — Shaft Diameter ¼" — Standard Mounting: For ¼" panel maximum, three No. 10-32 flat-head machine screws ⅜" long — See mtg. illus. "D." Weight, single unit: .75 lb. approx.

Depth Behind Panel		Single Unit	2 in Tandem	3 in Tandem
		2¼"	4⅝"	7"
No. of Taps	Total Rotation	Catalog No.¹	Catalog No.¹	Catalog No.¹
3	60°	**312-3**	312- 3-T2	(312- 3-T3)
4	90°	**312-4**	(312- 4-T2)	312- 4-T3
5	120°	312-5	312- 5-T2	(312- 5-T3)
6	150°	**312-6**	312- 6-T2	(312- 6-T3)
7	180°	**312-7**	(312- 7-T2)	(312- 7-T3)
8	210°	**312-8**	(312- 8-T2)	312- 8-T3
9	240°	312-9	(312- 9-T2)	(312- 9-T3)
10	270°	**312-10**	(312-10-T2)	**312-10-T3**
11	300°	312-11	(312-11-T2)	**312-11-T3**
12	330°	**312-12**	312-12-T2	**312-12-T3**
Recommended Knobs (See p. 22 for description		Catalog No. 5109A or 5110A	Catalog No. 5111A or 5112A	Catalog No. 5111A or 5112A

¹ **Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in** LIGHT FACE **print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.**

OHMITE® power tap switches, high current, non-shorting type

MODEL 412 TAP SWITCH

Alternating Current Rating **50 Amps. 300 Volts** — 150V. A.C. between taps — Diameter 4 3/16" — Shaft Diameter 1/4" — Standard Mounting: For 1/4" panel maximum three No. 10-32 flat-head machine screws 3/8" long — See mtg. illus. "E." Weight, single unit: 1.4 lbs. approx.

Depth Behind Panel		Single Unit 2 11/16"	2 in Tandem 5 15/32"	3 in Tandem 7 3/8"
No. of Taps	Total Rotation	Catalog No.[1]	Catalog No.[1]	Catalog No.[1]
3	60°	**412-3**	412- 3-T2	(412- 3-T3)
4	90°	**412-4**	412- 4-T2	412- 4-T3
5	120°	412-5	(412- 5-T2)	412- 5-T3
6	150°	**412-6**	(412- 6-T2)	(412- 6-T3)
7	180°	412-7	412- 7-T2	(412- 7-T3)
8	210°	**412-8**	412- 8-T2	412- 8-T3
9	240°	412-9	(412- 9-T2)	(412- 9-T3)
10	270°	**412-10**	412-10-T2	**412-10-T3**
11	300°	412-11	(412-11-T2)	(412-11-T3)
12	330°	**412-12**	412-12-T2	(412-12-T3)
Recommended Knobs (see p 22)		Catalog No. 5111A or 5112A	Catalog No. 5111A or 5112A	Catalog No. 5111A or 5112A

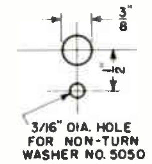
MODEL 608 TAP SWITCH

Alternating Current Rating **100 Amps. 300 Volts** — Diameter 6" — Shaft Diameter 3/8" — Standard Mounting: For 1" panel maximum, three flat-head machine screws 1/4"-20 x 1 1/4" — See mounting illustration "F." Weight, single unit: 5 lbs. approx.

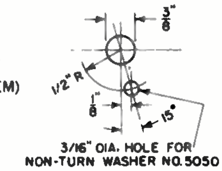
Depth Behind Panel		Single Unit 3 5/16"	2 in Tandem 6 15/16"	3 in Tandem 10 9/16"
No. of Taps	Total Rotation	Catalog No.[1]	Catalog No.[1]	Catalog No.[1]
3	80°	(608-3)	(608- 3-T2)	(608- 3-T3)
4	120°	608-4	(608- 4-T2)	(608- 4-T3)
5	160°	608-5	(608- 5-T2)	608- 5-T3
6	200°	**608-6**	608- 6-T2	(608- 6-T3)
7	240°	608-7	(608- 7-T2)	(608- 7-T3)
8	280°	**608-8**	**608- 8-T2**	**608- 8-T3**
Recommended Knobs (see p 22)		Catalog No. 5104A or 5105A	Catalog No. 5104A, 5115 or 5105A	Catalog No. 5115

TAP SWITCH MOUNTING DIMENSIONS

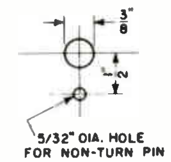
A MODEL 711 & 111 (SINGLE UNIT)



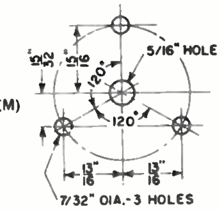
B MODEL 111 (TANDEM)



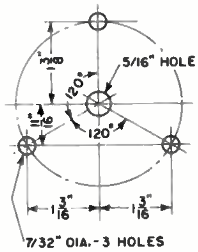
C MODEL 212 (SINGLE UNIT)



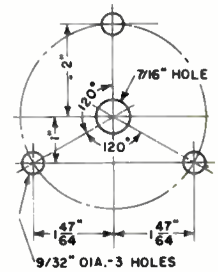
D MODEL 212 (TANDEM) MODEL 312 (ALL UNITS)



E MODEL 412 (ALL UNITS)



F MODEL 608 (ALL UNITS)



ALL CERAMIC OPEN TYPE TAP SWITCHES

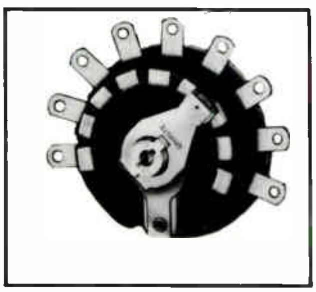
Designed to transfer currents of several amperes in circuits requiring high voltage insulation. Ceramic body construction is the same as employed in Models J and K rheostats (see page 21). Monel metal taps; silver-graphite brush.

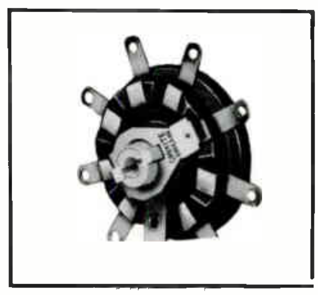
SHORTING TYPE SWITCH: Moving contact bridges closely spaced taps completing a new circuit before breaking the previous one. Switch arm is not indexed and can be left in any position.

NON-SHORTING SWITCH: Positively indexed, moving contact completely disconnects from one tap before contacting succeeding tap.

Switches up to 8 taps are approximately 3 1/4" diameter including lugs; 9 to 12 tap switches are approximately 4 1/4" diameter. Switches can be ordered assembled 2 to 3 in tandem. Single hole mounting by means of 3/8" diameter bushing and hexagon nut accommodates panels up to 1/4" thick (maximum). The "non-turn" lug requires a 3/16" panel hole 1/2" below the center of the shaft. Shaft diameter is 1/4". Recommended knob, Stock No. 5150, see Rheostat Knobs in Section 4750.

Maximum current capacity is 7 amperes but only 3 amperes at 120 V.A.C. should be interrupted. Current ratings are less for all direct current circuits above 20 volts, for inductive circuits and high voltages.





SHORTING TYPE†		NON-SHORTING TYPE†	
No. of Contacts	Catalog No.[1]	No. of Contacts	Catalog No.[1]
4	T-504-S	3	(T-503)
5	(T-505-S)	4	(T-504)
6	(T-506-S)	5	T-505
7	(T-507-S)	6	T-506
8	(T-508-S)	7	(T-507)
9	(T-1009-S)	8	T-508
10	(T-10010-S)	9	(T-1009)
11	(T-10011-S)	10	(T-10010)
12	T-10012-S	11	(T-10011)
		12	(T-10012)

† Avg. Wt. T-500 Series .28 lb.; T-100 Series .68 lb.

TAP SWITCH DIALS

J003

J004

Dials for Ohmite tap switches are made of aluminum, etched and enameled black. Dial markings are bright aluminum. The number of dial calibrations or position markings agree with the actual number of positions on the switch. Note, in the table, that dials for switches Models 212 and 312 are available in two diameters to suit the recommended knob.

Catalog No.[1]	For Model	For Knob †	Dial Dia.
5002-*	111 212 (Single) 312 (Single)	5109 5116 5150	2 3/4"
5003-*	212 (Tandem) 312 (Tandem) 412	5111 5152A	3 3/4"
5004-*	608	5104 5115	5 1/2"

* Specify no. of positions as a suffix.

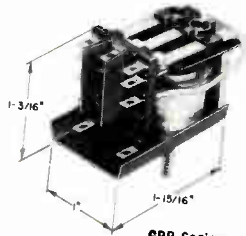
†See Rheostat Knobs, Section 4750.

[1] **Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in** LIGHT FACE print **are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.**

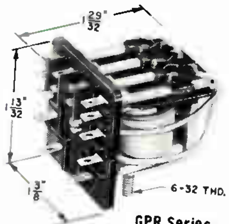
OHMITE® general purpose relays

MODEL GPR — INDICATOR, PLATE, THYRATRON AND LATCHING VERSIONS IN UNENCLOSED AND ENCLOSED TYPES

Simple, rugged, low cost relays handling substantial power for small size. Uncomplicated design provides unusual flexibility for making and changing connections and mounting. Stock includes relays in versatile enclosures, some with indicator light, also plate, thyratron and latching versions. Wide commercial and industrial use where economy and versatility are important.



GPR Series
1 to 3-Pole



GPR Series
4-Pole

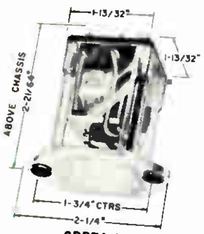
UNENCLOSED RELAYS

Basic (Unenclosed) Relay: All connections terminate on barrier-type terminal panel on combination solder — quick-connect (push-on) lugs which accept AMP 110 female connectors. The terminal panel is conveniently incorporated into printed circuit boards. Fixed contacts are integral inlay on terminal itself. Normally furnished with a 6-32 x ½" mounting stud and non-turn boss (or lug for 4-pole relays). A 6-32 threaded hole is optional. Unenclosed relays can also be mounted by plugging their panels into Ohmite SOGPR sockets. See "Socket" below.

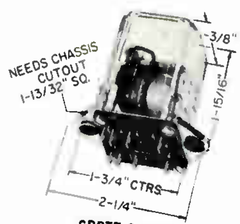
Contact Ratings: Two ratings — fine silver contacts, 5 amps at 115 VAC or 32 VDC resistive; silver-cadmium contacts, 10 amps.

Insulation: Tested at 1500 VAC.

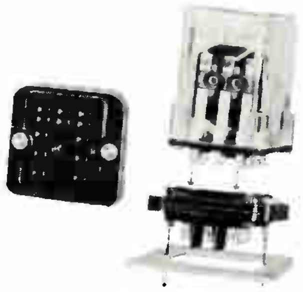
Coil Wattage: 1.4 watts DC operation; 1.6 watts (2.0 volt-amps) AC except 2.4 watts (3.70 volt-amps) for 4-pole AC and AC latching relays.



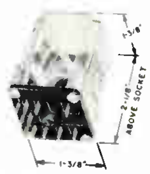
GPRTA Series
(Available on special order)



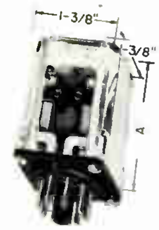
GPRTT Series
(Available on special order)



SOGPR Sockets



For Socket Mount
GPRTS Series



For Octal Plug
GPRTP Series

ENCLOSED RELAYS

GPRTA-, GPRTT-, GPRTS-, GPRTP-
Four types of clear plastic enclosures as follows:

Chassis Mounting Types: "GPRTA"—("Terminals-Above-Chassis" type) has terminal panel opposite to mounting flange; "GPRTT" —("Terminals-Through-Chassis" type) has terminal panel on same end as mounting flange, requires chassis cutout; "GPRTS" type (Terminals for Socket Use) is similar to GPRTT but has no mounting flanges. It is intended strictly for plug-in mounting in Ohmite socket "SOGPR" (see "Socket" below).

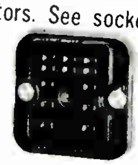
Plug Base Type: "GPRTP" — employs octal plug for 1 and 2 pole relays; 11-pin plug for 3-pole. The octal plug base is integral with relay for rigidity — is designed with recessed pins which meet UL spacing requirements (150V).

Indicator Relay: Incorporates light bulb to indicate energized condition of coil. Stocked only in GPRTP enclosures described in preceding. Neon bulb furnished with coil ratings 70 volts and above; incandescent bulbs for coil ratings below 70 volts.

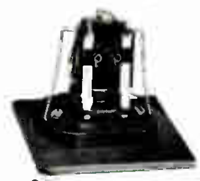
UL & CSA Approval: Column heads in the stock tables carry the UL (Underwriters' Laboratories) or CSA symbol (Canadian Standards Association) where applicable. The gray tint in the column indicates the relays are recognized under the "UL components program." The acceptability of such relays by UL depends upon their combination with other equipment such as sockets etc.

Socket (SOGPR): Unique socket fits the terminal panels of all GPR relays and provides over-the-surface spacing to meet UL requirements for 150 volts. Requires chassis cut-out to mount. Hold down springs (see illustration) for unenclosed and enclosed relays, are provided with each socket but are not required except under conditions of vibration or shock. Socket solder terminals will also accept AMP 110 quick-connectors. See socket listings.

SOCKETS FOR GPR, GPRTS RELAYS



For up to 3PDT: 1¾" square, requires 1¼" x 1½" cutout.* 2 holes (for No. 6 screws) on 1⅜" centers.
Catalog No. SOGPR-9



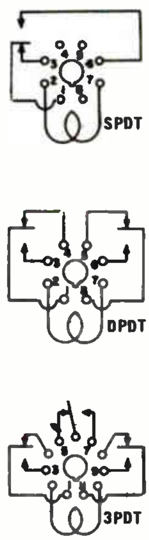
For 4-pole models, 1¾" x 2", requires 1½" x 1½" cutout.* 2 holes (for No. 6 screws) on 1⅝" centers.
Catalog No. SOGPR-12

*Std. punches and dies from Ward Machinery Co., Chicago. No. 28, Style 22N, 1¼ x 1½, for SOGPR-9: No. 28, Style 14R, 1½ x 1½, for SOGPR-12.

OHMITE® general purpose relays • GPR series

STOCK GPR RELAYS*

Plug wiring schemes for plug base (GPRTP) relays



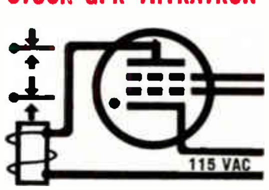
Con-tacts	COIL DATA Volts	Amps	Ohms	5 AMP CONTACTS UL-CSA UNEN-CLOSED Cat. No.[1] Prefix GPRX-	5 AMP CONTACTS UL CSA SOCKET MOUNT ENCLOSED (for SOGPR Socket)‡ Cat. No.[1] Prefix GPRTSX-	5 AMP CONTACTS UL-CSA PLUG BASE MOUNT ENCLOSED Cat. No.[1] Prefix GPRTPX-	10 AMP CONTACTS UL-CSA UNEN-CLOSED Cat. No.[1] Prefix GPRX-	10 AMP CONTACTS CSA SOCKET MOUNT ENCLOSED (for SOGPR Socket)‡ Cat. No.[1] Prefix GPRTSX-	10 AMP CONTACTS CSA PLUG BASE MOUNT ENCLOSED Cat. No.[1] Prefix GPRTPX-	10 AMP CONTACTS INDICATOR-PLUG BASE ENCLOSED Cat. No.[1] Prefix GPRTPX-
SPDT	6VAC	.334	4.2	(-3T)		(-3T)	(-203T)		(-203T)	
DPDT	6VAC	.334	4.2	-6T	(-6T)	(-6T)	(-206T)	(-206T)	(-206T)	(-291T)
3PDT	6VAC	.334	4.2	(-9T)	(-9T)	(-9T)	(-209T)	(-209T)	(-209T)	
4PDT	6VAC	.650	2.5	(-403T)	(-403T)		(-433T)	(-433T)		
SPDT	12VAC	.167	17	(-12T)		(-12T)	(-212T)		(-212T)	
DPDT	12VAC	.167	17	(-15T)	(-15T)	-15T	(-215T)	(-215T)	(-215T)	(-292T)
3PDT	12VAC	.167	17	(-18T)	(-18T)	(-18T)	(-218T)	(-218T)	(-218T)	
4PDT	12VAC	.309	10	(-406T)	(-406T)		(-436T)	(-436T)		
EPDT	24VAC	.084	65	(-21T)		(-21T)	(-221T)		(-221T)	
DPDT	24VAC	.084	65	**-24T**	(-24T)	-24T	(-224T)	(-224T)	-224T	(-293T)
3PDT	24VAC	.084	65	(-27T)	(-27T)	(-27T)	(-227T)	(-227T)	-227T	
4PDT	24VAC	.155	40	(-409T)	(-409T)		(-439T)	(-439T)		
SPDT	115VAC	.0174	1600	(-30T)		-30T	-230T		-230T	
DPDT	115VAC	.0174	1600	**-33T**	(-33T)	**-33T**	-233T	**-233T**	**-233T**	-294T
3PDT	115VAC	.0174	1600	-36T	(-36T)	-36T	-236T	(-236T)	**-236T**	
4PDT	115VAC	.0325	1000	-412T	**-412T**		**-442T**	**-442T**		
SPDT	230VAC	.0087	7000	(-39T)		(-39T)	(-239T)		(-239T)	
DPDT	230VAC	.0087	7000	(-42T)	(-42T)	(-42T)	(-242T)	(-242T)	-242T	(-295T)
3PDT	230VAC	.0087	7000	(-45T)	(-45T)	(-45T)	(-245T)	(-245T)	(-245T)	
4PDT	230VAC	.0147	4000	(-415T)	(-415T)		(-445T)	(-445T)		
SPDT	6VDC	.23	26	(-48T)		(-48T)	(-248T)		(-248T)	
DPDT	6VDC	.23	26	-51T	(-51T)	-51T	(-251T)	(-251T)	(-251T)	(-296T)
3PDT	6VDC	.23	26	(-54T)	(-54T)	(-54T)	(-254T)	(-254T)	(-254T)	
4PDT	6VDC	.23	26	(-418T)	(-418T)		(-448T)	(-448T)		
SPDT	12VDC	.114	105	-57T		(-57T)	(-257T)		(-257T)	
DPDT	12VDC	.114	105	**-60T**	(-60T)	-60T	-260T	(-260T)	-260T	(-297T)
3PDT	12VDC	.114	105	**-63T**	(-63T)	-63T	(-263T)	(-263T)	(-263T)	
4PDT	12VDC	.114	105	(-421T)	(-421T)		(-451T)	(-451T)		
SPDT	24VDC	.060	400	(-66T)		(-66T)	(-266T)		(-266T)	
DPDT	24VDC	.060	400	**-69T**	(-69T)	**-69T**	(-269T)	(-269T)	**-269T**	(-298T)
3PDT	24VDC	.060	400	-72T	**-72T**	-72T	(-272T)	(-272T)	-272T	
4PDT	24VDC	.060	400	(-424T)	(-424T)		(-454T)	**-454T**		
SPDT	110VDC	.0110	1000	(-75T)		(-75T)	(-275T)		(-275T)	
DPDT	110VDC	.0110	1000	(-78T)	(-78T)	(-78T)	(-278T)	(-278T)	-278T	(-299T)
3PDT	110VDC	.0110	1000	**-81T**	-81T	(-81T)	(-281T)	(-281T)	(-281T)	
4PDT	110VDC	.0110	1000	(-427T)	(-427T)		(-457T)	-457T		
Approx. weight				2.5 oz.	3.0 oz.	3.5 oz.	2.5 oz.	3.5 oz.	3.5 oz.	3.5 oz.

SENSITIVE PLATE CIRCUIT RELAYS — 5 AMP CONTACTS

Plate Relays: Feature same physical construction as standard general purpose relays but are adjusted for greater sensitivity and can be used as electronic circuit controls, i.e., in the plate circuits of standard vacuum tubes.

Con-tacts	COIL DATA Ohms	Pull-in Max. ma.	UNENCLOSED Cat. No.[1] Prefix GPRX-	SOCKET MOUNT ENCLOSED (for SOGPR Socket)‡ Cat. No.[1] Prefix GPRTSX-	PLUG BASE MOUNT ENCLOSED Cat. No.[1] Prefix GPRTPX-
SPDT	2500	7.2	-82T		(-82T)
DPDT	2500	10	(-83T)		-83T
3PDT	2500	12.3	(-84T)		(-84T)
4PDT	2500	15.0	(-463T)	(-463T)	
SPDT	5000	5	(-85T)		(-85T)
DPDT	5000	7.2	(-86T)		-86T
3PDT	5000	8.7	(-87T)		(-87T)
4PDT	5000	11	(466T)	(-466T)	
SPDT	10,000	3.6	(-88T)		(-88T)
DPDT	10,000	5	-89T		-89T
3PDT	10,000	6.1	(-90T)		-90T
4PDT	10,000	7.5	(-469T)	(-469T)	
Approx. weight			2.5 oz.	3.0 oz.	3.5 oz.

STOCK GPR THYRATRON RELAYS



Relay in Circuit Showing Thyratron

Contacts	5 AMP CONTACTS CSA UNEN-CLOSED Cat. No.[1] Prefix GPRX-	5 AMP CONTACTS ABOVE CHASSIS MTG. ENCLOSED Cat. No.[1] Prefix GPRTAX-†	5 AMP CONTACTS THRU-CHASSIS MTG. ENCLOSED Cat. No.[1] Prefix GPRTTX-†	5 AMP CONTACTS SOCKET MT. ENCLOSED (for SOGPR Socket)‡ Cat. No.[1] Prefix GPRTSX-	5 AMP CONTACTS PLUG BASE MOUNT ENCLOSED Cat. No.[1] Prefix GPRTPX-	10 AMP CONTACTS UNENCLOSED Cat. No.[1] Prefix GPRX-	10 AMP CONTACTS SOCKET MT. ENCLOSED (for SOGPR Socket)‡ Cat. No.[1] Prefix GPRTSX-	10 AMP CONTACTS PLUG BASE MOUNT ENCLOSED Cat. No.[1] Prefix GPRTPX-
SPDT	(-191T)	(-191T)	(-191T)		(-191T)	(-391T)		(-391T)
DPDT	(-192T)	(-192T)	(-192T)		(-192T)	(-392T)		(-392T)
3PDT	(-193T)	(-193T)	(-193T)		(-193T)	(-393T)		(-393T)
4PDT	(-473T)			(-473T)		(-483T)	(-483T)	

Thyratron Plate Relay: Designed specifically for plate circuit of thyratron tubes 2050 and 2D21 with 115 VAC supply (see diagram). Also suitable for operation in series with silicon controlled rectifiers from a 115 VAC supply. Ready to work, no capacitors or adjustments required, no chatter. Available unenclosed and in most GPR enclosures.

NOTES

*Column heads carry symbols to indicate UL or CSA (Canadian Standards Assn.) approval. The grey tint indicates that relay is recognized under UL "components program" (File No. E33069, Guide No. 380W1.14C Assignment No. 62C3559A). CSA File No. is 21309. See explanation in "UL and CSA Approval."

†4-Pole GPRTS relays are not covered by CSA.
‡GPRTA and GPRTT types as listed by UL, differ slightly from the stock versions above and consequently, are made to order. These UL versions have a "U" added to the catalog number, such as in "GPRTAU." They also have CSA approval.

[1] **Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.**

OHMITE® power relays • ratings to 25 amperes

MODEL DO RELAYS (AC or DC)

Particularly adaptable to aircraft and mobile equipment applications where severe shock and vibration are encountered. Design of molded parts around contact arms protects against mechanical injury. Stocked in 3-pole or 4-pole type, and also in hermetic enclosures and in latching types.

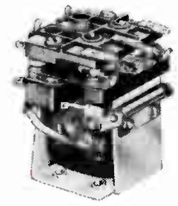
Coil Wattage: 3.00 watts, DC operation; 6.00 watts, 60 cycle AC. Maximum temperature rise 45°C, DC operation; 75°C, AC.

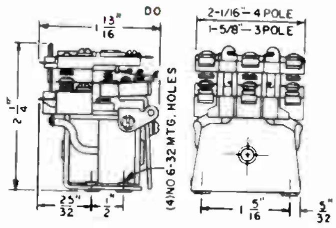
Coil Operating Voltage: Any voltage up to 230 VDC or 440 VAC, 60 cycle. Stock voltages in table.

Contacts: 10 amps nominal. Ratings are for 115 VAC or 32 VDC, resistive load.

Weight: Unenclosed 3-pole, 5 oz.; 4-pole, 6 oz.

STANDARD UNENCLOSED





DO RELAYS IN HERMETIC ENCLOSURES

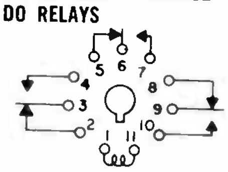
Stock DO relays with 115 volt coil in hermetically sealed metal enclosures, filled with dry nitrogen, provide protection for relay under most adverse ambient conditions. Both 3 and 4-pole DO relays are supplied in these enclosures with plug (DOHPX-) or solder terminal (DOHX-) connectors as illustrated. See listings in stock table at right.

Weight: 3-pole hermetic relay approx. 14 oz.; 4-pole approx. 15 oz.

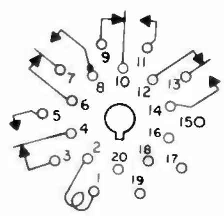
DOHPX-16T, 3PDT, 11 Prongs
DOHPX-15T, 4PDT, 20 Prongs

DOHX-22T, 3PDT, 14 Terminals
DOHX-23T, 4PDT, 14 Terminals

WIRING FOR PLUG-BASE DO RELAYS



DOHPX-16T



DOHPX-15T

STANDARD DO RELAYS — 10 & 20* AMP CONTACTS

Catalog No.¹	Contacts	Coil Data: Volts	Amps	DC Ohms
UNENCLOSED				
(DOX-50T)	3PDT	6VAC	2.33	0.36
(DOX-183T)	4PDT	6VAC	2.33	0.36
(DOX-49T)	3PDT	12VAC	1.28	1.40
(DOX-184T)	4PDT	12VAC	1.28	1.40
(DOX-181T)	3PDT	24VAC	.57	5.50
(DOX-185T)	4PDT	24VAC	.57	5.50
(DOX-226T)	DPST*	115VAC	.110	145.0
(DOUX-34)	DPST*	115VAC	.110	145.0
(DOX-227T)	3PST-N.O.	115VAC	.110	145.0
(DOUX-28)	3PST-N.O.	115VAC	.110	145.0
DOX-46T	3PDT	115VAC	.110	145.0
(DOUX-30)	3PDT	115VAC	.110	145.0
(DOX-228T)	4PST-N.O.	115VAC	.110	145.0
(DOUX-31)	4PST-N.O.	115VAC	.110	145.0
DOX-53T	4PDT	115VAC	.110	145.0
(DOUX-33)	4PDT	115VAC	.110	145.0
(DOX-61T)	3PDT	230VAC	.070	550.0
(DOX-130T)	4PDT	230VAC	.070	550.0
(DOX-145T)	3PDT	6VDC	.487	12.3
(DOX-186T)	4PDT	6VDC	.487	12.3
(DOX-51T)	3PDT	12VDC	.231	51.8
DOX-102T	4PDT	12VDC	.231	51.8
DOX-141T	3PDT	24VDC	.105	230.0
DOX-137T	4PDT	24VDC	.105	230.0
(DOX-93T)	3PDT	110VDC	.022	5000
DOX-187T	4PDT	110VDC	.022	5000
(DOX-182T)	3PDT	220VDC	.014	16,100
(DOX-188T)	4PDT	220VDC	.014	16,100
IN HERMETIC ENCLOSURE				
(DOHPX-16T)	3PDT	115VAC	.110	145.0
(DOHPX-15T)	4PDT	115VAC	.110	145.0
(DOHX-22T)	3PDT	115VAC	.110	145.0
(DOHX-23T)	4PDT	115VAC	.110	145.0

*DOX-226T and DOUX-34 20 amps, double break contacts.

MODEL DOS RELAYS

Wide application, general purpose relay, compact and lightweight. Handles loads usually demanded of much larger relays. Meets rigorous aircraft relay standards.

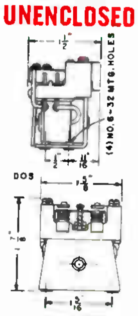
Coil Wattage: 2.5 watts, DC operation; 3 watts, 60 cycle AC. Maximum temperature rise 45°C, DC operation; 65°C, AC.

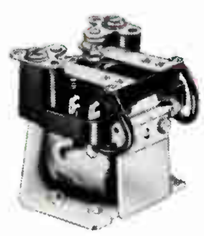
Coil Operating Voltage: Any voltage up to 230 VDC or 440 VAC, 60 cycles. Table lists stock voltages.

Contacts: 15 amps nominal. Rating is for 115 VAC or 32 VDC, resistive load.

Weight: Unenclosed, 4 oz.

STANDARD UNENCLOSED





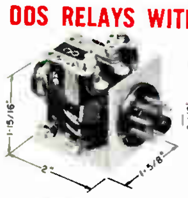
DOS RELAYS WITH PLUG-BASE, DUST-COVERS & HERMETIC ENCLOSURES

DOS relays with 115 VAC coils are available from stock with a standard octal plug base, unenclosed (DOSPX-1T) or with an octal plug base and drawn aluminum, removable dust-tight enclosure (DOSEPX-5T).

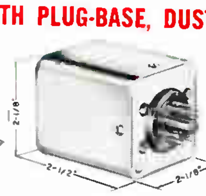
Weight: 8 oz. each.

Hermetically Sealed non-removable enclosures, filled with dry nitrogen, are also available to provide protection under adverse ambient conditions. DOS relays with 115 VAC or DC coils are provided in these enclosures with either octal plug (DOSHPX-) or solder-terminal (DOSHX-) connectors as illustrated. See listings and prices in DOS stock table.

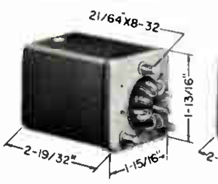
Weight: 8 oz. each approx.



DOSPX-1T
Octal Plug-Base

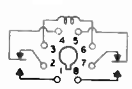


DOSEPX-5T
Octal Plug Base with Dust Cover

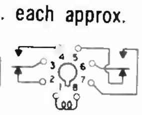


Hermetic Enclosures with 8 Terminals
DOSHX-39T, 115VDC
DOSHX-40T, 115VAC

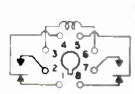
Hermetic Enclosures with Octal Plugs
DOSHPX-46T, 115VDC
DOSHPX-47T, 115VAC



DOSPX-1T



DOSEPX-5T



DOSHPX-46T, 47T

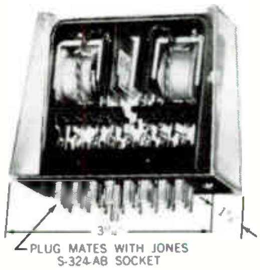
STOCK DOS RELAYS — 15 & 25* AMP CONTACTS

Catalog No.¹	Contacts	Coil Data: Volts	Amps	DC Ohms
UNENCLOSED				
(DOSX-229T)	SPST*	6VAC	.890	1.07
(DOSX-230T)	DPST-N.O.	6VAC	.890	1.07
DOSX-30T	DPDT	6VAC	.890	1.07
(DOSX-16T)	DPDT	12VAC	.460	4.20
(DOSX-231T)	SPST*	24VAC	.269	15.5
(DOSX-232T)	DPST-N.O.	24VAC	.269	15.5
DOSX-162T	DPDT	24VAC	.269	15.5
DOSX-233T	SPST*	115VAC	.043	450
(DOSUX-34)	SPST*	115VAC	.043	450
DOSX-234T	DPST-N.O.	115VAC	.043	450
(DOSUX-31)	DPST-N.O.	115VAC	.043	450
DOSX-7T	DPDT	115VAC	.043	450
DOSUX-33	DPDT	115VAC	.043	450
(DOSX-235T)	SPST*	230VAC	.030	1450
(DOSX-236T)	DPST-N.O.	230VAC	.030	1450
DOSX-12T	DPDT	230VAC	.030	1450
DOSX-158T	DPDT	6VDC	.450	13.4
DOSX-66T	DPDT	12VDC	.210	56.2
DOSX-9T	DPDT	24VDC	.105	230.0
DOSX-237T	SPST*	110VDC	.022	5000
(DOSX-238T)	DPST-N.O.	110VDC	.022	5000
DOSX-59T	DPDT	110VDC	.022	5000
(DOSX-177T)	DPDT	220VDC	.013	16,400
WITH PLUG BASE				
DOSPX-1T	DPDT	115VAC	.043	450
WITH DUST COVER/PLUG BASE				
DOSEPX-5T	DPDT	115VAC	.043	450
IN HERMETIC ENCLOSURE				
DOSHX-40T	DPDT	115VAC	.043	450
DOSHPX-47T	DPDT	115VAC	.043	450
(DOSHX-39T)	DPDT	110VDC	.022	5000
(DOSHPX-46T)	DPDT	110VDC	.022	5000

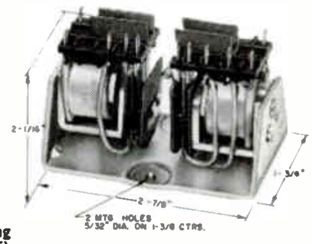
*Double-break contacts — 25 amp rating.

¹ Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.

OHMITE® latching relays & sensitive 15 amps relays



Enclosed Latching Relay (GPRLETP)



6PDT Latching Relay (GPRLE)

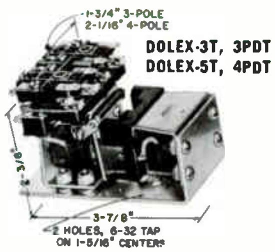
Latching Relay: Consists of two GPR relays with armatures linked so that the n.o. contacts of one are mechanically latched in closed position when, and after, this relay is energized. When 2nd relay is energized, first relay restores and latches 2nd. Permits switching of twice the number of circuits and holding without coil current. Unenclosed type "GPRLE." Enclosed type "GPRLETP" in clear plastic case with Jones plug P-324-SB fitting S-324-AB socket.

STOCK GPR LATCHING RELAYS — 5 AMP CONTACTS

Total Contacts	COIL DATA — (Each Coil) Volts	Amps	Ohms	Unenclosed GPRLE†	Enclosed Plug-Base GPRLETP†
4PDT	6VAC	.650	2.5	(GPRLEX-1T)	(GPRLETPX-1T)
6PDT	6VAC	.650	2.5	(GPRLEX-2T)	(GGRLETPX-2T)
4PDT	12VAC	.309	10.0	GPRLEX-3T	(GPRLETPX-3T)
6PDT	12VAC	.309	10.0	GPRLEX-4T	(GPRLETPX-4T)
4PDT	24VAC	.155	40.0	(GPRLEX-5T)	(GPRLETPX-5T)
6PDT	24VAC	.155	40.0	(GPRLEX-6T)	(GPRLETPX-6T)
4PDT	115VAC	.0325	1000	**GPRLEX-7T**	GPRLETPX-7T
6PDT	115VAC	.0325	1000	(GPRLEX-8T)	**GPRLETPX-8T**
4PDT	230VAC	.0147	4000	(GPRLEX-9T)	(GPRLETPX-9T)
6PDT	230VAC	.0147	4000	(GPRLEX-10T)	(GPRLETPX-10T)
4PDT	6VDC	.35	17	(GPRLEX-11T)	(GPRLETPX-11T)
6PDT	6VDC	.35	17	(GPRLEX-12T)	(GPRLETPX-12T)
4PDT	12VDC	.185	65	(GPRLEX-13T)	(GPRLETPX-13T)
6PDT	12VDC	.185	65	(GPRLEX-14T)	(GPRLETPX-14T)
4PDT	24VDC	.093	256	**GPRLEX-15T**	(GPRLETPX-15T)
6PDT	24VDC	.093	256	(GPRLEX-16T)	**GPRLETPX-16T**
4PDT	110VDC	.0221	5000	(GPRLEX-17T)	GPRLETPX-17T
6PDT	110VDC	.0221	5000	(GPRLEX-18T)	(GPRLETPX-18T)
Approx. weight				7.0 oz.	11.3 oz.

*Column heads carry symbols to indicate UL or CSA (Canadian Standards Assn.) approval. The gray tint indicates that relay is recognized under UL "components program" (File No. E33069, Guide No. 380W1.14C, Assignment No. 62C3559A). CSA File No. is 21309. See explanation in "UL and CSA Approval."

MODEL DO LATCHING RELAY (DOLEX-)



DOLEX-3T, 3PDT
DOLEX-5T, 4PDT

Weights: 3-pole — 16.5 oz.; 4-pole — 17 oz.

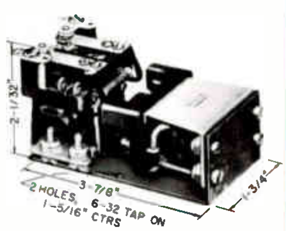
Consists of Model DO relay and a "reset magnet" with both armatures mechanically latched so that the normally open contacts of the relay remain closed when the relay energizing voltage is removed. The relay releases to normal position when the reset coil is pulsed. Permits "holding" of circuits without continuous coil current. Coils of stock units (both relays and reset coils) are 115 VAC. Available with 3 or 4-pole DO relays

STANDARD LATCHING TYPE

Catalog No.¹	Type	Volts	Coil Data † Amps	DC Ohms
(DOLEX-3T)	3PDT	115VAC	.110	145.0
(DOLEX-5T)	4PDT	115VAC	.110	145.0

†Coil data applies to relay part of latching assembly. Reset magnet operates on 115VAC, 60 cycle also.

MODEL DOS LATCHING RELAY (DOSLEX-)



Consists of Model DOS relay and a "reset magnet" with both armatures mechanically latched so that the normally open contacts of the relay remain closed when the relay energizing voltage is removed. The relay releases to normal position when the reset coil is pulsed. Permits "holding" of circuits without continuous coil current. Coils of stock units (both relay and reset magnet) are 115VAC.

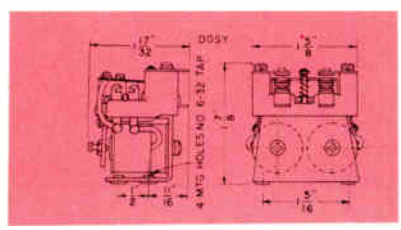
Weight: 14.2 oz.

LATCHING TYPE

Catalog No.¹	Type	Volts	Coil Data Amps †	DC Ohms
DOSLEX-1T	DPDT	115VAC	.043	450

†Coil data applies to relay part of latching assembly. Reset magnet operates on 115 VAC. 60 cycle also.

SENSITIVE MODEL DOSY RELAY FOR PLATE CIRCUITS — 15 AMPS



Similar in construction to Model DOS relay but equipped with twin coils for increased sensitivity. The DOSY relay is adaptable to a wide range of electronic control applications such as plate circuit controls, or as overload or underload controls in D.C. circuits to signal attainment of predetermined current levels.

Coil Wattage: 1.00 watt, with maximum temperature rise of 45°C. Lower wattages available.

Contacts: Stock combinations as listed. Ratings are for 115 VAC or 32 VDC, resistive load.

Weight: Approximately 4½ ounces.

Catalog No.¹	Type	Coil Data DC Ohms	Max. Pull-in Current	Contact Amps
DOSYX-67T	DPDT	10,000	8 MA	15
DOSYX-68T	DPDT	5,000	11 MA	15
DOSYX-69T	SPDT	10,000	5 MA	15
(DOSYX-70T)	SPDT	5,000	7 MA	15

¹ Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in de th. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.

OHMITE® variable transformers

Unique for the design innovations they incorporate, Ohmite "OHMITRAN" v.t.® variable transformers include exclusive field-proven features. They offer long, low maintenance operation with excellent regulation at any voltage setting within the rated load plus an output free of waveform distortion. Six frame sizes offer a wide range of electrical ratings to meet most industrial applications. These include three new, compact, low-power models (VT1, VT02, VT3,) which permit a fine choice of six ratings from 1.3 to 3.3 amperes.

UL LISTING: A number of VT4, VT8 and VT20 transformers used for 120 volt line operation are underwriters' laboratories listed. See tables, page 34 for details.

POSITIVE CURRENT TRANSFER . . . achieved with specially designed brushes connected through high conductivity contact arms or pigtails to a large slip ring which contacts a wide area of the collector ring. The brush contact assembly on the VT1, VT02, and VT3 is instantly replaceable, when necessary, as a result of a slide-on, snap-in design. Brushes of the other models are easily replaced also.

ADJUSTABLE SHAFT: On all Ohmite transformers, except the VT2LN, the shaft may be extended out from either the brush or opposite side as desired. On the VT1, VT02 and VT3, both single and tandem assemblies, this is an **exclusive** Ohmite feature which affords greater versatility of mounting and application. For example, substitution of a longer shaft or extension of the standard shaft allows actuation of other devices, such as switches or potentiometers without special construction. The shaft is freed simply by loosening set screw in the hub assembly. A double flat on the shaft permits two knob positions.

On the VT4, VT8, and VT20 types, the adjustable shaft feature permits **table or panel use.** "Ganged" or tandem VT4, VT8 and VT20 units employ a thru-shaft offering the same flexibility. On VT4 and VT8 units, shafts are fixed in the desired position by means of socket head screws located in the hub of each "brush-radiator" plate. The VT20 employs a unique collet-type shaft lock.

INTERCHANGEABLE WITH OTHER POPULAR TYPES: Basic "v.t." units have mounting provisions which match those of virtually all popular transformers of comparable current rating. Models VT4, VT8 and VT20 mount by means of bolts. Normally 3-hole mounting, single VT4 units can be "4-hole mounted" by means of adapter plate, see page 33. Individual Model VT1, VT02, VT2LN, or VT3 units mount by means of a standard ⅜-32 threaded bushing. All tandem assemblies mount by means of bolts or nuts. Knob, dial and mounting hardware are included with each transformer.

DIRECT READING, TWO SCALE DIAL . . . calibrated on one side for overvoltage connection; on the reverse side for line voltage connection. Dials normally included with transformer read clockwise for increasing voltage; counter-clockwise calibration available—see page 33.

WIRING AND CONNECTIONS: Wiring instructions to arrange various modes of operation are enclosed with all OHMITE variable transformers. Terminal panels or adjacent nameplate carry convenient wiring diagram, coded terminals and input and output data. Three way terminals on VT1, VT2LN, VT02, VT3 will accept ¼" push-on connectors, screws and nuts, or conventional soldering.

ROTATION OPTION: On VT4, VT8 and VT20 transformers connected for overvoltage, either clockwise or counter-clockwise increase of voltage can be arranged easily by the user. Increasing voltage in either direction can be arranged on all units connected for no-overvoltage output. Dials for counter-clockwise operation are stocked. See "Accessories."

OVERVOLTAGE OPTION: On all transformers with overvoltage feature, no-overvoltage operation can be arranged on the terminal panel.

NO-OVERVOLTAGE TRANSFORMERS ("N" suffix): Provide considerably more current due to heavier gage winding.

240-VOLT INPUT ("H" suffix): On units which are wound for 240-volt input, a 120 volt input tap is also provided. With the use of this input, the maximum current rating applies up to 120 volts output but beyond this reduces proportionately to approximately 50% at maximum voltage output.

LOW VOLTAGE INPUT ("L" feature): Designed for a maximum input of approximately 40 volts, with high current output.

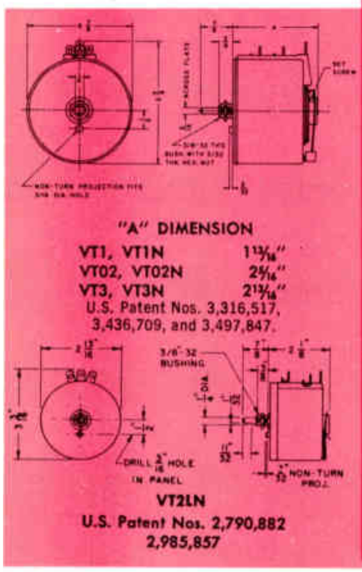
GROUNDED INPUT & OUTPUT ("C" feature): Units in type F or G cases can be provided with a three-conductor cord and outlet. One conductor is grounded to the case. This feature standard on all cased VT20 units and on all metered units.

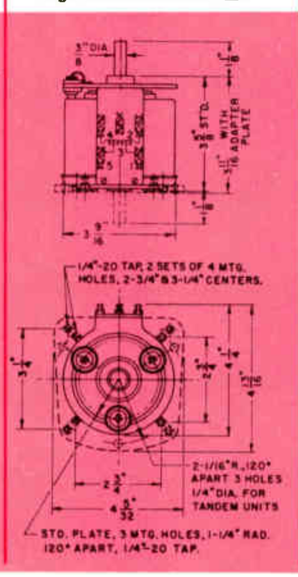
VT1,VT02,VT2LN,VT3 SERIES,SINGLE,UNCASED
Angle of rotation 320° ±5°
The VT1, rated 1 ampere, is the smallest commercial variable transformer available.

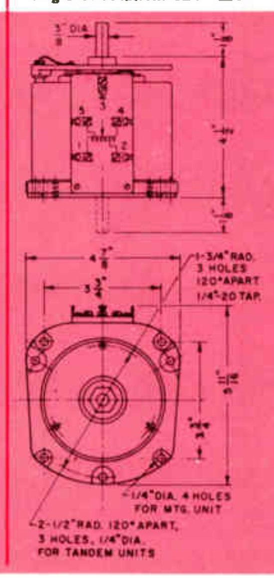
VT4 SERIES, SINGLE, UNCASED
Angle of rotation: 324° ±5°

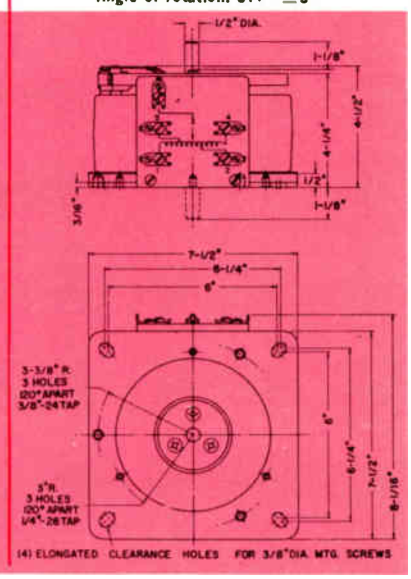
VT8 SERIES, SINGLE, UNCASED
Angle of rotation: 324° ±5°

VT20 SERIES, UNCASED
Angle of rotation: 317° ±5°









OHMITE® variable transformers

ENCLOSURES

Gray hammer tone finish. "Basic protective enclosures" (Type B) expose the transformer's terminal panel and mounting base and are supplied presently on VT20 models only. (See tandems in "B" enclosures below.) "Fixed mounting enclosures" (Type E) are intended for permanent mounting on table, panel or in-conduit-line. Standard portable units (Type F) carry a line cord, outlet socket, and fuse (VT20F has circuit breaker). Deluxe portable units (Type G), VT8 and VT20 only, have circuit breaker, overvoltage or no-overvoltage selector, handle which also serves as an easel.

METERED ENCLOSURES: VT8NFC, VT8GC, VT20NFC and VT20GC transformers are available with voltmeter (V), voltmeter and ammeter (A) or voltmeter and wattmeter (W). All have three-conductor grounded cord and outlet. All, except VT8NF group, are equipped with handles.

ENCLOSURE DIMENSIONS

Series	Case▲	W	D	H
VT1 or VT02	E	3⅜	2½*	4¼
	F	3⅜	2½*	4¼
VT4	E	4½	4½*	6³⁄₁₆
	F	4⅞	4½*	6¼
VT8	E	5³⁄₁₆	5¼*	7³⁄₁₆
	F	5¹⁷⁄₃₂	5¼*	7⅜
	FV, FVA, FVW	7⅜	5¼*	10½
	G	5³⁄₁₆†	5¼*	7⅜‡
	GV, GVA, GVW	7	5¼*	10½‡
	3E	5³⁄₁₆	15¾*	7³⁄₁₆
VT20	B	7⅝	8⅛	4⅞*
	E	7¾	5½*	10¹⁵⁄₁₆
	F	8¼	5½*	11¼
	FV, FVA, FVW	8¼	5½*	14¼
	G	7¾§	5½*	11¼‡
	GV, GVA, GVW	8¾	5½*	14¼‡

NOTES:
* Add 1" for knob thickness for VT8 types; ⅞" for VT1, 02 and VT4 types, 1¼" for VT20 types.
† 5¾" including handle fittings.
‡ Case height only. § 9" including handle fittings.
▲ V, A and W = voltmeter, ammeter and wattmeter respectively.

VT02F VT02E VT4E VT4F VT4FC VT8GCV (with voltmeter) VT8G VT20B VT8-3E

PARTS & ACCESSORIES

ADAPTER PLATE

For 4-hole mtg. of VT4—matches other popular 4-hole mtgs.; dimensions same as shown for front plate of VT4 tandems, page 33.

BRUSH-CONTACT ASSEMBLIES

VT1, VT1N, VT02, VT02N, VT3, VT3N - 6507; VT2LN - 6517; VT4 Series except VT4LN - 6515; VT8 Series except VT8H, HN, LN - 6515; VT4LN - 6518; VT8H, HN only - 6516H; VT8LN only - 6519; VT20 Series and VT20N - 6594; VT20H, HN only - 6596.

ADJUSTABLE STOP

For limiting rotational arc of transformers. Stop for VT4 Series - 6536; Stop for VT8 Series - 6537; Stop for VT20 Series - 6538.

FUSE LINKS

For VT4 - 6508; For VT4N - 6509; For VT20 - 6535.

EXTRA KNOBS

For VT1, VT02, VT2LN, VT3 Series - 5158; for VT4, VT8 Series - 5155; for VT20 Series - 5157.

EXTRA DIALS & DIALS WITH C.C.W.

Series	"UT" Dial Calibration	Cat. No.
VT1 VT02 VT2LN VT3	0-120, 0-132 CW	5005
	0-100, 100-0* CW	5011
	0-240, 0-264 CW	5019
VT4 and VT8	0-120, 0-140 CW	5006
	0-120, 0-140 CCW	5008
	0-240, 0-280 CW	5009
	0-240, 0-280 CCW	5010
	0-100, 100-0* CW	5012
	0-480, 0-560 CW	5018
VT20	0-120, 0-140 CW	5013
	0-120, 0-140 CCW	5014
	0-240, 0-280 CW	5015
	0-240, 0-280 CCW	5016
	0-100, 100-0 CW	5017

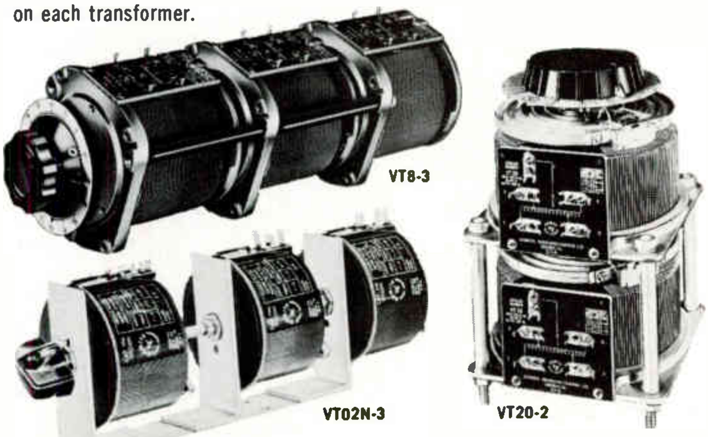
* Percent-of-output dial furnished with "LN" series units.

tandems & 3-phase

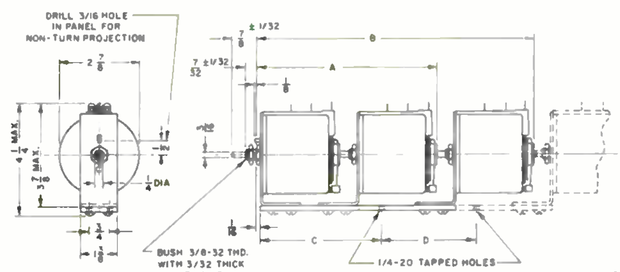
TANDEM OR GANGED UNITS: Two or 3-in-tandem assemblies are standard. Larger tandem assemblies available made to order. All tandem assemblies are normally furnished with inter-connections between the units. A few cased tandems are stocked. Tandems in "B" type enclosures have individual cases on each transformer.

TANDEM VT1, VT02, VT3 DIMENSIONS

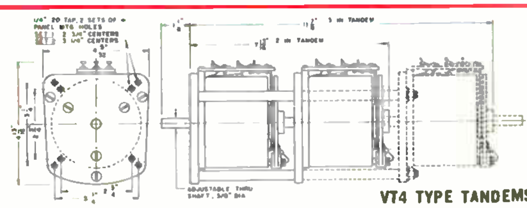
Series	A	B	C
VT1	4⁷⁄₃₂	6¹⁷⁄₃₂	4¼
VT02	5⁷⁄₃₂	8⅓₂	4½
VT3	6¹⁷⁄₃₂	9²⁷⁄₃₂	4½



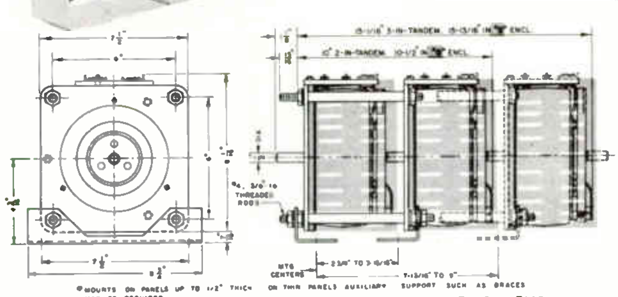
VT8-3 VT02N-3 VT20-2



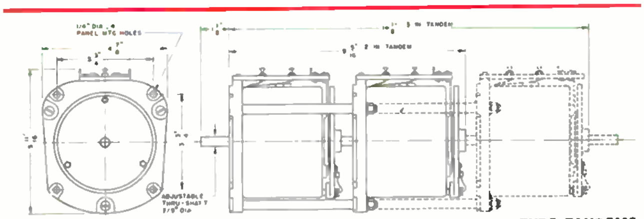
VT1, VT02, VT3 TYPE TANDEMS



VT4 TYPE TANDEMS



VT20 TYPE TANDEMS



VT8 TYPE TANDEMS

STOCK VARIABLE TRANSFORMERS

SINGLE PHASE

SINGLE TRANSFORMERS — UNCASED (Dimensions p. 32)

Input Volts	Freq. Hz from[1]	Feature or Connection	U.L. see foot-notes below	Maximum Output Volts	Maximum Output Amps	Catalog No.[13]	Wt. Lbs.[7]
40	60	Hi-amps, low volts		0-40	5.0	VT2LN	2.4
40	50	Hi-amps, low volts		0-40	12.0	VT4LN	5.25
40	50	Hi-amps, low volts		0-40	22.0	VT8LN	10.25
120	60[8]	Basic 1.0A Model		0-120/132	1.3	**VT1**	1.5
120	60	No overvoltage		0-120	1.5	**VT1N**	1.5
120	60[8]	Basic 1.75A Model		0-120/132	2.0	**VT02**	2.25
120	60	No overvoltage		0-120	2.5	**VT02N**	2.25
120	60[8]	Basic 2.6A Model		0-120/132	3.0	**VT3**	3.0
120	60	No overvoltage		0-120	3.3	**VT3N**	3.0
120	50	Basic 3.5A Model	11	0-120/140	3.5	**VT4**	5.25
120	50	No overvoltage	11	0-120	4.75	**VT4N**	5.25
120	50	Basic 7.5A Model	11	0-120/140	7.5	**VT8**	10.25
120	50	No overvoltage	11	0-120	10.0	**VT8N**	10.25
120	50	Basic 20A Model	11	0-120/140	20.0	VT20	22.0
120	50	No overvoltage	11	0-120	25.0	VT20N	22.0
240[2]	50	240V Input[2]		0-240/280	3.0	VT8H	10.25
240[2]	50	240V In. No ovrvlt.[2]		0-240	4.0	VT8HN	10.25
240[2]	50	240V Input[2]		0-240/280	9.0	VT20H	22.0
240[2]	50	240V In. No ovrvlt.[2]		0-240	11.0	VT20HN	22.0

SINGLE TRANSFORMERS — CASED (Dimensions p. 33)

Input Volts	Freq. Hz from[1]	Feature or Connection	U.L. see foot-notes below	Maximum Output Volts	Maximum Output Amps	Catalog No.[13]	Wt. Lbs.[7]
120	60[8]	Fixed Mtg.		0-120/132[4]	.8	(VT1E)	1.9
120	60[8]	Portable		0-132[3]	1.0	(VT-1F)	2.3
120	60	Fixed Mtg.		0-120	1.0	(VT1NE)	1.9
120	60	Portable		0-120	1.2	(VT1NF)	2.3
120	60[8]	Fixed Mtg.		0-120/132[4]	1.4	VT02E	2.8
120	60[8]	Portable		0-132[3]	1.75	VT02F	3.2
120	60	Fixed Mtg.		0-120	1.6	VT02NE	2.8
120	60	Portable		0-120	2.0	VT02NF	3.2
120	50	Fixed Mtg.	12	0-120/140[4]	2.8	VT4E	7.4
120	50	Portable	12	0-140[3]	3.5	VT4F	7.8
120	50	VT4F w/gnd. in. & out.	12	0-140[3]	3.5	VT4FC	7.8
120	50	Fixed Mtg.		0-120	3.8	(VT4NE)	7.4
120	50	Portable		0-120	4.75	VT4NF	7.8
120	50	VT4NF w/gnd. in. & out.		0-120	4.75	VT4NFC	7.8
120	50	Fixed Mtg.	12	0-120/140[4]	6.0	(VT8E)	13.5
120	50	Portable	12	0-140[3]	7.5	**VT8F**	13.8
120	50	VT8F w/gnd. in. & out.	12	0-140[3]	7.5	**VT8FC**	13.8
120	50	Deluxe Portable	12	0-120/140[3]	6.0	VT8G	14.2
120	50	VT8G w/gnd. in. & out.	12	0-120/140[3]	6.0	VT8GC	14.2
120	50	Fixed Mtg.		0-120	8.0	(VT8NE)	13.5
120	50	Portable		0-120	10.0	VT8NF	13.8
120	50	VT8NF w/gnd. in. & out.		0-120	10.0	VT8NFC	13.8
120	50	Basic Case		0-120/140	20.0	**VT20B**	22.5
120	50	Basic Case		0-120	25.0	(VT20NB)	22.5
120	50	Fixed Mtg.	12	0-120/140[4]	20.0	(VT20E)	29.0
120	50	Portable		0-140	20.0	(VT20FC)	31.0
120	50	Portable	12	0-120/140[3]	20.0	(VT20GC)	31.0
120	50	Fixed Mtg.	12	0-120	25.0	(VT20NE)	29.0
120	50	Portable		0-120	25.0	(VT20NFC)	31.0
240[2]	50	Basic Case		0-240/280	9.0	(VT20HB)	21.5
240[2]	50	Basic Case		0-240	11.0	(VT20HNB)	21.5
240[2]	50	Fixed Mtg.		0-240/280[4]	9.0	(VT20HE)	28.0
240[2]	50	Fixed Mtg.		0-240	11.0	(VT20HNE)	28.0
240[2]	50	Portable		0-240/280	9.0	(VT20HFC)	30.0
240[2]	50	Portable		0-240	11.0	(VT20HNFC)	30.0

SINGLE TRANSFORMERS — CASED WITH METERS (Dimensions p. 33)

Input Volts	Freq. Hz from[1]	Feature or Connection	Maximum Output Volts	Maximum Output Amps	Catalog No.[13]	Wt. Lbs.[7]
120	50	w/voltmeter, gnd. conn.	0-120/140[3]	6.0	VT8GCV	15.2
120	50	w/volt. & ammtr., gnd. conn.	0-120/140[3]	6.0	(VT8GCVA)	15.5
120	50	w/volt. & wattmtr., gnd. conn.	0-120/140[3]	6.0	(VT8GCVW)	15.5
120	50	w/voltmeter, gnd. conn.	0-120	10.0	(VT8NFCV)	14.8

SINGLE PHASE (contd.)

SINGLE TRANSFORMERS — CASED WITH METERS (Dimensions p. 33) (contd.)

Input Volts	Freq. Hz from[1]	Feature or Connection	Maximum Output Volts	Maximum Output Amps	Catalog No.[13]	Wt. Lbs.[7]
120	50	w/volt. & ammtr., gnd. conn.	0-120	10.0	(VT8NFCVA)	15.2
120	50	w/volt. & wattmtr., gnd. conn.	0-120	10.0	(VT8NFCVW)	15.2
120	50	w/voltmeter, gnd. conn.	0-120/140[3]	20.0	(VT20GCV)	32.0
120	50	w/volt. & ammtr., gnd. conn.	0-120/140[3]	20.0	(VT20GCVA)	32.2
120	50	w/volt. & wattmtr., gnd. conn.	0-120/140[3]	20.0	(VT20GCVW)	32.2
120	50	w/voltmeter, gnd. conn.	0-120	25.0	(VT20NFCV)	32.0
120	50	w/volt. & ammtr., gnd. conn.	0-120	25.0	(VT20NFCVA)	32.2
120	50	w/volt. & wattmtr., gnd. conn.	0-120	25.0	(VT20NFCVW)	32.2

TWO-IN-TANDEM ASSEMBLIES[5, 10] (Dimensions p. 33)

Input Volts	Freq. Hz from[1]	Feature or Connection	Maximum Output Volts	Maximum Output Amps	Catalog No.[13]	Wt. Lbs.[7]
240	60[8]	Series Conn.[6]	0-240/264	1.0	(VT1-2)	3.5
240	60	Series Conn.[6]	0-240	1.2	(VT1N-2)	3.5
240	60[8]	Series Conn.[6]	0-240/264	1.75	(VT02-2)	5.25
240	60	Series Conn.[6]	0-240	2.0	(VT02N-2)	5.25
240	60[8]	Series Conn.[6]	0-240/264	2.6	(VT3-2)	6.5
240	60	Series Conn.[6]	0-240	3.0	(VT3N-2)	6.5
240	50	Series Conn.[6]	0-240/280	3.5	(VT4-2)	11.3
240	50	Series Conn.[6]	0-240	4.75	(VT4N-2)	11.3
240	50	Series Conn.[6]	0-240/280	7.5	(VT8-2)	20.6
240	50	Series Conn.[6]	0-240	10.0	VT8N-2	20.6
240	50	Series Conn.[6]	0-240/280	20.0	(VT20-2)	45.0
240	50	Above unit, B case	0-240/280	20.0	(VT20-2B)	46.0
240	50	Series Conn.[6]	0-240	25.0	VT20N-2	45.0
240	50	Above unit, B case	0-240	25.0	(VT20N-2B)	46.0
480[2]	50	Series Conn.[6]	0-480/560	3.0	(VT8H-2)	20.6
480[2]	50	Series Conn.[6]	0-480	4.0	(VT8HN-2)	20.6
480[2]	50	Series Conn.[6]	0-480/560	9.0	(VT20H-2)	43
480[2]	50	Series Conn.[6]	0-480	11.0	(VT20HN-2)	43

THREE PHASE

Input Volts	Freq. Hz from[1]	Feature or Connection	Maximum Output Volts	Maximum Output Amps	Catalog No.[13]	Wt. Lbs.[7]
120	60[8]	Open Delta Conn.	0-120/132	1.0	(VT1-2)	3.5
120	60	Open Delta Conn.	0-120	1.2	(VT1N-2)	3.5
120	60[8]	Open Delta Conn.	0-120/132	1.75	(VT02-2)	5.25
120	60	Open Delta Conn.	0-120	2.0	(VT02N-2)	5.25
120	60[8]	Open Delta Conn.	0-120/132	2.6	(VT3-2)	6.5
120	60	Open Delta Conn.	0-120	3.0	(VT3N-2)	6.5
120	50	Open Delta Conn.	0-120/140	3.5	(VT4-2)	11.3
120	50	Open Delta Conn.	0-120	4.75	(VT4N-2)	11.3
120	50	Open Delta Conn.	0-120/140	7.5	(VT8-2)	20.6
120	50	Open Delta Conn.	0-120	10.0	VT8N-2	20.6
120	50	Open Delta Conn.	0-120/140	20.0	(VT20-2)	45.0
120	50	Above unit, B case	0-120/140	20.0	(VT20-2B)	46.0
120	50	Open Delta Conn.	0-120	25.0	(VT20N-2)	45.0
120	50	Above unit, B case	0-120	25.0	(VT20N-2B)	46.0
240[2]	50	Open Delta Conn.	0-240/280	3.0	(VT8H-2)	20.6
240[2]	50	Open Delta Conn.	0-240	4.0	(VT8HN-2)	20.6
240[2]	50	Open Delta Conn.	0-240/280	9.0	(VT20H-2)	43
240[2]	50	Open Delta Conn.	0-240	11.0	(VT20HN-2)	43

THREE-IN-TANDEM ASSEMBLIES[5, 10] (Dimensions p. 33)

Input Volts	Freq. Hz from[1]	Feature or Connection	Maximum Output Volts	Maximum Output Amps	Catalog No.[13]	Wt. Lbs.[7]
240	60	"Y" Conn.	0-240[9]	1.0	(VT1-3)	5.3
240	60	"Y" Conn.	0-240[9]	1.75	VT02-3	8.0
240	60	"Y" Conn.	0-240[9]	2.6	(VT3-3)	9.8
240	60[8]	"Y" Conn.	0-240/280	3.5	(VT4-3)	17.0
240	60[8]	"Y" Conn.	0-240/280	7.5	VT8-3	31.0
240	60[8]	Above unit, E case	0-240/280	6.0	(VT8-3E)	40.0
240	60[8]	"Y" Conn.	0-240/280	20.0	VT20-3	68.0
240	60[8]	Above unit, B case	0-240/280	20.0	VT20-3B	69.5
240	60	"Y" Conn.	0-240	25.0	(VT20N-3)	68.0
240	60	Above unit, B case	0-240	25.0	(VT20N-3B)	69.5
480[2]	60[8]	"Y" Conn.	0-480/560	3.0	**VT8H-3**	31.0
480[2]	60[8]	"Y" Conn.	0-480/560	9.0	(VT20H-3)	65.0
480[2]	60	"Y" Conn.	0-480	11.0	(VT20HN-3)	65.0

Footnotes for Stock Table

[1] Frequency shown is a minimum — units may be used up to 1000 cps.

[2] VT8H and VT20H and 240V output for VT8HN and VT20HN. With use of 120V input VT8H, VT8HN, VT20H, VT20HN also have taps for 120V input with 280V output for the max. current rating applies up to 120V output but reduces to approx. 50% at max. output voltage. In the case of tandem units, use of the low voltage inputs would correspondingly derate the current at the higher output voltages.

[3] Connected at factory for overvoltage output — easily reconnected by user for no-overvoltage output. On VT8G and VT20G, switch selects overvoltage or no-overvoltage.

[4] User wires for desired output. Dial normally calibrated for overvoltage.

[5] 2-in-tandem normally wired for series connection; 3-in-tandem for Y connection.

[6] When transformers are series connected, load cannot be grounded.

[7] Includes knob, dial and mounting hardware.

[8] May be used at 50 Hz if connected for no-overvoltage output.

[9] Overvoltage connection must not be used.

[10] 240/280 volt cw dial standard except on VT1, VT02 and VT3 tandems where 240/264 volt dial is standard or on VT8H-2, VT8HN-2, VT8H-3, VT20H-2, VT20HN-2, VT20H-3 and VT20HN-3 where 480/560 volt dial is standard. Request other dials if desired — see "Dials", previous page.

[11] Underwriters' Laboratories listed under components program (File Number E10946).

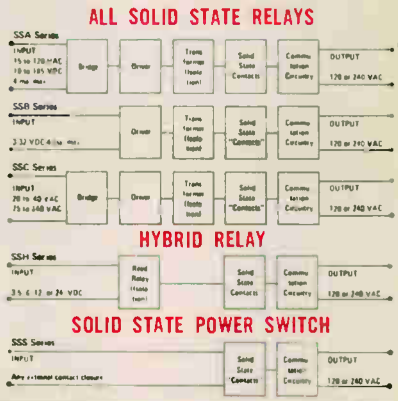
[12] Underwriters' Laboratories listed under apparatus program (File Number E10946).

[13] **Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a minimum handling charge per item.**

OHMITE® Solid State Relays & Switches

Originators of the HIGH POWER SOLID STATE RELAY

- For interfacing I.C. logic with motors, solenoids, lamps, heaters, etc.
- Complete false actuation protection
- Built-in inductive load commutation
- Substantially lower prices



SSB · 105 · SS · 1S

Input/Control Volts

SSA — 15-120 VAC/ 10-185 VDC
SSB — 3-32 VDC
SSC20 — 20-40 VAC/ 20-40 VDC
SSC120 — 75-140 VAC/ 40-185 VDC
SSH3 — 3-9 VDC
SSH6 — 5-9 VDC
SSH12 — 10-18 VDC
SSH24 — 20-30 VDC
SSS — Ext. Contact Closure

Load Volts

1 — 120 VAC
2 — 240 VAC

Load Amps[1]

02 — 2 amps
05 — 5 amps
10 — 10 amps
15 — 15 amps
25 — 25 amps

Contact Form

SS — SPST-N.O.
SD — SPDT Form D[2]
DS — DPST-N.O.[2]

Term. Style

1 — Solder/Faston
4 — P.C. Pins
5 — Octal Socket
6 — Octal Socket w/heatsink

Switching Option

No code= Standard Switch
S — Synchronous[3] (0 voltage turn-on)

Notes: [1] @ 25°C ambient, mounted. [2] Available SSA and SSB, 5A., std. switching only. [3] Available for models SSB, SSC, and SSH, SPST-N.O. "contact" form only. [4] 100 VDC max. for synch.

INPUT/CONTROL

	PURE SOLID STATE RELAYS								HYBRID RELAYS				S.S. POWER SWITCH
	SSA Series			SSB Series			SSC Series SPST-N.O., Form A		SSH Series SPST-N.O., Form A				SSS Series
	SPST-N.O.	DPST-N.O.	SPDT	SPST-N.O.	DPST-N.O.	SPDT	SSC20	SSC120	SSH3	SSH6	SSH12	SSH24	SPST-N.O.
Input Voltage	15 to 120 VAC 10 to 185 VDC[1]		25[2] to 120 VAC 10 to 185 VDC[1]	3 to 32 VDC (polarized)	4 to 32 VDC (polarized)	4 to 32 VDC (polarized)	20 to 40 VAC 20 to 40 VDC	75 to 140 VAC 40 to 185 VDC[4]	3 to 9 VDC 3.5 V. nom.	5 to 9 VDC 6 V. nom.	10 to 18 VDC 12 V. nom.	20 to 30 VDC 24 V. nom.	Any external contact closure capable of carrying 50 mA. current and insulated to withstand the line voltage being used.
Input Current	4 mA. max.	2.2 mA. max.	2.2 mA. max.	4 mA. max.	2.2 mA max.	2.2 mA.	10 mA. max.	18 mA. max.	11.5 mA.	33 mA.	17 mA.	10 mA.	
Threshold Volts	10 V. min.	10 V. min.	20 V. min. AC 10 V. min. DC	4.0 V. max.[3] 2.5 V. min.	4.5 V. max. 3.5 V. min.	4.5 V. max. 3.5 V. min.	5 VAC min. 5 VDC min.	20 VAC min. 10 VDC min.	3.5 V. max. 1.0 V. min.	5 V. max. 1 V. min.	10 V. max. 3 V. min.	20 V. max. 5 V. min.	
Dropout Volts	3	3	3	—	—	—	3	3	0.5 V.	0.5 V.	1.0 V.	2.0 V.	
Hysteresis	—	—	—	0.2 V.	0.2 V.	0.2 V.	—	—	—	—	—	—	
Coil Impedance	—	—	—	—	—	—	—	—	300 Ω	150 Ω	600 Ω	2000 Ω	

[1] Non-polarized. [2] Starting voltage for 120 VAC load model. 50 VAC start for 240 VAC load model. [3] 5.0 V. max. for synchronous switching models. [4] 100 VDC max. for synch.

OUTPUT/LOAD

Load Voltage: 120 or 240 VAC, rms., depending on model.

Load Ratings: (@ 25°C ambient).

Maximum:

Catalog Code	02	05	10	15	25
Mounted	2A.	5A.	10A.	15A.	25A
Free Air	2A.	3.5	4.5A.	5A.	8A

Minimum: 40 mA.

Surge Current: Withstand at least 10 times rated current for 1 cycle of load current.

Voltage Drop: Closed ("on"), 1.6 volts, typical.

Transient Protection: Ohmite relays and switches are protected from transient line voltages which can damage and cause false operation. Ohmite's field proven snubber network limits the dV/dT seen by the device to 1V/μsec., in the "off" state.

Dielectric Strength: 1500 Volts, rms for all units for input or output to heat sink. 1500 Volts, rms for input to output on standard non-synchronous units only.

Isolation:

Standard Switching:
500 Gigaohms between "coil" and "contacts," "contacts" to case and case to "coil."

Synchronous Switching:
500 Gigaohms between "coil" and case and "contacts" and case.
Between "coil" and "contacts:" See table.

	Load Voltage	
Series	120 V.	240 V.
SSC	220KΩ	470KΩ
SSB	200KΩ	470KΩ
SSH	150KΩ	220KΩ

Speed of Operation:

Drop-out (Turn "off"):
½ cycle load current, all models.

Pick-up (Turn "on"): See table.

Series	Switching Options: Std.	Switching Options: Synchro
SSA	500μsec.	—
SSB	500μsec.	½ cycle
SSC	500μsec.	½ cycle
SSH	1msec.	½ cycle
SSS	1msec.	—

MECHANICAL

Ambient Temperature Range: Storage: −55°C to +125°C. Operating: −40°C to +85°C**

Mounting: For full load ratings on Style 1 terminal models, mount 5 ampere models on an aluminum panel 6" square x ⅛" thick or equivalent; mount 10, 15 and 25 ampere models on a panel 9" square x 3/16" thick or equivalent. Ratings for styles 4 and 5 terminations are limited to the "free air" rating for Style 1 models unless an auxiliary heat dissipator used. Style 6 (octal socket with dissipator) models are rated 7 amperes maximum for equivalent Style 1, 10 and 15 ampere models.

Terminals: Style 1: Combination ¼" faston tab and solder lug. Also #8 screw adapters.* Style 4: Printed circuit pins, .032" diameter. Style 5: Octal socket (available on special order). Style 6: Octal socket w/heat sink (available on special order).

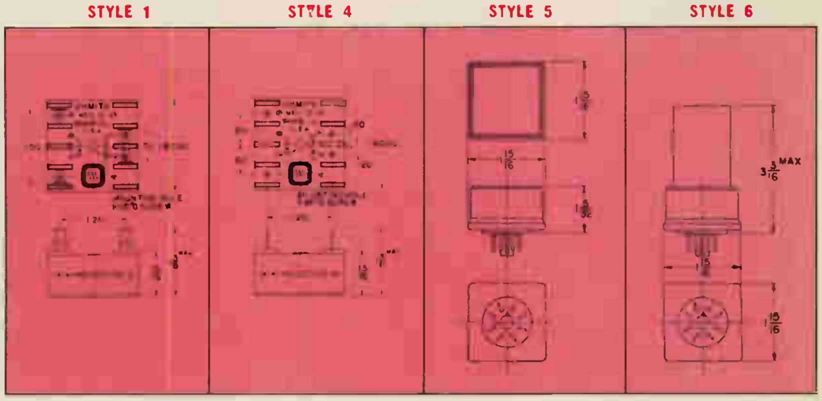
Weight: Approximately 2.5 ounces.

*Note: If screw terminals are required, specify Style 1 (faston tab) and order screw adapters, Cat. No. 5950, packed 10 per package.

**See factory for −55°C to +110°C Operating Temperature.

Note: For special requirements consult factory.

STYLE 1 STYLE 4 STYLE 5 STYLE 6



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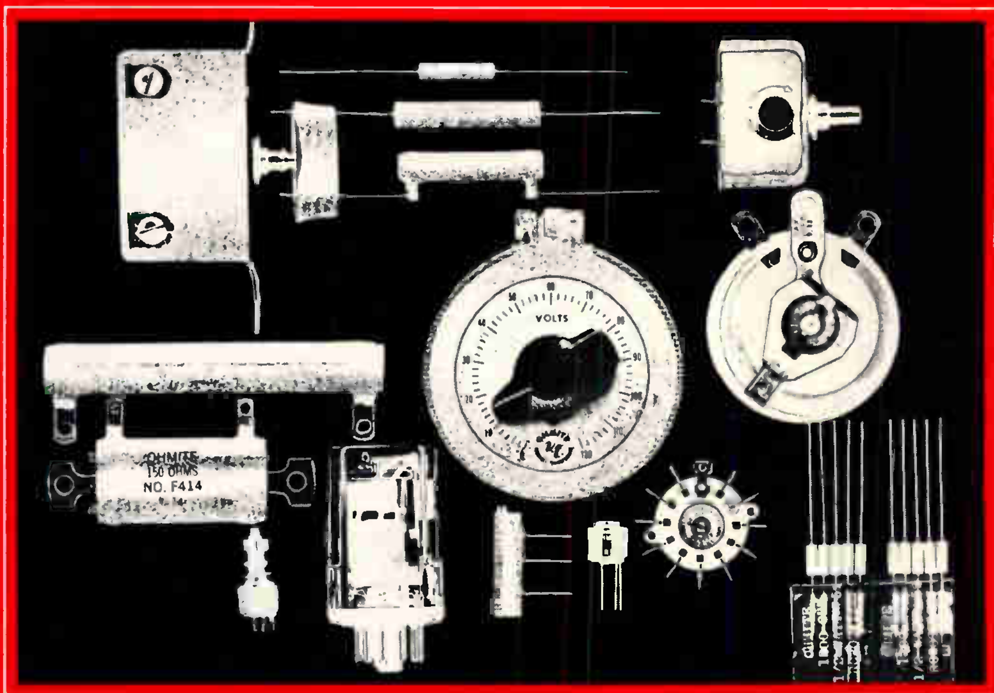
OHMITE

COMPONENT SELECTOR

Items in this catalog are available from authorized OHMITE Stocking Electronic Component Distributors.

CATALOG 300B

July, 1970 / Supersedes Catalog 300A



OHMITE
has the answer

CATALOG 300B

INDEX

PRODUCT LOCATOR

Catalog No.	Page	Description	Catalog No.	Page	Description
AFR101M-AFR505M	19	Single Turn Trimmer—¼ W.	1500-1557	10	Type 200 Resistor, 8 W.
ANP101M-ANP503M	19	25-Turn Trimmer—⅓ W.	1700-1772	10	Type 200 Resistor, 12 W.
AS3601-AS3684	23	Type AS Locking Pot.	1800-1860	10	Type 200 Resistor, 20 W.
ASM6661-ASM6676	23	Type AS ⅞" Shaft Pot.	1958-1959	9	Adjustable Lugs—Type 210
CA1041-CA5041	23	Type AB Potentiometer	1974	13	Adjustable Lugs—Corrib®
CB1031-CB5031	23	Type AB Potentiometer	2001-2018	11	Type 270N, 50 W.
CAB2-CAB48	16	Little Devil® Assortments	2050-2081	11	Type 270N, 12 W.
CAB91-CAB99	35	Type 995 Assortments	212-3 to 212-12-T3	24	Model 212 Tap Switch
CCU1031-CCU5041	23	Type AB Pot. Dual	2115-2171	9	Adjustable Lugs
CLU1011-CLU7542	23	Type AB Pot. Locking	2172-2176	13	Extra Term. Powr-Rib®
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0700-0725	8	Type 270 Resistor, 175 W.	5800-5897	3	PC-58 Radial Lead Resistor
0769-0796	9	Dividohm—75 Watt	5900-5909	4	Clips for Types 995 and 884
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0900-0925	8	Type 270 Resistor, 225 W.	6101-2 to 6120-K-4	18	Thru-bolt Type Brackets
0956-0973	9	Type 210 Resistor, 100 W.	6126P8½ to 6129P½	18	Thru-bolt Type Brackets
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ORDERING INFORMATION

For your convenience, we recommend that you place your orders with your local authorized OHMITE stocking distributor for standard OHMITE components listed in this catalog. Authorized OHMITE distributors stock factory-fresh OHMITE components in-depth and therefore are able to offer same-day or overnight service.

QUICK-DELIVERY COMPONENTS

You are assured of immediate delivery of those items listed in this catalog that appear in bold print. Bold listings indicate that these items have, over the years, become the most popular components on a national basis.

Items appearing in light face type are available from authorized OHMITE distributors but normally are not stocked in depth because they are not as popular as bold print items.

Items appearing in parentheses are non-stock standard items and are subject to a $15.00 per line item minimum charge.

FACTORY MINIMUM ORDER

The minimum order for standard components listed in this catalog, appearing in bold and light face type, ordered from the factory is $15.00 per order.

For items listed in parentheses, the minimum order is $15.00 per line item.

Most products are packaged in multiple packs. Orders for less-than-standard quantities will be automatically increased to the next standard package.

FACTORY TERMS

Standard payment terms for standard components ordered from the factory by firms with established credit is 1%, 10th and 25th, net 30 days. F.O.B. Skokie, Illinois.

RETURNS

Specific written permission to return goods must be obtained from your local OHMITE sales office.

DEC 1 6 1970

OHMITE radial lead resistors for P.C. boards

CLASS PC-58

3 WATT

5 WATT

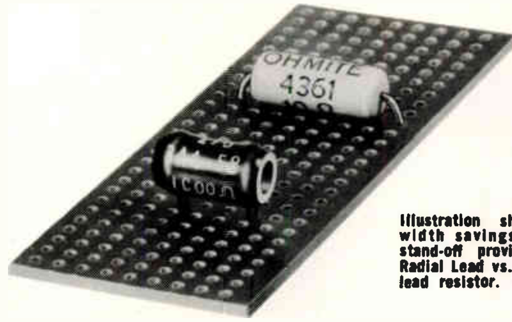


Illustration showing overall width savings and built-in stand-off provided by PC-58 Radial Lead vs. a typical axial lead resistor.

Increases productivity 28.1% — Saves circuit board space

If you are manually inserting axial lead resistors in printed circuit boards, it will pay you to examine the new Ohmite PC-58 resistor.

ADVANTAGES:

LABOR SAVING: Radial Leads eliminate cutting, bending, and forming of leads. Productivity is increased 28.1%. You achieve a 21.9% savings in labor cost. (Time Study Publication No. 163 available on request.)

SPACE SAVING: Radial leads reduce total length dimension required compared to axial lead types, increases packaging density possibilities.

POSITIVE POSITIONING: Built in stand-off automatically provides correct spacing between resistor and P.C. board.

COST SAVING: PC-58 resistors are priced lower than comparable axial lead types. This is in addition to savings in labor as explained above.

STANDARD SIZE: PC-58 Radial Leads fit standard .1 inch matrix boards with standard .046 inch diameter holes.

MARKINGS ALWAYS VISIBLE: Value and Ohmite code markings are always visible from the top of the PC-58. Eliminates time consuming orientation normally required of axial lead types.

CHOICE OF COATINGS: PC-58 resistors are available in ±5% tolerance with Vitreous Enamel (Type 270) for resistance values to 3300 ohms for 3-watt and to 6800 ohms for 5¼-watt or Ohmicone® silicone-ceramic (Type 470) for values over 3300 ohms and 6800 ohms for 3 and 5¼-watt sizes, respectively. For tolerances of ±3% and closer or for low T.C., specify Ohmicone® Type 474.

AVAILABILITY: Now standard PC-58 resistors are in stock at your local Ohmite authorized stocking distributor.

SPECIFICATIONS:

MECHANICAL

Coating: Vitreous Enamel or Ohmicone® (silicone-ceramic), depending on Type.

Terminals: Radial, solder-dipped.

Markings: Ohmite Code and Resistance (Ohms) Value.

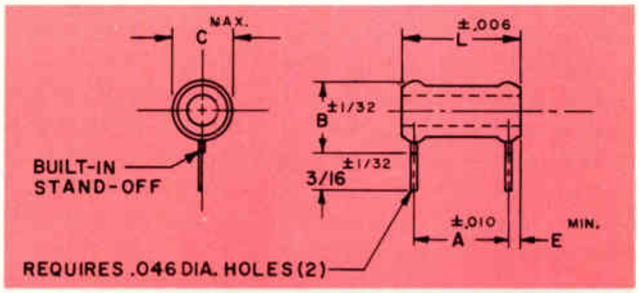
Weight: 3-Watt: .002 lbs.; 5¼ Watt: .003 lbs.

ELECTRICAL

Tolerance: ±5% for 1 ohm and above; ±10% below 1 ohm.

Wattage: 3-Watt, derated to 0 at 350°C—5¼-Watt, derated to 0 at 350°C

Temperature Coefficient: Less than 260 ppm/°C.



Rated Watts @ 25°C	DIMENSIONS (Inches)				
	A ±.010	B ±1/32	C Max.	E Min.	L ±.006
3	.300	.335	9/32	3/64	7/16
5¼	.500	.375	5/16	1/32	5/8

3-WATT

Free air rating thru 10K ohms.

Ohms	Catalog No.[1]	Max. Amps	Ohms	Catalog No.[1]	Max. Amps	Ohms	Catalog No.[1]	Max. Amps
1.0	5800	1.73	120	5817	.158	1200	5834	.0500
1.5	5801	1.41	150	5818	.141	1500	5835	.0447
2.0	5802	1.22	200	5819	.122	1800	5836	.0408
2.4	5803	1.12	250	5820	.110	2000	5837	.0387
3.0	5804	1.00	270	5821	.105	2500	5838	.0346
4.0	5805	.866	300	5822	.100	2700	5839	.0333
5.0	5806	.774	330	5823	.0953	3000	5840	.0316
7.5	5807	.632	400	5824	.0866	4000	5841*	.0274
10.0	5808	.548	450	5825	.0816	4700	5842*	.0253
15	5809	.447	500	5826	.0775	5000	5843*	.0245
20	5810	.387	560	5827	.0732	5600	5844*	.0231
30	5811	.316	600	5828	.0707	6200	5845*	.0220
50	5812	.245	620	5829	.0696	7000	5846*	.0209
56	5813	.231	750	5830	.0632	7500	5847*	.0200
68	5814	.210	800	5831	.0612	9000	5848*	.0182
82	5815	.191	900	5832	.0577	10000	5849*	.0173
100	5816	.173	1000	5833	.0548			

*NOTE: These resistors are Ohmicone® Coated, Type 470.

5¼-WATT

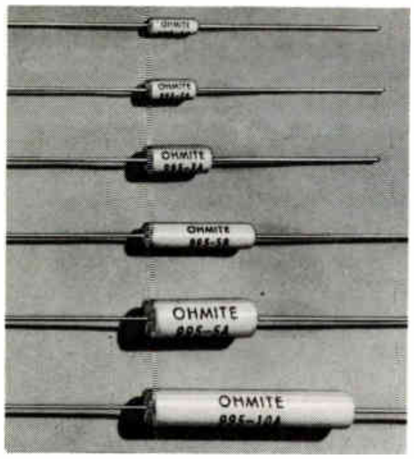
Free air rating thru 15K ohms.

Ohms	Catalog No.[1]	Max. Amps	Ohms	Catalog No.[1]	Max. Amps	Ohms	Catalog No.[1]	Max. Amps
1.0	5850	2.29	100	5864	.229	1800	5882	.0540
1.5	5850A	1.87	120	5865	.209	2000	5883	.0512
2.0	5851	1.62	150	5866	.187	2200	5883A	.0488
3.0	5851A	1.32	160	5867	.181	2500	5884	.0458
4.0	5851B	1.15	200	5868	.162	3000	5885	.0418
5.0	5852	1.02	220	5869	.154	3300	5885A	.0399
5.6	5852A	.968	250	5870	.145	3900	5885B	.0367
10.0	5853	.725	270	5870A	.139	4000	5886	.0362
15	5854	.592	300	5871	.132	4500	5887	.0341
18	5855	.540	330	5872	.126	5000	5888	.0324
20	5856	.512	350	5873	.122	5600	5889	.0306
22	5856A	.489	400	5874	.115	6000	5890	.0296
25	5857	.458	500	5875	.102	7500	5891*	.0265
30	5858	.418	510	5875A	.101	8200	5892*	.0253
40	5859	.362	560	5875B	.0968	9000	5893*	.0241
50	5860	.324	600	5876	.0935	9100	5893A*	.0240
51	5860A	.321	750	5877	.0837	10000	5894*	.0229
56	5860B	.306	800	5878	.0810	12000	5895*	.0209
68	5861	.278	1000	5879	.0725	15000	5896*	.0187
75	5862	.265	1200	5880	.0661	20000	5897*	.0152
82	5863	.253	1300	5881	.0635			

*NOTE: These resistors are Ohmicone® Coated, Type 470.

[1] All standard values shown above are popular values and are stocked by authorized OHMITE stocking distributors.

OHMITE type 995 MOLDED axial lead vitreous enameled resistors

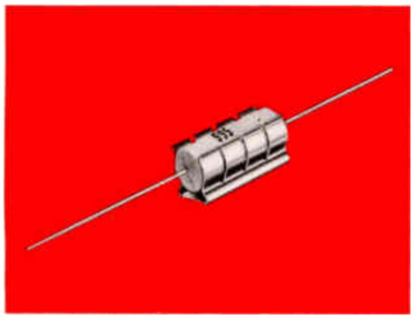


- **FIRST MOLDED WIREWOUND, VITREOUS ENAMEL RESISTOR**
- **INSULATED! Meets 1000 VAC Test**
- **WITHSTANDS 1500°F Temperatures without Distortion**
- **RESISTS Chipping, Breaking**
- **VITRIFIED MARKINGS, Resist Abrasion and Active Solvents**
- **UNIFORM SIZE Permits Clip-Mounting with Significant Heat Sink Benefits**
- **HIGH OVERLOAD CAPABILITY**

An exclusive technique (U. S. Patent No.'s 3,229,237 and 3,489,828) permits application of the vitreous enamel coating by **molding** instead of the conventional "dip" process. The dimensionally consistent and thicker coating that results, guarantees a 1000 VAC insulation rating plus unparalleled capability for withstanding very high temperatures, high humidity and immersion in salt solution.

These resistors are normally mounted by their axial leads. However, their consistent form also permits mounting in clips with heat sink benefits up to 100% (see "Clips" lower left). Resistor markings are also vitreous and will not burn off even under extreme overloads. Resistance tolerance is ±5%. Series 99 resistors meet the requirements of MIL-R-26 for "insulated" resistors. See Catalog 101 for specific MIL types.

MOUNTING CLIPS



Uniform shape and consistent dimensions of Series 99 and 88 (pages 6-7) resistors, permits them to be conveniently mounted in clips. If the clip is on a metal surface, the wattage capability of the resistor can increase by as much as 100%. Holes in clip base permit fastening to chassis by means of machine screws, eyelets or rivets.

CLIPS for TYPE 995 and 884* RESISTORS

Resistor Watts	Resistor Series	Clip Stock No.
1½	99	5900
2¼	99	5902
3	88	5904
3¼	99	5904
5	88	5905
5	99	5906
10	88	5909
11	99	5908

* See pages 6 and 7 for Type 884 resistors

1½ WATT

.422"x.125" Dia. Style 995-1A Avg. Wt., .0009 lb.

Ohms	Catalog No.[1]	Max. Amps	Ohms	Catalog No.[1]	Max. Amps
1.0	**4030**	1.24	75	4087	.141
1.1	(4031)	1.17	82	4089	.135
1.2	4032	1.12	91	**4091**	.128
1.3	4033	1.08	100	**4092**	.123
1.5	**4034**	1.00	110	**4093**	.117
1.6	4035	.97	120	4094	.112
1.8	4036	.91	130	4095	.108
2.0	**4037**	.87	150	(4096)	.100
2.2	**4038**	.83	160	(4097)	.097
2.4	4039	.79	180	4098	.091
2.7	4041	.75	200	**4099**	.087
3.0	**4042**	.71	220	**4100**	.083
3.3	4043	.67	240	(4101)	.079
3.6	4044	.65	250	(4102)	.077
3.9	4045	.62	270	(4103)	.075
4.0	4046	.61	300	**4104**	.071
4.3	(4047)	.59	330	**4105**	.067
4.7	(4048)	.56	350	(4105A)	.065
5.0	**4049**	.55	360	4106	.064
5.1	(4050)	.54	390	(4107)	.062
5.6	4051	.52	400	(4108)	.061
6.2	4053	.49	430	4109	.059
6.8	4054	.47	450	4109A	.058
7.5	4056	.45	470	**4110**	.056
8.2	4058	.43	500	**4111**	.055
9.1	(4060)	.41	510	**4112**	.054
10	**4061**	.39	560	4113	.052
11	4062	.37	600	**4114**	.050
12	4063	.35	620	4115	.049
13	4064	.34	680	4116	.047
15	(4065)	.32	700	4117	.046
16	4066	.31	750	4118	.045
18	(4067)	.29	800	4119	.043
20	4068	.27	820	(4120)	.043
22	4069	.26	900	(4121)	.041
24	4070	.25	910	(4122)	.041
25	(4071)	.25	1000	**4123**	.039
27	4072	.24	1100	(4124)	.037
30	4073	.22	1200	4125	.035
33	4074	.21	1300	4126	.034
35	(4074A)	.207	1400	(4126A)	.033
36	(4075)	.200	1500	**4127**	.032
39	4076	.196	1600	4128	.031
40	4077	.193	1800	4129	.029
43	(4078)	.187	2000	**4130**	.027
47	(4079)	.179	2200	4131	.026
50	**4080**	.173	2400	(4132)	.025
51	(4081)	.171	2500	4133	.025
56	4082	.164	2700	(4134)	.024
62	4084	.156	3000	**4135**	.022
68	4085	.149			

2¼ WATT

.375"x.188" Dia. Style 995-2A Avg. Wt., .0018 lb.

Ohms	Catalog No.[1]	Max. Amps	Ohms	Catalog No.[1]	Max. Amps
1.0	3860	1.50	68	(3916)	.18
1.1	(3861)	1.43	75	(3918)	.17
1.2	(3862)	1.37	82	(3920)	.16
1.3	(3863)	1.31	91	(3922)	.16
1.5	(3864)	1.22	100	3923	.15
1.6	3865	1.18	110	(3924)	.14
1.8	(3866)	1.11	120	(3925)	.14
2.0	(3867)	1.05	130	3926	.13
2.2	3868	1.01	150	**3927**	.12
2.4	(3869)	.97	160	3928	.12
2.7	(3871)	.91	180	**3929**	.11
3.0	3872	.86	200	(3930)	.10
3.3	3873	.82	220	3931	.10
3.6	(3874)	.79	240	(3932)	.097
3.9	(3875)	.76	250	3933	.094
4.0	3876	.73	270	3934	.091
4.3	(3877)	.72	300	3935	.086
4.7	3878	.69	330	(3936)	.082
5.0	3879	.67	350	3937	.080
5.1	3880	.66	360	(3938)	.079
5.6	3881	.63	390	(3939)	.076
6.2	3883	.60	400	(3940)	.075
6.8	3884	.57	430	(3941)	.072
7.5	(3886)	.55	450	(3942)	.071
8.2	3888	.52	470	3943	.069
9.1	(3890)	.50	500	3944	.067
10	3891	.47	510	(3945)	.066
11	3892	.45	560	(3946)	.063
12	3893	.43	600	(3947)	.061
13	(3894)	.41	620	(3948)	.060
15	3895	.39	680	(3949)	.057
16	(3896)	.37	700	**3950**	.056
18	(3897)	.35	750	(3951)	.055
20	3898	.33	800	(3952)	.053
22	3899	.32	820	3953	.052
24	(3900)	.31	900	(3954)	.050
25	3901	.30	910	(3955)	.050
27	3902	.29	1000	**3956**	.047
30	(3903)	.27	1100	3957	.045
33	(3904)	.26	1200	**3958**	.043
35	(3905)	.25	1300	3959	.041
36	(3906)	.25	1400	(3960)	.040
39	**3907**	.24	1500	(3961)	.039
40	(3908)	.24	1600	(3962)	.037
43	3909	.23	1800	(3963)	.035
47	3910	.22	2000	3964	.033
50	(3911)	.21	2200	3965	.032
51	(3912)	.21	2400	(3966)	.031
56	(3913)	.20	2500	3967	.030
62	3915	.19	2700	(3968)	.028
			3000	(3969)	.027

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

OHMITE type 995 MOLDED axial lead vitreous enameled resistors

3¼ WATT

.547"x.203" Dia. Style 995-3A Avg. Wt., .003 lb.

Ohms	Catalog No.[1]	Max. Amps	Ohms	Catalog No.[1]	Max. Amps
1.0	**4330**	1.80	200	**4399**	.13
1.1	(4331)	1.71	220	**4400**	.12
1.2	(4332)	1.65	240	4401	.11
1.3	(4333)	1.58	250	**4402**	.11
1.5	**4334**	1.47	270	**4403**	.109
1.6	(4335)	1.42	300	**4404**	.100
1.8	4336	1.34	330	**4405**	.099
2.0	**4337**	1.27	350	(4405A)	.096
2.2	4338	1.22	360	4406	.095
2.4	4339	1.16	390	**4407**	.091
2.7	**4341**	1.09	400	**4408**	.090
3.0	**4342**	1.04	430	4409	.087
3.3	4343	.99	450	**4409A**	.084
3.6	4344	.95	470	**4410**	.083
3.9	(4345)	.91	500	**4411**	.081
4.0	**4346**	.90	510	4412	.080
4.3	4347	.87	560	**4413**	.076
4.7	4348	.83	600	**4414**	.073
5.0	**4349**	.81	620	**4415**	.072
5.1	4350	.80	680	**4416**	.069
5.6	4351	.76	700	**4417**	.068
6.2	4353	.72	750	**4418**	.065
6.8	**4354**	.69	800	**4419**	.064
7.5	**4356**	.65	820	4420	.063
8.2	4358	.63	900	**4421**	.060
9.1	4360	.60	910	4422	.060
10	**4361**	.56	1000	**4423**	.056
11	4362	.54	1100	**4424**	.054
12	4363	.52	1200	**4425**	.052
13	4364	.50	1300	**4426**	.050
15	**4365**	.47	1400	(4426A)	.048
16	(4366)	.45	1500	**4427**	.047
18	**4367**	.42	1600	4428	.045
20	**4368**	.40	1800	**4429**	.042
22	**4369**	.39	2000	**4430**	.040
24	(4370)	.36	2200	**4431**	.039
25	**4371**	.36	2400	4432	.036
27	4372	.35	2500	**4433**	.036
30	**4373**	.30	2700	**4434**	.035
33	**4374**	.31	3000	**4435**	.033
35	4374A	.30	3300	**4436**	.031
36	(4375)	.30	3500	4436A	.030
39	**4376**	.29	3600	(4437)	.030
40	**4377**	.28	3900	4438	.029
43	(4378)	.27	4000	**4439**	.028
47	**4379**	.26	4300	(4440)	.027
50	**4380**	.25	4500	(4440A)	.027
51	4381	.25	4700	**4441**	.026
56	**4382**	.24	5000	**4442**	.025
62	4384	.23	5100	(4443)	.025
68	**4385**	.22	5600	4444	.024
75	**4387**	.21	6000	4445	.023
82	**4389**	.20	6200	4446	.023
91	4391	.19	6800	4447	.022
100	**4392**	.18	7000	**4448**	.021
110	(4393)	.17	7500	**4449**	.021
120	**4394**	.16	8000	4450	.020
130	4395	.16	8200	**4451**	.020
150	**4396**	.15	9000	4452	.019
160	4397	.14	9100	(4453)	.019
180	4398	.13	10000	**4454**	.018

5 WATT

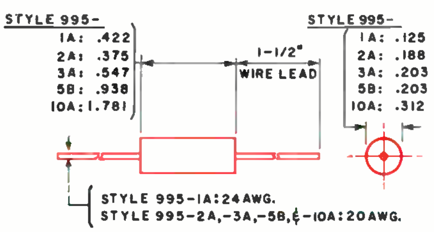
.938"x.203" Dia. Style 995-5B Avg. Wt., .004 lb.

Ohms	Catalog No.[1]	Max. Amps	Ohms	Catalog No.[1]	Max. Amps
1.0	**4530**	2.24	330	**4605**	.12
1.1	4531	2.13	350	**4605A**	.12
1.2	**4532**	2.04	360	(4606)	.12
1.3	(4533)	1.96	390	**4607**	.11
1.5	**4534**	1.83	400	**4608**	.11
1.6	4535	1.77	430	(4609)	.11
1.8	4536	1.67	450	4609A	.11
2.0	**4537**	1.58	470	**4610**	.10
2.2	4538	1.51	500	**4611**	.10
2.4	4539	1.44	510	**4612**	.10
2.7	4541	1.36	560	**4613**	.094
3.0	**4542**	1.29	600	**4614**	.091
3.3	(4543)	1.23	620	4615	.090
3.6	4544	1.18	680	4616	.086
3.9	(4545)	1.13	700	4617	.084
4.0	**4546**	1.11	750	**4618**	.082
4.3	(4547)	1.07	800	**4619**	.079
4.7	4548	1.03	820	**4620**	.078
5.0	**4549**	1.00	900	4621	.074
5.1	4550	.99	910	(4622)	.074
5.6	**4551**	.94	1000	**4623**	.071
6.2	4553	.90	1100	4624	.067
6.8	(4554)	.86	1200	**4625**	.065
7.5	4556	.82	1300	**4626**	.062
8.2	4558	.78	1400	(4626A)	.059
9.1	(4560)	.74	1500	**4627**	.058
10	**4561**	.71	1600	4628	.056
11	(4562)	.67	1800	**4629**	.053
12	**4563**	.65	2000	**4630**	.050
13	4564	.62	2200	**4631**	.048
15	**4565**	.58	2400	4632	.046
16	4566	.56	2500	**4633**	.045
18	**4567**	.53	2700	**4634**	.043
20	**4568**	.50	3000	**4635**	.041
22	**4569**	.48	3300	**4636**	.039
24	4570	.46	3500	4636A	.038
25	**4571**	.45	3600	(4637)	.037
27	4572	.43	3900	**4638**	.036
30	**4573**	.41	4000	**4639**	.035
33	4574	.39	4300	**4640**	.034
35	4574A	.38	4500	**4640A**	.033
36	(4575)	.37	4700	**4641**	.033
39	**4576**	.36	5000	**4642**	.032
40	**4577**	.35	5100	(4643)	.031
43	4578	.34	5600	**4644**	.030
47	**4579**	.33	6000	**4645**	.029
50	**4580**	.32	6200	(4646)	.028
51	**4581**	.31	6800	**4647**	.027
56	**4582**	.30	7000	4648	.027
62	4584	.28	7500	**4649**	.026
68	**4585**	.27	8000	**4650**	.025
75	**4587**	.26	8200	**4651**	.025
82	**4589**	.25	9000	**4652**	.024
91	(4591)	.23	9100	**4653**	.023
100	**4592**	.22	10000	**4654**	.022
110	4593	.21	11000	(4655)	.021
120	**4594**	.20	12000	**4656**	.020
130	4595	.20	13000	(4657)	.020
150	**4596**	.18	14000	(4657A)	.018
160	**4597**	.18	15000	**4658**	.018
180	4598	.17	16000	4659	.018
200	**4599**	.16	17000	4659B	.017
220	**4600**	.15	18000	4660	.017
240	4601	.14	20000	**4661**	.016
250	**4602**	.14	22000	**4662**	.015
270	**4603**	.14	24000	(4663)	.014
300	**4604**	.13	25000	**4664**	.014

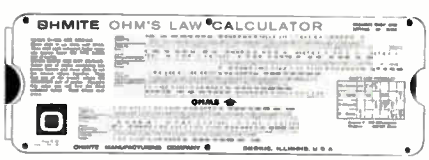
11 WATT

1.781"x.312" Dia. Style 995-10A Avg. Wt., .015 lb.

Ohms	Catalog No.[1]	Max. Amps	Ohms	Catalog No.[1]	Max. Amps
1.0	**4730**	3.32	450	(4809A)	.16
1.1	4731	3.16	470	**4810**	.15
1.2	(4732)	3.03	500	**4811**	.15
1.3	(4733)	2.91	510	4812	.15
1.5	4734	2.71	560	(4813)	.14
1.6	(4735)	2.62	600	4814	.14
1.8	4736	2.42	620	(4815)	.13
2.0	**4737**	2.34	680	4816	.13
2.2	(4738)	2.24	700	4817	.12
2.4	(4739)	2.14	750	**4818**	.12
2.7	4741	2.02	800	(4819)	.12
3.0	**4742**	1.92	820	4820	.12
3.3	(4743)	1.83	900	4821	.11
3.6	4744	1.75	910	4822	.11
3.9	(4745)	1.67	1000	**4823**	.11
4.0	**4746**	1.66	1100	4824	.10
4.3	4747	1.60	1200	4825	.096
4.7	4748	1.53	1300	(4826)	.092
5.0	**4749**	1.48	1400	4826A	.089
5.1	(4750)	1.47	1500	**4827**	.086
5.6	(4751)	1.40	1600	4828	.083
6.2	4753	1.33	1800	4829	.078
6.8	4754	1.27	2000	**4830**	.074
7.5	**4756**	1.21	2200	4831	.071
8.2	4758	1.16	2400	(4832)	.068
9.1	(4760)	1.10	2500	**4833**	.066
10	**4761**	1.05	2700	**4834**	.064
11	4762	1.00	3000	**4835**	.061
12	(4763)	.96	3300	4836	.058
13	4764	.92	3500	4836A	.056
15	**4765**	.86	3600	4837	.055
16	4766	.83	3900	(4838)	.053
18	4767	.78	4000	**4839**	.052
20	**4768**	.74	4300	4840	.050
22	**4769**	.71	4500	4840A	.049
24	(4770)	.68	4700	4841	.048
25	**4771**	.66	5000	**4842**	.047
27	4772	.64	5100	(4843)	.046
30	**4773**	.61	5600	4844	.044
33	**4774**	.58	6000	**4845**	.043
35	4774A	.56	6200	(4846)	.042
36	(4775)	.55	6800	**4847**	.040
39	**4776**	.53	7000	4848	.040
40	**4777**	.52	7500	4849	.038
43	4778	.50	8000	(4850)	.037
47	4779	.48	8200	4851	.037
50	**4780**	.47	9000	(4852)	.035
51	(4781)	.46	9100	(4853)	.035
56	4782	.44	10000	**4854**	.033
62	(4784)	.42	11000	4855	.031
68	**4785**	.40	12000	4856	.030
75	**4787**	.38	13000	(4857)	.029
82	**4789**	.37	14000	(4857B)	.028
91	(4791)	.35	15000	**4858**	.027
100	**4792**	.33	16000	(4859A)	.026
110	(4793)	.31	17000	(4859C)	.025
120	4794	.30	18000	(4860)	.024
130	4795	.29	20000	4861	.023
150	**4796**	.27	22000	4862	.022
160	4797	.26	24000	4863	.021
180	4798	.24	25000	**4864**	.021
200	**4799**	.23	27000	4865	.020
220	**4800**	.22	30000	4866	.019
240	4801	.21	33000	(4867)	.018
250	**4802**	.21	35000	(4867A)	.018
270	(4803)	.20	36000	4868	.017
300	**4804**	.19	39000	(4869)	.017
330	4805	.18	40000	**4870**	.016
350	**4805A**	.18	43000	4871	.016
360	(4806)	.17	45000	4871A	.016
390	(4807)	.17	47000	4872	.015
400	4808	.16	50000	**4873**	.015
430	4809	.16	51000	**4874**	.015



OHM'S LAW CALCULATOR . . .

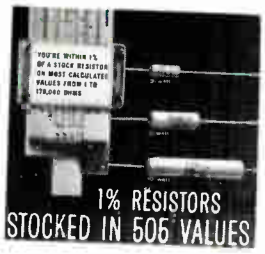


Solve Ohm's Law/Parallel Resistance problems with Ohmite's pocket-sized calculator. Also convenient A, B, C, and D slide rule scales for supplementary calculations. Resistance scales from 0.01 ohm to 100 megohms. Varnished cardboard or deluxe plastic model.

Type	Stock No.	Price
Cardboard	5180	$0.25
Plastic	5182	1.50

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

OHMITE type 884 Riteohm® Resistors—1% tolerance



molded for uniform shape and size

miniature precision resistors—1% tolerance

OHMICONE® molded • wirewound • aged for stability • insulated for 1000 volts • low T.C.

Type 884 Riteohm® Resistors are stocked in power ratings of 3, 5 and 10 watts depending upon resistance. Single layer wound on ceramic cores. Riteohm resistors feature a pressure-molded coating of tough, resilient Ohmicone® silicone-ceramic material which meets the MIL-R-26, 1000 VAC insulation test. Riteohms are aged for long term stability and exhibit negligible inductance at audio frequencies. Temperature coefficient of resistance is 0±10ppm/°C[1] for most values. Values shown are based on the MIL-Bell system of standard values. For non-standard values, closer tolerances, etc. contact your local Ohmite office.

3 WATTS	Rating in Free Air for Resistance Values to [illegible] Ohms	
Ohms	Catalog No.[2]	Max. Volts
0.100	80013	.547
0.121	80023	.602
0.150	80033	.670
0.182	(80043)	.739
0.200	80053	.774
0.221	80063	.814
0.249	80073	.864
0.274	80083	.906
0.332	(80093)	.998
0.392	80103	1.08
0.475	80113	1.19
0.499	80123	1.22
0.562	(80133)	1.30
0.681	80143	1.43
0.750	80153	1.50
0.825	80163	1.57
1.00	**80173**	1.73
1.02	(80183)	1.75
1.05	(80193)	1.77
1.07	(80203)	1.79
1.10	80213	1.82
1.13	(80223)	1.84
1.15	(80233)	1.86
1.18	(80243)	1.88
1.21	(80253)	1.91
1.24	(80263)	1.93
1.27	(80273)	1.95
1.30	(80283)	1.97
1.33	(80293)	2.00
1.37	(80303)	2.03
1.40	(80313)	2.05
1.43	80323	2.07
1.47	(80333)	2.10
1.50	80343	2.12
1.54	(80353)	2.15
1.58	(80363)	2.18
1.62	(80373)	2.20
1.65	(80383)	2.22
1.69	(80393)	2.25
1.74	(80403)	2.28
1.78	(80413)	2.31
1.82	(80423)	2.34
1.87	(80433)	2.37
1.91	(80443)	2.39
1.96	(80453)	2.42
2.00	80463	2.45
2.05	(80473)	2.48
2.10	(80483)	2.51
2.15	(80493)	2.54
2.21	(80503)	2.57
2.26	(80513)	2.60
2.32	(80523)	2.64
2.37	(80533)	2.67
2.43	(80543)	2.70
2.49	80553	2.73
2.55	(80563)	2.77
2.61	(80573)	2.80
2.67	(80583)	2.83
2.74	(80593)	2.87
2.80	(80603)	2.90
2.87	(80613)	2.93
2.94	(80623)	2.97
3.01	80633	3.00
3.09	(80643)	3.04
3.16	(80653)	3.08
3.24	(80663)	3.12
3.32	80673	3.16
3.40	(80683)	3.19
3.48	(80693)	3.23
3.57	(80703)	3.27
3.65	(80713)	3.31
3.74	(80723)	3.35

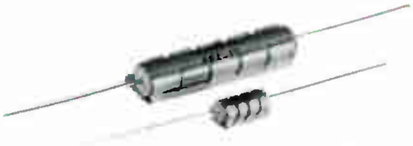
3 WATTS	Rating in Free Air for Resistance Values to [illegible] Ohms	
Ohms	Catalog No.[2]	Max. Volts
3.83	(80733)	3.39
3.92	(80743)	3.43
4.02	80753	3.47
4.12	(80763)	3.51
4.22	(80773)	3.56
4.32	(80783)	3.60
4.42	80793	3.64
4.53	80803	3.69
4.64	(80813)	3.73
4.75	(80823)	3.77
4.87	(80833)	3.82
4.99	(80843)	3.87
5.11	80853	3.91
5.23	(80863)	3.96
5.36	(80873)	4.01
5.49	(80883)	4.06
5.62	(80893)	4.10
5.76	(80903)	4.16
5.90	(80913)	4.20
6.04	(80923)	4.25
6.19	(80933)	4.31
6.34	(80943)	4.36
6.49	(80953)	4.41
6.65	(80963)	4.46
6.81	80973	4.52
6.98	(80983)	4.57
7.15	(80993)	4.63
7.32	(81003)	4.68
7.50	81013	4.74
7.68	(81023)	4.80
7.87	(81033)	4.86
8.06	81043	4.92
8.25	(81053)	4.97
8.45	(81063)	5.04
8.66	(81073)	5.10
8.87	(81083)	5.16
9.09	81093	5.22
9.31	(81103)	5.28
9.53	(81113)	5.34
9.76	(81123)	5.41
10.0	**81133**	5.47
10.2	(81143)	5.53
10.5	(81153)	5.61
10.7	(81163)	5.66
11.0	81173	5.74
11.3	(81183)	5.82
11.5	(81193)	5.87
11.8	(81203)	5.95
12.1	81213	6.02
12.4	(81223)	6.10
12.7	(81233)	6.17
13.0	81243	6.24
13.3	(81253)	6.32
13.7	(81263)	6.41
14.0	81273	6.48
14.3	(81283)	6.55
14.7	(81293)	6.64
15.0	81303	6.70
15.4	(81313)	6.80
15.8	(81323)	6.88
16.2	(81333)	6.97
16.5	(81343)	7.03
16.9	(81353)	7.12
17.4	(81363)	7.22
17.8	(81373)	7.30
18.2	81383	7.39
18.7	(81393)	7.49
19.1	(81403)	7.57
19.6	(81413)	7.66
20.0	81423	7.74
20.5	(81433)	7.84
21.0	(81443)	7.94

3 WATTS	Rating in Free Air for Resistance Values to [illegible] Ohms	
Ohms	Catalog No.[2]	Max. Volts
21.5	(81453)	8.03
22.1	81463	8.14
22.6	(81473)	8.23
23.2	(81483)	8.34
23.7	(81493)	8.43
24.3	81503	8.54
24.9	81513	8.64
25.5	(81523)	8.74
26.1	(81533)	8.84
26.7	(81543)	8.95
27.4	81553	9.06
28.0	(81563)	9.16
28.7	(81573)	9.28
29.4	(81583)	9.39
30.1	81593	9.50
30.9	(81603)	9.62
31.6	(81613)	9.74
32.4	(81623)	9.86
33.2	81633	9.98
34.0	(81643)	10.1
34.8	81653	10.2
35.7	(81663)	10.3
36.5	(81673)	10.5
37.4	(81683)	10.6
38.3	81693	10.7
39.2	81703	10.8
40.2	**81713**	11.0
41.2	(81723)	11.1
42.2	(81733)	11.2
43.2	81743	11.4
44.2	(81753)	11.5
45.3	(81763)	11.7
46.4	(81773)	11.8
47.5	81783	11.9
48.7	(81793)	12.1
49.9	81803	12.2
51.1	81813	12.4
52.3	(81823)	12.5
53.6	(81833)	12.7
54.9	(81843)	12.8
56.2	81853	13.0
57.6	(81863)	13.1
59.0	81873	13.3
60.4	81883	13.4
61.9	81893	13.6
63.4	(81903)	13.8
64.9	(81913)	13.9
66.5	(81923)	14.1
68.1	81933	14.3
69.8	(81943)	14.5
71.5	(81953)	14.6
73.2	(81963)	14.8
75.0	81973	15.0
76.8	(81983)	15.2
78.7	(81993)	15.4
80.6	(82003)	15.5
82.5	82013	15.7
84.5	(82023)	15.9
86.6	(82033)	16.1
88.7	82043	16.3
90.9	82053	16.5
93.1	(82063)	16.7
95.3	(82073)	16.9
97.6	(82083)	17.1
100	**82093**	17.3
102	(82103)	17.5
105	(82113)	17.7
107	(82123)	17.9
110	(82133)	18.2
113	(82143)	18.4
115	82153	18.6
118	(82163)	18.8

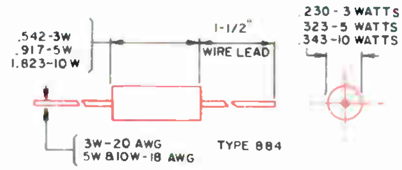
3 WATTS	Rating in Free Air for Resistance Values to [illegible] Ohms	
Ohms	Catalog No.[2]	Max. Volts
121	82173	19.1
124	(82183)	19.3
127	(82193)	19.5
130	82203	19.7
133	(82213)	20.0
137	(82223)	20.3
140	(82233)	20.5
143	(82243)	20.7
147	(82253)	21.0
150	82263	21.2
154	(82273)	21.5
158	(82283)	21.8
162	82293	22.0
165	(82303)	22.2
169	82313	22.5
174	82323	22.8
178	82333	23.1
182	82343	23.4
187	(82353)	23.7
191	(82363)	23.9
196	(82373)	24.2
200	82383	24.5
205	82393	24.8
210	(82403)	25.1
215	82413	25.4
221	82423	25.7
226	(82433)	26.0
232	(82443)	26.4
237	(82453)	26.7
243	(82463)	27.0
249	82473	27.3
255	82483	27.7
261	(82493)	28.0
267	(82503)	28.3
274	82513	28.7
280	(82523)	29.0
287	(82533)	29.3
294	(82543)	29.7
301	82553	30.0
309	(82563)	30.4
316	(82573)	30.8
324	(82583)	31.2
332	82593	31.6
340	82603	31.9
348	(82613)	32.3
357	(82623)	32.7
365	82633	33.1
374	82643	33.5
383	82653	33.9
392	82663	34.3
402	82673	34.7
412	(82683)	35.1
422	(82693)	35.6
432	82703	36.1
442	(82713)	36.4
453	82723	36.9
464	(82733)	37.3
475	82743	37.7
487	(82753)	38.2
499	82763	38.7
511	82773	39.1
523	(82783)	39.6
536	(82793)	40.1
549	(82803)	40.6
562	82813	41.0
576	(82823)	41.6
590	(82833)	42.0
604	82843	42.5
619	82853	43.1
634	(82863)	43.6
649	(82873)	44.1
665	(82883)	44.6

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

OHMITE



Uniform shape of Riteohms permits clip mounting for extra heat dissipation. The wattage capability can be increased by as much as 100% when clip is mounted to a metal surface. See Series 99 listings for clip ordering information.



Type 884 Riteohm® Resistors — 1% tolerance

3 WATTS	Rating in Free Air for Resistance Values to 13.3K Ohms		3 WATTS	Rating in Free Air for Resistance Values to 13.3K Ohms		3 WATTS	Rating in Free Air for Resistance Values to 13.3K Ohms		3 WATTS	Rating in Free Air for Resistance Values to 13.3K Ohms	
Ohms	Catalog No.[2]	Max. Volts	Ohms	Catalog No.[2]	Max. Volts	Ohms	Catalog No.[2]	Max. Volts	Ohms	Catalog No.[2]	Max. Volts
681	82893	45.2	1,650	(83263)	70.3	4,020	83633	110	9,760	(84003)	171
698	(82903)	45.7	1,690	(83273)	71.2	4,120	(83643)	111	10,000	**84013**	173
715	82913	46.3	1,740	(83283)	72.2	4,220	(83653)	112	10,200	(84023)	175
732	(82923)	46.8	1,780	83293	73.0	4,320	(83663)	114	10,500	(84033)	178
750	82933	47.4	1,820	83303	73.9	4,420	(83673)	115	10,700	(84043)	179
768	(82943)	48.0	1,870	(83313)	74.9	4,530	(83683)	117	11,000	(84053)	182
787	(82953)	48.6	1,910	(83323)	75.7	4,640	(83693)	118	11,300	(84063)	184
806	82963	49.2	1,960	(83333)	76.6	4,750	83703	119	11,500	(84073)	186
825	82973	49.7	2,000	83343	77.4	4,870	83713	121	11,800	(84083)	188
845	(82983)	50.4	2,050	(83353)	78.4	4,990	83723	122	12,100	(84093)	190
866	(82993)	51.0	2,100	(83363)	79.4	5,110	83733	124	12,400	(84103)	193
887	(83003)	51.6	2,150	83373	80.3	5,230	(83743)	125	12,700	(84113)	195
909	83013	52.2	2,210	83383	81.4	5,360	(83753)	127	13,000	(84123)	197
931	(83023)	52.8	2,260	83393	82.3	5,490	83763	128	13,300	(84133)	200
953	83033	53.4	2,320	(83403)	83.4	5,620	83773	130	13,700	(84143)	200
976	(83043)	54.1	2,370	(83413)	84.3	5,760	(83783)	131	14,000	(84153)	200
1,000	**83053**	54.7	2,430	83423	85.4	5,900	(83793)	133	14,300	(84163)	200
1,020	(83063)	55.3	2,490	83433	86.4	6,040	83803	134	14,700	(84173)	200
1,050	(83073)	56.1	2,550	(83443)	87.4	6,190	83813	136	15,000	84183	200
1,070	(83083)	56.6	2,610	(83453)	88.4	6,340	(83823)	138	15,400	(84193)	200
1,100	83093	57.4	2,670	(83463)	89.5	6,490	(83833)	140	15,800	(84203)	200
1,130	(83103)	58.2	2,740	83473	90.6	6,650	(83843)	141	16,200	(84213)	200
1,150	(83113)	58.7	2,800	(83483)	91.6	6,810	83853	143	16,500	(84223)	200
1,180	**83123**	59.5	2,870	(83493)	92.8	6,980	83863	145	16,900	(84233)	200
1,210	(83133)	60.2	2,940	83503	93.9	7,150	(83873)	146	17,400	(84243)	200
1,240	(83143)	61.0	3,010	83513	95.0	7,320	(83883)	148	17,800	(84253)	200
1,270	(83153)	61.7	3,090	83523	96.2	7,500	83893	150	18,200	(84263)	200
1,300	83163	62.4	3,160	**83533**	97.4	7,680	(83903)	152	18,700	(84273)	200
1,330	(83173)	63.2	3,240	83543	98.6	7,870	(83913)	154	19,100	(84283)	200
1,370	(83183)	64.1	3,320	83553	99.8	8,060	83923	155	19,600	(84293)	200
1,400	(83193)	64.8	3,400	(83563)	101	8,250	83933	157	20,000	84303	200
1,430	(83203)	65.5	3,480	83573	102	8,450	(83943)	159	20,500	84313	200
1,470	83213	66.4	3,570	(83583)	103	8,660	(83953)	161	21,000	(84323)	200
1,500	83223	67.0	3,650	(83593)	105	8,870	83963	163	21,500	(84333)	200
1,540	(83233)	68.0	3,740	(83603)	106	9,090	(83973)	165	22,100	84343	200
1,580	(83243)	68.8	3,830	(83613)	107	9,310	(83983)	167			
1,620	83253	69.7	3,920	83623	108	9,530	(83993)	169			

5 WATTS	Rating in Free Air for Resistance Values to 42.2K Ohms		5 WATTS	Rating in Free Air for Resistance Values to 42.2K Ohms		5 WATTS	Rating in Free Air for Resistance Values to 42.2K Ohms		5 WATTS	Rating in Free Air for Resistance Values to 42.2K Ohms	
Ohms	Catalog No.[2]	Max. Volts	Ohms	Catalog No.[2]	Max. Volts	Ohms	Catalog No.[2]	Max. Volts	Ohms	Catalog No.[2]	Max. Volts
22,600	(84355)	337	31,600	(84495)	397	44,200	(84635)	460	61,900	(84775)	460
23,200	(84365)	341	32,400	(84505)	402	45,300	84645	460	63,400	(84785)	460
23,700	84375	344	33,200	(84515)	407	46,400	(84655)	460	64,900	(84795)	460
24,300	(84385)	347	34,000	84525	412	47,500	84665	460	66,500	(84805)	460
24,900	84395	353	34,800	(84535)	417	48,700	(84675)	460	68,100	(84815)	460
25,500	84405	357	35,700	(84545)	422	49,900	84685	460	69,800	(84825)	460
26.100	(84415)	361	36,500	84555	427	51,100	84695	460	71,500	(84835)	460
26,700	(84425)	365	37,400	(84565)	432	52,300	(84705)	460	73.200	(84845)	460
27,400	84435	370	38,300	(84575)	437	53,600	(84715)	460	75,000	(84855)	460
28,000	(84445)	374	39,200	(84585)	442	54,900	(84725)	460	76,800	(84865)	460
28,700	(84455)	379	40,200	84595	448	56,200	(84735)	460	78,700	(84875)	460
29,400	(84465)	383	41,200	(84605)	454	57,600	(84745)	460	80,600	84885	460
30,100	84475	388	42,200	(84615)	460	59,000	(84755)	460			
30,900	(84485)	393	43,200	84625	460	60,400	(84765)	460			

10 WATTS	Rating in Free Air for Resistance Values to 121K Ohms		10 WATTS	Rating in Free Air for Resistance Values to 121K Ohms		10 WATTS	Rating in Free Air for Resistance Values to 121K Ohms		10 WATTS	Rating in Free Air for Resistance Values to 121K Ohms	
Ohms	Catalog No.[2]	Max. Volts	Ohms	Catalog No.[2]	Max. Volts	Ohms	Catalog No.[2]	Max. Volts	Ohms	Catalog No.[2]	Max. Volts
82,500	84890	908	105,000	(84990)	1,020	133,000	(85090)	1,100	169,000	(85190)	1,100
84,500	(84900)	919	107,000	(85000)	1,030	137,000	(85100)	1,100	174,000	85200	1,100
86,600	(84910)	930	110,000	(85010)	1,050	140,000	(85110)	1,100	178,000	(85210)	1,100
88,700	(84920)	942	113,000	(85020)	1,060	143,000	(85120)	1,100	182,000	(85220)	1,100
90,900	84930	952	115,000	(85030)	1,070	147,000	(85130)	1,100	187,000	(85230)	1,100
93,100	(84940)	965	118,000	(85040)	1,090	150,000	**85140**	1,100	191,000	(85240)	1,100
95,300	(84950)	976	121,000	(85050)	1,100	154,000	(85150)	1,100	196,000	(85250)	1,100
97,600	(84960)	988	124,000	(85060)	1,100	158,000	(85160)	1,100	200,000	**85260**	1,100
100,000	84970	1,000	127,000	(85070)	1,100	162,000	(85170)	1,100			
102,000	(84980)	1,010	130,000	(85080)	1,100	165,000	(85180)	1,100			

[1]T.C. of values in 3 Watt size under 97.6 ohms is as follows: From 97.6 thru 10 ohms, 0±20ppm/°C; from 9.76 thru 1.0 ohms, 0±50ppm/°C; below 1 ohm, 0±90ppm/°C.

[2] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

OHMITE type 270 vitreous enameled fixed resistors

These lug type resistors are wire-wound on high quality ceramic cores, protected and insulated by Ohmite vitreous enamel — the time-proved standard covering that is the best conductor of heat for a material which must also be a good electrical insulator.

Resistance tolerance is ±5% for values 1 ohm or higher; ±10% below 1 ohm.

Wattage ratings are for use in free air. When resistors are mounted in closed spaces or where the circulation of air is restricted, they should not be used at more than one-half rating. Currents and voltages for reduced ratings can be obtained by multiplying full rating by the following factors: 75% load = .86, 66% = .81, 50% = .71, 33% = .57, 25% = .50.

Mounting brackets are automatically supplied in individual unit packs; supplied only when specified in bulk pack orders. See page 18, "Mounting Brackets for Tubular Resistors" to specify other brackets.

12 WATT [illegible]		
Resist. Ohms	Cat. No.[1]	Max. Amps.
.51	3723	4.86
1.0	3730	3.46
1.5	3734	2.83
2.2	(3738)	2.34
3.3	3742	1.91
4.7	3746	1.60
6.8	3750	1.33
10	3754	1.10
12	3756	1.00
15	3758	.89
18	3760	.82
22	3762	.74
27	3764	.67
33	3766	.60
39	3768	.55
47	3770	.53
56	3772	.46
68	3774	.42
82	3776	.38
100	3778	.35
120	3780	.32
150	3782	.28
180	3784	.26
220	3786	.23
270	3788	.21
330	3790	.19
390	3792	.18
470	3794	.16
560	3796	.15
680	(3798)	.13
820	3800	.12
1,000	3802	.11
1,200	3804	.10
1,500	3806	.089
1,800	(3808)	.082
2,200	3810	.074
2,700	3812	.067
3,300	3814	.060
3,900	3816	.055
4,700	3818	.051
5,600	3820	.046
6,800	(3822)	.038
8,200	(3824)	.035
10,000	3826	.032
12,000	3828	.029
15,000	3830	.026
18,000	(3832)	.024
22,000	3834	.021
27,000	3836	.019
33,000	(3838)	.017
39,000	(3840)	.016
47,000	(3842)	.015
51,000	3843	.014

	25 WATT [illegible]		50 WATT [illegible]		100 WATT [illegible]		175 WATT [illegible]		225 WATT [illegible]	
Ohms Res.	Catalog No.[1]	Max. Amps.	Catalog No.[1]	Max. Amps.	Catalog No.[1]	Max. Amps.	Catalog No.[1]	Max. Amps.	Catalog No.[1]	Max. Amps.
1	0200J	5.00	0400J	7.07	0600C	10.00	0700C	13.2	0900C	15.00
2	0200K	3.54	0400K	5.00	0600D	7.07	0700D	9.35	0900D	10.60
3	0200L	2.88	0400L	4.07	0600E	5.77	0700E	7.63	0900E	8.67
4	0200N	2.50	0400N	3.53	0600F	5.00	(0700F)	6.6	0900F	7.50
5	0200A	2.24	0400A	3.16	0600A	4.47	0700A	5.92	0900A	6.72
10	0200B	1.58	0400B	2.23	0600B	3.16	0700B	4.18	0900B	4.74
15	0200R	1.29								
25	0200C	1.00	0400C	1.41	0601	2.00	0701	2.64	0901	3.00
50	0200D	.71	0400D	1.00	0602	1.41	0702	1.87	0902	2.12
75	0200E	.58	0400E	.82	0603	1.15	0703	1.52	0903	1.73
100	0200F	.50	0400F	.71	0604	1.00	0704	1.32	0904	1.50
125					0604B	.90	0704B	1.18		
150	0200G	.41	0400G	.58	0605	.82	0705	1.08	0905	1.25
200	0200H	.35	0400H	.50						
250	0201	.32	0401	.45	0606	.63	0706	.84	0906	.95
500	0202	.22	0402	.32	0607	.45	0707	.59	0907	.67
750	0203	.18	0403	.26	0608	.37	0708	.48	0908	.55
800	0204	.17	0404	.25						
1,000	0205	.16	0405	.22	0609	.32	0709	.42	0909	.47
1,500	0206	.13	0406	.18	0610	.26	0710	.34	0910	.39
2,000	0207	.12	0407	.16	0611	.22	0711	.30	0911	.34
2,500	0208	.10	0408	.14	0612	.20	(0712)	.26	0912	.30
3,000	0209	.091	0409	.13	0613	.18	0713	.24	0913	.27
3,500	0210	.084								
4,000	0211	.079	0410	.11						
5,000	0212	.070	0411	.10	0614	.14	0714	.19	0914	.21
6,000	0213	.064								
7,500	0214	.057	0412	.081	0615	.12	(0715)	.15	0915	.17
8,000			0413	.079						
10,000	0215	.050	0414	.071	0616	.10	0716	.13	0916	.15
12,000	0216	.045	(0415)	.064						
15,000	0217	.036	0416	.057	0617	.081	0717	.11	0917	.13
20,000	0218	.031	(0417)	.050	0618	.071	0718	.094	0918	.11
25,000	0219	.028	0418	.045	0619	.063	0719	.083	0919	.095
30,000	0220	.026			0620	.058	(0720)	.076	0920	.087
35,000	(0221)	.024	0419	.032						
40,000	0222	.022			0621	.050	(0721)	.066	0921	.075
50,000	0224	.019	0420	.026	0622	.045	(0722)	.059	0922	.067
60,000	0225	.016			0623	.041	(0723)	.054	(0923)	.061
70,000	0226	.013								
75,000			0421	.021	0624	.032	(0724)	.048	(0924)	.055
80,000	0227	.012								
100,000	0229	.0094	0422	.018	0625	.028	0725	.042	0925	.047
125,000			0423	.017						
150,000			0424	.015						
175,000			(0425)	.014						
200,000			0426	.012						
250,000			0428	.010						

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

OHMITE dividohm® type 210 adjustable vitreous enameled resistors

"Dividohm" resistors make ideal voltage dividers for original equipment and replacement in transmitters, rectifiers and other apparatus. Such tapped "bleeders" are made by using one or more adjustable lugs, as required. "Dividohms" are also handy for obtaining odd resistance values, for adjusting circuits, and for use on equipment which must be set to meet various line voltages.

"Dividohm" resistors are vitreous enameled resistors on which a narrow strip has been left uncovered to expose a portion of each turn. Contact to any wire in this strip is made by an embossed contact on the adjustable lug (supplied).

WATT RATING: The stated wattage rating applies only when the entire resistance is in the circuit. When the adjustable lug is set at an intermediate point, the wattage rating is reduced in approximately the same portion, i.e., if the lug is set at half the resistance, the wattage is reduced by one-half. A safe rule to follow is to make sure that the maximum rated current is not exceeded. This should be carefully checked particularly if the resistor will be used as a voltage divider with several adjustable lugs. Resistance tolerance is ±10% for the total resistance value.

[illegible]	12 WATT [illegible]		25 WATT [illegible]		50 WATT [illegible]		75 WATT [illegible]		100 WATT [illegible]		175 WATT [illegible]		225 WATT [illegible]	
[illegible]	Catalog No.[1]	Max. Amps.	Catalog No.[1]	Max. Amps.	Catalog No.[1]	Max. Amps.	Catalog No.[1]	Max. Amps.	Catalog No.[1]	Max. Amps.	Catalog No.[1]	Max. Amps.	Catalog No.[1]	Max. Amps.
[illegible]	**1001**	3.46	**0360**	5.00	**0560A**	7.07	0769A	8.66	**0956A**	10.0	**1156A**	13.2	**1356A**	15.00
[illegible]	**1002**	2.45	**0360B**	3.54	**0560B**	5.00	0769B	6.12	**0956B**	7.07	1156B	9.35	**1356B**	10.60
[illegible]	**1003**	2.00	**0361**	2.88	**0560C**	4.07	0769C	5.00	**0956C**	5.77	1156C	7.63	**1356C**	8.67
[illegible]					0560D	3.53	0769D	4.33	**0956D**	5.00	1156D	6.60	**1356D**	7.50
[illegible]	**1004**	1.54	**0362**	2.24	**0560**	3.16	**0769**	3.87	**0956**	4.47	**1156**	5.92	**1356**	6.72
[illegible]	1005	1.26	**0362B**	1.82										
[illegible]	**1006**	1.09	**0363**	1.58	**0561**	2.23	**0770**	2.74	**0957**	3.16	**1157**	4.18	**1357**	4.74
[illegible]	**1007**	.89	**0364**	1.29			**0771**	2.24						
[illegible]	1008	.77	**0364B**	1.12										
[illegible]	1009	.69	**0365**	1.00	**0562**	1.41	**0772**	1.73	**0958**	2.00	**1158**	2.64	**1358**	3.00
[illegible]	**1010**	.49	**0366**	.71	**0563**	1.00	**0773**	1.22	**0959**	1.41	**1159**	1.87	**1359**	2.12
[illegible]	**1011**	.40	**0367**	.58	**0564**	.82								
[illegible]	**1012**	.34	**0368**	.50	**0565**	.71	**0774**	.86	**0960**	1.00	**1160**	1.32	**1360**	1.50
[illegible]	**1013**	.28	**0369**	.41	**0566**	.58								
[illegible]	**1014**	.24	**0370**	.35	**0567**	.50	0774B	.61						
[illegible]	**1015**	.22	**0371**	.32	**0568**	.45	0775	.55	**0960B**	.63	**1160B**	.84	**1360B**	.95
[illegible]	**1016**	.20	**0371B**	.29	**0568B**	.41	**0775B**	.50						
[illegible]	1017	.18												
[illegible]	**1018**	.17	**0371C**	.25	**0568C**	.35	0775C	.43						
[illegible]	**1019**	.15	**0372**	.22	**0569**	.32	0776	.39	**0961**	.45	**1161**	.59	**1361**	.67
[illegible]	1020	.14												
[illegible]	**1021**	.13	**0373**	.18	**0570**	.26	0777	.32						
[illegible]	1022	.12	**0374**	.17	(0571)	.25	(0777B)	.30						
[illegible]	**1023**	.11	**0375**	.16	**0572**	.22	0778	.27	**0962**	.32	**1162**	.42	**1362**	.47
[illegible]	**1024**	.098	**0375B**	.14	0572B	.20	0778B	.24						
[illegible]	**1025**	.089	**0376**	.13	**0573**	.18	0779	.22	**0962B**	.26	1162B	.34	**1362B**	.39
[illegible]	**1026**	.077	**0377**	.12	**0574**	.16	0780	.19						
[illegible]	1027	.073	**0377B**	.11	(0574B)	.15	(0780B)	.18						
[illegible]	**1028**	.069	**0378**	.10	**0575**	.14	(0781)	.17	**0963**	.20	1163	.26	**1363**	.30
[illegible]	**1029**	.063	**0379**	.091	**0576**	.13	(0781B)	.16						
[illegible]	1030	.058	0380	.084	**0576B**	.12	(0782)	.15						
[illegible]	1031	.055	**0381**	.079	0577	.11	0782B	.14						
[illegible]	1032	.052	0381B	.074	**0577B**	.10	(0782C)	.13						
[illegible]	**1033**	.049	**0382**	.070	**0578**	.10	0783	.12	**0964**	.14	1164	.19	**1364**	.21
[illegible]	1034	.045	0383	.064	**0578B**	.091	(0783B)	.11						
[illegible]	1035	.042	(0383B)	.060	(0578C)	.084	(0783C)	.10						
[illegible]	1036	.040	**0384**	.057	(0579)	.081	(0784)	.10						
[illegible]	**1037**	.039	0384B	.055	**0580**	.079	(0784B)	.096						
[illegible]	(1038)	.037												
[illegible]	(1039)	.036	0384C	.052	(0580B)	.074	(0784C)	.091						
[illegible]	**1040**	.035	**0385**	.050	**0581**	.071	0785	.086	0965	.10	1165	.13	**1365**	.15
[illegible]			**0386**	.042	0582	.064	(0785B)	.079						
[illegible]			**0387**	.036	**0583**	.057	(0786)	.070	(0966)	.081	(1166)	.11	1366	.13
[illegible]			**0388**	.031	0584	.050	0787	.061	0967	.071	(1167)	.094	1367	.11
[illegible]			**0389**	.028	**0585**	.045	0788	.054	0968	.063	(1168)	.083	1368	.095
[illegible]					0586	.036	(0789)	.050	(0969)	.058	(1169)	.076	1369	.087
[illegible]							(0790)	.046						
[illegible]					0587	.029	(0791)	.043	0970	.050	(1170)	.066	(1370)	.075
[illegible]							(0792)	.035						
[illegible]					**0588**	.026	(0793)	.033	**0971**	.045	(1171)	.059	1371	.067
[illegible]					(0589)	.024	(0794)	.030						
[illegible]									(0972)	.032	(1172)	.048	(1372)	.055
[illegible]					(0590)	.021	(0795)	.026						
[illegible]					0591	.018	(0796)	.023	0973	.028	1173	.042	1373	.047

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

* Mounting brackets are automatically supplied in individual unit packs; supplied only when specified in bulk packs.

adjustable lugs

One "Screw Driver Type Adjustable Lug" is supplied with each unit. Lugs with a silver contact button can be ordered from the table shown below.

MOVING THE LUGS: Lugs always should be loosened completely before moving and not moved except while the current is off, in order to protect the exposed wire from mechanical or electrical injury and to protect the operator from dangerous voltages.

STANDARD

[illegible]	[illegible]		[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]
5/16	2115	1058	—	—
9/16	2121	0358	2122	0359
3/4	2125	1958	2126	1959
1 1/8	2133	2158	2134	2159

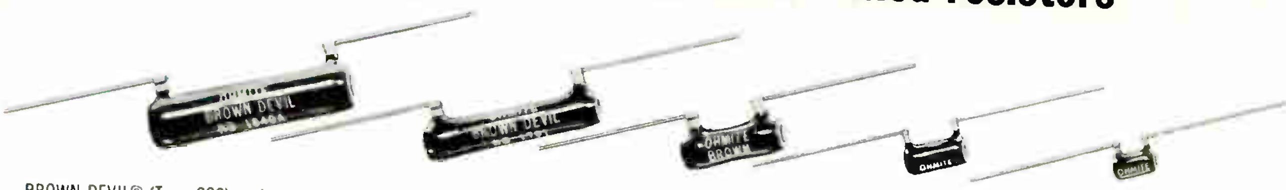
With SILVER CONTACT BUTTONS

[illegible]	[illegible]		[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]
5/16	2116	2161	—	—
9/16	2123	2164	2124	2165
3/4	2127	2166	2128	2167
1 1/8	2135	2170	2136	2171

DOUBLE THUMB SCREW ADJUSTABLE LUG

This adjustable lug, which is illustrated above, features two advantages — ease of adjustment and less chance of damaging the resistance wire while moving lugs. Available for 1⅛" cores. Catalog No. **2160**

OHMITE type 200 *brown devil®* fixed resistors



BROWN DEVIL® (Type 200) resistors, are vitreous enameled, wirewound units long famous for ruggedness and durability in small power resistors. With the emphasis towards miniaturization and the current industry trend towards higher operating temperatures, Ohmite has been able to increase the ratings on two Brown Devil sizes. The 5 watt size is now rated **8 watts** and the 10 watt size is now rated **12 watts**. The 20 watt unit retains the same rating. The higher ratings may be confidently applied to any 5 or 10 watt unit now in the possession of users or distributors. At this time also, to meet the demand for lower wattage units, Ohmite introduces two, new, small stock sizes — 3 and 5¼ watts.

Standard resistance tolerance is ±5% for values 1 ohm or higher; ±10% for values below 1 ohm. Tinned leads 1½" long: 3 and 5¼ watt, 20 AWG; 8, 12 and 20 watt, 18 AWG.

DIMENSIONS, WEIGHTS, CODES

Rating	3W	5¼W	8W	12W	20W
Core Dimen. Weight (lbs.)	7/16x.21D .003	5/8x1/4D .005	1x5/16D .01	1 3/4x5/16D .015	2x5/16D .03

Ohms	3 WATT Cat. No.[1]	Amps	5¼ WATT Cat. No.[1]	Amps	8 WATT Cat. No.[1]	Amps	12 WATT Cat. No.[1]	Amps	20 WATT Cat. No.[1]	Amps
0.5 1.0	**2712**	1.73	**2822**	2.29	**1500**	2.83	1700A 1701	4.90 3.46	1800A 1802A	6.32 4.47
1.1 1.2	(2713) (2714)	1.65 1.58	(2823) (2824)	2.19 2.09						
1.3 1.5	(2715) (2716)	1.52 1.41	(2825) 2826	2.01 1.87	1500B	2.30	**1704**	2.82		
1.6 1.8	(2717) (2718)	1.37 1.29	(2827) (2828)	1.81 1.71						
2.0 2.2	2719 (2720)	1.22 1.17	**2829** 2830	1.62 1.54	**1501**	2.00	1705	2.45	1802B	3.16
2.4 2.7	(2721) 2722	1.12 1.05	(2831) (2832)	1.48 1.39						
3.0 3.3	2723 2724	1.00 .95	2833 2834	1.32 1.24	1502	1.63	1706	2.00	1802C	2.58
3.6 3.9	2725 (2726)	.91 .88	2835 2836	1.21 1.16						
4.0 4.3	(2727)	.83	2837	1.10	**1503**	1.41	1707	1.73	1802D	2.24
4.7 5.0	2728	.80	2838	1.06	**1504**	1.26	1708	1.54	1803	2.00
5.1 5.6	2729 2730	.77 .73	**2839** 2840	1.01 .97						
6.2 6.8	2731 (2732)	.69 .66	(2841) (2842)	.92 .88						
7.5 8.2	2733 (2734)	.63 .60	2843 2844	.84 .80	**1505**	1.00	1709	1.26		
9.1 10	2735 2736	.57 .55	(2845) **2846**	.76 .72	**1506**	.89	1710	1.09	1804	1.41
11 12	(2737) (2738)	.52 .50	2847 2848	.69 .66	1507	.81	1711	1.00		
13 15	(2739) 2740	.48 .45	(2849) **2850**	.64 .59	**1508**	.73	1712	.89		
16 18	(2741) 2742	.43 .42	2851 (2852)	.57 .54						
20 22	2743 2744	.39 .37	**2853** 2854	.51 .49	**1509**	.63	1713	.77		
24 25	(2745)	.35	2855	.47	**1510**	.56	**1714**	.69	1805	.89
27 30	(2746) 2747	.33 .32	2856 2857	.44 .42	**1511**	.51	1715	.63		
33 35	2748	.30	(2858)	.40	1512	.47	1716	.58		
36 39	(2749) 2750	.29 .28	(2859) 2860	.38 .37						
40 43	(2751)	.26	(2861)	.35	**1513**	.44	**1717**	.54		
47 50	(2752)	.25	2862	.33	**1514**	.40	**1718**	.49	1806	.63
51 56	2753 2754	.24 .23	2863 2864	.32 .31						
62 68	2755 2756	.22 .21	2865 2866	.29 .28						
75 82	2757 (2758)	.20 .19	2867 2868	.27 .25	**1515**	.32	**1719**	.40	1807	.52
91 100	2759 2760	.18 .17	2869 **2870**	.24 .23	1516	.28	1720	.34	1808	.45
110 120	(2761) 2762	.16 .16	2871 2872	.22 .21						
125 130	(2763)	.15	(2873)	.20	**1517**	.25	1721	.31		
150 160	2764 (2765)	.14 .14	**2874** 2875	.19 .18	**1518**	.23	1722	.28	1809	.36
180 200	2766 **2767**	.13 .12	**2876** **2877**	.17 .16	**1519**	.20	**1723**	.24	1810	.32
220 225	2768	.12	2878	.16	1520	.18	1724	.23		
240 250	2769	.11	2879	.15	**1521**	.17	1725	.22	1811	.28
270 300	2770 2771	.11 .10	2880 **2881**	.14 .13	1522	.16	1726	.20	1812	.26
330 350	2772	.095	**2882**	.12	1523	.15	1727	.18	1813	.24
360 390	2773 (2774)	.091 .088	(2883) 2884	.12 .12						
400 430	2775	.083	2885	.11	**1524**	.14	1728	.17	1814	.22
450 470	2776	.080	**2886**	.11	1525	.13	1729	.16		

Ohms	3 WATT Cat. No.[1]	Amps	5¼ WATT Cat. No.[1]	Amps	8 WATT Cat. No.[1]	Amps	12 WATT Cat. No.[1]	Amps	20 WATT Cat. No.[1]	Amps
500 510	2777	.077	2887	.10	**1526**	.12	**1730**	.15	**1815**	.20
560 600	2778	.073	**2888**	.097	**1527**	.11	**1731**	.14		
620 650	(2779)	.070	2889	.092						
680 700	2780	.067	**2890**	.088	1528	.11	**1732**	.13	**1816** 1817	.18 .17
750 800	2781	.063	2891	.084	1529 1530	.10 .10	**1733** 1734	.12 .12	**1818** 1819	.16 .15
820 900	(2782)	.060	**2892**	.080	1531	.094	**1735**	.11	1820A	.15
910 1000	**2783** 2784	.057 .055	2893 **2894**	.076 .072	**1532**	.089	**1736**	.11	1821	.14
1100 1200	(2785) 2786	.052 .050	2895 2896	.069 .066	1533 **1534**	.085 .081	(1737) **1738**	.10 .10	**1822**	.13
1250 1300	(2787)	.048	2897	.063	1535	.080	1739	.097	1823	.12
1500 1600	2788 2789	.045 .043	**2898** (2899)	.059 .057	**1536**	.073	**1740**	.089	1824	.12
1750 1800	(2790)	.042	2900	.050	1537	.067	**1741**	.082	1825	.11
2000 2200	(2791) 2792	.039 .037	**2901** 2902	.047 .045	**1538**	.063	**1742**	.077	**1827**	.10
2250 2400	(2793)	.035	2903	.043	1539	.059	**1743**	.073	(1828)	.094
2500 2700	(2794)	.033	2904	.041	**1540**	.056	**1744**	.069	**1830**	.089
2750 3000	2795	.032	**2905**	.039	**1541**	.046	**1745**	.063	1831 1832	.085 .081
3300 3500	2796	.030	2906	.037	1542	.043	**1746**	.058	1833	.075
3600 3900	(2797) 2798	.029 .028	2907 2908	.035 .034						
4000 4300	(2799)	.026	(2909)	.032	**1543**	.040	**1747**	.054	1834	.070
4500 4700	2800	.025	2910	.031	**1544**	.038	**1748**	.051	1835	.066
5000 5100	(2801)	.024	2911	.030	**1545**	.036	**1749**	.049	1836	.063
5600 6000	(2802)	.023	2912	.028	**1546**	.033	**1750**	.044	1837	.057
6200 6800	2803 (2804)	.022 .021	2913 2914	.027 .026						
7000 7500	(2805)	.020	2915	.025	**1547** **1548**	.030 .029	1751 **1752**	.041 .036	(1838) 1839	.053 .051
8000 8200	2806	.019	2916	.023	1549	.029	**1753**	.035	(1840)	.050
8500 9000					1550	.027	(1754) 1754A	.034 .033	(1840A)	.047
9100 10K	(2807) 2808	.018 .016	(2917) **2918**	.022 .021	**1551**	.026	**1755**	.032	**1841**	.043
11K 12K			(2919) 2920	.020 .019			(1756) 1757	.030 .029		
12.5K 13K			(2921)	.019	1552	.023	1758	.028	1842	.032
13.5K 15K			2922	.017	**1553**	.021	(1759) 1761	.027 .026	1843	.029
16K 17.5K			2923	.017	1554	.019	(1762) 1763	.025 .024		
18K 20K			**2924** **2925**	.016 .014	1555	.018	1764 **1765**	.024 .022	**1844**	.026
22.5K 25K					1556 1557	.017 .015	1766 **1767**	.021 .020	1845	.023
30K 35K							**1768** **1769**	.018 .017	1846 1847	.021 .019
40K 45K							**1770** 1771	.016 .015	1848 (1849)	.018 .017
50K 55K							**1772**	.014	1850 (1851)	.016 .015
60K 65K									1852 1853	.015 .014
70K 75K									1854 (1855)	.014 .013
[illegible]									(1856) (1857)	.013 .012
[illegible]									(1858) 1859 1860	.012 .012 .011

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

OHMITE non-inductive

type 270N vitreous enameled fixed resistors

These non-inductively wound power resistors are widely used at radio frequencies for such purposes as dummy antennas, terminating resistors for antennas, and in diathermy apparatus. Their properly proportioned Ayrton-Perry type windings, reduce the inductance to low proportions (less than 1% of regular solenoid type resistors) while the distributed capacity is small. R.F. resistance is the same as the D.C. resistance over the useful range of frequencies.

Change of impedance with frequency is so slight that the resistors can be used throughout the broadcast band and at even higher frequencies, depending on the particular resistance to be used. All the resistors are lug-type tubular units which mount by means of non-magnetic mounting brackets (furnished). Ohmite's high grade ceramic construction and exclusive vitreous enamel coating assure long, reliable performance under full rated load. Resistance tolerance is ±5%.

12 WATT Core: 1¾"x5/16" Mtg. Ctr: 2⅜"—Av. Wt. .02 lb. Std. Mtg. Brkt.* No. 5B					
Ohms	Cat. No.[1]	Max. Milli-Amps	Ohms	Cat. No.[1]	Max. Milli-Amps
5	2050	1,540	600	(2066)	140
10	2051	1,090	700	(2067)	130
15	(2052)	890	800	(2068)	120
20	2053	770	900	(2069)	110
25	2054	690	1,000	(2070)	110
30	(2055)	630	1,500	(2071)	89
40	2056	550	2,000	(2072)	77
50	2057	490	2,500	(2073)	69
75	2058	400	3,000	(2074)	63
100	2059	340	4,000	(2075)	54
150	(2060)	280	5,000	(2076)	49
200	(2061)	240	6,000	(2077)	44
250	2062	220	7,500	(2078)	40
300	(2063)	200	8,000	(2079)	38
400	(2064)	170	9,000	(2080)	36
500	(2065)	150	10,000	(2081)	35

	50 WATT Core: 4"x⁹⁄₁₆" Mtg. Ctr: 4¾" Av. Wt. .09 lb. Std. Mtg. Brkt.* No. 9B		100 WATT Core: 6½"x¾" Mtg. Ctr: 7⅜"— Av. Wt. .20 lb. Std. Mtg. Brkt.* No. 12B		175 WATT Core: 8½"x1⅛" Mtg. Ctr: 9⅜"— Av. Wt. .50 lb. Std. Mtg. Brkt.* No. 18B	
Resist. Ohms	Cat. No.[1]	Max. Milliamps	Cat. No.[1]	Max. Milliamps	Cat. No.[1]	Max. Milliamps
5	(2001)	3,160	**2201**	4,470	**2401**	5,920
10	2002	2,230	**2202**	3,160	**2402**	4,180
25	2003	1,410	2203	2,000	**2403**	2,640
50	**2004**	1,000	**2204**	1,410	**2404**	1,870
100	(2005)	710	2205	1,000	**2405**	1,320
150	2006	580	(2206)	816	2406	1,090
200	(2007)	500	(2207)	707	(2407)	935
250	(2008)	450	(2208)	630	2408	840
500	2009	320	(2209)	450	2409	590
750	2010	260	2210	365	2410	480
1000	2011	220	(2211)	320	2411	420
1500	2012	180	2212	260	(2412)	340
2000	(2013)	160	(2213)	224	(2413)	290
2500	(2014)	140	(2214)	200	2414	260
3000	(2015)	130	2215	180	2415	240
3500	(2016)	119	(2216)	169	(2416)	222
4000	(2017)	110	(2217)	158	(2417)	208
5000	2018	100	(2218)	140	(2418)	190

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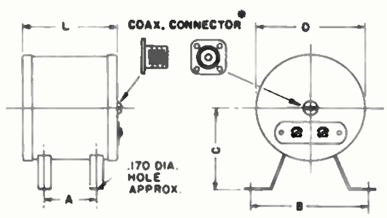
* Mounting brackets are automatically supplied in individual unit packs; supplied only when specified in bulk packs.

dummy-antenna resistors NON-INDUCTIVE

Ohmite Models D-101 and D-251 Dummy Antenna Resistors provide a simple, accurate, and direct means of measuring R.F. power for the radio amateur, experimenter and manufacturer and for operators of aviation, police and broadcast stations. These units consist of a number of special, vitreous enameled resistors connected in parallel in a concentric arrangement and mounted inside a perforated metal cage. The dummy antenna resistors feature constant R.F. resistance (within their recommended frequency range), low reactance, high wattage dissipation, and compactness. Actual D.C. resistance tolerance is ±5%.

The residual inductance and distributed capacitance have been kept to a minimum, thereby making the natural resonant frequency as high as possible. These factors and the D.C. resistance have been proportioned in such a manner as to give the best possible response characteristics. This resistor may be considered practically a "Non-Reactive Resistor."



Catalog Number	Dimensions (Inches) A	B	C	D	L
(D-101-52*), (D-101-73*)	1½	3½	2⅜	3⁵⁄₃₂	2²³⁄₃₂
(D-101-300), (D-101-600)	2¾	3½	2⅜	3⁵⁄₃₂	4⁷⁄₃₂
D-251-52*, (D-251-73*)	3⅛	3⅞	2½	3²³⁄₃₂	4¹⁹⁄₃₂
D-251-300, (D-251-600)	5⅛	3⅞	2½	3²³⁄₃₂	6¹³⁄₁₆

*Employs coax connector.

FREQUENCY CHARACTERISTICS OF OHMITE DUMMY ANTENNAS

Type	D-101				D-251			
Resistance	52 Ohms	73 Ohms	300 Ohms	600 Ohms	52 Ohms	73 Ohms	300 Ohms	600 Ohms
Maximum frequency at which Rs = Rdc ± 10%	22 mc	38 mc	22 mc	31 mc	19 mc	21 mc	15 mc	19 mc
Rs at this frequency	1.10 R dc	1.10 R dc	1.10 R dc	.90 R dc	1.10 R dc	1.10 R dc	1.10 R dc	.90 R dc
Z at this frequency	1.18 R dc	1.14 R dc	1.10 R dc	.99 R dc	1.25 R dc	1.13 R dc	1.15 R dc	1.00 R dc
Maximum frequency at which Z = Rdc ± 10%	18 mc	32 mc	22 mc	60 mc	13 mc	19 mc	13 mc	30 mc
Rs at this frequency	1.06 R dc	1.07 R dc	1.10 R dc	.60 R dc	1.03 R dc	1.07 R dc	1.08 R dc	.64 R dc
Z at this frequency	1.10 R dc	1.10 R dc	1.10 R dc	.90 R dc	1.10 R dc	1.10 R dc	1.10 R dc	.90 R dc

Cat. No.[1]	Watts	*±5% Ohms*	Net Lbs.
(D-101-52)	100	52	.60
(D-101-73)	100	73	.60
(D-101-300)	100	300	.65
(D-101-600)	100	600	.65
D-251-52	250	52	1.25
(D-251-73)	250	73	1.25
(D-251-300)	250	300	1.50
D-251-600	250	600	1.50

Rdc D.C. Resistance of Dummy Antenna
Rs .. Effective Series Resistance of Dummy Antenna
Z ... Scalar Value of Impedance of Dummy Antenna

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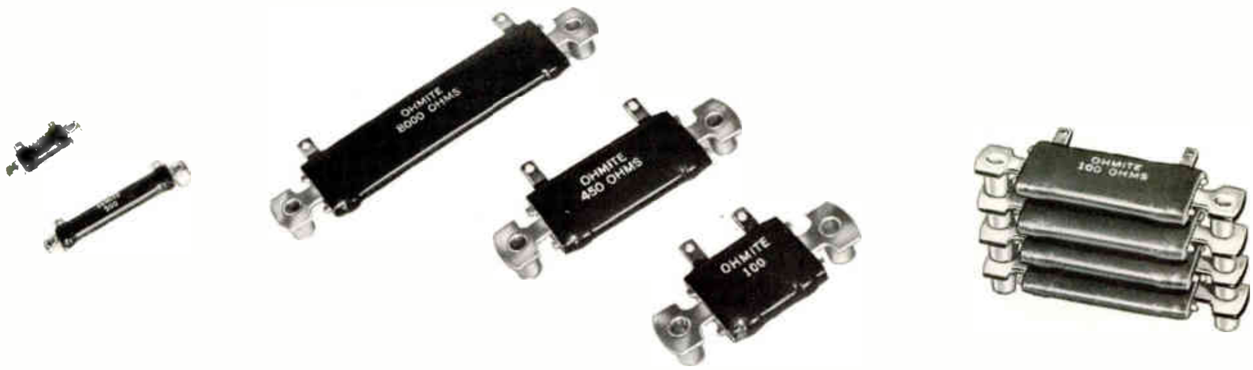
OHMITE type 250 "THIN" vitreous enameled resistors

Ohmite "Thin" Resistors are intended for use in equipment where space is at a premium. They are wound on flat, oval shaped ceramic cores, and covered with Ohmite's exclusive vitreous enamel coating. Resistance tolerance, ±5%.

Integral mounting brackets extend through the resistor core to equalize heat distribution and to conduct heat directly to the mounting surface—provides equivalent wattage with less bulk and in less space. Wattage ratings assume the use of a metal mounting surface. Reduce ratings 15% for non-metallic surfaces.

"Thin" resistors are mounted or compactly stacked by means of bracket studs which are hollow to receive assembly bolts. The load should be reduced for each unit when resistors are stacked or used in confined, poorly ventilated spaces. Total height from bottom of mounting stud to top of resistor is approximately 5/16" for the Standard units and 11/32" for the Miniature units.

For other sizes, closer tolerances, non-stacking brackets, Dividohm adjustable or other features, consult factory.



	MINIATURE SIZES						STANDARD SIZES								
	10 WATT* Core: 3/4"x3/8"x1/8"—Mtg. Ctr. 1" Stud Hole .125"—Av. Wt. .007 lb.			20 WATT* Core: 2"x3/8"x1/8"—Mtg. Ctr. 2¼" Stud Hole .125"—Av. Wt. .015 lb.			30 WATT* Core: 1¼"x1"x1/8"—Mtg. Ctr. 2" Stud Hole .196"—Av. Wt. .037 lb.			40 WATT* Core: 2"x1"x1/8"—Mtg. Ctr. 2¾" Stud Hole .196"—Av. Wt. .052 lb.			55 WATT* Core: 3½"x1"x1/8"—Mtg. Ctr. 4¼" Stud Hole .196"—Av. Wt. .095 lb.		
Resist. Ohms	Cat. No.[1]	Max. Volts	Max. Amps	Cat. No.[1]	Max. Volts	Max. Amps	Cat. No.[1]	Max. Volts	Max. Amps	Cat. No.[1]	Max. Volts	Max. Amps	Cat. No.[1]	Max. Volts	Max. Amps
1	**F101**	3.16	3.16	F201	4.47	4.47	F301	5.47	5.47	**F401**	6.32	6.32	**F501**	7.42	7.42
1.5							(F302)	6.70	4.47	F402	7.74	5.16	F502	8.25	6.05
2	F102	4.47	2.24	**F202**	6.32	3.16	(F303)	7.74	3.88	**F403**	8.94	4.47	**F503**	10.4	5.24
3							F304	9.45	3.17	F404	10.9	3.65	F504	12.8	4.28
4										(F405)	12.6	3.16	F505	14.8	3.70
5	**F103**	7.07	1.41	**F203**	10.0	2.00	**F305**	12.2	2.46	F406	14.1	2.83	F506	16.6	3.32
7.5	F104	8.66	1.15							F407	17.3	2.31	(F507)	20.6	2.72
10	F105	10.0	1.00	**F204**	14.1	1.41	F306	17.3	1.73	**F408**	20.0	2.00	F508	23.4	2.34
15	(F106)	12.2	0.82	**F205**	17.3	1.16	**F307**	21.2	1.42						
20	**F107**	14.1	0.71												
25	F108	15.8	0.63	F206	22.3	0.89	F308	27.4	1.10	**F409**	31.6	1.26	**F509**	37.1	1.48
30	F109	17.3	0.58												
40	F110	20.0	0.50	F207	28.3	0.71	F309	34.6	0.87	**F410**	40.0	1.00	**F510**	46.9	1.17
50	**F111**	22.3	0.45	**F208**	31.6	0.63	F310	38.7	0.77	F411	44.7	0.89	**F511**	52.4	1.05
75	**F112**	27.4	0.36	F209	38.7	0.52	F311	47.4	0.63	(F412)	54.8	0.73	(F512)	64.2	0.86
100	**F113**	31.6	0.32	**F210**	44.7	0.45	F312	54.8	0.55	F413	63.2	0.63	F513	74.1	0.74
125	F114	35.3	0.28												
150	**F115**	38.7	0.26	**F211**	54.8	0.36	(F313)	67.0	0.45	(F414)	77.4	0.52	F514	82.5	0.61
200	F116	44.7	0.22	**F212**	63.2	0.32	(F314)	77.4	0.39	(F415)	89.4	0.45	F515	104.0	0.52
250	**F117**	50.0	0.20	F213	70.7	0.28	F315	86.6	0.35	(F416)	100.0	0.40	F516	117.0	0.47
300	F118	54.8	0.18	F214	77.4	0.26									
400	**F119**	63.2	0.16	**F215**	89.4	0.22	(F316)	108.0	0.28	(F417)	126.0	0.32	F517	148.0	0.37
500	**F120**	70.7	0.14	**F216**	100.0	0.20	F317	122.0	0.25	F418	141.0	0.28	F518	166.0	0.33
600	(F121)	77.4	0.13												
750	F122	86.6	0.12				(F318)	150.0	0.20	F419	173.0	0.23	(F519)	206.0	0.27
800				F217	126.0	0.16									
1000	F123	100.0	0.10	F218	141.0	0.14	F319	173.0	0.17	(F420)	200.0	0.20	(F520)	234.0	0.23
1250	(F124)	111.0	0.089	**F219**	158.0	0.12									
1500	F125	122.0	0.081	**F220**	173.0	0.12	F320	212.0	0.14	(F421)	245.0	0.16	(F521)	287.0	0.19
1750	F126	132.0	0.075												
2000	F127	141.0	0.071	(F221)	200.0	0.10	(F321)	245.0	0.12	F422	283.0	0.14	(F522)	332.0	0.17
2500	**F128**	158.0	0.063	(F222)	223.0	0.089	F322	274.0	0.11	(F423)	316.0	0.13	(F523)	371.0	0.15
3000	**F129**	173.0	0.057	(F223)	245.0	0.081	(F323)	300.0	0.10	(F424)	345.0	0.12	(F524)	406.0	0.14
3500				(F224)	264.0	0.075									
4000	F130	200.0	0.050	(F225)	283.0	0.070	F324	346.0	0.087	(F425)	400.0	0.10	(F525)	469.0	0.12
5000	(F131)	223.0	0.045	F226	316.0	0.063	(F325)	387.0	0.076	(F426)	447.0	0.089	(F526)	524.0	0.10
6000				(F227)	346.0	0.058									
7500				(F228)	387.0	0.052	(F326)	424.0	0.057	(F427)	548.0	0.073	(F527)	642.0	0.086
10000				**F229**	445.0	0.045	(F327)	490.0	0.049	F428	632.0	0.063	F528	741.0	0.074
12500				(F230)	500.0	0.040									
15000				**F231**	555.0	0.036				(F429)	670.0	0.045	(F529)	825.0	0.061
20000				(F232)	625.0	0.032				(F430)	774.0	0.039	(F530)	1040.0	0.052
25000				(F233)	715.0	0.028				(F431)	866.0	0.035	(F531)	1170.0	0.047
30000				(F234)	770.0	0.026							(F532)	1210.0	0.040
35000				(F235)	835.0	0.024									
40000				(F236)	910.0	0.022									
50000				F237	990.0	0.020									

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*Ratings are based on use of steel panel mounting and should be reduced on non-metallic mounting surface because of reduced thermal conductivity.

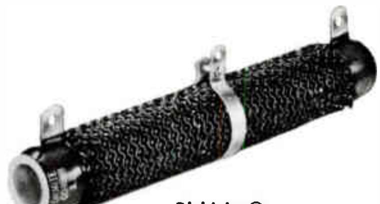
OHMITE corrib® HIGH CURRENT LOW OHMS resistors

STOCK CORRIBS — 300 WATT SIZE
Type 280 Fixed; 230 Dividohm®

Core: 8½x1⅛" Fixed or Adjustable (DIVIDOHM)
Avg. Weight (Fixed) .61 lb.; (Dividohm) .64 lb.

Ohms	Amps.	Fixed¹ Catalog No.	Dividohm*¹ Catalog No.
.10	54.7	**2501**	2601
.12	50.0	**2502**	(2602)
.16	43.3	2503	2603
.20	38.7	**2504**	(2604)
.25	34.6	**2505**	**2605**
.31	31.1	**2506**	2606
.40	27.4	(2507)	2607
.50	24.5	**2508**	**2608**
.63	21.8	2509	2609
.80	19.3	2510	2610
1.0	17.3	**2511**	2611
1.2	15.8	**2512**	(2612)
1.6	13.7	2513	2613
2.0	12.2	**2514**	2614
2.5	10.9	2515	2615
3.1	9.8	**2516**	2616
4.0	8.6	2517	2617
5.0	7.7	**2518**	2618
6.3	6.9	2519	2619
8.0	6.1	2520	2620
10.0	5.5	**2521**	2621
12.0	5.0	2522	**2622**
16.0	4.3	2523	2623
20.0	3.8	**2524**	**2624**

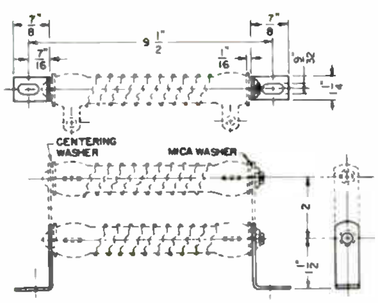
*Adjustable Lug Stk. No. 1974 supplied with Dividohm.



THRU-BOLT MOUNTING BRACKETS FOR CORRIBS

Includes 2 brackets; bolt; centering, mica, and lock washers; nuts. Diagram below.

No. of Resistors	Catalog No.
1	6126P8½
2	6127P8½
3	6128P8½
4	6129P8½



High current, low resistance, heavy duty units used in motor starting, dynamic braking, etc. "Corrib" type units employ a corrugated ribbon of resistance alloy. This is space-wound edge-wise around a ceramic tube. Vitreous enamel is fused around the alloy ribbon to lock the turns securely in place. Heavy lug terminals. Resistance tolerance is ±10%.

Available in fixed or Dividohm® adjustable types. Dividohm® type is similar to fixed and includes one adjustable lug. Rating of Fixed or Dividohm® stock units—300 watts—reduce unit load for stack-mounted resistors; core size (bare) 8½" long x1⅛" diameter. Other sizes made to order.

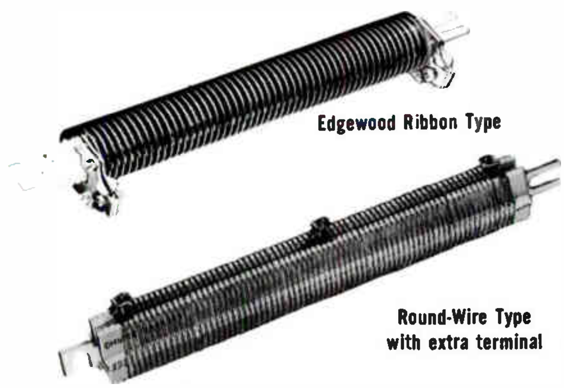
EXTRA ADJUSTABLE LUGS FOR CORRIBS

For Dividohm	Lug Catalog No.
2601 to 2618	1974-B
2619 to 2624	1974-A

powr-rib® HIGH CURRENT LOW OHMS resistors

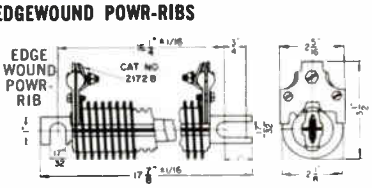
Even higher power handling capability—approximately 700 to 1000 watts—is available in stock, "Powr-Rib" resistors. These are UNCOATED types and are wound either edgewise with ribbon ("Edgewound" type) or with round wire (Round-Wire type).

The core of these units consists of ceramic segments on a metal bar which is slotted on both ends for rapid installation. Standard resistance tolerance is ±10%. Terminals clamp onto the resistor wire and may be moved in from the ends for intermediate resistance values. Extra terminals available for use as taps. See diagrams for terminals. Terminal Stk. No. 2172G (not shown) has screw connections.



STYLE 080-5 EDGEWOUND POWR-RIBS

Ohms*	H ±⅛	D +⅛ —0
.10-.22	3$\frac{5}{16}$	2⅛
.25-1.00	3⅛	1⅞
1.30-1.60	2$\frac{15}{16}$	1⅞
2.2, 2.8, 4.5, 5.4	2½	1¾
3.5, 6.8, 8.5	2$\frac{7}{16}$	1⅝

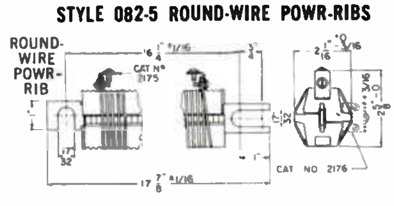


*.10 to 1.00 Ω with terminal No. 2172B
1.3 to 8.5 Ω with terminal No. 2172G

Avg. Weight .18Ω or less, 4 lbs.; .22Ω and up, 2 lbs.

Catalog No.¹	Ohms	Max. Amps.	Catalog No.¹	Ohms	Max. Amps.
2301	.10	100	2318	.67	41
2302	.12	91	**2311**	.75	39
2303A	.14	89	**2312**	1.00	33
2304A	.16	78	**2319**	1.30	29
2305A	.18	75	**2313**	1.60	26
2306A	.22	68	**2331A**	2.20	18.4
2306	.25	63	**2332A**	2.80	16.3
2308A	.30	57	**2333A**	3.50	14.6
2308	.33	54	**2334A**	4.50	12.7
2309A	.37	50	**2335A**	5.40	11.8
2310	.50	47	**2336A**	6.80	10.3
2317	.60	43	**2337A**	8.50	9.4

STYLE 082-5 ROUND-WIRE POWR-RIBS



Avg. Weight 3¼ lbs.

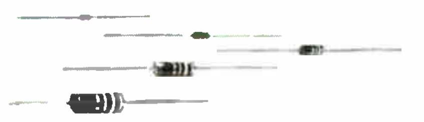
Catalog No.¹	Ohms	Max. Amps.
2338	11.0	8.3
2339	13.0	7.6
2340	17.0	6.6
2341	20.0	5.9
2342	25.0	5.1

EXTRA TERMINALS

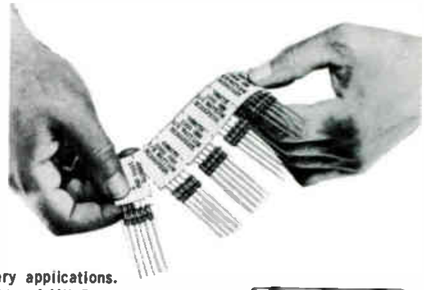
For Round Wire Powr-Rib		For Edgewound Powr-Rib	
Descrip	Catalog No.	Descrip	Catalog No.
In-Line Mtg. 90° Mtg.	2175 (2176)	30 Amps & more 29 Amps & less	2172B 2172G

¹ Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

OHMITE *Little Devil*® molded composition resistors on "Tally Tape"®



"Tally Tape," Ohmite's wonderfully convenient packaging presently provides for 1/4, 1/2, 1 and 2-watt resistors. Each perforated segment holds 5 resistors — prevents spilling or tangling — simplifies counting — is printed for quick identification — guarantees original, factory-fresh stock.



Now Includes MIL-R-11 Types

Little Devils, Ohmite's famous molded composition resistors, find broad use in commercial and military applications. The 1/8, 1/4, 1/2, 1 and 2-watt sizes, which conform respectively to Styles RC05, RC07, RC20, RC32 and RC42 of MIL-R-11, meet all the stringent requirements of this military specification. The five sizes available satisfy a wide range of design and service needs.

Little Devils have molded insulation for high dielectric strength. Noted advantages of these units are great stability, low noise level, low voltage coefficient, high insulation breakdown voltage and rapid heat dissipation. They may be used at full rated wattage at 70°C (158°F) ambient temperature.

Little Devils are available from stock in standard EIA resistance values in the tolerances and resistance ranges shown in the price table. Ratings for maximum continuous RMS voltage drop are high: 150 volts for 1/8 watt units, 250 volts for 1/4 watt, 350 volts for 1/2 watt, 500 volts for 1 watt, and 750 volts for 2 watt units. See "Little Devil" Resistor Assortments page 16.

Color Coder 10¢

CATALOG NO. 5190

1/8 WATT — MIL Type: RC 05* — Size: .145"L. x .062"D. — Leads: .015" D. x 1" L.

Resistance	Catalog Number ±5%	Catalog Number ±10%
2.7 ohms	OB27G5	OB27G1
3.0 ohms	OB30G5	
3.3 ohms	OB33G5	OB33G1
3.6 ohms	OB36G5	
3.9 ohms	OB39G5	OB39G1
4.3 ohms	OB43G5	
4.7 ohms	OB47G5	OB47G1
5.1 ohms	OB51G5	
5.6 ohms	OB56G5	OB56G1
6.2 ohms	OB62G5	
6.8 ohms	OB68G5	OB68G1
7.5 ohms	OB75G5	
8.2 ohms	OB82G5	OB82G1
9.1 ohms	OB91G5	
10. ohms	OB1005	OB1001
11. ohms	OB1105	
12. ohms	OB1205	OB1201
13. ohms	OB1305	
15. ohms	OB1505	OB1501
16. ohms	OB1605	
18. ohms	OB1805	OB1801
20. ohms	OB2005	
22. ohms	OB2205	OB2201
24. ohms	OB2405	
27. ohms	OB2705	OB2701
30. ohms	OB3005	
33. ohms	OB3305	OB3301
36. ohms	OB3605	
39. ohms	OB3905	OB3901
43. ohms	OB4305	
47. ohms	OB4705	OB4701
51. ohms	OB5105	
56. ohms	OB5605	OB5601

1/8 WATT — MIL Type: RC 05* — Size: .145"L. x .062"D. — Leads: .015" D. x 1" L.

Resistance	Catalog Number ±5%	Catalog Number ±10%
62. ohms	OB6205	
68. ohms	OB6805	OB6801
75. ohms	OB7505	
82. ohms	OB8205	OB8201
91. ohms	OB9105	
100. ohms	OB1015	OB1011
110. ohms	OB1115	
120. ohms	OB1215	OB1211
130. ohms	OB1315	
150. ohms	OB1515	OB1511
160. ohms	OB1615	
180. ohms	OB1815	OB1811
200. ohms	OB2015	
220. ohms	OB2215	OB2211
240. ohms	OB2415	
270. ohms	OB2715	OB2711
300. ohms	OB3015	
330. ohms	OB3315	OB3311
360. ohms	OB3615	
390. ohms	OB3915	OB3911
430. ohms	OB4315	
470. ohms	OB4715	OB4711
510. ohms	OB5115	
560. ohms	OB5615	OB5611
620. ohms	OB6215	
680. ohms	OB6815	OB6811
750. ohms	OB7515	
820. ohms	OB8215	OB8211
910. ohms	OB9115	
1,000. ohms	OB1025	OB1021
1,100. ohms	OB1125	
1,200. ohms	OB1225	OB1221
1,300. ohms	OB1325	

1/8 WATT — MIL Type: RC 05* — Size: .145"L. x .062"D. — Leads: .015" D. x 1" L.

Resistance	Catalog Number ±5%	Catalog Number ±10%
1,500. ohms	OB1525	OB1521
1,600. ohms	OB1625	
1,800. ohms	OB1825	OB1821
2,000. ohms	OB2025	
2,200. ohms	OB2225	OB2221
2,400. ohms	OB2425	
2,700. ohms	OB2725	OB2721
3,000. ohms	OB3025	
3,300. ohms	OB3325	OB3321
3,600. ohms	OB3625	
3,900. ohms	OB3925	OB3921
4,300. ohms	OB4325	
4,700. ohms	OB4725	OB4721
5,100. ohms	OB5125	
5,600. ohms	OB5625	OB5621
6,200. ohms	OB6225	
6,800. ohms	OB6825	OB6821
7,500. ohms	OB7525	
8,200. ohms	OB8225	OB8221
9,100. ohms	OB9125	
10,000. ohms	OB1035	OB1031
11,000. ohms	OB1135	
12,000. ohms	OB1235	OB1231
13,000. ohms	OB1335	
15,000. ohms	OB1535	OB1531
16,000. ohms	OB1635	
18,000. ohms	OB1835	OB1831
20,000. ohms	OB2035	
22,000. ohms	OB2235	OB2231
24,000. ohms	OB2435	
27,000. ohms	OB2735	OB2731
30,000. ohms	OB3035	
33,000. ohms	OB3335	OB3331

1/8 WATT — MIL Type: RC 05* — Size: .145"L. x .062"D. — Leads: .015" D. x 1" L.

Resistance	Catalog Number ±5%	Catalog Number ±10%
36,000. ohms	OB3635	
39,000. ohms	OB3935	OB3931
43,000. ohms	OB4335	
47,000. ohms	OB4735	OB4731
51,000. ohms	OB5135	
56,000. ohms	OB5635	OB5631
62,000. ohms	OB6235	
68,000. ohms	OB6835	OB6831
75,000. ohms	OB7535	
82,000. ohms	OB8235	OB8231
91,000. ohms	OB9135	
0.1 megs	OB1045	OB1041
0.11 megs	OB1145	
0.12 megs	OB1245	OB1241
0.13 megs	OB1345	
0.15 megs	OB1545	OB1541
0.16 megs	OB1645	
0.18 megs	OB1845	OB1841
0.20 megs	OB2045	
0.22 megs	OB2245	OB2241
0.24 megs	OB2445	
0.27 megs	OB2745	OB2741
0.30 megs	OB3045	
0.33 megs	OB3345	OB3341
0.36 megs	OB3645	
0.39 megs	OB3945	OB3941
0.43 megs	OB4345	
0.47 megs	OB4745	OB4741
0.51 megs	OB5145	
0.56 megs	OB5645	OB5641
0.62 megs	OB6245	
0.68 megs	OB6845	OB6841
0.75 megs	OB7545	

1/8 WATT — MIL Type: RC 05* — Size: .145"L. x .062"D. — Leads: .015" D. x 1" L.

Resistance	Catalog Number ±5%	Catalog Number ±10%
0.82 megs	OB8245	OB8241
0.91 megs	OB9145	
1. megs	OB1055	OB1051
1.1 megs	OB1155	
1.2 megs	OB1255	OB1251
1.3 megs	OB1355	
1.5 megs	OB1555	OB1551
1.6 megs	OB1655	
1.8 megs	OB1855	OB1851
2.0 megs	OB2055	
2.2 megs	OB2255	OB2251
2.4 megs	OB2455	
2.7 megs	OB2755	OB2751
3.0 megs	OB3055	
3.3 megs	OB3355	OB3351
3.6 megs	OB3655	
3.9 megs	OB3955	OB3951
4.3 megs	OB4355	
4.7 megs	OB4755	OB4751
5.1 megs	OB5155	
5.6 megs	OB5655	OB5651
6.2 megs	OB6255	
6.8 megs	OB6855	OB6851
7.5 megs	OB7555	
8.2 megs	OB8255	OB8251
9.1 megs	OB9155	
10. megs	OB1065	OB1061
11. megs	OB1165	
12. megs	OB1265	OB1261
13. megs	OB1365	
15. megs	OB1565	OB1561
16. megs	OB1665	
18. megs	OB1865	OB1861
20. megs	OB2065	
22. megs	OB2265	OB2261

1/4 WATT — MIL Type: RC 07 — Size: 1/4"L. x .090"D. — Leads: .025"D. x 1½"L.

Resistance	Catalog Number ±5%	Catalog Number ±10%
2.7 ohms	OC27G5	OC27G1
3.0 ohms	OC30G5	
3.3 ohms	OC33G5	OC33G1
3.6 ohms	OC36G5	
3.9 ohms	OC39G5	OC39G1
4.3 ohms	OC43G5	
4.7 ohms	OC47G5	OC47G1
5.1 ohms	OC51G5	
5.6 ohms	OC56G5	OC56G1
6.2 ohms	OC62G5	
6.8 ohms	OC68G5	OC68G1
7.5 ohms	OC75G5	
8.2 ohms	OC82G5	OC82G1
9.1 ohms	OC91G5	
10. ohms	OC1005	OC1001
11. ohms	OC1105	
12. ohms	OC1205	OC1201
13. ohms	OC1305	
15. ohms	OC1505	OC1501
16. ohms	OC1605	
18. ohms	OC1805	OC1801
20. ohms	OC2005	
22. ohms	OC2205	OC2201
24. ohms	OC2405	
27. ohms	OC2705	OC2701
30. ohms	OC3005	
33. ohms	OC3305	OC3301
36. ohms	OC3605	
39. ohms	OC3905	OC3901
43. ohms	OC4305	
47. ohms	OC4705	OC4701
51. ohms	OC5105	
56. ohms	OC5605	OC5601
62. ohms	OC6205	

1/4 WATT — MIL Type: RC 07 — Size: 1/4"L. x .090"D. — Leads: .025"D. x 1½"L.

Resistance	Catalog Number ±5%	Catalog Number ±10%
68. ohms	OC6805	OC6801
75. ohms	OC7505	
82. ohms	OC8205	OC8201
91. ohms	OC9105	
100. ohms	OC1015	OC1011
110. ohms	OC1115	
120. ohms	OC1215	OC1211
130. ohms	OC1315	
150. ohms	OC1515	OC1511
160. ohms	OC1615	
180. ohms	OC1815	OC1811
200. ohms	OC2015	
220. ohms	OC2215	OC2211
240. ohms	OC2415	
270. ohms	OC2715	OC2711
300. ohms	OC3015	
330. ohms	OC3315	OC3311
360. ohms	OC3615	
390. ohms	OC3915	OC3911
430. ohms	OC4315	
470. ohms	OC4715	OC4711
510. ohms	OC5115	
560. ohms	OC5615	OC5611
620. ohms	OC6215	
680. ohms	OC6815	OC6811
750. ohms	OC7515	
820. ohms	OC8215	OC8211
910. ohms	OC9115	
1,000. ohms	OC1025	OC1021
1,100. ohms	OC1125	
1,200. ohms	OC1225	OC1221
1,300. ohms	OC1325	
1,500. ohms	OC1525	OC1521
1,600. ohms	OC1625	

1/4 WATT — MIL Type: RC 07 — Size: 1/4"L. x .090"D. — Leads: .025"D. x 1½"L.

Resistance	Catalog Number ±5%	Catalog Number ±10%
1,800. ohms	OC1825	OC1821
2,000. ohms	OC2025	
2,200. ohms	OC2225	OC2221
2,400. ohms	OC2425	
2,700. ohms	OC2725	OC2721
3,000. ohms	OC3025	
3,300. ohms	OC3325	OC3321
3,600. ohms	OC3625	
3,900. ohms	OC3925	OC3921
4,300. ohms	OC4325	
4,700. ohms	OC4725	OC4721
5,100. ohms	OC5125	
5,600. ohms	OC5625	OC5621
6,200. ohms	OC6225	
6,800. ohms	OC6825	OC6821
7,500. ohms	OC7525	
8,200. ohms	OC8225	OC8221
9,100. ohms	OC9125	
10,000. ohms	OC1035	OC1031
11,000. ohms	OC1135	
12,000. ohms	OC1235	OC1231
13,000. ohms	OC1335	
15,000. ohms	OC1535	OC1531
16,000. ohms	OC1635	
18,000. ohms	OC1835	OC1831
20,000. ohms	OC2035	
22,000. ohms	OC2235	OC2231
24,000. ohms	OC2435	
27,000. ohms	OC2735	OC2731
30,000. ohms	OC3035	
33,000. ohms	OC3335	OC3331
36,000. ohms	OC3635	
39,000. ohms	OC3935	OC3931
43,000. ohms	OC4335	

1/4 WATT — MIL Type: RC 07 — Size: 1/4"L. x .090"D. — Leads: .025"D. x 1½"L.

Resistance	Catalog Number ±5%	Catalog Number ±10%
47,000. ohms	OC4735	OC4731
51,000. ohms	OC5135	
56,000. ohms	OC5635	OC5631
62,000. ohms	OC6235	
68,000. ohms	OC6835	OC6831
75,000. ohms	OC7535	
82,000. ohms	OC8235	OC8231
91,000. ohms	OC9135	
0.1 megs	OC1045	OC1041
0.11 megs	OC1145	
0.12 megs	OC1245	OC1241
0.13 megs	OC1345	
0.15 megs	OC1545	OC1541
0.16 megs	OC1645	
0.18 megs	OC1845	OC1841
0.20 megs	OC2045	
0.22 megs	OC2245	OC2241
0.24 megs	OC2445	
0.27 megs	OC2745	OC2741
0.30 megs	OC3045	
0.33 megs	OC3345	OC3341
0.36 megs	OC3645	
0.39 megs	OC3945	OC3941
0.43 megs	OC4345	
0.47 megs	OC4745	OC4741
0.51 megs	OC5145	
0.56 megs	OC5645	OC5641
0.62 megs	OC6245	
0.68 megs	OC6845	OC6841
0.75 megs	OC7545	
0.82 megs	OC8245	OC8241
0.91 megs	OC9145	
1. megs	OC1055	OC1051
1.1 megs	OC1155	

1/4 WATT — MIL Type: RC 07 — Size: 1/4"L. x .090"D. — Leads: .025"D. x 1½"L.

Resistance	Catalog Number ±5%	Catalog Number ±10%
1.2 megs	OC1255	OC1251
1.3 megs	OC1355	
1.5 megs	OC1555	OC1551
1.6 megs	OC1655	
1.8 megs	OC1855	OC1851
2.0 megs	OC2055	
2.2 megs	OC2255	OC2251
2.4 megs	OC2455	
2.7 megs	OC2755	OC2751
3.0 megs	OC3055	
3.3 megs	OC3355	OC3351
3.6 megs	OC3655	
3.9 megs	OC3955	OC3951
4.3 megs	OC4355	
4.7 megs	OC4755	OC4751
5.1 megs	OC5155	
5.6 megs	OC5655	OC5651
6.2 megs	OC6255	
6.8 megs	OC6855	OC6851
7.5 megs	OC7555	
8.2 megs	OC8255	OC8251
9.1 megs	OC9155	
10. megs	OC1065	OC1061
11. megs	OC1165	
12. megs	OC1265	OC1261
13. megs	OC1365	
15. megs	OC1565	OC1561
16. megs	OC1665	
18. megs	OC1865	OC1861
20. megs	OC2065	
22. megs	OC2265	OC2261

* Items appearing in BOLD print are popular values and are usually stocked by authorized OHMITE distributors. Items appearing in LIGHT FACE print are available from stocking distributors but normally are not stocked in depth.

½ WATT — Mil. Type: RC 20

Resistance	Catalog Number ±5%	±10%
1. ohms	OE10G5	OE10G1
1.1 ohms	OE11G5	
1.2 ohms	OE12G5	OE12G1
1.3 ohms	OE13G5	
1.5 ohms	OE15G5	OE15G1
1.6 ohms	OE16G5	
1.8 ohms	OE18G5	OE18G1
2. ohms	OE20G5	
2.2 ohms	OE22G5	OE22G1
2.4 ohms	OE24G5	
2.7 ohms	OE27G5	OE27G1
3.0 ohms	OE30G5	
3.3 ohms	OE33G5	OE33G1
3.6 ohms	OE36G5	
3.9 ohms	OE39G5	OE39G1
4.3 ohms	OE43G5	
4.7 ohms	OE47G5	OE47G1
5.1 ohms	OE51G5	
5.6 ohms	OE56G5	OE56G1
6.2 ohms	OE62G5	
6.8 ohms	OE68G5	OS68G1
7.5 ohms	OE75G5	
8.2 ohms	OE82G5	OE82G1
9.1 ohms	OE91G5	
10. ohms	OE1005	OE1001
11. ohms	OE1105	
12. ohms	OE1205	OE1201
13. ohms	OE1305	
15. ohms	OE1505	OE1501
16. ohms	OE1605	
18. ohms	OE1805	OE1801
20. ohms	OE2005	
22. ohms	OE2205	OE2201
24. ohms	OE2405	
27. ohms	OE2705	OE2701
30. ohms	OE3005	

Resistance	Catalog Number ±5%	±10%
33. ohms	OE3305	OE3301
36. ohms	OE3605	
39. ohms	OE3905	OE3901
43. ohms	OE4305	
47. ohms	OE4705	OE4701
51. ohms	OE5105	
56. ohms	OE5605	OE5601
62. ohms	OE6205	
68. ohms	OE6805	OE6801
75. ohms	OE7505	
82. ohms	OE8205	OE8201
91. ohms	OE9105	
100. ohms	OE1015	OE1011
110. ohms	OE1115	
120. ohms	OE1215	OE1211
130. ohms	OE1315	
150. ohms	OE1515	OE1511
160. ohms	OE1615	
180. ohms	OE1815	OE1811
200. ohms	OE2015	
220. ohms	OE2215	OE2211
240. ohms	OE2415	
270. ohms	OE2715	OE2711
300. ohms	OE3015	
330. ohms	OE3315	OE3311
360. ohms	OE3615	
390. ohms	OE3915	OE3911
430. ohms	OE4315	
470. ohms	OE4715	OE4711
510. ohms	OE5115	
560. ohms	OE5615	OE5611
620. ohms	OE6215	
680. ohms	OE6815	OE6811
750. ohms	OE7515	
820. ohms	OE8215	OE8211
910. ohms	OE9115	

Resistance	Catalog Number ±5%	±10%
1,000. ohms	OE1025	OE1021
1,100. ohms	OE1125	
1,200. ohms	OE1225	OE1221
1,300. ohms	OE1325	
1,500. ohms	OE1525	OE1521
1,600. ohms	OE1625	
1,800. ohms	OE1825	OE1821
2,000. ohms	OE2025	
2,200. ohms	OE2225	OE2221
2,400. ohms	OE2425	
2,700. ohms	OE2725	OE2721
3,000. ohms	OE3025	
3,300. ohms	OE3325	OE3321
3,600. ohms	OE3625	
3,900. ohms	OE3925	OE3921
4,300. ohms	OE4325	
4,700. ohms	OE4725	OE4721
5,100. ohms	OE5125	
5,600. ohms	OE5625	OE5621
6,200. ohms	OE6225	
6,800. ohms	OE6825	OE6821
7,500. ohms	OE7525	
8,200. ohms	OE8225	OE8221
9,100. ohms	OE9125	
10,000. ohms	OE1035	OE1031
11,000. ohms	OE1135	
12,000. ohms	OE1235	OE1231
13,000. ohms	OE1335	
15,000. ohms	OE1535	OE1531
16,000. ohms	OE1635	
18,000. ohms	OE1835	OE1831
20,000. ohms	OE2035	
22,000. ohms	OE2235	OE2231
24,000. ohms	OE2435	
27,000. ohms	OE2735	OE2731
30,000. ohms	OE3035	

Resistance	Catalog Number ±5%	±10%
33,000. ohms	OE3335	OE3331
36,000. ohms	OE3635	
39,000. ohms	OE3935	OE3931
43,000. ohms	OE4335	
47,000. ohms	OE4735	OE4731
51,000. ohms	OE5135	
56,000. ohms	OE5635	OE5631
62,000. ohms	OE6235	
68,000. ohms	OE6835	OE6831
75,000. ohms	OE7535	
82,000. ohms	OE8235	OE8231
91,000. ohms	OE9135	
0.1 megs	OE1045	OE1041
0.11 megs	OE1145	
0.12 megs	OE1245	OE1241
0.13 megs	OE1345	
0.15 megs	OE1545	OE1541
0.16 megs	OE1645	
0.18 megs	OE1845	OE1841
0.20 megs	OE2045	
0.22 megs	OE2245	OE2241
0.24 megs	OE2445	
0.27 megs	OE2745	OE2741
0.30 megs	OE3045	
0.33 megs	OE3345	OE3341
0.36 megs	OE3645	
0.39 megs	OE3945	OE3941
0.43 megs	OE4345	
0.47 megs	OE4745	OE4741
0.51 megs	OE5145	
0.56 megs	OE5645	OE5641
0.62 megs	OE6245	
0.68 megs	OE6845	OE6841
0.75 megs	OE7545	
0.82 megs	OE8245	OE8241
0.91 megs	OE9145	

Resistance	Catalog Number ±5%	±10%
1. megs	OE1055	OE1051
1.1 megs	OE1155	
1.2 megs	OE1255	OE1251
1.3 megs	OE1355	
1.5 megs	OE1555	OE1551
1.6 megs	OE1655	
1.8 megs	OE1855	OE1851
2.0 megs	OE2055	
2.2 megs	OE2255	OE2251
2.4 megs	OE2455	
2.7 megs	OE2755	OE2751
3.0 megs	OE3055	
3.3 megs	OE3355	OE3351
3.6 megs	OE3655	
3.9 megs	OE3955	OE3951
4.3 megs	OE4355	
4.7 megs	OE4755	OE4751
5.1 megs	OE5155	
5.6 megs	OE5655	OE5651
6.2 megs	OE6255	
6.8 megs	OE6855	OE6851
7.5 megs	OE7555	
8.2 megs	OE8255	OE8251
9.1 megs	OE9155	
10. megs	OE1065	OE1061
11. megs	OE1165	
12. megs	OE1265	OE1261
13. megs	OE1365	
15. megs	OE1565	OE1561
16. megs	OE1665	
18. megs	OE1865	OE1861
20. megs	OE2065	
22. megs	OE2265	OE2261

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Resistance	Catalog Number ±5%	±10%
2.7 ohms	OG27G5	OG27G1
3.0 ohms	OG30G5	
3.3 ohms	OG33G5	OG33G1
3.6 ohms	OG36G5	
3.9 ohms	OG39G5	OG39G1
4.3 ohms	OG43G5	
4.7 ohms	OG47G5	OG47G1
5.1 ohms	OG51G5	
5.6 ohms	OG56G5	OG56G1
6.2 ohms	OG62G5	
6.8 ohms	OG68G5	OG68G1
7.5 ohms	OG75G5	
8.2 ohms	OG82G5	OG82G1
9.1 ohms	OG91G5	
10. ohms	OG1005	OG1001
11. ohms	OG1105	
12. ohms	OG1205	OG1201
13. ohms	OG1305	
15. ohms	OG1505	OG1501
16. ohms	OG1605	
18. ohms	OG1805	OG1801
20. ohms	OG2005	
22. ohms	OG2205	OG2201
24. ohms	OG2405	
27. ohms	OG2705	OG2701
30. ohms	OG3005	
33. ohms	OG3305	OG3301
36. ohms	OG3605	
39. ohms	OG3905	OG3901
43. ohms	OG4305	
47. ohms	OG4705	OG4701
51. ohms	OG5105	
56. ohms	OG5605	OG5601
62. ohms	OG6205	

Resistance	Catalog Number ±5%	±10%
68. ohms	OG6805	OG6801
75. ohms	OG7505	
82. ohms	OG8205	OG8201
91. ohms	OG9105	
100. ohms	OG1015	OG1011
110. ohms	OG1115	
120. ohms	OG1215	OG1211
130. ohms	OG1315	
150. ohms	OG1515	OG1511
160. ohms	OG1615	
180. ohms	OG1815	OG1811
200. ohms	OG2015	
220. ohms	OG2215	OG2211
240. ohms	OG2415	
270. ohms	OG2715	OG2711
300. ohms	OG3015	
330. ohms	OG3315	OG3311
360. ohms	OG3615	
390. ohms	OG3915	OG3911
430. ohms	OG4315	
470. ohms	OG4715	OG4711
510. ohms	OG5115	
560. ohms	OG5615	OG5611
620. ohms	OG6215	
680. ohms	OG6815	OG6811
750. ohms	OG7515	
820. ohms	OG8215	OG8211
910. ohms	OG9115	
1,000. ohms	OG1025	OG1021
1,100. ohms	OG1125	
1,200. ohms	OG1225	OG1221
1,300. ohms	OG1325	
1,500. ohms	OG1525	OG1521
1,600. ohms	OG1625	

Resistance	Catalog Number ±5%	±10%
1,800. ohms	OG1825	OG1821
2,000. ohms	OG2025	
2,200. ohms	OG2225	OG2221
2,400. ohms	OG2425	
2,700. ohms	OG2725	OG2721
3,000. ohms	OG3025	
3,300. ohms	OG3325	OG3321
3,600. ohms	OG3625	
3,900. ohms	OG3925	OG3921
4,300. ohms	OG4325	
4,700. ohms	OG4725	OG4721
5,100. ohms	OG5125	
5,600. ohms	OG5625	OG5621
6,200. ohms	OG6225	
6,800. ohms	OG6825	OG6821
7,500. ohms	OG7525	
8,200. ohms	OG8225	OG8221
9,100. ohms	OG9125	
10,000. ohms	OG1035	OG1031
11,000. ohms	OG1135	
12,000. ohms	OG1235	OG1231
13,000. ohms	OG1335	
15,000. ohms	OG1535	OG1531
16,000. ohms	OG1635	
18,000. ohms	OG1835	OG1831
20,000. ohms	OG2035	
22,000. ohms	OG2235	OG2231
24,000. ohms	OG2435	
27,000. ohms	OG2735	OG2731
30,000. ohms	OG3035	
33,000. ohms	OG3335	OG3331
36,000. ohms	OG3635	
39,000. ohms	OG3935	OG3931
43,000. ohms	OG4335	

Resistance	Catalog Number ±5%	±10%
47,000. ohms	OG4735	OG4731
51,000. ohms	OG5135	
56,000. ohms	OG5635	OG5631
62,000. ohms	OG6235	
68,000. ohms	OG6835	OG6831
75,000. ohms	OG7535	
82,000. ohms	OG8235	OG8231
91,000. ohms	OG9135	
0.1 megs	OG1045	OG1041
0.11 megs	OG1145	
0.12 megs	OG1245	OG1241
0.13 megs	OG1345	
0.15 megs	OG1545	OG1541
0.16 megs	OG1645	
0.18 megs	OG1845	OG1841
0.20 megs	OG2045	
0.22 megs	OG2245	OG2241
0.24 megs	OG2445	
0.27 megs	OG2745	OG2741
0.30 megs	OG3045	
0.33 megs	OG3345	OG3341
0.36 megs	OG3645	
0.39 megs	OG3945	OG3941
0.43 megs	OG4345	
0.47 megs	OG4745	OG4741
0.51 megs	OG5145	
0.56 megs	OG5645	OG5641
0.62 megs	OG6245	
0.68 megs	OG6845	OG6841
0.75 megs	OG7545	
0.82 megs	OG8245	OG8241
0.91 megs	OG9145	
1. megs	OG1055	OG1051
1.1 megs	OG1155	

Resistance	Catalog Number ±5%	±10%
1.2 megs	OG1255	OG1251
1.3 megs	OG1355	
1.5 megs	OG1555	OG1551
1.6 megs	OG1655	
1.8 megs	OG1855	OG1851
2.0 megs	OG2055	
2.2 megs	OG2255	OG2251
2.4 megs	OG2455	
2.7 megs	OG2755	OG2751
3.0 megs	OG3055	
3.3 megs	OG3355	OG3351
3.6 megs	OG3655	
3.9 megs	OG3955	OG3951
4.3 megs	OG4355	
4.7 megs	OG4755	OG4751
5.1 megs	OG5155	
5.6 megs	OG5655	OG5651
6.2 megs	OG6255	
6.8 megs	OG6855	OG6851
7.5 megs	OG7555	
8.2 megs	OG8255	OG8251
9.1 megs	OG9155	
10. megs	OG1065	OG1061
11. megs	OG1165	
12. megs	OG1265	OG1261
13. megs	OG1365	
15. megs	OG1565	OG1561
16. megs	OG1665	
18. megs	OG1865	OG1861
20. megs	OG2065	
22. megs	OG2265	OG2261

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Resistance	Catalog Number ±5%	±10%
10. ohms	OH1005	OH1001
11. ohms	OH1105	
12. ohms	OH1205	OH1201
13. ohms	OH1305	
15. ohms	OH1505	OH1501
16. ohms	OH1605	
18. ohms	OH1805	OH1801
20. ohms	OH2005	
22. ohms	OH2205	OH2201
24. ohms	OH2405	
27. ohms	OH2705	OH2701
30. ohms	OH3005	
33. ohms	OH3305	OH3301
36. ohms	OH3605	
39. ohms	OH3905	OH3901
43. ohms	OH4305	
47. ohms	OH4705	OH4701
51. ohms	OH5105	
56. ohms	OH5605	OH5601
62. ohms	OH6205	
68. ohms	OH6805	OH6801
75. ohms	OH7505	
82. ohms	OH8205	OH8201
91. ohms	OH9105	
100. ohms	OH1015	OH1011
110. ohms	OH1115	
120. ohms	OH1215	OH1211
130. ohms	OH1315	
150. ohms	OH1515	OH1511
160. ohms	OH1615	
180. ohms	OH1815	OH1811

Resistance	Catalog Number ±5%	±10%
200. ohms	OH2015	
220. ohms	OH2215	OH2211
240. ohms	OH2415	
270. ohms	OH2715	OH2711
300. ohms	OH3015	
330. ohms	OH3315	OH3311
360. ohms	OH3615	
390. ohms	OH3915	OH3911
430. ohms	OH4315	
470. ohms	OH4715	OH4711
510. ohms	OH5115	
560. ohms	OH5615	OH5611
620. ohms	OH6215	
680. ohms	OH6815	OH6811
750. ohms	OH7515	
820. ohms	OH8215	OH8211
910. ohms	OH9115	
1,000. ohms	OH1025	OH1021
1,100. ohms	OH1125	
1,200. ohms	OH1225	OH1221
1,300. ohms	OH1325	
1,500. ohms	OH1525	OH1521
1,600. ohms	OH1625	
1,800. ohms	OH1825	OH1821
2,000. ohms	OH2025	
2,200. ohms	OH2225	OH2221
2,400. ohms	OH2425	
2,700. ohms	OH2725	OH2721
3,000. ohms	OH3025	
3,300. ohms	OH3325	OH3321
3,600. ohms	OH3625	

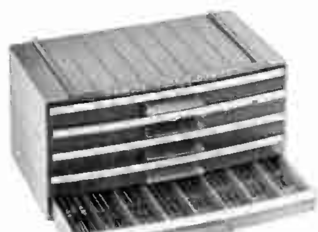
Resistance	Catalog Number ±5%	±10%
3,900. ohms	OH3925	OH3921
4,300. ohms	OH4325	
4,700. ohms	OH4725	OH4721
5,100. ohms	OH5125	
5,600. ohms	OH5625	OH5621
6,200. ohms	OH6225	
6,800. ohms	OH6825	OH6821
7,500. ohms	OH7525	
8,200. ohms	OH8225	OH8221
9,100. ohms	OH9125	
10,000. ohms	OH1035	OH1031
11,000. ohms	OH1135	
12 000. ohms	OH1235	OH1231
13,000. ohms	OH1335	
15,000. ohms	OH1535	OH1531
16,000. ohms	OH1635	
18,000. ohms	OH1835	OH1831
20,000. ohms	OH2035	
22,000. ohms	OH2235	OH2231
24,000. ohms	OH2435	
27,000. ohms	OH2735	OH2731
30,000. ohms	OH3035	
33,000. ohms	OH3335	OH3331
36,000. ohms	OH3635	
39 000. ohms	OH3935	OH3931
43,000. ohms	OH4335	
47,000. ohms	OH4735	OH4731
51,000. ohms	OH5135	
56,000. ohms	OH5635	OH5631
62,000. ohms	OH6235	
68,000. ohms	OH6835	OH6831

Resistance	Catalog Number ±5%	±10%
75,000. ohms	OH7535	
82,000. ohms	OH8235	OH8231
91,000. ohms	OH9135	
0.1 megs	OH1045	OH1041
0.11 megs	OH1145	
0.12 megs	OH1245	OH1241
0.13 megs	OH1345	
0.15 megs	OH1545	OH1541
0.16 megs	OH1645	
0.18 megs	OH1845	AH1841
0.20 megs	OH2045	
0.22 megs	OH2245	OH2241
0.24 megs	OH2445	
0.27 megs	OH2745	OH2741
0.30 megs	OH3045	
0.33 megs	OH3345	OH3341
0.36 megs	OH3645	
0.39 megs	OH3945	OH3941
0.43 megs	OH4345	
0.47 megs	OH4745	OH4741
0.51 megs	OH5145	
0.56 megs	OH5645	OH5641
0.62 megs	OH6245	
0.68 megs	OH6845	OH6841
0.75 megs	OH7545	
0.82 megs	OH8245	AH8241
0.91 megs	OH9145	
1. megs	OH1055	OH1051
1.1 megs	OH1155	
1.2 megs	OH1255	OH1251
1.3 megs	OH1355	

Resistance	Catalog Number ±5%	±10%
1.5 megs	OH1555	OH1551
1.6 megs	OH1655	
1.8 megs	OH1855	OH1851
2.0 megs	OH2055	
2.2 megs	OH2255	OH2251
2.4 megs	OH2455	
2.7 megs	OH2755	OH2751
3.0 ohms	OH3055	
3.3 megs	OH3355	OH3351
3.6 megs	OH3655	
3.9 megs	OH3955	OH3951
4.3 megs	OH4355	
4.7 megs	OH4755	OH4751
5.1 megs	OH5155	
5.6 megs	OH5655	OH5651
6.2 megs	OH6255	
6.8 megs	OH6855	OH6851
7.5 megs	OH7555	
8.2 megs	OH8255	OH8251
9.1 megs	OH9155	
10. megs	OH1065	OH1061
11. megs	OH1165	
12. megs	OH1265	OH1261
13. megs	OH1365	
15. megs	OH1565	OH1561
16. megs	OH1665	
18. megs		OH1861
22. megs		OH2261

*Min. Resistance under MIL-R-11 is 10 ohms.
‡Min. Resistance under MIL-R-11 is 2.7 ohms.
[1] Items appearing in BOLD print are popular values and are usually stocked by authorized OHMITE distributors. Items appearing in LIGHT FACE print are available from stocking distributors but normally are not stocked in depth.

OHMITE *Little Devil*® industrial and service resistor assortments



RESISTORS AND HANDY CABINET FOR THE PRICE OF THE RESISTORS ALONE

Select the composition resistor you need, right on the job from time-saving Little Devil® Assortments. Ohmite now offers seven industrial assortments in addition to the four service assortments that have been so popular for many years. In this complete line, there is an assortment to fill every industrial and service need. An attractive plastic cabinet or cabinet assembly is furnished at no extra cost with each assortment. Each drawer of a single 5-drawer cabinet has eight compartments, all individually labeled. Dimensions of the single cabinet are 9" long, 4¾" high, 5¼" deep. Dovetail tops and bottoms facilitate stacking. Cabinet assemblies for industrial assortments are riveted to metal strips which afford rigidity and permit hanging of the unit on the wall.

Of the seven industrial assortments, there are three ±10% tolerance assortments of ¼, ½ or 1 watt sizes each containing 80 values. A two-cabinet assembly is furnished for these assortments. Four 5% tolerance assortments provide 160 values each of resistors in the ⅛, ¼, ½, or 1 watt sizes. A four-cabinet assembly is furnished for each of these assortments.

The four popular service assortments provide ±10% tolerance resistors in a single cabinet in ¼, ½, 1 or 2 watt sizes.

Cabinets are factory packed in accordance with the tables shown below.

11 ASSORTMENTS

Assortment	Catalog No.	Quantity of Resistors	Wattage Size	Net Price
INDUSTRIAL ±10% Tolerance 80 Resistance Values 2 Cabinets	CAB-25	1000	¼	$ 70.00
	CAB-26	1000	½	60.00
	CAB-27	600	1	54.00
INDUSTRIAL ±5% Tolerance 160 Resistance Values 4 Cabinets	CAB-45	1000	⅛	225.00
	CAB-46	1500	¼	210.00
	CAB-47	1500	½	180.00
	CAB-48	900	1	160.00
RADIO & TV SERVICE KITS ±10% Tolerance 37 Values—CAB-4 40 Values—Others 1 Cabinet	CAB-4	150	¼	19.50
	CAB-10	150	½	18.00
	CAB-2	125	1	22.50
	CAB-3	125	2	30.00

Prices Subject to Change Without Notice

10% TOLERANCE ASSORTMENTS

10% Resistance Values	CAB-4, ¼ W (Service)	CAB-10, ½ W (Service)	CAB-2, 1 W (Service)	CAB-3, 2 W (Service)	CAB-25, ¼ W (Industrial)	CAB-26, ½ W (Industrial)	CAB-27, 1 W (Industrial)	10% Resistance Values	CAB-4, ¼ W (Service)	CAB-10, ½ W (Service)	CAB-2, 1 W (Service)	CAB-3, 2 W (Service)	CAB-25, ¼ W (Industrial)	CAB-26, ½ W (Industrial)	CAB-27, 1 W (Industrial)
2.7					5	5	10	6,800	5	1	1	1	30	15	10
3.3					5	5	5	8,200					20	5	5
3.9					5	5	5	10,000	10	10	10	10	30	30	10
4.7					5	5	10	12,000					20	15	5
5.6					5	5	5	15,000	5	3	3	3	30	5	10
6.8					5	5	10	18,000					20	5	5
10		1	1	1	20	20	10	22,000	5	5	5	5	30	30	10
12					5	5	5	27,000	5	10	10	10	20	20	10
15		1	1	1	5	5	10	33,000	3	3	1	1	20	20	10
18					5	5	5	39,000	3	5	5	5	5	15	10
22					5	5	10	47,000	5	10	10	10	30	30	10
27		1	1	1	5	5	10	56,000					20	15	5
33					5	5	10	68,000	3	3	1	1	20	20	5
39					5	5	5	82,000	2	1	1	1	5	15	5
47	5	1	1	1	20	20	10	0.10 meg.	10	10	10	10	30	30	10
56					5	5	5	0.12 meg.					5	5	5
68					5	5	5	0.15 meg.	3	5	5	5	5	15	10
82					5	5	5	0.18 meg.					5	5	5
100	5	5	1	1	30	30	10	0.22 meg.	3	3	1	1	20	20	10
120					5	5	5	0.27 meg.	3	10	10	10	5	20	10
150	1	1	1	1	20	15	10	0.33 meg.	3	3	1	1	20	15	5
180					5	5	5	0.39 meg.					5	5	5
220					20	20	10	0.47 meg.	5	10	10	10	20	30	10
270	3	3	1	1	30	15	10	0.56 meg.					5	5	5
330	1	1	1	1	20	15	10	0.68 meg.	1	1	1	1	5	5	5
390					5	5	10	0.82 meg.					5	5	5
470	3	3	1	1	20	30	10	1.0 meg.	10	10	10	10	30	30	10
560					5	15	10	1.2 meg.					5	5	5
680	1	1	1	1	20	15	10	1.5 meg.	1	1	1	1	5	5	5
820					5	5	5	1.8 meg.					5	5	5
1,000	10	5	3	3	5	30	10	2.2 meg.	1	1	1	1	5	15	5
1,200					5	5	10	2.7 meg.	1	3	1	1	5	5	5
1,500	5	1	1	1	20	20	10	3.3 meg.					5	15	5
1,800					5	15	5	3.9 meg.	1	1	1	1	5	5	5
2,200	10	1	1	1	30	30	10	4.7 meg.	1	1	1	1	5	5	5
2,700	5	3	3	3	20	15	10	5.6 meg.					5	5	5
3,300					30	20	10	6.8 meg.	1	1	1	1	5	5	5
3,900					20	5	10	10.0 meg.	1	1	1	1	5	5	5
4,700	10	10	5	5	30	30	10	15.0 meg.					5	5	5
5,600					5	20	5	22.0 meg.					5	5	5

Quantities in Each Assortment: Service Assortments (CAB-4, CAB-10, CAB-2, CAB-3); Industrial Assortments (CAB-25, CAB-26, CAB-27).

5% TOLERANCE ASSORTMENTS

Quantities in Each Assortment — Industrial Assortments

5% Resistance Values	CAB-45, ⅛ W	CAB-46, ¼ W	CAB-47, ½ W	CAB-48, 1 W	5% Resistance Values	CAB-45, ⅛ W	CAB-46, ¼ W	CAB-47, ½ W	CAB-48, 1 W	5% Resistance Values	CAB-45, ⅛ W	CAB-46, ¼ W	CAB-47, ½ W	CAB-48, 1 W	5% Resistance Values	CAB-45, ⅛ W	CAB-46, ¼ W	CAB-47, ½ W	CAB-48, 1 W
2.7	5	5	5	5	160	5	5	5	5	7,500	5	5	5	5	0.36 meg.	5	5	5	5
3.0	5	5	5	5	180	20	5	5	5	8,200	5	25	15	5	0.39 meg.	5	5	5	5
3.3	5	5	5	5	200	5	5	15	10	9,100	5	5	5	5	0.43 meg.	5	5	5	5
3.6	5	5	5	5	220	10	25	15	10	10,000	20	30	30	10	0.47 meg.	5	10	20	5
3.9	5	5	5	5	240	5	5	5	5	11,000	5	5	5	5	0.51 meg.	5	5	5	5
4.7	5	5	5	5	270	5	10	15	10	12,000	10	25	20	5	0.56 meg.	5	5	5	5
5.1	5	5	5	5	300	5	5	5	5	13,000	5	5	5	5	0.62 meg.	5	5	5	5
5.6	5	5	5	5	330	5	25	15	10	15,000	5	30	30	5	0.68 meg.	5	5	5	5
6.8	5	5	5	5	360	5	5	5	5	16,000	5	5	5	5	0.75 meg.	5	5	5	5
7.5	5	5	5	5	390	5	10	15	5	18,000	5	10	15	5	0.82 meg.	5	5	5	5
8.2	5	5	5	5	430	5	5	5	5	20,000	5	25	15	5	0.91 meg.	5	5	5	5
9.1	5	5	5	5	470	10	25	20	10	22,000	5	25	30	10	1.0 meg.	5	25	20	5
10	20	25	30	10	510	5	10	15	10	24,000	5	5	15	5	1.1 meg.	5	5	5	5
11	5	5	5	5	560	5	10	15	5	27,000	5	10	15	5	1.2 meg.	5	5	5	5
12	5	5	5	5	620	5	5	15	5	30,000	5	10	5	5	1.3 meg.	5	5	5	5
15	5	5	5	5	680	5	10	5	10	33,000	5	25	20	5	1.5 meg.	5	10	5	5
16	5	5	5	5	750	5	5	5	5	36,000	5	5	5	5	1.6 meg.	5	5	5	5
18	5	5	5	5	820	5	10	5	5	39,000	5	10	15	5	1.8 meg.	5	5	5	5
20	5	5	5	5	910	5	5	5	5	43,000	5	5	5	5	2.0 meg.	5	5	5	5
22	5	5	5	5	1,000	20	30	30	10	47,000	10	25	20	10	2.2 meg.	5	5	5	5
24	5	5	5	5	1,100	5	5	5	5	51,000	5	10	15	5	2.4 meg.	5	5	5	5
27	5	5	15	5	1,200	10	25	15	10	56,000	5	5	15	5	2.7 meg.	5	5	5	5
30	5	5	5	5	1,300	5	5	5	5	62,000	5	5	5	5	3.0 meg.	5	5	5	5
33	5	5	5	5	1,500	20	10	20	5	68,000	5	10	15	5	3.3 meg.	5	5	5	5
36	5	5	5	5	1,600	5	5	5	5	75,000	5	5	5	5	3.6 meg.	5	5	5	5
39	5	5	5	5	1,800	5	25	15	5	82,000	5	10	5	5	3.9 meg.	5	5	5	5
43	5	5	5	5	2,000	20	25	30	10	91,000	5	5	5	5	4.3 meg.	5	5	5	5
47	10	10	5	5	2,200	20	30	30	10	0.10 meg.	20	30	30	10	4.7 meg.	5	5	5	5
51	10	10	15	10	2,400	5	10	5	5	0.11 meg.	5	5	5	5	5.1 meg.	5	5	5	5
56	5	5	5	5	2,700	10	25	15	5	0.12 meg.	5	5	5	5	5.6 meg.	5	5	5	5
62	5	5	5	5	3,000	5	10	15	5	0.13 meg.	5	5	5	5	6.2 meg.	5	5	5	5
68	5	5	5	5	3,300	5	25	30	5	0.15 meg.	5	10	15	5	6.8 meg.	5	5	5	5
75	5	5	20	5	3,600	5	5	5	5	0.16 meg.	5	5	5	5	7.5 meg.	5	5	5	5
82	5	5	5	5	3,900	10	25	15	5	0.18 meg.	5	5	5	5	8.2 meg.	5	5	5	5
91	5	5	5	5	4,300	5	5	5	5	0.20 meg.	5	10	5	5	10.0 meg.	5	5	5	5
100	20	30	30	10	4,700	20	30	30	10	0.22 meg.	5	5	15	5	12.0 meg.	5	5	5	5
110	5	5	5	5	5,100	10	25	15	5	0.24 meg.	5	5	5	5	15.0 meg.	5	5	5	5
120	5	5	5	5	5,600	5	25	15	5	0.27 meg.	5	5	5	5	18.0 meg.	5	5	5	5
130	5	5	5	5	6,200	5	10	5	5	0.30 meg.	5	5	5	5	20.0 meg.	5	5	5	5
150	5	10	15	10	6,800	5	30	20	5	0.33 meg.	5	5	5	5	22.0 meg.	5	5	5	5

[1] ITEMS APPEARING IN BOLD PRINT ARE POPULAR VALUES AND ARE USUALLY STOCKED BY AUTHORIZED OHMITE DISTRIBUTORS.

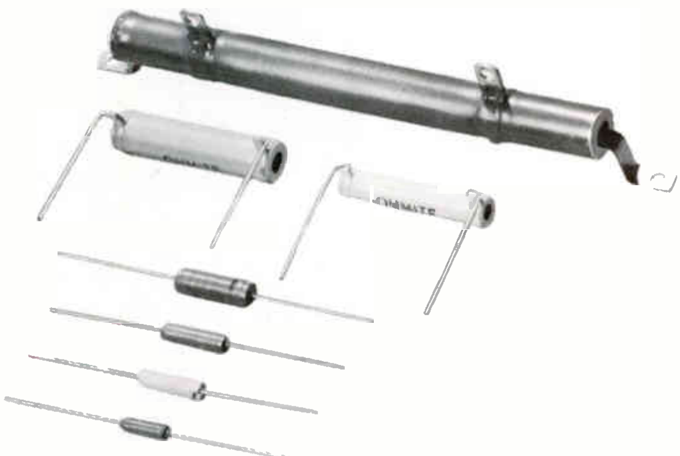
power line chokes

Catalog No.[1]	Inductance Micro-henries	Amps.	Total D.C. Ohms	Core	Weight lbs.
Z-20	14	5	0.15	4" x 5/16"	.11
Z-21	15	10	0.07	6½" x ¾"	.31
Z-22	18	20	0.045	8½" x 1⅛"	.73
(*Z-30)	110	20	0.085	8½" x 1⅛"	1.45

*One section is wound as a second layer over the other. Non-magnetic brackets furnished with each choke.

Prevents high-frequency currents of radio transmitters, diathermy and therapeutic equipment from going out over the power lines and interfering with nearby radio receiving sets. They are used as filters in conjunction with two grounding capacitors of 0.1 microfarad capacity each. The Z-20 Choke is also used at radio receivers to keep out interference. All chokes consist of two, single-layer windings on a single ceramic core, insulated and protected by moisture-proof coating.

radio frequency plate chokes



This series of seven, single-layer-wound, solenoid type radio frequency plate chokes, covers the entire frequency range of 3 to 520 megacycles. The stock number corresponds to the approximate frequency at which maximum efficiency will be obtained, but the chokes may be used at any other frequencies within their operating ranges, as listed in the price table.

Chokes of the four highest frequencies are wound on low power factor plastic cores while the other three units are wound on steatite tubes. Windings are insulated and protected by a moisture-proof coating. The single

Catalog No.[1]	Operating Range	Inductance Micro-henries	D.C. Res. Ohms*	Rated Current Amps	Resonant Freq. Mc	Core	Wt. Lbs.
Z-7	3 to 20 Mc.	84.0	4.70	1.00	13	6" x 9/16"	.106
Z-14	7 to 35 Mc.	44.0	2.60	0.68	23	2" x 7/16"	.026
Z-28	20 to 60 Mc.	21.0	2.70	0.60	41	1¾" x 5/16"	.011
Z-50	35 to 110 Mc.	7.0	0.98	1.00	79	1" x 9/32"	.005
Z-144	80 to 200 Mc.	1.8	0.33	1.10	168	¾" x 3/16"	.002
Z-235	160 to 350 Mc.	0.84	0.14	1.70	300	¾" x 3/16"	.002
Z-460	320 to 520 Mc.	0.20	0.034	4.00	500	½" x 5/32"	.001

Non-magnetic Brackets Furnished with Z-7.
* At 100 ma, 25°C ambient.

layer winding is designed to avoid adverse harmonic effects and also prevents breakdown from high r.f. potentials. Non-magnetic mounting brackets are furnished with the largest size, Z-7. The Z-14 and Z-28 have wire leads welded to lug type terminals; the Z-50, Z-144, Z-235 and Z-460 have axial-type wire leads.

Any one of these chokes may be selected for a particular frequency within its recommended operating range with the assurance that it will give excellent performance. Selection should be made, however, subject to the following qualification. It is generally advisable to select a choke with a resonant frequency (see chart) slightly higher than the desired operating frequency since any additional capacity to ground will tend to shift the resonant frequency closer to the operating frequency. Also, for this reason, the frequency designated by the catalog number of a choke is lower than its natural resonant frequency.

parasitic suppressor

The P-300 Suppressor is designed to prevent unwanted ultra-high-frequency parasitic oscillations which occur in the plate and grid leads of push-pull and parallel tube circuits. The P-300 is a non-inductive, 50 ohm, vitreous enameled resistor combined with a choke (in parallel) of .3 microhenries inductance and .003 ohms D.C. resistance. The two form a small integral unit only 1¾" long overall and 21/32" diameter. The unit may be mounted directly in the grid lead without extra support.

Model P-300 Wt. .04 lb. ....Net 1-9 $1.90

diode metersaver protects meters

Designed to protect sensitive (high internal resistance) meters against burnout due to overload even where potential is reversed. Introduces negligible error. Consists of 2 silicon diodes in compact case with leads and lugs. Connects across meter terminals without regard for polarity. Shunts excess current around meters — for example, can convert 200 times overload to 3 times overload. Allows use of less expensive meter fuses. Can be used with meters of low internal resistance but use of series resistor is then recommended.

Catalog No. OMC7111 ....Net (1-99) $1.98

[1] **Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.**

OHMITE 0.1% precision Determ-Ohm® resistance box

The new Ohmite Precision Determ-ohm® is a resistance decade box with an accuracy of ±0.1%. Four models cover the resistance range from 1 ohm to 1 megohm in a choice of three-4 decade and one-6 decade models.

Simplified selection of resistance values is accomplished by operation of rocker-type thumbwheel switches. Resistance setting is indicated by a direct in-line numeric readout. Unique switch feature (pat. pend.) allows advancing or decreasing of values directly from 9 thru 0 to 1 or vice versa, without retracing all the other values.

The housing is a functional sloping panel metal case equipped with universal binding posts and a grounded metallic binding post for effective shielding.

SPECIFICATIONS

Accuracy: 0.1% (plus .01Ω max. contact and circuit resistance per decade).

Selection: Rocker-type thumbwheel switches, continuous rotation in either direction.

Switch Life: In excess of 50,000 operations.

Power: ¼ Watt per resistor.

Operating Temperature: +15 to +35°C.

T.C. of Resistors: ±10 ppm/°C, max. 20 ppm/°C.

MAXIMUM CURRENT RATINGS

(Do not exceed 500 Volts.)

Resistance Range (Ohms)	Maximum Current (Milliamps)
1-9	710
10-99	220
100-999	71
1000-9999	22
10,000-99,999	7.1
100,000-999,999	1.1

SELECTION AND PRICING

Resistance Range (Ohms)	Ohms Per Step	Number of Decades	Catalog Number	Net Price
0 to 9.999K	1	4	3405	$85.00
0 to 99.99K	10	4	3406	85.00
0 to 999.9K	100	4	3407	90.00
0 to 999.999K	1	6	3410	125.00

PRICES SUBJECT TO CHANGE WITHOUT NOTICE.

thru-bolt type mounting brackets for tubular resistors

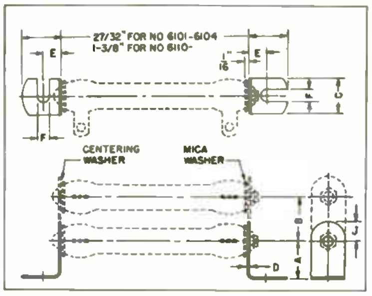
These sturdy cadmium-plated steel brackets mount tubular resistors type 270 (fixed) and type 210 (adjustable Dividohm®) via thru-bolts and centering washers with mica insulating washers. Slotted, consisting of one end-slot and one side-slot bracket, and elongated styles are offered.

THRU-BOLT BRACKET CATALOG NUMBER			FOR TUBULAR RESISTOR	
SLOTTED STYLE	ELONGATED STYLE	WATT SIZE	FIXED TYPE CATALOG NUMBER	DIVIDOHM CATALOG NUMBER
—	6120-D-1¾	12	3723-3843	1001-1040
6101-2	6120-K-2	25	0200A-0229	0360-0389
6101-4	6120-K-4	50	0400A-0428	0560-0591
6101-6	—	75	—	0769-0796
6104-6½	—	100	0600A-0625	0956-0973
6110-8½	—	175	0700A-0725	1156-1173
6110-10½	—	225	0900A-0925	1356-1373

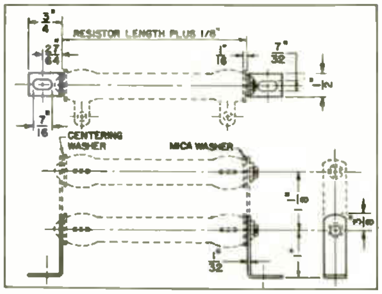
DIMENSIONS FOR SLOTTED BRACKET

Cat. No. Type	A	B	C	D	E	F	J
6101	25/32	15/16	3/4	1/32	7/16	1/4	13/32
6104	25/32	1 1/8	3/4	1/32	7/16	1/4	13/32
6110	1	1 3/4	1 1/8	1/16	13/16	5/16	9/16

SLOTTED BRACKET TYPE

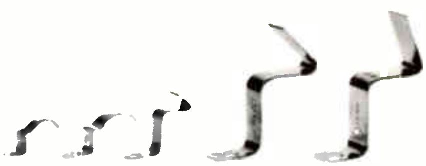


ELONGATED BRACKET TYPE



mounting brackets for tubular resistors

Brackets fit inside the cores of tubular resistors and remain in place by friction. The standard bracket (indicated by catalog number without suffix) is cadmium plated steel. An "S" suffix on the catalog number indicates spring steel: a "B" suffix indicates brass.



Spring steel brackets are excellent where vibration is involved; brass brackets are used with non-inductive resistors or for corrosion resistance. A pair of standard brackets is supplied with each individually boxed resistor sold through distributors. Brackets are not automatically supplied for bulk resistor orders. Brackets are sold in lots of 100 pieces (50 pair).

Catalog No.	Mtg. Screw Max.	Fits these Resistors	Weight Lbs. 100 pcs.
5, 5S, 5B	6	12 W Brown Devil or Divid.	.17
7, 7S, 7B	6	20W Brown Devil	.24
9, 9S, 9B	6	25, 50W Fixed; 25, 50, 75W Dividohm	.30
12, 12S, 12B	10	100W Fixed or Dividohm	1.30
18, 18S, 18B	10	175, 225W Fixed or Divid.	1.50

*100 pieces per pkg. — Minimum Order

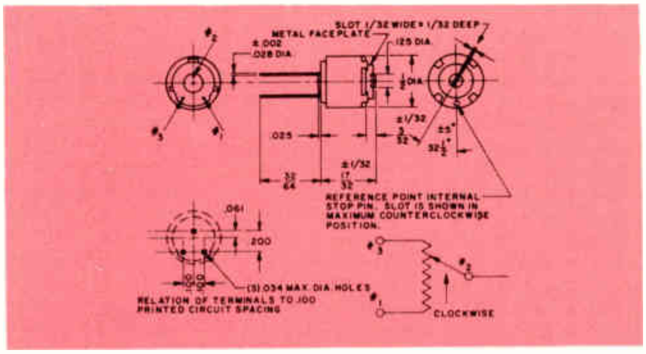
OHMITE hot molded single-turn trimmers

TYPE AFR — SINGLE TURN

OHMITE type AFR Trimmers are single-turn controls built to withstand severe environmental conditions. Their unique design includes a hot-molded resistor track bridged by a single moving molded contact brush. Resistance material, collector track material, insulation material and metal terminals are all molded together at one time into a single, solid, integral structure. There are no cracks or crevices to admit moisture.

Enclosure of the Ohmite type AFR is non-magnetic, corrosion resistant, and splash-proof. Type AFR Trimmers are designed for screwdriver adjustment. Fixed stops withstand a maximum shaft torque of 2 inch-pounds.

In excess of 50,000 operational cycles with low "noise" level initially — decreasing with use — can be expected in conventional applications.



CHARACTERISTICS:

Power Rating: ¼ watt @ +70° C ambient temperature. Derate power linearly to zero at +120° C ambient for resistance values to 0.5 megohms. Additional derating required for resistance values over 0.1 megohms at ambients higher than 70° C.

Resistance Range: 100 ohms to 5.0 megohms. Resistance change is nominally linear with shaft rotation.

Tolerance: ±20% standard.

Temperature Range: —55° C to +120° C.

Working Voltage: 350 volts, RMS, maximum.

Dielectric Strength: 750 VAC, RMS, at sea level.

Adjustment: Single turn, 295 ±5 degrees.

Torque: 0.25 to 3.0 inch-ounces.

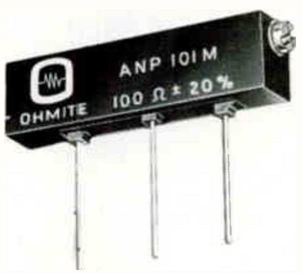
Leads: Designed for mounting directly on printed wiring boards using the terminal leads which are spaced to fit the 0.1" printed wiring board standard spacing.

STOCK OHMITE TYPE AFR TRIMMERS

Ohms ±20%	Catalog Number	Ohms ±20%	Catalog Number
100	AFR 101M	25,000	AFR 253M
250	AFR 251M	50,000	AFR 503M
500	AFR 501M	.1 meg	AFR 104M
1,000	AFR 102M	.25 meg	AFR 254M
2,500	AFR 252M	.5 meg	AFR 504M
5,000	AFR 502M	1.0 meg	AFR 105M
10,000	AFR 103M	2.5 meg	AFR 255M
		5.0 meg	AFR 505M

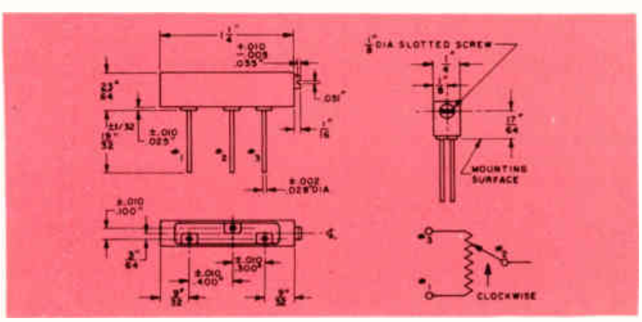
hot molded 25-turn trimmers

TYPE ANP — 25-TURN



Ohmite type ANP Hot-Molded Trimmers are continuously adjustable 25-turn variable resistors intended primarily for trimmer applications. Designed for use on printed circuit boards, these dependable three-terminal devices can be applied as either rheostats or potentiometers with equally satisfactory results. Stepless and relatively non-inductive regardless of resistance value. Unexcelled stability of setting in normal environmental conditions.

The type ANP Trimmer is produced by a hot-molding process using a high insulation material together with a hot molded resistance track, low resistance collector track and terminal pins — all combined into a single, solid, integral structure. The type ANP is splash-proof, dust-tight and can be mounted by its own rugged terminals.



CHARACTERISTICS:

Power Rating: ⅓ watt @ 50° C ambient temperature. Derate power linearly to zero at 100° C.

Resistance Range: 100 ohms to 0.1 megohms. Resistance change is nominally linear with shaft rotation.

Tolerance: Standard resistance tolerance is ±20%.

Temperature Range: —55° C to +100° C.

Working Voltage: 350 volts RMS, maximum at sea level.

Dielectric Strength: 700 volts RMS maximum, at sea level.

Insulation Resistance: 1000 megohms minimum.

Adjustment: 25 ± 3 turns for continuous resistance change. Mechanical release at end positions. Turning torque is 0.10 to 8 inches-ounce. Slotted for screwdriver adjustment.

Leads: Pin type terminals, spaced in accordance with 0.1" printed wiring board grid system.

STOCK OHMITE TYPE ANP TRIMMERS

Ohms ±20%	Catalog Number	Ohms ±20%	Catalog Number
100	ANP-101M	5,000	ANP-502M
250	ANP-251M	10,000	ANP-103M
500	ANP-501M	25,000	ANP-253M
1,000	ANP-102M	50,000	ANP-503M
2,500	ANP-252M	.1 meg	ANP-104M

OHMITE vitreous enameled rheostats (potentiometers)

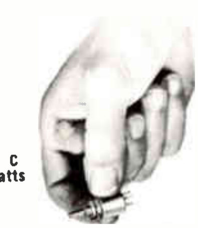
Now, Ohmite offers TWELVE sizes in its line of famous rheostats ranging from 7.5 to 1000 watts. Nothing to shrink or burn, all models are metal and ceramic construction and coated with Ohmite's exclusive vitreous enamel or Ohmicone® silicone ceramic. The revolutionary Model C, 7½ watt miniature unit, **the smallest rheostat of its rating available,** employs this same construction! All Model C stock units and the enclosed Model E unit, are normally supplied in a corrosion-resistant dust-proof case. Model C units are stocked in both standard and locking type bushings.

In all Ohmite rheostats, the resistance wire is wound on a solid ceramic core. The turns are locked in place with tough, protective vitreous enamel or Ohmicone® silicone ceramic. Pivoted, universal action mounting of the brush, assures perfect contact. Metal-graphite contact brushes, varied to fit current and resistance, insure good contact with negligible wear of the wire. Terminals at each end of the winding permit connection of the unit as a potentiometer.

Models H, J, G, K, L, P, and N, marked "Series A," are listed under the Underwriter's Laboratories Reexamination Service. RHEOSTAT KNOBS are listed on page 20. Rheostats can be supplied to meet military specification MIL-R-22.

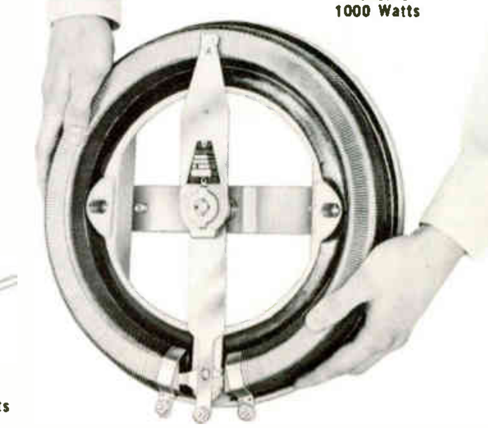
RATINGS: Current ratings shown, assume use in free air. If units are enclosed, currents should be reduced to as much as 50% depending upon ventilation. The rated current causes the rheostat to dissipate its rated wattage when its full resistance is in the circuit.

SPECIAL RHEOSTAT FEATURES: Hundreds of features to meet your special rheostat requirements can be furnished. Submit your specifications.



Model C
7½ Watts

NOW, FOR ITS RATING INDUSTRY'S SMALLEST RHEOSTAT!



Model U
1000 Watts

Unenclosed
Model E
12½ Watts

Enclosed
Model E
12½ Watts

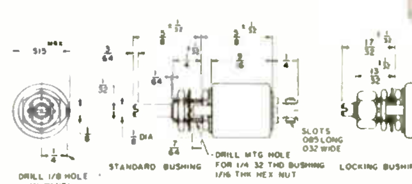
MODEL "C" — 7½ WATT* — STANDARD & LOCKING BUSHINGS

Diameter .515" max. — Depth behind panel ⅞" — Shaft ⅛" diameter, slotted for both types; Std. shaft accommodates knob — Rotation 300° — Mounting for panels up to ⅛" by means of ¼"-32 bushing and hex. nut — Non-turn lug requires ⅛" hole ¼" below center of shaft — No. 5151 knob recommended — Solder terminals also fit EIA type TS-E3R100 transistor socket — Wt. 0.27 oz.

Ohms	Amps.	Standard Shaft Catalog No.[1]	Locking Shaft Catalog No.[1]
10	.86	4908	**4948**
15	.71	**4909**	(4949)
25	.55	4910	(4950)
35	.46	(4911)	(4951)
50	.39	4912	(4952)
75	.32	(4913)	(4953)
100	.27	**4914**	4954
150	.22	(4915)	(4955)
200	.19	(4916)	(4956)
250	.17	4917	(4957)
350	.15	4918	**4958**
500	.12	4919	(4959)
750	.10	(4920)	(4960)
1000	.086	4921	4961
1500	.071	(4922)	(4962)
2500	.055	(4923)	4963
3500	.046	(4924)	(4964)
5000	.039	4925	4965

*Rating on metal panel — unit is silicone-ceramic coated.

Locking-type Model C mounted in socket on panel. Solder terminals fit transistor socket.



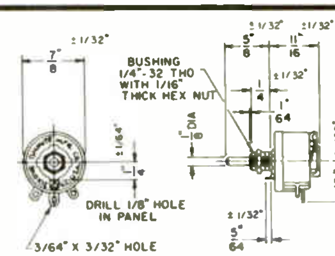
MODEL "E" — 12½ WATT* — UNENCLOSED & ENCLOSEO

Diameter ⅞"; Diameter with dust-tight aluminum enclosure 1¾₄" — Depth behind panel ¹¹⁄₁₆"; for enclosed, 1⁷⁄₃₂" — Rotation 300° — Mounts on panels up to ⅛" by means of ¼"-32 bushing and hex nut — Non-turn lug requires ⅛" hole ¼" below center of shaft. No. 5151 knob recommended—Wt. 0.6 oz.; enclosed 0.85 oz.

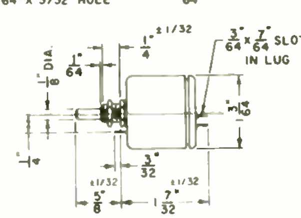
Total Ohms	Max. Amps	Steps Appr.	Unenclosed Catalog No.[1]	Enclosed Catalog No[1]
1	3.53	28	**0101**	(W0101)
2	2.50	29	**0102**	(W0102)
2.5	2.24	29	(0102A)	(W0102A)
3	2.04	38	**0103**	(W0103)
5	1.58	51	0103A	(W0103A)
6	1.44	35	**0104**	(W0104)
8	1.25	53	**0105**	(W0105)
10	1.12	50	**0106**	W0106
15	.91	70	**0107**	(W0107)
25	.71	72	**0108**	W0108
35	.60	82	**0109**	(W0109)
50	.50	92	**0110**	(W0110)
75	.41	105	**0111**	(W0111)
100	.35	102	**0112**	W0112
125	.32	110	**0113**	(W0113)
150	.29	130	(0113A)	(W0113A)
175	.27	155	**0114**	(W0114)
200	.25	135	0114A	(W0114A)
250	.22	170	**0115**	W0115
350	.19	190	**0116**	(W0116)
500	.16	210	**0117**	(W0117)
750	.13	200	**0118**	(W0118)
1,000	.11	260	**0119**	W0119
1,500	.091	209	**0120**	(W0120)
2,500	.071	323	**0121**	W0121
3,500	.060	400	**0122†**	(W0122†)
5,000	.050	340	**0123†**	W0123†
7,500	.041*	420	4190†	W4190†
10,000	.035*	560	**4191†**	(W04191†)
12,500	.031*	480	(4192†)	(W04192†)
15,000	.029*	490	**4193†**	(W04193†)

*Rating on metal panel. †Silicone-ceramic coating — 350V maximum; 7500 ohms = 305V

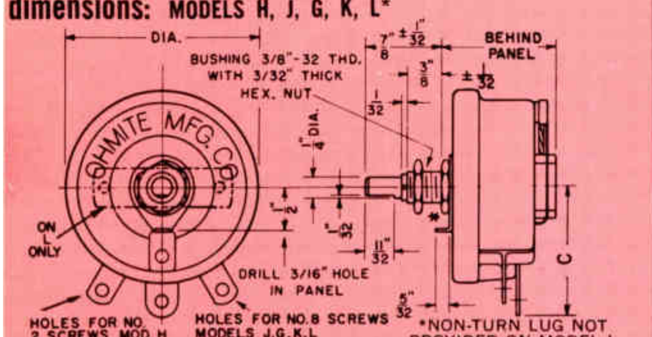
MODEL E



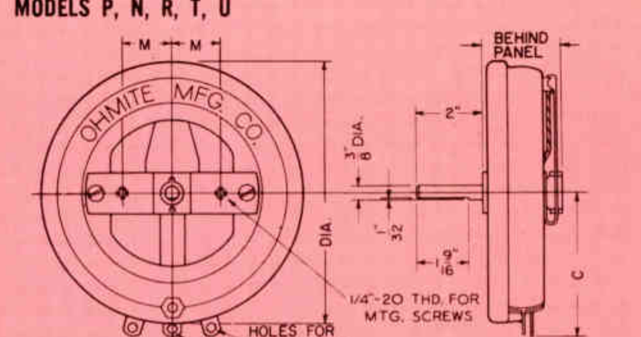
MODEL E ENCLOSEO



dimensions: MODELS H, J, G, K, L*



MODELS P, N, R, T, U



[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

OHMITE vitreous enameled rheostats (potentiometers)

25 WATT

MODEL "H," SERIES A

Dia. 1 5/16" — Depth behind panel 1 3/8" — Shaft 1/4" dia. Rotation 300° — Mounts on panels up to 1/4" by means of 3/8"-32 Bushing and Hex. Nut — Non-turn lug requires 3/16" hole 1/2" below ctr. of shaft — No. 5150 knob recom. — C dimension is 15/16" — Weight 0.19 lb.

Catalog No.[1]	Total Ohms	Max. Amps	Steps Approx.
0140	1	5.000	30
0141	2	3.540	29
0142	3	2.880	51
0143	6	2.040	50
0144	8	1.770	52
0145	10	1.580	52
0146	15	1.290	74
0147	25	1.000	95
0148	35	.845	107
0149	50	.707	97
0150	75	.575	117
0151	100	.500	123
0152	125	.445	155
0153	175	.375	171
0154	250	.316	159
0155	350	.267	210
0156	500	.222	245
0157	750	.182	286
0158	1,000	.155	305
0159	1,500	.129	380
0160	2,500	.100	300
0161	3,500	.084	335
0162	5,000	.070	380
4200†	7,500	.058	590
4201†	10,000	.050	525
4202†	15,000	.041	750
4203†	20,000	.035	750
4204†	25,000	.032	700

† Silicone-ceramic coating, 500V max. Not listed UL Ser. A.

50 WATT

MODEL "J," SERIES A

Dia. 2 5/16" — Depth behind panel 1 3/8" — Shaft 1/4" dia. Rotation 300° — Mounts on panels up to 1/4" by means of 3/8"-32 Bushing and Hex. Nut — Non-turn lug requires 3/16" hole 1/2" below ctr. of shaft — No. 5150 knob recom. — C dimension is 1 5/16" — Weight 0.32 lb.

Catalog No.[1]	Total Ohms	Max. Amps	Steps Approx.
0308	0.5	10.000	25
0309	1	7.070	44
0310	2	5.000	44
0311	4	3.530	44
0312	6	2.880	74
0313	8	2.500	82
0314	12	2.040	85
0315	16	1.760	89
0316	22	1.500	98
0317	35	1.190	126
0318	50	1.000	111
0319	80	.790	143
0320	125	.630	177
0321	150	.575	175
0322	225	.470	203
0323	300	.408	215
0324	500	.316	286
0325	800	.250	286
0326	1,000	.224	360
0327	1,600	.176	368
0328	2,500	.141	463
0329	3,500	.119	510
0330	5,000	.100	442
0331	8,000	.079	560
0332	10,000	.070	567
4210†	15,000	.058	700
4211†	20,000	.050	850
4212†	25,000	.045	950
4213†	30,000	.041	900
(4214†)	40,000	.035	950
4215†	50,000	.032	1130

† Silicone-ceramic coating, 750V max. Not listed UL Ser. A.

75 WATT

MODEL "G," SERIES A

Dia. 2 3/4" — Depth behind panel 1 3/4" — Shaft 1/4" dia. Rotation 300° — Mounts on panels up to 1/4" by means of 3/8"-32 Bushing and Hex. Nut — Non-turn lug requires 3/16" hole 1/2" below ctr. of shaft — No. 5150 knob recom. — C dimension is 1 23/32" — Weight 0.52 lb.

Catalog No.[1]	Total Ohms	Max. Amps	Steps Approx.
1100	0.5	12.300	28
(1101)	1	8.660	27
1102	2	6.120	28
1103	3	5.000	53
1104	5	3.880	54
1105	7.5	3.160	51
1106	10	2.740	55
1107	16	2.170	131
1108	25	1.730	113
1109	50	1.230	143
1110	75	1.000	134
1111	100	.866	180
1112	200	.612	186
1113	300	.500	217
1114	400	.433	230
1115	500	.388	291
(1116)	750	.316	345
1117	1,000	.274	351
(1118)	1,500	.224	434
1119	2,000	.194	450
(1120)	2,500	.173	448
(1121)	5,000	.123	590
(1122)	7,500	.100	544
1123	10,000	.087	568

100 WATT

MODEL "K," SERIES A

Dia. 3 1/8" — Depth behind panel 1 3/4" — Shaft 1/4" dia. Rotation 300° — Mounts on panels up to 1/4" by means of 3/8"-32 Bushing and Hex. Nut — Non-turn lug requires 3/16" hole 1/2" below ctr. of shaft — No. 5150 knob recom. — C dimension is 1 23/32" — Weight 0.64 lb.

Catalog No.[1]	Total Ohms	Max. Amps	Steps Approx.
0440	0.5	14.100	33
0441	1	10.000	33
0442	2	7.070	33
0443	3	5.750	30
0444	5	4.470	57
0445	7.5	3.650	60
0446	10	3.160	57
0447	16	2.500	124
0448	25	2.000	107
0449	50	1.410	135
0450	75	1.150	158
0451	100	1.000	168
0452	200	.707	213
0453	300	.575	259
0454	400	.500	270
0455	500	.447	269
0456	750	.365	319
0457	1,000	.316	330
0458	1,500	.258	402
0459	2,000	.224	417
0460	2,500	.200	515
0461	5,000	.141	560
0462	7,500	.115	495
0463	10,000	.100	673

150 WATT

MODEL "L," SERIES A

Dia. 4" — Depth behind panel 2" — Shaft 1/4" diameter. Rotation 300° — Mounting for panels up to 1/4", 3/8"-32 Bushing and Hex. Nut or two 10-32 flat head screws, mounting centers 7/8" each side of center of shaft on line perpendicular to center terminal. — Stock No. 5150 knob recom. — C dimension is 2 5/32" — Weight 1.1 lbs.

Catalog No.[1]	Total Ohms	Max. Amps	Steps Approx.
0524	0.5	17.300	28
0525	1	12.300	44
0526	2	8.650	43
0527	3	7.070	74
0528	5	5.480	78
0529	7.5	4.470	81
0530	10	3.880	77
0531	15	3.163	130
0532	25	2.450	114
0533	35	2.070	125
0534	50	1.735	142
0535	75	1.415	170
0536	100	1.225	177
0537	150	1.000	215
0538	200	.865	229
0539	250	.775	285
0540	350	.655	315
0541	500	.548	366
0542	750	.447	335
0543	1,250	.346	453
0544	1,800	.288	497
0545	2,250	.259	511
0546	3,000	.224	526
0547	4,500	.182	630
0548	7,500	.141	894
0549	10,000	.122	929

225 WATT

MODEL "P," SERIES A

Dia. 5" — Depth behind panel 2 1/8" — Shaft 3/8" dia. Rotation 310° — Mounting for panels up to 1 1/4" by two 1/4"-20 screws, mounting centers (M) 7/8" each side of center of shaft on center line of cross-bar. — Stock No. 5105 Knob Recommended — C dimension is 2 21/32" — Weight 2 lbs.

Catalog No.[1]	Total Ohms	Max. Amps	Steps Approx.
(1250)	1.0	15.000	42
1251	2.0	10.600	42
1252	3.0	8.660	43
(1253)	4.0	7.500	57
1254	5.0	6.710	57
(1255)	7.5	5.490	61
1256	10.0	4.740	103
1257	15.0	3.870	109
1258	25.0	3.000	115
1259	50.0	2.120	183
1260	75.0	1.730	192
1261	100	1.500	268
1262	150	1.220	256
1263	200	1.060	337
1264	300	.866	323
1265	400	.750	343
1266	700	.567	484
1267	900	.500	493
1268	1,200	.433	520
1269	1,500	.387	647
1270	1,750	.358	603
1270A	2,000	.336	650
1271	2,500	.300	652

300 WATT

MODEL "N," SERIES A

Dia. 6" — Depth behind panel 2 3/8" — Shaft 3/8" dia. Rotation 320° — Mounting for panels up to 1 1/4" by two 1/4"-20 screws, mounting centers (M) 1 3/16" each side of center of shaft on center line of cross-bar. — Stock No. 5105 Knob Recommended — C dimension is 3 1/16" — Weight 2.6 lbs.

Catalog No.[1]	Total Ohms	Max. Amps	Steps Approx.
0650	1.0	17.320	50
0651	2.0	12.240	52
0652	3.0	10.000	52
0653	4.0	8.660	78
0654	5.0	7.750	78
0655	7.5	6.320	72
0656	10.0	5.480	78
0657	15.0	4.470	144
0658	25.0	3.460	135
0659	50.0	2.450	218
0660	75.0	2.000	225
0661	100	1.730	285
0662	150	1.410	342
0663	200	1.220	363
0664	300	1.000	424
0665	400	.866	454
0666	700	.655	504
0667	900	.578	528
0668	1,200	.500	546
0669	1,500	.447	678
(0670)	1,750	.414	626
(0670A)	2,000	.387	700
0671	2,500	.346	708

500 WATT

MODEL "R"

Dia. 8" — Depth behind panel 2 1/8" — Shaft 3/8" dia. Rotation 325° — Mounting for panels up to 1 1/4" by two 1/4"-20 screws, mounting centers (M) 1 1/2" each side of center of shaft on center line of cross-bar. — Stock No. 5105 Knob Recommended — C dimension is 4 5/16" — Weight 4 lbs.

Catalog No.[1]	Total Ohms	Max. Amps	Steps Approx.
0849	1.0	22.300	69
0850	1.5	18.200	79
(0851)	2.0	15.800	75
(0852)	2.5	14.100	76
0853	3.0	12.900	78
0854	4.0	11.200	73
0855	5.0	10.000	103
0856	8.0	7.900	103
0857	12.5	6.300	103
0858	16.0	5.600	188
0859	25.0	4.470	204
0860	40.0	3.540	206
0872	50.0	3.160	206
0861	80.0	2.520	327
0862	125	2.000	327
0863	175	1.690	423
0864	250	1.410	488
0865	325	1.240	500
0866	500	1.000	609
0867	750	.817	727
0868	1,000	.707	771
0869	1,500	.577	935
0870	2,000	.500	980
0871	2,500	.447	968

750 WATT

MODEL "T"

Dia. 10" — Depth behind panel 3" — Shaft 3/8" dia. Rotation 330° — Mounting for panels up to 1 1/4" by two 1/4"-20 screws, mounting centers (M) 1 7/8" each side of center of shaft on center line of cross-bar. — Stock No. 5105 Knob Recommended — is 5 5/16" — Weight 7.6 lbs.

Catalog No.[1]	Total Ohms	Max. Amps	Steps Approx.
1300	1.0	27.400	71
(1301)	1.5	22.300	91
1302	2.0	19.400	103
(1303)	2.5	17.300	99
(1304)	3.0	15.800	94
(1305)	4.0	13.600	91
1306	5.0	12.200	102
1307	8.0	9.650	98
1308	10.0	8.650	138
(1309)	12.5	7.750	138
1310	16.0	6.820	140
1311	25.0	5.470	138
1312	50.0	3.870	248
1313	80.0	3.060	250
1314	100	2.740	248
1315	160	2.170	446
1316	200	1.940	442
1317	300	1.580	540
1318	400	1.370	583
(1319)	600	1.117	684
(1320)	750	1.000	686
1321	1,200	.791	870
(1322)	1,800	.646	1,042
(1322A)	2,000	.610	900
(1323)	2,500	.547	1,170

1000 WATT

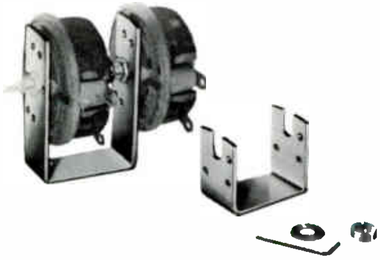
MODEL "U"

Dia. 12" — Depth behind panel 3" — Shaft 3/8" dia. Rotation 335° — Mounting for panels up to 1 1/4" by two 1/4"-20 screws, mounting centers (M) 3" each side of center of shaft on center line of cross-bar. — Stock No. 5105 Knob Recommended — C dimension is 6 3/8" — Weight 10 lbs.

Catalog No.[1]	Total Ohms	Max. Amps	Steps Approx.
1450	1.0	31.600	86
1451	1.5	25.800	89
1452	2.0	22.400	115
1453	2.5	20.000	122
1454	3.0	18.300	125
1455	4.0	15.800	118
1456	5.0	14.100	122
1457	8.0	11.200	116
1458	10.0	10.000	114
(1459)	12.5	8.950	181
1460	16.0	7.900	164
1461	25.0	6.330	181
1462	50.0	4.470	321
1463	75.0	3.650	301
1464	100	3.160	321
1465	175	2.390	520
1466	225	2.110	608
1467	300	1.830	640
1468	400	1.580	685
1469	500	1.410	687
1470	750	1.150	806
1471	1,000	1.000	855
1472	1,500	.816	1,026
1473	2,500	.633	1,097

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

OHMITE rheostat tandem coupling kits



Tandem rheostat assemblies can be ordered from the factory or assembled by the user with these kits which permit assembly of two units. Each kit consists of a steel "U" frame, a coupling with set screw, mica washer, Allen wrench and instructions.

Rheostat shafts are joined by the coupling which is fastened to the shaft of the rear unit. Projections on the coupling fit a recess on the rear of the hub of the front unit.

Three kits are available as follows:

Cat. No. 6532—Mounts Models H or J, also accommodates Models H, J, G, K or L in rear position.

Cat. No. 6533—Mounts G, K or L units, also accommodates Models H, J, G, K or L in rear position.

Cat. No. 6591—Mounts Model E units only.

Catalog No.	Max. Panel	Weight
6532	5/32″*	.17 lb.
6533	1/8″*	.41
6591	1/16″	.044

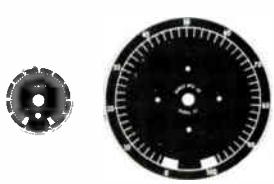
*Using No. 5150 Knob.

black bakelite knobs

Catalog No.[1] Standard	Hex-Socket	Description	Knob Dia.	Hole Dia.
5102		Bar Knob, 2¼″ long		¼″
5103	5103A	Bar Knob, 1¼″ long		¼″
5104	5104A	Handwheel with Pointer	3¼″	⅜″
5105		Handwheel without Pointer	3¼″	⅜″
5106		Handwheel with Pointer	3¼″	¼″
5107		Handwheel without Pointer	3¼″	¼″
5109	5109A	Finger-Grip with Pointer	1⅝″	¼″
5110	5110A	Finger-Grip without Pointer	1⅝″	¼″
5111	5111A	Finger-Grip with Pointer	2⅜″	¼″
5112	5112A	Finger-Grip without Pointer	2⅜″	¼″
(*5115)		Bar Knob, 4¾″ long		⅜″
5116	5116A	Bar Knob, 1½″ long		¼″
5150	5150A	Finger-Grip	1½″	¼″
5151		Finger-Grip	¾″	⅛″
5152A		Like 5104 but shorter pointer	3¼″	¼″

* Requires pin and tapped hole in shaft. Standard knobs have slotted set-screw(s); knobs ordered with "A" suffix have hex socket set-screw(s).

rheostat dials



Handsomely finished dials for Ohmite rheostats and other apparatus, feature bright figures and lines on etched black background. Divisions marked from 0 to 100 indicate approximate percentage of rheostat resistance in circuit.

Catalog No.	For Rheostat	Dial Dia.	Recom'd. Knobs*
5007	C, E	1¼″	5151
5000	H, J, G, K, L	2 3/16″	5150, 5116, 5103
5001	P, N, R, T, U	5½″	5104, 5106

*See Bakelite Knobs above

heat control rheostats

A convenient control for regulating the temperature of soldering irons, melting pots (such as those used for solder, wax, potting material) or other heater loads. With soldering irons, it permits quick adjustment of operating heat for the type of job and grade of solder.

Wattage of Device To Be Controlled: Watts	Volts	Rheostat Control Catalog No.	Cage Dimensions: Dia.	Height	Net Weight lbs.	Net Price 1 Qty.
40—65	115	(SRC65)	3⅛″	2″	.58	$15.50
85—100	115	SRC100	3⅛″	2″	.58	15.50
120—150	115	(SRC150)	3¾″	2⅜″	.93	17.50
175—220	115	(SRC220)	3¾″	2⅜″	1.05	21.50
300—350	115	(SRC350)	4½″	2⅜″	1.63	24.00
430—500	115	(SRC500)	7½″	3¼″	2.25	29.50

Consists of vitreous enameled rheostat housed in a perforated metal cage, with knob and dial. Supplied with series plug and six feet of heater type cord. The cord from the heater load is plugged into the series plug which is then plugged into a receptacle. Order in accordance with expected maximum wattage load.

high wattage t-pad and l-pad attenuators

Stepless control of speaker volume with essentially constant impedance is provided by Ohmite attenuators. In use, these units are interposed between high power amplifiers and speaker or speakers.

Housed in gray, perforated metal cage 3⅛″ high, 2⅝″ wide and extending 4¼″ behind panel for L-pads; 6¼″ for T-pads. Shaft ¼″ and bushing ⅜″ diameter; bushing length is for ¼″ maximum panel (specify greater thicknesses). Mounted with two 10/32 screws (supplied) on 2⅝″ vertical centers.

T-PAD ATTENUATORS			L-PAD ATTENUATORS		
25 WATT Avg. Wt. 1.44 lbs.			25 WATT Avg. Wt. 1 lb.		
Catalog No.	Line Impedance in Ohms	Net Price 1 Qty.	Catalog No.	Line Impedance in Ohms	Net Price 1 Qty.
(3001)	15	$30.00	(3201)	15	$27.50
(3002)	50	30.00	(3202)	50	27.50
(3003)	200	30.00	(3203)	200	27.50
(3004)	500	30.00	(3204)	500	27.50
50 WATT Avg. Wt. 1.88 lbs.			50 WATT Avg. Wt. 1.25 lbs.		
(3101)	15	$30.50	(3301)	15	$29.00
(3102)	50	30.50	(3302)	50	29.00
(3103)	200	30.50	(3303)	200	29.00
(3104)	500	30.50	(3304)	500	29.00

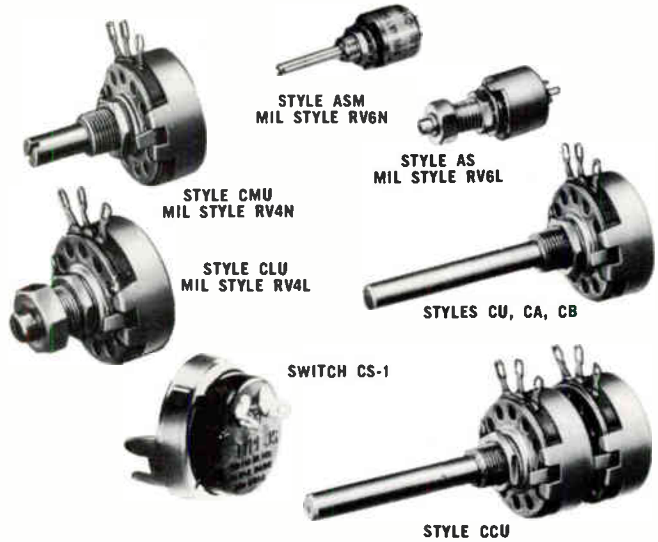
[1] **Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.**

OHMITE molded composition potentiometers

Ohmite molded composition potentiometers are used in commercial and military electronic applications where high-quality and dependable performance are important. Type AB is rated 2 watts at 70°C ambient and is available with ⅞" slotted shaft (CMU), 2" unslotted shaft (CU, CA, CB, CCU) and locking type bushing with slotted shaft (CLU). Type AS is a miniature unit rated ½ watt. It is available with locking type bushing and slotted shaft (Style AS) and standard bushing with longer (slotted) shaft for knob control (Style ASM).

Because the resistance element is a thick, solid-molded ring — not a sprayed film or paint-type resistor — longer life and smoother operation are obtained. This is due also to the molded composition contact. Units are dust and splash proof, fungus and corrosion resistant and meet the requirements of military specification MIL-R-94. Styles CMU, CLU, AS and ASM conform respectively to MIL-R-94, Styles RV4N, RV4L, RV6L and RV6N.

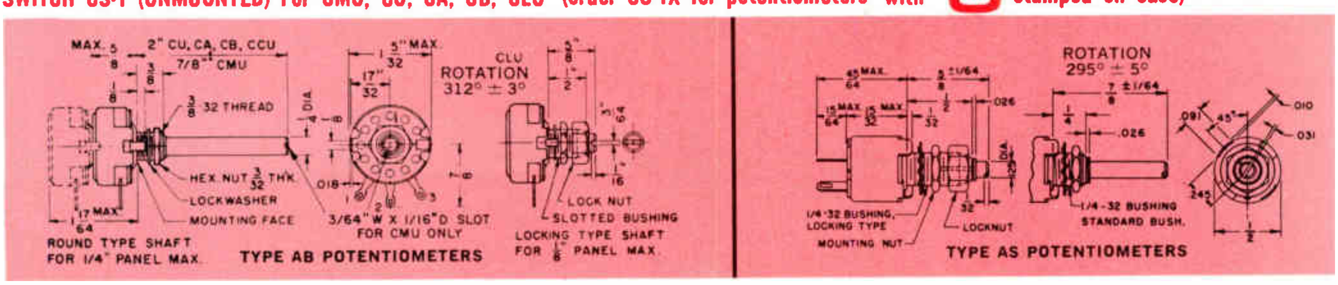
Styles and tapers are listed in table. Dimensions of all stock units are shown below. A SPST switch for single AB controls can be supplied (see below table).



STOCK "POTS" — MIL Units are Stamped with MIL and Commercial Designations

Resistance	TYPE AB (1⅛" Dia.) Rated 2 Watts[1] — Single Unit ⅞" Shaft		Single Unit 2" Shaft			Locking		Dual	TYPE AS (½" Dia.) Rated ½ Watt[1] — Miniature Locking		Miniature ⅞" Shaft	
Ohms Except As Noted Tol. ±10% except * ±20%	Style CMU Linear	MIL Designation (Cat. No. Prefix RV4N-AYSD-)	Style CU Linear	Style CA CW log	Style CB CCW log	Style CLU Linear	MIL Designation (Cat. No. Prefix RV4L-AYSA-)	Style CCU Linear (Resistance Shown is for Each Unit)	Style AS Linear	MIL Designation (Cat. No. Prefix RV6L-AYSA-)	Style ASM Linear	MIL Designation (Cat. No. Prefix RV6N-AYSD-)
50	**CMU5001**	500A	**CU5001**			**CLU5001**	500A					
100	**CMU1011**	101A	**CU1011**			**CLU1011**	101A		**AS3601**	101A	ASM6661	101A
150	CMU1511	151A	CU1511			CLU1511	151A					
250	**CMU2511**	251A	**CU2511**			**CLU2511**	251A		AS3602	251A	ASM6662	251A
350	CMU3511	351A	CU3511			CLU3511	351A					
500	**CMU5011**	501A	**CU5011**			**CLU5011**	501A		**AS3603**	501A	**ASM6663**	501A
750	CMU7511	751A	CU7511			CLU7511	751A					
1,000	**CMU1021**	102A	**CU1021**			**CLU1021**	102A		**AS3604**	102A	**ASM6664**	102A
1,500	CMU1521	152A	**CU1521**			**CLU1521**	152A					
2,500	**CMU2521**	252A	**CU2521**			**CLU2521**	252A		**AS3605**	252A	**ASM6665**	252A
3,500	CMU3521	352A	CU3521			CLU3521	352A					
5,000	**CMU5021**	502A	**CU5021**			**CLU5021**	502A		**AS3606**	502A	**ASM6666**	502A
7,500	CMU7521	752A	CU7521			CLU7521	752A					
10,000	**CMU1031**	103A	**CU1031**		CB1031	**CLU1031**	103A	**CCU1031**	**AS3607**	103A	**ASM6667**	103A
15,000	**CMU1531**	153A	CU1531			CLU1531	153A					
25,000	**CMU2531**	253A	**CU2531**		CB2531	**CLU2531**	253A	**CCU2531**	**AS3608**	253A	ASM6668	253A
35,000	CMU3531	353A	CU3531			CLU3531	353A					
50,000	**CMU5031**	503A	**CU5031**		**CB5031**	**CLU5031**	503A	**CCU5031**	**AS3609**	503A	**ASM6669**	503A
75,000	CMU7531	753A	CU7531			CLU7531	753A					
.1 meg.	**CMU1041**	104A	**CU1041**	**CA1041**		**CLU1041**	104A	**CCU1041**	**AS3610**	104A	**ASM6670**	104A
.15 meg.	CMU1541	154A	CU1541			CLU1541	154A					
.25 meg.	**CMU2541**	254A	**CU2541**	CA2541		**CLU2541**	254A	CCU2541	**AS3611**	254A	ASM6671	254A
.35 meg.	CMU3541	354A	CU3541			CLU3541	354A					
.5 meg.	**CMU5041**	504A	**CU5041**	CA5041		**CLU5041**	504A	CCU5041	AS3612	504A	ASM6672	504A
.75 meg.*	CMU7542	754B	CU7542			CLU7542	754B					
1.0 meg.*	**CMU1052**	105B	**CU1052**	CA1052		**CLU1052**	105B	CCU1052	**AS3613**	105B	ASM6673	105B
1.5 meg.*	CMU1552	155B	CU1552			CLU1552	155B					
2.0 meg.*	CMU2052	205B	CU2052			CLU2052	205B		AS3684	205B	ASM6674	205B
2.5 meg.*	CMU2552	255B	**CU2552**	CA2552		CLU2552	255B		AS3614	255B	ASM6675	255B
3.5 meg.*	CMU3552	355B	CU3552			CLU3552	355B					
5.0 meg.*	CMU5052	505B	CU5052			CLU5052	505B		AS3615	505B	ASM6676	505B
Weight	.064 lb.		.084 lb.			.070 lb.		.123 lb.	.017 lb.		.017 lb.	

SWITCH CS-1 (UNMOUNTED) For CMU, CU, CA, CB, CLU (order CS-1X for potentiometers with [Ohmite logo] stamped on case)



[1] Items appearing in BOLD print are popular values and are usually stocked by authorized OHMITE distributors. Items appearing in LIGHT FACE print are available from stocking distributors but normally are not stocked in depth.

OHMITE power tap switches, high current, non-shorting type

Introducing

MODEL 711
Smallest Switch for Its Rating

Ohmite single pole, rotary, multi-position switches have proven their durability over many years in demanding applications. Such applications are found in switchboards, arc welders, spot welders, battery chargers, motor controls, tapped transformers, X-ray equipment, diathermy equipment, radio transmitters, electrical machine tools and many other products. Six sizes, including the new, miniature Model 711, provide a choice of ratings from 7 amperes at 125 volts to 100 amperes at 300 volts AC. A choice of number of taps is provided up to the maximums indicated. All switches are enclosed except for the Models 711 and 111. All switches feature the slow-break, quick-make action deemed so desirable for switching of AC current.

The five sizes offering ratings from 15 amperes to 100 amperes (Models 111, 212, 312, 412 and 608) feature all ceramic, arc-proof bodies and solid silver alloy, fixed and movable contacts. The large, thick, silver-alloy fixed contact disks are permanently welded to copper studs. These, in turn, are riveted and soldered to sturdy terminal lugs, assuring a permanent mechanical and electrical joint. The rotor (moving) contact, also of solid silver-alloy, is riveted and soldered to the contact arm. Face of the rotor contact is slightly rounded assuring a perfect seating of the contacts with a slight rubbing, self-cleaning motion on every operation.

The new Model 711 tap switch was designed to achieve high current capability with small size. It is actually smaller than many low current instrument switches. It interrupts 7 amperes at 125 VAC and can carry 15 amperes AC or DC. The Model 711 features a melamine phenolic body with solid silver alloy fixed and movable contacts. Dual-purpose terminals allow connection by soldering or by means of 3/16" quick-connectors. This switch is stocked as a single, unenclosed unit, but is available made-to-order in enclosed tandem assemblies up to 10 units or as a single enclosed unit.

The following Ohmite Tap Switches are listed by the Underwriters' Laboratories, Inc., Reexamination Service for use where the acceptability of combination (with other apparatus) has been determined by them: Models 111, 212, 312 and 412. Variations from the basic switch design, identified by suffixes A, B, C, or X are also Underwriters' approved. When the switches are not factory installed, screw terminals are specified by the Underwriters' Laboratories for Model 312 and soldering lugs for Model 412. Further information on terminal fittings is available on request. When an Underwriters' approved unit is required, specify this on the order.

MODEL 711 TAP SWITCH

Alternating Current Rating 7 Amps. 125 Volts — Diameter 1⅛" — Shaft Diameter ¼" — Standard Mounting: For ⅛" panel maximum, by means of ⅜"-32 threaded bushing and hex. nut. See mounting illustration "A." Weight, single unit: .047 lb. approximately. Dual-purpose terminals accept 3/16" quick-connectors as well as soldering. Non-turn lug can be positioned at "12, 3, 6, and 9 o'clock."

Depth Behind Panel		Single Unit 1 3/16"
No. of Taps	Total Rotation	Catalog No.[1]
3	60°	711-3
4	90°	**711-4**
5	120°	711-5
6	150°	711-6
7	180°	(711-7)
8	210°	711-8
9	240°	(711-9)
10	270°	(711-10)
11	300°	(711-11)
Recommended Knobs— (See p. 22 for description)		Catalog No. 5103A

MODEL 111 TAP SWITCH

Alternating Current Rating 15 Amps. 125 Volts — Diameter 1¾" — Shaft Diameter ¼" — Standard Mounting: For ¼" panel maximum, by means of ⅜"-32 threaded bushing and hex. nut. See mounting illustration "A." For Tandem Mounting see illustration "B." Weight, single unit: .16 lb. approximately.

Depth Behind Panel		Single Unit 1⅛"	2 in Tandem 2¾"
No. of Taps	Total Rotation	Catalog No.[1]	Catalog No.[1]
3	60°	**111-3**	**111-3 -T2**
4	90°	**111-4**	**111-4 -T2**
5	120°	**111-5**	**111-5 -T2**
6	150°	**111-6**	111-6 -T2
7	180°	**111-7**	(111-7 -T2)
8	210°	**111-8**	**111-8 -T2**
9	240°	**111-9**	(111-9 -T2)
10	270°	**111-10**	(111-10-T2)
11	300°	**111-11**	111-11-T2
Recommended Knobs— (See p. 22 for description)		Catalog No. 5150A to 5116A	Catalog No. 5109A or 5110A

MODEL 212 TAP SWITCH

Alternating Current Rating 20 Amps. 150 Volts — Diameter 2¼" — Shaft Diameter ¼" — Standard Mounting: For ¼" panel maximum, by means of ⅜"-32 threaded bushing and hex. nut — See mounting illustration "C." Tandem Mounting for ¼" panel maximum, three No. 10-32 flat-head machine screws ⅜" long — See mounting illustration "D." Weight, single unit: .4 lb. approximately.

Depth Behind Panel		Single Unit 1¾"	2 in Tandem 4 3/16"	3 in Tandem 6 5/16"
No. of Taps	Total Rotation	Catalog No.[1]	Catalog No.[1]	Catalog No.[1]
3	60°	**212-3**	**212- 3-T2**	212- 3-T3
4	90°	**212-4**	212- 4-T2	(212- 4-T3)
5	120°	**212-5**	(212- 5-T2)	(212- 5-T3)
6	150°	**212-6**	212- 6-T2	212- 6-T3
7	180°	212-7	(212- 7-T2)	(212- 7-T3)
8	210°	**212-8**	212- 8-T2	(212- 8-T3)
9	240°	**212-9**	(212- 9-T2)	(212- 9-T3)
10	270°	**212-10**	(212-10-T2)	(212-10-T3)
11	300°	**212-11**	(212-11-T2)	(212-11-T3)
12	330°	**212-12**	**212-12-T2**	(212-12-T3)
Recommended Knobs (See p. 22 for description)		Catalog No. 5150A or 5116A	Catalog No. 5111A or 5112A	Catalog No. 5111A or 5112A

MODEL 312 TAP SWITCH

Alternating Current Rating 30 Amps. 300 Volts — 150V A.C. between taps — Diameter 3 5/16" — Shaft Diameter ¼" — Standard Mounting: For ¼" panel maximum, three No. 10-32 flat-head machine screws ⅜" long — See mtg. illus. "D." Weight, single unit: .75 lb. approx.

Depth Behind Panel		Single Unit 2¼"	2 in Tandem 4⅝"	3 in Tandem 7"
No. of Taps	Total Rotation	Catalog No.[1]	Catalog No.[1]	Catalog No.[1]
3	60°	**312-3**	(312- 3-T2)	(312- 3-T3)
4	90°	**312-4**	(312- 4-T2)	312- 4-T3
5	120°	**312-5**	312- 5-T2	312- 5-T3
6	150°	**312-6**	312- 6-T2	(312- 6-T3)
7	180°	**312-7**	(312- 7-T2)	(312- 7-T3)
8	210°	**312-8**	312- 8-T2	**312- 8-T3**
9	240°	312-9	(312- 9-T2)	312- 9-T3
10	270°	**312-10**	(312-10-T2)	**312-10-T3**
11	300°	312-11	(312-11-T2)	(312-11-T3)
12	330°	**312-12**	(312-12-T2)	312-12-T3
Recommended Knobs (See p. 22 for description		Catalog No. 5109A or 5110A	Catalog No. 5111A or 5112A	Catalog No. 5111A or 5112A

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OHMITE power tap switches, high current, non-shorting type

MODEL 412 TAP SWITCH

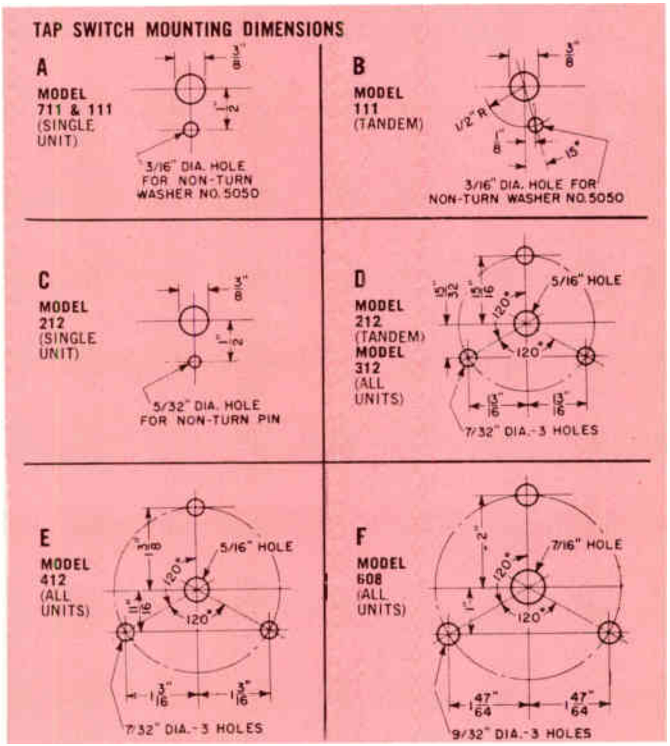
Alternating Current Rating 50 Amps. 300 Volts — 150V. A.C. between taps — Diameter 4 3/16" — Shaft Diameter 1/4" — Standard Mounting: For 1/4" panel maximum three No. 10-32 flat-head machine screws 3/8" long — See mtg. illus. "E." Weight, single unit: 1.4 lbs. approx.

Depth Behind Panel		Single Unit 2 1/16"	2 in Tandem 5 1/32"	3 in Tandem 7 5/8"
No. of Taps	Total Rotation	Catalog No.[1]	Catalog No.[1]	Catalog No.[1]
3	60°	**412-3**	412- 3-T2	(412- 3T-3)
4	**90°**	**412-4**	(412- 4-T2)	412- 4-T3
5	120°	412-5	(412- 5-T2)	412- 5-T3
6	150°	**412-6**	(412- 6-T2)	412- 6-T3
7	180°	412-7	412- 7-T2	(412- 7-T3)
8	210°	**412-8**	412- 8-T2	412- 8-T3
9	240°	412-9	(412- 9-T2)	(412- 9-T3)
10	270°	**412-10**	**412-10-T2**	**412-10-T3**
11	300°	**412-11**	(412-11-T2)	(412-11-T3)
12	330°	**412-12**	**412-12-T2**	412-12-T3
Recommended Knobs (see p 22)		Catalog No. 5111A or 5112A	Catalog No. 5111A or 5112A	Catalog No. 5111A or 5112A

MODEL 608 TAP SWITCH

Alternating Current Rating 100 Amps. 300 Volts — Diameter 6" — Shaft Diameter 3/8" — Standard Mounting: For 1" panel maximum, three flat-head machine screws 1/4"-20 x 1 1/4" — See mounting illustration "F." Weight, single unit: 5 lbs. approx.

Depth Behind Panel		Single Unit 3 5/16"	2 in Tandem 6 13/16"	3 in Tandem 10 5/16"
No. of Taps	Total Rotation	Catalog No.[1]	Catalog No.[1]	Catalog No.[1]
3	80°	608-3	(608- 3-T2)	(608- 3-T3)
4	120°	608-4	(608- 4-T2)	(608- 4-T3)
5	160°	608-5	(608- 5-T2)	**608- 5-T3**
6	200°	**608-6**	608- 6-T2	608- 6-T3
7	240°	**608-7**	(608- 7-T2)	(608- 7-T3)
8	280°	**608-8**	**608- 8-T2**	**608- 8-T3**
Recommended Knobs (see p 22)		Catalog No. 5104A or 5105A	Catalog No. 5104A, 5115 or 5105A	Catalog No. 5115



ALL CERAMIC OPEN TYPE TAP SWITCHES

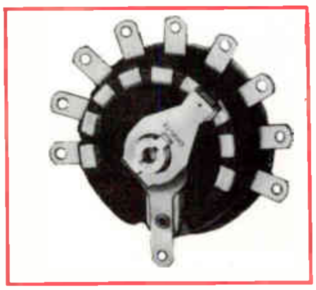
Designed to transfer currents of several amperes in circuits requiring high voltage insulation. Ceramic body construction is the same as employed in Models J and K rheostats (see page 21). Monel metal taps; silver-graphite brush.

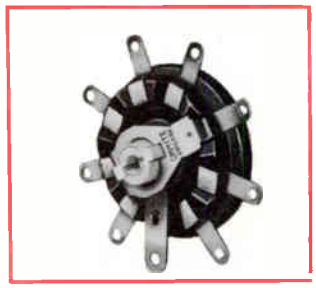
SHORTING TYPE SWITCH: Moving contact bridges closely spaced taps completing a new circuit before breaking the previous one. Switch arm is not indexed and can be left in any position.

NON-SHORTING SWITCH: Positively indexed, moving contact completely disconnects from one tap before contacting succeeding tap.

Switches up to 8 taps are approximately 3 1/4" diameter including lugs; 9 to 12 tap switches are approximately 4 1/4" diameter. Switches can be ordered assembled 2 to 3 in tandem. Single hole mounting by means of 3/8" diameter bushing and hexagon nut accommodates panels up to 1/4" thick (maximum). The "non-turn" lug requires a 3/16" panel hole 1/2" below the center of the shaft. Shaft diameter is 1/4". Recommended knob, Stock No. 5150, see page 22.

Maximum current capacity is 7 amperes but only 3 amperes at 120 V.A.C. should be interrupted. Current ratings are less for all direct current circuits above 20 volts, for inductive circuits and high voltages.

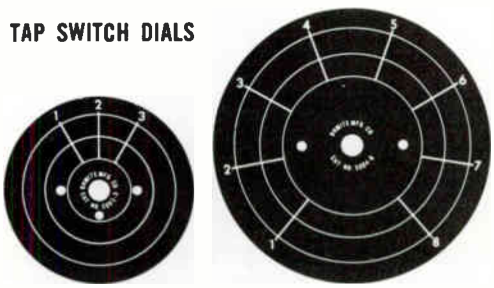




SHORTING TYPE†		NON-SHORTING TYPE†	
No. of Contacts	Catalog No.[1]	No. of Contacts	Catalog No.[1]
4	(T-504-S)	3	(T-503)
5	(T-505-S)	4	(T-504)
6	(T-506-S)	5	T-505
7	(T-507-S)	6	T-506
8	(T-508-S)	7	(T-507)
9	(T-1009-S)	8	(T-508)
10	(T-10010-S)	9	(T-1009)
11	(T-10011-S)	10	(T-10010)
12	(T-10012-S)	11	(T-10011)
		12	(T-10012)

† Avg. Wt. T-500 Series .28 lb.; T-100 Series .68 lb.

TAP SWITCH DIALS



Dials for Ohmite tap switches are made of aluminum, etched and enameled black. Dial markings are bright aluminum. The number of dial calibrations or position markings agree with the actual number of positions on the switch. Note, in the table, that dials for switches Models 212 and 312 are available in two diameters to suit the recommended knob.

Catalog No.[1]	For Model	For Knob	Dial Dia.
(5002-*)	111 212 (Single) 312 (Single)	5109 5116 5150	2 3/4"
(5003-*)	212 (Tandem) 312 (Tandem) 412	5111 5152A	3 3/4"
(5004-*)	608	5104 5115	5 1/2"

* Specify no. of positions as a suffix.

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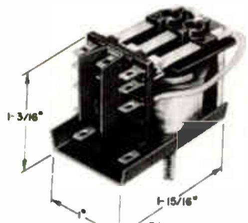
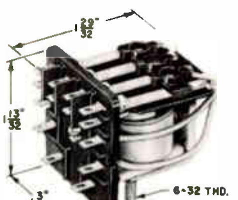
OHMITE general purpose relays

MODEL GPR — INDICATOR, PLATE, THYRATRON AND LATCHING VERSIONS IN UNENCLOSED AND ENCLOSED TYPES

Simple, rugged, low cost relays handling substantial power for small size. Uncomplicated design provides unusual flexibility for making and changing connections and mounting. Stock includes relays in versatile enclosures, some with indicator light, also plate, thyratron and latching versions. Wide commercial and industrial use where economy and versatility are important.



GPR 3-Pole



GPR 4-Pole

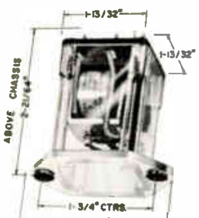
UNENCLOSED RELAYS

Basic (Unenclosed) Relay: All connections terminate on barrier-type terminal panel on combination solder — quick-connect (push-on) lugs which accept AMP 110 female connectors. The terminal panel is conveniently incorporated into printed circuit boards. Fixed contacts are integral inlay on terminal itself. Normally furnished with a 6-32 x ½" mounting stud and non-turn boss (or lug for 4-pole relays). A 6-32 threaded hole is optional. Unenclosed relays can also be mounted by plugging their panels into Ohmite SOGPR sockets. See "Socket" below.

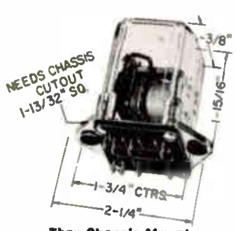
Contact Ratings: Two ratings — fine silver contacts, 5 amps at 115 VAC or 32 VDC resistive; silver-cadmium contacts, 10 amps.

Insulation: Tested at 1500 VAC.

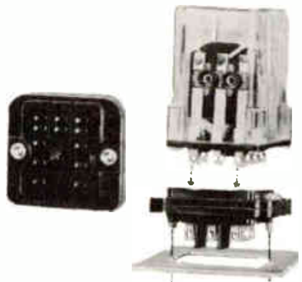
Coil Wattage: 1.4 watts DC operation; 1.6 watts (2.0 volt-amps) AC except 2.4 watts (3.70 volt-amps) for 4-pole AC and AC latching relays.



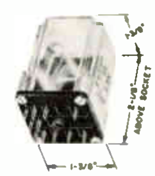
Above - Chassis Mount
GPRTA



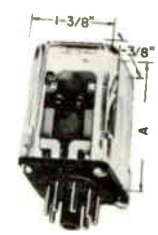
Thru-Chassis Mount
GPRTT



SOGPR Sockets



For Socket Mount
GPRTS



For Octal Plug
GPRTP

ENCLOSED RELAYS

(GPRTA-, GPRTT-, GPRTS-, GPRTP-)
Four types of clear plastic enclosures as follows:

Chassis Mounting Types: "GPRTA"—("Terminals-Above-Chassis" type) has terminal panel opposite to mounting flange; "GPRTT" —("Terminals-Through-Chassis" type) has terminal panel on same end as mounting flange, requires chassis cutout; "GPRTS" type (Terminals for Socket Use) is similar to GPRTT but has no mounting flanges. It is intended strictly for plug-in mounting in Ohmite socket "SOGPR" (see "Socket" below).

Plug Base Type: "GPRTP" — employs octal plug for 1 and 2 pole relays; 11-pin plug for 3-pole. The octal plug base is integral with relay for rigidity — is designed with recessed pins which meet UL spacing requirements (150V).

Socket (SOGPR): Unique socket fits the terminal panels of all GPR relays and provides over-the-surface spacing to meet UL requirements for 150 volts. Requires chassis cut-out to mount. Hold down springs (see illustration) for unenclosed and enclosed relays, are provided with each socket but are not required except under conditions of vibration or shock. Socket solder terminals will also accept AMP 11 quick-connectors. See socket listings.

SOCKETS FOR GPR, GPRTS RELAYS

For up to 3PDT: 1¾" square, requires 1¼" x 1½" cutout.* 2 holes (for No. 6 screws) on 1⅜" centers.
Catalog No. SOGPR-9

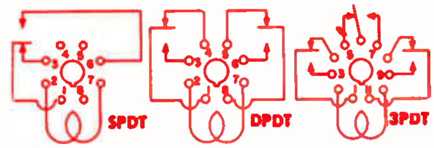
For 4-pole models, 1¾" x 2", requires 1½" x 1½" cutout.* 2 holes (for No. 6 screws) on 1⅝" centers.
Catalog No. SOGPR-12

*Std. punches and dies from Ward Machinery Co., Chicago. No. 28, Style 22N, 1¼ x 1½, for SOGPR-9: No. 28, Style 14R, 1½ x 1½, for SOGPR-12.

Indicator Relay: Incorporates light bulb to indicate energized condition of coil. Stocked only in GPRTP enclosures described in preceding. Neon bulb furnished with coil ratings 70 volts and above; incandescent bulbs for coil ratings below 70 volts.

UL & CSA Approval: Column heads in the stock tables carry the UL (Underwriters' Laboratories) or CSA symbol (Canadian Standards Association) where applicable. The gray tint in the column indicates the relays are recognized under the "UL components program." The acceptability of such relays by UL depends upon their combination with other equipment such as sockets etc.

OHMITE general purpose relays



Plug wiring schemes for plug base (GPRTP) relays

MODEL GPR — CONTINUED

STOCK GPR RELAYS*

Contacts	Coil Data Volts	Coil Data Amps	Coil Data Ohms	5 Amp. Contacts: UL CSA UNENCLOSED Cat. No.[1] Prefix GPRX	5 Amp.: ABOVE CHASSIS MTG. ENCLOSED Cat. No.[1] Prefix GPRTAX-†	5 Amp.: THRU-CHASSIS MTG. ENCLOSED Cat. No.[1] Prefix GPRTTX-†	5 Amp.: SOCKET MOUNT ENCLOSED (for SOGPR Socket)‡ UL CSA Cat. No.[1] Prefix GPRTSX-	5 Amp.: UL CSA PLUG BASE MT. ENCLOSED Cat. No.[1] Prefix GPRTPX-	10 Amp. Contacts: UL CSA UNENCLOSED Cat. No.[1] Prefix GPRX-	10 Amp.: CSA SOCKET MOUNT ENCLOSED (for SOGPR Socket)‡ Cat. No.[1] Prefix GPRTSX-	10 Amp.: CSA PLUG BASE MT. ENCLOSED Cat. No.[1] Prefix GPRTPX-	10 Amp.: INDICATOR-PLUG BASE ENCLOSED Cat. No.[1] Prefix GPRTPX-
SPDT	6VAC	.334	4.2	(-3T)	(-3T)	(-3T)		(-3T)	(-203T)		(-203T)	
DPDT	6VAC	.334	4.2	-6T	(-6T)	(-6T)	(-6T)	-6T	(-206T)	(-206T)	-206T	(-291T)
3PDT	6VAC	.334	4.2	(-9T)	(-9T)	(-9T)	(-9T)	-9T	(-209T)	(-209T)	-209T	
4PDT	6VAC	.650	2.5	-403T			(-403T)		(-433T)	(-433T)		
SPDT	12VAC	.167	17	(-12T)	(-12T)	(-12T)		(-12T)	(-212T)		(-212T)	
DPDT	12VAC	.167	17	-15T	(-15T)	(-15T)	(-15T)	-15T	(-215T)	(-215T)	-215T	(-292T)
3PDT	12VAC	.167	17	(-18T)	(-18T)	(-18T)	(-18T)	-18T	(-218T)	(-218T)	(-218T)	
4PDT	12VAC	.309	10	(-406T)			(-406T		(-436T)	(-436T)		
SPDT	24VAC	.084	65	(-21T)	(-21T)	(-21T)		(-21T)	(-221T)		(-221T)	
DPDT	24VAC	.084	65	**-24T**	**-24T**	(-24T)	(-24T)	-24T	(-224T)	(-224T)	**-224T**	(-293T)
3PDT	24VAC	.084	65	(-27T)	-27T	(-27T)	(-27T)	-27T	(-227T)	(-227T)	**-227T**	
4PDT	24VAC	.155	40	-409T			(-409T)		(-439T)	(-439T)		
SPDT	115VAC	.0174	1600	(-30T)	(-30T)	(-30T)		(-30T)	-230T		-230T	
DPDT	115VAC	.0174	1600	**-33T**	-33T	(-33T)	(-33T)	**-33T**	-233T	**-233T**	**-233T**	**-294T**
3PDT	115VAC	.0174	1600	**-36T**	-36T	(-36T)	(-36T)	**-36T**	(-236T)	(-236T)	**-236T**	
4PDT	115VAC	.0325	1000	-412T			**-412T**		**-442T**	**-442T**		
SPDT	230VAC	.0087	7000	(-39T)	(-39T)	(-39T)		(-39T)	(-239T)		(-239T)	
DPDT	230VAC	.0087	7000	-42T	(-42T)	(-42T)	(-42T)	-42T	-242T	(-242T)	-242T	(-295T)
3PDT	230VAC	.0087	7000	(-45T)	-45T	(-45T)	(-45T)	-45T	(-245T)	(-245T)	-245T	
4PDT	230VAC	.0147	4000	(-415T)			(-415T)		(-445T)	(-445T)		
SPDT	6VDC	.23	26	(-48T)	(-48T)	(-48T)		(-48T)	(-248T)		(-248T)	
DPDT	6VDC	.23	26	-51T	(-51T)	(-51T)	**-51T**	-51T	(-251T)	(-251T)	-251T	(-296T)
3PDT	6VDC	.23	26	(-54T)	(-54T)	(-54T)	(-54T)	-54T	(-254T)	(-254T)	-254T	
4PDT	6VDC	.23	26	(-418T)			(-418T)		(-448T)	(-448T)		
SPDT	12VDC	.114	105	-57T	(-57T)	(-57T)		(-57T)	(-257T)		(-257T)	
DPDT	12VDC	.114	105	**-60T**	-60T	(-60T)	(-60T)	-60T	**-260T**	(-260T)	-260T	(-297T)
3PDT	12VDC	.114	105	**-63T**	(-63T)	(-63T)	(-63T)	**-63T**	(-263T)	(-263T)	-263T	
4PDT	12VDC	.114	105	-421T			(-421T)		(-451T)	(-451T)		
SPDT	24VDC	.060	400	-66T	(-66T)	(-66T)		(-66T)	(-266T)		(-266T)	
DPDT	24VDC	.060	400	**-69T**	(-69T)	(-69T)	(-69T)	**-69T**	(-269T)	(-269T)	**-269T**	(-298T)
3PDT	24VDC	.060	400	-72T	(-72T)	(-72T)	-72T	-72T	(-272T)	(-272T)	**-272T**	
4PDT	24VDC	.060	400	-424T			(-424T)		-454T	**-454T**		
SPDT	110VDC	.0110	10,000	(-75T)	(-75T)	(-75T)		(-75T)	(-275T)		(-275T)	
DPDT	110VDC	.0110	10,000	(-78T)	(-78T)	(-78T)	(-78T)	-78T	(-278T)	(-278T)	-278T	(-299T)
3PDT	110VDC	.0110	10,000	**-81T**	-81T	-81T	**-81T**	-81T	-281T	(-281T)	-281T	
4PDT	110VDC	.0110	10,000	(-427T)			-427T		-457T	-457T		
Approx. weight				2.5 oz.	3.0 oz.	3.0 oz.	3.0 oz.	3.5 oz.	2.5 oz.	3.5 oz.	3.5 oz.	3.5 oz.

*Column heads carry symbols to indicate UL or CSA (Canadian Standards Assn.) approval. The grey tint indicates that relay is recognized under UL "components program" (File No. E33069, Guide No. 380W1.14C, Assignment No. 62C3559A). CSA File No. is 21309. See explanation in "UL and CSA Approval."

†4-Pole GPRTS relays are not covered by CSA.
‡GPRTA and GPRTT types as listed by UL, differ slightly from the stock versions above and consequently, are made to order. These UL versions have a "U" added to the catalog number, such as in "GPRTAU." They also have CSA approval.

STOCK GPR PLATE CIRCUIT RELAYS — 5 AMP CONTACTS

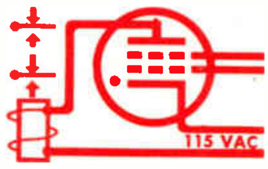
Plate Relays: Feature same physical construction as standard general purpose relays but are adjusted for greater sensitivity and can be used as electronic circuit controls, i.e., in the plate circuits of standard vacuum tubes.

Contacts	Coil Data Ohms	Coil Data Pull-in Max. ma.	UL UNENCLOSED Cat. No.[1] Prefix GFRX-	ABOVE CHASSIS MTG. ENCLOSED Cat. No.[1] Prefix GPRTAX-†	THRU-CHASSIS MTG. ENCLOSED Cat. No.[1] Prefix GPRTTX-†	SOCKET MOUNT UL ENCLOSED (for SOGPR Socket)‡ Cat. No.[1] Prefix GPRTSX-	UL CSA PLUG BASE MT. ENCLOSED Cat. No.[1] Prefix GPRTPX-
SPDT	2500	7.2	-82T	(-82T)	(-82T)		(-82T)
DPDT	2500	10	(-83T)	(-83T)	(-83T)		-83T
3PDT	2500	12.3	(-84T)	(-84T)	(-84T)		-84T
4PDT	2500	15.0	(-463T)			(-463T)	
SPDT	5000	5	(-85T)	(-85T)	(-85T)		(-85T)
DPDT	5000	7.2	(-86T)	(-86T)	(-86T)		**-86T**
3PDT	5000	8.7	(-87T)	(-87T)	(-87T)		(-87T)
4PDT	5000	11	(466T)			(-466T)	
SPDT	10,000	3.6	(-88T)	(-88T)	(-88T)		(-88T)
DPDT	10,000	5	-89T	(-89T)	(-89T)		-89T
3PDT	10,000	6.1	(-90T)	(-90T)	(-90T)		**-90T**
4PDT	10,000	7.5	(-469T)			(-469T)	
Approx. weight			2.5 oz.	3.0 oz.	3.0 oz.	3.0 oz.	3.5 oz.

[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

OHMITE general purpose relays

Thyratron Plate Relay: Designed specifically for plate circuit of thyratron tubes 2050 and 2D21 with 115 VAC supply (see diagram). Also suitable for operation in series with silicon controlled rectifiers from a 115 VAC supply. Ready to work, no capacitors or adjustments required, no chatter. Available unenclosed and in most GPR enclosures.



Relay in circuit Showing Thyratron

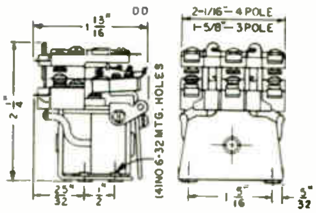
STOCK GPR THYRATRON RELAYS

	5 AMP CONTACTS					10 AMP CONTACTS		
Contacts	UNENCLOSED Cat. No.[1] Prefix GPRX-	ABOVE CHASSIS MTG. ENCLOSED Cat. No.[1] Prefix GPRTAX-†	THRU-CHASSIS MTG. ENCLOSED Cat. No.[1] Prefix GPRTTX-†	SOCKET MOUNT ENCLOSED (for SOGPR Socket)‡ Cat. No.[1] Prefix GPRTSX-	PLUG BASE MT. ENCLOSED Cat. No.[1] Prefix GPRTPX-	UNENCLOSED Cat. No.[1] Prefix GPRX-	SOCKET MOUNT ENCLOSED (for SOGPR Socket)‡ Cat. No.[1] Prefix GPRTSX-	PLUG BASE MT. ENCLOSED Cat. No.[1] Prefix GPRTPX-
SPDT	**-191T**	(-191T)	(-191T)		(-191T)	(-391T)		(-391T)
DPDT	**-192T**	(-192T)	(-192T)		(-192T)	-392T		(-392T)
3PDT	(-193T)	(-193T)	(-193T)		(-193T)	(-393T)		(-393T)
4PDT	(-473T)			(-473T)		(-483T)	(-483T)	

MODEL DO RELAYS AC or DC

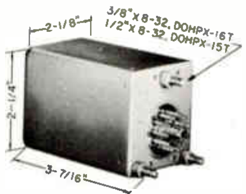
Particularly adaptable to aircraft and mobile equipment applications where severe shock and vibration are encountered. Design of molded parts around contact arms protects against mechanical injury. Stocked in 3-pole or 4-pole type, and also in hermetic enclosures and in latching types.

Coil Wattage: 3.00 watts, DC operation; 6.00 watts, 60 cycle AC. Maximum temperature rise 45°C, DC operation; 75°C, AC.
Coil Operating Voltage: Any voltage up to 230 VDC or 440 VAC, 60 cycle. Stock voltages in table.
Contacts: 10 amps nominal. Ratings are for 115 VAC or 32 VDC, resistive load.
Weight: Unenclosed 3-pole, 5 oz.; 4-pole, 6 oz.

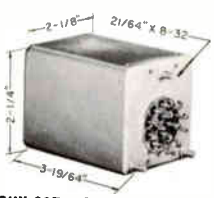


DO RELAYS IN HERMETIC ENCLOSURES

Stock DO relays with 115 volt coil in hermetically sealed metal enclosures, filled with dry nitrogen. Enclosures provide protection for relay under most adverse ambient conditions. Both 3 and 4-pole DO relays are supplied in these enclosures with plug (DOHPX-) or solder terminal (DOHX-) connectors as illustrated. See listings in stock table above.
Weights: 3-pole hermetic relay approx. 14 oz.; 4-pole approx. 15 oz.

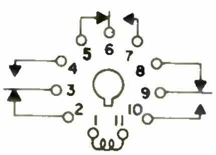


DOHPX-16T, 3PDT, 11 Prongs
DOHPX-15T, 4PDT, 20 Prongs

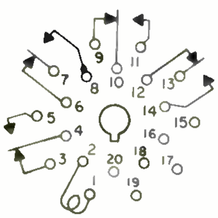


DOHX-22T, 3PDT, 14 Terminals
DOHX-23T, 4PDT, 14 Terminals

WIRING FOR PLUG-BASE STOCK DO RELAYS



DOHPX-16T
Mates with Amphenol 77 MIP 11 Socket



DOHPX-15T
Mates with Amphenol 77 MIP 20 Socket

STOCK DO RELAYS — 10 AMP CONTACTS*

Catalog No.[1]	Type‡	Volts	Coil Data Amps	DC Ohms
UNENCLOSED				
DOX-50T	3PDT	6VAC	2.33	0.36
(DOX-183T)	4PDT	6VAC	2.33	0.36
(DOX-49T)	3PDT	12VAC	1.28	1.40
(DOX-184T)	4PDT	12VAC	1.28	1.40
DOX-181T	3PDT	24VAC	.57	5.50
(DOX-185T)	4PDT	24VAC	.57	5.50
(DOX-226T)	DPST*	115VAC	.110	145.0
(DOUX-34§)	DPST*	115VAC	.110	145.0
DOX-227T	3PST	115VAC	.110	145.0
(DOUX-28§)	3PST	115VAC	.110	145.0
DOX46T	3PDT	115VAC	.110	145.0
(DOUX-30§)	3PDT	115VAC	.110	145.0
DOX-228T	4PST	115VAC	.110	145.0
(DOUX-31§)	4PST	115VAC	.110	145.0
DOX-53T	4PDT	115VAC	.110	145.0
(DOUX-33§)	4PDT	115VAC	.110	145.0
DOX-61T	3PDT	230VAC	.070	550.0
(DOX-130T)	4PDT	230VAC	.070	550.0
(DOX-145T)	3PDT	6VDC	.487	12.3
(DOX-186T)	4PDT	6VDC	.487	12.3
DOX-51T	3PDT	12VDC	.231	51.8
DOX-102T	4PDT	12VDC	.231	51.8
DOX-141T	3PDT	24VDC	.105	230.0
DOX-137T	4PDT	24VDC	.105	230.0
DOX-93T	3PDT	110VDC	.022	5,000
DOX-187T	4PDT	110VDC	.022	5,000
(DOX-182T)	3PDT	220VDC	.014	16,100
(DOX-188T)	4PDT	220VDC	.014	16,100
IN HERMETIC ENCLOSURE				
(DOHPX-16T)	3PDT	115VAC	.110	145.0
(DOHPX-15T)	4PDT	115VAC	.110	145.0
(DOHX-22T)	3PDT	115VAC	.110	145.0
DOHX-23T	4PDT	115VAC	.110	145.0

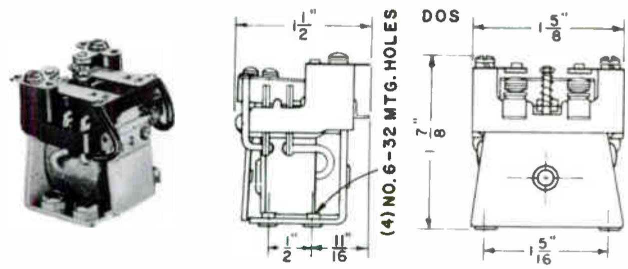
*Except DOX-226T, DOUX-34 20 amps, double break contacts.
‡All single-throw (- - ST) relays are normally open.
§Listed by UL.

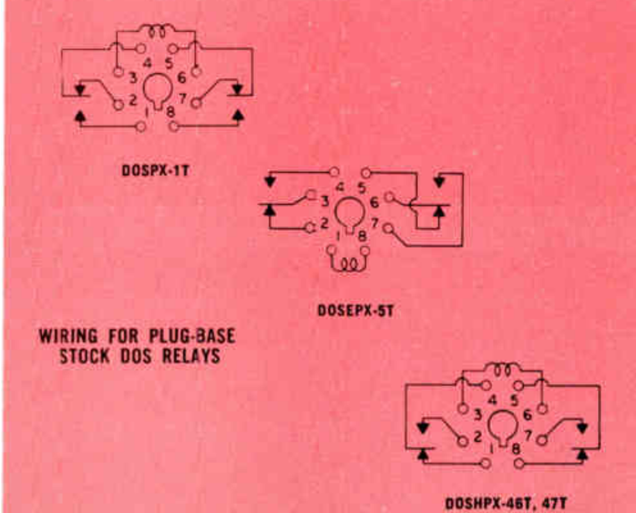
[1] Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

OHMITE general purpose relays

MODEL DOS RELAYS AC or DC

Wide application, general purpose relay, compact and lightweight. Handles loads usually demanded of much larger relays. Meets rigorous aircraft relay standards.





WIRING FOR PLUG-BASE STOCK DOS RELAYS

Coil Wattage: 2.5 watts, DC operation; 3 watts, 60 cycle AC. Maximum temperature rise 45°C, DC operation; 65°C, AC.

Coil Operating Voltage: Any voltage up to 230 VDC or 440 VAC, 60 cycles. Table lists stock voltages.

Contacts: 15 amps nominal. Rating is for 115 VAC or 32 VDC, resistive load.

Weight: Unenclosed, 4 ounces.

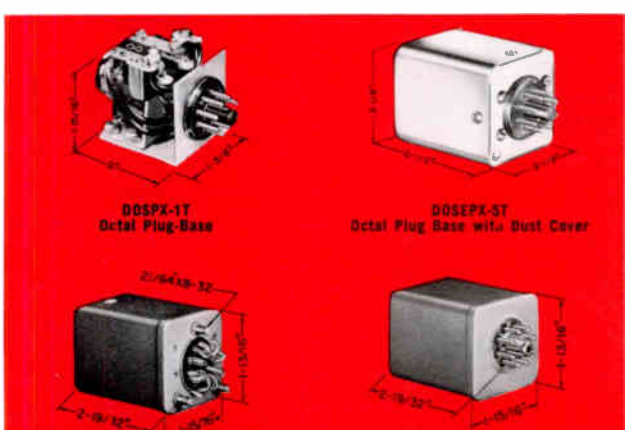
DOS RELAYS WITH PLUG-BASE OR IN DUST-TIGHT OR HERMETIC ENCLOSURES

DOS relays with 115 volt AC coils are available from stock with a standard octal plug base, unenclosed (DOSPX-1T) or with an octal plug base and drawn aluminum, removable dust-tight enclosure (DOSEPX-5T).

Weights: 8 oz. each.

Hermetically Sealed non-removable enclosures, filled with dry nitrogen, are also available to provide protection under adverse ambient conditions. DOS relays with 115 volt AC or DC coils are provided in these enclosures with either octal plug (DOSHPX-) or solder-terminal (DOSHX-) connectors as illustrated. See listings and prices in DOS stock table.

Weights: 8 oz. each approx.



DOSPX-1T
Octal Plug-Base

DOSEPX-5T
Octal Plug Base with Dust Cover

Hermetic Enclosures with 8 Terminals
DOSHX-39T, 115VDC
DOSHX-40T, 115VAC

Hermetic Enclosures with Octal Plugs
DOSHPX-46T, 115VDC
DOSHPX-47T, 115VAC

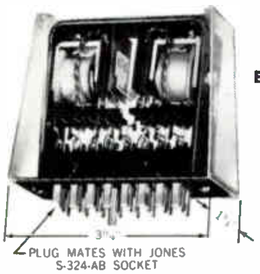
STOCK DOS RELAYS — 15 AMP CONTACTS*

Catalog No.[1]	Type‡	Volts	Coil Data Amps	DC Ohms
UNENCLOSED				
(DOSX-229T)	SPST*	6VAC	.890	1.07
(DOSX-230T)	DPST	6VAC	.890	1.07
(DOSX-30T)	DPDT	6VAC	.890	1.07
DOSX-16T	DPDT	12VAC	.460	4.20
(DOSX-231T)	SPST*	24VAC	.269	15.5
DOSX-232T	DPST	24VAC	.269	15.5
DOSX-162T	DPDT	24VAC	.269	15.5
DOSX-233T	SPST*	115VAC	.043	450
(DOSUX-34§)	SPST*	115VAC	.043	450
DOSX-234T	DPST	115VAC	.043	450
(DOSUX-31§)	DPST	115VAC	.043	450
DOSX-7T	DPDT	115VAC	.043	450
(DOSUX-33§)	DPDT	115VAC	.043	450
(DOSX-235T)	SPST*	230VAC	.030	1,450
(DOSX-236T)	DPST	230VAC	.030	1,450
DOSX-12T	DPDT	230VAC	.030	1,450
DOSX-158T	DPDT	6VDC	.450	13.4
DOSX-66T	DPDT	12VDC	.210	56.2
DOSX-9T	DPDT	24VDC	.105	230.0
DOSX-237T	SPST*	110VDC	.022	5,000
(DOSX-238T)	DPST	110VDC	.022	5,000
DOSX-59T	DPDT	110VDC	.022	5,000
(DOSX-177T)	DPDT	220VDC	.013	16,400
WITH PLUG BASE				
DOSPX-1T	DPDT	115VAC	.043	450
WITH DUST COVER				
DOSEPX-5T	DPDT	115VAC	.043	450
IN HERMETIC ENCLOSURE				
DOSHX-40T	DPDT	115VAC	.043	450
DOSHPX-47T	DPDT	115VAC	.043	450
(DOSHX-39T)	DPDT	110VDC	.022	5,000
(DOSHPX-46T)	DPDT	110VDC	.022	5,000

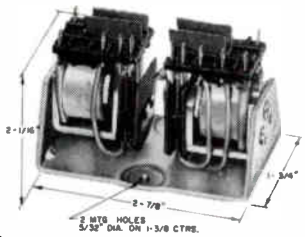
*Except relays with * which have double-break contacts — 25 amp rating.
‡Single throw relays (- - ST) are normally open.
§Listed by UL.

[1] Popular items appear in BOLO print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

OHMITE latching relays



Enclosed Latching Relay (GPRLETP)



6PDT Latching Relay (GPRLE)

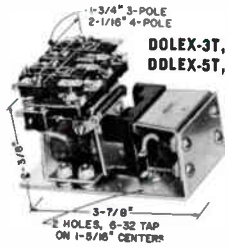
Latching Relay: Consists of two GPR relays with armatures linked so that the n.o. contacts of one are mechanically latched in closed position when, and after, this relay is energized. When 2nd relay is energized, first relay restores and latches 2nd. Permits switching of twice the number of circuits and holding without coil current. Unenclosed type "GPRLE." Enclosed type "GPRLETP" in clear plastic case with Jones plug P-324-SB fitting S-324-AB socket.

STOCK GPR LATCHING RELAYS — 5 AMP CONTACTS

Total Contacts	COIL DATA — (Each Coil) Volts	Amps	Ohms	Unenclosed GPRLE†	Enclosed Plug-Base GPRLETP†
4PDT	6VAC	.650	2.5	(GPRLEX-1T)	(GPRLETPX-1T)
6PDT	6VAC	.650	2.5	(GPRLEX-2T)	(PGRLETPX-2T)
4PDT	12VAC	.309	10.0	GPRLEX-3T	(GPRLETPX-3T)
6PDT	12VAC	.309	10.0	GPRLEX-4T	(GPRLETPX-4T)
4PDT	24VAC	.155	40.0	(GPRLEX-5T)	GPRLETPX-5T
6PDT	24VAC	.155	40.0	(GPRLEX-6T)	(GPRLETPX-6T)
4PDT	115VAC	.0325	1000	**GPRLEX-7T**	**GPRLETPX-7T**
6PDT	115VAC	.0325	1000	(GPRLEX-8T)	**GPRLETPX-8T**
4PDT	230VAC	.0147	4000	(GPRLEX-9T)	(GPRLETPX-9T)
6PDT	230VAC	.0147	4000	(GPRLEX-10T)	GPRLETPX-10T
4PDT	6VDC	.23	26	(GPRLEX-11T)	(GPRLETPX-11T)
6PDT	6VDC	.23	26	(GPRLEX-12T)	(GPRLETPX-12T)
4PDT	12VDC	.114	105	(GPRLEX-13T)	(GPRLETPX-13T)
6PDT	12VDC	.114	105	(GPRLEX-14T)	GPRLETPX-14T
4PDT	24VDC	.060	400	**GPRLEX-15T**	**GPRLETPX-15T**
6PDT	24VDC	.060	400	(GPRLEX-16T)	**GPRLETPX-16T**
4PDT	110VDC	.0110	10,000	(GPRLEX-17T)	GPRLETPX-17T
6PDT	110VDC	.0110	10,000	(GPRLEX-18T)	GPRLETPX-18T
Approx. weight				7.0 oz.	11.3 oz.

*Column heads carry symbols to indicate UL or CSA (Canadian Standards Assn.) approval. The gray tint indicates that relay is recognized under UL "components program" (File No. E33069, Guide No. 380W1.14C, Assignment No. 62C3559A). CSA File No. is 21309. See explanation in "UL and CSA Approval."

MODEL DO LATCHING RELAY (DOLEX-)



Weights: 3-pole — 16.5 oz.; 4-pole — 17 oz.

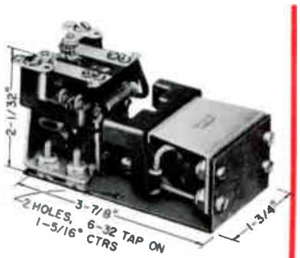
Consists of Model DO relay and a "reset magnet" with both armatures mechanically latched so that the normally open contacts of the relay remain closed when the relay energizing voltage is removed. The relay releases to normal position when the reset coil is pulsed. Permits "holding" of circuits without continuous coil current. Coils of stock units (both relays and reset coils) are 115 VAC. Available with 3 or 4-pole DO relays

LATCHING TYPE

Catalog No.¹	Type	Volts	Coil Data † Amps	DC Ohms
DOLEX-3T	3PDT	115VAC	.110	145.0
DOLEX-5T	4PDT	115VAC	.110	145.0

†Coil data applies to relay part of latching assembly. Reset magnet operates on 115VAC, 60 cycle also.

MODEL DOS LATCHING RELAY (DOSLEX-)



Consists of Model DOS relay and a "reset magnet" with both armatures mechanically latched so that the normally open contacts of the relay remain closed when the relay energizing voltage is removed. The relay releases to normal position when the reset coil is pulsed. Permits "holding" of circuits without continuous coil current. Coils of stock units (both relay and reset magnet) are 115VAC.

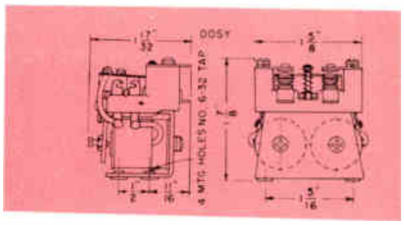
Weight: 14.2 oz.

LATCHING TYPE

Catalog No.¹	Type	Volts	Coil Data Amps †	DC Ohms
DOSLEX-1T	DPDT	115VAC	.043	450

†Coil data applies to relay part of latching assembly. Reset magnet operates on 115 VAC, 60 cycle also.

MODEL DOSY RELAY FOR PLATE CIRCUITS



Similar in construction to Model DOS relay but equipped with twin coils for increased sensitivity. The DOSY relay is adaptable to a wide range of electronic control applications such as plate circuit controls, or as overload or underload controls in D.C. circuits to signal attainment of predetermined current levels.

Coil Wattage: 1.00 watt, with maximum temperature rise of 45°C. Lower wattages available.

Contacts: Stock combinations as listed. Ratings are for 115 VAC or 32 VDC, resistive load.

Weight: Approximately 4½ ounces.

Catalog No.¹	Type	Coil Data DC Ohms	Max. Pull-in Current	Contact Amps
DOSYX-67T	DPDT	10,000	8 MA	15
(DOSYX-68T)	DPDT	5,000	11 MA	15
DOSYX-69T	SPDT	10,000	5 MA	15
(DOSYX-70T)	SPDT	5,000	7 MA	15

¹ Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

OHMITE OHMITROL® solid state power and motor speed controls

- SAVE SPACE, SAVE POWER, SAVE $$
- SMALLEST 1 & 2 KW CONTROL
- LONG LIFE
- AC & DC OUTPUT TYPES
- INTEGRAL TRIMMER ADJUSTS CONTROL RANGE FOR DIFFERENT APPLICATIONS
- INCORPORATES ON-OFF SWITCH

USE IT TO CONTROL

POWER
MODEL PCA: AC Output

Shaded pole motors
Permanent split capacitor motors
Universal motors
Heaters—both resistive and infra-red

MOTOR SPEED
MODEL PCD: DC Output

Shunt wound motors
Series wound motors
Permanent magnet motors
Magnetic clutches and brakes

Now, for the first time, a Solid State Power Control is available which is adaptable to a wide variety of applications by a simple turn of a screwdriver!

An internal trimmer allows the starting point of the control voltage of the Ohmitrol to be set anywhere within the stated trimmer voltage range. (This adjustment can be preset at the factory at small additional cost).

From the starting point to full line voltage, infinitely smooth control is obtained by means of the control knob. An "on-off" line switch actuated at the counterclockwise end of the control knob rotator is provided on all models.

Ohmite solid state power controls are the smallest 1 or 2 KW controls available and offer the advantages not only of convenient size, but also of power savings, long life and low initial cost.

Two styles are available: the component style for panel mounting in equipment, and the lightweight, self-contained portable style. Portable units are completely self contained with grounded line cord and standard grounded AC receptacle.

Ohmitrol Controls are available with AC output and with two kinds of DC output delivered simultaneously. One kind consists of rectified DC, at approximately full line voltage; the other is the variable or controlled DC. This double output is useful, for example, for controlling shunt wound motors. Two-way terminals at the rear of the controls accept quick-connectors (push-on connectors), or can be soldered.

PORTABLE STYLE

Catalog No.
PCA-1001
PCD-1001
PCA-1021
PCD-1021

SPECIFICATIONS AND ORDERING INFORMATION

		120 Volt Types	240 Volt Types
LOAD RATING	PCA Models	1 KW, 8.3 Amps. AC	2 KW, 8.3 Amps
	PCD Models	3.5 Amp DC-Motorload 6.0 Amp DC-Resistive	3.5 Amp DC-Motorload 6.0 Amp DC-Resistive
INPUT		120v AC, 60 Hz†	240v AC, 60 Hz†
OUTPUT		0-120v AC (PCA), DC (PCD)	0-240v AC (PCA), DC (PCD)
TRIMMER VOLTAGE RANGE		0-70 Volts	0-200 Volts

Mounting (Component Style) 3/8"-32 Bushing, Non-Turn Projection on 1/2" centers with shaft.
Knob (not included) Recommend Catalog No. 5150.
Terminals (Component Style) Two-way Accept 1/4" Faston connectors or soldering.
† 50 Hz also available. Contact factory.

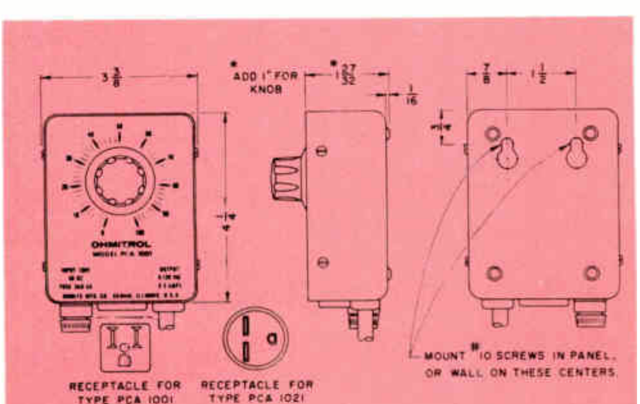
COMPONENT STYLE*

Catalog No.
PCD-1000
PCA-1000
PCA-1020
PCD-1020

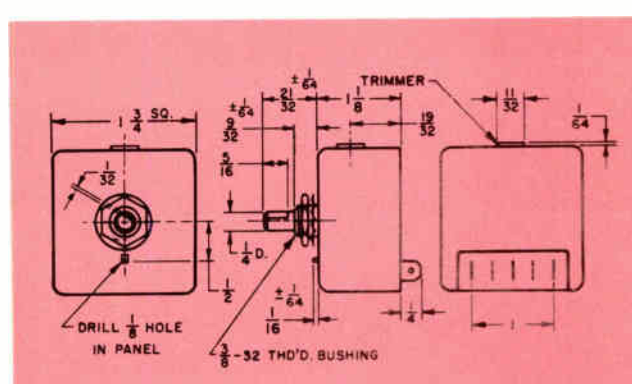
* Knob not included

Catalog No.	Input	Output
PCA-1001	120 VAC	0-120 VAC
PCD-1001	60 Hz	Pulsating 0-120 VDC and Full 120 VDC
PCA-1021	240 VAC	0-240 VAC
PCD-1021	60 Hz	Pulsating 0-240 VDC and Full 240 VDC

Catalog No.	Input	Output
PCA-1000	120 VAC	0-120 VAC
PCD-1000	60 Hz	Pulsating 0-120 VDC and Full 120 VDC
PCA-1020	240 VAC	0-240 VAC
PCD-1020	60 Hz	Pulsating 0-240 VDC and Full 240 VDC



Mounting Dimensions Portable Style



Mounting Dimensions Component Style

OHMITE variable transformers

OHMITRAN v.t.® VARIABLE TRANSFORMER

Unique for the design innovations they incorporate, Ohmite "OHMITRAN" v.t.® variable transformers include exclusive field-proven features. They offer long, low maintenance operation with excellent regulation at any voltage setting within the rated load plus an output free of waveform distortion. Six frame sizes offer a wide range of electrical ratings to meet most industrial applications. These include three new, compact, low-power models (VT1, VT02, VT3,) which permit a fine choice of six ratings from 1 to 3 amperes.

The VT1, rated 1 ampere, is the smallest commercial variable transformer available.

UL LISTING: A number of VT4, VT8 and VT20 transformers used for 120 volt line operation are underwriters' laboratories listed. See tables, page 26 for details.

POSITIVE CURRENT TRANSFER . . . achieved with specially designed brushes connected through high conductivity contact arms or pigtails to a large slip ring which contacts a wide area of the collector ring. The brush contact assembly on the VT1, VT02, and VT3 is instantly replaceable, when necessary, as a result of a slide-on, snap-in design. Brushes of the other models are easily replaced also.

ADJUSTABLE SHAFT: On all Ohmite transformers, except the VT2LN, the shaft may be extended out from either the brush or opposite side as desired. On the VT1, VT02 and VT3, both single and tandem assemblies, this is an **exclusive** Ohmite feature which affords greater versatility of mounting and application. For example, substitution of a longer shaft or extension of the standard shaft allows actuation of other devices, such as switches or potentiometers without special construction. The shaft is freed simply by loosening set screw in the hub assembly. A double flat on the shaft permits two knob positions.

On the VT4, VT8, and VT20 types, the adjustable shaft feature permits **table or panel** use. "Ganged" or tandem VT4, VT8 and VT20 units employ a thru-shaft offering the same flexibility. On VT4 and VT8 units, shafts are fixed in the desired position by means of socket head screws located in the hub of each "brush-radiator" plate. The VT20 employs a unique collet-type shaft lock.

INTERCHANGEABLE WITH OTHER POPULAR TYPES: Basic "v.t." units have mounting provisions which match those of virtually all popular transformers of comparable current rating. Models VT4, VT8 and VT20 mount by means of bolts. Normally 3-hole mounting, single VT4 units can be "4-hole mounted" by means of adapter plate, see page 35. Individual Model VT1, VT02, VT2LN, or VT3 units mount by means of a standard ⅜-32 threaded bushing. All tandem assemblies mount by means of bolts or nuts. Knob, dial and mounting hardware are included with each transformer.

DIRECT READING, TWO SCALE DIAL . . . calibrated on one side for overvoltage connection; on the reverse side for line voltage connection. Dials normally included with transformer read clockwise for increasing voltage; counter-clockwise calibration available—see page 35.

WIRING AND CONNECTIONS: Wiring instructions to arrange various modes of operation are enclosed with all OHMITE variable transformers. Terminal panels or adjacent nameplate carry convenient wiring diagram, coded terminals and input and output data. Three way terminals on VT1, VT2LN, VT02, VT3 will accept ¼" push-on connectors, screws and nuts, or conventional soldering.

ROTATION OPTION: On VT4, VT8 and VT20 transformers connected for overvoltage, either clockwise or counter-clockwise increase of voltage can be arranged easily by the user. Increasing voltage in either direction can be arranged on all units connected for no-overvoltage output. Dials for counter-clockwise operation are stocked. See "Accessories."

OVERVOLTAGE OPTION: On all transformers with overvoltage feature, no-overvoltage operation can be arranged on the terminal panel.

NO-OVERVOLTAGE TRANSFORMERS ("N" suffix): Provide considerably more current due to heavier gage winding.

240-VOLT INPUT ("H" suffix): On units which are wound for 240-volt input, a 120 volt input tap is also provided. With the use of this input, the maximum current rating applies up to 120 volts output but beyond this reduces proportionately to approximately 50% at maximum voltage output.

LOW VOLTAGE INPUT ("L" feature): Designed for a maximum input of approximately 40 volts, with high current output.

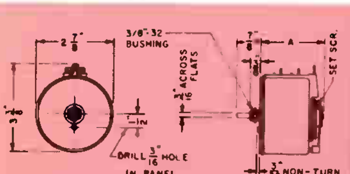
GROUNDED INPUT & OUTPUT ("C" feature): Units in type F or G cases can be provided with a three-conductor cord and outlet. One conductor is grounded to the case. This feature standard on all cased VT20 units and on all metered units.

VT1, VT02, VT2LN, VT3, SINGLE, UNCASED
Angle of rotation 320° ±5°

VT4 TYPES, SINGLE, UNCASED
Angle of rotation: 324° ±5°

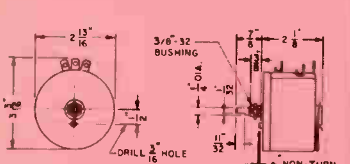
VT8 TYPES, SINGLE, UNCASED
Angle of rotation: 324° ±5°

VT20 TYPES, UNCASED
Angle of rotation: 317° ±5°

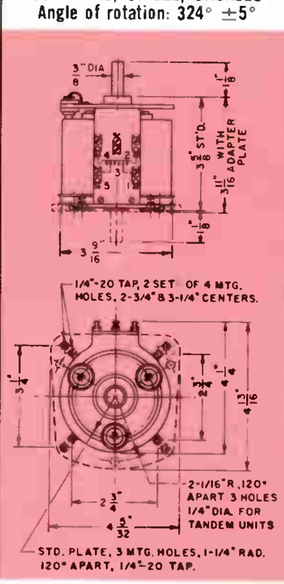


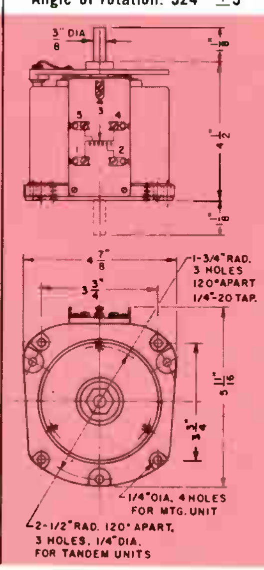
"A" DIMENSION

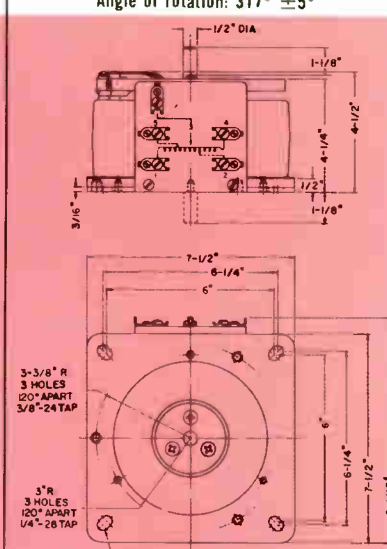
VT1, VT1N	1 11/16"
VT02, VT02N	2 5/16"
VT3, VT3N	2 13/16"



VT2LN
U.S. Patent Nos. 2,790,882
2,985,857







OHMITE variable transformers

ENCLOSED OR CASED UNITS: In gray hammer tone finish. "Basic protective enclosures" (Type B) expose the transformer's terminal panel and mounting base and are supplied presently on VT20 models only. (See tandems in "B" enclosures below.) "Fixed mounting enclosures" (Type E) are intended for permanent mounting on table, panel or inconduit-line. Standard portable units (Type F) carry a line cord, outlet socket, and fuse except for VT20F which has a circuit breaker. Deluxe portable units (Type G) utilize a circuit breaker, can be switched to overvoltage or no-overvoltage as desired, have a handle which also serves as an easel.

METERED ENCLOSURES: VT8NFC, VT8GC, VT20NFC and VT20GC transformers are available with voltmeter (V), voltmeter and ammeter (A) or voltmeter and wattmeter (W). The metered transformer enclosures are larger than the non-metered types of comparable designation, (see dimensions below). All stock metered units have the three-conductor grounded cord and outlet and all, except the VT8NF group, are equipped with carrying handles.

SINGLE UNIT CASE DIMENSIONS

Series	Case◆	W	D	H
VT1 or VT02	E	3⅜	2½*	4¼
	F	3⅜	2½*	4¼
VT4	E	4½	4½*	6³⁄₁₆
	F	4⅞	4½*	6¼
VT8	E	5³⁄₁₆	5¼*	7³⁄₁₆
	F	5¹⁷⁄₃₂	5¼*	7⅜
	FV, FVA, FVW	7⅜	5¼*	10½
	G	5³⁄₁₆†	5¼*	7⅜‡
	GV, GVA, GVW	7	5¼*	10½‡
	3E	5³⁄₁₆	15¾*	7³⁄₁₆
VT20	B	7⅝	8⅛	4⅞*
	E	7¾	5½*	10¹⁵⁄₁₆
	F	8¼	5½*	11¼
	FV, FVA, FVW	8¼	5½‡	14‡
	G	7¾§	5½*	11¼‡
	GV, GVA, GVW	8¼	5½‡	14‡

* Add 1" for knob thickness for VT8 types; ⅞" for VT1, 02 and VT4 types, 1¼" for VT20 types.

† 5¾" including handle fittings.

‡ Case height only.

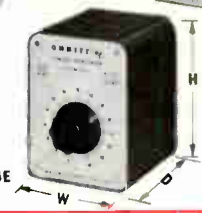
§ 9" including handle fittings.

◆ V, A and W = voltmeter, ammeter and wattmeter respectively.


VT20B


VT02E


VT02F



VT4E


VT4F


VT4FC


VT8-3E


VT8GCV (with voltmeter)

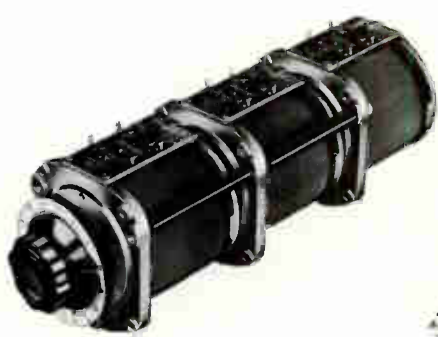

VT8G

TANDEM OR GANGED UNITS: Two or 3-in-tandem assemblies are standard. Larger tandem assemblies available made to order. All tandem assemblies are normally furnished with inter-connections between the units. A few cased tandems are stocked. Tandems in "B" type enclosures have individual cases on each transformer.

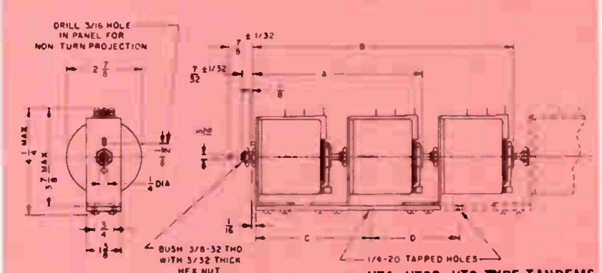
TANDEM VT1, VT02, VT3 DIMENSIONS

	A	B	C
VT1	4⁷⁄₃₂	6¹⁷⁄₃₂	4¼
VT02	5⁷⁄₃₂	8¹⁄₃₂	4½
VT3	6¹⁷⁄₃₂	9²⁷⁄₃₂	4½

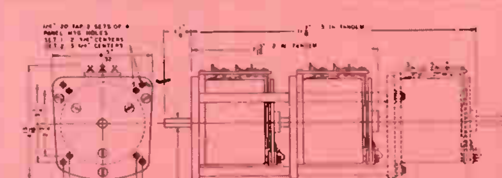

VT02N-3

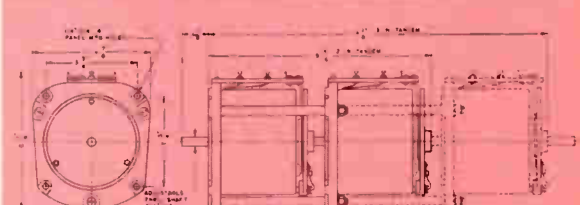

VT8-3

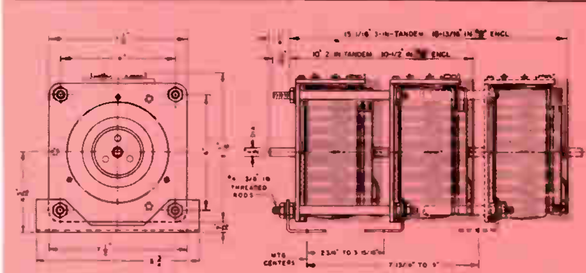

VT20-2



VT1, VT02, VT3 TYPE TANDEMS


VT4 TYPE TANDEMS


VT8 TYPE TANDEMS


VT20 TYPE TANDEMS

See page 34 for ratings and ordering information.

STOCK VARIABLE TRANSFORMERS

SINGLE PHASE

SINGLE TRANSFORMERS — UNCASED (Dimensions p. 32)

Input Volts	Freq. Hz from[1]	Feature or Connection	U.L. see foot-notes below	Maximum Output Volts	Maximum Output Amps	Catalog No.[12]	Wt. Lbs.[7]
40	60	Hi-amps, low volts		0-40	5.0	VT2LN	2.4
40	50	Hi-amps, low volts		0-40	12.0	(VT4LN)	5.25
40	50	Hi-amps, low volts		0-40	22.0	**VT8LN**	10.25
120	60[8]	Basic 1.0A Model		0-120/132	1.3	**VT1**	1.5
120	60	No overvoltage		0-120	1.5	**VT1N**	1.5
120	60[8]	Basic 1.75A Model		0-120/132	2.0	**VT02**	2.25
120	60	No overvoltage		0-120	2.5	**VT02N**	2.25
120	60[8]	Basic 2.6A Model		0-120/132	3.0	**VT3**	3.0
120	60	No overvoltage		0-120	3.0	**VT3N**	3.0
120	50	Basic 3.5A Model	11	0-120/140	3.5	**VT4**	5.25
120	50	No overvoltage	11	0-120	4.75	**VT4N**	5.25
120	50	Basic 7.5A Model	11	0-120/140	7.5	**VT8**	10.25
120	50	No overvoltage	11	0-120	10.0	**VT8N**	10.25
120	50	Basic 20A Model	11	0-120/140	20.0	**VT20**	22.0
120	50	No overvoltage	11	0-120	25.0	**VT20N**	22.0
240[2]	50	240V Input[2]		0-240/280	3.0	**VT8H**	10.25
240[2]	50	240V In. No ovrvlt.[2]		0-240	4.0	**VT8HN**	10.25
240[2]	50	240V Input[2]		0-240/280	9.0	(VT20H)	22.0
240[2]	50	240V In. No ovrvlt.[2]		0-240	11.0	(VT20HN)	22.0

SINGLE TRANSFORMERS — CASED (Dimensions p. 33)

Input Volts	Freq. Hz from	Feature or Connection	U.L.	Max. Output Volts	Amps	Catalog No.	Wt. Lbs.
120	60[8]	Fixed Mtg.		0-120/132[4]	.8	(VT1E)	1.9
120	60[8]	Portable		0-132[3]	1.0	VT1F	2.3
120	60	Fixed Mtg.		0-120	1.0	(VT1NE)	1.9
120	60	Portable		0-120	1.2	(VT1NF)	2.3
120	60[8]	Fixed Mtg.		0-120/132[4]	1.4	(VT02E)	2.8
120	60[8]	Portable		0-132[3]	1.75	**VT02F**	3.2
120	60	Fixed Mtg.		0-120	1.6	(VT02NE)	2.8
120	60	Portable		0-120	2.0	VT02NF	3.2
120	50	Fixed Mtg.	12	0-120/140[4]	2.8	(VT4E)	7.4
120	50	Portable	12	0-140[3]	3.5	VT4F	7.8
120	50	VT4F w/gnd. in. & out.	12	0-140[3]	3.5	**VT4FC**	7.8
120	50	Fixed Mtg.		0-120	3.8	(VT4NE)	7.4
120	50	Portable		0-120	4.75	(VT4NF)	7.8
120	50	VT4NF w/gnd. in. & out.		0-120	4.75	VT4NFC	7.8
120	50	Fixed Mtg.	12	0-120/140[4]	6.0	(VT8E)	13.5
120	50	Portable	12	0-140[3]	7.5	**VT8F**	13.8
120	50	VT8F w/gnd. in. & out.	12	0-140[3]	7.5	**VT8FC**	13.8
120	50	Deluxe Portable	12	0-120/140[3]	6.0	VT8G	14.2
120	50	VT8G w/gnd. in. & out.	12	0-120/140[3]	6.0	VT8GC	14.2
120	50	Fixed Mtg.		0-120	8.0	VT8NE	13.5
120	50	Portable		0-120	10.0	(VT8NF)	13.8
120	50	VT8NF w/gnd. in. & out.		0-120	10.0	VT8NFC	13.8
120	50	Basic Case		0-120/140	20.0	**VT20B**	22.5
120	50	Basic Case		0-120	25.0	(VT20NB)	22.5
120	50	Fixed Mtg.	12	0-120/140[4]	20.0	(VT20E)	29.0
120	50	Portable		0-140	20.0	(VT20FC)	31.0
120	50	Portable	12	0-120/140[3]	20.0	(VT20GC)	31.0
120	50	Fixed Mtg.	12	0-120	25.0	(VT20NE)	29.0
120	50	Portable		0-120	25.0	(VT20NFC)	31.0
240[2]	50	Basic Case		0-240/280	9.0	(VT20HB)	21.5
240[2]	50	Basic Case		0-240	11.0	(VT20HNB)	21.5
240[2]	50	Fixed Mtg.		0-240/280[4]	9.0	(VT20HE)	28.0
240[2]	50	Fixed Mtg.		0-240	11.0	(VT20HNE)	28.0
240[2]	50	Portable		0-240/280	9.0	(VT20HFC)	30.0
240[2]	50	Portable		0-240	11.0	(VT20HNFC)	30.0

SINGLE TRANSFORMERS — CASED WITH METERS (Dimensions p. 33)

Input Volts	Freq. Hz from	Feature or Connection	Max. Output Volts	Amps	Catalog No.	Wt. Lbs.
120	50	w/voltmeter, gnd. conn.	0-120/140[3]	6.0	**(VT8GCV)**	15.2
120	50	w/volt. & ammtr., gnd. conn.	0-120/140[3]	6.0	**(VT8GCVA)**	15.5
120	50	w/volt. & wattmtr., gnd. conn.	0-120/140[3]	6.0	**(VT8GCVW)**	15.5
120	50	w/voltmeter, gnd. conn.	0-120	10.0	**(VT8NFCV)**	14.8

SINGLE PHASE (contd.)

SINGLE TRANSFORMERS — CASED WITH METERS (Dimensions p. 33) (contd.)

Input Volts	Freq. Hz from	Feature or Connection	Maximum Output Volts	Maximum Output Amps	Catalog No.	Wt. Lbs.
120	50	w/volt. & ammtr., gnd. conn.	0-120	10.0	(VT8NFCVA)	15.2
120	50	w/volt. & wattmtr., gnd. conn.	0-120	10.0	(VT8NFCVW)	15.2
120	50	w/voltmeter, gnd. conn.	0-120/140[3]	20.0	(VT20GCV)	32.0
120	50	w/volt. & ammtr., gnd. conn.	0-120/140[3]	20.0	(VT20GCVA)	32.2
120	50	w/volt. & wattmtr., gnd. conn.	0-120/140[3]	20.0	(VT20GCVW)	32.2
120	50	w/voltmeter, gnd. conn.	0-120	25.0	(VT20NFCV)	32.0
120	50	w/volt. & ammtr., gnd. conn.	0-120	25.0	(VT20NFCVA)	32.2
120	50	w/volt. & wattmtr., gnd. conn.	0-120	25.0	(VT20NFCVW)	32.2

TWO-IN-TANDEM ASSEMBLIES[5,10] (Dimensions p. 33)

Input Volts	Freq. Hz from	Feature or Connection	Max. Output Volts	Amps	Catalog No.	Wt. Lbs.
240	60[8]	Series Conn.[6]	0-240/264	1.0	(VT1-2)	3.5
240	60	Series Conn.[6]	0-240	1.2	(VT1N-2)	3.5
240	60[8]	Series Conn.[6]	0-240/264	1.75	(VT02-2)	5.25
240	60	Series Conn.[6]	0-240	2.0	(VT02N-2)	5.25
240	60[8]	Series Conn.[6]	0-240/264	2.6	VT3-2	6.5
240	60	Series Conn.[6]	0-240	3.0	(VT3N-2)	6.5
240	50	Series Conn.[6]	0-240/280	3.5	(VT4-2)	11.3
240	50	Series Conn.[6]	0-240	4.75	(VT4N-2)	11.3
240	50	Series Conn.[6]	0-240/280	7.5	(VT8-2)	20.6
240	50	Series Conn.[6]	0-240	10.0	VT8N-2	20.6
240	50	Series Conn.[6]	0-240/280	20.0	(VT20-2)	45.0
240	50	Above unit, B case	0-240/280	20.0	(VT20-2B)	46.0
240	50	Series Conn.[6]	0-240	25.0	VT20N-2	45.0
240	50	Above unit, B case	0-240	25.0	(VT20N-2B)	46.0
480[2]	50	Series Conn.[6]	0-480/560	3.0	(VT8H-2)	20.6
480[2]	50	Series Conn.[6]	0-480	4.0	(VT8HN-2)	20.6
480[2]	50	Series Conn.[6]	0-480/560	9.0	(VT20H-2)	43
480[2]	50	Series Conn.[6]	0-480	11.0	(VT20HN-2)	43

THREE PHASE

Input Volts	Freq. Hz from	Feature or Connection	Max. Output Volts	Amps	Catalog No.	Wt. Lbs.
120	60[8]	Open Delta Conn.	0-120/132	1.0	(VT1-2)	3.5
120	60	Open Delta Conn.	0-120	1.2	(VT1N-2)	3.5
120	60[8]	Open Delta Conn.	0-120/132	1.75	(VT02-2)	5.25
120	60	Open Delta Conn.	0-120	2.0	(VT02N-2)	5.25
120	60[8]	Open Delta Conn.	0-120/132	2.6	(VT3-2)	6.5
120	60	Open Delta Conn.	0-120	3.0	(VT3N-2)	6.5
120	50	Open Delta Conn.	0-120/140	3.5	(VT4-2)	11.3
120	50	Open Delta Conn.	0-120	4.75	(VT4N-2)	11.3
120	50	Open Delta Conn.	0-120/140	7.5	(VT8-2)	20.6
120	50	Open Delta Conn.	0-120	10.0	VT8N-2	20.6
120	50	Open Delta Conn.	0-120/140	20.0	(VT20-2)	45.0
120	50	Above unit, B case	0-120/140	20.0	(VT20-2B)	46.0
120	50	Open Delta Conn.	0-120	25.0	VT20N-2	45.0
120	50	Above unit, B case	0-120	25.0	(VT20N-2B)	46.0
240[2]	50	Open Delta Conn.	0-240/280	3.0	(VT8H-2)	20.6
240[2]	50	Open Delta Conn.	0-240	4.0	(VT8HN-2)	20.6
240[2]	50	Open Delta Conn.	0-240/280	9.0	(VT20H-2)	43
240[2]	50	Open Delta Conn.	0-240	11.0	(VT20HN-2)	43

THREE-IN-TANDEM ASSEMBLIES[5,10] (Dimensions p. 33)

Input Volts	Freq. Hz from	Feature or Connection	Max. Output Volts	Amps	Catalog No.	Wt. Lbs.
240	60	"Y" Conn.	0-240[9]	1.0	(VT1-3)	5.3
240	60	"Y" Conn.	0-240[9]	1.75	VT02-3	8.0
240	60	"Y" Conn.	0-240[9]	2.6	(VT3-3)	9.8
240	60[8]	"Y" Conn.	0-240/280	3.5	VT4-3	17.0
240	60[8]	"Y" Conn.	0-240/280	7.5	(VT8-3)	31.0
240	60[8]	Above unit, E case	0-240/280	6.0	(VT8-3E)	40.0
240	60[8]	"Y" Conn.	0-240/280	20.0	VT20-3	68.0
240	60[8]	Above unit, B case	0-240/280	20.0	**VT20-3B**	69.5
240	60	"Y" Conn.	0-240	25.0	(VT20N-3)	68.0
240	60	Above unit, B case	0-240	25.0	(VT20N-3B)	69.5
480[2]	60[8]	"Y" Conn.	0-480/560	3.0	**VT8H-3**	31.0
480[2]	60[8]	"Y" Conn.	0-480/560	9.0	(VT20H-3)	65.0
480[2]	60	"Y" Conn.	0-480	11.0	(VT20HN-3)	65.0

Footnotes for Stock Table

[1] Frequency shown is a minimum — units may be used up to 1000 cps.

[2] VT8H and VT20H and 240V output for VT8HN and VT20HN. With use of 120V input VT8H, VT8HN, VT20H, VT20HN also have taps for 120V input with 280V output for the max. current rating applies up to 120V output but reduces to approx. 50% at max. output voltage. In the case of tandem units, use of the low voltage inputs would correspondingly derate the current at the higher output voltages.

[3] Connected at factory for overvoltage output — easily reconnected by user for no-overvoltage output. On VT8G and VT20G, switch selects overvoltage or no-overvoltage.

[4] User wires for desired output. Dial normally calibrated for overvoltage.

[5] 2-in-tandem normally wired for series connection; 3-in-tandem for Y connection.

[6] When transformers are series connected, load cannot be grounded.

[7] Includes knob, dial and mounting hardware.

[8] May be used at 50 Hz. if connected for no-overvoltage output.

[9] Overvoltage connection must not be used.

[10] 240/280 volt cw dial standard except on VT1, VT02 and VT3 tandems where 240/264 volt dial is standard or on VT8H-2, VT8HN-2, VT8H-3, VT20H-2, VT20HN-2, VT20H-3 and VT20HN-3 where 480/560 volt dial is standard. Request other dials if desired — see "Dials" above.

[11] Underwriters' Laboratories listed under components program (File Number E10946).

[12] Underwriters' Laboratories listed under apparatus program (File Number E10946).

Popular items appear in BOLD print and are usually in stock at authorized Ohmite stocking distributors. Items appearing in LIGHT FACE print are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to a $15.00 per line item minimum charge.

OHMITE variable transformers

ACCESSORIES — PARTS

ADAPTER PLATE for 4-hole mtg. of VT4 — matches other popular 4-hole mtgs.; dimensions same as shown for front plate of VT4 tandems, page 33. Catalog No. 6512

Brush-Contact Assemblies for . . .	Catalog No.
VT1, VT1N, VT02, VT02N, VT3, VT3N	6507
VT2LN	6517
VT4 Types except VT4LN	6515
VT8 Types except VT8H, HN, LN	6515
VT4LN	6518
VT8H, HN only	6516H
VT8LN only	6519
VT20 Types and VT20N	6594
VT20H, HN only	6596

ADJUSTABLE STOP for limiting rotational arc of transformers.	Catalog No.
Stop for VT4 types	6536
Stop for VT8 types	6537
Stop for VT20 types	6538

FUSE LINKS	Catalog No.
For VT4	6508
For VT4N	6509

EXTRA DIALS AND DIALS WITH C.C.W. CALIBRATION

V.T.	Dial Calibration	Catalog No.
VT1, VT02, VT2LN, VT3	0-120, 0-132 CW	5005
	0-100, 100-0* CW	5011
	0-240, 0-264 CW	5019
VT4 and VT8	0-120, 0-140 CW	5006
	0-120, 0-140 CCW	5008
	0-240, 0-280 CW	5009
	0-240, 0-280, CCW	5010
	0-100, 100-0* CW	5012
	0-480, 0-560 CW	5018
VT20	0-120, 0-140 CW	5013
	0-120, 0-140 CCW	5014
	0-240, 0-280 CW	5015
	0-240, 0-280 CCW	5016
	0-100, 100-0 CW	5017

*Percent-of-output dial furnished with "LN" series units.

EXTRA KNOBS FOR UNCASED UNITS

	Catalog No.
For VT1, VT02, VT2LN, VT3 types	5158
For VT4, VT8 types	5155
For VT20 Types	5157

MOTOR-DRIVEN ASSEMBLIES

Single or tandem assemblies can be supplied with motor drives, direct from the factory. Either AC or DC motors are available. Standard AC motor drives have traverse speeds of 3-4, 10-12, 40-50, 100-120 seconds. Typical traverse speeds for DC drives are 4, 8, 16, 30 and 45 seconds. Write to the factory for more information.

wire-wound

resistor assortments

of type 995 axial lead MOLDED vitreous enamel

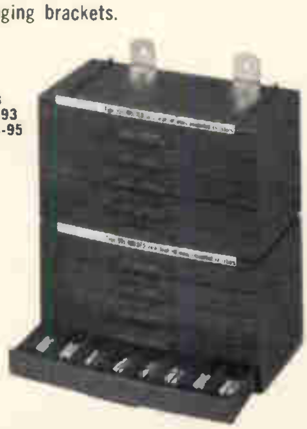
- Perfect for R & D and Prototype Labs
- All popular values included.
- Resistors and handy cabinet for the resistors alone.
- 4 Wattage sizes to choose from.
- Contents clearly marked on front of each drawer segment.

Select the wire-wound resistor you need, right on the job. All the popular resistance values, as determined by national usage, are contained in these handy, compact assortments.

The attractive plastic cabinet is furnished at no extra cost with each assortment. Cabinets are factory packed in accordance with the table (shown at right) which states the quantities of each resistance value per assortment. Each drawer segment is individually labeled. Dovetail tops and bottoms of cabinets facilitate stacking. Dimensions for single cabinets are 9" long x 4¾" high x 5¼" deep; double cabinets are 10" high, including wall hanging brackets.

Single Cabinets for CAB-91 and CAB-99

Double Cabinets for CAB-93 and CAB-95



SPECIFICATIONS AND PRICING

Nominal Wattage Size	Catalog Number	Number of Res. Values	Quantity of Resistors	Net Price
1½ W.	CAB-91	40	167	$110.00
3¼ W.	CAB-93	71	325	205.00
5 W.	CAB-95	75	355	240.00
11 W.	CAB-99	40	185	140.00

PRICES SUBJECT TO CHANGE WITHOUT NOTICE.

±5% Resistance Values	Quantities and Resistance for Each Assortment: 1½ Watt CAB-91	3¼ Watt CAB-93	5 Watt CAB-95	11 Watt CAB-99	±5% Resistance Values	Quantities and Resistance for Each Assortment: 1½ Watt CAB-91	3¼ Watt CAB-93	5 Watt CAB-95	11 Watt CAB-99
1.0	10	7	7	5	470	5	7	4	4
1.2	—	—	4	—	500	5	7	7	5
1.5	5	4	4	—	510	5	—	4	—
2.0	5	4	4	5	560	—	4	4	—
2.2	5	—	—	—	600	5	7	4	—
2.7	—	4	—	—	620	—	4	—	—
3.0	5	4	4	5	680	2	7	—	—
4.0	3	4	4	5	700	—	4	—	—
5.0	5	7	7	5	750	2	7	7	5
5.6	—	1	4	—	800	2	4	4	—
6.8	—	4	—	—	820	—	—	4	—
7.5	3	4	1	5	900	—	4	—	—
10.0	10	4	7	5	1000	5	7	7	5
12	—	1	4	—	1200	2	4	4	—
15	5	7	7	5	1300	—	7	7	—
18	—	1	4	—	1500	5	7	4	4
20	3	4	7	5	1800	2	4	4	—
22	2	7	4	5	2000	5	7	7	4
25	—	4	7	5	2200	2	4	4	—
30	3	4	4	5	2500	2	4	4	4
33	—	4	—	—	2700	—	4	1	—
39	—	4	4	5	3000	5	4	7	4
40	3	4	4	5	3300	—	4	4	—
47	—	4	4	—	3900	—	1	1	—
50	5	7	7	5	4000	—	4	4	4
51	—	—	7	—	4300	—	—	4	—
56	2	4	4	—	4500	—	—	—	—
68	2	4	4	5	4700	—	4	4	—
75	2	7	4	4	5000	—	4	7	4
82	—	4	4	5	5600	—	1	4	—
91	5	—	—	—	6000	—	—	4	—
100	5	7	7	5	6800	—	1	5	4
110	5	—	—	—	7000	—	4	—	—
120	—	7	4	—	7500	—	3	—	—
150	—	4	4	5	8000	—	—	4	—
160	—	1	4	—	8200	—	4	4	—
200	5	7	7	5	9000	—	—	4	—
220	5	7	7	—	9100	—	—	—	—
250	—	4	7	5	10,000	—	7	7	4
270	—	4	4	—	12,000	—	—	4	—
300	5	7	7	5	15,000	—	—	4	4
330	5	4	4	—	20,000	—	—	4	—
350	—	—	4	4	22,000	—	—	4	—
390	—	4	4	—	25,000	—	—	4	4
400	—	4	4	—	40,000	—	—	—	4
450	—	4	—	—	50,000	—	—	—	4

OHMITE

has the answer

in products for today's & tomorrow's circuitry

Ohmite Manufacturing Company a North American Philips company
3600 Howard Street, Skokie, Illinois 60076 • (312) 675-2600 • TWX: 910-223-0805 • TELEX 72 4433

Printed in U.S.A.

Publication 231

OHMITE

MANUFACTURER'S PRICE SCHEDULE

JULY 12, 1971

This price schedule contains prices in quantities available from authorized Ohmite Stocking Distributors and the Factory. For quantities greater than shown, please contact your local Ohmite Sales Office or the Factory. Minimum charges, exclusive of transportation charges are: $25.00 per order. Terms: 1%, 10th and 25th, net 30 days, F.O.B. our factory. Prices subject to change without notice.

Little Rebel T.M. carbon film resistors

	Tolerance	Resistance Range (Ohms)	UNIT NET PRICES Standard Package Is 50 Units						
			1-9	10-99	100-249	250-499	500-999	1000-4999	5000 & Up
⅛ WATT TYPE OJ	5% (J)	10 to 220K	$.34	$.16	$.14	$.13	$.12	$.095	$.093
¼ WATT TYPE OK	5% (J)	1.0 to 9.1	.29	.11	.08	.069	.058	.041	.035
		10 to 1M	.26	.10	.07	.063	.053	.037	.032
½ WATT TYPE OL	5% (J)	1.0 to 2.4	.26	.13	.07	.057	.048	.042	.040
		2.7 to 1M	.24	.12	.06	.052	.044	.038	.037

OHMITRIM™ wirewound rectilinear multiturn resistance trimmer

NUMBER	1-9	10-24	25-49	50-99	100-249	250 &up
TPS 10 thru 5K ohms	1.75	1.60	1.45	1.35	1.25	1.15
TPS 10K ohms	1.85	1.70	1.55	1.45	1.35	1.25
TPS 20K ohms	2.00	1.85	1.70	1.60	1.50	1.40
TPW 10 thru 5K ohms	1.75	1.60	1.45	1.35	1.25	1.15
TPW 10K ohms	1.85	1.70	1.55	1.45	1.35	1.25
TPW 20K ohms	2.00	1.85	1.70	1.60	1.50	1.40

TYPE 442 wirewound axial lead resistors

available from the Factory only.

2 WATT, TYPE 442-2	1-9	10-49	50-99	100-249	250 - 499	500 & UP
.1 thru .9 ohms	$ .87	$ .75	$ .61	$ .49	$ .40	$ .37
1.0 thru 100 ohms	.71	.61	.50	.40	.33	.30
100 thru 1K ohms	.66	.57	.46	.37	.30	.28
1001 thru 5K ohms	.74	.63	.52	.41	.34	.31
5001 thru 6500 ohms	.92	.80	.65	.53	.42	.39
3 WATT, TYPE 442-3A						
.1 thru .9 ohms	.68	.58	.48	.37	.31	.29
1.0 thru 100 ohms	.55	.47	.39	.30	.25	.23
100 thru 1K ohms	.50	.43	.35	.28	.23	.21
1001 thru 5K ohms	.55	.47	.39	.30	.25	.23
5001 thru 10K ohms	.68	.58	.48	.37	.31	.29
5 WATT, TYPE 442-5						
.1 thru .9 ohms	.74	.63	.52	.41	.33	.31
1.0 thru 100 ohms	.61	.52	.43	.34	.27	.26
100 thru 1K ohms	.55	.47	.39	.30	.25	.23
1001 thru 5K ohms	.61	.52	.43	.34	.27	.26
5001 thru 10K ohms	.71	.60	.50	.39	.32	.30
10,001 thru 20K ohms	.84	.71	.59	.46	.38	.35
20,001 thru 25K ohms	.92	.78	.64	.51	.51	.39
7 WATT, TYPE 442-7						
.1 thru .9 ohms	.76	.65	.54	.43	.35	.32
1.0 thru 100 ohms	.63	.54	.44	.36	.29	.26
100 thru 1K ohms	.58	.50	.41	.33	.27	.24
1001 thru 5K ohms	.63	.54	.44	.36	.29	.26
5001 thru 10K ohms	.74	.64	.52	.41	.34	.31
10,001 thru 20K ohms	.87	.75	.61	.49	.40	.37
20,001 thru 25K ohms	.92	.80	.65	.52	.42	.39
25,001 thru 37K ohms	1.02	.88	.72	.57	.47	.43
37,001 thru 75K ohms	1.26	1.05	.89	.70	.58	.53
75,001 thru 100K ohms	2.10	1.80	1.48	1.20	.97	.88

Ohmite Manufacturing Company a North American Philips company
3601 Howard Street, Skokie, Illinois 60076/Phone (312) 675-2600/TWX: 910-223-0805/Telex 72-4433

MS-100

OHMITE

MAR 26 1971

MANUFACTURER'S PRICE SCHEDULE

STANDARD RESISTANCE & ELECTRO-MECHANICAL PRODUCTS

MAY 4, 1970

Supersedes all previous schedules.

This Schedule contains prices for all Ohmite standard catalog items, as described in the Component Selectar Catalog, in quantities available from authorized Ohmite Stocking Distributors. For quantities greater than shown, please contact your local Ohmite Sales Office or the Factory.

Minimum charges, exclusive of transportation charges are:

•**Items Bold and Light face listed:** $15.00 per order.

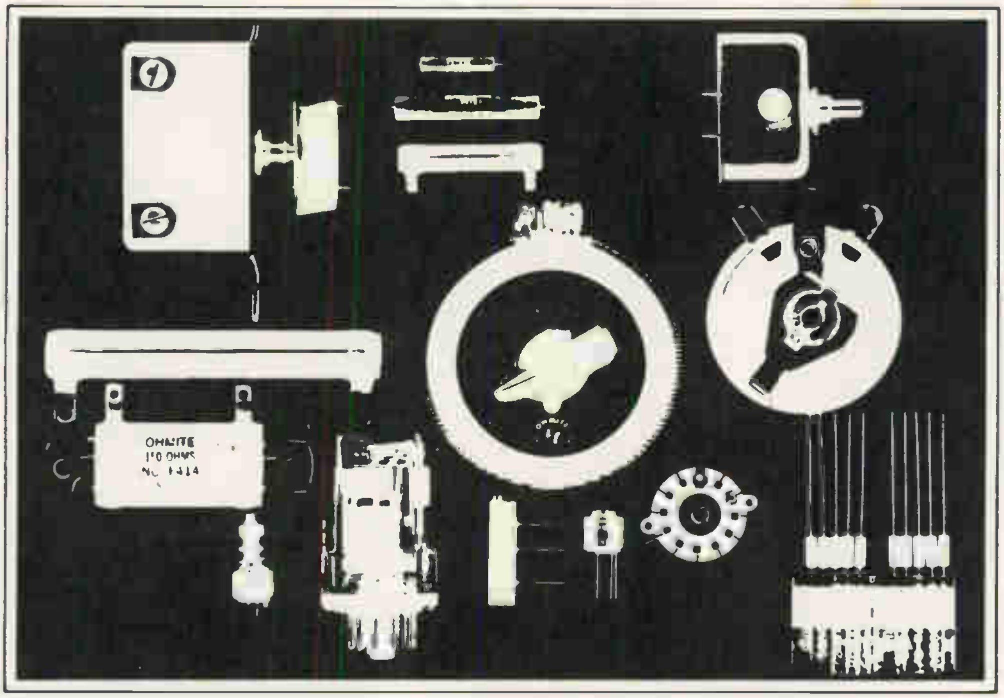
*•**Items in Parenthesis:** $25.00 per item per order.

(Bold, Light face and Parenthesis are indicated in the Component Selector Catalog.)

Terms: 1%, 10th and 25th, net 30 days, F.O.B. our factory.

Prices subject to change without notice.

*Effective March 1, 1971



OHMITE
has the answer

PRODUCT IDENTIFIER

Prices in this schedule are arranged in numeric-alpha order. For your convenience we have also provided a cross-reference of numbers and their descriptions. Complete descriptions of catalog items are contained in the Ohmite Component Selector Catalog.

Catalog No.	Description
AFR101M-AFR505M	Single Turn Trimmer - 1/4 W.
ANP101M-ANP503M	25-Turn Trimmer - 1/3 W.
AS3601-AS3684	Type AS Locking Pot.
ASM6661-ASM6676	Type AS 7/8" Shaft Pot.
CA1041-CA5041	Type AB Potentiometer
CB1031-CB5031	Type AB Potentiometer
CAB2-CAB48	Little Devil® Assortments
CAB91-CAB99	Type 995 Assortments
CCU1031-CCU5041	Type AB Pot. Dual
CLU1011-CLU7542	Type AB Pot. Locking
CMU1011-CMU7542	Type AB Pot. Locking
CS-1	Type AB Pot. Switch
CU1011-CU7542	Type AB Pot. Locking
DOXXXXX	Relays
D101-52 to D251-600	Dummy Antenna
F101-F532	Type 250 Resistor
GPRXXXX	GPR Relays
OMC-7111	Meter Saver
OB1001-OB9175	Little Devil® Resistors, 1/8 W.
OC1001-OC9175	Little Devil® Resistors, 1/4 W.
OE1001-OE9175	Little Devil® Resistors, 1/2 W.
OG1001-OG9175	Little Devil® Resistors, 1 W.
OH1001-OH9175	Little Devil® Resistors, 2 W.
PCA1000-PCA1021	Ohmitrol® Power Controls
PCD1000-PCD1021	Ohmitrol® Power Controls
P-300	Parasitic Suppressor
SOGPR	Relay Sockets
SRC65-SRC500	Heat Control Rheostat
T503-T10012-S	Ceramic Tap Switch
VTXXX	Ohmitran® V.T.
W0101-W0123	Model "E" Rheostat
W4190-W4193	Model "E" Rheostat
Z7 to Z460	Chokes
5 to 18S	Spring - Grip Mtg. Brkts.
0101-0123	Model "E" Rheostats
0140-0162	Model "H" Rheostats
0200-0229	Type 270 Resistors, 25 W.
0308-0332	Model "J" Rheostats
0358-0359	Adj. Lug. - Type 210
0360-0389	Dividohm - 25 Watt
0400-0428	Type 270 Resistor, 50 W.
0440-0463	Model "K" Rheostat
0524-0549	Model "L" Rheostat
0560-0591	Dividohm - 50 Watt
0600-0625	Type 270 Resistor, 100 W.
0650-0671	Model "N" Rheostat
0700-0725	Type 270 Resistor, 175 W.
0769-0796	Dividohm - 75 Watt
0849-0871	Model "R" Rheostat
0900-0925	Type 270 Resistor, 225 W.
0956-0973	Type 210 Resistor, 100 W.
1001-1040	Type 210 Resistor, 12 W.
1058	Adj. Lug - Type 210
1100-1123	Model "G" Rheostat
111-XXX	Model 111 Tap Switch
1156-1173	Type 210 Resistor, 175 W.
1250-1271	Model "P" Rheostat
1300-1323	Model "T" Rheostat
1356-1373	Type 210 Resistor, 225 W.
1450-1473	Model "U" Rheostat

Catalog No.	Description
1500-1557	Type 200 Resistor, 8 W.
1700-1772	Type 200 Resistor, 12 W.
1800-1860	Type 200 Resistor, 20 W.
1958-1959	Adjustable Lugs - Type 210
1974	Adjustable Lugs - Corrib®
2001-2018	Type 270N, 50 W.
2050-2081	Type 270N, 12 W.
212-3 to 212-12-T3	Model 212 Tap Switch
2115-2171	Adjustable Lugs
2172-2176	Extra Term. Powr-Rib®
2201-2218	Type 270N, 100 W.
2301-2342	Type 080-5 - Powr-Rib®
2401-2418	Type 270N, 175 W.
2501-2524	Type 280 Corrib®
2601-2624	Type 230 Corrib®
2712-2808	Type 200 Resistor, 3 W.
2822-2925	Type 200 Resistor, 5-1/4 W.
3001-3004	"T" Pad Attenuators
3101-3104	"T" Pad Attenuators
312-3 to 312-12-T3	Model 312 Tap Switches
3201-3204	"L" Pad Attenuators
3301-3304	"L" Pad Attenuators
3405-3410	Determ-ohm Box
3723-3843	Type 270, 12 W.
3860-3969	Style 995-2A, 2-1/4 W.
4030-4119	Style 995-1A, 1-1/2 W.
412-3 to 412-12-T3	Model 412 Tap Switch
4120-4135	Style 995-1A, 1-1/2 W.
4190-4193	Model "E" Rheostat
4200-4204	Model "H" Rheostat
4210-4215	Model "J" Rheostat
4330-4454	Style 995-3A, 3-1/4 W.
4530-4664	Style 995-5B, 5 W.
4730-4874	Style 995-10A, 11 W.
4908-4925	Model "C" Std. Shaft
4948-4965	Model "C" Lock. Shaft
5000-5001	Rheostat Dials
5002-5004	Tap Switch Dials
5005-5006	V.T. Dials
5007	Rheostat Dials
5008-5010	V.T. Dials
5011-5019	V.T. Dials
5102-5152	Bakelite Knobs
5155-5158	V.T. Knobs
5180-5182	Ohm's Law Calculator
5190	Little Devil® Color Coder
5800-5897	PC-58 Radial Lead Resistor
5900-5909	Clips for Types 995 and 884
608-3 to 608-8-T3	Model 608 Tap Switch
6101-2 to 6120-K-4	Thru-bolt Type Brackets
6126P8-1/2 to 6129P8-1/2	Thru-bolt Type Brackets
6507-6519	V.T. Brush Contact Assm.
6532-6533	Rheostat Tandem Kits
6536-6538	V.T. Adjustable Stop
6591	Rheostat Tandem Kit
6594, 6596	V.T. Brush Contact Assm.
711-3 to 711-11	Model 711 Tap Switch
80013-85260	Type 884 Riteohm® Resistors

Ohmite Manufacturing Company a North American Philips Company
3660 Howard Street, Skokie, Illinois 60076/Phone (312) 675-2600/TWX: 910-223-0805/TELEX 72-4433

Prices shown are recommended resale schedules offered through authorized Ohmite stocking distributors. Prices for quantities greater than shown are available from your local Ohmite Sales Office or the Factory.

NUMBER	NET PRICES/PKG. (100) 1 -9	10 -24	25 &UP
5,5S,5B	3.90	3.32	2.73
7,7S,7B	4.10	3.49	2.87
9,9S,9B	3.50	2.98	2.45
12,12S,12B	7.00	5.95	4.90
18,18S,18B	7.00	5.95	4.90

NUMBER	UNIT NET PRICES 1 -4	5 -9	10 -24	25 -49	50 &UP
0101 THRU 0106	5.50	4.68	3.69	3.03	2.26
0107 THRU 0118	4.80	4.08	3.22	2.64	1.97
0119 THRU 0121	5.50	4.68	3.69	3.03	2.26
0122 AND 0123	5.80	4.93	3.89	3.19	2.38
0140 THRU 0145	5.50	4.68	3.69	3.03	2.26
0146 THRU 0157	4.80	4.08	3.22	2.64	1.97
0158 THRU 0160	5.50	4.68	3.69	3.03	2.26
0161 AND 0162	5.80	4.93	3.89	3.19	2.38

NUMBER	UNIT NET PRICES 1 -9	10 -24	25 -99	100 -249	250 -499	500 &UP
0200A THRU 0200R	.83	.71	.58	.50	.42	.39
0201 THRU 0205	.83	.71	.58	.50	.42	.39
0206 THRU 0212	.86	.73	.60	.52	.43	.40
0213 THRU 0215	.97	.82	.68	.58	.49	.46
0216 THRU 0218	1.05	.89	.74	.63	.53	.49
0219 THRU 0222	1.20	1.02	.84	.72	.60	.56
0224 AND 0225	1.40	1.19	.98	.84	.70	.66
0226 AND 0227	1.60	1.36	1.12	.96	.80	.75
0229	1.85	1.57	1.30	1.11	.93	.87

NUMBER	UNIT NET PRICES 1 -4	5 -9	10 -24	25 -49	50 &UP
0308 THRU 0312	6.30	5.36	4.22	3.47	2.58
0313 THRU 0324	5.70	4.85	3.82	3.14	2.34
0325 THRU 0328	6.00	5.10	4.02	3.30	2.46
0329 THRU 0332	6.30	5.36	4.22	3.47	2.58

NUMBER	UNIT NET PRICES 1 -9	10 -24	25 -99	100 -249	250 -499	500 &UP
0360 THRU 0375	1.45	1.23	1.02	.87	.73	.68
0375B THRU 0382	1.50	1.28	1.05	.90	.75	.71
0383 THRU 0385	1.60	1.36	1.12	.96	.80	.75
0386 THRU 0388	1.65	1.40	1.16	.99	.83	.78
0389	1.80	1.53	1.26	1.08	.90	.85

NUMBER	UNIT NET PRICES 1 -9	10 -24	25 -99	100 &UP
0400A THRU 0400H	1.30	1.11	.91	.78
0400J	1.75	1.49	1.23	1.05
0400K & 0400L	1.30	1.11	.91	.78
0400N	1.30	1.11	.91	.78
0401 THRU 0411	1.30	1.11	.91	.78
0412 THRU 0414	1.40	1.19	.98	.84
0415 THRU 0417	1.55	1.32	1.09	.93
0418 AND 0419	1.75	1.49	1.23	1.05
0420	2.00	1.70	1.40	1.20
0421	2.25	1.91	1.58	1.35
0422	2.45	2.08	1.72	1.47
0423	2.95	2.51	2.07	1.77
0424	3.10	2.64	2.17	1.86
0425	3.20	2.72	2.24	1.92
0426	3.30	2.81	2.31	1.98
0428	3.70	3.15	2.59	2.22

NUMBER	UNIT NET PRICES 1 -4	5 -9	10 -24	25 &UP
0440 THRU 0446	9.20	7.82	6.16	5.06

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NUMBER	UNIT NET PRICES 1-4	5-9	10-24	25 &UP
0447 THRU 0456	8.70	7.40	5.83	4.79
0457 THRU 0460	9.20	7.82	6.16	5.06
0461	9.80	8.33	6.57	5.39
0462	10.60	9.01	7.10	5.83
0463	11.10	9.44	7.44	6.11
0524 THRU 0531	11.60	9.86	7.77	6.38
0532 THRU 0541	11.10	9.44	7.44	6.11
0542 AND 0543	11.60	9.86	7.77	6.38
0544 THRU 0546	12.40	10.54	8.31	6.82
0547	12.90	10.97	8.64	7.10
0548	13.40	11.39	8.98	7.37
0549	14.70	12.50	9.85	8.09

NUMBER	UNIT NET PRICES 1-9	10-24	25-99	100 &UP
0560	1.90	1.62	1.33	1.14
0560A	2.45	2.08	1.72	1.47
0560B THRU 0572	1.90	1.62	1.33	1.14
0572B THRU 0578	2.00	1.70	1.40	1.20
0578B THRU 0581	2.10	1.79	1.47	1.26
0582 THRU 0584	2.20	1.87	1.54	1.32
0585 THRU 0587	2.45	2.08	1.72	1.47
0588 AND 0589	2.60	2.21	1.82	1.56
0590	2.90	2.47	2.03	1.74
0591	3.10	2.64	2.17	1.86
0600A AND 0600B	1.75	1.49	1.23	1.05
0600C THRU 0600E	2.45	2.08	1.72	1.47
0600F	1.75	1.49	1.23	1.05
0601 THRU 0609	1.75	1.49	1.23	1.05
0610 THRU 0614	1.80	1.53	1.26	1.08
0615 AND 0616	1.95	1.66	1.37	1.17
0617 AND 0618	2.10	1.79	1.47	1.26
0619 THRU 0621	2.40	2.04	1.68	1.44
0622 AND 0623	2.50	2.13	1.75	1.50
0624	2.75	2.34	1.93	1.65
0625	3.10	2.64	2.17	1.86

NUMBER	UNIT NET PRICES 1-2	3 &UP
0650 THRU 0671	18.75	15.94

NUMBER	UNIT NET PRICES 1-9	10-24	25-99	100 &UP
0700A	3.55	3.02	2.49	2.13
0700B	2.55	2.17	1.79	1.53
0700C THRU 0700E	3.55	3.02	2.49	2.13
0701 THRU 0709	2.55	2.17	1.79	1.53
0710 THRU 0714	2.60	2.21	1.82	1.56
0715 AND 0716	2.85	2.42	2.00	1.71
0717 AND 0718	3.05	2.59	2.14	1.83
0719 THRU 0721	3.15	2.68	2.21	1.89
0722 AND 0723	3.25	2.76	2.28	1.95
0724	3.45	2.93	2.42	2.07
0725	3.65	3.10	2.56	2.19
0769	2.10	1.79	1.47	1.26
0769A AND 0769B	2.70	2.30	1.89	1.62
0769C AND 0769D	2.10	1.79	1.47	1.26
0770 THRU 0778	2.10	1.79	1.47	1.26
0778B THRU 0783	2.15	1.83	1.51	1.29
0783B THRU 0785	2.25	1.91	1.58	1.35
0785B THRU 0787	2.40	2.04	1.68	1.44
0788 THRU 0791	2.60	2.21	1.82	1.56
0792 THRU 0794	2.85	2.42	2.00	1.71
0795	3.10	2.64	2.17	1.86
0796	3.30	2.81	2.31	1.98

NUMBER	UNIT NET PRICES 1-2	3 &UP
0849 THRU 0872	27.00	22.95

NUMBER	UNIT NET PRICES 1-9	10-24	25-99	100 &UP
0900A	3.90	3.32	2.73	2.34
0900B	2.75	2.34	1.93	1.65
0900C THRU 0900F	3.90	3.32	2.73	2.34
0901 THRU 0909	2.75	2.34	1.93	1.65
0910 THRU 0914	2.85	2.42	2.00	1.71
0915 AND 0916	3.05	2.59	2.14	1.83
0917 AND 0918	3.25	2.76	2.28	1.95
0919 THRU 0921	3.35	2.85	2.35	2.01
0922 AND 0923	3.45	2.93	2.42	2.07
0924	3.65	3.10	2.56	2.19
0925	3.90	3.32	2.73	2.34
0956	2.40	2.04	1.68	1.44
0956A THRU 0956C	3.05	2.59	2.14	1.83
0956D THRU 0962	2.40	2.04	1.68	1.44
0962B THRU 0964	2.45	2.08	1.72	1.47
0965	2.60	2.21	1.82	1.56
0966 AND 0967	2.75	2.34	1.93	1.65
0968 THRU 0970	3.05	2.59	2.14	1.83
0971	3.10	2.64	2.17	1.86
0972	3.40	2.89	2.38	2.04
0973	3.70	3.15	2.59	2.22

NUMBER	UNIT NET PRICES 1-4	5-9	10 &UP
111-3	4.25	3.61	2.55
111-4	4.40	3.74	2.64
111-5	4.50	3.83	2.70
111-6	4.65	3.95	2.79
111-7	4.75	4.04	2.85
111-8	4.95	4.21	2.97
111-9	5.00	4.25	3.00
111-10	5.20	4.42	3.12
111-11	5.30	4.51	3.18

NUMBER	UNIT NET PRICES 1-2	3 &UP
111-3-T2	12.25	10.54
111-4-T2	12.50	10.75
111-5-T2	12.75	10.97
111-6-T2	13.00	11.18
111-7-T2	13.25	11.40
111-8-T2	13.50	11.61
111-9-T2	13.75	11.83
111-10-T2	14.00	12.04
111-11-T2	14.25	12.26

NUMBER	UNIT NET PRICES 1-9	10-24	25-99	100-249	250-499	500 &UP
1001 THRU 1023	1.30	1.11	.91	.78	.65	.61
1024 THRU 1033	1.35	1.15	.95	.81	.68	.63
1034 THRU 1040	1.45	1.23	1.02	.87	.73	.68

NUMBER	UNIT NET PRICES 1-4	5-9	10-24	25 &UP
1100 THRU 1106	8.20	6.97	5.49	4.51
1107 THRU 1115	7.60	6.46	5.09	4.18
1116 THRU 1120	8.20	6.97	5.49	4.51
1121	8.90	7.57	5.96	4.90
1122 AND 1123	9.60	8.16	6.43	5.28

NUMBER	UNIT NET PRICES 1-9	10-24	25-99	100 &UP
1156 THRU 1156D	4.60	3.91	3.22	2.76
1157 THRU 1162	3.55	3.02	2.49	2.13
1162B THRU 1164	3.60	3.06	2.52	2.16
1165	3.80	3.23	2.66	2.28

Ohmite Manufacturing Company a North American Philips Company
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NUMBER	1 -9	10 -24	25 -99	100 &UP
1166 AND 1167	4.00	3.40	2.80	2.40
1168 THRU 1170	4.15	3.53	2.91	2.49
1171	4.25	3.61	2.98	2.55
1172	4.45	3.78	3.12	2.67
1173	4.65	3.95	3.26	2.79

NUMBER	1 -2	3 &UP
1250 THRU 1271	17.00	14.45
1300 THRU 1323	38.00	32.30

NUMBER	1 -9	10 -24	25 -99	100 &UP
1356 THRU 1356D	4.85	4.12	3.40	2.91
1357 THRU 1362	3.75	3.19	2.63	2.25
1362B THRU 1364	3.80	3.23	2.66	2.28
1365	4.00	3.40	2.80	2.40
1366 AND 1367	4.25	3.61	2.98	2.55
1368 THRU 1370	4.35	3.70	3.05	2.61
1371	4.45	3.78	3.12	2.67
1372	4.65	3.95	3.26	2.79
1373	4.90	4.17	3.43	2.94

NUMBER	1 -2	3 &UP
1450 THRU 1473	44.00	37.40

NUMBER	1 -9	10 -24	25 -99	100 -249	250 -499	500 &UP
1500 THRU 1532	.60	.51	.42	.36	.30	.28
1533 THRU 1545	.63	.54	.44	.38	.32	.30
1546 THRU 1551	.66	.56	.46	.40	.33	.31
1552 THRU 1555	.73	.62	.51	.44	.37	.34
1556 THRU 1557	.77	.65	.54	.46	.39	.36
1700A THRU 1736	.65	.55	.46	.39	.33	.31
1737 THRU 1749	.69	.59	.48	.41	.35	.32
1750 THRU 1755	.80	.68	.56	.48	.40	.38
1756 THRU 1765	.90	.77	.63	.54	.45	.42
1766 THRU 1770	.94	.80	.66	.56	.47	.44
1771 AND 1772	1.10	.94	.77	.66	.55	.52
1800A	1.10	.94	.77	.66	.55	.52
1802A THRU 1821	.77	.65	.54	.46	.39	.36
1822 THRU 1836	.80	.68	.56	.48	.40	.38
1837 THRU 1841	.94	.80	.66	.56	.47	.44
1842 THRU 1844	.96	.82	.67	.58	.48	.45
1845 THRU 1848	1.15	.98	.81	.69	.58	.54
1849 THRU 1852	1.30	1.11	.91	.78	.65	.61
1853 THRU 1856	1.55	1.32	1.09	.93	.78	.73
1857 THRU 1860	1.80	1.53	1.26	1.08	.90	.85

NUMBER	1 -9	10 -24	25 &UP
1974A	.25	.21	.18
1974B	.25	.21	.18

NUMBER	1 -9	10 -24	25 -99	100 &UP
2001 THRU 2011	2.55	2.17	1.79	1.53
2012 THRU 2018	2.60	2.21	1.82	1.56
2050 THRU 2070	1.30	1.11	.91	.78
2071 THRU 2076	1.40	1.19	.98	.84
2077 THRU 2091	1.60	1.36	1.12	.96

NUMBER	1 -4	5 -9	10 &UP
212-3	8.30	7.06	4.98
212-4	8.50	7.23	5.10
212-5	8.60	7.31	5.16
212-6	8.90	7.57	5.34
212-7	9.10	7.74	5.46
212-8	9.30	7.91	5.58
212-9	9.50	8.08	5.70
212-10	9.60	8.16	5.76
212-11	9.90	8.42	5.94
212-12	10.00	8.50	6.00

NUMBER	1 -2	3 &UP
212-3-T2	20.25	17.42
212-4-T2	20.50	17.63
212-5-T2	21.00	18.06
212-6-T2	21.50	18.49
212-7-T2	21.75	18.71
212-8-T2	22.25	19.14
212-9-T2	22.50	19.35
212-10-T2	23.00	19.78
212-11-T2	23.25	20.00
212-12-T2	23.75	20.43

NUMBER	-1	2 &UP
212-3-T3	30.50	26.54
212-4-T3	31.00	26.97
212-5-T3	31.50	27.41
212-6-T3	32.00	27.84
212-7-T3	33.00	28.71
212-8-T3	33.50	29.15
212-9-T3	34.00	29.58
212-10-T3	34.50	30.02
212-11-T3	35.00	30.45
212-12-T3	36.00	31.32

NUMBER	1 -9	10 -24	25 &UP
2115 WAS 1058	.16	.14	.11
2116 WAS 2161	.40	.34	.28
2121 WAS 0358	.16	.14	.11
2122 WAS 0359	.35	.30	.25
2123 WAS 2164	.40	.34	.28
2124 WAS 2165	.59	.50	.41
2125 WAS 1958	.16	.14	.11
2126 WAS 1959	.35	.30	.25
2127 WAS 2166	.40	.34	.28
2128 WAS 2167	.59	.50	.41
2133 WAS 2158	.25	.21	.18
2134 WAS 2159	.44	.37	.31
2135 WAS 2170	.49	.42	.34
2136 WAS 2171	.68	.58	.48
2160	.93	.79	.65

NUMBER	-1	-2	3 -4	5 &UP
2172B	1.25	1.06	.94	.88
2172G	.46	.39	.35	.32
2175	.67	.57	.50	.47
2176	1.20	1.02	.90	.84

NUMBER	1 -9	10 -24	25 -99	100 &UP
2201 THRU 2211	3.45	2.93	2.42	2.07
2212 THRU 2218	3.60	3.06	2.52	2.16

NUMBER	-1	-2	3 -4	5 &UP
2301	30.50	25.93	22.88	21.35

All tables: UNIT NET PRICES

Prices shown are recommended resale schedules offered through authorized Ohmite stocking distributors. Prices for quantities greater than shown are available from your local Ohmite Sales Office or the Factory.

NUMBER	UNIT NET PRICES 1	2	3 -4	5 &UP
2302	27.00	22.95	20.25	18.90
2303A	22.25	18.91	16.69	15.58
2304A	20.75	17.64	15.56	14.53
2305A	19.75	16.79	14.81	13.83
2306A	16.75	14.24	12.56	11.73
2306	16.25	13.81	12.19	11.38
2308A	15.00	12.75	11.25	10.50
2308	13.90	11.82	10.43	9.73
2309A	13.10	11.14	9.83	9.17
2310	22.25	18.91	16.69	15.58
2311	18.00	15.30	13.50	12.60
2312	15.25	12.96	11.44	10.68
2313	12.30	10.46	9.23	8.61
2317	20.00	17.00	15.00	14.00
2318	19.00	16.15	14.25	13.30
2319	13.40	11.39	10.05	9.38
2331A	9.70	8.25	7.28	6.79
2332A	9.00	7.65	6.75	6.30
2333A	8.00	6.80	6.00	5.60
2334A	14.20	12.07	10.65	9.94
2335A	13.40	11.39	10.05	9.38
2336A	12.60	10.71	9.45	8.82
2337A	11.80	10.03	8.85	8.26
2338	15.75	13.39	11.81	11.03
2339	15.50	13.18	11.63	10.85
2340	15.00	12.75	11.25	10.50
2341	15.00	12.75	11.25	10.50
2342	14.70	12.50	11.03	10.29

NUMBER	UNIT NET PRICES 1 -9	10 -24	25 -99	100 &UP
2401	7.20	6.12	5.04	4.32
2402 THRU 2411	5.20	4.42	3.64	3.12
2412 THRU 2418	5.20	4.42	3.64	3.12

NUMBER	UNIT NET PRICES 1 -9	10 -24	25 &UP
2501 THRU 2504	5.60	4.76	3.92
2505 THRU 2510	4.80	4.08	3.36
2511 THRU 2524	3.95	3.36	2.77
2601 THRU 2604	6.60	5.61	4.62
2605 THRU 2610	5.80	4.93	4.06
2611 THRU 2624	5.00	4.25	3.50

NUMBER	UNIT NET PRICES 1 -9	10 -24	25 -99	100 -249	250 -499	500 &UP
2712 THRU 2784	.56	.46	.39	.34	.28	.26
2785 THRU 2800	.60	.51	.42	.36	.30	.28
2801 THRU 2808	.63	.54	.44	.38	.32	.30
2822 THRU 2894	.60	.51	.42	.36	.30	.28
2895 THRU 2910	.63	.54	.44	.38	.32	.30
2911 THRU 2918	.66	.56	.46	.40	.33	.31
2919 THRU 2925	.73	.62	.51	.44	.37	.34

NUMBER	UNIT NET PRICES 1 -4	5 -9	10 &UP
312-3	11.25	9.56	6.75
312-4	11.25	9.56	6.75
312-5	11.50	9.78	6.90
312-6	11.75	9.99	7.05
312-7	12.00	10.20	7.20
312-8	12.25	10.41	7.35
312-9	12.25	10.41	7.35
312-10	12.50	10.63	7.50
312-11	12.75	10.84	7.65
312-12	13.00	11.05	7.80

NUMBER	UNIT NET PRICES 1 -2	3 &UP
312-3-T2	27.00	23.22

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NUMBER	UNIT NET PRICES 1 -2	3 &UP
312-4-T2	27.50	23.65
312-5-T2	28.00	24.08
312-6-T2	28.50	24.51
312-7-T2	29.00	24.94
312-8-T2	29.00	24.94
312-9-T2	29.50	25.37
312-10-T2	30.00	25.80
312-11-T2	30.50	26.23
312-12-T2	30.50	26.23

NUMBER	UNIT NET PRICES -1	2 &UP
312-3-T3	41.00	35.67
312-4-T3	41.50	36.11
312-5-T3	42.00	36.54
312-6-T3	42.50	36.98
312-7-T3	43.00	37.41
312-8-T3	43.50	37.85
312-9-T3	44.50	38.72
312-10-T3	45.00	39.15
312-11-T3	45.50	39.59
312-12-T3	46.00	40.02

NUMBER	UNIT NET PRICES 1 -4	5 -9	10 &UP
3001 THRU 3004	31.50	26.78	21.11
3101 THRU 3104	32.00	27.20	21.44
3201 THRU 3204	29.00	24.65	19.43
3301 THRU 3304	30.50	25.93	20.44

NUMBER	UNIT NET PRICES NET
3401	54.00
3402	54.00
3403	54.00
3404	54.00
3405	85.00
3406	85.00
3407	90.00
3410	125.00

NUMBER	UNIT NET PRICES 1 -9	10 -24	25 -99	100 -249	250 -499	500 &UP
3723 THRU 3802	.66	.56	.46	.40	.33	.31
3804 THRU 3818	.70	.60	.49	.42	.35	.33
3820 THRU 3826	.81	.69	.57	.49	.41	.38
3828 THRU 3832	.90	.77	.63	.54	.45	.42
3834 THRU 3840	.95	.81	.67	.57	.48	.45
3842 AND 3843	1.10	.94	.77	.66	.55	.52
3860 THRU 3956	.64	.54	.45	.38	.32	.30
3957 THRU 3969	.68	.58	.48	.41	.34	.32
4030 THRU 4123	.66	.56	.46	.40	.33	.31
4124 THRU 4135	.70	.60	.49	.42	.35	.33

NUMBER	UNIT NET PRICES 1 -4	5 -9	10 &UP
412-3	14.75	12.54	8.85
412-4	15.00	12.75	9.00
412-5	15.25	12.96	9.15
412-6	15.50	13.18	9.30
412-7	15.75	13.39	9.45
412-8	16.00	13.60	9.60
412-9	16.25	13.81	9.75
412-10	16.75	14.24	10.05
412-11	17.00	14.45	10.20
412-12	17.25	14.66	10.35

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NUMBER	UNIT NET PRICES 1-2	3 &UP
412-3-T2	34.00	29.24
412-4-T2	34.50	29.67
412-5-T2	35.00	30.10
412-6-T2	36.00	30.96
412-7-T2	36.50	31.39
412-8-T2	37.00	31.82
412-9-T2	37.50	32.25
412-10-T2	38.00	32.68
412-11-T2	38.50	33.11
412-12-T2	39.50	33.97

NUMBER	UNIT NET PRICES -1	2 &UP
412-3-T3	51.00	44.37
412-4-T3	52.00	45.24
412-5-T3	53.00	46.11
412-6-T3	54.00	46.98
412-7-T3	55.00	47.85
412-8-T3	55.00	47.85
412-9-T3	56.00	48.72
412-10-T3	57.00	49.59
412-11-T3	58.00	50.46
412-12-T3	59.00	51.33

NUMBER	UNIT NET PRICES 1-4	5-9	10-24	25-49	50 &UP
4190 AND 4191	6.00	5.10	4.02	3.30	2.46
4192 AND 4193	6.60	5.61	4.42	3.63	2.71
4200 AND 4201	6.00	5.10	4.02	3.30	2.46
4202	6.60	5.61	4.42	3.63	2.71
4203	7.30	6.21	4.89	4.02	2.99
4204	8.10	6.89	5.43	4.46	3.32
4210	7.20	6.12	4.82	3.96	2.95
4211	8.10	6.89	5.43	4.46	3.32
4212	9.00	7.65	6.03	4.95	3.69
4213	10.00	8.50	6.70	5.50	4.10
4214	11.50	9.78	7.71	6.33	4.72
4215	12.60	10.71	8.44	6.93	5.17

NUMBER	UNIT NET PRICES 1-9	10-24	25-99	100-249	250-499	500 &UP
4330 THRU 4423	.63	.54	.44	.38	.32	.30
4424 THRU 4442	.66	.56	.46	.40	.33	.31
4443 THRU 4454	.70	.60	.49	.42	.35	.33
4530 THRU 4623	.66	.56	.46	.40	.33	.31
4624 THRU 4642	.70	.60	.49	.42	.35	.33
4643 THRU 4654	.75	.64	.53	.45	.38	.35
4655 THRU 4661	.84	.71	.59	.50	.42	.39
4662 THRU 4664	.88	.75	.62	.53	.44	.41
4730 THRU 4823	.72	.61	.50	.43	.36	.34
4824 THRU 4842	.79	.67	.55	.47	.40	.37
4843 THRU 4854	.90	.77	.63	.54	.45	.42
4855A THRU 4861	1.00	.85	.70	.60	.50	.47
4862 THRU 4870	1.05	.89	.74	.63	.53	.49
4871 THRU 4874	1.20	1.02	.84	.72	.60	.56

NUMBER	UNIT NET PRICES 1-4	5-9	10 &UP
4908 THRU 4920	9.50	8.08	5.70
4921 THRU 4923	10.80	9.18	6.48
4924 AND 4925	11.30	9.61	6.78
4948 THRU 4960	11.60	8.93	6.26
4961 THRU 4963	12.90	9.93	6.97
4964 AND 4965	13.40	10.32	7.24

NUMBER	UNIT NET PRICES 1-9	10-49	50 &UP
5000	.30	.26	.20

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NUMBER	UNIT NET PRICES 1 -9	10 -49	50 &UP
5001	.74	.63	.48
5002	.49	.42	.32
5003	.73	.62	.47
5004	.82	.70	.53
5005	.30	.26	.20
5006	.55	.47	.36
5007	.30	.26	.20
5008	.55	.47	.36
5009	.55	.47	.36
5010	1.00	.85	.65
5011	.55	.47	.36
5012	.55	.47	.36
5013	1.30	1.11	.85
5014	1.30	1.11	.85
5015	1.30	1.11	.85
5016	1.30	1.11	.85
5017	1.30	1.11	.85
5018	1.00	.85	.65
5019	.55	.47	.36
5102	.53	.45	.34
5103	.22	.19	.14
5104	1.45	1.23	.94
5105	1.22	1.04	.79
5106	1.45	1.23	.94
5107	1.22	1.04	.79
5109	.93	.79	.60
5110	.86	.73	.56
5111	1.39	1.18	.90
5112	1.27	1.08	.83
5115	3.15	2.68	2.05
5116	.53	.45	.34
5150	.30	.26	.20
5151	.30	.26	.20
5152A	1.68	1.43	1.09
5155	1.10	.94	.72
5157	2.00	1.70	1.30
5158	.40	.34	.26

NUMBER	NET (UNIT NET PRICES)
5180	.25
5182	1.50
5190	.10

NUMBER	UNIT NET PRICES 1 -9	10 -24	25 -99	100 -249	250 -499	500 &UP
5800 THRU 5833	.54	.46	.38	.32	.27	.25
5834 THRU 5843	.58	.49	.41	.35	.29	.27
5844 THRU 5849	.61	.52	.43	.37	.31	.29
5850 THRU 5879	.58	.49	.41	.35	.29	.27
5880 THRU 5888	.61	.52	.43	.37	.31	.29
5889 THRU 5894	.64	.54	.45	.38	.32	.30
5895 THRU 5897	.71	.60	.50	.43	.36	.33

NUMBER	UNIT NET PRICES 1 -99	100 -499	500 &UP
5900 THRU 5909	.21	.16	.13

NUMBER	UNIT NET PRICES 1 -4	5 &UP
608-3	26.50	22.53
608-4	27.00	22.95
608-5	27.50	23.38
608-6	27.50	23.38
608-7	28.00	23.80
608-8	28.50	24.23

NUMBER	UNIT NET PRICES 1 -2	3 &UP
608-3-T2	60.00	51.60

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NUMBER	UNIT NET PRICES 1-2	3 &UP
608-4-T2	61.00	52.46
608-5-T2	62.00	53.32
608-6-T2	63.00	54.18
608-7-T2	63.00	54.18
608-8-T2	64.00	55.04

NUMBER	UNIT NET PRICES -1	2 &UP
608-3-T3	89.00	77.43
608-4-T3	91.00	79.17
608-5-T3	92.00	80.04
608-6-T3	93.00	80.91
608-7-T3	94.00	81.78
608-8-T3	95.00	82.65

NUMBER	UNIT NET PRICES 1-9	10-24	25-99	100 &UP
6101-2	.83	.71	.58	.50
6101-4	.83	.71	.58	.50
6101-6	.83	.71	.58	.50
6104-6-1/2	1.00	.85	.70	.60
6110-8-1/2	1.50	1.28	1.05	.90
6110-10-1/2	1.50	1.28	1.05	.90
6120-D-1-3/4	.83	.71	.58	.50
6120-K-2	.83	.71	.58	.50
6120-K-4	.83	.71	.58	.50

NUMBER	UNIT NET PRICES 1-9	10-24	25 &UP
6126P8-1/2	.87	.74	.61
6127P8-1/2	1.70	1.45	1.19
6128P8-1/2	2.35	2.00	1.65
6129P8-1/2	2.80	2.38	1.96

NUMBER	UNIT NET PRICES 1-9	10-24	25-99	100 &UP
6507	1.10	.99	.91	.83
6508	.05	.05	.04	.04
6509	.05	.05	.04	.04
6512	1.10	.99	.91	.83
6515	1.10	.99	.91	.83
6516H	1.35	1.22	1.11	1.01
6517	2.20	1.98	1.82	1.65
6518	2.20	1.98	1.82	1.65
6519	2.70	2.43	2.23	2.03

NUMBER	UNIT NET PRICES 1-4	5-9	10-24	25 &UP
6532	2.30	1.96	1.54	1.27
6533	2.90	2.47	1.94	1.60

NUMBER	UNIT NET PRICES 1-9	10-24	25-99	100 &UP
6536	.55	.50	.45	.41
6537	.55	.50	.45	.41
6538	1.10	.99	.91	.83

NUMBER	UNIT NET PRICES 1-4	5-9	10-24	25 &UP
6591	2.30	1.96	1.54	1.27

NUMBER	UNIT NET PRICES 1-9	10-24	25-99	100 &UP
6594	1.90	1.71	1.57	1.43

NUMBER	UNIT NET PRICES 1-9	10-24	25-99	100 &UP
6596	1.90	1.71	1.57	1.43

NUMBER	UNIT NET PRICES 1-4	5-9	10 &UP
711-3	3.65	3.10	2.19
711-4	3.75	3.19	2.25
711-5	3.85	3.27	2.31
711-6	4.00	3.40	2.40
711-7	4.10	3.49	2.46
711-8	4.20	3.57	2.52
711-9	4.30	3.66	2.58
711-10	4.45	3.78	2.67
711-11	4.55	3.87	2.73

NUMBER	UNIT NET PRICES 1-9	10-24	25-99	100 &UP
80013-80173	1.40	1.19	.98	.84
80183-81133	1.00	.85	.70	.60
81143-83053	.97	.82	.68	.58
83063-84013	.99	.84	.69	.59
84023-84303	1.20	1.02	.84	.72
84313-84343	1.30	1.11	.91	.78
84355-84585	1.50	1.28	1.05	.90
84595-84685	1.75	1.49	1.23	1.05
84695-84885	1.85	1.57	1.30	1.11
84890-84970	3.05	2.59	2.14	1.83
84980-85060	3.45	2.93	2.42	2.07
85070-85140	3.75	3.19	2.63	2.25
85150-85260	4.50	3.83	3.15	2.70

NUMBER	UNIT NET PRICES 1-9	10-24	25 &UP
AFR-101M TO AFR-505M	3.00	2.60	2.20
ANP-101M TO ANP-503M	3.30	2.90	2.50

NUMBER	UNIT NET PRICES 1-9	10-49	50-99	100 &UP
AS3601 THRU AS3684	5.10	4.59	4.23	3.57
ASM6661 THRU ASM6676	5.10	4.59	4.23	3.57

NUMBER	UNIT NET PRICES NET
CAB-2	22.50
CAB-3	30.00
CAB-4	19.50
CAB-10	18.00
CAB-25	70.00
CAB-26	60.00
CAB-27	54.00
CAB-45	225.00
CAB-46	210.00
CAB-47	180.00
CAB-48	160.00
CAB-91	110.00
CAB-93	205.00
CAB-95	240.00
CAB-99	140.00

NUMBER	UNIT NET PRICES 1-9	10-49	50-99	100 &UP
CA1041 THRU CA5041	2.25	2.03	1.87	1.69
CB1031 THRU CB5031	2.25	2.03	1.87	1.69
CCU1031 THRU CCU5041	5.85	5.27	4.86	4.39
CLU1011 THRU CLU7542	2.55	2.30	2.12	1.91
CMU1011 THRU CMU7542	1.95	1.76	1.62	1.46
CS-1	.66	.59	.55	.50
CU1011 THRU CU7542	1.95	1.76	1.62	1.46

NUMBER	UNIT NET PRICES 1-9	10-24	25 &UP
D-101-52	13.50	11.48	9.45

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NUMBER	1 -9	10 -24	25 &UP
		UNIT NET PRICES	
D-101-73	13.50	11.48	9.45
D-101-300	9.00	7.65	6.30
D-101-600	9.00	7.65	6.30
D-251-52	18.00	15.30	12.60
D-251-73	18.00	15.30	12.60
D-251-300	18.00	15.30	12.60
D-251-600	18.00	15.30	12.60

NUMBER	1 -24	25 -49	50 -99	100 &UP
		UNIT NET PRICES		
DOHPX-15T	30.00	28.50	27.00	21.00
DOHPX-16T	24.00	22.80	21.60	16.80
DOHX-22T	23.25	22.09	20.93	16.28
DOHX-23T	25.00	23.75	22.50	17.50
DOLEX-3T	16.50	15.68	14.85	11.55
DOLEX-5T	18.00	17.10	16.20	12.60
DOSEPX-5T	9.00	8.55	8.10	6.30
DOSHPX-46T	15.00	14.25	13.50	10.50
DOSHPX-47T	14.90	14.16	13.41	10.43
DOSHX-39T	14.90	14.16	13.41	10.43
DOSHX-40T	14.80	14.06	13.32	10.36
DOSLEX-1T	13.10	12.45	11.79	9.17
DOSPX-1T	7.90	7.51	7.11	5.53
DOSUX-31	6.70	6.37	6.03	4.69
DOSUX-33	7.20	6.84	6.48	5.04
DOSUX-34	6.60	6.27	5.94	4.62
DOSX-7T	6.00	5.70	5.40	4.20
DOSX-9T	5.40	5.13	4.86	3.78
DOSX-12T	6.40	6.08	5.76	4.48
DOSX-16T	6.00	5.70	5.40	4.20
DOSX-30T	6.00	5.70	5.40	4.20
DOSX-59T	6.10	5.80	5.49	4.27
DOSX-66T	5.40	5.13	4.86	3.78
DOSX 158T	5.40	5.13	4.86	3.78
DOSX 162T	6.00	5.70	5.40	4.20
DOSX-177T	6.70	6.37	6.03	4.69
DOSX-229T	5.30	5.04	4.77	3.71
DOSX-230T	5.40	5.13	4.86	3.78
DOSX-231T	5.30	5.04	4.77	3.71
DOSX-232T	5.40	5.13	4.86	3.78
DOSX-233T	5.30	5.04	4.77	3.71
DOSX-234T	5.40	5.13	4.86	3.78
DOSX-235T	5.70	5.42	5.13	3.99
DOSX-236T	5.80	5.51	5.22	4.06
DOSX-237T	5.50	5.23	4.95	3.85
DOSX-238T	5.60	5.32	5.04	3.92
DOSYX-67T	6.70	6.37	6.03	4.69
DOSYX-68T	6.70	6.37	6.03	4.69
DOSYX-69T	6.10	5.80	5.49	4.27
DOSYX-70T	6.10	5.80	5.49	4.27
DOUX-28	9.80	9.31	8.82	6.86
DOUX-30	10.70	10.17	9.63	7.49
DOUX-31	10.90	10.36	9.81	7.63
DOUX-33	12.10	11.50	10.89	8.47
DOUX-34	10.70	10.17	9.63	7.49
DOX-46T	9.50	9.03	8.55	6.65
DOX-49T	9.50	9.03	8.55	6.65
DOX-50T	9.50	9.03	8.55	6.65
DOX-51T	8.20	7.79	7.38	5.74
DOX-53T	10.80	10.26	9.72	7.56
DOX-61T	9.90	9.41	8.91	6.93
DOX-93T	8.80	8.36	7.92	6.16
DOX-102T	9.50	9.03	8.55	6.65
DOX-130T	11.20	10.64	10.08	7.84
DOX-137T	9.50	9.03	8.55	6.65
DOX-141T	8.20	7.79	7.38	5.74
DOX-145T	8.20	7.79	7.38	5.74
DOX-181T	9.50	9.03	8.55	6.65
DOX-182T	9.60	9.12	8.64	6.72
DOX-183T	10.80	10.26	9.72	7.56
DOX-184T	10.80	10.26	9.72	7.56
DOX-185T	10.80	10.26	9.72	7.56
DOX-186T	9.50	9.03	8.55	6.65
DOX-187T	10.10	9.60	9.09	7.07
DOX-188T	10.90	10.36	9.81	7.63

NUMBER	1 -24	25 -49	50 -99	100 &UP
		UNIT NET PRICES		
DOX-226T	9.40	8.93	8.46	6.58
DOX-227T	8.60	8.17	7.74	6.02
DOX-228T	9.60	9.12	8.64	6.72

NUMBER	1 -9	10 -24	25 -99	100 &UP
		UNIT NET PRICES		
F101 THRU F128	1.05	.89	.74	.63
F129 THRU F131	1.15	.98	.81	.69
F201 THRU F222	1.15	.98	.81	.69
F223 THRU F226	1.20	1.02	.84	.72
F227 AND F228	1.25	1.06	.88	.75
F229	1.35	1.15	.95	.81
F230 AND F231	1.35	1.15	.95	.81
F232	1.45	1.23	1.02	.87
F233	1.50	1.28	1.05	.90
F234 AND F235	1.55	1.32	1.09	.93
F236 AND F237	1.65	1.40	1.16	.99
F301 THRU F322	1.60	1.36	1.12	.96
F323 THRU F325	1.75	1.49	1.23	1.05
F326	1.80	1.53	1.26	1.08
F327	1.85	1.57	1.30	1.11
F401 THRU F423	1.65	1.40	1.16	.99
F424 THRU F426	1.80	1.53	1.26	1.08
F427	1.85	1.57	1.30	1.11
F428	2.00	1.70	1.40	1.20
F429	2.15	1.83	1.51	1.29
F430	2.25	1.91	1.58	1.35
F431	2.35	2.00	1.65	1.41
F501 THRU F523	2.00	1.70	1.40	1.20
F524 THRU F526	2.10	1.79	1.47	1.26
F527	2.15	1.83	1.51	1.29
F528	2.30	1.96	1.61	1.38
F529	2.40	2.04	1.68	1.44
F530	2.45	2.08	1.72	1.47
F531	2.60	2.21	1.82	1.56
F532	2.75	2.34	1.93	1.65

NUMBER	1 -24	25 -49	50 -99	100 &UP
		UNIT NET PRICES		
GPRLETPX-1T	18.00	17.10	16.20	12.60
GPRLETPX-2T	21.25	20.19	19.13	14.88
GPRLETPX-3T	18.00	17.10	16.20	12.60
GPRLETPX-4T	21.25	20.19	19.13	14.88
GPRLETPX-5T	18.00	17.10	16.20	12.60
GPRLETPX-6T	21.25	20.19	19.13	14.88
GPRLETPX-7T	18.00	17.10	16.20	12.60
GPRLETPX-8T	21.25	20.19	19.13	14.88
GPRLETPX-9T	18.75	17.81	16.88	13.13
GPRLETPX-10T	22.25	21.14	20.03	15.58
GPRLETPX-11T	16.75	15.91	15.08	11.73
GPRLETPX-12T	20.00	19.00	18.00	14.00
GPRLETPX-13T	16.75	15.91	15.08	11.73
GPRLETPX-14T	20.00	19.00	18.00	14.00
GPRLETPX-15T	16.75	15.91	15.08	11.73
GPRLETPX-16T	20.00	19.00	18.00	14.00
GPRLETPX-17T	18.25	17.34	16.43	12.78
GPRLETPX-18T	21.50	20.43	19.35	15.05
GPRLEX-1T	11.40	10.83	10.26	7.98
GPRLEX-2T	13.70	13.02	12.33	9.59
GPRLEX-3T	11.40	10.83	10.26	7.98
GPRLEX-4T	13.70	13.02	12.33	9.59
GPRLEX-5T	11.40	10.83	10.26	7.98
GPRLEX-6T	13.70	13.02	12.33	9.59
GPRLEX-7T	11.40	10.83	10.26	7.98
GPRLEX-8T	13.70	13.02	12.33	9.59
GPRLEX-9T	12.30	11.69	11.07	8.61
GPRLEX-10T	14.60	13.87	13.14	10.22
GPRLEX-11T	10.30	9.79	9.27	7.21
GPRLEX-12T	12.50	11.88	11.25	8.75
GPRLEX-13T	10.30	9.79	9.27	7.21
GPRLEX-14T	12.50	11.88	11.25	8.75
GPRLEX-15T	10.30	9.79	9.27	7.21

Prices shown are recommended resale schedules offered through authorized Ohmite stocking distributors. Prices for quantities greater than shown are available from your local Ohmite Sales Office or the Factory.

NUMBER	UNIT NET PRICES 1 -24	25 -49	50 -99	100 &UP
GPRLEX-16T	12.50	11.88	11.25	8.75
GPRLEX-17T	11.60	11.02	10.44	8.12
GPRLEX-18T	13.80	13.11	12.42	9.66
GPRTAX-3T	5.70	5.42	5.13	3.99
GPRTAX-6T	6.40	6.08	5.76	4.48
GPRTAX-9T	7.40	7.03	6.66	5.18
GPRTAX-12T	5.70	5.42	5.13	3.99
GPRTAX-15T	6.40	6.08	5.76	4.48
GPRTAX-18T	7.40	7.03	6.66	5.18
GPRTAX-21T	5.70	5.42	5.13	3.99
GPRTAX-24T	6.40	6.08	5.76	4.48
GPRTAX-27T	7.40	7.03	6.66	5.18
GPRTAX-30T	5.70	5.42	5.13	3.99
GPRTAX-33T	6.40	6.08	5.76	4.48
GPRTAX-36T	7.40	7.03	6.66	5.18
GPRTAX-39T	6.10	5.80	5.49	4.27
GPRTAX-42T	6.80	6.46	6.12	4.76
GPRTAX-45T	7.80	7.41	7.02	5.46
GPRTAX-48T	5.50	5.23	4.95	3.85
GPRTAX-51T	5.90	5.61	5.31	4.13
GPRTAX-54T	6.90	6.56	6.21	4.83
GPRTAX-57T	5.50	5.23	4.95	3.85
GPRTAX-60T	5.90	5.61	5.31	4.13
GPRTAX-63T	6.90	6.56	6.21	4.83
GPRTAX-66T	5.50	5.23	4.95	3.85
GPRTAX-69T	5.90	5.61	5.31	4.13
GPRTAX-72T	6.90	6.56	6.21	4.83
GPRTAX-75T	6.10	5.80	5.49	4.27
GPRTAX-78T	6.60	6.27	5.94	4.62
GPRTAX-81T	7.60	7.22	6.84	5.32
GPRTAX-82T	6.00	5.70	5.40	4.20
GPRTAX-83T	6.20	5.89	5.58	4.34
GPRTAX-84T	7.20	6.84	6.48	5.04
GPRTAX-85T	6.10	5.80	5.49	4.27
GPRTAX-86T	6.30	5.99	5.67	4.41
GPRTAX-87T	7.30	6.94	6.57	5.11
GPRTAX-88T	6.60	6.27	5.94	4.62
GPRTAX-89T	6.80	6.46	6.12	4.76
GPRTAX-90T	7.80	7.41	7.02	5.46
GPRTAX-191T	5.80	5.51	5.22	4.06
GPRTAX-192T	6.60	6.27	5.94	4.62
GPRTAX-193T	7.50	7.13	6.75	5.25
GPRTPX-3T	5.90	5.61	5.31	4.13
GPRTPX-6T	6.60	6.27	5.94	4.62
GPRTPX-9T	8.20	7.79	7.38	5.74
GPRTPX-12T	5.90	5.61	5.31	4.13
GPRTPX-15T	6.60	6.27	5.94	4.62
GPRTPX-18T	8.20	7.79	7.38	5.74
GPRTPX-21T	5.90	5.61	5.31	4.13
GPRTPX-24T	6.60	6.27	5.94	4.62
GPRTPX-27T	8.20	7.79	7.38	5.74
GPRTPX-30T	5.90	5.61	5.31	4.13
GPRTPX-33T	6.60	6.27	5.94	4.62
GPRTPX-36T	8.20	7.79	7.38	5.74
GPRTPX-39T	6.30	5.99	5.67	4.41
GPRTPX-42T	7.00	6.65	6.30	4.90
GPRTPX-45T	8.60	8.17	7.74	6.02
GPRTPX-48T	5.90	5.61	5.31	4.13
GPRTPX-51T	6.60	6.27	5.94	4.62
GPRTPX-54T	8.10	7.70	7.29	5.67
GPRTPX-57T	5.90	5.61	5.31	4.13
GPRTPX-60T	6.60	6.27	5.94	4.62
GPRTPX-63T	8.10	7.70	7.29	5.67
GPRTPX-66T	5.90	5.61	5.31	4.13
GPRTPX-69T	6.60	6.27	5.94	4.62
GPRTPX-72T	8.10	7.70	7.29	5.67
GPRTPX-75T	6.50	6.18	5.85	4.55
GPRTPX-78T	7.20	6.84	6.48	5.04
GPRTPX-81T	8.70	8.27	7.83	6.09
GPRTPX-82T	6.40	6.08	5.76	4.48
GPRTPX-83T	6.80	6.46	6.12	4.76
GPRTPX-84T	8.40	7.98	7.56	5.88
GPRTPX-85T	6.50	6.18	5.85	4.55
GPRTPX-86T	7.00	6.65	6.30	4.90
GPRTPX-87T	8.50	8.08	7.65	5.95
GPRTPX-88T	7.00	6.65	6.30	4.90

NUMBER	UNIT NET PRICES 1 -24	25 -49	50 -99	100 &UP
GPRTPX-89T	7.40	7.03	6.66	5.18
GPRTPX-90T	8.90	8.46	8.01	6.23
GPRTPX-191T	6.10	5.80	5.49	4.27
GPRTPX-192T	6.80	6.46	6.12	4.76
GPRTPX-193T	8.30	7.89	7.47	5.81
GPRTPX-203T	6.00	5.70	5.40	4.20
GPRTPX-206T	6.80	6.46	6.12	4.76
GPRTPX-209T	8.50	8.08	7.65	5.95
GPRTPX-212T	6.00	5.70	5.40	4.20
GPRTPX-215T	6.80	6.46	6.12	4.76
GPRTPX-218T	8.50	8.08	7.65	5.95
GPRTPX-221T	6.00	5.70	5.40	4.20
GPRTPX-224T	6.80	6.46	6.12	4.76
GPRTPX-227T	8.50	8.08	7.65	5.95
GPRTPX-230T	6.00	5.70	5.40	4.20
GPRTPX-233T	6.80	6.46	6.12	4.76
GPRTPX-236T	8.50	8.08	7.65	5.95
GPRTPX-239T	6.40	6.08	5.76	4.48
GPRTPX-242T	7.20	6.84	6.48	5.04
GPRTPX-245T	8.90	8.46	8.01	6.23
GPRTPX-248T	6.00	5.70	5.40	4.20
GPRTPX-251T	6.80	6.46	6.12	4.76
GPRTPX-254T	8.40	7.98	7.56	5.88
GPRTPX-257T	6.00	5.70	5.40	4.20
GPRTPX-260T	6.80	6.46	6.12	4.76
GPRTPX-263T	8.40	7.98	7.56	5.88
GPRTPX-266T	6.00	5.70	5.40	4.20
GPRTPX-269T	6.80	6.46	6.12	4.76
GPRTPX-272T	8.40	7.98	7.56	5.88
GPRTPX-275T	6.60	6.27	5.94	4.62
GPRTPX-278T	7.40	7.03	6.66	5.18
GPRTPX-281T	9.10	8.65	8.19	6.37
GPRTPX-291T	7.45	7.08	6.71	5.22
GPRTPX-292T	7.45	7.08	6.71	5.22
GPRTPX-293T	7.45	7.08	6.71	5.22
GPRTPX-294T	7.45	7.08	6.71	5.22
GPRTPX-295T	7.90	7.51	7.11	5.53
GPRTPX-296T	7.40	7.03	6.66	5.18
GPRTPX-297T	7.40	7.03	6.66	5.18
GPRTPX-298T	7.40	7.03	6.66	5.18
GPRTPX-299T	8.05	7.65	7.25	5.64
GPRTPX-391T	6.20	5.89	5.58	4.34
GPRTPX-392T	7.00	6.65	6.30	4.90
GPRTPX-393T	8.70	8.27	7.83	6.09
GPRTSX-6T	6.30	5.99	5.67	4.41
GPRTSX-9T	7.30	6.94	6.57	5.11
GPRTSX-15T	6.30	5.99	5.67	4.41
GPRTSX-18T	7.30	6.94	6.57	5.11
GPRTSX-24T	6.30	5.99	5.67	4.41
GPRTSX-27T	7.30	6.94	6.57	5.11
GPRTSX-33T	6.30	5.99	5.67	4.41
GPRTSX-36T	7.30	6.94	6.57	5.11
GPRTSX-42T	6.70	6.37	6.03	4.69
GPRTSX-45T	7.70	7.32	6.93	5.39
GPRTSX-51T	5.80	5.51	5.22	4.06
GPRTSX-54T	6.80	6.46	6.12	4.76
GPRTSX-60T	5.80	5.51	5.22	4.06
GPRTSX-63T	6.80	6.46	6.12	4.76
GPRTSX-69T	5.80	5.51	5.22	4.06
GPRTSX-72T	6.80	6.46	6.12	4.76
GPRTSX-78T	6.40	6.08	5.76	4.48
GPRTSX-81T	7.50	7.13	6.75	5.25
GPRTSX-206T	6.50	6.18	5.85	4.55
GPRTSX-209T	7.60	7.22	6.84	5.32
GPRTSX-215T	6.50	6.18	5.85	4.55
GPRTSX-218T	7.60	7.22	6.84	5.32
GPRTSX-224T	6.50	6.18	5.85	4.55
GPRTSX-227T	7.60	7.22	6.84	5.32
GPRTSX-233T	6.50	6.18	5.85	4.55
GPRTSX-236T	7.60	7.22	6.84	5.32
GPRTSX-242T	6.90	6.56	6.21	4.83
GPRTSX-245T	8.00	7.60	7.20	5.60
GPRTSX-251T	6.00	5.70	5.40	4.20
GPRTSX-254T	7.10	6.75	6.39	4.97
GPRTSX-260T	6.00	5.70	5.40	4.20
GPRTSX-263T	7.10	6.75	6.39	4.97

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NUMBER	UNIT NET PRICES 1 -24	25 -49	50 -99	100 &UP
GPRTSX-269T	6.00	5.70	5.40	4.20
GPRTSX-272T	7.10	6.75	6.39	4.97
GPRTSX-278T	6.70	6.37	6.03	4.69
GPRTSX-281T	7.80	7.41	7.02	5.46
GPRTSX-403T	8.60	8.17	7.74	6.02
GPRTSX-406T	8.60	8.17	7.74	6.02
GPRTSX-409T	8.60	8.17	7.74	6.02
GPRTSX-412T	8.60	8.17	7.74	6.02
GPRTSX-415T	9.00	8.55	8.10	6.30
GPRTSX-418T	8.30	7.89	7.47	5.81
GPRTSX-421T	8.30	7.89	7.47	5.81
GPRTSX-424T	8.30	7.89	7.47	5.81
GPRTSX-427T	8.90	8.46	8.01	6.23
GPRTSX-433T	8.90	8.46	8.01	6.23
GPRTSX-436T	8.90	8.46	8.01	6.23
GPRTSX-439T	8.90	8.46	8.01	6.23
GPRTSX-442T	8.90	8.46	8.01	6.23
GPRTSX-445T	9.40	8.93	8.46	6.58
GPRTSX-448T	8.60	8.17	7.74	6.02
GPRTSX-451T	8.60	8.17	7.74	6.02
GPRTSX-454T	8.60	8.17	7.74	6.02
GPRTSX-457T	9.30	8.84	8.37	6.51
GPRTSX-463T	9.30	8.84	8.37	6.51
GPRTSX-466T	9.40	8.93	8.46	6.58
GPRTSX-469T	9.80	9.31	8.82	6.86
GPRTSX-473T	8.80	8.36	7.92	6.16
GPRTSX-483T	9.10	8.65	8.19	6.37
GPRTTX-3T	5.70	5.42	5.13	3.99
GPRTTX-6T	6.40	6.08	5.76	4.48
GPRTTX-9T	7.40	7.03	6.66	5.18
GPRTTX-12T	5.70	5.42	5.13	3.99
GPRTTX-15T	6.40	6.08	5.76	4.48
GPRTTX-18T	7.40	7.03	6.66	5.18
GPRTTX-21T	5.70	5.42	5.13	3.99
GPRTTX-24T	6.40	6.08	5.76	4.48
GPRTTX-27T	7.40	7.03	6.66	5.18
GPRTTX-30T	5.70	5.42	5.13	3.99
GPRTTX-33T	6.40	6.08	5.76	4.48
GPRTTX-36T	7.40	7.03	6.66	5.18
GPRTTX-39T	6.10	5.80	5.49	4.27
GPRTTX-42T	6.80	6.46	6.12	4.76
GPRTTX-45T	7.80	7.41	7.02	5.46
GPRTTX-48T	5.50	5.23	4.95	3.85
GPRTTX-51T	5.90	5.61	5.31	4.13
GPRTTX-54T	6.90	6.56	6.21	4.83
GPRTTX-57T	5.50	5.23	4.95	3.85
GPRTTX-60T	5.90	5.61	5.31	4.13
GPRTTX-63T	6.90	6.56	6.21	4.83
GPRTTX-66T	5.50	5.23	4.95	3.85
GPRTTX-69T	5.90	5.61	5.31	4.13
GPRTTX-72T	6.90	6.56	6.21	4.83
GPRTTX-75T	6.10	5.80	5.49	4.27
GPRTTX-78T	6.60	6.27	5.94	4.62
GPRTTX-81T	7.60	7.22	6.84	5.32
GPRTTX-82T	6.00	5.70	5.40	4.20
GPRTTX-83T	6.20	5.89	5.58	4.34
GPRTTX-84T	7.20	6.84	6.48	5.04
GPRTTX-85T	6.10	5.80	5.49	4.27
GPRTTX-86T	6.30	5.99	5.67	4.41
GPRTTX-87T	7.30	6.94	6.57	5.11
GPRTTX-88T	6.60	6.27	5.94	4.62
GPRTTX-89T	6.80	6.46	6.12	4.76
GPRTTX-90T	7.80	7.41	7.02	5.46
GPRTTX-191T	5.80	5.51	5.22	4.06
GPRTTX-192T	6.60	6.27	5.94	4.62
GPRTTX-193T	7.50	7.13	6.75	5.25
GPRX-3T	3.50	3.33	3.15	2.45
GPRX-6T	4.20	3.99	3.78	2.94
GPRX-9T	4.60	4.37	4.14	3.22
GPRX-12T	3.50	3.33	3.15	2.45
GPRX-15T	4.20	3.99	3.78	2.94
GPRX-18T	4.60	4.37	4.14	3.22
GPRX-21T	3.50	3.33	3.15	2.45
GPRX-24T	4.20	3.99	3.78	2.94
GPRX-27T	4.60	4.37	4.14	3.22
GPRX-30T	3.50	3.33	3.15	2.45

NUMBER	UNIT NET PRICES 1 -24	25 -49	50 -99	100 &UP
GPRX-33T	4.20	3.99	3.78	2.94
GPRX-36T	4.60	4.37	4.14	3.22
GPRX-39T	3.90	3.71	3.51	2.73
GPRX-42T	4.60	4.37	4.14	3.22
GPRX-45T	5.00	4.75	4.50	3.50
GPRX-48T	3.30	3.14	2.97	2.31
GPRX-51T	3.70	3.52	3.33	2.59
GPRX-54T	4.20	3.99	3.78	2.94
GPRX-57T	3.30	3.14	2.97	2.31
GPRX-60T	3.70	3.52	3.33	2.59
GPRX-63T	4.20	3.99	3.78	2.94
GPRX-66T	3.30	3.14	2.97	2.31
GPRX-69T	3.70	3.52	3.33	2.59
GPRX-72T	4.20	3.99	3.78	2.94
GPRX-75T	3.95	3.75	3.56	2.77
GPRX-78T	4.35	4.13	3.92	3.05
GPRX-81T	4.85	4.61	4.37	3.40
GPRX-82T	3.95	3.75	3.56	2.77
GPRX-83T	4.50	4.28	4.05	3.15
GPRX-84T	5.20	4.94	4.68	3.64
GPRX-85T	4.05	3.85	3.65	2.84
GPRX-86T	4.60	4.37	4.14	3.22
GPRX-87T	5.30	5.04	4.77	3.71
GPRX-88T	4.50	4.28	4.05	3.15
GPRX-89T	5.10	4.85	4.59	3.57
GPRX-90T	5.70	5.42	5.13	3.99
GPRX-191T	3.65	3.47	3.29	2.56
GPRX-192T	4.35	4.13	3.92	3.05
GPRX-193T	4.80	4.56	4.32	3.36
GPRX-203T	3.55	3.37	3.20	2.49
GPRX-206T	4.30	4.09	3.87	3.01
GPRX-209T	4.80	4.56	4.32	3.36
GPRX-212T	3.55	3.37	3.20	2.49
GPRX-215T	4.30	4.09	3.87	3.01
GPRX-218T	4.80	4.56	4.32	3.36
GPRX-221T	3.55	3.37	3.20	2.49
GPRX-224T	4.30	4.09	3.87	3.01
GPRX-227T	4.80	4.56	4.32	3.36
GPRX-230T	3.55	3.37	3.20	2.49
GPRX-233T	4.30	4.09	3.87	3.01
GPRX-236T	4.80	4.56	4.32	3.36
GPRX-239T	3.95	3.75	3.56	2.77
GPRX-242T	4.75	4.51	4.28	3.33
GPRX-245T	5.20	4.94	4.68	3.64
GPRX-248T	3.40	3.23	3.06	2.38
GPRX-251T	3.80	3.61	3.42	2.66
GPRX-254T	4.35	4.13	3.92	3.05
GPRX-257T	3.40	3.23	3.06	2.38
GPRX-260T	3.80	3.61	3.42	2.66
GPRX-263T	4.35	4.13	3.92	3.05
GPRX-266T	3.40	3.23	3.06	2.38
GPRX-269T	3.80	3.61	3.42	2.66
GPRX-272T	4.35	4.13	3.92	3.05
GPRX-275T	4.00	3.80	3.60	2.80
GPRX-278T	4.40	4.18	3.96	3.08
GPRX-281T	5.00	4.75	4.50	3.50
GPRX-391T	3.70	3.52	3.33	2.59
GPRX-392T	4.45	4.23	4.01	3.12
GPRX-393T	4.95	4.70	4.46	3.47
GPRX-403T	5.50	5.23	4.95	3.85
GPRX-406T	5.50	5.23	4.95	3.85
GPRX-409T	5.50	5.23	4.95	3.85
GPRX-412T	5.50	5.23	4.95	3.85
GPRX-415T	5.90	5.61	5.31	4.13
GPRX-418T	5.10	4.85	4.59	3.57
GPRX-421T	5.10	4.85	4.59	3.57
GPRX-424T	5.10	4.85	4.59	3.57
GPRX-427T	5.80	5.51	5.22	4.06
GPRX-433T	5.60	5.32	5.04	3.92
GPRX-436T	5.60	5.32	5.04	3.92
GPRX-439T	5.60	5.32	5.04	3.92
GPRX-442T	5.60	5.32	5.04	3.92
GPRX-445T	6.00	5.70	5.40	4.20
GPRX-448T	5.30	5.04	4.77	3.71
GPRX-451T	5.30	5.04	4.77	3.71
GPRX-454T	5.30	5.04	4.77	3.71

Prices shown are recommended resale schedules offered through authorized Ohmite stocking distributors. Prices for quantities greater than shown are available from your local Ohmite Sales Office or the Factory.

NUMBER	1 -24	25 -49	50 -99	100 &UP
		UNIT NET PRICES		
GPRX-457T	5.90	5.61	5.31	4.13
GPRX-463T	6.10	5.80	5.49	4.27
GPRX-466T	6.20	5.89	5.58	4.34
GPRX-469T	6.70	6.37	6.03	4.69
GPRX-473T	5.60	5.32	5.04	3.92
GPRX-483T	5.80	5.51	5.22	4.06

NUMBER	UNIT NET PRICES NET
LD600	9.30
LD600-3	11.30
LD600-3N	9.50
LD600N	7.00

NUMBER

OB1001-OB9175
OC1001-OC9175
OE1001-OE9175
OG1001-OG9175
OH1001-OH9175

For Little Devil® Resistor Prices, see page 15.

NUMBER	1 -99	100 -999	1000 &UP
		UNIT NET PRICES	
OMC-7111	1.98	1.49	1.25

NUMBER	1 -9	10 -24	25 &UP
		UNIT NET PRICES	
P-300	2.00	1.70	1.40

NUMBER	1 -9	10 -24	25 &UP
		UNIT NET PRICES	
PCA-1000	20.75	18.68	16.60
PCA-1001	31.50	28.35	25.20
PCA-1020	23.75	21.38	19.00
PCA-1021	34.50	31.05	27.60
PCD-1000	38.50	34.65	30.80
PCD-1001	49.50	44.55	39.60
PCD-1020	42.00	37.80	33.60
PCD-1021	53.00	47.70	42.40

NUMBER	1 -9	10 -24	25 -99	100 &UP
		UNIT NET PRICES		
RW67V 0.10-0.90 OHMS	1.10	.94	.77	.66
RW67V 1.0-1000 OHMS	.80	.68	.56	.48
RW67V 1001-3600 OHMS	.85	.72	.60	.51
RW68V 0.10-0.90 OHMS	1.20	1.02	.84	.72
RW68V 1.0-1000 OHMS	.88	.75	.62	.53
RW68V 1001-5000 OHMS	.94	.80	.66	.56
RW68V 5001-8200 OHMS	1.05	.89	.74	.63
RW69V 0.10-0.90 OHMS	1.05	.89	.74	.63
RW69V 1.0-910 OHMS	.77	.65	.54	.46
RW69V 1100-2K OHMS	.80	.68	.56	.48

NUMBER	1 -24	25 -49	50 -99	100 &UP
		UNIT NET PRICES		
SOGPR-9	1.10	1.05	.99	.77
SOGPR-12	1.25	1.19	1.13	.88

NUMBER	1 -4	5 -9	10 &UP
		UNIT NET PRICES	
SRC-65	16.25	13.81	10.89
SRC-100	16.25	13.81	10.89
SRC-150	18.50	15.73	12.40
SRC-220	22.50	19.13	15.08
SRC-350	25.00	21.25	16.75
SRC-500	31.00	26.35	20.77

NUMBER	1 -4	5 -9	10 &UP
		UNIT NET PRICES	
T-503	4.65	3.95	3.12
T-504	4.95	4.21	3.32
T-504-S	4.40	3.74	2.95
T-505	5.20	4.42	3.48
T-505-S	4.65	3.95	3.12
T-506	5.50	4.68	3.69
T-506-S	4.95	4.21	3.32
T-507	5.70	4.85	3.82
T-507-S	5.20	4.42	3.48
T-508	6.00	5.10	4.02
T-508-S	5.50	4.68	3.69
T-1009	8.40	7.14	5.63
T-1009-S	7.80	6.63	5.23
T-10010	8.60	7.31	5.76
T-10010-S	8.10	6.89	5.43
T-10011	8.90	7.57	5.96
T-10011-S	8.30	7.06	5.56
T-10012	9.20	7.82	6.16
T-10012-S	8.60	7.31	5.76

NUMBER	1 -9	10 -24	25 -99	100 &UP
		UNIT NET PRICES		
VT02	12.00	10.80	9.90	9.00
VT02E	18.50	16.65	15.26	13.88
VT02F	21.00	18.90	17.33	15.75
VT02N	12.00	10.80	9.90	9.00
VT02NE	18.50	16.65	15.26	13.88
VT02NF	21.00	18.90	17.33	15.75
VT1	12.50	11.25	10.31	9.38
VT1E	20.00	18.00	16.50	15.00
VT1F	23.00	20.70	18.98	17.25
VT1N	12.50	11.25	10.31	9.38
VT1NE	20.00	18.00	16.50	15.00
VT1NF	23.00	20.70	18.98	17.25
VT2LN	14.00	12.60	11.55	10.50
VT3	13.00	11.70	10.73	9.75
VT3N	13.00	11.70	10.73	9.75
VT4	17.50	15.75	14.44	13.13
VT4E	24.00	21.60	19.80	18.00
VT4F	26.00	23.40	21.45	19.50
VT4FC	30.50	27.45	25.16	22.88
VT4LN	20.00	18.00	16.50	15.00
VT4N	17.50	15.75	14.44	13.13
VT4NE	24.00	21.60	19.80	18.00
VT4NF	26.50	23.85	21.86	19.88
VT4NFC	30.50	27.45	25.16	22.88
VT8	23.00	20.70	18.98	17.25
VT8E	30.00	27.00	24.75	22.50
VT8F	32.00	28.80	26.40	24.00
VT8FC	35.75	32.18	29.49	26.81
VT8G	35.75	32.18	29.49	26.81
VT8GC	39.50	35.55	32.59	29.63
VT8GCV	75.00	67.50	61.88	56.25
VT8GCVA	112.00	100.80	92.40	84.00
VT8GCVW	151.00	135.90	124.58	113.25
VT8H	25.50	22.95	21.04	19.13
VT8HN	25.50	22.95	21.04	19.13
VT8LN	25.50	22.95	21.04	19.13
VT8N	23.00	20.70	18.98	17.25
VT8NE	29.75	26.78	24.54	22.31
VT8NF	32.00	28.80	26.40	24.00
VT8NFC	35.75	32.18	29.49	26.81
VT8NFCV	70.50	63.45	58.16	52.88
VT8NFCVA	109.00	98.10	89.93	81.75
VT8NFCVW	146.00	131.40	120.45	109.50
VT20	63.00	56.70	51.98	47.25
VT20B	69.00	62.10	56.93	51.75
VT20E	86.00	77.40	70.95	64.50
VT20FC	96.00	86.40	79.20	72.00
VT20GC	110.00	99.00	90.75	82.50
VT20GCV	158.00	142.20	130.35	118.50
VT20GCVA	196.00	176.40	161.70	147.00
VT20GCVW	281.00	252.90	231.83	210.75
VT20H	65.00	58.50	53.63	48.75
VT20HB	73.00	65.70	60.23	54.75

Prices shown are recommended resale schedules offered through authorized Ohmite stocking distributors. Prices for quantities greater than shown are available from your local Ohmite Sales Office or the Factory.

NUMBER	UNIT NET PRICES 1 -9	10 -24	25 -99	100 &UP
VT20HE	88.00	79.20	72.60	66.00
VT20HEC	98.00	88.20	80.85	73.50
VT20HN	65.00	58.50	53.63	48.75
VT20HNB	73.00	65.70	60.23	54.75
VT20HNE	88.00	79.20	72.60	66.00
VT20HNEC	98.00	88.20	80.85	73.50
VT20N	63.00	56.70	51.98	47.25
VT20NB	69.00	62.10	56.93	51.75
VT20NE	86.00	77.40	70.95	64.50
VT20NEC	96.00	86.40	79.20	72.00
VT20NECV	143.00	128.70	117.98	107.25
VT20NECVA	180.00	162.00	148.50	135.00
VT20NECVW	265.00	238.50	218.63	198.75

NUMBER	UNIT NET PRICES 1 -4	5 -12	13 -49	50 &UP
VT02-2	36.00	32.40	29.70	27.00
VT02N-2	36.00	32.40	29.70	27.00
VT1-2	39.00	35.10	32.18	29.25
VT1N-2	39.00	35.10	32.18	29.25
VT3-2	37.50	33.75	30.94	28.13
VT3N-2	37.50	33.75	30.94	28.13
VT4-2	49.50	44.55	40.84	37.13
VT4N-2	49.50	44.55	40.84	37.13
VT8-2	61.00	54.90	50.33	45.75
VT8H-2	66.00	59.40	54.45	49.50
VT8HN-2	66.00	59.40	54.45	49.50
VT8N-2	61.00	54.90	50.33	45.75
VT20-2	144.00	129.60	118.80	108.00
VT20-2B	157.00	141.30	129.53	117.75
VT20H-2	149.00	134.10	122.93	111.75
VT20HN-2	149.00	134.10	122.93	111.75
VT20N-2	144.00	129.60	118.80	108.00
VT20N-2B	157.00	141.30	129.53	117.75

NUMBER	UNIT NET PRICES 1 -3	4 -8	9 -33	34 &UP
VT02-3	52.00	46.80	42.90	39.00
VT1-3	57.00	51.30	47.03	42.75
VT3-3	55.00	49.50	45.38	41.25
VT4-3	71.00	63.90	58.58	53.25
VT8-3	88.00	79.20	72.60	66.00
VT8-3E	107.00	96.30	88.28	80.25
VT8H-3	96.00	86.40	79.20	72.00
VT20-3	211.00	189.90	174.08	158.25
VT20-3B	231.00	207.90	190.58	173.25
VT20H-3	219.00	197.10	180.68	164.25
VT20HN-3	219.00	197.10	180.68	164.25
VT20N-3	211.00	189.90	174.08	158.25
VT20N-3B	231.00	207.90	190.58	173.25

NUMBER	UNIT NET PRICES 1 -4	5 -9	10 -24	25 &UP
W0101 THRU W0106	7.50	6.38	5.03	4.13
W0107 THRU W0118	6.90	5.87	4.62	3.80
W0119 THRU W0121	7.50	6.38	5.03	4.13
W0122 AND W0123	7.80	6.63	5.23	4.29
W4190 AND W4191	8.00	6.80	5.36	4.40
W4192 AND W4193	8.70	7.40	5.83	4.79

NUMBER	UNIT NET PRICES 1 -9	10 -24	25 &UP
Z-7	1.50	1.28	1.05
Z-14	.75	.64	.53
Z-20	2.20	1.87	1.54
Z-21	2.90	2.47	2.03
Z-22	6.60	5.61	4.62
Z-28	.64	.54	.45

NUMBER	UNIT NET PRICES 1 -9	10 -24	25 &UP
Z-30	8.20	6.97	5.74
Z-50	.51	.43	.36
Z-144	.48	.41	.34
Z-235	.48	.41	.34
Z-460	.48	.41	.34

Little Devil®

molded composition resistors on "Tally Tape" packaging

	Tolerance	Resistance Range (Ohms)	UNIT NET PRICES 1-9	10-99	100-249	250-499	500-999	1000-4999	5000 & Up
1/8 WATT RC-05 TYPE OB	5% (J)	2.7 to 9.1	$.37	$.175	$.165	$.158	$.153	$.147	$.142
		10 to 22M	.34	.158	.150	.144	.139	.134	.130
	10% (K)	2.7 to 8.2	.27	.125	.117	.112	.108	.105	.103
		10 to 22M	.24	.112	.106	.102	.098	.095	.093
1/4 WATT RC-07 TYPE OC	5% (J)	2.7 to 9.1	.29	.11	.10	.09	.08	.069	.058
		10 to 1M	.26	.10	.07	.063	.053	.037	.032
		1.1M to 22M	.29	.11	.10	.09	.08	.069	.058
	10% (K)	2.7 to 8.2	.14	.09	.08	.069	.058	.044	.033
		10 to 1M	.13	.06	.05	.04	.03	.02	.019
		1.2M to 22M	.14	.09	.08	.069	.058	.044	.033
1/2 WATT RC-20 TYPE OE	5% (J)	1.0 to 2.4	.26	.13	.11	.09	.08	.069	.059
		2.7 to 22M	.24	.12	.06	.052	.044	.038	.037
	10% (K)	1.0 to 2.2	.13	.08	.07	.059	.048	.036	.028
		2.7 to 22M	.12	.06	.04	.033	.025	.019	.018
1 WATT RC-32 TYPE OG	5% (J)	2.7 to 22M	.36	.18	.08	.077	.069	.062	.059
	10% (K)	2.7 to 22M	.18	.09	.05	.046	.038	.031	.029
2 WATT RC-42 TYPE OH	5% (J)	10 to 22M	.48	.30	.15	.143	.135	.10	.094
	10% (K)	10 to 22M	.24	.19	.10	.089	.081	.052	.049

Ohmite Manufacturing Company a North American Philips Company
3660 Howard Street, Skokie, Illinois 60076/Phone (312) 675-2600/TWX: 910-223-0805/TELEX 72-4433

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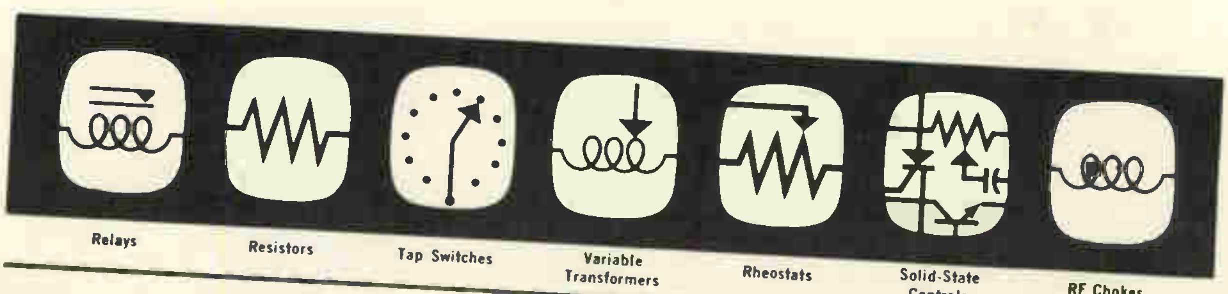
has the answer

in products for today's & tomorrow's circuitry



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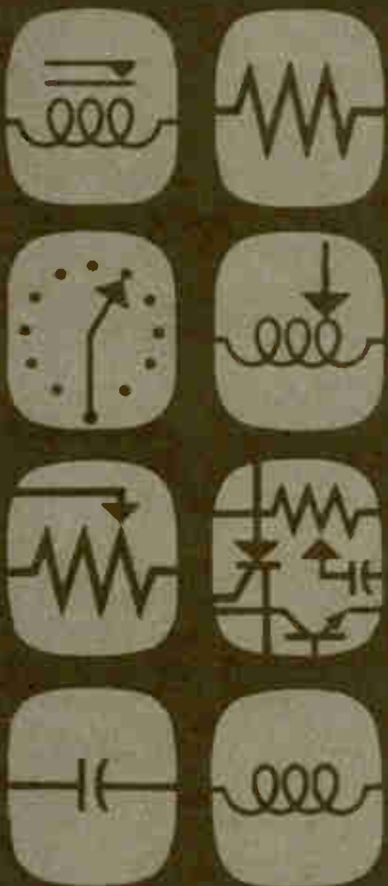


contact your nearest

OHMITE

stocking distributor for instant availability

AUTHORIZED OHMITE STOCKING ELECTRONIC COMPONENT DISTRIBUTORS

STATE AND CITY	NAME	ADDRESS	ZIP	AREA CODE	TELEPHONE*
ALABAMA					
Birmingham	Ack Radio Supply	3101 4th Ave., S.	35233	205	322-0588
Birmingham	James W. Clary Company	1713 Second Ave., S.	35233	205	322-2486
Birmingham	M. G. Electronics & Equipment Co.	3112 6th Ave., S.	35233	205	328-4525
Decatur	Mock Electronics	902 Bank Street	35601	205	353-6324
Dothan	Hand Supply Company	705 S. Oates St.	36302	205	792-3148
Huntsville	Electronic Wholesalers, Inc.	2310 Bob Wallace, S.W.	35805	205	539-5722
Mobile	Forbes Electronic Distributing Company, Inc.	57 N. Washington	36602	205	432-7661
Mobile	Nelson Radio & Supply Company, Inc.	1541 S. Beltline Hwy.	36601	205	479-1471
Montgomery	Forbes-Godfrey TV Electronics, Inc.	915 S. Court St.	36104	205	263-0283
Montgomery	Nolin-McInnis, Inc.	211-205 Commerce St.	36103	205	262-4885
Opelika	Southern Electronics Corp.	309 S. 10th	36801	205	745-6478
Selma	Poe's Electronic Parts	8 Sylvan St.	36701	205	874-5324
ALASKA					
Anchorage	Yukon Radio Supply, Inc.	3222 Commercial Drive	99501	907	277-1497
Ketchikan	Service Electric Co., Inc.	744 Water St.	99901	907	225-2168
ARIZONA					
Phoenix	Sterling Electronics Corp.	1930 N. 22nd Ave.	85009	602	258-4531 TLX
Phoenix	R. V. Weatherford	1917 N. 25th Dr.	85005	602	272-7144 TWX
Tucson	Inland Electronic Supply Co.	715 E. Broadway	85717	602	624-4402
ARKANSAS					
El Dorado	Industrial Electronic Supply, Inc.	413 W. Main St.	71730	501	862-4901
Fort Smith	Wise Radio & T.V. Supply, Inc.	1001 Tawson Ave.	72901	501	783-8926
Little Rock	Carlton-Bates Co.	1210 E. 6th St.	72202	501	375-5375
Little Rock	Southern Electronics Corp.	1419 Main St.	72203	501	375-8887
Little Rock	David White Electronics, Inc.	1222 Main St.	72203	501	376-1391
CALIFORNIA					
Chatsworth	Westates Electronics Corp.	20151 Bahama St.	91311	213	341-4411 TLX
El Monte	Kimball & Stark	3053 North Tyler Ave.	91734	213	444-2594
Fresno	Jack C. Arbuckle	2349 Kern St.	93721	209	264-6554
Glendale	R. V. Weatherford Co.	6921 San Fernando Rd.	91201	213	849-3451 TWX
Hollywood	Hollywood Radio & Electronics	5250 Hollywood	90027	213	466-3181 TWX
Hollywood	Yale Radio Electric Co.	6616 Sunset Blvd.	90028	213	465-3186
Inglewood	Newark Electronics Co., Inc.	4747 W. Century Blvd.	90309	213	678-0441 TWX
Los Angeles	California Electronic Supply	1911 Armacost Ave.	90025	213	879-0760 TWX

*NOTE: TLX indicates that the distributor also maintains a Western Union TELEX facility.
TWX indicates that the distributor also subscribes to the Bell System's Teletypewriter Exchange Service.

AUTHORIZED OHMITE STOCKING ELECTRONIC COMPONENT DISTRIBUTORS

STATE AND CITY	NAME	ADDRESS	ZIP	AREA CODE	TELEPHONE*
CALIFORNIA (Continued)					
Los Angeles	Federated Purchaser, Inc.	11820 Olympic Blvd.	90064	213	272-8771
Los Angeles	Kierulff Electronics Inc.	2585 Commerce Way	90022	213	685-5511
Los Angeles	Radio Products Sales Inc.	1501 S. Hill St.	90015	213	748-1271
Mountain View	Brill Electronics	1065 Terra Bella Ave.	94040	415	961-1500
Mountain View	Elmar Electronics Inc.	2288 Charleston Rd.	94041	415	961-3611
Oakland	Brill Electronics	610 East Tenth St.	94606	415	834-5888 TWX
Palo Alto	Zack Electronics	654 High St.	94301	415	326-5432
Pasadena	Milo of California	1759 E. Colorado Ave.	91106	213	681-8111 TWX
Redwood City	Fortune Electronics	695 Veterans Blvd.	94063	415	365-4000
Sacramento	Dunlap Electronics	1800 18th St.	95809	916	444-8070
San Diego	Milo of California	2060 India St.	92101	714	232-8951 TWX
San Diego	Western Radio & TV Supply Co.	1415 India St.	92112	714	239-0361
San Francisco	Zack Electronics	1444 Market St.	94102	415	626-1444
San Jose	Quement Electronics	1000 S. Bascom Ave.	95128	408	294-0464
Santa Barbara	Channel Radio Supply	18 E. Ortega St.	93101	805	965-8551
COLORADO					
Denver	Electronic Parts Co.	1277 Broadway	80202	303	266-3755
Denver	Kierulff Electronics	10890 East 47th Ave.	80239	303	343-8090 TWX
Denver	Newark Denver Electronics	2170 S. Grape	80222	303	757-3351 TWX
Denver	L. B. Walker Radio	300 Bryant St.	80219	303	935-2406
Pueblo	Johnson Electric Co.	324 S. Union Ave.	81003	303	543-1746
CONNECTICUT					
East Haven	J. V. Electronics	690 Main St.	06512	203	469-2321
DELAWARE					
Wilmington	Radio Electric Service Co.	3rd & Tantall Sts.	19801	302	655-4401
DISTRICT OF COLUMBIA					
Washington	Electronic Wholesalers, Inc.	2345 Sherman Ave. N.W.	20001	202	483-5200 TLX
FLORIDA					
Jacksonville	Southeast Electronics Inc.	1125 Roselle	33204	904	356-3007
Miami	Electronic Equipment Co.	2701 N.W. 42nd Ave.	33142	305	635-0421 TLX
Orlando	Hammond Electronics	911 W. Central Blvd.	32802	305	241-6601
Panama City	Central Electronic Supply	318 Luverne	32401	904	785-0237
Pensacola	Grice Electronics Inc.	320 E. Gregory	32501	904	433-4616
St. Petersburg	Cooper Radio Co.	165 13th St. N.	33705	813	894-7607
Tallahassee	Dell Electronics Inc.	227 W. Carolina St.	32301	904	224-5145
Tampa	Thurow Electronics	1215 Water St.	33602	813	223-1694 TLX
GEORGIA					
Atlanta	Jackson Electronics Supply Co., Inc.	1135 Chattahoochee NW	30318	404	355-2223
Atlanta	Southeastern Radio Parts Co.	430 W. Peachtree NW	30308	404	524-7536
Atlanta	Specialty Distributing Co., Inc.	763 Juniper St. NE	30308	404	873-2521
Columbus	Westad, Inc.	1028 13th St.	31901	404	327-3208
Hapeville	Electro-Tech Inc.	3020 Commerce Way	30054	404	767-8761
IDAHO					
Boise	S. R. Ross Company	418 N. Orchard St.	83704	208	342-3559
Lewiston	Columbia Electric	9th & F Sts.	83501	208	743-7151
Pocatello	Hanson Inc.	609 S. First Ave.	83201	208	233-6480
ILLINOIS					
Champaign	Electronic Parts Co.	905 S. Neil Street	61820	217	356-1896
Chicago	Allied Radio Corp.	100 N. Western Ave.	60680	312	421-6800 TWX
Chicago	Electronic Distributors Inc.	4900 N. Elston Ave.	60630	312	283-4800
Chicago	Newark Electronics Inc.	500 N. Pulaski Rd.	60024	312	638-4411 TWX,TLX
Danville	Bud Electronic Supply	22 N. Jackson	61832	217	446-0925
Decatur	York Radio & TV Corp.	590 N. Broadway	62523	217	423-3484
Elgin	Stolz-Wicks, Inc.	415 Dundee	60120	312	741-4506
Jacksonville	Baptist Electronic Sup.	419 S. Mauvaisterre St.	62650	217	245-4109
Joliet	Keck Electric Corp.	1225 E. Washington St.	60434	815	726-6153
Oak Park	Melvin Electronics, Inc.	541 W. Madison St.	60302	312	385-5800
Peoria	Klaus Radio & Electric Co.	8400 N. Pioneer Pkwy.	61614	309	691-4840
Rockford	J & M Electronics, Inc.	2001 Ninth St.	61101	815	963-6445
Rockford	Midwest Associated Dists.	225 S. 6th St.	61108	815	964-4657
Springfield	Bilbo Electronics, Inc.	217 E. Washington St.	62701	217	544-8444
Springfield	Bruce Electronics	1120 E. Capitol Ave.	62703	217	528-7523
Skokie	Merquip Electronics, Inc.	7701 N. Austin Ave.	60076	312	965-7500 TWX
INDIANA					
Anderson	Electronic Sup. of Anderson	2228 Columbus Ave.	46014	317	664-3381
Angola	Lakeland Radio Supply	525 S. West St.	46703	219	665-6311
Evansville	Ohio Valley Sound, Inc.	20 E. Sycamore St.	47713	812	425-6173
Fort Wayne	Fort Wayne Electronics Sup.	3606 Maumee Ave.	46803	219	742-4346
Fort Wayne	Warren Radio	625 E. Wayne St.	46801	219	743-5344
Indianapolis	Graham Electronics Sup., Inc.	122 S. Senate	46225	317	634-8486
Indianapolis	Ra-Dis-Co., Inc.	814 N. Senate	46206	317	637-5571 TLX
Marion	Myers Radio Supply, Inc.	115 W. 22nd St.	46952	317	664-7394
Michigan City	Tri-State Electrical Sup.	216 E. Michigan	46360	219	872-5551
Muncie	Muncie Electronics Sup., Inc.	222 N. Madison	47305	317	288-8837
Portage	Portage Electric Supply	6487 Melton Rd.	46368	219	762-3126
South Bend	Radio Distribution Co., Inc.	1212 High St.	46624	219	287-2911

STATE AND CITY	NAME	ADDRESS	ZIP	AREA CODE	TELEPHONE*
IOWA					
Cedar Rapids	Deeco, Inc.	2500 16th Ave. S.W.	52406	319	365-7551 TWX
Cedar Rapids	Iowa Radio Supply	719 Center Point Road, N.E.	52402	319	364-6154
Davenport	Klaus Radio & Electric	311 E. 2nd St.	52801	319	326-4436
Davenport	TCR Distributors	1205 East River Dr.	52808	319	323-8051
Des Moines	Gifford-Brown, Inc.	1400 W. Walnut	50307	515	243-1257
Des Moines	Mid-State Distributing	1201-03 Grand	50309	515	288-7231
Sioux City	Molstad Distributing	208 4th St.	51101	712	255-8023
Waterloo	Farnsworth Electronics	201-205 E. Mullan Ave.	50704	319	234-6681
KANSAS					
Salina	Electronics, Inc.	227 N. Santa Fe Ave.	67401	913	827-7377
Topeka	Acme Radio Supply	135 Kansas Ave.	66603	913	235-1363
Wichita	Interstate Electronic Sup.	230 Ida St.	67211	316	264-6317
Wichita	Radio Electronic Co., Inc.	115 Loura	67211	316	267-5214
KENTUCKY					
Hopkinsville	Randolph & Hale, Inc.	729 E. 4th St.	42240	502	885-5357
Lexington	Radio Electronic Equipment Company	480 Skain Ave.	40508	606	255-6661
Louisville	Peerless Electronics	1815 So. 7th St.	40208	502	637-7677
Louisville	P. I. Burks Company	842 South Seventh St.	40203	502	583-2871
Paducah	Warren Radio Company	455 S. 31st	42001	502	442-4367
LOUISIANA					
Lafayette	Ralphs of Lafayette, Inc.	3004 Cameron	70501	318	369-9816
Lake Charles	Wholesale Radio Equipment, Inc.	1722 Common St.	70604	318	439-2431
Monroe	C & O Electronics	201 S. Stanley Ave.	71201	318	323-5732
New Orleans	Columbia Radio & Supply Co.	3940 3rd St.	70125	504	822-1570
New Orleans	Radio Parts Inc.	1112 Magazine	70130	504	522-0217
New Orleans	Southern Radio Supply	1909 Tulane	70112	504	524-2343
New Orleans	Sterling Electronics Corp.	537 Claiborne Ave.	70112	504	522-8726
Opelousas	Opelousas Radio Equipment	730 Grolee St.	70570	318	942-5702
Shreveport	Industrial Electronic Supply	2422 Southern Ave.	71104	318	422-9459
Shreveport	Kolemay Sales Co. Div. of Sterling Electronics Corp.	2530 Linwood Ave.	71103	318	423-4256
MAINE					
Portland	Holmes Distributors, Inc.	510 Cumberland Ave.	04104	207	774-5901
MARYLAND					
Baltimore	Kann Ellert Electronics Inc.	2050 Rockrose Ave.	21211	301	889-4242
Baltimore	Radio Electric Service Co.	1026 Cromwell Bridge Rd.	21204	301	823-0070
Baltimore	A. R. Spartana Co.	237-239 N. Gay	21202	301	727-0484
Hagerstown	Allegheny Electronics, Inc.	1301 Potomic Ave.	21704	301	739-6460
Rockville	Capitol Radio Wholesalers	12227 Wilkins Ave.	20852	301	942-7505
Rockville	Pioneer Washington Electronics Inc.	1037 Taft St.	20850	301	427-3300
MASSACHUSETTS					
Boston	De Mambro Radio Supply Co.	1095 Commonwealth Ave.	02215	617	787-1200
Boston	A. W. Mayer Co.	895 Boylston St.	02115	617	267-5530
Boston	Sager Electrical Supply Co.	172 High St.	02107	617	542-2281
Cambridge	Electrical Supply Corp.	205 Alewife Brook Pkwy.	02138	617	491-3300
Canton	Texas Instrument Supply	480 Neponset St.	02021	617	828-5020
Dedham	Gerber Electronics	851 Providence Hwy. US Rt. 1	02026	617	329-2400
Lynn	Land Electronics Supply Co.	9R Franklin St.	01902	617	592-2220
Newton	Cramer Electronics	320 Needham St.	02164	617	969-7700
Springfield	T. F. Cushing Inc.	1026 Bay St.	01101	413	788-7341
Springfield	Soundco Electronic Supply Co.	147 Dwight St.	01103	413	739-3847
Worcester	Radio Maintenance Supply	80 Thomas St.	01680	617	756-8311
MICHIGAN					
Ann Arbor	Wedemeyer Electronic Supply	215 N. 4th Ave.	48107	313	665-8611
Detroit	Newark Detroit Electronics	20700 Hubbell	48237	313	548-0250 TWX
Detroit	Radio Specialties Co.	12775 Lyndon St.	48227	313	272-4212 TWX
Flint	Shand Electronics Inc.	2401 S. Dort Hwy.	48507	313	743-8940
Grand Rapids	Newark Ind. Electronics	2114 S. Division	49507	616	452-1411 TWX
Jackson	Fulton Radio Supply Co.	1208 Greenwood	49204	517	489-6519
Kalamazoo	Electronic Supply Corp.	429 Kalamazoo Ave.	49006	616	381-4620
Muskegon	Western Electronic Supply	1781 5th St.	49440	616	722-7628
MINNESOTA					
Duluth	Northwest Radio	123 E. First St.	55802	218	727-1565
Edina	Lew Bonn Co.	7275 Bush Lake Rd.	55435	612	941-4860
Minneapolis	Electronic Center	107 Third Ave. N.	55401	612	338-5881
Minneapolis	Harry Starks Inc.	112 Third Ave. N.	55401	612	332-1325
St. Paul	Gopher Electronics	2520 W. Larpenteur	55113	612	645-0241
MISSISSIPPI					
Columbus	Columbus Electronics Inc.	1502 Highway 45 North	39702	601	328-8426
Greenville	Tri-State Electronics Inc.	223 Highway 1 South	39703	601	335-3594
Gulf Port	E. A. Helwick Electronics	2214 25th Ave.	39501	601	863-1295
Jackson	Ellington Electronic Supply	824 S. Gallatin	39204	601	355-0561
Jackson	Swan Electronics	342 N. Gallatin	39501	601	352-5516
Meridian	Risher Radio Supply Co.	3510 8th St.	39301	601	485-8802
Natchez	Radio & Electronic Supply Company	528 S. Canal St.	39120	601	442-2151
Pascagoula	May Electronics Sup.	1412 Ingalls Ave.	39567	601	762-1903

***NOTE: TLX** indicates that the distributor also maintains a Western Union TELEX facility.
TWX indicates that the distributor also subscribes to the Bell System's Teletypewriter Exchange Service.

STATE AND CITY	NAME	ADDRESS	ZIP	AREA CODE	TELEPHONE*
MISSOURI					
Joplin	Four State Radio Sup.	402 Wall St.	64801	417	624-0368
Kansas City	Burstein-Applebee Co.	3199 Mercier St.	64111	816	531-5614
Kansas City	Walters Radio Sup., Inc.	3635 Main St.	64111	816	531-7015
Kansas City	Texas Instrument Supply	2916 Holmes Ave.	64109	816	753-4750
Springfield	Reed Radio & Sup.	805 Boonville Ave.	65801	417	869-0752
St. Joseph	St. Joseph Radio & Supply Co.	720 S. 9th St.	64501	816	233-3118
St. Louis	Electronic Components for Industry	2605 S. Hanley Rd.	63144	314	647-5505
St. Louis	Olive Industrial Electronics	6662 Olive St.	63130	314	863-7800 TWX
St. Louis	Radonics Electronics Inc.	4445 Gustine	63116	314	353-8313
St. Louis	Van Sickle Radio Electronics	1915 Washington St.	63103	314	241-2700
MONTANA					
Billings	Television & Electronic Supply Company	2305 Montana Ave.	59101	406	252-7193
NEBRASKA					
Lincoln	Scott Electronic Sup.	4040 Adams St.	68504	402	434-8308
Omaha	Radio Equipment Co. of Omaha	625 N. 18th St.	68102	402	341-7700
Scottsbluff	Joachim Radio Sup.	1913 Broadway	69361	308	632-2181
NEVADA					
Las Vegas	Industrial Electronics	300 W. Utah St.	89102	702	384-2151
Las Vegas	Electronic Supply Co.	1112 S. Casino Center Blve.	89104	702	384-5666
NEW HAMPSHIRE					
Concord	Evans Radio Co.	Bow Jct. P.O. Box 893	03301	603	225-3358
NEW JERSEY					
Camden	General Radio Sup. Co.	600 N. Penn St.	08102	609	964-8560
Clark	Texas Instruments Sup. Co.	301 Central Ave.	07065	201	382-6400
Hanover	State Electronics Parts Corp.	36 Route 10	07936	201	887-2550
Newark	Aaron Lippman & Co.	99-107 Newark St.	07103	201	621-9300
Perth Amboy	Sterling/Atlas Electronics, Inc.	774 Pfeiffer Blvd.	08861	201	442-8000
Springfield	Federated Purchaser, Inc.	155 U.S. Route 22	07081	201	376-8900
NEW MEXICO					
Albuquerque	Sterling Electronics	1712 Lomas Blvd., NE	87103	505	247-2486
Albuquerque	Walker Radio Corp.	102 Granite, N.W.	87101	505	247-2288
NEW YORK					
Binghamton	Federal Electronics Inc.	Box 1208	13902	607	748-8211
Buffalo	Genesee Radio & Parts Co.	2550 Deleware Ave.	14216	716	873-9661 TWX
Buffalo	Radio Equipment Co.	147 Genesee St.	14203	716	856-1415
Buffalo	Summit Distributors Inc.	916 Main St.	14202	716	884-3450
Cheektowaga	Standard Electronics, Inc.	3519 Union St.	14225	716	685-4330
East Farmingdale	Harrison Radio Corp.	20 Smith St. Rt. 110	11735	516	293-7979 TLX
Elmira	Brady Supply Corp.	649 Madison Ave.	14902	607	733-6591 TWX
Elmsford	Melville Radio	1 Nepperham Ave.	10523	914	592-7100
Farmingdale	Arrow Electronics Inc.	900 Broad Hollow Rd.	11735	516	694-6800 TWX
Jamaica	Norman Radio Distributors, Inc.	94-29 Merrick Rd.	11433	212	739-4651
Long Island City	H. L. Dalis, Inc.	35-35 24th St.	11106	212	361-1100
Lynbrook	Peerless Radio Corp.	19 Wilbur St.	11563	516	593-2121 TWX
New York	Midway Industrial Electronics, Inc.	15 W. 45th St.	10036	212	765-9830
New York	Milgray Electronics Inc.	160 Varick St.	10013	212	989-1600
New York	Milo Electronics Corp.	325 Hudson St.	10013	212	924-5000
New York	Newark Electronics Center, Inc.	160 Fifth Ave.	10010	212	255-4600
New York	Terminal-Hudson Electronics, Inc.	236 W. 17th St.	10011	212	243-5200 TWX
Richmond Hill	Anchor Electronics Dist. Corp.	116-01 101st St.	11419	212	846-2420
Rochester	Masline Electronics	511 Clinton Ave. S.	14620	716	546-5373
Rochester	Rochester Radio Supply Co.	140 W. Main St.	14614	716	454-7800
Rome	Rome Electronics Inc.	108 Spring St.	13440	315	337-5400
Schenectady	Adirondak Electronics Inc.	2469 Albany St.	12304	518	346-4717
Syossett	Lafayette Radio Electronis Corp.	111 Jericho Turnpike	11791	516	921-7700
Syracuse	Stewart W. Smith Inc.	325 East Water St.	13202	315	422-0323
Troy	Trojan Electronic Supply Co.	15 Middleberg St.	12181	518	274-4481
White Plains	Westchester Electronics	602-610 Mamaroneck Ave.	10605	914	949-2400
Woodbury	Harvey Radio Co.	60 Crossways Park W.	11797	516	921-8700 TWX
NORTH CAROLINA					
Charlotte	Armature Winding Co.	1001 N. First St.	28202	704	333-2158
Charlotte	Dixie Radio Supply Co.	2220 S. Tryon St.	28203	704	377-5413
Concord	Mac Victor Electronics Supply Inc.	Hwy. 29/Florence Ave.	28025	704	786-4175
Fayetteville	Eastern Radio Supply Inc.	952 Bragg St.	28303	919	485-2161
Gastonia	Shiflet & Dickson, Inc.	1008 W. Franklin Ave.	28052	704	867-7284
Greensboro	Carolina Radio Supply	834 Huffman St.	27405	919	273-8669
Greenville	Womack Electronics Supply	306 W. Boyd	27834	919	725-8711 TLX
Winston-Salem	Electronic Wholesalers	938 Burke St.	27102	919	725-8711 TLX
NORTH DAKOTA					
Fargo	Bristol Distributing Co.	1345 Main Ave.	58102	701	232-7493
Fargo	Radio and TV Equipment Inc.	1418 First Ave. North	58102	701	232-8993

STATE AND CITY	NAME	ADDRESS	ZIP	AREA CODE	TELEPHONE*
OHIO					
Akron	Akron Electronics Supply Co.	107 S. Arlington St.	44306	216	762-8818
Akron	Sun Radio Co.	110 E. Market St.	44308	216	434-2171
Ashtabula	Morrison Radio Supply	331 Center St.	44004	216	997-6161
Canton	Burroughs-Amiet Electronics Co.	2075 Fulton Rd. N.W.	44718	216	455-0271
Cincinnati	Hughes-Peters, Inc.	4865 Duck Creek Rd.	45227	513	351-2000
Cincinnati	Mytronic Company	1843 N. Reading Rd.	45215	513	733-1661
Cincinnati	Newark-Herrlinger Electronics	112 Liberty St.	45210	513	421-5282 TWX
Cincinnati	United Radio Inc.	7713 Reinhold Dr.	45237	513	761-4030
Cleveland	Brodhead Garrett Co.	4560 E. 71st St.	44105	216	341-0248
Cleveland	Pioneer Standard Electronics Inc.	5403 Prospect Ave.	44103	216	432-0010
Cleveland	Radio Electronic Parts Corp. (REPCO)	3235 Prospect Ave.	44115	216	881-6060
Cleveland	Winteradio & Electronics Supply Inc.	1468 W. 25th St.	44113	216	621-9383
Columbus	Buckeye Electronic Distrs.	242 E. Long St.	43215	614	228-3265
Columbus	Hughes-Peters, Inc.	481 E. 11th Ave.	43211	614	294-5351
Columbus	Thompson Electric Supplies, Inc.	182 E. Long St.	43215	614	228-6191
Dayton	Esco Inc.	221 Crane St.	45403	513	224-9192
Dayton	Srepco Electronics Div. Pioneer Standard	314 Leo St.	45404	513	224-0871 TLX
Dayton	Stotts Friedman Co.	108 N. Jefferson	45402	513	224-1111
Lima	Lima Radio Parts Co.	600 N. Main St.	45801	419	223-5075
Mansfield	Servex Electronic Distrs. Inc.	775 Spring Mill Rd.	44906	419	524-1811
Marion	Servex Electronic Distrs. Inc.	224 N. Prospect Ave.	43302	614	383-3117
Springfield	Pioneer Standard Electronics	1300 St. Paris	45504	513	399-8811
Toledo	Warren Radio Co.	1002 Adams St.	43601	419	248-3364
Warren	Rem Electronic Supply	264 W. Market St.	44481	216	399-2777
Youngstown	Ross Radio Company	325 W. Federal St.	44503	216	746-8881
OKLAHOMA					
Bartlesville	Cummins Electronic Supply	700 E. Frank Phillips Blvd.	74003	918	336-4448
Oklahoma City	Miller-Jackson Inc.	121 E. California	73104	405	235-8426
Oklahoma City	Trice Wholesale Electronics	4701 Stiles	73105	405	524-4411
Tulsa	Hall-Mark Electronics	7489 E. 46th Pl. South	74145	918	835-8458
Tulsa	Oil Capitol Electronics	708 S. Sheridan	74115	918	836-2541
Tulsa	Radio, Inc.	1000 S. Main St.	74119	918	587-9123 TWX
OREGON					
Eugene	Vitus Electric Supply Co.	140 E. 5th Ave.	97401	503	345-4377
Medford	Verl G. Walker Co.	205 W. Jackson	97501	503	773-7557
Portland	Eoff Electric Co.	509 NW 10th	97209	503	222-9411
Portland	Lou A. Johnson Co. Inc.	2720 NW 29th	97210	503	222-9551
Portland	United Radio Supply	22 NW 9th Ave.	97209	503	226-6334
PENNSYLVANIA					
Allentown	Federated Purchaser, Inc.	936 Union Blvd.	18103	215	433-7441 TWX
Allentown	A. A. Peters Inc.	404 Union Blvd.	18103	215	434-5237
Allentown	Valley Electronics Supply	101 N. Seventh St.	18101	215	435-9696
Altoona	Allegheny Electronics Inc.	1720 Union Ave.	16601	814	944-0827
Drexel Hill	Kass Electronics Distributors	2502 Township Line Rd.	19026	215	449-2300
Erie	J. V. Duncombe Electronic Corp.	721 Parade St.	16503	814	454-5278
Erie	Warren Radio	1315 Peach St.	16501	814	454-5285
Harrisburg	Pyttronic Industries, Inc.	2525 N. 7th St.	17105	717	233-6591 TWX
Hazleton	Moyer Electronic Supply Co.	758 N. Locust St.	18201	412	455-3631
McKeesport	Barno Radio Co.	5403 W. Smithfield St.	15135	412	751-5966
New Brighton	Television Parts Co. Inc.	518 Fifth Ave.	15066	412	846-3000
Philadelphia	Almo Industrial Electronics Inc.	913 Arch St.	19107	215	922-5918 TWX, TLX
Philadelphia	Herbach & Rademan	1204 Arch	19107	215	569-9500
Philadelphia	Philadelphia Electronics, Inc.	1225 Vine St.	19107	215	568-8288
Philadelphia	Radio Electric Service Co. of Pennsylvania, Inc.	701 Arch St.	19106	215	925-5840 TWX
Pittsburgh	Cameradio Company	2801 Liberty Ave.	15222	412	391-4000 TWX
Pittsburgh	McCullough Electric Co.	419 Fort Pitt Blvd.	15219	412	261-2420
Pittsburgh	R. P. C. Electronics	620 Alpha Dr.	15238	412	782-3770
Reading	George D. Barbey Co., Inc.	333 N. 4th	19603	215	376-7451
Scranton	Pursell Electronics	1221-37 N. Washington	18509	717	346-2011
State College	Alvo Electronics Distributors, Inc.	103 S. Pugh St.	16801	814	238-0505
St. Marys	B & R Electric Co.	26 Railroad St.	15857	814	834-2814
Westchester	West Chester Electric Supply Co.	716 E. Market St.	19380	215	696-7500
RHODE ISLAND					
Providence	Wm. Dandreta & Co.	28 Wolcott St.	02908	401	861-2800
Warwick	W. H. Edwards Co., Inc.	55 Electronic Drive	02888	401	781-8000
SOUTH CAROLINA					
Charleston	Wholesale Radio Supply Co.	515 E. Bay St.	29403	803	722-2634
Greeneville	Sawyer Electronics Corp.	1210 Poinsett Hwy.	29403	803	235-0438
SOUTH DAKOTA					
Rapid City	Black Hills Electronic Supply	726 Jackson Blvd.	57701	605	886-5749
Sioux Falls	Warren Supply Co.	196 W. 6th St. South	57102	605	336-1830
TENNESSEE					
Chattanooga	Curle Radio Supply Co.	439 Broad St.	37402	615	266-4728
Chattanooga	Specialty Distributing Co.	1313 Central Ave.	37408	615	267-9531
Kingsport	Radio Electric Supply	961 E. Sullivan	37660	615	247-8111
Knoxville	Bondurant Bros. Co.	906 E. Sevier	37901	615	523-9144
Knoxville	McClung Appliances	310 Georgia St. N.E.	37919	615	524-1811
Memphis	Bluff City Distributing Co.	234 East St.	38101	901	276-4501
Memphis	Teague Electronics	2122 Madison Ave.	38104	901	274-8740
Memphis	W & W Distributing Co.	644-646 Madison Ave.	38103	901	527-4628
Nashville	Electra Distributing Co.	1914 West End Ave.	37203	615	255-8444

STATE AND CITY	NAME	ADDRESS	ZIP	AREA CODE	TELEPHONE*
TEXAS					
Austin	Hargis-Austin Inc.	410 Baylor	78703	512	478-6618
Austin	Wholesale Electronic Supply of Austin	703 West 7th	78703	512	478-9568
Beaumont	Covington Distributing Co.	410 Ave. C	77704	713	835-5392
Corpus Christi	Wicks Radio Equipment Co.	513 Staples St.	78401	512	884-8285
Dallas	Adleta Electronics Co.	1907 Mc Kinney Ave.	75201	214	741-3151
Dallas	All-State Electronics Co.	2411 Ross Ave.	75201	214	741-3281
Dallas	Southwest Radio Supply Co.	1820 N. Harwood	75201	214	741-6272
Dallas	Texas Instruments Supply Co.	6000 Denton Dr.	75235	214	357-6121 TLX
Dallas	Wholesale Electronic Supply	2809 Ross Ave.	75201	214	824-3001
Dallas	Wilkinson Bros.	2406 Ross	75221	214	747-1571
El Paso	Midland Specialty Co.	2235 Wyoming Ave.	79903	915	533-9555
El Paso	Sunland Supply Co.	2227 Texas Ave.	79901	915	533-5901
Fort Worth	Swieco, Inc.	1512 E. Landcaster	76101	817	332-7157
Fort Worth	Wholesale Electronic Supply	550 S. Freeway	76104	817	336-0461
Houston	Harrison Equipment Co., Inc.	1422 San Jacinto St.	77001	713	224-9131
Houston	Sterling Electronics	4201 Southwest Freeway	77027	713	666-3811
Houston	Wofford Electronics Co.	Box 12367	77017	713	644-1838
Lubbock	Nunn Electric Supply	1817 Fourth St.	79417	806	765-5741
Lubbock	R & R Electronic Supply	1607 Avenue "G"	79417	806	765-5737
McAllen	Rio Radio Supply Co.	608-610 S. Broadway	78501	512	686-8622
Odessa	Midland Specialty Company	2101 Andrews Highway	79760	915	337-7365
Port Arthur	Diehl Radio & T.V. Supply	2120 7th St.	77640	713	982-6310
Richardson	The Altair Company	405 North Plano	75080	214	231-5166
San Angelo	Gunter Wholesale Co.	606 S. Irving St.	76901	915	655-9181
San Antonio	Perry Shankle Company	1801 S. Flores St.	78204	512	223-1801
San Antonio	Sterling Electronics Inc.	4600 San Pedro	78212	512	735-9173 TLX
Texarkana	McCulloch Electronic Supply	1222 Main St.	75501	214	792-6923
Tyler	Cole Electronic Supply Co.	3357 Bonner	75701	214	594-3545
UTAH					
Ogden	Ballard Supply Corp.	3109 Washington	84403	801	394-5541
Salt Lake City	S. R. Ross, Inc.	1212 S. State St.	84110	801	328-0591
Salt Lake City	Standard Supply	225 E. 6th South	84110	801	355-2971
VIRGINIA					
Charlottesville	Virginia Radio Supply Co.	717 Henry Ave.	22902	703	296-4184
Norfolk	Radio Parts Distributing Co.	5652 E. Virginia Beach	23502	703	855-8095
Richmond	Meridian Electronics Inc.	1001 W. Broad St.	23220	703	355-0669
WASHINGTON					
Seattle	Electronic Supply Corp.	250 N.E. 45th St.	98105	206	632-2222
Seattle	Radar Electric Co.	168 Western Ave .W.	98119	206	282-2511 TWX
Seattle	Western Electronic Supply	717 Dexter Ave.	98109	206	284-0200
Seattle	Wyle Laboratories Liberty Electronics NW Div.	5305 2nd Ave. S.	98108	206	763-8200
Spokane	Columbia Electric	E3420 Ferry St.	99220	509	534-0611
Spokane	Northwest Electronics	730 E. 1st Ave.	99220	509	534-2644
Tacoma	C & G Electronics Co.	2502 Jefferson Ave.	98402	206	272-3181
Yakima	Lay and Nord Company	511 S. 3rd St.	98901	509	453-5591
WEST VIRGINIA					
Charleston	Charleston Electrical Sup. Co.	312 MacCorkle Ave. SE	25329	304	346-8161
Huntington	Electronic Supply Inc.	222 7th Ave.	25701	304	523-6448
Wheeling	Radio Parts Co. Inc.	1301 Main St.	26003	304	232-7630
WISCONSIN					
Eau Claire	J. H. Larson Electrical Co.	1809 Western Ave.	54701	715	834-3111
Green Bay	Northern Radio & Television	1585 Main Street	54302	414	435-3789
Kenosha	CimEnterprises Chester Electronics Sup. Div.	1220 60th St.	53140	414	658-4616
Madison	Satterfield Electronics Inc.	1900 S. Park St.	53713	608	257-4801
Milwaukee	Electronic Expeditors Inc.	6045 N. Green Bay Ave.	53209	414	871-3000 TWX
Milwaukee	Hall-Mark Electronics	11820 W. Ripley Ave.	53226	414	476-1270
Milwaukee	Marsh Radio Supply Co.	6047 W. Beloit Rd.	53219	414	545-6500
Milwaukee	Radio Parts Co.	1314 N. Seventh St.	53204	414	276-4160
Wausau	Electronics Inc.	643 S. 3rd Ave.	54401	715	845-4671
WYOMING					
Casper	Hathaway Electrical Supply	333 N. Wolcott	82601	307	234-1821

*NOTE: **TLX** indicates that the distributor also maintains a Western Union TELEX facility.
TWX indicates that the distributor also subscribes to the Bell System's Teletypewriter Exchange Service.

PRINTED IN U.S.A.

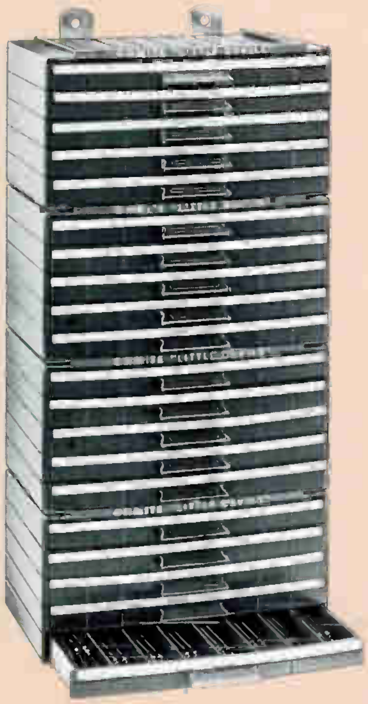
JAN 16 1971

OHMITE ®

Little Devil

INDUSTRIAL and SERVICE RESISTOR ASSORTMENTS

RESISTORS AND HANDY CABINET FOR THE PRICE OF THE RESISTORS ALONE



Typical 5% Tol. Industrial Ass't.

Select the composition resistor you need, right on the job from time-saving Little Devil Assortments. Ohmite now offers *seven industrial* assortments in addition to the four service assortments that have been so popular for many years. In this complete line, there is an assortment to fill every industrial and service need. An attractive plastic cabinet or cabinet assembly is furnished at no extra cost with each assortment. Each drawer of a single 5-drawer cabinet has eight compartments, all individually labeled. Dimensions of the single cabinet are 9″ long, 4¾″ high, 5¼″ deep. Dovetail tops and bottoms facilitate stacking. Cabinet assemblies for industrial assortments are riveted to metal strips which afford rigidity and permit hanging of the unit on the wall.

Of the seven industrial assortments, there are three ±10% tolerance assortments of ¼, ½ or 1 watt sizes each containing 80 values. A two-cabinet assembly is furnished for these assortments. Four 5% tolerance assortments provide 160 values each of resistors in the ⅛, ¼, ½, or 1 watt sizes. A four-cabinet assembly is furnished for each of these assortments.

The four popular *service* assortments provide ±10% tolerance resistors in a single cabinet in ¼, ½, 1 or 2 watt sizes.

Cabinets are factory packed in accordance with the tables (shown on the next 2 pages of this bulletin) which state the quantities of each resistance value and tolerance for each assortment.

Typical 10% Tol. Industrial Ass't.

11 INDUSTRIAL and SERVICE ASSORTMENTS

SOLD ONLY THROUGH OHMITE DISTRIBUTORS

Assortment	Stock No.	Quantity of Resistors	Wattage Size	Net Price
INDUSTRIAL ±10% Tolerance 80 Resistance Values 2 Cabinets	CAB-25 CAB-26 CAB-27	1000 1000 600	¼ ½ 1	$ 70.00 60.00 54.00
INDUSTRIAL ±5% Tolerance 160 Resistance Values 4 Cabinets	CAB-45 CAB-46 CAB-47 CAB-48	1000 1500 1500 900	⅛ ¼ ½ 1	225.00 210.00 180.00 160.00
RADIO AND TV SERVICE KITS ±10% Tolerance 37 Values—CAB-4 40 Values—Others 1 Cabinet	CAB-4 CAB-10 CAB-2 CAB-3	150 150 125 125	¼ ½ 1 2	19.50 18.00 22.50 30.00

Typical Service Assortment

Prices Subject to Change Without Notice

BULLETIN 301A

OHMITE MANUFACTURING COMPANY
3601 Howard Street, Skokie, Illinois 60076

Little Devil RESISTOR ASSORTMENTS

10% TOLERANCE ASSORTMENTS

QUANTITIES IN EACH ASSORTMENT

10% RESISTANCE VALUES	SERVICE ASST'S.				INDUS. ASST'S.		
	CAB-4 ¼ W	CAB-10 ½ W	CAB-2 1 W	CAB-3 2 W	CAB-25 ¼ W	CAB-26 ½ W	CAB-27 1 W
2.7					5	5	10
3.3					5	5	5
3.9					5	5	5
4.7					5	5	10
5.6					5	5	5
6.8					5	5	10
10		1	1	1	20	20	10
12					5	5	5
15		1	1	1	5	5	10
18					5	5	5
22					5	5	10
27		1	1	1	5	5	10
33					5	5	10
39					5	5	5
47	5	1	1	1	20	20	10
56					5	5	5
68					5	5	5
82					5	5	5
100	5	5	1	1	30	30	10
120					5	5	5
150	1	1	1	1	20	15	10
180					5	5	5
220					20	20	10
270	3	3	1	1	30	15	10
330	1	1	1	1	20	15	10
390					5	5	10
470	3	3	1	1	20	30	10
560					5	15	10
680	1	1	1	1	20	15	10
820					5	5	5
1,000	10	5	3	3	5	30	10
1,200					5	5	10
1,500	5	1	1	1	20	20	10
1,800					5	15	5
2,200	10	1	1	1	30	30	10
2,700	5	3	3	3	20	15	10
3,300					30	20	10
3,900					20	5	10
4,700	10	10	5	5	30	30	10
5,600					5	20	5

QUANTITIES IN EACH ASSORTMENT

10% RESISTANCE VALUES (CONT.)	SERVICE ASST'S.				INDUS. ASST'S.		
	CAB-4 ¼ W	CAB-10 ½ W	CAB-2 1 W	CAB-3 2 W	CAB-25 ¼ W	CAB-26 ½ W	CAB-27 1 W
6,800	5	1	1	1	30	15	10
8,200					20	5	5
10,000	10	10	10	10	30	30	10
12,000					20	15	5
15,000	5	3	3	3	30	5	10
18,000					20	5	5
22,000	5	5	5	5	30	30	10
27,000	5	10	10	10	20	20	10
33,000	3	3	1	1	20	20	10
39,000	3	5	5	5	5	15	10
47,000	5	10	10	10	30	30	10
56,000					20	15	5
68,000	3	3	1	1	20	20	5
82,000	2	1	1	1	5	15	5
0.10 meg.	10	10	10	10	30	30	10
0.12 meg.					5	5	5
0.15 meg.	3	5	5	5	5	15	10
0.18 meg.					5	5	5
0.22 meg.	3	3	1	1	20	20	10
0.27 meg.	3	10	10	10	5	20	10
0.33 meg.	3	3	1	1	20	15	5
0.39 meg.					5	5	5
0.47 meg.	5	10	10	10	20	30	10
0.56 meg.					5	5	5
0.68 meg.	1	1	1	1	5	5	5
0.82 meg.					5	5	5
1.0 meg.	10	10	10	10	30	30	10
1.2 meg.					5	5	5
1.5 meg.	1	1	1	1	5	5	5
1.8 meg.					5	5	5
2.2 meg.	1	1	1	1	5	15	5
2.7 meg.	1	3	1	1	5	5	5
3.3 meg.					5	15	5
3.9 meg.	1	1	1	1	5	5	5
4.7 meg.	1	1	1	1	5	5	5
5.6 meg.					5	5	5
6.8 meg.	1	1	1	1	5	5	5
10.0 meg.	1	1	1	1	5	5	5
15.0 meg.					5	5	5
22.0 meg.					5	5	5

5% TOLERANCE ASSORTMENTS

QUANTITIES IN EACH ASSORTMENT

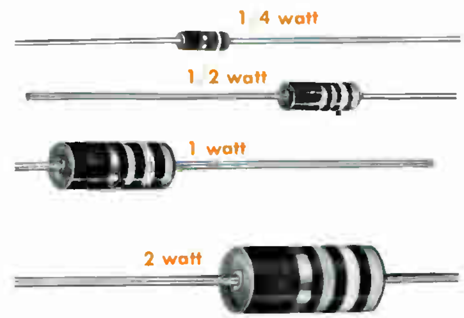
5% RESISTANCE VALUES	INDUSTRIAL ASSORTMENTS CAB-45 ⅛ W	CAB-46 ¼ W	CAB-47 ½ W	CAB-48 1 W
2.7	5	5	5	5
3.0	5	5	5	5
3.3	5	5	5	5
3.6	5	5	5	5
3.9	5	5	5	5
4.7	5	5	5	5
5.1	5	5	5	5
5.6	5	5	5	5
6.8	5	5	5	5
7.5	5	5	5	5
8.2	5	5	5	5
9.1	5	5	5	5
10	20	25	30	10
11	5	5	5	5
12	5	5	5	5
15	5	5	5	5
16	5	5	5	5
18	5	5	5	5
20	5	5	5	5
22	5	5	5	5
24	5	5	5	5
27	5	5	15	5
30	5	5	5	5
33	5	5	5	5
36	5	5	5	5
39	5	5	5	5
43	5	5	5	5
47	10	10	5	5
51	10	10	15	10
56	5	5	5	5
62	5	5	5	5
68	5	5	5	5
75	5	5	20	5
82	5	5	5	5
91	5	5	5	5
100	20	30	30	10
110	5	5	5	5
120	5	5	5	5
130	5	5	5	5
150	5	10	15	10
160	5	5	5	5
180	20	5	5	5
200	5	5	15	10
220	10	25	15	10
240	5	5	5	5
270	5	10	15	10
300	5	5	5	5
330	5	25	15	10
360	5	5	5	5
390	5	10	15	5
430	5	5	5	5
470	10	25	20	10
510	5	10	15	10
560	5	10	15	5
620	5	5	15	5
680	5	10	5	10
750	5	5	5	5
820	5	10	5	5
910	5	5	5	5
1,000	20	30	30	10
1,100	5	5	5	5
1,200	10	25	15	10
1,300	5	5	5	5
1,500	20	10	20	5
1,600	5	5	5	5
1,800	5	25	15	5
2,000	20	25	30	10
2,200	20	30	30	10
2,400	5	10	5	5
2,700	10	25	15	5
3,000	5	10	15	5
3,300	5	25	30	5
3,600	5	5	5	5
3,900	10	25	15	5
4,300	5	5	5	5
4,700	20	30	30	10
5,100	10	25	15	5
5,600	5	25	15	5
6,200	5	10	5	5
6,800	5	30	20	5

QUANTITIES IN EACH ASSORTMENT

5% RESISTANCE VALUES (CONT.)	INDUSTRIAL ASSORTMENTS CAB-45 ⅛ W	CAB-46 ¼ W	CAB-47 ½ W	CAB-48 1 W
7,500	5	5	5	5
8,200	5	25	15	5
9,100	5	5	5	5
10,000	20	30	30	10
11,000	5	5	5	5
12,000	10	25	20	5
13,000	5	5	5	5
15,000	5	30	30	5
16,000	5	5	5	5
18,000	5	10	15	5
20,000	5	25	15	5
22,000	5	25	30	10
24,000	5	5	15	5
27,000	5	10	15	5
30,000	5	10	5	5
33,000	5	25	20	5
36,000	5	5	5	5
39,000	5	10	15	5
43,000	5	5	5	5
47,000	10	25	20	10
51,000	5	10	15	5
56,000	5	5	15	5
62,000	5	5	5	5
68,000	5	10	15	5
75,000	5	5	5	5
82,000	5	10	5	5
91,000	5	5	5	5
0.10 meg.	20	30	30	10
0.11 meg.	5	5	5	5
0.12 meg.	5	5	5	5
0.13 meg.	5	5	5	5
0.15 meg.	5	10	15	5
0.16 meg.	5	5	5	5
0.18 meg.	5	5	5	5
0.20 meg.	5	10	5	5
0.22 meg.	5	5	15	5
0.24 meg.	5	5	5	5
0.27 meg.	5	5	5	5
0.30 meg.	5	5	5	5
0.33 meg.	5	5	5	5
0.36 meg.	5	5	5	5
0.39 meg.	5	5	5	5
0.43 meg.	5	5	5	5
0.47 meg.	5	10	20	5
0.51 meg.	5	5	5	5
0.56 meg.	5	5	5	5
0.62 meg.	5	5	5	5
0.68 meg.	5	5	5	5
0.75 meg.	5	5	5	5
0.82 meg.	5	5	5	5
0.91 meg.	5	5	5	5
1.0 meg.	5	25	20	5
1.1 meg.	5	5	5	5
1.2 meg.	5	5	5	5
1.3 meg.	5	5	5	5
1.5 meg.	5	10	5	5
1.6 meg.	5	5	5	5
1.8 meg.	5	5	5	5
2.0 meg.	5	5	5	5
2.2 meg.	5	5	5	5
2.4 meg.	5	5	5	5
2.7 meg.	5	5	5	5
3.0 meg.	5	5	5	5
3.3 meg.	5	5	5	5
3.6 meg.	5	5	5	5
3.9 meg.	5	5	5	5
4.3 meg.	5	5	5	5
4.7 meg.	5	5	5	5
5.1 meg.	5	5	5	5
5.6 meg.	5	5	5	5
6.2 meg.	5	5	5	5
6.8 meg.	5	5	5	5
7.5 meg.	5	5	5	5
8.2 meg.	5	5	5	5
10.0 meg.	5	5	5	5
12.0 meg.	5	5	5	5
15.0 meg.	5	5	5	5
18.0 meg.	5	5	5	5
20.0 meg.	5	5	5	5
22.0 meg.	5	5	5	5

Little Devil® MOLDED COMPOSITION RESISTORS

SOLD ONLY THROUGH OHMITE DISTRIBUTORS



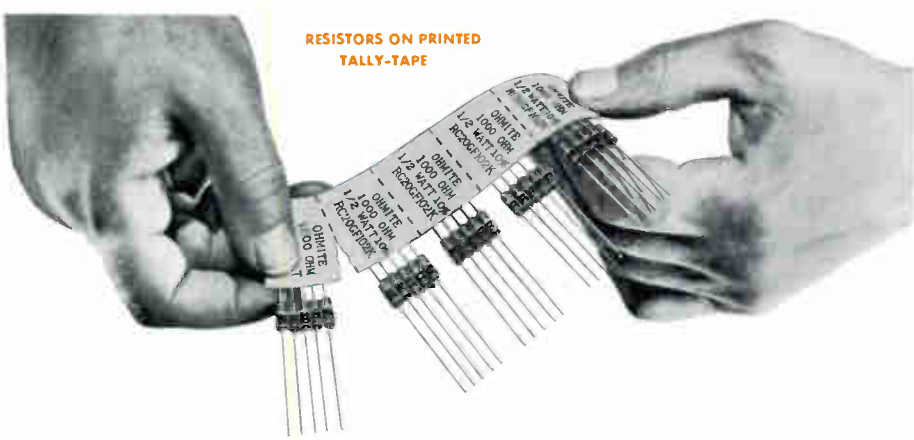
Little Devils, Ohmite's famous molded composition resistors are available in five sizes—the subminiature 1/8 watt, and the 1/4, 1/2, 1 and 2 watt sizes. These high quality resistors find broad use in commercial and military applications.

All sizes have molded insulation for high dielectric strength. Other noted advantages are great stability, low noise level, low voltage coefficient, high insulation breakdown voltage and rapid heat dissipation. "Little Devils" may be used at full rated wattage at 70° C (158° F) ambient temperature.

The 1/8, 1/4, 1/2, 1 and 2 watt sizes conform to certain styles of MIL-R-11F as shown in the "Price" table below and meet the stringent requirements of this military specification.

All the resistors are available from stock in the standard EIA resistance values (see table below) in the tolerances and ranges shown in the price table below. Ratings for maximum continuous RMS voltage drop are high: 150 volts for 1/8 watt units, 250 volts for 1/4 watt, 350 volts for 1/2 watt, 500 volts for 1 watt, and 750 volts for 2 watt units.

"Tally Tape," Ohmite's wonderfully convenient packaging is now provided for the 1/4, 1/2, 1 and 2 watt resistors. Each perforated tape segment holds 5 resistors neatly aligned, spill-proof, tangle-proof and easy to count! Individual resistors are easily pulled from the strip ready to use. In addition to the standard EIA color coding on the resistors, each **Tally Tape** segment is imprinted with the value, size, tolerance and the MIL type designation, where applicable. **With Tally Tape you know that you are getting original, factory fresh stock.**



PRICES, RESISTANCE RANGES, DIMENSIONS

Watts	Size Lgth.	Size Dia.	Lead† Dia.	Resistance Range From	Resistance Range Thru	MIL Type	±5% Net 1-4	±5% Net 5-49	±10% Net 1-4	±10% Net 5-49
1/8	.145"	.062"	.015	2.7 ohms	9.1 ohms	RC 05‡	37c **LIDNU**	31c **LIDNU**	27c **LIDVS**	22c **LIDVS**
				10 ohms	22 megs		34c **LIDNU**	28c **LIDNU**	24c **LIDVS**	20c **LIDVS**
1/4	1/4"	.090"	.025	2.7 ohms	9.1 ohms	RC 07	29c **LIDED**	24c **LIDED**	14c **LIDSM**	12c **LIDSM**
				10 ohms	22 megs		26c **LIDED**	22c **LIDED**	13c **LIDSM**	11c **LIDSM**
1/2	3/8"	9/64"	.033	1 ohm	2.4 ohms	RC 20*	26c **LIDFA**	22c **LIDFA**	13c **LIDLO**	11c **LIDLO**
				2.7 ohms	22 megs		24c **LIDFA**	20c **LIDFA**	12c **LIDLO**	10c **LIDLO**
1	9/16"	7/32"	.041	2.7 ohms	22 megs	RC 32	36c **LIDBU**	30c **LIDBU**	18c **LIDME**	15c **LIDME**
2	11/16"	5/16"	.046	10 ohms	22 megs	RC 42	48c **LIDOC**	40c **LIDOC**	24c **LIDHI**	20c **LIDHI**

†All leads 1½" long except 1/8 watt size which are 1".

*Minimum resistance under MIL-R-11 is 2.7 ohms.
‡Minimum resistance under MIL-R-11 is 10 ohms.

STANDARD EIA VALUES

Figures in large, bold type are ±10% EIA values. *All* values listed are ±5% values. Price table lists the various "Little Devil" sizes and indicates the tolerances and resistance ranges in which they are supplied.

Ohms	Ohms	Ohms	Ohms	Megs.	Megs.
1.0	36	**1200**	43000	**0.1**	3.6
1.1	**39**	1300	**47000**	0.11	**3.9**
1.2	43	**1500**	51000	**0.12**	4.3
1.3	**47**	1600	**56000**	0.13	**4.7**
1.5	51	**1800**	62000	**0.15**	5.1
1.6	**56**	2000	**68000**	0.16	**5.6**
1.8	62	**2200**	75000	**0.18**	6.2
2.0	**68**	2400	**82000**	0.20	**6.8**
2.2	75	**2700**	91000	**0.22**	7.5
2.4	**82**	3000	....	0.24	**8.2**
2.7	91	**3300**	....	**0.27**	9.1
3.0	**100**	3600	....	0.30	**10.0**
3.3	110	**3900**	....	**0.33**	11.0
3.6	**120**	4300	....	0.36	**12.0**
3.9	130	**4700**	....	**0.39**	13.0
4.3	**150**	5100	....	0.43	**15.0**
4.7	160	**5600**	....	**0.47**	16.0
5.1	**180**	6200	....	0.51	**18.0**
5.6	200	**6800**	....	**0.56**	20.0
6.2	**220**	7500	....	0.62	**22.0**
6.8	240	**8200**	....	**0.68**	....
7.5	**270**	9100	....	0.75	....
8.2	300	**10000**	....	**0.82**	....
9.1	**330**	11000	....	0.91	....
10	360	**12000**	....	**1.0**	....
11	**390**	13000	....	1.1	....
12	430	**15000**	....	**1.2**	....
13	**470**	16000	....	1.3	....
15	510	**18000**	....	**1.5**	....
16	**560**	20000	....	1.6	....
18	620	**22000**	....	**1.8**	....
20	**680**	24000	....	2.0	....
22	750	**27000**	....	**2.2**	....
24	**820**	30000	....	2.4	....
27	910	**33000**	....	**2.7**	....
30	**1000**	36000	....	3.0	....
33	1100	**39000**	....	**3.3**	....

wire wound resistor assortments

of type 995 axial lead Molded vitreous enamel

Single Cabinet for CAB-91 and CAB-99

Double Cabinet for CAB-93 and CAB-95

OHMITE has another new answer

- Perfect for R & D and Prototype Labs
- All popular values included
- Resistors and handy cabinet for the price of the resistors alone
- 4 Wattage sizes to choose from
- Contents clearly marked on front of each drawer

Select the wire-wound resistor you need, right on the job. All the popular resistance values, as determined by national usage, are contained in these handy, compact assortments.

The attractive plastic cabinet is furnished at no extra cost with each assortment. Cabinets are factory packed. Each drawer segment is individually labeled. Dovetail tops and bottoms of cabinets facilitate stacking. Dimensions for single cabinets are 9" long x 4-3/4" high x 5-1/4" deep, double cabinets are 10-1/2" high, including wall hanging brackets.

Quantities and resistance values for each assortment shown on next page.

SPECIFICATIONS and PRICING

Nominal Wattage Size	Catalog Number	Number of Res. Values	Quantity of Resistors	Net Price
1½ W.	CAB-91	40	167	$110.00
3¼ W.	CAB-93	71	325	205.00
5 W.	CAB-95	75	355	240.00
11 W.	CAB-99	40	185	140.00

Prices subject to change without notice

QUANTITIES AND RESISTANCE VALUES FOR EACH ASSORTMENT

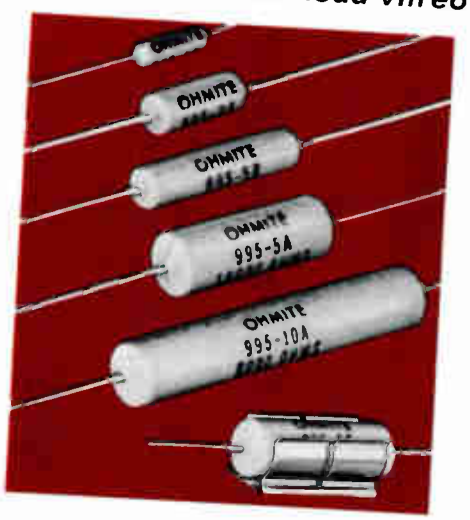
±5% Resistance Values	1½ Watt CAB-91	3¼ Watt CAB-93	5 Watt CAB-95	11 Watt CAB-99
1.0	10	7	7	5
1.2			4	
1.5	5	4	4	
2.0	5	4	4	5
2.2	5			
2.7		4		
3.0	5	4	4	5
4.0	3	4	4	5
5.0	5	7	7	5
5.6		1	4	
6.8		4		
7.5	3	4	1	5
10.0	10	4	7	5
12		1	4	
15	5	7	7	5
18		1	4	
20	3	4	7	5
22	2	7	4	5
25		4	7	5
30	3	4	4	5
33		4		
39		4	4	5
40	3	4	4	5
47		4	4	
50	5	7	7	5
51			7	
56	2	4	4	
68	2	4	4	5
75	2	7	4	4
82		4	4	5

±5% Resistance Values	1½ Watt CAB-91	3¼ Watt CAB-93	5 Watt CAB-95	11 Watt CAB-99
91	5			
100	5	7	7	5
110	5			
120		7	4	
150		4	4	5
160		1	4	
200	5	7	7	5
220	5	7	7	
250		4	7	5
270		4	4	
300	5	7	7	5
330	5	4	4	
350			4	4
390		4	4	
400		4	4	
450		4		
470	5	7	4	4
500	5	7	7	5
510	5		4	
560		4	4	
600	5	7	4	
620		4		
680	2	7		
700		4		
750	2	7	7	5
800	2	4	4	
820			4	
900		4		
1000	5	7	7	5
1200	2	4	4	

±5% Resistance Values	1½ Watt CAB-91	3¼ Watt CAB-93	5 Watt CAB-95	11 Watt CAB-99
1300		7	7	
1500	5	7	4	4
1800	2	4	4	
2000	5	7	7	4
2200	2	4	4	
2500	2	4	4	4
2700		4	1	
3000	5	4	7	4
3300		4	4	
3900		1	1	
4000		4	4	4
4300			4	
4700		4	4	
5000		4	7	4
5600		1	4	
6000			4	
6800		1	5	4
7000		4		
7500		3		
8000			4	
8200		4	4	
9000			4	
10,000		7	7	4
12,000			4	
15,000			4	4
20,000			4	
22,000			4	
25,000			4	4
40,000				4
50,000				4

about Type 995 MOLDED axial lead vitreous enameled resistors.

- FIRST MOLDED WIREWOUND, VITREOUS ENAMEL RESISTOR
- INSULATED! Meets 1000 VAC Test
- WITHSTANDS 1500°F Temperatures without Distortion
- RESISTS Chipping, Breaking
- VITRIFIED MARKINGS, Resist Abrasion and Active Solvents
- UNIFORM SIZE Permits Clip-Mounting with Significant Heat Sink Benefits
- HIGH OVERLOAD CAPABILITY



An exclusive technique (U.S. Patent No. 3,229,237) permits application of the vitreous enamel coating by *molding* instead of the conventional "dip" process. The dimensionally consistent and thicker coating that results, guarantees a 1000 VAC insulation rating plus unparalleled capability for withstanding very high temperatures, high humidity and immersion in salt solution.

These resistors are normally mounted by their axial leads. However, their consistent form also permits mounting in clips with heat sink benefits up to 100% (see Clip in illustration). Resistor markings are also vitreous and will not burn off even under extreme overloads. Resistance tolerance is ±5%.

Ohmite Manufacturing Company a North American Philips company
3660 Howard Street, Skokie, Illinois 60076/Phone (312) 675-2600/TWX: 910-223-0805/Telex 72-4433

PRINTED IN U.S.A.

Publication 225

NOV 7 1970

OHMITE
A North American Philips Company

POSTFREE ORDER FORM

Simply fold, staple and mail to OHMITE.

Please ship the following Lab items

0.1% Precision Determ-ohm Box

Quantity	Cat. No.	Price
	3405	$ 85.00
	3406	85.00
	3407	90.00
	3410	125.00

Assortments of Type 995 Resistors

Cat. No.	Price	Quantity
CAB-91	$110.00	
CAB-93	205.00	
CAB-95	240.00	
CAB-99	140.00	

Fold

Fold

Prices F.O.B. factory. Terms: 1%, 10th & 25th, net 30 days to rated firms.

Date ______________ Purchase Order No. ______________

Ship via ☐ Cheapest Way ☐ Other ______________

■ Bill to:

Company Name

Street address/P.O. no.

City State Zip

Fold

Fold

■ Ship to:

Company Name

Street address/P.O. no.

City State Zip

Mark Shipping Label: ______________

☐ I am unable to buy at present but wish to see a sales representative. (But please write name and address above).

OHMITE MANUFACTURING COMPANY 3601 Howard Street Skokie, Ill. 60076

New! 0.1% precision Determ-ohm® resistance decade box for R & D lab and testing.

Patent Pending

OHMITE has another new answer

- Precision 0.1%, + .01Ω accuracy per decade
- Direct In-line Numeric Readout
- Simplified selection of resistance values
- Continuous rotation Rocker-type thumbwheel switches
- Choice of four resistance ranges to one megohm

SPECIFICATIONS AND PRICING ON NEXT PAGE . . . .

JUL 2 1970

The new Ohmite Precision Determ-ohm® is a resistance decade box with an accuracy of ±0.1%. Four models cover the resistance range from 1 ohm to 1 megohm in a choice of 4 and 6-decade models.

Simplified selection of resistance values is accomplished by operation of rocker-type thumbwheel switches. Resistance setting is indicated by a direct in-line numeric readout to 4 or 6 significant digits depending on model. Pushing the lower portion of the rocker advances the number, pushing the upper portion of the rocker decreases the number. Unique switch feature (pat. pend.) allows advancing or decreasing of values directly from 9 thru 0 to 1 or vice versa, without retracing all the other values.

The housing is a functional sloping panel metal case equipped with universal binding posts and a grounded metallic binding post for effective shielding. In addition to being a handsome addition to the R & D lab, the **precision Determ-ohm** is ideal for production line testing applications and checkout procedures in ground support operations.

SPECIFICATIONS

Accuracy: 0.1% (plus .01Ω max. contact and circuit resistance per decade)
Selection: Rocker-type thumbwheel switches, continuous rotation in either direction.
Switch Life: In excess of 50,000 operations
Power: 1/4 Watt per resistor
Operating Temperature: +15 to +35°C.
T.C. of Resistors: ±10 ppm/°C, max. 20 ppm/°C.
Size: 5" w. x 4¼" d. x 4¼" h.
Weight: 1.6 lbs.
Finish: Metallic Blue

MAXIMUM CURRENT RATINGS

(Do not exceed 500 Volts)

Resistance Range (Ohms)	Max. Current (milliamps)
1-9	710
10-99	220
100-999	71
1000-9999	22
10,000-999,999	7.1
100,000-999,999	1.1

Cat. Nos. 3405, 3406, 3407

Cat. No. 3410

SELECTION and PRICING

Resistance Range (Ohms)	Ohms Per Step	Number of Decades (Switches)	Catalog Number	Net Price
0 to 9.999K	1	4	3405	$ 85.00
0 to 99.99K	10	4	3406	85.00
0 to 999.9K	100	4	3407	90.00
0 to 999.999K	1	6	3410	125.00

Prices subject to change without notice.

Ohmite Manufacturing Company a North American Philips Company
3660 Howard Street, Skokie, Illinois 60076 Phone (312) 675-2600/TWX: 910-223-0805/Telex 72-4433

TAP SWITCHES

CATALOG SEQUENCE 400

OHMITE

TAP SWITCHES 400

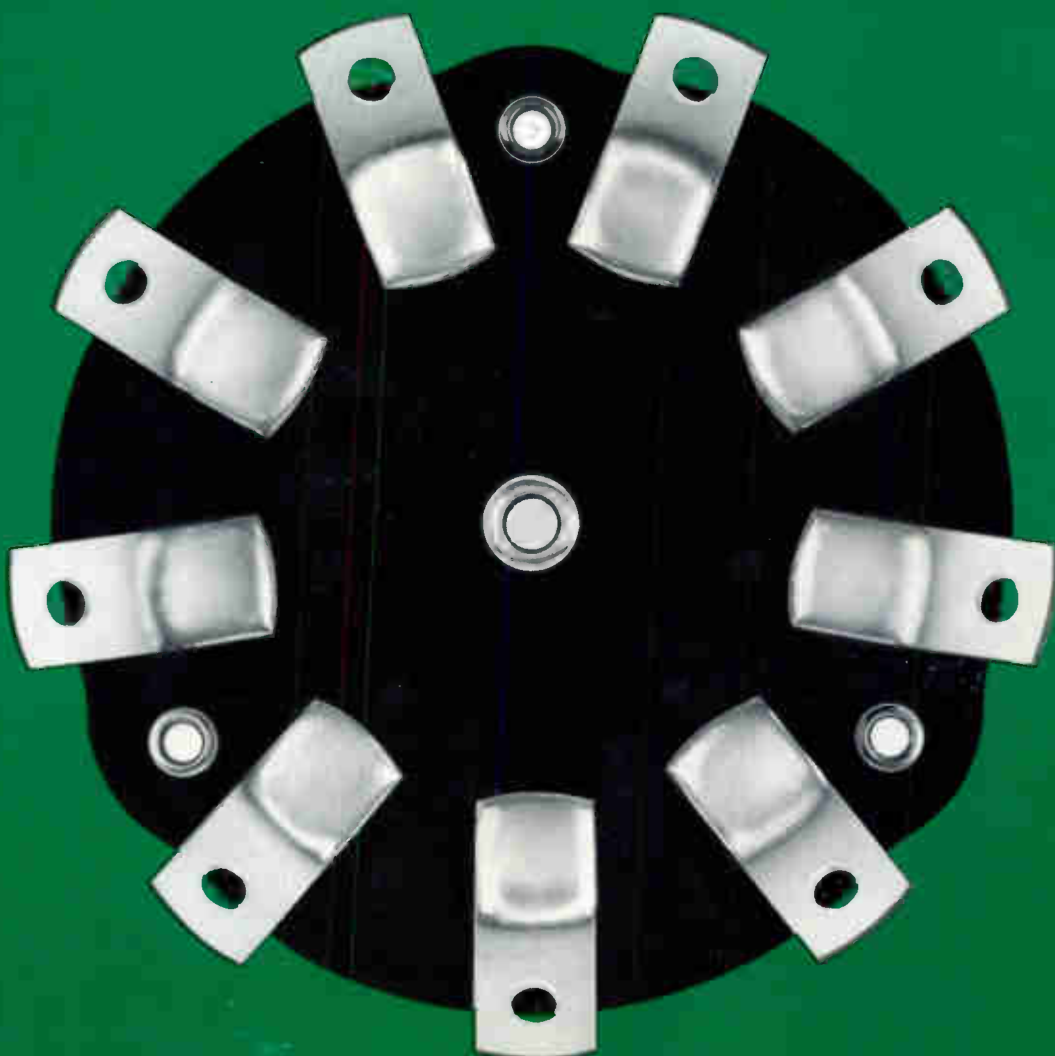
TAP SWITCHES
400

OHMITE

ROTARY TAP SWITCHES

CATALOG 401

AUGUST, 1970



ROTARY TAP SWITCHES

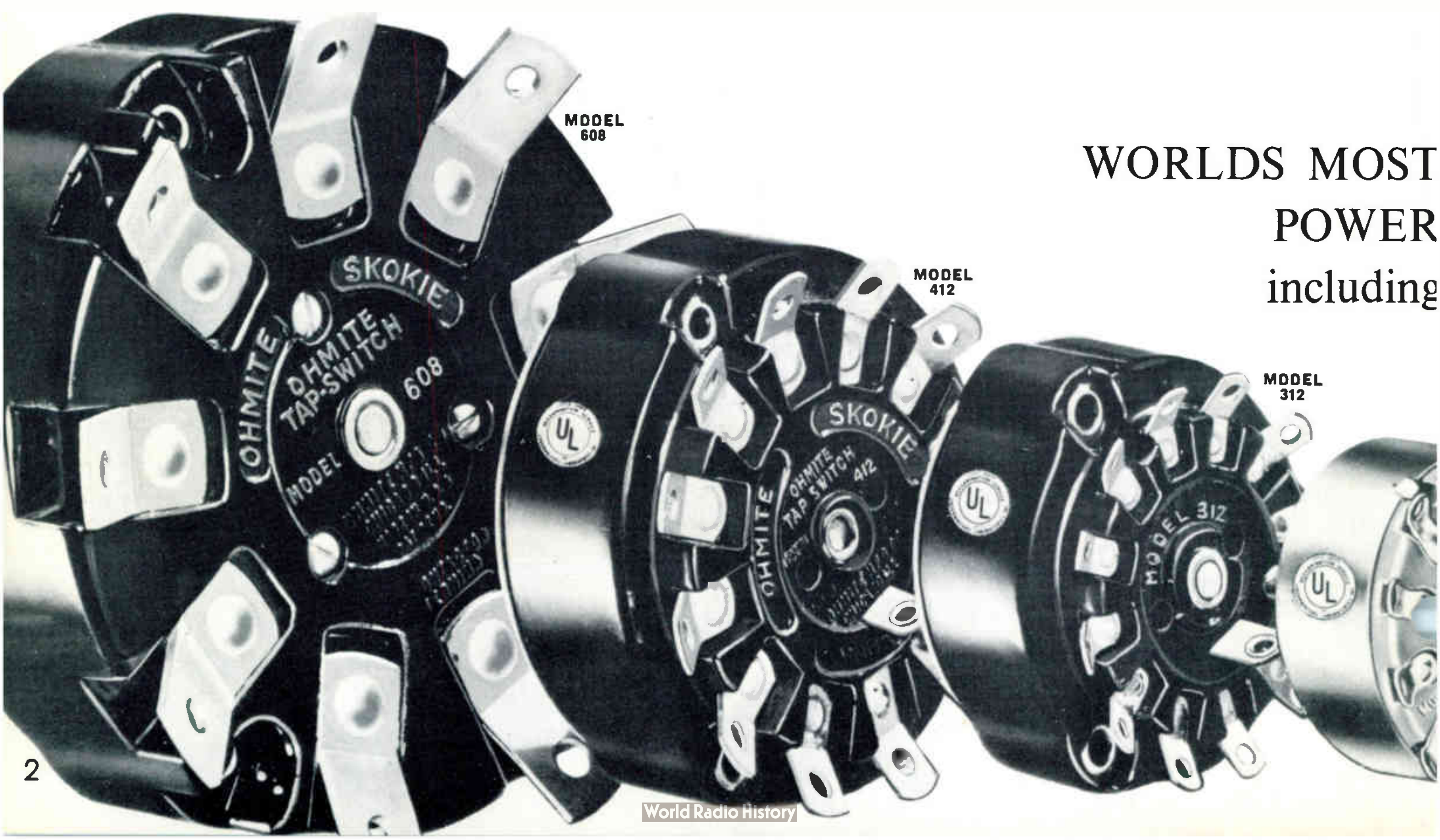
OHMITE

INDEX

Compactness, dependability and convenience in operation distinguish time-proven Ohmite rotary tap switches. Ceramic and metal construction (except melamine-phenolic for Model 711) assures resistance to arcing, burning and charring. These switches are designed particularly for heavy duty alternating current use. Each switch is a single-pole, rotary, multi-position unit which can be assembled in gangs or "tandems" of 2 or 3 to form multi-pole assemblies. Any number of positions can be provided on a switch up to the permissible maximum which is indicated in the description for each switch.

"POWER-TYPE" switches (enclosed except for Models 711 and 111) are offered in high current ratings of 15 to 100 amperes AC, although they may be used in DC circuits under proper conditions. These rugged non-shorting units are intended for load-break applications at these high currents. Contacts of these switches are thick, silver-alloy discs welded to copper studs. A cam and roller mechanism provides the "break" and "make" action.

"OPEN-TYPE" or unenclosed switches, the second variety, are designed to transfer much lighter currents (break 3 amperes, standstill 7 amperes). These switches employ taps consisting of monel metal bands. They are available in both non-shorting and shorting varieties and are described on page 11.



WORLDS MOST
POWER
including

Selection

LOAD: When the load consists of tungsten filament lamps, there is a starting surge which may be ten times the normal current. While Ohmite tap switches will withstand large surges, this factor should be allowed for in some measure, if operation is to be very frequent.

LIFE: All switches, regardless of type or manufacturer, are subject to mechanical and electrical wear and therefore have a useful life which may be very long but is obviously limited. The ratio between the actual current and the switch rating will have some effect on the life of the contacts. When the number of operations becomes very great, mechanical fatigue in the spring materials may be the determining factor. Special long-life switches can be supplied.

ENVIRONMENTAL CONDITIONS: The maximum standstill (or carrying current) of a switch is limited by the permissible temperature rise of the contacts and other parts. If the switch is to be used at an ambient temperature much higher than the 40°C standard reference, the rating may be affected. Recommendations made on request. The presence of dust in the application may dictate the use of an enclosed switch or special provisions.

ELECTRICAL RATINGS: The ratings given for Ohmite tap switches are for both interrupting and carrying operation except where otherwise indicated. The interrupting ratings for power-type switches conform to Underwriters' Laboratories spacings for use only on alternating current circuits, either inductive or non-inductive, i.e., at any power factor. Switches can be used, however, on higher voltages (300 V. for Model 111 or 212 and 600 V. for 312, 412 or 608) with reduced current where load-break is involved. Load-break switches for 440 or 600 V. use are provided with additional internal insulation. Current ratings are reduced on the basis of a fixed load wattage. The formula is:

$$I_{HI\text{-}V} = \frac{\text{Rated Volts}}{\text{High Volts}} \times \text{Rated Amps}$$

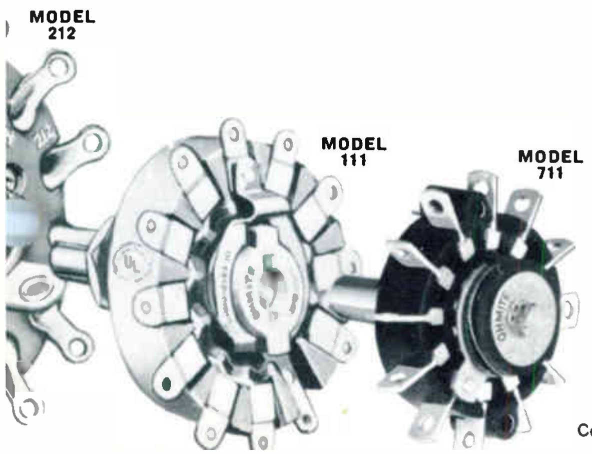
Full rated currents can be handled where load-break is not involved. Considerably greater currents can be handled where extremely short pulses are to be carried without load-break. Switches can be used also with rated line voltage between taps. (Also see "Stage Lighting Switch," page 9.) Use at conditions other than standard is not UL listed, except where special arrangements are made.

The switches may be used on direct current non-inductive circuits up to 20 volts at full current ratings; recommendations for other conditions will be supplied on request.

SWITCH INSULATION: Ohmite switches withstand testing at 2000 volts AC (except 1250 volts AC for Model 711) with the voltage applied either between taps or to ground (between contacts and shaft). However, such voltages should not be considered as the working voltage. Ceramic insulation, used in Models except 711, is permanent in nature, unaffected by age and resistant to arcing. Plastic material used in Model 711 has excellent physical and electrical stability and resistance to arc-tracking.

COMPLETE LINE OF TAP SWITCHES

the 711, smallest switch for its rating



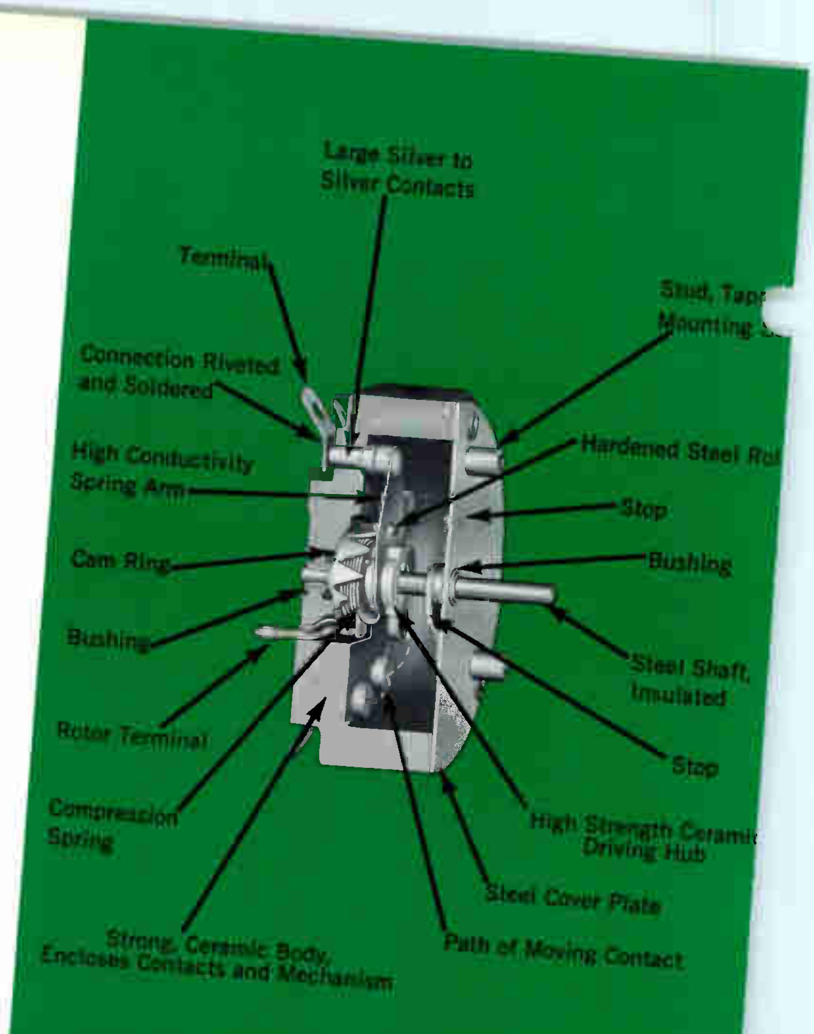
GUIDE TO OHMITE TAP SWITCHES

MODEL	Mode of Switching	RATINGS[4] AC Standard[1]	AC Extended[2]	DC Non-Ind. Load	Max. No. of Contacts
POWER-TYPE, STANDARD & MADE-TO-ORDER					
711	Non-Shorting	7A, 125V.	15A, 125V.[5]	7A, 20V.	11
111		15A, 125V.	7.5A, 250V.	15A, 20V.	11
212		20A, 150V.	10A, 300V.	20A, 20V.	12
312		30A, 300V.	15A, 600V.	30A, 20V.	12
412		50A, 300V.	25A, 600V.	50A, 20V.	12
608		100A, 300V.	50A, 600V.	100A, 20V.	8
OPEN-TYPE, STANDARD					
		Carry	Load Break	Non-Ind. Load	
T-50	Non-Shorting	7A.	3A, 120V.	3A, 20V.	8
T-100		7A.	3A, 120V.	3A, 20V.	12
T-50-S	Shorting	10A.	3A, 120V.	3A, 20V.	8
T-100-S		10A.	3A, 120V.	3A, 20V.	12
OPEN-TYPE, MADE-TO-ORDER					
T-25 to T-1000	Non-Shorting	5A to 32A	Note (3)	3A, 20V.	6 to 58
T-25-S to T-1000-S	Shorting	5A to 32A	Note (3)	3A, 20V.	11 to 77

NOTE: (1)—Standard rating is also U.L. rating for Models 111, 212, 312, and 412. (2)—See above for explanation of ratings. (3)—Ratings depend on contacts used. (4)—Ratings are load-break unless otherwise marked. (5)—Carry

OHMITE

POWER TAP SWITCHES



Cutaway view of typical enclosed power-type tap switch

Compactness for the current rating combined with high insulation value is the basis of this switch design. Ideal switch insulation is provided by the inert, arc-resistant ceramic material used in the heavy one-piece bodies. Switch shafts are electrically "dead," insulated by strong hubs of ceramic or, in some instances, reinforced plastic. Contacts and mechanism are enclosed and protected (except for Models 111 and 711).

The fixed contacts are large diameter, thick, silver-alloy discs permanently brazed to copper studs (inlaid silver-alloy on Model 111 one-piece contact-terminals). The studs are fastened to sturdy terminal lugs by both riveting and soldering to assure a permanent mechanical and electrical joint. The rotor (moving) contact is silver-alloy, generously proportioned and riveted and soldered to the contact arm. The face of the rotor contact is slightly rounded assuring a perfect seating of the contacts with a slight rubbing, self-cleaning motion on every operation.

The silver-to-silver contact feature of the Ohmite tap switch reduces contact resistance to a minimum and requires no maintenance.

The contact arm of high conductivity, non-ferrous spring metal, carries the current to the rotor terminal and provides strong pressure at the contacts. An independent coil spring maintains the pressure between the contact arm and the rotor terminal; the contacting surfaces are plated to assure continued good conductivity.

"Slow-Break" Mechanism Specially Designed for AC Use: A positive cam-and-roller mechanism provides the "slow-break, quick-make" action proved best for switching AC current. The relatively slow separation of the contacts means that the alternating current wave will most probably pass through zero value sometime during the separation, hence minimizing sparking and increasing contact life. The contact arm carries a steel roller which follows the contour of a fixed cam ring as the shaft is turned. This action lifts the contact arm and moving contact from one fixed contact and positions it on the next fixed contact with strong pressure and a slight wiping, self-cleaning action.

UL LISTINGS: Ohmite Tap Switches listed by the Underwriters' Laboratories, Inc. Reexamination Service, include Model 111, Model 212, Model 312 and Model 412 where the use in combination with other components or equipment has been accepted by Underwriters. Variations from the basic switch design, identified by suffixes A, B, C, D, E or H are also Underwriters' listed. Write for specific information. When an Underwriters' listed unit is required, specify on the order.

TANDEM (GANGED) SWITCHES

Switches assembled in gangs or in "tandem," form multi-pole arrangements. Tandem assemblies of power-type switches are stocked. Model 111 is stocked in 2-in-tandem; Models 212, 312, 412 and 608 are stocked in 2- and 3-in-tandem versions (see diagrams on pages 5, 6 and 7 for tandem dimensions). Standard panel thickness is 1/8" for Model 711; 1/4" for 111, 212, 312 and 412; and 1" for Model 608. For use on greater panel thicknesses, tandem assemblies must be made to order. Different models (including 111, 212, 312 and 412) may be combined in the same tandem assembly (3 switches maximum).

Two-in-tandem enclosed

Actual Size
Single unenclosed

MODEL 711 MINIATURE

BREAKS 7 AMPS., 125 VAC,
CARRIES 15 AMPS., 125 VOLTS

OHMITE

SPECIFICATIONS

DEPTH BEHIND PANEL: 13/16" max

DIAMETER: 9/16" overall.

SHAFT: 1/4" Diameter.

STANDARD MOUNTING: By means of 3/8"-32 bushing for 1/8" thick maximum panel, except 1/16" maximum panel for enclosed single switches (suffix "E"). *Four non-turn lug positions are possible* on the single, unenclosed switch. Recesses in body of switch permit positioning of non-turn washer at "12, 3, 6 and 9 o'clock."

MAXIMUM NO. OF TAPS: 11.

WEIGHT: .047 lb. approx. single unenclosed.

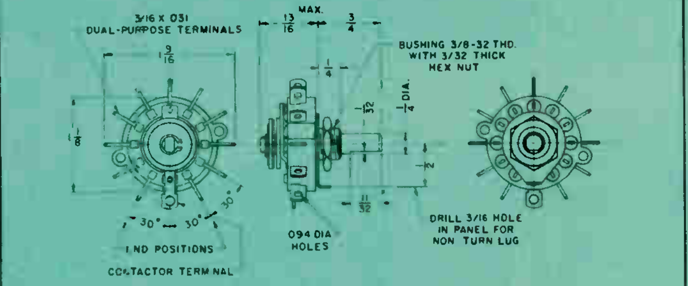
RECOMMENDED KNOB: Cat. No. 5103. Optional extra.

TORQUE: 7 to 12 inch-ounces.

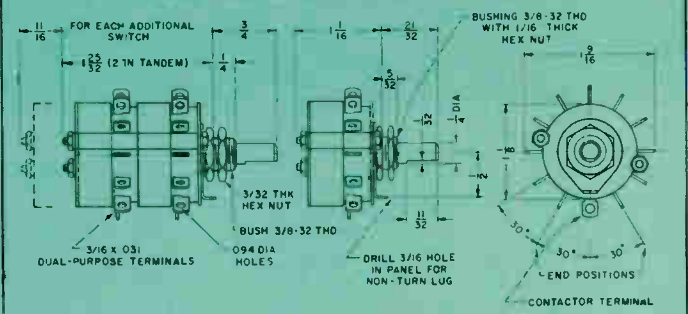
DUAL PURPOSE TERMINALS: Soldering or 3/16" quick-connectors.

AVAILABLE STYLES AND CODES: Single unenclosed and up to five-in-tandem assemblies are standard. Consult factory for tandems with more than five switches. (Tandem assemblies are inherently enclosed—see diagrams. To specify an *enclosed* single switch add an "E" to the catalog number as in "711-3E").

Single, unenclosed switch



Tandem assemblies and single enclosed



STANDARD MODEL 711 TAP SWITCHES

		Standard Single Unit Unenclosed*	Made-To-Order			
			2-in-Tandem	3-in-Tandem	4-in-Tandem	5-in-Tandem
Depth Behind Panel		13/16"	1[illegible]"	2[illegible]"	3[illegible]"	3[illegible]"
No. of Taps	Total Rotation	Cat.[1] No.	Cat. No.	Cat. No.	Cat. No.	Cat. No.
3	60°	711-3	711-3-T2	711-3-T3	711-3-T4	711-3-T5
4	90°	**711-4**	711-4-T2	711-4-T3	711-4-T4	711-4-T5
5	120°	711-5	711-5-T2	711-5-T3	711-5-T4	711-5-T5
6	150°	711-6	711-6-T2	711-6-T3	711-6-T4	711-6-T5
7	180°	(711-7)	711-7-T2	711-7-T3	711-7-T4	711-7-T5
8	210°	711-8	711-8-T2	711-8-T3	711-8-T4	711-8-T5
9	240°	(711-9)	711-9-T2	711-9-T3	711-9-T4	711-9-T5
10	270°	(711-10)	711-10-T2	711-10-T3	711-10-T4	711-10-T5
11	300°	(711-11)	711-11-T2	711-11-T3	711-11-T4	711-11-T5
Rec'mnd Knobs (see p. 10 for desc.)		Cat. No. 5103A	Cat. No. 5103A	Cat. No. 5116A	Cat. No. 5116A	Cat. No. 5116A

Add "E" suffix for enclosed version.

[1]Items in bold print are usually in stock. Items in light face are available from stocking distributors but are not normally stocked in depth. Parentheses indicate non-stock standard items subject to $15.00 per line item minimum charge.

MODEL 111

15 AMPS., 125 VAC.

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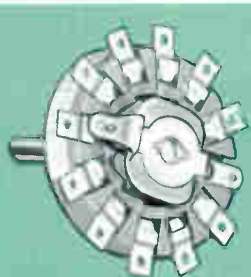


SPECIFICATIONS

SHAFT: 1/4" Diameter.

DIAMETER: 1 3/4".

STANDARD MOUNTING: For 1/4" panel, maximum, by means of 3/8"-32 bushing and hex. nut. A 3/16" hole is required for the non-turn washer No. 5050.

MAXIMUM NUMBER OF TAPS: 11.

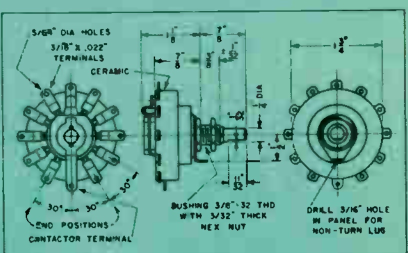
WEIGHT: 0.16 lbs. approximately.

RECOMMENDED KNOB: No. 5116A. Optional extra.

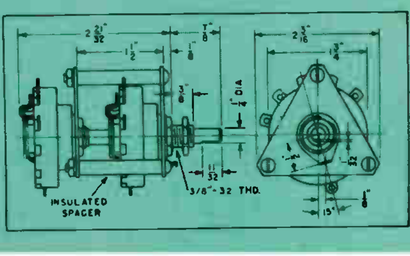
TORQUE: 1.5 to 3.8 inch-pounds, approximately.

TERMINALS: Soldering type. (Also quick-connect terminals —Model 111A, see page 9.)

Model 111 differs in type from the other switches in this series only by not being enclosed.



Single switch



Tandem assembly

		Single Unit	2 in Tandem
Depth Behind Panel		[illegible]	[illegible]
No. of Taps	Total Rotation	Catalog No.[1]	Catalog No.[1]
3	60°	**111-3**	**111-3 -T2**
4	90°	**111-4**	**111-4 -T2**
5	120°	**111-5**	**111-5 -T2**
6	150°	**111-6**	111-6 -T2
7	180°	**111-7**	(111-7 -T2)
8	210°	**111-8**	**111-8 -T2**
9	240°	**111-9**	(111-9 -T2)
10	270°	**111-10**	(111-10-T2)
11	300°	**111-11**	111-11-T2
Recommended Knobs—(See p. 10 for description)		Catalog No. 5150A or 5116A	Catalog No. 5109A or 5110A

[1]Items in bold print are usually in stock. Items in light face are less popular and therefore not normally stocked in depth. Parentheses indicate non-stock standard items subject to $15.00 per line item minimum charge.

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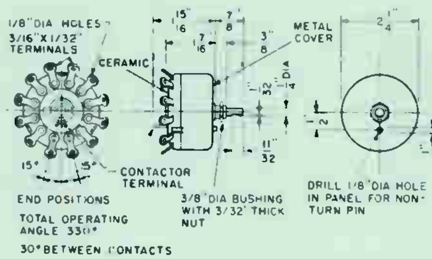
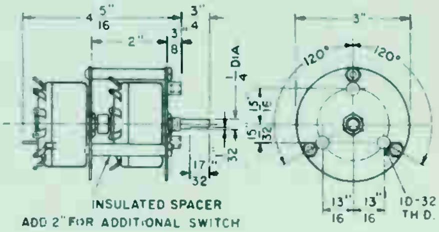
MODEL 212

20 AMPS., 150 VAC.



Single switch

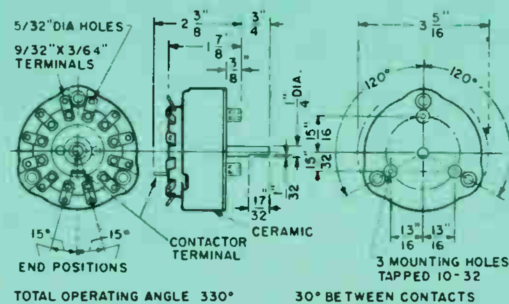


Tandem assembly

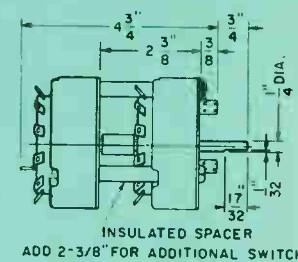
OHMITE

MODEL 312

30 AMPS., 300 VAC.
150 VOLTS BETWEEN TAPS.



Single switch

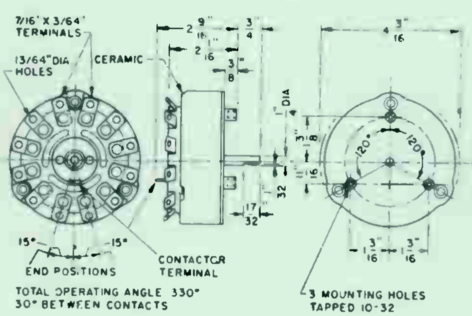


Tandem assembly

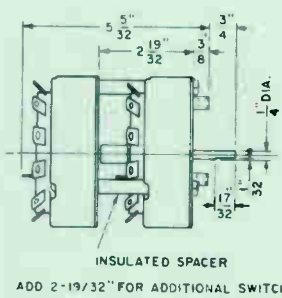
OHMITE

MODEL 412

50 AMPS., 300 VAC.
150 VOLTS BETWEEN TAPS.



Single switch

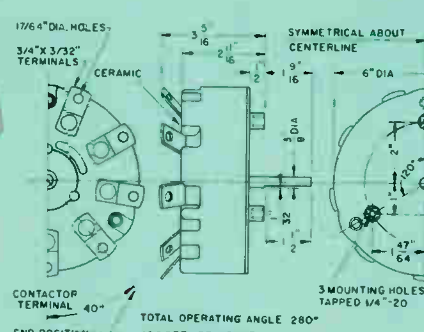


Tandem assembly

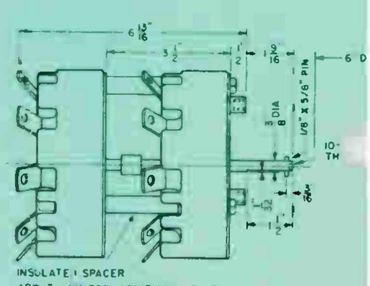
OHMITE

MODEL 608

100 AMPS., 300 VAC.



Single switch



Tandem assembly

SPECIFICATIONS

DIAMETER: 2¼".

SHAFT: ¼" Diameter.

STANDARD MOUNTING: For ¼" panel, maximum, by means of ⅜"-32 threaded bushing and hex. nut. A ⅛" hole is required for the non-turn pin.

MAXIMUM NUMBER OF TAPS: 12.

WEIGHT: 0.4 lbs. approximately.

RECOMMENDED KNOB: No. 5116A. Optional extra.

TORQUE: 3 to 7 inch-pounds, approximately.

TERMINALS: Soldering type. (Also quick-connect terminals —Model 212D, see page 9.)

Model 212 differs in type from the larger switches by having a cup-shaped metal cover.

Depth Behind Panel		Single Unit 1¾"	2 in Tandem 4 5/16"	3 in Tandem 6 5/16"
No. of Taps	Total Rotation	Catalog No.[1]	Catalog No.[1]	Catalog No.[1]
3	60°	**212-3**	**212- 3-T2**	212- 3-T3
4	90°	**212-4**	212- 4-T2	(212- 4-T3)
5	120°	**212-5**	(212- 5-T2)	(212- 5-T3)
6	150°	**212-6**	212- 6-T2	212- 6-T3
7	180°	212-7	(212- 7-T2)	(212- 7-T3)
8	210°	**212-8**	212- 8-T2	(212- 8-T3)
9	240°	**212-9**	(212- 9-T2)	(212- 9-T3)
10	270°	**212-10**	(212-10-T2)	(212-10-T3)
11	300°	**212-11**	(212-11-T2)	(212-11-T3)
12	330°	**212-12**	**212-12-T2**	(212-12-T3)
Recommended Knobs—(See p. 10 for description)		Catalog No. 5150A or 5116A	Catalog No. 5111A or 5112A	Catalog No. 5111A or 5112A

[1] Items in bold print are usually in stock. Items in light face are less popular and therefore not normally stocked in depth. Parentheses indicate non-stock standard items subject to $15.00 per line item minimum charge.

SPECIFICATIONS

DIAMETER: 3 5/16".

SHAFT: ¼" Diameter.

STANDARD MOUNTING: For ¼" panel, maximum. Three No. 10-32 flat-head machine screws ⅜" long are supplied. Drill 5/16" hole in panel for shaft.

MAXIMUM NUMBER OF TAPS: 12.

WEIGHT: 0.75 lb., approximately.

RECOMMENDED KNOB: No. 5109A. Optional Extra.

TORQUE: 3 to 7 inch-pounds, approximately.

TERMINALS: For use with soldering lugs, No. 6 screws or direct soldering.

Depth Behind Panel		Single Unit 2¼"	2 in Tandem 4¾"	3 in Tandem 7⅛"
No. of Taps	Total Rotation	Catalog No.[1]	Catalog No.[1]	Catalog No.[1]
3	60°	**312-3**	(312- 3-T2)	(312- 3-T3)
4	90°	**312-4**	(312- 4-T2)	312- 4-T3
5	120°	**312-5**	312- 5-T2	312- 5-T3
6	150°	**312-6**	311- 6-T2	(312- 6-T3)
7	180°	**312-7**	(312- 7-T2)	(312- 7-T3)
8	210°	**312-8**	312- 8-T2	**312- 8-T3**
9	240°	312-9	(312- 9-T2)	312- 9-T3
10	270°	**312-10**	(312-10-T2)	**312-10-T3**
11	300°	312-11	(312-11-T2)	(312-11-T3)
12	330°	**312-12**	(312-12-T2)	312-12-T3
Recommended Knobs (See p. 10 for description)		Catalog No. 5109A or 5110A	Catalog No. 5111A or 5112A	Catalog No. 5111A or 5112A

[1] Items in bold print are usually in stock. Items in light face are less popular and therefore not normally stocked in depth. Parentheses indicate non-stock standard items subject to $15.00 per line item minimum charge.

SPECIFICATIONS

DIAMETER: 4 3/16".

SHAFT: ¼" Diameter.

STANDARD MOUNTING: For ¼" panel, maximum. Three No. 10-32 flat-head machine screws ⅜" long are supplied. Drill 5/16" hole in panel for shaft

MAXIMUM NUMBER OF TAPS: 12.

WEIGHT: 1.4 lbs., approximately.

RECOMMENDED KNOB: No. 5111A. Optional extra.

TORQUE: 3 to 8 inch-pounds, approximately.

TERMINALS: For use with soldering lugs, No. 10 screws or direct soldering of wires.

Depth Behind Panel		Single Unit 2 9/16"	2 in Tandem 5 [illegible]"	3 in Tandem 7¾"
No. of Taps	Total Rotation	Catalog No.[1]	Catalog No.[1]	Catalog No.[1]
3	60°	412-3	412- 3-T2	(412- 3-T3)
4	90°	412-4	(412- 4-T2)	412- 4-T3
5	120°	412-5	(412- 5-T2)	412- 5-T3
6	150°	**412-6**	(412- 6-T2)	412- 6-T3
7	180°	412-7	412- 7-T2	(412- 7-T3)
8	210°	**412-8**	412- 8-T2	412- 8-T3
9	240°	412-9	(412- 9-T2)	(412- 9-T3)
10	270°	**412-10**	**412-10-T2**	**412-10-T3**
11	300°	**412-11**	(412-11-T2)	(412-11-T3)
12	330°	**412-12**	**412-12-T2**	412-12-T3
Recommended Knobs (see p. 10)		Catalog No. 5111A or 5112A	Catalog No. 5111A or 5112A	Catalog No. 5111A or 5112A

[1] Items in bold print are usually in stock. Items in light face are less popular and therefore not normally stocked in depth. Parentheses indicate non-stock standard items subject to $15.00 per line item minimum charge.

SPECIFICATIONS

DIAMETER: 6".

SHAFT: ⅜" Diameter.

STANDARD MOUNTING: For 1" panel, maximum. Three flat-head machine screws ¼"-20 × 1¼" long are supplied. Drill 7/16" hole in panel for shaft.

MAXIMUM NUMBER OF TAPS: 8.

WEIGHT: 5 lbs., approximately.

RECOMMENDED KNOB: No. 5104A. Optional extra.

TORQUE: 25 to 35 inch-pounds, approximately.

TERMINALS: For use with soldering lugs or ¼" bolts.

Depth Behind Panel		Single Unit 3 5/16"	2 in Tandem 6 13/16"	3 in Tandem 10 5/16"
No. of Taps	Total Rotation	Catalog No.[1]	Catalog No.[1]	Catalog No.[1]
3	80°	608-3	(608- 3-T2)	(608- 3-T3)
4	120°	608-4	(608- 4-T2)	(608- 4-T3)
5	160°	608-5	(608- 5-T2)	**608- 5-T3**
6	200°	**608-6**	608- 6-T2	608- 6-T3
7	240°	**608-7**	(608- 7-T2)	(608- 7-T3)
8	280°	**608-8**	**608- 8-T2**	**608- 8-T3**
Recommended Knobs (see p. 10)		Catalog No. 5104A or 5105A	Catalog No. 5104A or 5115A or 5105A	Catalog No. 5115

[1] Items in bold print are usually in stock. Items in light face are less popular and therefore not normally stocked in depth. Parentheses indicate non-stock standard items subject to $15.00 per line item minimum charge.

SPECIAL FEATURES

OHMITE

SPECIAL CONTACT SPACING

Switches with less than the maximum number of taps are furnished ordinarily with the standard contact spacing of 30° (40° for Model 608). However, switches of limited number of taps, as shown in the table, can be supplied with contacts spaced 2 or 3 times standard. Switches can be made, also, without a stop so that there are no end positions to the shaft rotation.

Model	Maximum No. of Taps	Tap Spacing	Total Rotation (Maximum)
212, 312, 412	6	60°	300°
212, 312, 412	4	90°	270°
608	4	80°	240°
608	3	120°	240°

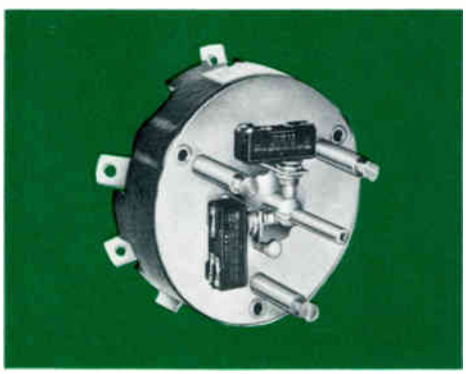
SPECIAL SHAFTS AND BUSHINGS

Standard switches can be mounted on any thickness of panel up to the maximum specified. Switches can be supplied at increased cost with shafts or bushings made for mounting on any of the following panel thicknesses: 1/8″, 1/2″, 3/4″, 1″, 1 1/2″ and 2″. Special length shafts can be provided also, as well as shafts without flat or with slot for screw driver adjustment, or with rear extension.

SWITCHES WITH OFF-POSITION

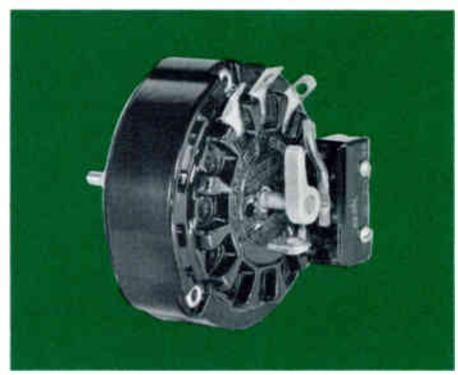
Model 608 can be supplied with 320° rotation, including eight contacts and an off-position at the contactor terminal location. In general, on switches where an off-position is desired, it is more economical for the user to leave one contact unwired than to call for an off-position on the switch. The latter requires special work, as the contact must be mounted in any case.

AUXILIARY SWITCHES



Model 608 with two auxiliary switches

Model 111 with toggle switch



Model 412 with sensitive switch

AUXILIARY SWITCH OPERATED AT EACH POSITION

All models of tap switches except Model 711 can be supplied with a sensitive switch which must be operated by pushing on the knob before the tap switch shaft can be rotated to another position. The sensitive switch is returned to its normal position when the knob is restored.

A tap switch with auxiliary switch is used in two general ways. So that any tap can be selected without operating intermediate taps, and without requiring use of a separately operated load switch, an auxiliary switch is connected in series with the tap switch common lead and serves to hold the circuit open while the knob is being rotated.

To use a tap switch as a selector for line voltage DC applications, the auxiliary switch controls a separate electro-magnetic contactor which opens and closes the load circuit.

Orders or inquiries should give complete description of the tap switch, auxiliary switch (including its load) operating requirements, and whether the auxiliary switch is to be supplied wired to the tap switch center lead.

AUXILIARY SWITCH OPERATED AT ONE POSITION ONLY

All models of tap switches except Model 711 can be supplied with a toggle switch or sensitive switch mounted on the tap switch and arranged so the auxiliary switch is operated when the tap switch shaft is rotated between a prescribed pair of contacts. Orders and inquiries should give complete description of tap switch, auxiliary switch and operating location.

SPECIAL TERMINALS

OHMITE

QUICK-CONNECT TERMINALS

Model 111 and 212 switches can be supplied with tab terminals designed to mate with ¼" "quick-connect" or "push-on" female connectors. This mode of connection is used where a sequence of wiring must be periodically modified or where accessibility for service is important. Savings may be effected in wiring of equipments through elimination of soldering and its attendant series of hand operations. Model "212D" is furnished with tab Type No. 53-25D for ¼" connectors only. Model "111A" is provided with tab Type No. 53-25B, Ohmite's exclusive "Three-Way" terminal. This unique terminal accommodates three different types of connection as follows:

Model 212D tap switch with quick-connect terminals

(1) Accepts standard ¼" female quick-connector

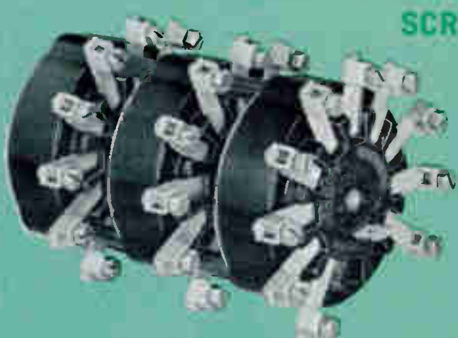
(2) Accepts 6-32 screw and nut

(3) Accepts soldering

Specify Model 111A or 212D where tab terminals are required.

Model 111A tap switch with Three-Way quick-connect terminals.

SCREW-CLAMP AND TWIN CABLE TERMINALS



SPECIAL SCREW-CLAMP terminals on 3-in-tandem Model 412 tap switch, simplify attachment of heavy cables.

Switch Models 312, 412 and 608 can be provided with special terminals to accommodate heavy cable or to suit unusual wiring schemes. Some users attach a lug to the wire, then bolt the lug to the switch terminal. With the screw-clamp terminal, the cable is merely inserted in the opening and clamped in place with the hex-head screw. This arrangement also permits quick changes of connections. Twin cable terminals facilitate parallel or multiple wiring to other components.

TWIN CABLE TERMINALS on Model 412 switch facilitate parallel connections to other switches. Cables may be crimped or soldered.

STAGE LIGHTING SWITCH FOR 208/240 VOLTS BETWEEN TAPS

Where 120 volt stage lighting or other circuits also present voltages of 208 volts (3-phase) or 240 volts (single phase) between adjacent taps, a modified Model 312, designated "312H" may be used. It is Underwriters' Laboratories listed. Load rating of the Model 312H is 20 amperes at 120 VAC for tungsten filament lamp circuits—the maximum allowed for stage lighting circuits. The greater voltages between taps occur when the terminals are connected to different phases of a three-phase system or to opposite sides of the familiar 120/240 volt 3-wire system. Various modifications, including the insertion of fibre barriers between external terminals, assure the necessary between-taps spacing. Same choice of number of taps as standard Model 312.

Model 312H

KNOBS, DIALS AND PANEL MARKINGS

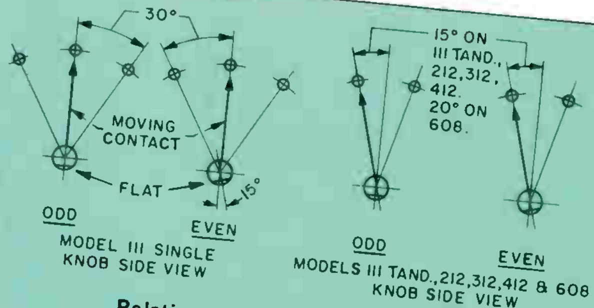
PANEL MARKINGS—

Tap Locations—Flats on Shafts

Panels should be marked so first and last positions are equally spaced counter-clockwise and clockwise from the top center-line, with the switch mounted with the center-lead down. Flats on the shafts of switches having odd or even numbers of taps are located differently so as to make this possible.

Viewed from the terminal side, the terminals are always divided around the switch top center-line as follows:

Model	Contact Arrangement
111	One more contact to left of top on even-numbered switches.
212, 312, 412, 608	One more contact to left of top on odd-numbered switches.



Relative location of flat on shaft

TAP SWITCH KNOBS

Knobs are made of black phenolic plastic. They fasten by means of two hexagon socket set screws, except No. 5150A which has only one and No. 5115 which requires a tapped hole and a driving pin as furnished on the shaft of the Model 608 tandem assembly. Pointers are nickel-plated.

Numbers 5150A, 5109A, 5110A and 5116A are for use with Models 111, 212, and 312; the larger knobs are preferred for Model 412 and the tandem versions of these models as well as the open-type switches. See recommendations with switch listings and with dial description.

Ordering: Specify knobs as a separate item.

Description	Knob Diameter	Hole Diameter	Pointer Radius	Catalog Number
Bar Knobs, 1¼″ long	—	¼″	⅝″	5103-A
Handwheel with Pointer	3¼″	⅜″	2$\frac{9}{32}$″	5104-A
Handwheel without Pointer	3¼″	⅜″	—	5105-A
Handwheel with Pointer	3¼″	¼″	2$\frac{9}{32}$″	5106-A
Handwheel without Pointer	3¼″	¼″	—	5107-A
Finger-Grip with Pointer	1⅝″	¼″	1$\frac{5}{32}$″	5109-A
Finger-Grip without Pointer	1⅝″	¼″	—	5110-A
Finger-Grip with Pointer	2⅜″	¼″	1$\frac{17}{32}$″	5111-A
Finger-Grip without Pointer	2⅜″	¼″	—	5112-A
Bar Knob, 4¾″ long	—	⅜″	1$\frac{15}{16}$″	5115
Bar Knob, 1½″ long	—	¼″	¾″	5116-A
Finger-Grip Knob	1½″	¼″	—	5150-A
Handwheel with Pointer	3¼″	¼″	1$\frac{13}{16}$″	5152-A

TAP SWITCH DIALS

Typical Tap Switch Dials

Dials are made with different numbers of taps from 2 to 12 to agree with the rotations of the various switches and in three diameters to coordinate properly with appropriate knobs. They are made of aluminum with the markings bright on a black background. Dials used with a single Model 111 or 212 are secured by the switch mounting nut. Other dials fasten by No. 6 screws (or the switch mounting screws, provided holes are pierced in the dials). Number of positions must be specified as a suffix to the catalog number.

For Model	Angle Between Taps	Positions	For Use With Knob	Dial Dia.	Cat. No. (Specify Positions as a Suffix)
111*	30°	2 to 11	5109A 5116A 5150A	2¾″	5002-....
212 (Single) 312 (Single)	30°	2 to 12			
212 (Tandem) 312 (Tandem) 412	30°	2 to 12	5111A 5152A	3¾″	5003-....
608	40°	2 to 8	5104A 5115	5½″	5004-....

*When Dial No. 5002 is used with Model 111 Tandem, the non-turn nib on the switch is not used to locate the dial.

OPEN TYPE SWITCHES

OHMITE

All-ceramic Open-type tap switches are designed to transfer currents of several amperes in circuits requiring high voltage insulation. The body consists of a porcelain base to which a porcelain ring, carrying the fixed contacts is vitreous enameled or otherwise secured. Contact is made to the monel metal taps by a silver-graphite brush of very low resistance. Ceramic parts which withstand a test voltage of **3000 VAC** insulate the bushing and shaft from the electrical circuit.

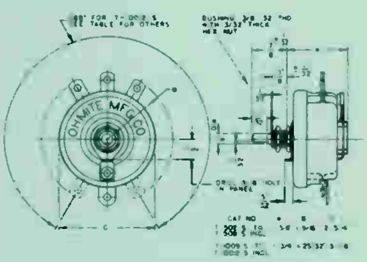
Made-to-Order: Ten diameters from 1⁹⁄₁₆" to 12" with the maximum possible number of contacts increasing with the diameter. The maximum voltage to be applied between adjacent contacts determines the minimum practicable spacing between the contacts.

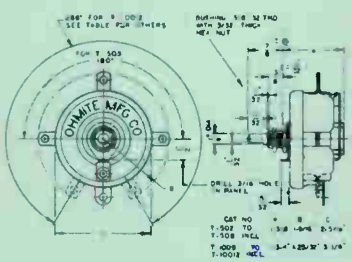
Angular Spacing and Rotation: The angle between taps on the non-shorting switches and the total rotation (up to the maximum) generally can be made as desired. Shorting type switches must have the contacts close together so the moving contact can bridge from one to the other in passing. The total angle of rotation increases with the number of contacts.

Switch Model†	Base Diameter	APPROX. MAX. NO. OF CONTACTS* Shorting ³⁄₁₆" ⁹⁄₃₂" ⅜" ½"	Non-Shorting ³⁄₁₆" ⁹⁄₃₂" ⅜" ½"	Maximum Angle of Rotation
T-25	1⁹⁄₁₆"	11, 8, — —	6, 5, — —	300°
T-50	2⁵⁄₁₆"	15, 11 — —	9, 8 — —	300°
T-75	2¾"	19, 14, 11 —	11, 9, 8 —	300°
T-100	3⅛"	21, 15, 12 —	17, 12, 11 —	300°
T-150	4"	27, 20, 16 —	22, 18, 15 —	300°
T-225	5"	— 28, 22, 17	— 25, 20. 16	310°
T-300	6"	— 35, 28, 21	— 28, 24. 19	315°
T-500	8"	— 48, 37, 29	— 37, 31, 25	325°
T-750	10"	— 63, 50, 38	— 47, 40, 33	330°
T-1000	12"	— 77. 61, 47	— 58, 49, 40	335°

*Number of contacts depends on type of contact and other factors. Consult factory.

†T-25 to T-150—¼" diameter shaft—⅜"-32 bushing mounting. T-225 to T-1000—⅜" diameter shaft—mounts by 2 screws.





Standard shorting switches					
No. of Contacts	Catalog No.†	Approx. Degrees Rotation	Dimensions A	B	C
4	(T-504 S)	90			
5	(T-505 S)	120			
6	(T-506 S)	150	1⅝"	1⁹⁄₁₆"	2⁵⁄₁₆"
7	(T-507 S)	180			
8	(T-508 S)	210			
9	(T-1009 S)	210			
10	(T-10010-S)	236	1¾"	1²⁵⁄₃₂"	3⅛"
11	(T-10011 S)	262			
12	(T-10012 S)	288			

Standard, non-shorting switches					
No. of Contacts	Catalog No.†	Approx. Degrees Rotation	Dimensions A	B	C
3	(T-503)	180			
4	(T-504)	180			
5	T-505	180	1⅝"	1⁹⁄₁₆"	2⁵⁄₁₆"
6	T-506	296			
7	(T-507)	270			
8	(T-508)	296			
9	(T-1009)	288			
10	(T-10010)	288	1¾"	1²⁵⁄₃₂"	3⅛"
11	(T-10011)	288			
12	(T-10012)	288			

†Parentheses indicate non-stock standard items subject to $15.00 per line item minimum charge. Avg. Wt. T-50_ Series .28 lbs. T-100_ Series .68 lb.

Shorting Type

Non-Shorting Type

Current and Voltage Ratings: The maximum *standstill* current varies with the model and lug width from 5A. on a T-25, to 32A. on the T-225 to T-1000 models. Solid silver-alloy fixed ontacts may be used on the higher currents and for better interrupting capacity. Interrupting currents vary with circuit conditions. Nominal maximum is 3A. at 120 VAC. Current ratings are less for all direct current circuits above 20 volts, for inductive circuits and for high voltages. Recommendations given on receipt of details. The load break rating is also somewhat dependent upon the desired life. While the stock switches are nominally insulated for 300 V. and the larger switches (T-225 and up) are insulated for 600 V., they are both frequently used at higher voltage, depending upon the application.

RATCHET MECHANISM: Ratchet mechanisms should be used on all shorting switches where sparking might otherwise occur, on all tandems and on other non-shorting, single-pole switches where increased indexing action is desired. The ratchet action indexing mechanism, definitely positions the moving contact over each tap. Maximum number of taps for use with ratchet is 15 on Models T-25 to T-50 and 20 on T-225 to T-1000. The mechanism adds to the depth behind the panel, ⁹⁄₃₂" for T-25 to T-150, ⁹⁄₁₆" for T-225 to T-1000. The switch mounts by two No. 10-32 screws located ¾" on each side of the shaft (as illustrated) for T-25 to T-150; ¼-20 screws on 1³⁄₁₆" centers are employed for the T-225 to T-1000 switches. Pairs of contacts can be bridged by a variation of the design.

When ordering Ratchet Action—Stopping on Lugs (Model TA), specify the Code Word RATAP

TANDEM MOUNTINGS: Tandems are limited usually to 2 decks and are not always practical when large numbers of contacts are involved. Ratchet-action is generally recommended. Consult factory for details on specific applications.

KNOBS: Refer to page 10.

OHMITE

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Ohmite Manufacturing Company a North American Philips company
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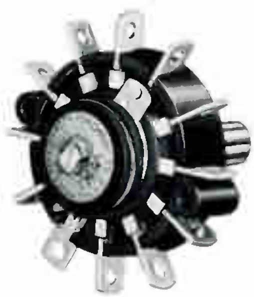
PRINTED IN U.S.A. FORM 262

Obsolete ? 12/70

OHMITE

MODEL 711 *Miniature* POWER TAP SWITCH

(Single-Pole, Non-Shorting Selector Switch)



ACTUAL SIZE

BREAKS 7 AMPS AT 125 VAC

CARRIES 15 AMPS

SMALLER.. THAN MANY LOW CURRENT, INSTRUMENT SWITCHES!

The Model 711 is definitely a power switch! You know that immediately when you learn its power rating—it interrupts 7 amperes at 125 VAC and carries 15 amperes at 125 volts AC or DC.

This single pole, non-shorting rotary selector switch, extends the Ohmite line of Power Tap Switches down to the "miniature" size classification (body diameter 1⅛″, depth behind panel 13/16″ max.) but nevertheless provides a unit which can handle a "man-sized" amount of current.

The culmination of over 28 years of experience in producing tap switches, the Model 711 embodies advanced design principles, generous use of quality materials and superior workmanship to make its extraordinary capability possible.

(See reverse side for data and listings.)

OHMITE MANUFACTURING COMPANY
3601 Howard Street, Skokie, Illinois 60076

BULLETIN 403

Model 711 *Miniature* Tap Switch

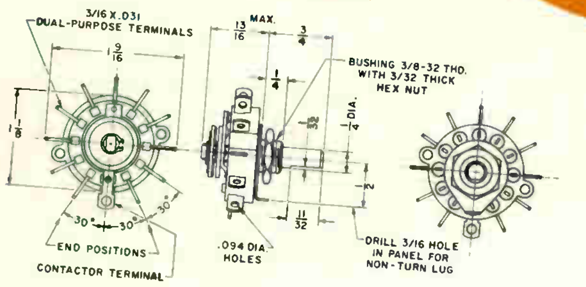
OHMITE

FEATURES and SPECIFICATIONS

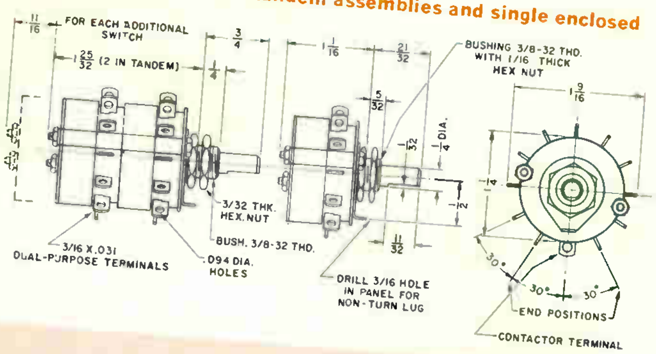
Two-in-tandem

switch assembly

Dimensions
single, unenclosed switch



Dimensions,
tandem assemblies and single enclosed



RATING: Interrupts 7 amperes at 125 VAC (75% power factor load); 7 amperes at 20 VDC, non-inductive load. Standstill (carry) rating, 15 amperes at 125 volts AC or DC.

SOLID SILVER ALLOY INLAY . . . for stationary contacts; silver alloy button for movable contact. Current is carried through thick conductors and not through assembly springs.

DUAL PURPOSE TERMINALS . . . allow connection by soldering or by means of 3⁄16″ female quick-connectors.

SLOW-BREAK, QUICK-MAKE ACTION . . . the action deemed best for switching of AC current is achieved with a cam and cam follower arrangement. This action provides positive indexing and a wiping, self-cleaning meeting of contacts to assure positive, low resistance connections.

HIGH INSULATION RESISTANCE . . . is provided by the melamine-phenolic body which resists the formation of arc tracks. Terminals positioned for maximum between-terminal insulation.

DIMENSIONS (single, unenclosed): Body diameter 1⅛″; overall diameter 1⁹⁄₁₆″; depth behind panel 13⁄16″ maximum. See diagrams for enclosed single and tandem assemblies.

MOUNTING: Mounts by means of ⅜-32 bushing for ⅛″ thick maximum panel, except 1⁄16″ maximum panel for enclosed single switches (suffix "E"). *Four non-turn lug positions are possible* on the single, unenclosed switch. Recesses in body of switch permit positioning of non-turn washer at "12, 3, 6 and 9 o'clock."

AVAILABLE STYLES and CODES: Single unenclosed and up to five-in-tandem assemblies are standard. Consult factory for tandems with more than five switches. (Tandem assemblies are inherently enclosed—see diagrams. To specify an *enclosed* single switch, add an "E" to the catalog number as in "711-2E.")

STANDARD MODEL 711 TAP SWITCHES†

		Single Unit Unenclosed*	2-in-Tandem	3-in-Tandem	4-in-Tandem	5-in-Tandem
Depth Behind Panel		13⁄16″	1 25⁄32″	2 15⁄32″	3 5⁄32″	3 27⁄32″
No. of Taps	Total Rotation	Cat. No.	Cat. No.	Cat. No.	Cat. No.	Cat. No.
2	30°	711-2	711-2-T2	711-2-T3	711-2-T4	711-2-T5
3	60°	711-3	711-3-T2	711-3-T3	711-3-T4	711-3-T5
4	90°	711-4	711-4-T2	711-4-T3	711-4-T4	711-4-T5
5	120°	711-5	711-5-T2	711-5-T3	711-5-T4	711-5-T5
6	150°	711-6	711-6-T2	711-6-T3	711-6-T4	711-6-T5
7	180°	711-7	711-7-T2	711-7-T3	711-7-T4	711-7-T5
8	210°	711-8	711-8-T2	711-8-T3	711-8-T4	711-8-T5
9	240°	711-9	711-9-T2	711-9-T3	711-9-T4	711-9-T5
10	270°	711-10	711-10-T2	711-10-T3	711-10-T4	711-10-T5
11	300°	711-11	711-11-T2	711-11-T3	711-11-T4	711-11-T5

*Weight .047 lb.; Add "E" suffix for enclosed version.
†Recommended knob: No. 5103

OHMITE MANUFACTURING COMPANY • 3601 HOWARD ST. • SKOKIE, ILLINOIS 60076

RESISTORS • RHEOSTATS • TAP SWITCHES • RELAYS • VARIABLE TRANSFORMERS
TANTALUM CAPACITORS • SOLID STATE CONTROLS • R. F. CHOKES

Printed in USA 2-67

VARIABLE TRANSFORMERS

VARIABLE TRANSFORMERS 500

CATALOG SEQUENCE 500

OHMITE

OHMITE

OHMITRAN vt®

VARIABLE TRANSFORMERS

CATALOG 501

JANUARY, 1971

Supersedes all previous catalogs and bulletins.

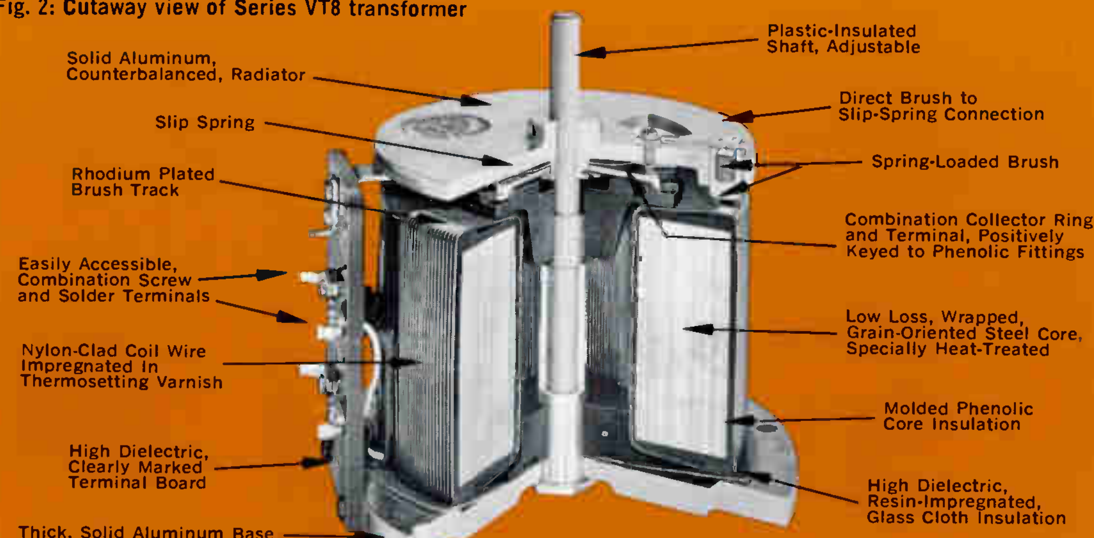
OHMITE

OHMITRAN v.t.® VARIABLE TRANSFORMERS

OHMITRAN v.t.® VARIABLE TRANSFORMERS

Unique for the design innovations they incorporate, Ohmite OHMITRAN v.t.® variable transformers include exclusive field-proven features. They offer long, low maintenance operation with excellent regulation at any voltage setting within the rated load plus an output free of waveform distortion. Six frame sizes offer a wide range of electrical ratings to meet most industrial applications. These include three new compact, low-power models (VT1, VT02, VT3) which permit a fine choice of six ratings from 1.3 to 3.3 amperes.

Fig. 2: Cutaway view of Series VT8 transformer



OHMITRAN v.t.® VARIABLE TRANSFORMER

INDEX

OHMITE Manufacturing Company

FEB 26 1971

February, 1971

Dear Ohmite Customer:

Meet the new breed of Ohmitran Variable Transformers for 1971.

Enclosed is our brand new catalog of Ohmite Variable Transformers. We think the many new items and changes incorporated into the V.T. line deserve your attention. Some highlights are:

1. Both U.L. and CSA approvals, where indicated.
2. New higher ratings: more amps for the money!
   A. New higher constant current ratings for Series VT1, VT02 and VT3.
   B. Addition of Constant Impedance ratings for all series.
   C. New "non U.L." ratings for VT4 Series.
3. Connection Schematics so that you can design your production wiring hook-ups from the catalog.
4. More descriptive information about lab bench types and other enclosed models.

Couple all these features with Ohmite's most competitive pricing, and you have one heck of a Variable Transformer source. Availability? Off-the-shelf from authorized stocking distributors listed on the back side of the enclosed price schedule. Or, if you prefer, from the factory.

Very truly yours,

OHMITE MANUFACTURING COMPANY

Max Sanders

Max Sanders
Director of Marketing

P.S.: Please insert Catalog 501 in section 500 of your Ohmite 3-ring binder. Please discard all previous publications.

MS:ss 280B

3601 Howard Street, Skokie, Illinois 60076 • Phone: (312) 675-2600 • TWX: 910-223-0805 • TELEX 72 4433

OHMITE
A North American Philips Company

MANUFACTURER'S PRICE SCHEDULE

OHMITE

FEB 26 1971

OHMITRAN *v.t.*® VARIABLE TRANSFORMERS

OHMITRAN *v.t.*® VARIABLE TRANSFORMER

Terms: 1%, 10th and 25th, net 30 days, F.O.B. our factory.
Prices subject to change without notice.

MAY 4, 1970

Prices shown are recommended resale schedules offered through authorized Ohmite stocking distributors. Prices for quantities greater than shown are available from your local Ohmite Sales Office or the Factory.

NUMBER	UNIT NET PRICES 1 -9	10 -24	25 -99	100 &UP
VT02	12.00	10.80	9.90	9.00
VT02E	18.50	16.65	15.26	13.88
VT02F	21.00	18.90	17.33	15.75
VT02N	12.00	10.80	9.90	9.00
VT02NE	18.50	16.65	15.26	13.88
VT02NF	21.00	18.90	17.33	15.75
VT1	12.50	11.25	10.31	9.38
VT1E	20.00	18.00	16.50	15.00
VT1F	23.00	20.70	18.98	17.25
VT1N	12.50	11.25	10.31	9.38
VT1NE	20.00	18.00	16.50	15.00
VT1NF	23.00	20.70	18.98	17.25
VT2LN	14.00	12.60	11.55	10.50
VT3	13.00	11.70	10.73	9.75
VT3N	13.00	11.70	10.73	9.75
VT4	17.50	15.75	14.44	13.13
VT4E	24.00	21.60	19.80	18.00
VT4F	26.00	23.40	21.45	19.50
VT4FC	30.50	27.45	25.16	22.88
VT4LN	20.00	18.00	16.50	15.00
VT4N	17.50	15.75	14.44	13.13
VT4NE	24.00	21.60	19.80	18.00
VT4NF	26.50	23.85	21.86	19.88
VT4NFC	30.50	27.45	25.16	22.88
VT8	23.00	20.70	18.98	17.25
VT8E	30.00	27.00	24.75	22.50
VT8F	32.00	28.80	26.40	24.00
VT8FC	35.75	32.18	29.49	26.81
VT8G	35.75	32.18	29.49	26.81
VT8GC	39.50	35.55	32.59	29.63
VT8GCV	75.00	67.50	61.88	56.25
VT8GCVA	112.00	100.80	92.40	84.00
VT8GCVW	151.00	135.90	124.58	113.25
VT8H	25.50	22.95	21.04	19.13
VT8HN	25.50	22.95	21.04	19.13
VT8LN	25.50	22.95	21.04	19.13
VT8N	23.00	20.70	18.98	17.25
VT8NE	29.75	26.78	24.54	22.31
VT8NF	32.00	28.80	26.40	24.00
VT8NFC	35.75	32.18	29.49	26.81
VT8NFCV	70.50	63.45	58.16	52.88
VT8NFCVA	109.00	98.10	89.93	81.75
VT8NFCVW	146.00	131.40	120.45	109.50
VT20	63.00	56.70	51.98	47.25
VT20B	69.00	62.10	56.93	51.75
VT20E	86.00	77.40	70.95	64.50
VT20FC	96.00	86.40	79.20	72.00
VT20GC	110.00	99.00	90.75	82.50
VT20GCV	158.00	142.20	130.35	118.50
VT20GCVA	196.00	176.40	161.70	147.00
VT20GCVW	281.00	252.90	231.83	210.75
VT20H	65.00	58.50	53.63	48.75
VT20HB	73.00	65.70	60.23	54.75

NUMBER	UNIT NET PRICES 1 -9	10 -24	25 -99	100 &UP
VT20HE	88.00	79.20	72.60	66.00
VT20HFC	98.00	88.20	80.85	73.50
VT20HN	65.00	58.50	53.63	48.75
VT20HNB	73.00	65.70	60.23	54.75
VT20HNE	88.00	79.20	72.60	66.00
VT20HNFC	98.00	88.20	80.85	73.50
VT20N	63.00	56.70	51.98	47.25
VT20NB	69.00	62.10	56.93	51.75
VT20NF	86.00	77.40	70.95	64.50
VT20NFC	96.00	86.40	79.20	72.00
VT20NFCV	143.00	128.70	117.98	107.25
VT20NFCVA	180.00	162.00	148.50	135.00
VT20NFCVW	265.00	238.50	218.63	198.75

NUMBER	UNIT NET PRICES 1 -4	5 -12	13 -49	50 &UP
VT02-2	36.00	32.40	29.70	27.00
VT02N-2	36.00	32.40	29.70	27.00
VT1-2	39.00	35.10	32.18	29.25
VT1N-2	39.00	35.10	32.18	29.25
VT3-2	37.50	33.75	30.94	28.13
VT3N-2	37.50	33.75	30.94	28.13
VT4-2	49.50	44.55	40.84	37.13
VT4N-2	49.50	44.55	40.84	37.13
VT8-2	61.00	54.90	50.33	45.75
VT8H-2	66.00	59.40	54.45	49.50
VT8HN-2	66.00	59.40	54.45	49.50
VT8N-2	61.00	54.90	50.33	45.75
VT20-2	144.00	129.60	118.80	108.00
VT20-2B	157.00	141.30	129.53	117.75
VT20H-2	149.00	134.10	122.93	111.75
VT20HN-2	149.00	134.10	122.93	111.75
VT20N-2	144.00	129.60	118.80	108.00
VT20N-2B	157.00	141.30	129.53	117.75

NUMBER	UNIT NET PRICES 1 -3	4 -8	9 -33	34 &UP
VT02-3	52.00	46.80	42.90	39.00
VT1-3	57.00	51.30	47.03	42.75
VT3-3	55.00	49.50	45.38	41.25
VT4-3	71.00	63.90	58.58	53.25
VT8-3	88.00	79.20	72.60	66.00
VT8-3E	107.00	96.30	88.28	80.25
VT8H-3	96.00	86.40	79.20	72.00
VT20-3	211.00	189.90	174.08	158.25
VT20-3B	231.00	207.90	190.58	173.25
VT20H-3	219.00	197.10	180.68	164.25
VT20HN-3	219.00	197.10	180.68	164.25
VT20N-3	211.00	189.90	174.08	158.25
VT20N-3B	231.00	207.90	190.58	173.25

Ohmite Manufacturing Company a North American Philips Company
3660 Howard Street, Skokie, Illinois 60076/Phone (312) 675-2600/TWX: 910-223-0805/TELEX 72-4433

OHMITE STOCKING DISTRIBUTORS
FOR VARIABLE TRANSFORMERS

STATE AND CITY	NAME	ADDRESS	ZIP	AREA CODE	TELEPHONE
ALASKA					
Anchorage	Yukon Radio Supply Co.	3222 Commercial Dr.	99501	907	277-1497
Fairbanks	Yukon Radio Sup. of Fairbanks, Inc.	1112 Cushman Street	99701	907	452-1011
ARIZONA					
Phoenix	Parts Electronic	1310 N. 7th St.	85006	602	258-6476
Phoenix	Sterling Electronics Corp.	1930 N. 22nd Ave.	85009	602	258-4531
Phoenix	R.V. Weatherford	1917 N. 25th Dr.	85005	602	272-7144
Tucson	Inland Electronic Supply Co.	715 E. Broadway	85717	602	624-4402
ARKANSAS					
Fort Smith	Wise Radio & T.V. Supply, Inc.	1001 Towson Avenue	72901	501	783-8926
CALIFORNIA					
Costa Mesa	H.W. Wright Co.	126 Rochester St.	92626	714	548-7745
El Monte	Kimball & Stark, Inc.	3053 N. Tyler Ave.	91734	213	444-2594
Hollywood	Yale Radio Electric Co.	6616 Sunset Blvd.	90028	213	465-3186
Inglewood	Newark Electronics Co., Inc.	4747 W. Century Blvd.	90309	213	678-0441
Los Angeles	California Electronic Supply Co.	1911 Armacost Ave.	90025	213	879-0760
Los Angeles	Radio Products Sales Inc.	1501 S. Hill St.	90015	213	748-1271
Palo Alto	Zack Electronics	654 High Street	94301	415	326-5432
Pasadena	Milo of California	1759 E. Colorado Blvd.	91106	213	681-8111
San Francisco	Zack Electronics	1444 Market Street	94102	415	626-1444
CONNECTICUT					
Waterbury	Bond Radio Supply Co.	439 Main Street	06702	203	753-1184
ILLINOIS					
Chicago	Allied Radio Corp.	100 N. Western	60680	312	829-9100
Chicago	Newark Electronics Inc.	500 N. Pulaski Rd.	60024	312	638-4411
Joliet	Keck Electric Corp.	1225 E. Washington St.	60434	815	726-6153
Oak Park	Melvin Electronics, Inc.	541 W. Madison St.	60302	312	385-5800
INDIANA					
South Bend	Radio Distribution Co., Inc.	1212 High Street	46624	219	287-2911
IOWA					
Cedar Rapids	Deeco, Inc.	2500 16th Ave., S.W.	52406	319	365-7551
KANSAS					
Wichita	Radio Electronic Co., Inc.	115 Loura	67211	316	267-5214
MAINE					
Portland	Holmes Distributors, Inc.	510 Cumberland Avenue	04104	207	774-5901
MARYLAND					
Rockville	Capitol Radio Wholesalers	12270 Wilkins Ave.	20852	301	881-2270
MASSACHUSETTS					
Boston	Sager Electrical Supply Co.	172 High Street	02107	617	542-2281
Cambridge	Electrical Supply Corp.	205 Alewife Brook Pkwy.	02138	617	491-3300
Dedham	Gerber Electronics	851 Providence Hwy.US Rt.1	02026	617	329-2400
Leominster	Plastic Molders Supply Co.	614 Main Street	01453	617	537-2495
Lynn	Land Electronics Supply Co.	9R Franklin Street	01902	617	592-2220
Medford	Empire Electrical Company	54 Mystic Avenue	02155	617	395-5000
Newton	Cramer Electronics	85 Wells Avenue	02159	617	969-7700
Springfield	T.F. Cushing, Inc.	1026 Bay Street	01101	413	788-7341
MICHIGAN					
Detroit	Newark Detroit Electronics	20700 Hubbell	48237	313	548-0250
Detroit	Radio Specialties Co.	12775 Lyndon St.	48227	313	272-4212
Grand Rapids	Newark Ind. Electronics	2114 S. Division	49507	616	452-1411
Muskegon	Western Electronic Supply	1781 5th St.	49440	616	722-7628
MINNESOTA					
Minneapolis	Newark Elect. Corp.	336 Hoover Street, N.E.	55143	612	331-6350
Minneapolis	Harry Starks, Inc.	112 Third Avenue, N.	55401	612	332-1325
St. Paul	Gopher Electronics	2520 W. Larpenteur	55113	612	645-0241
MISSISSIPPI					
Greenville	Tri-State Electronics, Inc.	223 Highway 1 South	39703	601	335-3594
MISSOURI					
Joplin	Four State Radio Supply	402 Wall Street	64801	417	624-0368
Kansas City	Walters Radio Supply, Inc.	3635 Main Street	64111	816	531-7015
St. Louis	Olive Industrial Electronics	6662 Olive Street	63130	314	863-7800
St. Louis	Van Sickle Radio Electronics	1915 Washington Street	63103	314	241-2700
NEBRASKA					
Lincoln	Scott Electronic Supply	4040 Adams Street	68504	402	434-8308
Omaha	Radio Equipt. Co. of Omaha	625 N. 18th Street	68102	402	341-7700
NEVADA					
Las Vegas	Industrial Electronics	300 W. Utah Street	89102	702	384-2151
NEW JERSEY					
Camden	General Radio Sup. Co.	600 N. Penn Street	08102	609	964-8560
Hanover	State Electronics Parts Corp.	36 Route 10	07936	201	887-2550
Pennsauken	Radio Electric Service Co.	Airport & Central Ave.	08110	609	662-4000
NEW YORK					
Farmingdale	Arrow Electronics, Inc.	900 Broad Hollow Rd.	11735	516	694-6800
Jamaica	Norman Radio Distributors, Inc.	94-29 Merrick Rd.	11433	212	739-4651
Lynbrook	Peerless Radio Corp.	19 Wilbur Street	11563	516	593-2121
New York	Terminal-Hudson Electronics, Inc.	236 W. 17th Street	10011	212	243-5200
Richmond Hill	Anchor Electronics Dist. Corp.	116-01 101st Street	11419	212	846-2420
OREGON					
Eugene	Vitus Electric	140 East Fifth Avenue	97401	503	345-4377
Klamath Falls	R.F. Supply	509 Commercial St.	97601	503	882-4451
Medford	Verl G. Walker Co.	205 W. Jackson Street	97501	503	773-7557
Portland	Consolidated Elect. Distrs.	2053 N.W. Upshur Street	97208	503	224-3200
Portland	Eoff Electric Co.	509 N.W. Tenth Avenue	97209	503	222-9411
PENNSYLVANIA					
Folcroft	Arrow Electronics	700 Carpenters Crossing	19032	215	534-3200
RHODE ISLAND					
Pawtucket	New England Electrical Co.	265 Pine Street	02860	401	725-7400
Providence	Wm. Dandreta & Company	28 Wolcott Street	02908	401	861-2800
Warwick	W.H. Edwards Co., Inc.	55 Electronic Drive	02888	401	781-8000
TENNESSEE					
Nashville	Randolph & Rice	1213 McGavock Street	37203	615	255-5602
TEXAS					
El Paso	Midland Specialty Co.	2235 Wyoming Ave.	79903	915	533-9555
WASHINGTON					
Seattle	Radar Electric Company	168 Western Avenue, W.	98119	206	282-2511
CANADA					
Willowdale Ont.	A.C. Simmonds & Sons, Ltd.	285 Yorkland Boulevard		416	491-1010

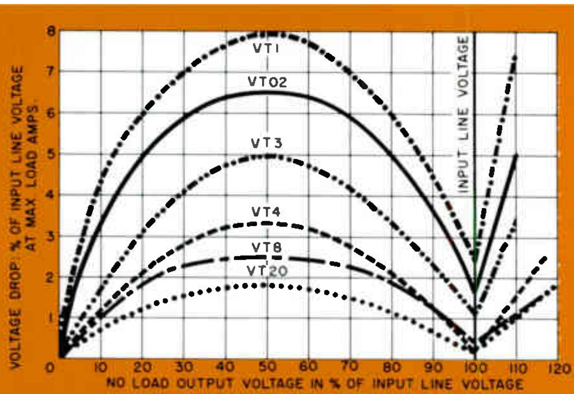


Fig. 3: Typical voltage regulation curves

Fig. 4: Derating for ambient temperatures above 50° C.

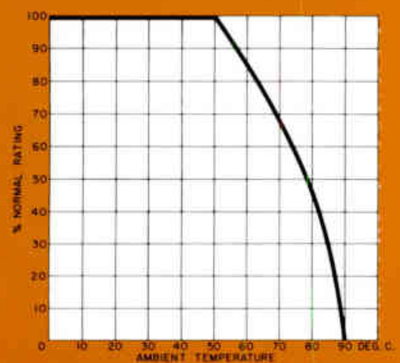
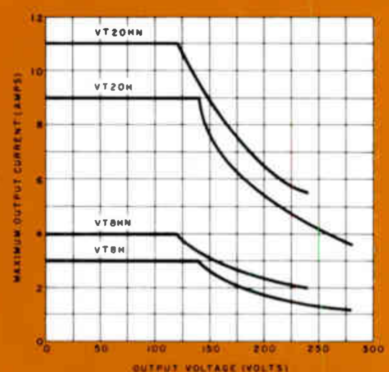


Fig. 5: Derating for use of 120-volt input on 240-volt transformers ("H" type).



FEATURES

POSITIVE CURRENT TRANSFER . . . achieved with specially designed brushes connected through high conductivity contact arms or pigtails to a large slip ring which contacts a wide area of the collector ring. The brush contact assembly on VT1, VT02, and VT3 is instantly replaceable, when necessary, as a result of a slide-on, snap-in design. Brushes of the other models are easily replaced also.

ADJUSTABLE SHAFT: On all Ohmitran v.t.® transformers, except the VT2LN, the shaft may be extended out from either the brush or opposite side as desired. On the VT1, VT02 and VT3, both single and tandem assemblies, this is an **exclusive** Ohmitran feature which affords greater versatility of mounting and application. For example, substitution of a longer shaft or extension of the standard shaft allows actuation of other devices, such as switches or potentiometers without special construction. The shaft is freed simply by loosening set screw in the hub assembly. A double flat on the shaft permits two knob positions.

On the VT4, VT8, and VT20 types, the adjustable shaft feature permits **table or panel use.** "Ganged" or tandem VT4, VT8 and VT20 units employ a thru-shaft offering the same flexibility. On VT4 and VT8 units, shafts are fixed in the desired position by means of socket head screws located in the hub of each "brush-radiator" plate. The VT20 employs a unique collet-type shaft lock.

INTERCHANGEABLE WITH OTHER POPULAR TYPES: Basic Ohmitran v.t.® units have mounting provisions which match those of virtually all popular transformers of comparable current rating. Models VT4, VT8 and VT20 mount by means of bolts. Normally 3-hole mounting, single VT4 units can be "4-hole mounted" by means of adapter plate, see page 9. Individual Model VT1, VT02, VT2LN, or VT3 units mount by means of a standard 3⁄8-32 threaded bushing. All tandem assemblies mount by means of bolts or nuts. Knob, dial and mounting hardware are included with each transformer.

EXCELLENT REGULATION: Figure 3 illustrates very negligible variation in output voltage from no-load to full-load current for all basic Ohmitran v.t.® models. The curves trace the voltage drop at any brush setting when full load is applied. Voltage drops for loads less than full load are proportional.

ENCLOSED OR CASED UNITS: In gray hammer tone finish. **Basic protective enclosures** (Type B) expose the transformer's terminal panel and mounting base and are supplied on VT20 models only. (See tandems in "B" enclosures on page 12 and 13.) **Fixed mounting enclosures** (Type E) are intended for permanent mounting on table, panel or in-conduit-line. **Standard portable units** (Type F) carry a line cord, outlet socket, and fuse except for VT20F which has a circuit breaker. **Deluxe portable units** (Type G), available for VT8 and VT20 models utilize a circuit breaker, can be switched to overvoltage or no-overvoltage as desired and have a handle which also serves as an easel.

METERED ENCLOSURES: VT8NFC, VT8GC, VT20NFC and VT20GC transformers are available with voltmeter (V), voltmeter and ammeter (A) or voltmeter and Wattmeter (W). The metered transformer enclosures are larger than the non-metered types of comparable designation, (see dimensions in tables on pages 10 and 13). All stock metered units have the three-conductor grounded cord and outlet. All except the VT8NF group, are equipped with carrying handles.

TANDEM OR GANGED UNITS: Two or 3-in-tandem assemblies are standard. Larger tandem assemblies available made-to-order. Standard 2-in-tandem assemblies are normally factory wired for series or open delta-connection; 3-in-tandem assemblies are normally wired for wye-connection, unless otherwise specified. A few cased tandems are stocked. Tandems in "B" type enclosures have individual cases on each transformer.

DIRECT READING, TWO-SCALE DIAL . . . calibrated on one side for overvoltage connection; on the reverse side for line voltage connection. Dials normally included with transformers are voltage calibrated (except LN types) and read clockwise for increasing voltage; counter-clockwise calibration and "percent-of-output" types, calibrated from 0-100, are also available—see page 15.

TEMPERATURE: Ratings are based on an ambient temperature from −55°C to +50°C. For applications operating continuously in ambients higher than 50°C, the output current is derated according to the curve shown in Figure 4.

UL and CSA LISTING: A number of Ohmitran v.t.® transformers used for 120 volt line operation are Underwriters' Laboratories and Canadian Standards Association listed. For details, see tables contained in each frame size description section and Application/Selection Guide, page 5.

LINE FREQUENCY RATINGS: Most VT1, VT02 and VT3 types—60 to over 1000 cps, some from 50 cps where indicated. All VT4, VT8 and VT20 types—50 to over 1000 cps except where otherwise indicated.

OHMITE

WIRING AND CONNECTIONS

WIRING AND CONNECTIONS: Wiring instructions to arrange various modes of operation are enclosed with all OHMITE variable transformers. Terminal panels or adjacent nameplate carry convenient wiring diagram, coded terminals and input and output data. Three way terminals on VT1, VT2LN, VT02, VT3 will accept ¼" push-on connectors, screws and nuts, or conventional soldering.

ROTATION OPTION: On VT4, VT8 and VT20 transformers connected for overvoltage, either clockwise or counter-clockwise increase of voltage can be arranged easily by the user. Increasing voltage in either direction can be arranged on all units connected for no-overvoltage output. Dials for counter-clockwise operation are stocked. See page 15.

OVERVOLTAGE OPTION: On all transformers with overvoltage feature, (Fig. 6A), a choice of either overvoltage or no-overvoltage operation can be arranged on the terminal panel. The overvoltage feature allows compensation to be made for a 10 percent drop in line voltage and thus provides a wider working range.

NO-OVERVOLTAGE TRANSFORMERS ("N" suffix): Provide considerably more current due to heavier gage winding.

240-VOLT INPUT ("H" suffix): On units which are wound for 240-volt input, a 120 volt input tap is also provided. With the use of this input, the maximum current rating applies up to 120 volts output but beyond this reduces proportionately to approximately 50% at maximum voltage output. See Fig. 5, page 3.

LOW VOLTAGE INPUT ("L" suffix): Designed for a maximum input of approximately 40 volts, with high current output.

GROUNDED INPUT & OUTPUT ("C" suffix): Units in type F or G cases can be provided with a three-conductor cord and outlet. One conductor is grounded to the case. This feature standard on all cased VT20 units and on all metered units.

WIRING TANDEM ASSEMBLIES: Tandem assemblies may be wired for individual unit operation. Two-in-tandem assemblies can also be wired for series or open-delta connection; **series** for single-phase input at a line voltage double that of the individual transformer's input rating, with or without overvoltage output (see Fig. 6D); **open delta** for 3-phase input, with or without overvoltage output (see Fig. 6F).

Three-in-tandem assemblies may be wired for wye connection, 3-phase input at line voltage double that of the individual transformer's input rating, with or without overvoltage output (see Fig. 6H).

No-overvoltage (N suffix) type transformers can be connected as discussed above but without overvoltage option. See model descriptions and Application/Selection Guide, page 5, for details.

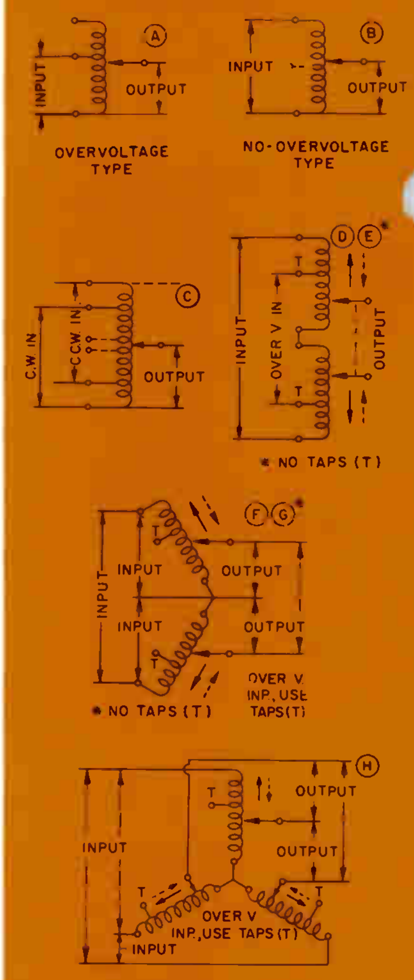


Fig. 6: Simplified basic transformer circuits. (In the case of VT4, VT8 and VT20 types, circuits D, F and H would also have overvoltage taps for CCW rotation. Taps shown in dotted line in circuits B and C represent 120 volt inputs on "H" models only.)

ORDERING INFORMATION

Catalog Number Feature Suffix Codes Explained

The physical or frame size of a given variable transformer is indicated by a basic catalog number, such as VT1 or VT8. Optional features are indicated by suffixes to the basic catalog number such as VT8N-2 which specifies two units of VT8 frame size, in tandem, each wound without overvoltage feature. Order from table of available types given for each basic size. For special features, combinations of features not listed and motor driven assemblies, Ohmite invites your inquiries.

SUFFIX	FEATURE
A.	Built-in Ammeter for portable style enclosures.
B.	Protective enclosure with basic transformer's terminal panel and base exposed.
C.	3-conductor, grounded input line and output receptacle.
E.	Enclosure with knockouts for permanent mounting in a conduit line.
F.	Portable enclosure with switch, line cord/plug, outlet receptacle and fuse.
G.	Deluxe portable enclosure with 3-position switch to select nominal or overvoltage and "off," has line cord/plug, outlet recepticle, circuit breaker and adjustable handle.
H.	240 volt input, has tap for 120-volt input with 240 or 280 volt output.
L.	Low voltage input and output (40 V. max.), high current output.
N.	No overvoltage provision for higher current rating.
V.	Built-in Voltmeter for portable style enclosures.
W.	Built-in Wattmeter for portable style enclosures.
—2	Two transformers assembled in tandem.
—3	Three transformers assembled in tandem.

APPLICATION/SELECTION GUIDE STANDARD TRANSFORMERS

OHMITE

SINGLE PHASE

SINGLE TRANSFORMERS—UNCASED

Input Volts	Freq. Hz from[1]	Feature or Connection	UL / SA footnotes	Maximum Output Volts	Maximum Output Amps	Catalog No.[13]	Wt. Lbs.[7]
40	50	Hi-amps, low volts		0-40	5.0	VT2LN	2.4
40	50	Hi-amps, low volts	14	0-40	12.0	VT4LN	5.25
40	50	Hi-amps, low volts	14	0-40	22.0	VT8LN	10.25
120	60[8]	Basic 1.3A Model	14	0-120/132	1.3	VT1	1.5
120	60	No overvoltage	14	0-120	1.5	VT1N	1.5
120	60[8]	Basic 2.0A Model	14	0-120/132	2.0	VT02	2.25
120	60	No overvoltage	14	0-120	2.5	VT02N	2.25
120	60[8]	Basic 3.0A Model	11	0-120/132	3.0	VT3	3.0
120	60	No overvoltage	11	0-120	3.3	VT3N	3.0
120	50	Basic 3.5A Model	11, 14	0-120/140	3.5	VT4	5.25
120	50	No overvoltage	11, 14	0-120	4.75	VT4N	5.25
120	50	Basic 7.5A Model	11, 14	0-120/140	7.5	VT8	10.25
120	50	No overvoltage	11, 14	0-120	10.0	VT8N	10.25
120	50	Basic 20A Model	11	0-120/140	20.0	VT20	22.0
120	50	No overvoltage	11	0-120	25.0	VT20N	22.0
240[2]	50	240V Input[2]	11	0-240/280	3.0	VT8H	10.25
240[2]	50	240V In. No ovrvlt.[2]	14	0-240	4.0	VT8HN	10.25
240[2]	50	240V Input[2]		0-240/280	9.0	VT20H	22.0
240[2]	50	240V In. No ovrvlt.[2]		0-240	11.0	VT20HN	22.0

SINGLE TRANSFORMERS—CASED

Input Volts	Freq. Hz from[1]	Feature or Connection	UL / SA footnotes	Maximum Output Volts	Maximum Output Amps	Catalog No.[13]	Wt. Lbs.[7]
120	60[8]	Fixed Mtg.		0-120/132[4]	.8	VT1E	1.9
120	60[8]	Portable		0-132[3]	1.0	VT1F	2.3
120	60	Fixed Mtg.		0-120	1.0	VT1NE	1.9
120	60	Portable		0-120	1.2	VT1NF	2.3
120	60[8]	Fixed Mtg.		0-120/132[4]	1.4	VT02E	2.8
120	60[8]	Portable		0-132[3]	1.75	VT02F	3.2
120	60	Fixed Mtg.		0-120	1.6	VT02NE	2.8
120	60	Portable		0-120	2.0	VT02NF	3.2
120	50	Fixed Mtg.	12, 15	0-120/140[4]	2.8	VT4E	7.4
120	50	Portable	12	0-140[3]	3.5	VT4F	7.8
120	50	VT4F w/gnd. in. & out.	12, 15	0-140[3]	3.5	VT4FC	7.8
120	50	Fixed Mtg.	15	0-120	3.8	VT4NE	7.4
120	50	Portable		0-120	4.75	VT4NF	7.8
120	50	VT4NF w/gnd. in. & out.	15	0-120	4.75	VT4NFC	7.8
120	50	Fixed Mtg.	12, 15	0-120/140[4]	6.0	VT8E	13.5
120	50	Portable	12	0-140[3]	7.5	VT8F	13.8
120	50	VT8F w/gnd. in. & out.	12, 15	0-140[3]	7.5	VT8FC	13.8
120	50	Deluxe Portable	12	0-120/140[3]	6.0	VT8G	14.2
120	50	VT8G w/gnd. in. & out.	12, 15	0-120/140[3]	6.0	VT8GC	14.2
120	50	Fixed Mtg.	15	0-120	8.0	VT8NE	13.5
120	50	Portable		0-120	10.0	VT8NF	13.8
120	50	VT8NF w/gnd. in. & out.	15	0-120	10.0	VT8NFC	13.8
120	50	Basic Case		0-120/140	20.0	VT20B	22.5
120	50	Basic Case		0-120	25.0	VT20NB	22.5
120	50	Fixed Mtg.	12	0-120/140[4]	16.0	VT20E	29.0
120	50	Portable		0-140	20.0	VT20FC	31.0
120	50	Portable	12	0-120/140[3]	16.0	VT20GC	31.0
120	50	Fixed Mtg.	12	0-120	20.0	VT20NE	29.0
120	50	Portable		0-120	25.0	VT20NFC	31.0
240[2]	50	Basic Case		0-240/280	9.0	VT20HB	22.5
240[2]	50	Basic Case		0-240	11.0	VT20HNB	22.5
240[2]	50	Fixed Mtg.		0-240/280[4]	7.2	VT20HE	28.0
240[2]	50	Fixed Mtg.		0-240	8.8	VT20HNE	28.0
240[2]	50	Portable		0-240/280	9.0	VT20HFC	30.0
240[2]	50	Portable		0-240	11.0	VT20HNFC	30.0

SINGLE TRANSFORMERS—CASED WITH METERS

Input Volts	Freq. Hz from[1]	Feature or Connection	UL / SA footnotes	Maximum Output Volts	Maximum Output Amps	Catalog No.[13]	Wt. Lbs.[7]
120	50	w/voltmeter, gnd. conn.	15	0-120/140[3]	6.0	VT8GCV	15.2
120	50	w/volt. & ammtr., gnd. conn.	15	0-120/140[3]	6.0	VT8GCVA	15.5
120	50	w/volt. & wattmtr., gnd. conn.	15	0-120/140[3]	6.0	VT8GCVW	15.5
120	50	w/voltmeter, gnd. conn.	15	0-120	10.0	VT8NFCV	14.8

Notes:
[1] Frequency shown is a minimum—units may be used up to 1000 cps.
[2] VT8H, VT8HN, VT20H, VT20HN also have taps for 120V input with 280V output for VT8H and VT20H and 240V output for VT8HN and VT20HN. With use of 120V input the max. current rating applies up to 120V output but reduces to approx. 50% at max. output voltage. In the case of tandem units use of the low voltage inputs would correspondingly derate the current at the higher output voltages.
[3] Connected at factory for overvoltage output—easily reconnected by user for no-overvoltage output. On VT8G and VT20G, switch selects overvoltage or no overvoltage.
[4] User wires for desired output. Dial normally calibrated for overvoltage.
[5] 2-in-tandem normally wired for series connection: 3-in-tandem for Y connection.
[6] When transformers are series connected, load cannot be grounded.
[7] Includes knob, dial and mounting hardware.
[8] May be used at 50 Hz if connected for no-overvoltage output.

SINGLE PHASE (contd.)

SINGLE TRANSFORMERS—CASED WITH METERS (contd.)

Input Volts	Freq. Hz from[1]	Feature or Connection	UL / SA footnotes	Maximum Output Volts	Maximum Output Amps	Catalog No.[13]	Wt. Lbs.[7]
120	50	w/volt. & ammtr., gnd. conn.	15	0-120	10.0	VT8NFCVA	15.2
120	50	w/volt. & wattmtr., gnd. conn.	15	0-120	10.0	VT8NFCVW	15.2
120	50	w/voltmeter, gnd. conn.		0-120/140[3]	16.0	VT20GCV	32.0
120	50	w/volt. & ammtr., gnd. conn.		0-120/140[3]	16.0	VT20GCVA	32.2
120	50	w/volt. & wattmtr., gnd. conn.		0-120/140[3]	16.0	VT20GCVW	32.2
120	50	w/voltmeter, gnd. conn.		0-120	25.0	VT20NFCV	32.0
120	50	w/volt. & ammtr., gnd. conn.		0-120	25.0	VT20NFCVA	32.2
120	50	w/volt. & wattmtr., gnd. conn.		0-120	25.0	VT20NFCVW	32.2

TWO IN TANDEM ASSEMBLIES [5] [10] (Dimensions p. 33)

Input Volts	Freq. Hz from[1]	Feature or Connection	UL / SA footnotes	Maximum Output Volts	Maximum Output Amps	Catalog No.[13]	Wt. Lbs.[7]
240	60[8]	Series Conn.[6]	14	0-240/264	1.3	VT1-2	3.5
240	60	Series Conn.[6]	14	0-240	1.5	VT1N-2	3.5
240	60[8]	Series Conn.[6]	14	0-240/264	2.0	VT02-2	5.25
240	60	Series Conn.[6]	14	0-240	2.5	VT02N-2	5.25
240	60[8]	Series Conn.[6]	14	0-240/264	3.0	VT3-2	6.5
240	60	Series Conn.[6]	14	0-240	3.3	VT3N-2	6.5
240	50	Series Conn.[6]	11, 14	0-240/280	3.5	VT4-2	11.3
240	50	Series Conn.[6]	11, 14	0-240	4.75	VT4N-2	11.3
240	50	Series Conn.[6]	11, 14	0-240/280	7.5	VT8-2	20.6
240	50	Series Conn.[6]	11, 14	0-240	10.0	VT8N-2	20.6
240	50	Series Conn.[6]	11, 14	0-240/280	20.0	VT20-2	45.0
240	50	Above unit, B case		0-240/280	20.0	VT20-2B	46.0
240	50	Series Conn.[6]	11	0-240	25.0	VT20N-2	45.0
240	50	Above unit, B case		0-240	25.0	VT20N-2B	46.0
480[2]	50	Series Conn.[6]		0-480/560	3.0	VT8H-2	20.6
480[2]	50	Series Conn.[6]		0-480	4.0	VT8HN-2	20.6
480[2]	50	Series Conn.[6]		0-480/560	9.0	VT20H-2	43
480[2]	50	Series Conn.[6]		0-480	11.0	VT20HN-2	43

THREE PHASE

Input Volts	Freq. Hz from[1]	Feature or Connection	UL / SA footnotes	Maximum Output Volts	Maximum Output Amps	Catalog No.[13]	Wt. Lbs.[7]
120	60[8]	Open Delta Conn.	14	0-120/132	1.3	VT1-2	3.5
120	60	Open Delta Conn.	14	0-120	1.5	VT1N-2	3.5
120	60[8]	Open Delta Conn.	14	0-120/132	2.0	VT02-2	5.25
120	60	Open Delta Conn.	14	0-120	2.5	VT02N-2	5.25
120	60[8]	Open Delta Conn.	14	0-120/132	3.0	VT3-2	6.5
120	60	Open Delta Conn.	14	0-120	3.3	VT3N-2	6.5
120	50	Open Delta Conn.	11, 14	0-120/140	3.5	VT4-2	11.3
120	50	Open Delta Conn.	11, 14	0-120	4.75	VT4N-2	11.3
120	50	Open Delta Conn.	11, 14	0-120/140	7.5	VT8-2	20.6
120	50	Open Delta Conn.	11, 14	0-120	10.0	VT8N-2	20.6
120	50	Open Delta Conn.	11, 14	0-120/140	20.0	VT20-2	45.0
120	50	Above unit, B case		0-120/140	20.0	VT20-2B	46.0
120	50	Open Delta Conn.	11, 14	0-120	25.0	VT20N-2	45.0
120	50	Above unit, B case		0-120	25.0	VT20N-2B	46.0
240[2]	50	Open Delta Conn.	14	0-240/280	3.0	VT8H-2	20.6
240[2]	50	Open Delta Conn.	14	0-240	4.0	VT8HN-2	20.6
240[2]	50	Open Delta Conn.		0-240/280	9.0	VT20H-2	43
240[2]	50	Open Delta Conn.		0-240	11.0	VT20HN-2	43

THREE-IN-TANDEM ASSEMBLIES [5] [10]

Input Volts	Freq. Hz from[1]	Feature or Connection	UL / SA footnotes	Maximum Output Volts	Maximum Output Amps	Catalog No.[13]	Wt. Lbs.[7]
240	60	"Y" Conn.	14	0-240[9]	1.3	VT1-3	5.3
240	60	"Y" Conn.	11	0-240[9]	2.0	VT02-3	8.0
240	60	"Y" Conn.	11	0-240[9]	3.0	VT3-3	9.8
240	60[8]	"Y" Conn.	11, 14	0-240/280	3.5	VT4-3	17.0
240	60[8]	"Y" Conn.	11, 14	0-240/280	7.5	VT8-3	31.0
240	60[8]	Above unit, E case	11	0-240/280	6.0	VT8-3E	40.0
240	60[8]	"Y" Conn.	11, 14	0-240/280	20.0	VT20-3	68.0
240	60[8]	Above unit, B case		0-240/280	20.0	VT20-3B	69.5
240	60	"Y" Conn.	11, 14	0-240	25.0	VT20N-3	68.0
240	60	Above unit, B case		0-240	25.0	VT20N-3B	69.5
480[2]	60[8]	"Y" Conn.		0-480/560	3.0	VT8H-3	31.0
480[2]	60[8]	"Y" Conn.		0-480/560	9.0	VT20H-3	65.0
480[2]	60	"Y" Conn.		0-480	11.0	VT20HN-3	65.0

[9] Overvoltage connection must not be used.
[10] 240/280 volt cw dial standard except on VT1, VT02 and VT3 tandems where 240/264 volt dial is standard or on VT8H-2, VT8HN-2, VT8H-3, VT20H-2, VT20HN-2, VT20H-3 and VT20HN-3 where 480/560 volt dial is standard. Request other dials if desired—see "Dials" above.
[11] Underwriters' Laboratories listed under components program (File Number E10946).
[12] Underwriters' Laboratories listed under apparatus program (File Number E10946).
[13] Some items are classified "non-stock standard" due to limited usage and therefore are not stocked. Consult latest issue of catalog 300 series for availability.
[14] CSA Listed for use only in equipment where the suitability of the combination is to be determined by the Testing Laboratories. (File No. 21309).
[15] CSA Listed as apparatus. (File No. 21309).

LOW POWER SERIES VT1, VT02, VT3

OHMITE

Save dollars and space! Select the rating closest to your needs; 1.3 A through 3.3 A.

Ohmite is the first to anticipate and meet the needs of industry with this line of low power, highly compact Variable Transformers. A choice of six ratings ranging from 1.3 to 3.3 amperes in overvoltage and no-overvoltage types are offered with the same bushing mounting arrangements and small base silhouette.

Adjustable Shaft, an exclusive Ohmite feature on bushing mounted units, makes it possible to extend the shaft from either end or to substitute a longer shaft. A set screw in the hub assembly is readily loosened (see Fig. 8) with a #6 hex key. This feature affords greater versatility in mounting and application. For example, the transformer can be mounted with the brush adjacent to the panel by means of a bracket to allow access for servicing. The shaft can also be extended to allow actuation of other devices (switches and potentiometers) without the necessity of special construction. A double flat on the shaft permits the knob pointer to be in line with, or 180° opposed to the brush-contact position.

Instantly Replaceable Brush Contacts. A brush-contact assembly with over size heat sink is instantly replaced, when necessary, as a result of a slide-on snap-in design that assures permanent positive retention of the contact.

Heat Dissipation Improved. Increased heat dissipation efficiency is obtained with an insulated metal base, which though insulated, nevertheless conducts more heat to the panel than plastic types.

Three-way Terminals. Ohmite's 3-way terminals are standard and permit connections to be made with conventional soldering, with standard ¼ inch quick-connector (push-on) clips and with #2 screws and nuts.

SPECIFICATIONS

Frequency: 60 to over 1000 Hz

Rotation Angle: 320° ±5°

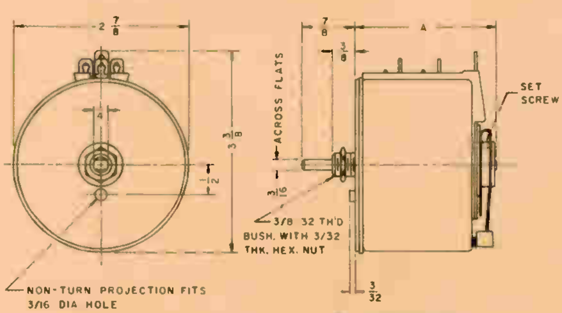
Torque:	Single	2-Tandem	3-Tandem
	3-15 in.-oz.	10-40 in.-oz.	20-60 in.-oz.

Termination: Combination ¼ inch quick-connect, solder and No. 2 screw and nuts.

Replacement Parts and Accessories:

- Brush-contact assembly for VT1, VT02 & VT3 types —Catalog No. 6507.
- Extra Knob for uncased types—Catalog No. 5158.
- Special Purpose Dials—see page 15.

U.S. Patent Nos. 3,316,517, 3,436,709 and 3,497,847



"A" DIMENSION

VT1	1$\frac{13}{16}$	VT02N	2$\frac{5}{16}$
VT1N	1$\frac{13}{16}$	VT3	2$\frac{13}{16}$
VT02	2$\frac{5}{16}$	VT3N	2$\frac{13}{16}$

Fig. 7: Dimensions for basic uncased single models.

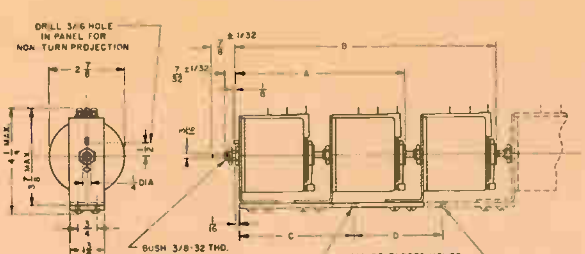
Model VT1, VT1N

Model VT02, VT02N

Model VT3, VT3N

Fig. 8: Set-screw in hub assembly readily loosened with #6 hex key to extend shaft from either end or substitute a longer shaft.

Fig. 11: VT02F VT02NF similar



TANDEM VT1, VT02, VT3 DIMENSIONS

	A	B	C
VT1	4$\frac{7}{32}$	6$\frac{17}{32}$	4¼
VT02	5$\frac{7}{32}$	8$\frac{1}{32}$	4½
VT3	6$\frac{17}{32}$	9$\frac{27}{32}$	4½

VT02N-3

Fig. 9: VT1, VT02, VT3 type tandems.

VT1 and VT02 CASE DIMENSIONS

Type	W	D*	H
E	3⅜	2½	4¼
F	3⅜	2½	4¼

*Add ⅞" for knob thickness.

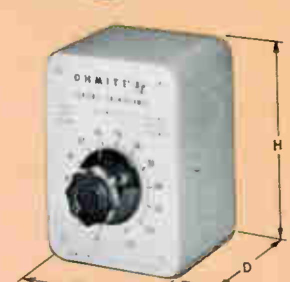


Fig. 10: VT02E VT02NE similar

STANDARD VT1 TYPES

1.5 Amps with overvoltage feature • 1.75 Amps, no-overvoltage feature.

Includes knob and 5005 dial (120 V.) or 5019 dial (240 V.) Tandem assemblies are factory inter-connected

DESCRIPTION		CATALOG[1] NUMBER	INPUT VOLTS	FREQ.[2] FROM (Hz)	OUTPUT (Max.) VOLTS	CONSTANT CURRENT AMPS	CONSTANT IMPEDANCE AMPS[16]	FIG. NO.	KNOB ROTA-[3]TION	CONNECTIONS TERMINALS INPUT	JUMPER[4]	OUTPUT	WEIGHT[5] (LBS.)
SINGLE TRANSFORMERS (Single Phase)													
Basic uncased model, overvoltage		(SA) VT1	120	50[6]	0-120	1.5[8]	2.0	12A	CW	1-2	—	1-3	1.5
									CCW	1-2	—	2-3	
				60	0-132	1.5[8]	—	12A	CW	1-4	—	1-3	
Basic uncased model, no-overvoltage		(SA) VT1N	120	60	0-120	1.75[9]	2.25	12B	CW	1-2	—	1-3	1.5
									CCW	1-2	—	2-3	
Cased, fixed mounting, overvoltage		VT1E	120	50[6]	0-120	.8	1.2	12A	CW	1-2	—	1-3	1.9
									CCW	1-2	—	2-3	
				60	0-132[7]	.8	—	12A	CW	1-4	—	1-3	
Cased, fixed mounting, no-overvoltage		VT1NE	120	60	0-120	1.0	1.5	12B	CW	1-2	—	1-3	1.9
									CCW	1-2	—	2-3	
Portable enclosure, overvoltage		VT1F	120	50[6]	0-120	1.0	1.5	12A	CW	1-2	—	1-3	2.3
				60	0-132[10]	1.0	—	12A	FACTORY WIRED				
Portable enclosure, no-overvoltage		VT1NF	120	60	0-120	1.2	1.8	12B	FACTORY WIRED				2.3
TWO-IN-TANDEM ASSEMBLIES[11] (Single & Three Phase)													
Basic uncased, overvoltage feature.	Series Connected[12] 1φ	(SA) VT1-2	240	50[6]	0-240	1.3	2.0[13]	12C	CW	2-2	1-1	3-3	3.5
									CCW	1-1	2-2	3-3	
				60	0-264	1.3	—	12C	CW	4-4	1-1	3-3	
	Open Delta Connected 3φ		120	50[6]	0-120	1.3	2.0	12C	CW	2-1-2	1-1	3-1-3	
									CCW	1-2-1	2-2	3-2-3	
				60	0-132	1.3	—	12C	CW	4-1-4	1-1	3-1-3	
Basic uncased, no-overvoltage feature.	Series Connected[12] 1φ	(SA) VT1N-2	240	60	0-240	1.5	2.25	12D	CW	2-2	1-1	3-3	3.5
									CCW	1-1	2-2	3-3	
	Open Delta Connected 3φ		120	60	0-120	1.5	2.25	120	CW	2-1-2	1-1	3-1-3	
									CCW	1-2-1	2-2	3-2-3	
THREE-IN-TANDEM ASSEMBLY (Three Phase)													
Basic Uncased, Wye connected		(SA) VT1-3	240	60	0-240[13]	1.3	2.0	12E	CW	2-2-2	1-1-1	3-3-3	5.3
									CCW	1-1-2	2-2-2	3-3-3	

STANDARD VT02 TYPES

2.2 Amps with overvoltage feature • 2.7 Amps, no-overvoltage feature.

Includes knob and 5005 dial (120 V.) or 5019 dial (240 V.) Tandem assemblies are factory inter-connected

DESCRIPTION		CATALOG[1] NUMBER	INPUT VOLTS	FREQ.[2] FROM (Hz)	OUTPUT (Max.) VOLTS	CONSTANT CURRENT AMPS	CONSTANT IMPEDANCE AMPS[16]	FIG. NO.	KNOB ROTA-[3]TION	CONNECTIONS TERMINALS INPUT	JUMPER[4]	OUTPUT	WEIGHT[5] (LBS.)
SINGLE TRANSFORMERS (Single Phase)													
Basic uncased model, overvoltage		(SA) VT02	120	50[6]	0-120	2.2[14]	2.8	12A	CW	1-2	—	1-3	2.25
									CCW	1-2	—	2-3	
				60	0-132	2.2[14]	—	12A	CW	1-4	—	1-3	
Basic uncased model, no-overvoltage		(SA) VT02N	120	60	0-120	2.7[15]	3.5	12B	CW	1-2	—	1-3	2.25
									CCW	1-2	—	2-3	
Cased, fixed mounting, overvoltage		VT02E	120	50[6]	0-120	1.4	1.8	12A	CW	1-2	—	1-3	2.8
									CCW	1-2	—	2-3	
				60	0-132	1.4	—	12A	CW	1-4	—	1-3	
Case, fixed mounting, no-overvoltage		VT02NE	120	60	0-120	1.6	2.2	12B	CW	1-2	—	1-3	2.8
									CCW	1-2	—	2-3	
Portable enclosure, overvoltage		VT02F	120	50[6]	0-120	1.75	2.4	12A	CW	1-2	—	1-3	3.2
				60	0-132[10]	1.75	—	12A	FACTORY WIRED				
Portable enclosure, no overvoltage		VT02NF	120	60	0-120	2.0	2.8	12B	FACTORY WIRED				3.2
TWO-IN-TANDEM ASSEMBLIES[11] (Single & Three Phase)													
Basic uncased, overvoltage feature.	Series Connected[12] 1φ	(SA) VT02-2	240	50[6]	0-240	2.0	2.8	12C	CW	2-2	1-1	3-3	5.25
									CCW	1-1	2-2	3-3	
				60	0-264	2.0	—	12C	CW	4-4	1-1	3-3	
	Open Delta Connected 3φ		120	50[6]	0-120	2.0	2.8	12C	CW	2-1-2	1-1	3-1-3	
									CCW	1-2-1	2-2	3-2-3	
				60	0-132	2.0	2.8[13]	12C	CW	4-1-4	1-1	3-1-3	
Basic uncased, no-overvoltage feature.	Series Connected[12] 1φ	(SA) VT02N-2	240	60	0-240	2.5	3.5	120	CW	2-2	1-1	3-3	2.8
									CCW	1-1	2-2	3-3	
	Open Delta Connected 3φ		120	60	0-120	2.5	3.5	120	CW	2-1-2	1-1	3-1-3	
									CCW	1-2-1	2-2	3-2-3	
THREE-IN-TANDEM ASSEMBLY (Three Phase)													
Basic uncased wye, connected		(SA) VT02-3	240	60	0-240[13]	2.0	2.8	12E	CW	2-2-2	1-1-1	3-3-3	8.0
									CCW	1-1-1	2-2-2	3-3-3	

STANDARD VT3 TYPES

3.0 Amps with overvoltage feature • 3.3 Amps, no-overvoltage feature.

Includes knob and 5005 dial (120 V.) or 5019 (240 V.). Tandem assemblies are factory inter-connected

DESCRIPTION		CATALOG[1] NUMBER	INPUT VOLTS	FREQ.[2] FROM (Hz)	OUTPUT (Max.) VOLTS	CONSTANT CURRENT AMPS	CONSTANT IMPEDANCE AMPS[16]	FIG. NO.	KNOB ROTA-[3]TION	CONNECTIONS TERMINALS INPUT	JUMPER[4]	OUTPUT	WEIGHT[5] (LBS.)
SINGLE TRANSFORMERS (Single Phase)													
Basic uncased model, overvoltage		(SA) VT3	120	50[6]	0-120	3.0	4.0	12A	CW	1-2	—	1-3	3.0
									CCW	1-2	—	2-3	
				60	0-132	3.0	—	12A	CW	1-4	—	1-3	
Basic uncased model, no-overvoltage		(SA) VT3N	120	60	0-120	3.3	4.4	12B	CW	1-2	—	1-3	3.0
									CCW	1-2	—	2-3	
TWO-IN-TANDEM ASSEMBLIES[11] (Single & Three Phase)													
Basic uncased, overvoltage feature.	Series Connected[12] 1φ	(SA) VT3-2	240	50[6]	0-240	3.0	4.0	12C	CW	2-2	1-1	3-3	6.5
									CCW	1-1	2-2	3-3	
				60	0-264	3.0	—	12C	CW	4-4	1-1	3-3	
	Open Delta Connected 3φ		120	50[6]	0-120	3.0	4.0[13]	12C	CW	2-1-2	1-1	3-1-3	
									CCW	1-2-1	2-2	3-2-3	
				60	0-132	3.0	—	12C	CW	4-1-4	1-1	3-1-3	
Basic uncased, no-overvoltage feature.	Series Connected[12] 1φ	(SA) VT3N-2	240	60	0-240	3.3	4.4	120	CW	2-2	1-1	3-3	6.5
									CCW	1-1	2-2	3-3	
	Open Delta Connected 3φ		120	60	0-120	3.3	4.4	120	CW	2-1-2	1-1	3-1-3	
									CCW	1-2-1	2-2	3-2-3	
THREE-IN-TANDEM ASSEMBLY (Three Phase)													
Basic Uncased, Wye connected		(SA) VT3-3	240	60	0-240[13]	3.0	4.0	12E	CW	2-2-2	1-1-1	3-3-3	9.8
									CCW	1-1-1	2-2-2	3-3-3	

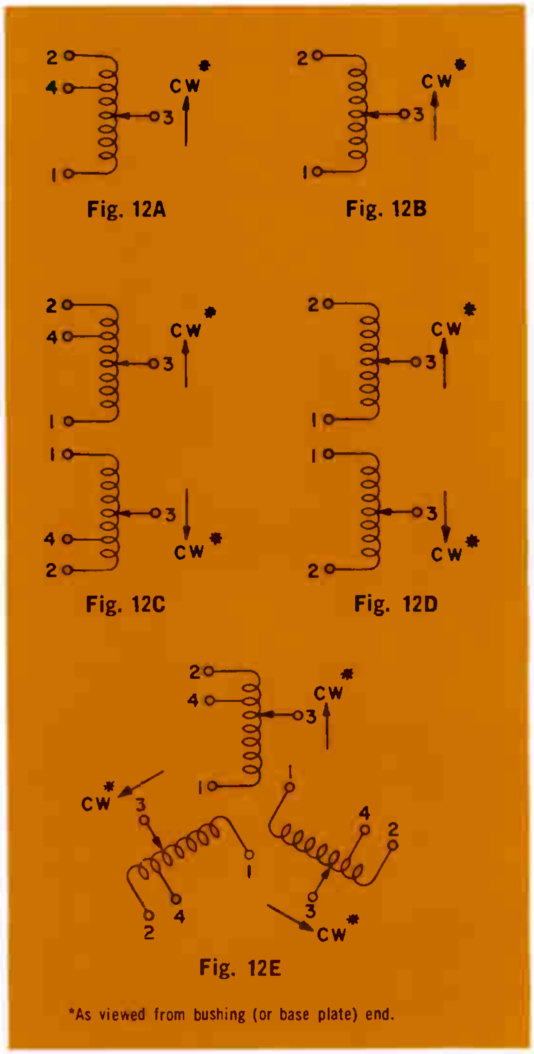


Figure 12: Terminal Connection Schematics for Series VT1, VT02, and VT3.

Footnotes:

1 Some items are classified "non-stock stnadard" due to limited usage and therefore are not stocked. Consult latest issue of Catalog 300 series for availability.
2 Frequency shown is a minimum—units may be used up to 1000 Hz.
3 As viewed from bushing (base plate) end.
4 Factory wired jumpers are: for 2-in-tandem, 1-1; for 3-in-tandem, 1-1-1.
5 Includes knob, dial and mounting hardware.
6 May be used at 50 Hz if connected for no-overvoltage.
7 User wires for desired output. Dial calibrated for overvoltage.
8 Rating when mounted on metal panel. Derate to 1.3 A when mounted on bracket or non-metalic panel.
9 Rating when mounted on metal panel. Derate to 1.5 A when mounted on bracket or non-metalic panel.
10 Factory connected for overvoltage output. Easily re-connected for no-overvoltage output by user.
11 Two-In-Tandem assemblies are wired for series connection, single phase; for 3-phase, open delta.
12 When transformers are series connected, load cannot be grounded.
13 Overvoltage connection must not be used.
14 Rating when mounted on metal panel. Derate to 2.0 A when mounted on bracket or non-metalic panel.
15 Rating when mounted on a metal panel. Derate to 2.5 A when mounted on bracket or non-metalic panel.
16 With a constant impedance load the current shown in this column can be drawn at maximum voltage (if the line voltage is connected across the full winding) and proportionately less at any intermediate point. CAUTION: Over-voltage connection must not be used.

(SA) For use only in equipment where the suitability of the combination is to be determined by the testing laboratories. Approval is for unmounted constant current.

SERIES VT4

3.5 Amps. with overvoltage/4.75 Amps. no-overvoltage type

OHMITE

Ohmite standard of quality is designed into the VT4 series of Ohmitran v.t.® variable transformers. Extra economy can be realized utilizing the newly published non-U.L. ratings in selection of the right VT for your application. No longer is it necessary to purchase a more expensive transformer because the available rating does not fall near your requirements.

The adjustable shaft, an exclusive Ohmite feature, makes it possible to extend the shaft from either end or to substitute a longer shaft. This affords greater versatility of mounting and application. For example, by means of a bracket, the transformer can be mounted with the brush adjacent to the panel to allow easy access for servicing. The shaft can also be extended to allow actuation of other devices such as switches and potentiometers without special construction.

Basic units can be either panel mounted or set-up for bench-top use. Three-hole mounting is standard but a 4-hole mounting adapter plate (see Accessories below) to match other popular 4-hole mountings is available.

A complete instruction manual detailing installation with mounting hole templates, and servicing is included with each unit.

SPECIFICATIONS

Frequency: 50 to over 1000 Hz

Rotation angle: 324° ±5°

Torque: Single unit: 15-25 in-oz.
2-Tandem: 30-60 in-oz.
3-Tandem: 50-85 in-oz.

Termination: No. 6-32 screws. Quick-connect terminals available on special order.

REPLACEMENT PARTS AND ACCESSORIES

—Brush-contact assembly for VT4 types (except VT4LN)—Catalog number 6515

—Four hole mounting adapter plate (See Fig. 14 for Dimensions)—Catalog number 6512

—Extra knob for uncased units—Catalog number 5155

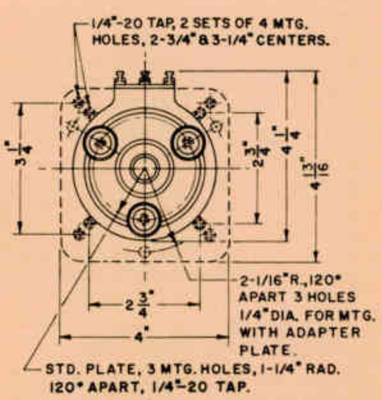
—Special purpose dials—see page 15.

—Adjustable stop for limiting rotation arc—Catalog number 6536

—Fuse link for VT4 types—Catalog number 6508

—Fuse link for VT4N types—Catalog number 6509

Fig. 13: VT4 arranged for panel mounting.



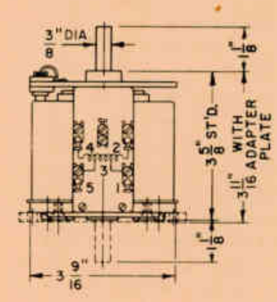


Fig. 14: Dimensions—VT4, VT4N basic uncased construction.

VT4 CASE DIMENSIONS

Type	W	D*	H
E	4½	4½	6$\frac{3}{16}$
F	4⅞	4½	6¼

*Add ⅞" for knob thickness.

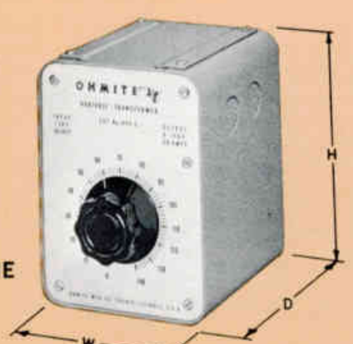


Fig. 17: VT4E; VT4NE similar

Fig. 18: VT4FC; VT4NFC similar

Fig. 19: VT4F; VT4NF similar

STANDARD VT4 TYPES

3.5 Amps U.L. with overvoltage • 4.75 U.L. without overvoltage feature
4.5 Amps non-U.L. with overvoltage • 6.25 non-U.L. without overvoltage feature
Includes knob and 5006 dial (120 V.) or 5009 dial (240 V.). Tandem assemblies are factory inter-connected.

DESCRIPTION	CATALOG[1] NUMBER	INPUT VOLTS	FREQ.[2] FROM Hz	OUTPUT (Max.) VOLTS	CONSTANT CURRENT U.L. CSA LISTED AMPS[9]	CONSTANT CURRENT NON-U.L. LISTED AMPS	CONSTANT IMPEDANCE AMPS[11]	FIG. NO.	CONNECTIONS KNOB ROTATION[10]	TERMINALS INPUT	TERMINALS JUMPER[8]	TERMINALS OUTPUT	WEIGHT[3] (LBS.)
SINGLE TRANSFORMERS (Single Phase)													
Basic uncased model, overvoltage feature	VT4	120	50	0-120	3.5	4.5	6.0	20A	CW	2-4	—	2-3	5.25
									CCW	2-4	—	4-3	
				0-140	3.5	4.5	—	20A	CW	2-5	—	2-3	
									CCW	4-1	—	4-3	
Basic uncased model, no-overvoltage feature	VT4N	120	50	0-120	4.75	6.25	8.0	20B	CW	1-2	—	2-3	5.25
									CCW	1-2	—	1-3	
Cased, fixed mounting, overvoltage	VT4E	120	50	0-120	2.8	2.8	3.7	20A	CW	2-4	—	2-3	7.4
									CCW	2-4	—	4-3	
				0-140[4]	2.8	2.8	—	20A	CW	2-5	—	2-3	
									CCW	4-1	—	4-3	
Cased, fixed mounting, no-overvoltage	VT4NE	120	50	0-120	3.5	3.8	5.0	20B	CW	1-2	—	2-3	7.4
									CCW	1-2	—	1-3	
Portable enclosure, overvoltage	VT4F	120	50	0-140[5]	3.8	3.5	—	—	FACTORY WIRED				7.8
Portable enclosure, no-overvoltage	VT4NF	120	50	0-120	4.75	4.75	6.3	—	FACTORY WIRED				7.8
VT4F with grounded input/output	VT4FC	120	50	0-140[5]	3.5	3.5	—	—	FACTORY WIRED				7.8
VT4NF with grounded input/output	VT4NFC	120	50	0-120	4.75	4.75	6.3	—	FACTORY WIRED				7.8
TWO-IN-TANDEM ASSEMBLIES[6] (Single and Three Phase)													
Basic uncased over-voltage feature — Series Connected[7] 1φ	VT4-2	240	50	0-240	3.5	4.5	6.0	20C	CW	4-4	2-2	3-3	11.3
									CCW	2-2	4-4	3-3	
				0-280	3.5	4.5	—	20C	CW	5-5	2-2	3-3	
									CCW	1-1	4-4	3-3	
Basic uncased over-voltage feature — Open Delta Connected 3φ		120	50	0-120	3.5	4.5	6.0	20C	CW	4-2-4	2-2	3-2-3	
									CCW	2-4-2	4-4	3-4-3	
				0-140	3.5	4.5	—	20C	CW	5-2-5	2-2	3-2-3	
									CCW	1-4-1	4-4	3-4-3	
Basic uncased no-over-voltage feature — Series Connected[7] 1φ	VT4N-2	240	50	0-240	4.75	6.25	8.0	20D	CW	1-1	2-2	3-3	11.3
									CCW	2-2	1-1	3-3	
Basic uncased no-over-voltage feature — Open Delta Connected 3φ		120	50	0-120	4.75	6.25	8.0	20D	CW	1-2-1	2-2	3-2-3	
									CCW	2-1-2	1-1	3-1-3	
THREE-IN-TANDEM ASSEMBLIES (Three Phase)													
Uncased, Wye Connected	VT4-3	240	50	0-240	3.5	4.5	6.0	20E	CW	4-4-4	2-2-2	3-3-3	17.3
									CCW	2-2-2	4-4-4	3-3-3	
			60	0-280	3.5	4.5	—	20E	CW	5-5-5	2-2-2	3-3-3	
									CCW	1-1-1	4-4-4	3-3-3	

Footnotes:

[1] Some items are classified "non-stock standard" due to limited usage and therefore are not stocked. Consult latest issue of Catalog 300 series for availability.

[2] Frequency shown is a minimum—units may be used up to 1000 Hz.

[3] Includes knob, dial and mounting hardware.

[4] User wires for desired output. Dial calibrated for overvoltage.

[5] Factory connected for overvoltage output. Easily reconnected for no-overvoltage output by user.

[6] Two-In-Tandem assemblies are wired for series connection, single phase; for 3-phase, open delta.

[7] When transformers are series connected, load cannot be grounded.

[8] Factory wired jumpers are: for VT4-2, 2-2; for VT4N-2, 2-2; for VT4-3, 2-2-2.

[9] Under components program—Underwriters' Laboratories (File No. E10946) listed: Cat. Nos. VT4, VT4-2, -3, VT4N, VT4N-2, -3. CSA approved: Cat. Nos. VT4, VT4-2, -3, VT4N, VT4N-2 (File number 21309).
Under apparatus program—Underwriters' Laboratories (File No. E10946) listed: Cat. Nos. VT4E, VT4F, VT4FC. CSA approved: Cat. Nos. VT4E, VT4FC, VT4NFC. (File Number 21309).

[10] As viewed from base plate end.

[11] With a constant impedance load the current shown in this column can be drawn at maximum voltage (if the line voltage is connected across the full winding) and proportionately less at any intermediate point. CAUTION: Over-voltage connection must not be used.

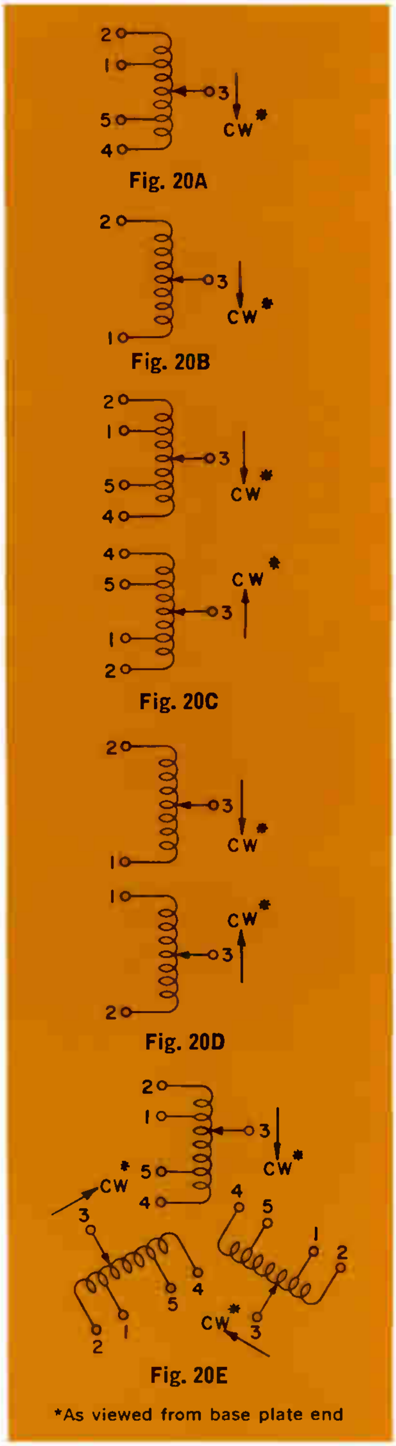


Fig. 20A
Fig. 20B
Fig. 20C
Fig. 20D
Fig. 20E
*As viewed from base plate end

Fig. 20: Terminal Connection Schematics for VT4 Series.

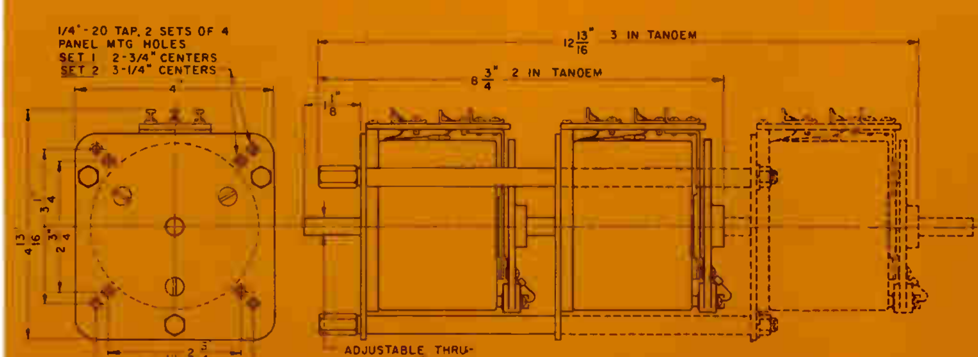


Fig. 16: Dimensions—VT4 type tandems


Fig. 15: VT4-2; VT4-3 similar

SERIES VT8

7.5 Amps with overvoltage/ 10 Amps no-overvoltage type

OHMITE

Compact, the VT8 series requires at least one-half inch less back-of-panel depth than others. Long, maintenance-free life, excellent regulation at any point within rated load and an output free of wave form distortion are other distinguishing features of the VT8 series.

As with all Ohmitran v.t.® transformers, the VT8 series features an adjustable shaft so that you may panel mount or set-up on bench or other horizontal mounting surface. The shaft is fixed in the desired position by means of socket head screws located in the hub of the brush-radiator plate.

A complete line of enclosed models, including portable models with built-in meters are offered with a choice of overvoltage and no-overvoltage feature.

Included with each unit is a complete instruction manual detailing servicing and installation.

SPECIFICATIONS

Frequency: 50 to over 1000 Hz.

Rotation Angle: 324° ±5°

Torque: Single Unit: 20-35 inch-ounces
2-Tandem: 45-70 inch-ounces
3-Tandem: 80-115 inch-ounces

Terminations: No. 6 screws. Quick-connect terminals available on special order.

REPLACEMENT PARTS and ACCESSORIES

—Brush-contact assembly for VT8 and VT8N types—Catalog Number 6515

—Brush-contact assembly for VT8H and VT8HN types—Catalog Number 6516H

—Adjustable stop for limiting rotation arc—Catalog Number 6537

—Extra knob for uncased units—Catalog Number 5155

—Special purpose dials—see page 15.

Fig. 21: VT8 arranged for panel mtg.

VT8N is similar

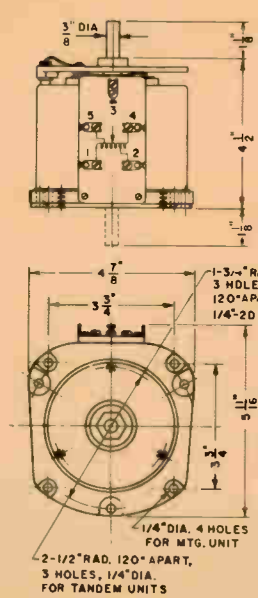


Fig. 22: Dimensions —VT8 and VT8N types

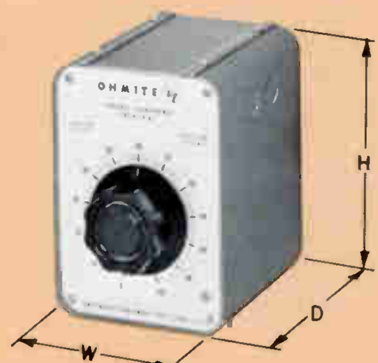


Fig. 23: VT8E; VT8NE similar

Fig. 24: VT8FC; VT8F has a 2-conductor socket & plug

Fig. 26: VT8GCV (with voltmeter) VT8GCVA (with volt and ammeter VT8GCVW (with volt and wattmeter

Fig. 25: VT8G; VT8GC has 3-conductor socket & plug

VT8 CASE DIMENSIONS

Fig. No.	Case Style	W	D[2]	H
23	E	5 3/16	5 1/4	7 3/16
24	F	5 17/32	5 1/4	7 3/8
	FV, etc.	7 3/8	5 1/4	10 1/2
25	G	5 3/16[1]	5 1/4	7 3/8[3]
26	GV, etc.	7	5 1/4	10 1/2[3]
28	3E	5 3/16	15 3/4	7 3/16

[1] 5 3/4" including handle fittings.
[2] Add 1" for knob thickness.
[3] Case height only. Does not include handle.

STANDARD VT8 TYPES

7.5 Amps, overvoltage • 10.0 Amps, no-overvoltage feature

Includes knob and 5006 dial (120.V) or 5009 dial (240 V.). Tandem assemblies are factory inter-connected.

DESCRIPTION		CATALOG[1] NUMBER	INPUT VOLTS	FREQ.[2] FROM (Hz)	OUTPUT (Max.) VOLTS	OUTPUT (Max.) CONSTANT CURRENT U.L. CSA[11] AMPS	OUTPUT (Max.) CON-[12] STANT IMPEDANCE AMPS	CONNECTION SCHEMATIC Fig. No. (see page 14)	WEIGHT[3] (LBS.)
SINGLE TRANSFORMERS (Single Phase)									
Basic uncased model, overvoltage feature.		VT8	120	50	0-120/140	7.5	9.0	39A	10.25
Basic uncased model, no-overvoltage feature.		VT8N	120	50	0-120	10.0	12.0	39B	10.25
Cased, Fixed mounting, overvoltage.		VT8E	120	50	0-120/140[4]	6.0	7.2	39A	13.5
Cased, Fixed mounting, no-overvoltage.		VT8NE	120	50	0-120	8.0	9.5	39B	13.5
Portable enclosure, overvoltage.		VT8F	120	50	0-140[5]	7.5	—	Factory Wired	13.8
Portable enclosure, no-overvoltage.		VT8NF	120	50	0-120	10.0	12.0	Factory Wired	13.8
VT8F with grounded input/output.		VT8FC	120	50	0-140[5]	7.5	—	Factory Wired	13.8
VT8NF with grounded input/output.		VT8NFC	120	50	0-120	10.0	12.0	Factory Wired	13.8
VT8NFC with volt meter.		VT8NFCV	120	50	0-120	10.0	12.0	Factory Wired	14.8
VT8NFC with volt and ammeter.		VT8NFCVA	120	50	0-120	10.0	12.0	Factory Wired	15.2
VT8NFC with volt and wattmeters.		VT8NFCVW	120	50	0-120	10.0	12.0	Factory Wired	15.2
Deluxe Portable, overvoltage.		VT8G	120	50	0-120/140[6]	6.0	7.2	Factory Wired	14.2
VT8G with grounded input/output.		VT8GC	120	50	0-120/140[6]	6.0	7.2	Factory Wired	14.2
VT8GC with voltmeter.		VT8GCV	120	50	0-120/140[6]	6.0	7.2	Factory Wired	15.2
VT8GC with volt and ammeters.		VT8GCVA	120	50	0-120/140[6]	6.0	7.2	Factory Wired	15.5
VT8GC with volt and wattmeter.		VT8GCVW	120	50	0-120/140[6]	6.0	7.2	Factory Wired	15.5
Basic, uncased, overvoltage feature, 240 V. input with 120 V. tap.		VT8H	240	50	0-240/280	3.0	3.6	39C	10.25
			120	50	0-280	3.0[7]	—		
Basic, uncased, no-overvoltage feature, 240 V. input with 120 V. tap.		VT8HN	240	50	0-240	4.0	4.8	39D	10.25
			120	50	0-240	4.0[7]	4.8		
TWO-IN-TANDEM[8] (Single and Three Phase)									
Basic, uncased, overvoltage	240 V, Input, Series Connected[9], 1ϕ	VT8-2	240	50	0-240/280	7.5	9.0	39F	20.6
	120 V Input, Open Delta Connected, 3ϕ		120	50	0-120/140	7.5	9.0		20.6
Basic, uncased, no-overvoltage	240 V, Input, Series Connected[9], 1ϕ	VT8N-2	240	50	0-240	10.0	12.0	39G	20.6
	120 V Input, Open Delta Connected, 3ϕ		120	50	0-120	10.0	12.0		20.6
Basic, uncased, overvoltage	240 V, Input, Series Connected[9], 1ϕ	VT8H-2	480	50	0-480/560	3.0	3.6	39K	20.6
	120 V Input, Open Delta Connected, 3ϕ		240	50	0-240/280	3.0	3.6		20.6
Basic, uncased, no-overvoltage	240 V, Input, Series Connected[9], 1ϕ	VT8HN-2	480	50	0-480	4.0	4.8	39L	20.6
	120 V Input, Open Delta Connected, 3ϕ		240	50	0-240	4.0	4.8		20.6
THREE-IN-TANDEM (Three Phase)									
Uncased, Wye connected		VT8-3	240	60[10]	0-240/280	7.5	9.0	39H	31.0
Fixed mounting case, wye connected		VT8-3E	240	60[10]	0-240/280	6.0	7.2	39H	41.5
Uncased 480 V. input, wye connected		VT8H-3	480	60[10]	0-480/560	3.0	3.6	39N	31.0

See page 14 for connection schematic details

Footnotes:

[1] Some items are classified "non-stock standard" due to limited usage and therefore are not stocked. Consult latest issue of Catalog 300 series for availability.

[2] Frequency shown is a minimum—units may be used up to 1000 Hz.

[3] Includes knob, dial and mounting hardware.

[4] User wires for desired output. Dial calibrated for overvoltage.

[5] Factory connected for overvoltage output. Easily reconnected for no-overvoltage output by user.

[6] Switch selects overvoltage or line voltage output mode.

[7] When 120 volt input tap is used, unit must be derated for output greater than 120 volts. See Figure 5, page 3.

[8] Two-In-Tandem assemblies are wired for series connection, single phase; for 3-phase, open delta.

[9] When transformers are series connected, load cannot be grounded.

[10] May be used at 50 Hz if connected for no-overvoltage.

[11] Under components program—Underwriters' Laboratories (File No. E10946 listed: Cat. Nos. VT8, VT8-2, -3, VT8N, VT8N-2. CSA approved: VT8, VT8-2, -3, VT8N, VT8N-2, VT8H, VT8H-2, VT8HN, VT8HN-2. (File No. 21309).

Under apparatus program—Underwriters' Laboratories (File No. E10946) listed Cat. Nos. VT8E, VT8F, VT8FC, VT8G, VT8GC. CSA approved: VT8E, VT8-3E, VT8FC, VT8GC, VT8GCV, VT8GCVA, VT8GCVW, VT8NE, VT8NFC, VT8NFCV, VT8NFCVA, VT8NFCVW. (File No. 21309).

[12] With a constant impedance load the current shown in this column can be drawn at maximum voltage (if the line voltage is connected across the full winding) and proportionately less at any intermediate point. CAUTION: Over-voltage connection must not be used.

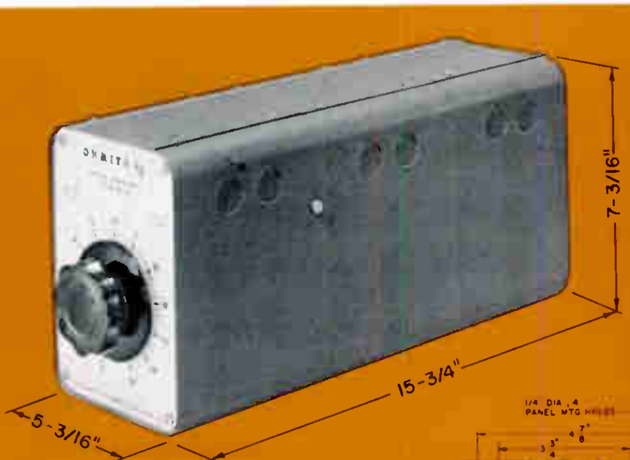


Fig. 28: VT8-3E

Fig. 29: VT8-3; VT8-2 similar

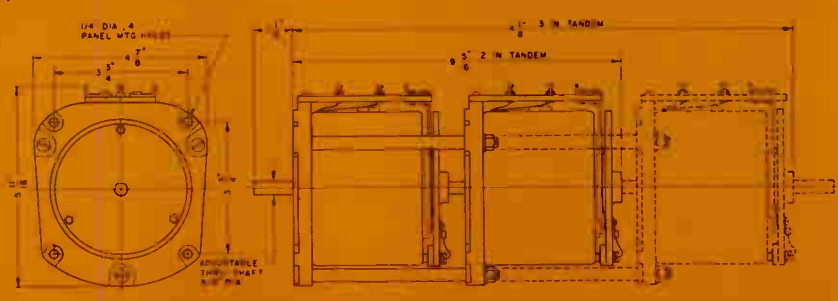


Fig. 27: Dimensions—VT8 type tandems

SERIES VT20

20 Amps with overvoltage/ 25 Amps no-overvoltage type.

Whether you use the VT20 series as a laboratory instrument or a system's component, you will be specifying a variable transformer with distinctive sturdiness of construction. To provide an extra margin of heat dissipation, the VT20's brush assembly is oversize. Added stability under conditions of vibration is assured by the unique counter-balanced radiator plate.

As with all Ohmitran V.T.'s, the VT20 series features an adjustable shaft which means the shaft may be extended from either end of the transformer as required for panel or horizontal surface mounting. A unique collet-type shaft lock permits ready repositioning of the shaft without scarring or defacing shaft surface.

VT20 series are offered in a choice of the overvoltage variety for low-line compensation, and the no-overvoltage version for higher current rating. A special "B" type case, a round ventilated enclosure with exposed terminal panel and base is an ideal accessory where protection of the winding area is required. The deluxe portable enclosure, type G, is also available with built-in meters and is an excellent lab instrument.

Also included in the VT20 series is the high voltage input version, type VT20H. In addition to the higher voltage input, a tap for lower voltage is provided and the terminals are brought out to the terminal panel to facilitate wiring.

A complete instruction manual detailing installation with mounting holes templates and servicing are included with each unit.

SPECIFICATIONS

Frequency: 50 to over 1000 Hz.

Rotation Angle: 317° ±5°

Torque: Single unit: 45- 90 inch-oz.
2-Tandem: 90-180 inch-oz.
3-Tandem: 200-300 inch-oz.

Terminations: VT20 series: No. 10 screws; VT20H Series: No. 6 screws. Quick-connect terminals available on special order.

REPLACEMENT PARTS and ACCESSORIES

—Brush-contact assembly for VT20 and VT20N types —Catalog Number 6594

—Brush-contact assembly for VT20H and VT20HN types—Catalog Number 6596

—Adjustable stop for limiting rotation arc—Catalog Number 6538

—Extra knob for uncased units—Catalog Number 5157

—Special purpose dials—see page 15.

—Fuse link—Catalog Number 6535

Fig. 30: VT20; VT20N similar

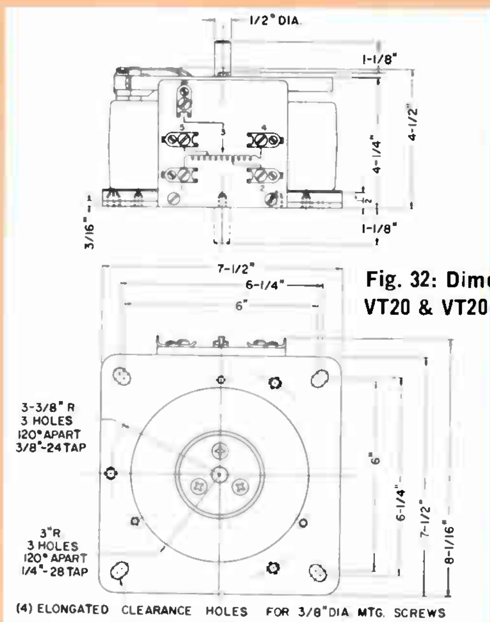


Fig. 32: Dimensions—VT20 & VT20N types

Fig: 33: VT20-2, Two-in-Tandem. VT20-3 (3-Tandem) similar

Fig. 31: VT20B; VT20NB similar

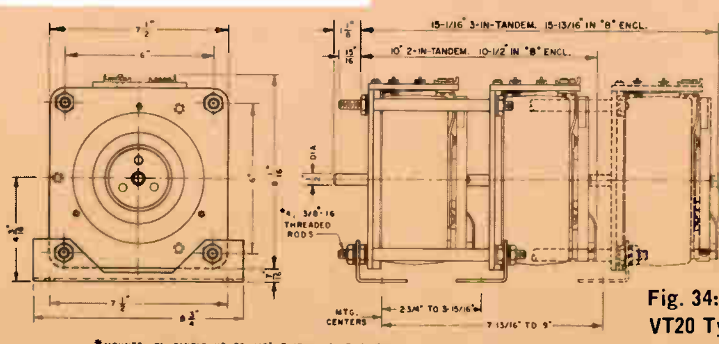


Fig. 34: Dimensions—VT20 Type Tandems

STANDARD VT20 TYPES

20 Amps, overvoltage • 25 Amps, no overvoltage feature

Includes knob and 5013 dial (120 V.) or 5015 (240 V.). Tandem assemblies are factory inter-connected.

DESCRIPTION		CATALOG[1] NUMBER	INPUT VOLTS	FREQ.[2] FROM Hz	OUTPUT (max.) VOLTS	CONSTANT CURRENT UL AMPS	CONSTANT[15] IMPEDANCE AMPS	CONNECTION SCHEMATIC FIG. NO. (See page 14)	WEIGHT[3] (LBS.)
SINGLE TRANSFORMERS (Single Phase)									
Basic uncased model, overvoltage feature		VT20	120	50	0-120/140	20.0[11]	23.0	39A	22.0
VT20 without overvoltage feature		VT20N	120	50	0-120	25.0[11]	25.0	39B	22.0
"B" type enclosure, overvoltage		VT20B	120	50	0-120/140	20.0	23.0	39A	22.5
VT20B without overvoltage feature		VT20NB	120	50	0-120	25.0	25.0	39B	22.5
Cased, fixed mounting, overvoltage		VT20E	120	50	0-120/140[4]	16.0[12]	18.0	39A	29.0
VT20E without overvoltage feature		VT20NE	120	50	0-120	20.0[12]	20.0	39B	29.0
Portable enclosure w/grounded in/out, overvoltage		VT20FC	120	50	0-140[5]	20.0	—	Factory Wired	31.0
VT20FC without overvoltage feature		VT20NFC	120	50	0-120	25.0	25.0	Factory Wired	31.0
VT20NFC with voltmeter		VT20NFCV	120	50	0-120	25.0	25.0	Factory Wired	32.0
VT20NFC with volt and ammeter		VT20NFCVA	120	50	0-120	25.0	25.0	Factory Wired	32.0
VT20NFC with volt and wattmeter		VT20NFCVW	120	50	0-120	25.0	25.0	Factory Wired	32.0
Deluxe Portable, grounded in/out, overvoltage		VT20GC	120	50	0-120/140[6]	16.0[12]	18.0	Factory Wired	31.0
VT20GC with voltmeter		VT20GCV	120	50	0-120/140[6]	16.0	18.0	Factory Wired	32.0
VT20GC with volt and ammeter		VT20GCVA	120	50	0-120/140[6]	16.0	18.0	Factory Wired	32.2
VT20GC with volt and wattmeter		VT20GCVW	120	50	0-120/140[6]	16.0	18.0	Factory Wired	32.2
Basic uncased model, overvoltage 240 V. input with 120 V. tap		VT20H	240	50	0-240/280	5.0	10.25	39C	22.0
			120	50	0-280	9.0[7]	—		
VT20H with no-overvoltage		VT20HN	240	50	0-240	11.0	12.5	39E	22.0
			120	50	0-240	11.0[7]	12.5		
VT20H in type "B" enclosure		VT20HB	240	50	0-240/280	9.0	10.25	39C	22.5
			120	50	0-280	9.0[7]	—		
VT20HN in type "B" enclosure		VT20HNB	240	50	0-240	11.0	12.5	39E	22.5
			120	50	0-240	11.0[7]	12.5		
Cased, fixed mounting type, overvoltage, 240 V. input with 120 V. tap		VT20HE	240	50	0-240/280[4]	7.2	8.2	39C	28.0
			120	50	0-280	7.2[7]	—		
VT20HE without overvoltage feature		VT20HNE	240	50	0-240	8.8	10.0	39E	28.0
			120	50	0-240	8.8[7]	10.0		
Portable enclosure with grounded in/out overvoltage, 240 V. input with 120 V. tap		VT20HFC	240	50	0-280[5]	9.0	—	Factory Wired	30.0
			120	50	0-280[13]	9.0[7]	—		
VT20HFC without overvoltage feature		VT20HNFC	240	50	0-240	11.0	12.5	Factory Wired	30.0
			120	50	0-240[14]	11.0[7]	12.5		
TWO-IN-TANDEM[8] (Single and Three Phase)									
Basic, uncased, overvoltage	240 V. Input, Series Connected[9], 1ϕ	VT20-2	240	50	0-240/280	20.0[11]	23.0	39F	45
	120 V. Input, Open Delta Connected, 3ϕ		120	50	0-120/140				
Basic, uncased, no-overvoltage	240 V. Input, Series Connected[9], 1ϕ	VT20N-2	240	50	0-240	25.0[11]	25.0	39G	45
	120 V. Input, Open Delta Connected, 3ϕ		120	50	0-120				
"B" type enclosure overvoltage	240 V. Input, Series Connected[9], 1ϕ	VT20-2B	240	50	0-240/280	20.0	23.0	39F	46
	120 V. Input, Open Delta Connected, 3ϕ		120	50	0-120/140				
"B" type enclosure no-overvoltage	240 V. Input, Series Connected[9], 1ϕ	VT20N-2B	240	50	0-240	25.0	25.0	39G	46
	120 V. Input, Open Delta Connected, 3ϕ		120	50	0-120				
Uncased with overvoltage	480 V. Input Series Connected[9], 1ϕ	VT20H-2	480	50	0-480/560	9.0[7]	10.25	39K	43
	240 V. Input Open Delta Connected, 3ϕ		240	50	0-240/280				
VT20H-2 without overvoltage feature	480 V. Input Series Connected[9], 1ϕ	VT20HN-2	480	50	0-480	11.0[7]	12.5	39M	43
	240 V. Input Open Delta Connected, 3ϕ		240	50	0-240				
THREE-IN-TANDEM (Three Phase)									
Uncased, Wye connected, overvoltage		VT20-3	240	60[10]	0-240/280	20.0[11]	23.0	39H	58.0
VT20-3 without overvoltage feature		VT20N-3	240	60	0-240	25.0[11]	25.0	39J	58.0
"B" type enclosure, overvoltage		VT20-3B	240	60[10]	0-240/280	20.0	23.0	39H	69.5
VT20-3B without overvoltage feature		VT20N-3B	240	60	0-240	25.0	25.0	39J	69.5
Uncased, 480 V. input with 240 V. tap, overvoltage		VT20H-3	480	60[10]	0-480/560[4]	9.0	10.25	39N	65
			240	60[10]	0-560	9.0[7]	—		
VT20H-3 without overvoltage feature		VT20HN-3	480	60	0-480	11.0	—	39P	65
			240	60	0-480	11.0[7]	—		

See page 14 for connection schematic details

Footnotes:

[1] Some items are classified "non-stock standard" due to limited usage and therefore are not stocked. Consult latest issue of Catalog 300 series for availability.

[2] Frequency shown is a minimum—units may be used up to 1000 Hz.

[3] Includes knob, dial and mounting hardware.

[4] User wires for desired output. Dial calibrated for overvoltage.

[5] Factory connected for overvoltage output. Easily reconnected for no-overvoltage output by user.

[6] Switch selects overvoltage or line voltage output mode.

[7] When 120 volt input tap is used, unit must be derated for output greater than 120 volts. See Figure 5, page 3.

[8] Two-In-Tandem assemblies are wired for series connection, single phase; for 3-phase, open delta.

[9] When transformers are series connected, load cannot be grounded.

[10] May be used at 50 Hz if connected for no-overvoltage.

[11] Underwriters' Laboratories listed under components program (File Number E10946).

[12] Underwriters' Laboratories listed under apparatus program (File Number E10946).

[13] Factory connected for overvoltage output with 240 V. input. Has to be re-connected for 120 V. input by user.

[14] Factory connected for 240 V. input. Has to be reconnected for 120 V. input.

[15] With a constant impedance load the current shown in this column can be drawn at maximum voltage (if the line voltage is connected across the full winding) and proportionately less at any intermediate point. CAUTION: Over-voltage connection must not be used.

Fig. 35: VT20E

Fig. 36: VT20FC

Fig. 37. VT20GC

Fig. 38: VT20GCVW (with volt and watt-meter.) VT20GCVA & VT20GCV similar

VT20 CASE DIMENSIONS

Fig. No.	Case Style	W	D	H
31	B	7⅝	8⅛	4⅞
35	E	7¾	5½[2]	1015/16
36	F	8¼	5½[2]	11¼
—	FV, etc.	8¼	5½[2]	14¼
37	G	7¾[1]	5½[2]	11¼[3]
38	GV, etc.	8¾[1]	5½[2]	14¼[3]

[1] 9" including handle fittings.
[2] Add 1¼" for knob thickness.
[3] Case height only. Does not include handle.

OHMITE

TERMINAL CONNECTION SCHEMATICS

VT8 AND VT20 TRANSFORMERS

Fig. 39A

Knob* Rotation	Input 120V.	Output 0-120V.	Output 0-140V.
CW	4-1	4-3	
CCW	4-1	1-3	
CW	4-5		4-3
CCW	1-2		1-3

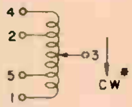


Fig. 39B

Knob* Rotation	Input 120V[1]	Output 0-120[2]
CW	1-2	2-3
CCW	1-2	1-3

[1] 40 for VT4LN, VT8LN.
[2] 0-40 for VT4LN, VT8LN.

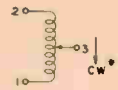


Fig. 39C

Knob* Rotation	Input 120V.	Input 240V.	Output 0-240V.	Output 0-280V.
CW		4-1	4-3	
CCW		4-1	1-3	
CW		4-5		4-3
CCW		1-2		1-3
CW	4-7			4-3
CCW	1-6			1-3

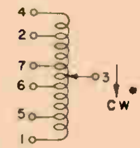


Fig. 39D

Knob* Rotation	Input 120V.	Input 240V.	Output 0-240V.
CW		1-2	2-3
CCW		1-2	1-3
CW	2-4		2-3
CCW	1-4		1-3

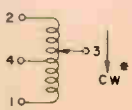


Fig. 39E

Knob* Rotation	Input 120V.	Input 240V.	Output 0-240V.
CW		1-2	2-3
CCW		1-2	1-3
CW	2-5		2-3
CCW	1-4		1-3

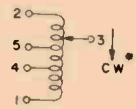


Fig. 39F

Single-Phase Series Operation

Knob* Rotation	Input 240V.	Jumper	Output 0-240V.	Output 0-280V.
CW	1-1	4-4	3-3	
CCW	4-4	1-1	3-3	
CW	5-5	4-4		3-3
CCW	2-2	1-1		3-3

3-Phase Open Delta Operation

Knob* Rotation	Input 120V.	Jumper	Output 0-120V.	Output 0-140V.
CW	1-4-1	4-4	3-4-3	
CCW	4-1-4	1-1	3-1-3	
CW	5-4-5	4-4		3-4-3
CCW	2-1-2	1-1		3-1-3

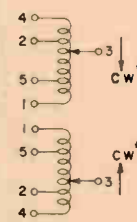


Fig. 39G

Single-Phase Series Operation

Knob* Rotation	Input 240V.	Jumper	Output 0-240V.
CW	1-1	2-2	3-3
CCW	2-2	1-1	3-3

3-Phase Open Delta Operation

Knob* Rotation	Input 120V.	Jumper	Output 0-120V.
CW	1-2-1	2-2	3-2-3
CCW	2-1-2	1-1	3-1-3

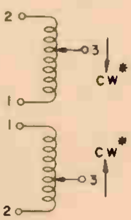


Fig. 39H

Knob* Rotation	Input 240V.	Jumper	Output 0-240V.	Output 0-280V.
CW	1-1-1	4-4-4	3-3-3	
CCW	4-4-4	1-1-1	3-3-3	
CW	5-5-5	4-4-4		3-3-3
CCW	2-2-2	1-1-1		3-3-3

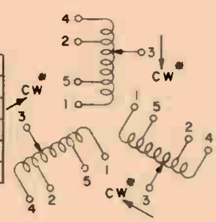


Fig. 39J

Knob* Rotation	Input 240V.	Jumper	Output 0-240V.
CW	1-1-1	2-2-2	3-3-3
CCW	2-2-2	1-1-1	3-3-3

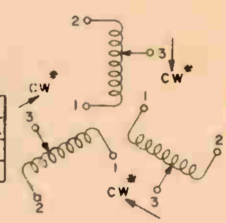


Fig. 39K

Single-Phase Series Operation

Knob* Rotation	Input 240V.	Input 480V.	Jumper	Output 0-480V.	Output 0-560V.
CW		1-1	4-4	3-3	
CCW		4-4	1-1	3-3	
CW		5-5	4-4		3-3
CCW		2-2	1-1		3-3
CW	7-7		4-4		3-3
CCW	6-6		1-1		3-3

3-Phase Open Delta Operation

Knob* Rotation	Input 120V.	Input 240V.	Jumper	Output 0-240V.	Output 0-280V.
CW		1-4-1	4-4	3-4-3	
CCW		4-1-4	1-1	3-1-3	
CW		5-4-5	4-4		3-4-3
CCW		2-1-2	1-1		3-1-3
CW	7-4-7		4-4		3-4-3
CCW	6-1-6		1-1		3-1-3

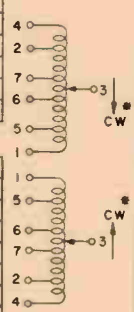


Fig. 39L

Single-Phase Series Operation

Knob* Rotation	Input 0-240V.	Input 0-480V.	Jumper	Output 0-480V.
CW		1-1	2-2	3-3
CCW		2-2	1-1	3-3
CW	4-4		2-2	3-3
CCW	4-4		1-1	3-3

3-Phase Open Delta Operation

Knob* Rotation	Input 120V.	Input 240V.	Jumper	Output 0-240V.
CW		1-2-1	2-2	3-2-3
CCW		2-1-2	1-1	3-1-3
CW	4-2-4		2-2	3-2-3
CCW	4-1-4		1-1	3-1-3

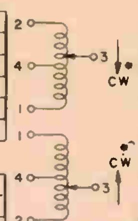


Fig. 39M

Single-Phase Series Operation

Knob* Rotation	Input 240V.	Input 480V.	Jumper	Output 0-480V.
CW		1-1	2-2	3-3
CCW		2-2	1-1	3-3
CW	5-5		2-2	3-3
CCW	4-4		1-1	3-3

3-Phase Open Delta Operation

Knob* Rotation	Input 120V.	Input 240V.	Jumper	Output 0-240V.
CW		1-2-1	2-2	3-2-3
CCW		2-1-2	1-1	3-1-3
CW	5-2-5		2-2	3-2-3
CCW	4-1-4		1-1	3-1-3

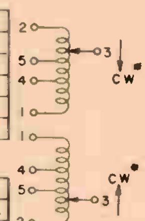


Fig. 39N

Knob* Rotation	Input 240V.	Input 480V.	Jumper	Output 0-480V.	Output 0-560V.
CW		1-1-1	4-4-4	3-3-3	
CCW		4-4-4	1-1-1	3-3-3	
CW		5-5-5	4-4-4		3-3-3
CCW		2-2-2	1-1-1		3-3-3
CW	7-7-7		4-4-4		3-3-3
CCW	6-6-6		1-1-1		3-3-3

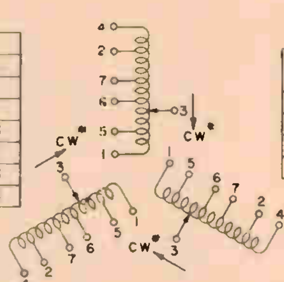
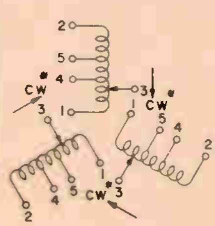


Fig. 39P

Knob* Rotation	Input 240V.	Input 480V.	Jumper	Output 0-480V.
CW		1-1-1	2-2-2	3-3-3
CCW		2-2-2	1-1-1	3-3-3
CW	5-5-5		2-2-2	3-3-3
CCW	4-4-4		1-1-1	3-3-3



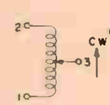


Fig. 39Q

Knob* Rotation	Input 40V.	Output 0-40V.
CW	1-2	1-3
CCW	1-2	2-3

*As viewed from base plate end.

Originally developed by OHMITE, Series LN variable transformers are designed to meet the control requirements for low-voltage, high-current power supplies used with semi-conductor apparatus. They are intended for inputs of 40 volts or less at 50 to over 1000 Hertz. Special brushes and heavy wire enable these units to carry their rated currents within normal temperature specifications. They are supplied with 0-100, "percent-of-output" dials. Constructed in the conventional frame sizes for VT2, VT4 and VT8 units, they can be made to order in tandem assemblies or enclosures or can be modified to meet special requirements. Physical size of VT4LN and VT8LN are same as VT4 (pages 8, 9) and VT8 (pages 10, 11), respectively. Dimensions for VT2LN are shown at right.


Fig. 40: VT2LN


Fig. 41: VT4LN


Fig. 42: VT8LN

STANDARD LN HI-CURRENT/LO-VOLTAGE TRANSFORMERS

Includes knob and 5011 dial (VT2LN) or 5112 dial (VT4LN and VT8LN). Frequency from 50 to over 1000 Hertz.

CATALOG[1] NUMBER	INPUT VOLTS (max.)	OUTPUT (max)		CONNECTION SCHEMATIC FIG. 39 (See page 14)	WEIGHT[2] (LBS.)
		VOLTS	CONSTANT CURRENT (AMPS)		
VT2LN	40	0-40	5.0	39Q	2.4
VT4LN Ⓢ	40	0-40	12.0	39B	5.25
VT8LN Ⓢ	40	0-40	22.0	39B	10.25

[1] Some items are classified "non-stock standard" due to limited usage and therefore are not stocked. Consult latest issue of Catalog 300 series for availability.

[2] Includes knob, dial and mounting hardware.

Ⓢ Approved under component program

U.S. Patent Nos. 2,790,882 and 2,985,857

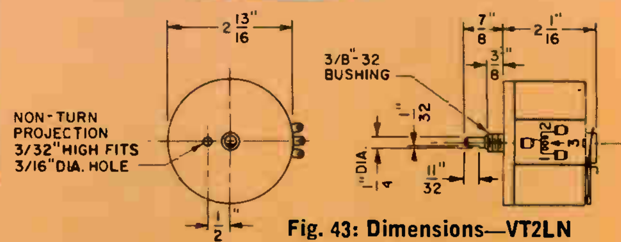


Fig. 43: Dimensions—VT2LN

DIRECT READING, REVERSIBLE DIALS

OHMITE

DIRECT READING, REVERSIBLE DIALS . . . calibrated on one side for overvoltage connection; on the reverse side for normal line connection. Dials normally included with transformers are voltage calibrated (except LN types) and read clockwise for increasing voltage; counter-clockwise calibration and "per-cent-of-output" types, calibrated from 0-100, are also available.

V.T. SERIES	REVERSIBLE DIAL CALIBRATION			FIGURE NUMBER	CATALOG NUMBER[1]
	NORMAL LINE	OVERVOLTAGE	DIRECTION		
VT1 VT02 VT2LN VT3	0-120	0-132	C.W.	44	**5005**
	0-100	100-0	C.W.	44	5011[4]
	0-240	0-260	C.W.	44	5019
VT4 and VT8	0-120	0-140	C.W.	45	**5006**
	0-120	0-140	C.C.W.	45	5008
	0-240	0-280	C.W.	45	5009
	0-240	0-280	C.C.W.	45	**5010**[2]
	0-100	100-0	C.W.	45	5012[4]
	0-480	0-560	C.W.	45	5018
VT20	0-120	0-140	C.W.	46	**5013**
	0-120	0-140	C.C.W.	46	5014
	0-240	0-280	C.W.	46	**5015**[3]
	0-240	0-280	C.C.W.	46	5016
	0-100	100-0	C.W.	46	5017[4]
	0-480	0-560	C.W.	46	5025

[1] Bold indicates standard dial furnished with basic model

[2] Furnished with VT8H

[3] Furnished with VT20H

[4] Percent-of-output dial.

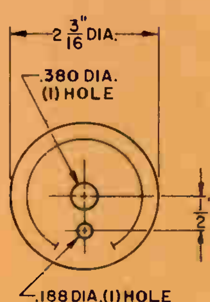


Fig. 44: For series VT1, VT02, VT2LN and VT3.

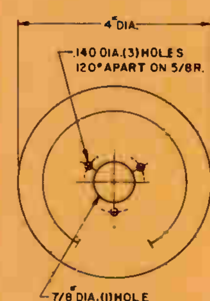


Fig. 45: For series VT4 and VT8.

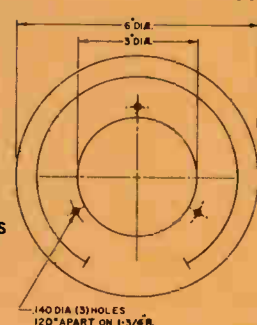


Fig. 46: For series VT20.

SPECIAL V.T. TRANSFORMERS

Fast engineering and delivery on "specials" has long been a distinguishing mark of Ohmite service to industry. Here are some of the modifications commonly requested:

Special Tandem Assemblies: Any reasonable number of transformers beyond that listed for the standard tandem assemblies can be supplied. Transformers in the assembly can be all of the same size or of different sizes. Also, transformers can be furnished in tandem with rheostats, tap switches, potentiometers or other devices. Tandem elements can be controlled in unison by means of a common shaft, or individually with a concentric control.

Auxiliary Switches: Transformers can be equipped with switch or switches arranged to operate at any point in the rotational arc.

Special Windings: Where special input or output voltages are involved or extra heavy load capacity is required, transformers with special windings can be supplied. Supplementary fixed voltages can be obtained with fixed taps. Transformers with an adjustable tap working on a bared side of the winding also can be supplied.

Motor-Driven Assemblies: Motor-driven single and tandem units may be obtained completely assembled to any specification direct from the factory.

Special Enclosures: Ohmite can supply modified standard enclosures or special enclosures such as "explosion proof" types.

Special Mechanical Features: Shafts, for example, can be provided in special lengths or with flats, splines, slots or locking device.

Ohmite invites your inquiry for all types of non-standard units.

Fig. 47: VT2 with two tracks—each brush is controlled individually with concentric shaft

Fig. 48: Special VT2—20-volt input, 30-volt output at 5 amps. Binding post terminals

Fig. 49: VT4 and VT2 in tandem with concentric control

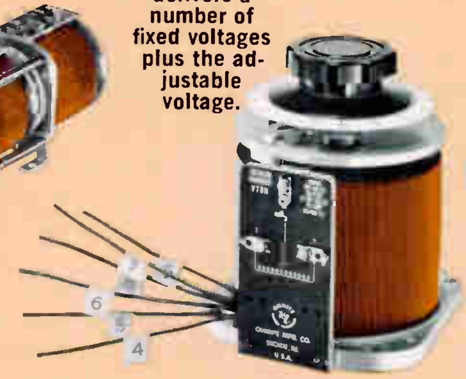


Fig. 50: Multi-tap transformer delivers a number of fixed voltages plus the adjustable voltage.

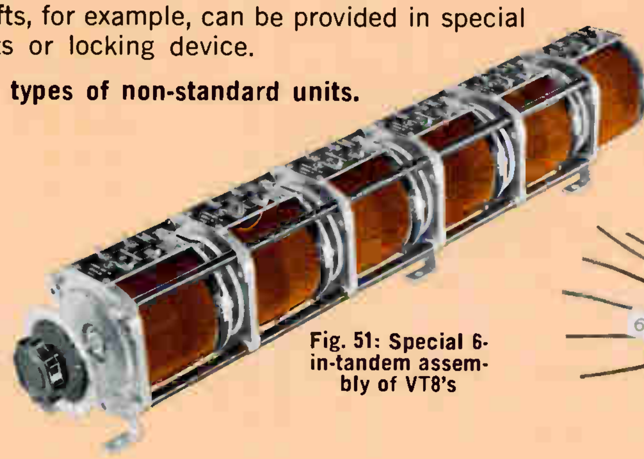


Fig. 51: Special 6-in-tandem assembly of VT8's

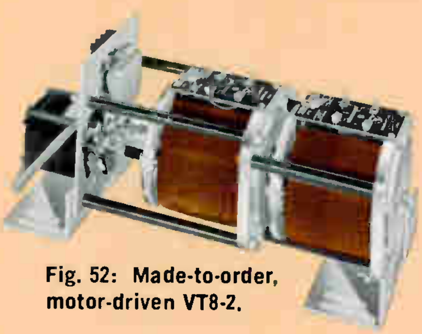


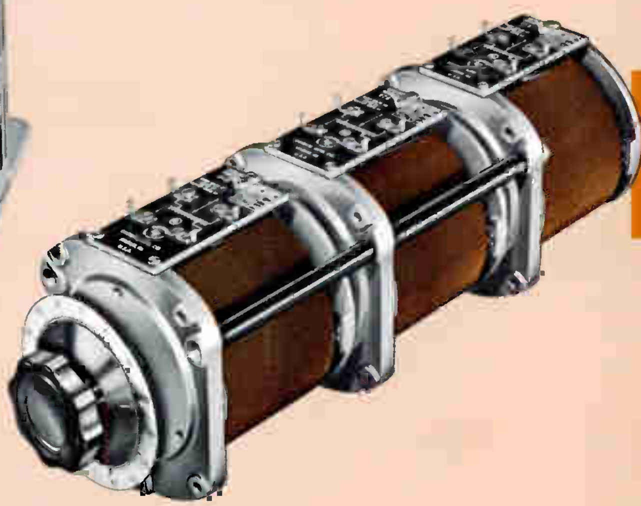
Fig. 52: Made-to-order, motor-driven VT8-2.

Obsolete
see 501

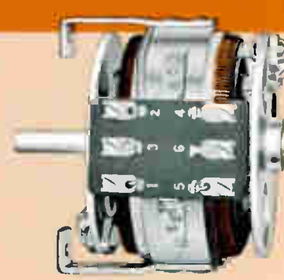
OHMITE V.T.®

VARIABLE TRANSFORMERS

CONTENTS



CATALOG 500A



OHMITE MANUFACTURING COMPANY, 3601 HOWARD ST., SKOKIE, ILL.

"v.t." VARIABLE TRANSFORMERS

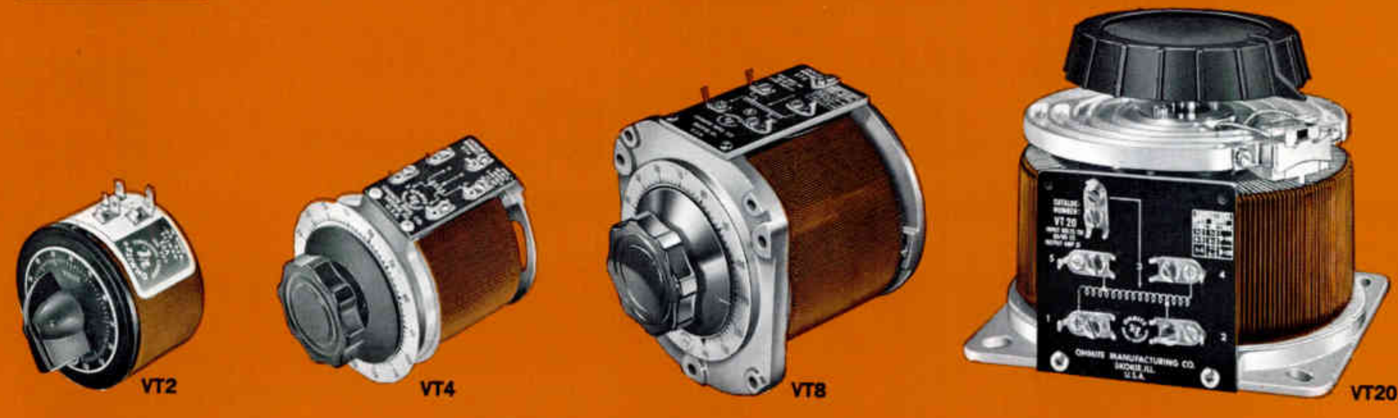


Fig. 1: Basic frame sizes of "v.t." line

A fresh approach to variable transformer design by OHMITE, and made to the same universally recognized high quality as other Ohmite components. Ratings now extend to 25 amperes to provide a range suitable to a large percentage of industrial applications. In addition to a number of unique design features, Ohmite Variable Transformers incorporate exclusive features which have been field-proven for years on famous Ohmite rheostats. Long, maintenance-free life, excellent regulation at any point within rated load and an output free of wave-form distortion are other distinguishing characteristics of "*v.t.*" variable transformers. *All units deliver their rated current at any brush setting.*

UL Approval: Series VT4 and VT8 type transformers have received Underwriters' Laboratories approval. Approval is pending on other models.

Positive Current Transfer . . . achieved in traditional OHMITE fashion by means of a pigtail directly connecting the brush to the large slip-ring which contacts a wide area of the collector ring (Fig. 2).

Table or Panel Use: On VT4, VT8 and VT20 type units, shafts may be extended out from either the brush or base side as desired. "Ganged" (tandem) VT4, VT8 or VT20 units employ a "thru-shaft" offering the same flexibility. On VT4 and VT8 units, such shafts are fixed in the desired position by means of socket head screws located in the hub of each "brush-radiator" plate (Fig. 4). The VT20 employs a collet-type shaft lock—see page TR9.

Interchangeable with Other Popular Types: Basic "*v.t.*" units have mounting provisions which match those of virtually all popular transformers of comparable current rating. Knob, dial and mounting hardware are included with each transformer. See individual model descriptions and diagrams.

Direct Reading, Reversible Dial . . . calibrated on one side for overvoltage connection; on the reverse side for normal line connection. Dials normally included with transformers are voltage calibrated (except LN types) and read clockwise for increasing voltage; counter-clockwise calibration and "percent-of-output" types, calibrated from 0-100, are also available.

DIALS

"v.t."	Dial Calibration	Stock No.
VT2	0-120, 0-132 C.W.	5005
	0-100, 100-0* C.W.	5011
VT4 and VT8	0-120, 0-140 C.W.	5006
	0-120, 0-140 C.C.W.	5008
	0-240, 0-280 C.W.	5009
	0-240, 0-280 C.C.W.	5010
	0-100, 100-0* C.W.	5012
VT20	0-120, 0-140 C.W.	5013
	0-120, 0-140 C.C.W.	5014
	0-240, 0-280 C.W.	5015
	0-240, 0-280 C.C.W.	5016

*Percent-of-output dial.

Line Frequency Ratings: Most VT2 types—60 to over 400 cps, some from 50 cps where indicated. All VT4, VT8 and VT20 types—50 to over 400 cps except where otherwise indicated.

Enclosures: "Basic protective enclosures" (Type B) expose the transformer's terminal panel and mounting base and are supplied presently on VT20 models only. "Fixed mounting enclosures" (Type E) are intended for permanent connection and mounting on table, panel or in-conduit-line. Standard portable units (Type F) carry a line cord, outlet socket, and fuse. Deluxe portable units available in VT8 only (Type G) utilize a circuit breaker, and can be switched to overvoltage or no-overvoltage as desired (see "Features").

Tandem (Ganged) Units: Two or 3-in-tandem assemblies are standard. More than 3 are supplied on special order. Construction is exceedingly sturdy, employing rigid mounting plates and heavy, threaded and insulated spacers. All tandem assemblies are normally

V.t.® VARIABLE TRANSFORMERS

OHMITE

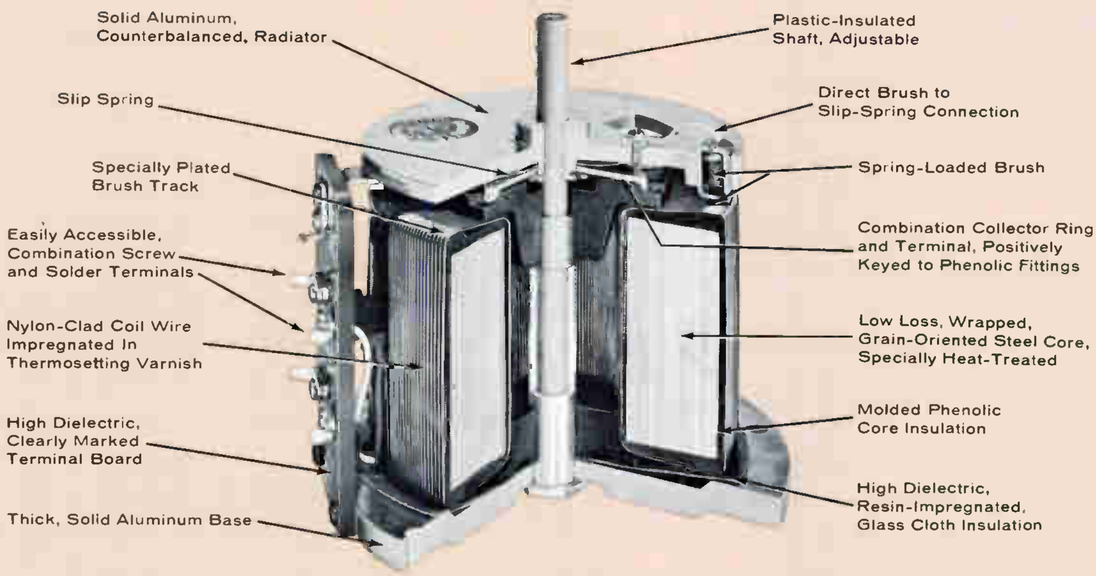


Fig. 2: Cutaway view VT8 transformer

furnished without interconnections between the units. These may be connected by the user for various purposes as described in "Mode of Wiring," below. Factory wired tandem assemblies can be provided at additional cost.

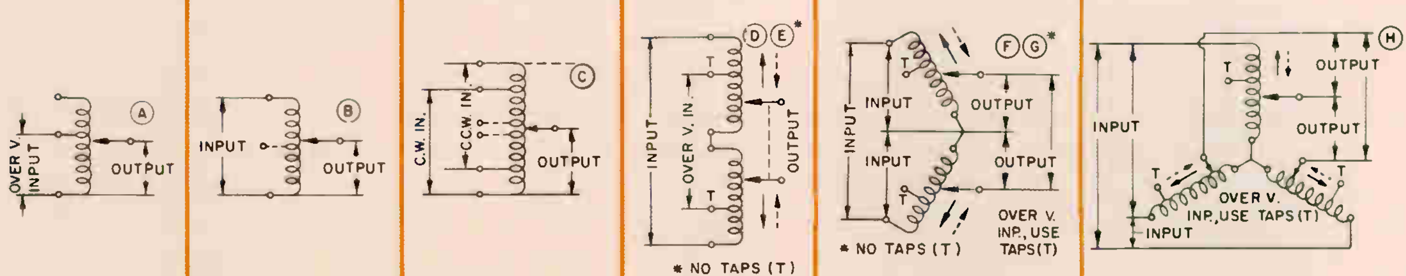
FEATURES AND CATALOG NUMBER CODES

The physical or frame size of a given transformer assembly is indicated by a basic designation. Various features are indicated by suffixes. "VT8" is an example of a basic designation.

Feature Suffixes: The following suffixes shown at right, added to the basic size designation, indicate various features on the transformer. Thus, "VT8N-2 indicates two units of "8" frame size, in tandem, each wound without overvoltage feature using heavier gage wire for greater current output. Order from table of available types given for each basic size. For special features or combinations not listed here, Ohmite invites your inquiries. *(Cont. on next page)*

	Suffix	Feature
Special Winding	A	No overvoltage provision—unit has same current rating as std., overvoltage unit (Fig. 3B).
	N	No overvoltage provision but unit has higher current rating due to heavier gage winding (Fig. 3B).
	L	Low voltage input and output (40V max.) high current output.
	H	Single unit, wound for 240-volt, single phase input—Has tap for 120 volt input with 240- or 280-volt output. (Figs. 3B, 3C resp.).
Enclosures	B	Simple protective enclosure which exposes transformer terminal panel and base.
	E	Enclosure with knockouts for fixed mounting in conduit line.
	F	Portable enclosure with switch, line cord, outlet and fuse.
	G	Deluxe portable enclosure with on-off, overvoltage selection switch, line cord, outlet, circuit breaker, adj. handle.
Special Cord	C	3-conductor, grounded input and output.
Units in Assembly	2	Two units in tandem.
	3	Three units in tandem.

Fig. 3: Simplified basic transformer circuits. (In the case of VT4, VT8 and VT20 types, circuits D, F and H would also have overvoltage taps for CCW rotation. Taps shown in dotted line in circuits B and C represent 120 volt inputs on "H" models only.)



MODE OF WIRING AND CONNECTIONS

Wiring instructions to arrange various modes of operation are enclosed with Ohmite transformers. On VT4, VT8 and VT20 types, a rigid plastic terminal panel carries convenient wiring diagram, coded terminals and input and output data. On VT2 types, diagram, coding and data, are provided on a plastic nameplate.

Overvoltage Option: On all units with overvoltage feature (Fig. 3A) either overvoltage or no-overvoltage output can be arranged on the terminal panel.

Rotation Option: On VT4, VT8 and VT20 transformers connected for overvoltage, either clockwise or counterclockwise increase of voltage can be arranged quickly by the user (Fig. 3C). Increasing voltage in either direction can be arranged on all units connected for no-overvoltage output.

240-Volt Input ("H" feature): On units which are wound for 240-volt input, a 120 volt input tap is also provided (Figs. 3B and C—dotted taps). With use of this input, the maximum current rating applies up to 120 volts output but beyond this reduces in accordance with Fig. 7.

Low Voltage Input ("L" feature): Designed for a maximum input of 40 volts with relatively high current output (see page TR8).

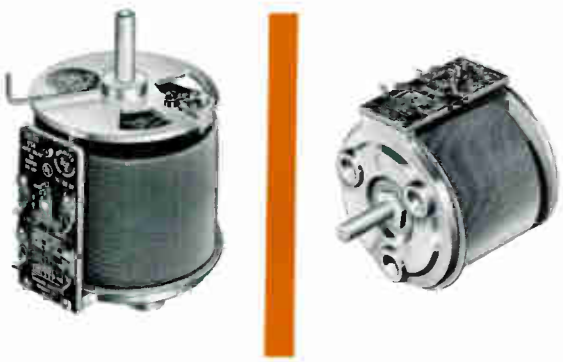
WIRING TANDEM ASSEMBLIES

Tandem assemblies may be wired for individual unit operation. Two-in-tandem assemblies can also be wired as follows:

(1) SERIES connection for 1-phase input at a line voltage double that of the individual transformer's input rating—with or without overvoltage output (Fig. 3D).

(2) OPEN DELTA connection for 3-phase input, with or without overvoltage output (Fig. 3F).

Fig. 4: On VT4, VT8 and VT20 types, shaft can be moved from brush side (left) to base side (right). Socket head screws (left) in radiator hub of VT4 and VT8 hold shaft. (See Fig. 33 for VT20 shaft lock.)



Three-in-tandem assemblies may be wired for:

(1) "Y" connection for 3-phase input at line voltage double that of the individual transformer's input rating with or without overvoltage output (Fig. 3H).

"N" type (no-overvoltage) transformers can be connected as shown in the foregoing but, of course, without overvoltage option. See model descriptions following, and Application-Selection Guide on last page.

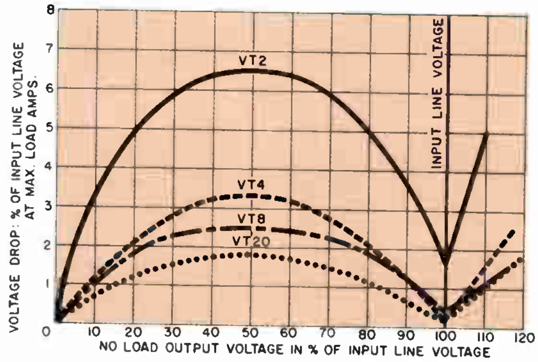


Fig. 5: Typical voltage regulation curves

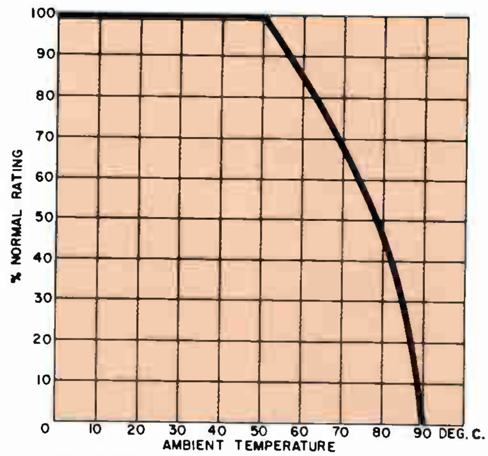


Fig. 6: Derating for ambient temperature

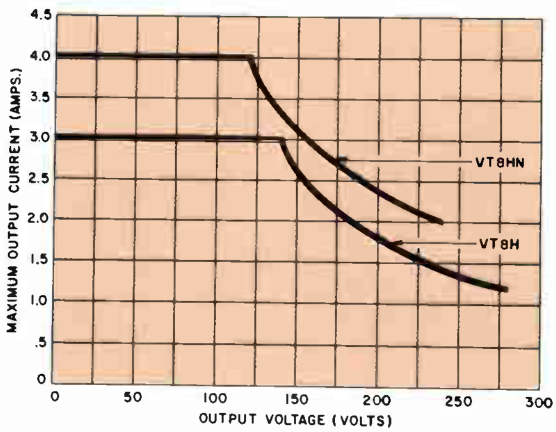


Fig. 7: Derating for use of 120-volt input on 240-volt transformers ("H" type).

VT2 VARIABLE TRANSFORMERS

1.75 AMPS with OVERVOLTAGE

2.0 AMPS NO-OVERVOLTAGE TYPE

Fig. 8: Basic VT2

Panel mounting. Combination type solder terminals will also accept ¼" wide quick-connect receptacles.

STOCK VT2 TYPES

Includes knob and dial; specify 240V dial if desired. Freq. 60 to over 400 cps. Rotation angle 320° ± 5°. Torque[8]. Tandem assemblies furnished without interconnection.

Units in Assy.[8]	Stock No.[1]	Feature or Connection[1]	Fig. 3 det.	Phase	Max. In. Volts	Max. Out. Volts at Rated Amps	Nom. Amps	Weight Lbs.
1	VT2[2,9]	Basic unit	A	1	120	0-120[6] 0-132	1.75	2.4
	VT2E[9]	Fixed mtg. case	A	1	120	0-120/132[3]	1.40	2.8
	VT2F[9]	Portable case	A	1	120	0-132[4]	1.75	3.2
	VT2N	No overvoltage	B	1	120	0-120[6]	2.00	2.4
	VT2NE	Fixed mtg. case	B	1	120	0-120	1.60	2.8
	VT2NF	Portable case	B	1	120	0-120	2.00	3.2
	VT2LN	Hi-amps, lo-volts	B	1	40	0-40	5.00	2.4
2	VT2-2[9]	Series conn.	D[5]	1	240	0-240[6] 0-264	1.75	5.25
		Open delta conn.	F	3	120	0-120[6] 0-132	1.75	
	VT2N-2	Series conn.	E[5]	1	240	0-240[6]	2.00	5.25
		Open delta conn.	G	3	120	0-120[6]	2.00	
3	VT2-3	"Y" connection	H	3	240	0-240[6,7]	1.75	8.0

[1] Complete explanation given Pages TR2-TR4.
[2] VT2A (1.75 amps, no-overvoltage), can be supplied.
[3] User wires for desired output—standard dial calibrated for overvoltage. Specify no-overvoltage dial if required.
[4] Normally connected at factory for overvoltage output. Easily reconnected for no-overvoltage output by user.
[5] With series-connected units load cannot be grounded.
[6] Nominal rating.
[7] Overvoltage connection cannot be used.
[8] Torque (inch-oz.): Single units, 3-6; 2-in-tandem, 10-20; 3-in-tandem, 15-30.
[9] 50 cps if connected for no-overvoltage output.

Brush assembly for VT2 Types except VT2LN . . . . Cat. No. 6514
Brush assembly for VT2LN . . . . Cat. No. 6517
Extra dials, Page 2. Extra knobs for uncased units . . . . Cat. No. 5158

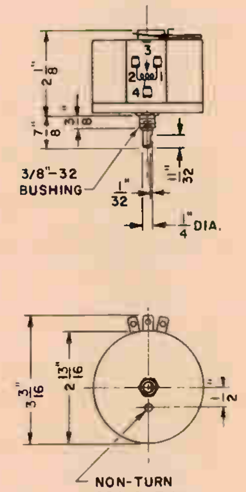


Fig. 9: Dimensions—VT2

Fig. 10: VT2E
VT2NE similar

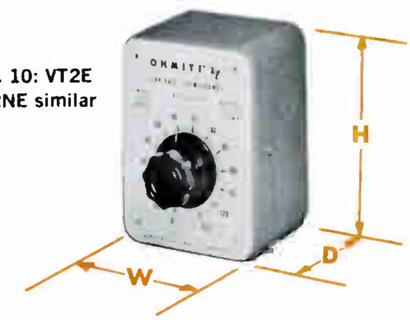


Fig. 11: VT2F
VT2NF similar

VT2 CASE DIMENSIONS

Type	W	D*	H
E	3⅜	2½	4¼
F	3⅜	2½	4¼

*Add ⅞" for knob thickness.

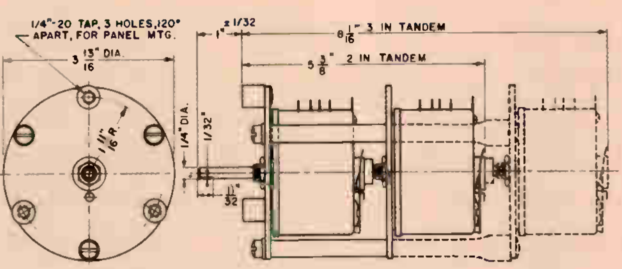


Fig. 12: Dimensions—VT2 Type Tandems

Fig. 13: VT2-3
VT2-2 similar

Fig. 14: VT4 arr. for panel mtg.

VT4 VARIABLE TRANSFORMERS

3.5 AMPS with OVERVOLTAGE
4.75 AMPS NO-OVERVOLTAGE TYPE

Table or panel mounting. Three-hole mounting is normally provided, but a 4-hole mounting adapter plate (see accessories below) to match other popular 4-hole mountings, is available.

STOCK VT4 TYPES

Includes knob and dial; specify 240V dial if desired. Freq. 50 to over 400 cps. Rotation angle 324° ± 5°. Torque[7]. Tandem assemblies furnished without interconnection.

Units in Assy.[7]	Stock No.[2]	Feature or Connection[2]	Fig. 3 det.	Phase	Max. In. Volts	Max. Out. Volts at Rated Amps	Nom. Amps	Weight Lbs.
1	VT4[3]	Basic unit	C	1	120	0-120/140	3.5	5.25
	VT4E	Fixed mtg. case	C	1	120	0-120/140[4]	2.8	7.4
	VT4F	Portable case	C	1	120	0-140[5]	3.5	7.8
	VT4FC	VT4F w/gnd. in. and out.	C	1	120	0-140[5]	3.5	7.8
	VT4N	No overvoltage	B	1	120	0-120	4.75	5.25
	VT4NE	Fixed mtg. case	B	1	120	0-120	3.8	7.4
	VT4NF	Portable case	B	1	120	0-120	4.75	7.8
	VT4NFC	VT4NF w/gnd. in. and out.	B	1	120	0-120	4.75	7.8
	VT4LN	Hi-amps, lo volts	B	1	40	0-40	12	5.25
2	VT4-2	Series conn.	D[6]	1	240	0-240/280	3.5	11.3
		Open delta conn.	F	3	120	0-120/140	3.5	
	VT4N-2	Series conn.	E[6]	1	240	0-240	4.75	11.3
		Open delta conn.	G	3	120	0-120	4.75	
3	VT4-3[1]	"Y" connection	H	3	240	0-240/280[1]	3.5	17.0

[1] 60 cps min. on "Y" connected units wired for overvoltage.
[2] Complete explanation, page TR2-TR4.
[3] VT4A (3.5 amps—no overvoltage) can be supplied.
[4] User wires for desired output—standard dial calibrated for overvoltage. Specify no-overvoltage dial if required.
[5] Normally connected at factory for overvoltage output. Easily reconnected for no-overvoltage output by user.
[6] With series-connected units, load cannot be grounded.
[7] Torque (inch.-oz.): Single unit 15-25; 2-in-tandem, 30-60; 3-in-tandem, 50-85.

Brush assembly for VT4 types except VT4LN . . . . Cat. No. 6515
Brush assembly for VT4LN . . . . Cat. No. 6518
Four-hole mtg. adapter plate (Dimensions, Figs. 15, 19) . . . . Cat. No. 6512
Extra dials or dials with CCW Calibrations, Page 2.
Extra knobs for uncased units . . . . Cat. No. 5155
Adjustable stop for limiting rotation arc . . . . Cat. No. 6536

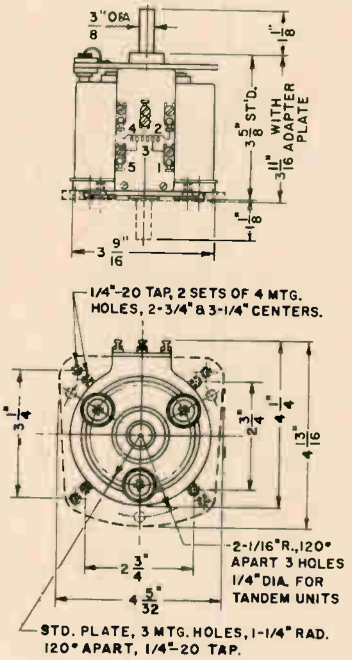


Fig. 15: Dimensions—VT4

VT4 CASE DIMENSIONS

Type	W	D*	H
E	4½	4½	6 3/16
F	4 7/8	4½	6¼

*Add ⅞" for knob thickness.

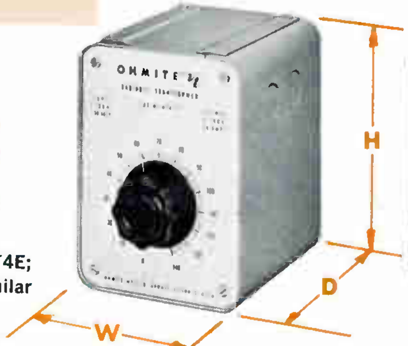


Fig. 16: VT4E; VT4NE similar

Fig. 17: VT4FC; VT4NFC similar

Fig. 17A: VT4F; VT4NF similar

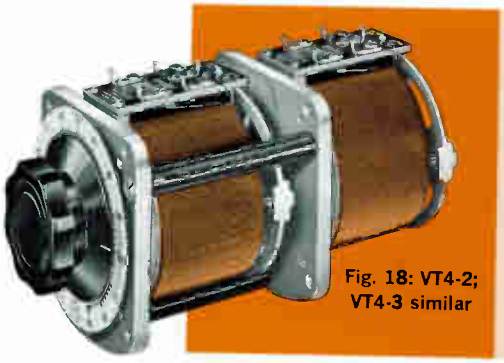


Fig. 18: VT4-2; VT4-3 similar

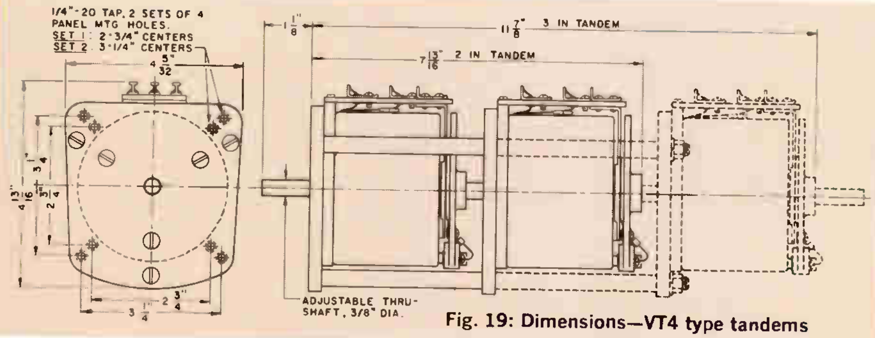


Fig. 19: Dimensions—VT4 type tandems

VT8 VARIABLE TRANSFORMERS

7.5 AMPS with OVERVOLTAGE

10 AMPS NO-OVERVOLTAGE TYPE

Table or panel mounting. This series includes individual units for 220-240 volt input.

Fig. 20: VT8 arr. for panel mtg.

STOCK VT8 TYPES

Includes knob and dial; specify 240V dial if desired. Freq. 50 to over 400 cps. Rotation angle 324° ± 5°. Torque[9]. Tandem assemblies furnished without interconnection.

Units in Assy.[9]	Stock No.[2]	Feature or Connection[2]	Fig. 3 det.	Phase	Max. In. Volts	Max. Out. Volts at Rated Amps	Nom. Amps	Weight Lbs.
1	VT8[3]	Basic unit	C	1	120	0-120/140	7.5	10.25
	VT8E	Fixed mtg. case	C	1	120	0-120/140[5]	6.0	13.5
	VT8F	Portable case	C	1	120	0-140[6]	7.5	13.8
	VT8FC	VT8F w/gnd. in. and out.	C	1	120	0-140[6]	7.5	13.8
	VT8G	Deluxe, Portable	C	1	120	0-120/140[7]	6.0	14.2
	VT8GC	VT8G w/gnd. in. and out.	C	1	120	0-120/140[7]	6.0	14.2
	VT8N	No overvoltage	B	1	120	0-120	10.0	10.25
	VT8NE	Fixed mtg. case	B	1	120	0-120	8.0	13.5
	VT8NF	Portable case	B	1	120	0-120	10.0	13.8
	VT8NFC	VT8NF w/gnd. in. and out.	B	1	120	0-120	10.0	13.8
	VT8LN	Hi amps, lo volts	B	1	40	0-40	22	10.25
	VT8H	240 input	C	1	240 120	0-240/280 0-280[4]	3.0 3.0[4]	10.25
	VT8HN	240V in., no overvoltage	B	1	240 120	0-240 0-240[4]	4.0 4.0[4]	10.25
2	VT8-2	Series conn. Open delta conn.	D[8] F	1 3	240 120	0-240/280 0-120/140	7.5 7.5	20.6
	VT8N-2	Series conn. Open delta conn.	E[8] G	1 3	240 120	0-240 0-120	10.0 10.0	20.6
	VT8H-2	Series conn. Open delta conn.	D[8] F	1 3	480 240	0-480/560 0-240/280	3.0 3.0	20.6
	VT8HN-2	Series conn. Open delta conn.	E[8] G	1 3	480 240	0-480 0-240	4.0 4.0	20.6
3	VT8-3	"Y" connection	H	3	240	0-240/280[1]	7.5	31.0
	VT8-3E	Fixed mtg. case	H	3	240	0-240/280[1]	6.0	41.5
	VT8H-3	"Y" connection	H	3	480	0-480/560[1]	3.0	31.0

[1] 60 cps min. on "Y" conn. units wired for over-voltage.
[2] Complete explanation, pages TR2-TR4.
[3] VT8A (7.5 amps, no-overvoltage) can be supplied.
[4] When 120 volt input tap is used, unit must be derated for output greater than 120V (Fig. 7).
[5] User wires for desired output—standard dial calibrated for overvoltage. Specify no-overvoltage dial if required.
[6] Normally connected at factory for overvoltage output—easily reconnected by user for no-overvoltage output.
[7] Switch selects overvoltage or line voltage output.
[8] With series-connected units load cannot be grounded.
[9] Torque (inch-oz.): Single unit, 20-35; 2-in-tandem 45-70; 3-in-tandem, 80-115.

Brush assembly for VT8 types except those below . . . . Cat. No. 6516
Brush assembly for VT8H, HN only . . . . Cat. No. 6516H
Brush assembly for VT8LN only . . . . Cat. No. 6519
Extra dials or dials with CCW calibration, see Page 2.
Extra knobs for uncased units . . . . Cat. No. 5155
Adjustable stop for limiting rotation arc . . . . Cat. No. 6537

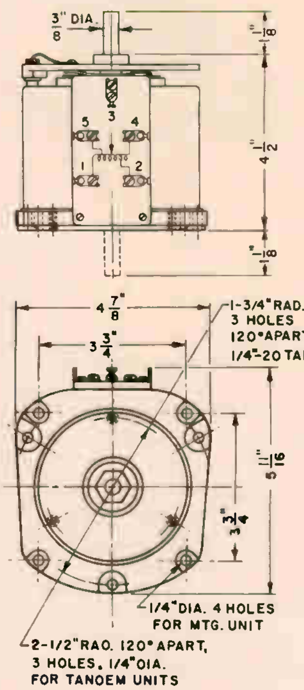


Fig. 21: Dimensions—VT8

TANDEM ASSEM. DIMENSIONS —NEXT PAGE

VT8 CASE DIMENSIONS

Type	W	D*	H
E	5 3/16	5 1/4	7 3/16
F	5 17/32	5 1/4	7 3/8
G	5 3/16†	5 1/4	7 3/8‡

*Add 1" for Knob Thickness.
†5 3/4" including handle fittings.
‡Case height only.

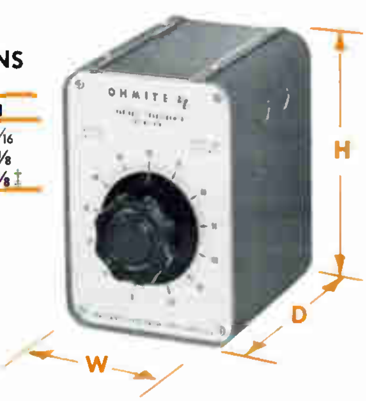


Fig. 22: VT8E; VT8NE similar

Fig. 23: VT8FC; VT8F has 2 cond. socket & plug

Fig. 24: VT8G; VT8GC has 3-cond. socket & plug

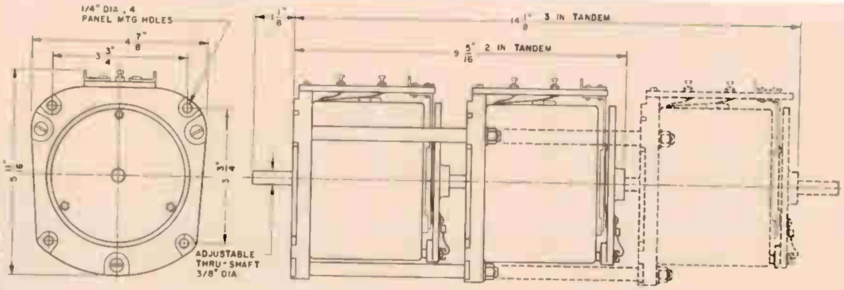


Fig. 26: Dimensions—VT8 type tandems

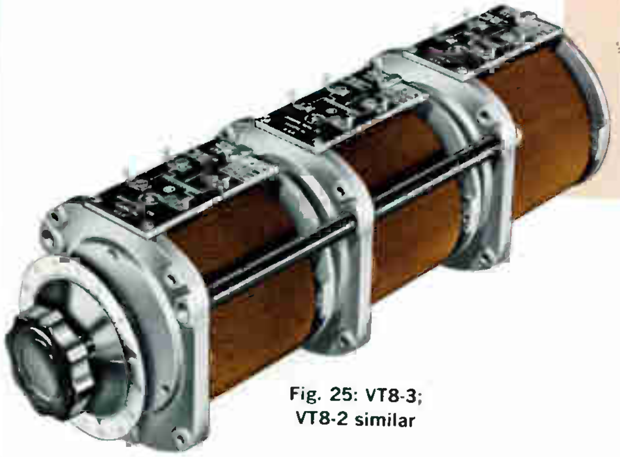


Fig. 25: VT8-3; VT8-2 similar

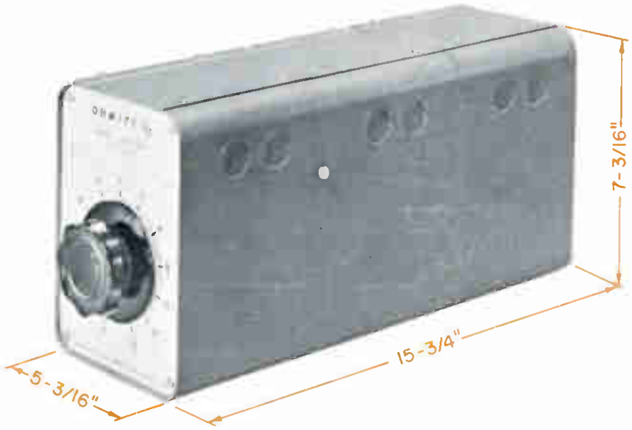


Fig. 27: VT8-3E

SERIES "LN" HI-CURRENT LO-VOLTAGE TRANSFORMERS

Fig. 28: VT2LN
Max. volts input—40
Max. amps output—5

Fig. 29: VT4LN
Max. volts input—40
Max. amps output—12

Fig. 30: VT8LN
Max. volts input—40
Max. amps output—22

Originally developed by OHMITE, Series LN variable transformers were designed to meet the control requirements for low-voltage, high-current power supplies used with semi-conductor apparatus. They are intended for inputs of 40 volts or less at 50 to over 400 cycles per second. Special brushes and heavy wire enable these units to carry their rated currents within normal temperature specifications. They are supplied with 0-100, "percent-of-output" dials. Constructed in the conventional frame sizes for VT2, VT4 and VT8 units, they can be made to order in tandem assemblies or enclosures or can be modified to meet special requirements. Physical and electrical data for these units will be found in the respective sections dealing with Series VT2, VT4 and VT8 transformers.

VT20 VARIABLE TRANSFORMERS

20 AMPS with OVERVOLTAGE

25 AMPS NO-OVERVOLTAGE TYPE

OHMITE

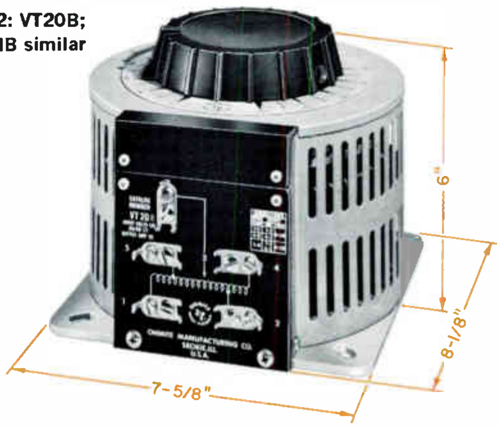
Distinctive sturdiness of construction and mounting versatility. The radiator plate is counterbalanced for stability under conditions of vibration to compensate for the weight of the oversize brush assembly, furnished to provide an extra margin of heat dissipation. The shaft can be extended from either side of the transformer as required for panel or horizontal surface mounting. *A unique collet-type shaft lock permits ready repositioning of the shaft without scoring or defacing the shaft surface (see Fig. 33).*

At present, Ohmite offers the Model VT20 overvoltage type and the higher rated VT20N, no-overvoltage type. These units are also supplied in a "B" type case (VT20B, VT20NB) a simple, ventilated enclosure which differs from Ohmite's optional E, F and G enclosures in being round and in exposing the transformer's terminal panel and base. Tandem assemblies unenclosed or in "B" type enclosures are also available. The VT20 series will eventually include the high voltage and enclosure variations shown for the VT8 series.

Continued on next page

Fig. 31: VT20; VT20N similar

Fig. 32: VT20B; VT20NB similar



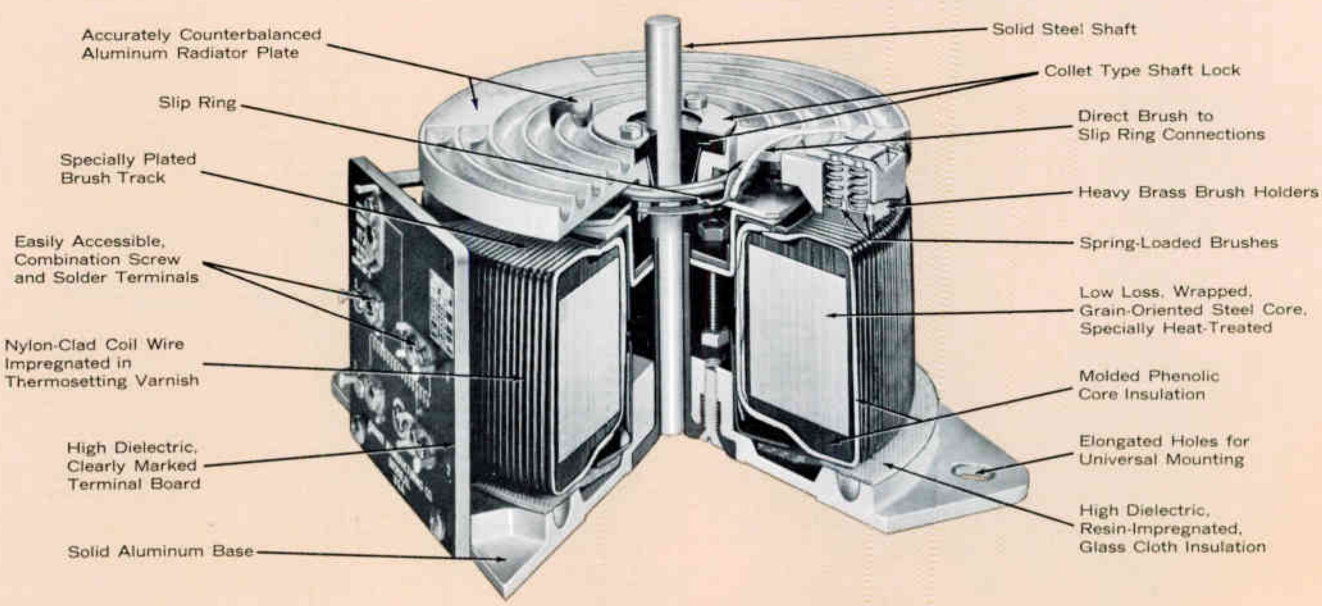


Fig. 33: Cutaway View of VT20

VT20 (continued)

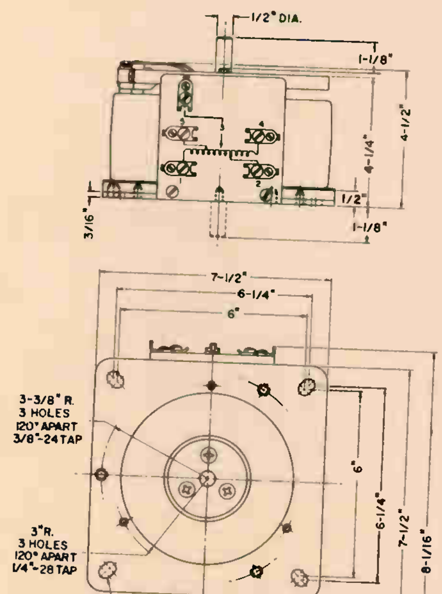


Fig. 34: Dimensions—VT20

STOCK VT20 TYPES

Includes knob and dial; specify 240V dial if desired. Freq. 50 to over 400 cps. Rotation angle 317° ± 5°. Torque[5]. Tandem assemblies furnished without interconnection.

Units in Assy.[5]	Stock No.	Feature or Connection[6]	Fig. 3 det.	Phase	Max. In. Volts	Max. Out. Volts at Rated Amps	Nom. Amps	Weight Lbs.
1	VT20[3]	Basic unit	C	1	120	0-120/140	20	22
	VT20B	Basic case	C	1	120	0-120/140	20	22
	VT20N	No overvoltage	B	1	120	0-120	25	22
	VT20NB	Basic case	B	1	120	0-120	25	22
2	VT20-2	Series conn.[4]	D	1	240	0-240/280	20	45
		Open delta conn.	F	3	120	0-120/140	20	
	VT20-2B	VT20-2 in B case—Same connections and outputs as VT20-2						46
	VT20N-2	Series conn.[4]	E	1	240	0-240	25	45
		Open delta conn.[2]	G	3	120	0-120	25	
	VT20N-2B	VT20N-2 in B case—Same connections and outputs as VT20N-2						46
3	VT20-3	Y conn.[1]	H	3	240	0-240/280	20	68
	VT20-3B	VT20-3 in B case—Same connection and outputs as VT20-3						69.5
	VT20N-3[2]	Y conn.[2]	H	3	240	0-240	25	68
	VT20N-3B[2]	VT20N-3 in B case—Same connection and outputs as VT20N-3						69.5

[1] 60 cps min. on "Y" connected units wired for over-voltage.
[2] 60 cps minimum.
[3] VT20A (20 amps, no overvoltage) can be supplied.
[4] With series-connected units load cannot be grounded.
[5] Torque (inch-oz.): Single unit, 45-90; 2-in-tandem, 90-180; 3-in-tandem, 200-300.
[6] Complete explanation Pages TR2-TR4.

Brush-Contact assembly for VT20 types except VT20N .... Cat. No. 6590
Brush-Contact assembly for VT20N type .... Cat. No. 6594
Extra knob .... Cat. No. 5157
Extra dials or dials with CCW calibration, see Page 2.

Fig. 35: VT20-2; VT20-3 similar

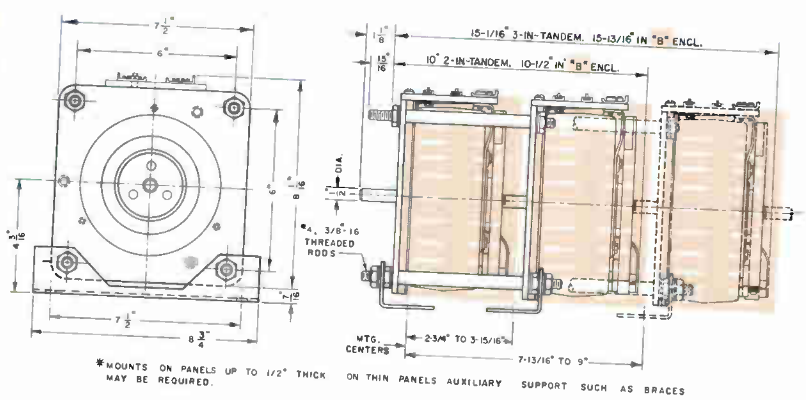


Fig. 36: Dimensions—VT20 Type Tandems

SPECIAL V.T.® TRANSFORMERS

OHMITE

Fig. 37: Special 6-in-tandem assembly of VT8's

Fig. 38: VT2 with two tracks—each brush is controlled individually with concentric shaft

Fig. 39: Special VT2 —20-volt input, 30-volt output at 5 amps. Binding post terminals

Fast engineering and delivery on "specials" has long been a distinguishing mark of Ohmite service to industry. Here are some of the modifications commonly requested:

Special Tandem Assemblies: Any reasonable number of transformers beyond that listed for the standard tandem assemblies can be supplied. Transformers in the assembly can be all of the same size or of different sizes. Also, transformers can be furnished in tandem with rheostats, tap switches, potentiometers or other devices. Tandem elements can be controlled in unison by means of a common shaft, or individually with a concentric control.

Auxiliary Switches: Transformers can be equipped with switch or switches arranged to operate at any point in the rotational arc.

Special Windings: Where special input or output voltages are involved or extra heavy load capacity is required, transformers with special windings can be supplied. Supplementary fixed voltages can be obtained with fixed taps. Transformers with an adjustable tap working on a bared side of the winding also can be supplied.

Motor-Driven Assemblies: Single or tandem assemblies can be easily and quickly "motorized" with Ohmite "do-it-yourself" motor modules. Request Bulletin 167. Motor-driven units can also be obtained completely assembled to any specification direct from the factory.

Special Enclosures: Ohmite can supply modified standard enclosures or special enclosures such as "explosion proof" types.

Special Mechanical Features: Shafts, for example, can be provided in special lengths or with flats, splines, slots or locking device.

Ohmite invites your inquiry for all types of non-standard units.

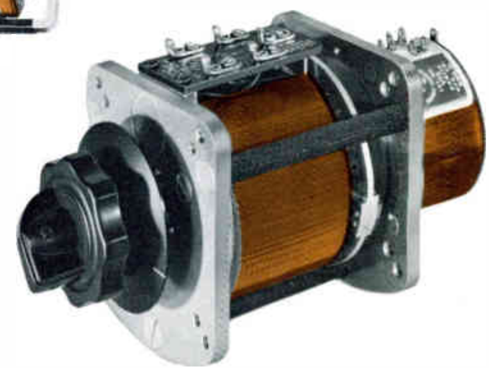


Fig. 40: VT4 and VT2 in tandem with concentric control

Fig. 41: Rheostat-transformer tandem assembly

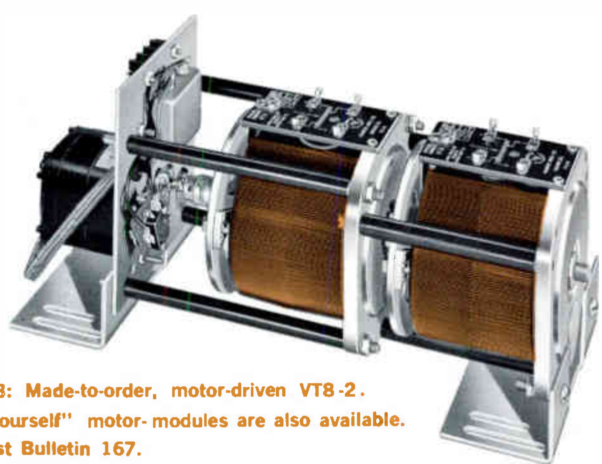


Fig. 43: Made-to-order, motor-driven VT8-2. "Do-it-yourself" motor- modules are also available. Request Bulletin 167.

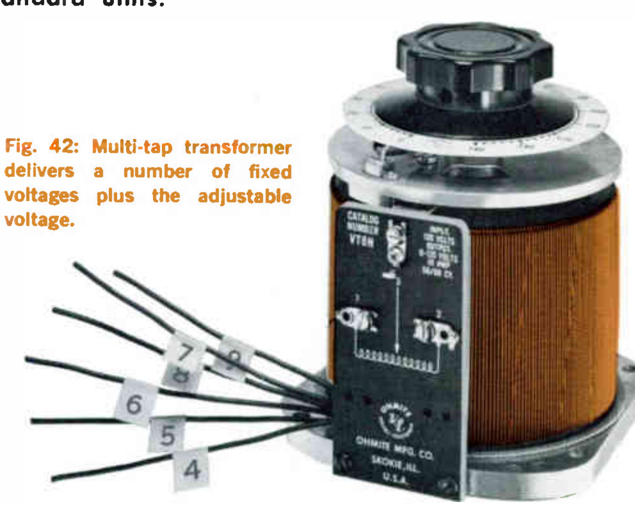


Fig. 42: Multi-tap transformer delivers a number of fixed voltages plus the adjustable voltage.

APPLICATION—SELECTION GUIDE

Input Volts	Freq.[1] cps. from...	Maximum Output Amps.	Maximum Output Volts	Feature or Connection[11]	Fig. 3 Det.	Stock No.	See Page	Torque (in.—oz.) min.	Torque (in.—oz.) max.	Weight Lbs.[7]
SINGLE-PHASE										
				SINGLE TRANSFORMERS—UNCASED						
40	50	5	0-40	Hi-amps, low volts	B	VT2LN	5	3	6	2.4
40	50	12.0	0-40	Hi-amps, low volts	B	VT4LN	6	15	25	5.25
40	50	22.0	0-40	Hi-amps, low volts	B	VT8LN	7	20	35	10.25
120	60[8]	1.75	0-120/132	Basic 1.75A Model	A	VT2	5	3	6	2.4
120	60	2.0	0-120	No overvoltage	B	VT2N	5	3	6	2.4
120	50	3.5	0-120/140	Basic 3.5A Model	C	VT4	6	15	25	5.25
120	50	4.75	0-120	No overvoltage	B	VT4N	6	15	25	5.25
120	50	7.5	0-120/140	Basic 7.5A Model	C	VT8	7	20	35	10.25
120	50	10.0	0-120	No overvoltage	B	VT8N	7	20	35	10.25
120	50	20.0	0-120/140	Basic 20A Model	C	VT20	9	45	90	22.0
120	50	25.0	0-120	No overvoltage	B	VT20N	9	45	90	22.0
240[2]	50	3.0	0-240/280	240V Input[2]	C[2]	VT8H	7	20	35	10.25
240[2]	50	4.0	0-240	240V No ovrvlt.[2]	B[2]	VT8HN	7	20	35	10.25
				SINGLE TRANSFORMERS—CASED						
120	60[8]	1.4	0-132[4]	Fixed Mtg.	A	VT2E	5	3	6	2.8
120	60[8]	1.75	0-132[3]	Portable	A	VT2F	5	3	6	3.2
120	60	1.6	0-120	Fixed Mtg.	B	VT2NE	5	3	6	2.8
120	60	2.0	0-120	Portable	B	VT2NF	5	3	6	3.2
120	50	2.8	0-140[4]	Fixed Mtg.	C	VT4E	6	15	25	7.4
120	50	3.5	0-140[3]	Portable	C	VT4F	6	15	25	7.8
120	50	3.5	0-140[3]	VT4F W/gnd. in. and out.	C	VT4FC	6	15	25	7.8
120	50	3.8	0-120	Fixed Mtg.	B	VT4NE	6	15	25	7.4
120	50	4.75	0-120	Portable	B	VT4NF	6	15	25	7.8
120	50	4.75	0-120	VT4NF w/gnd. in. and out.	B	VT4NFC	6	15	25	7.8
120	50	6.0	0-140[4]	Fixed Mtg.	C	VT8E	7	20	35	13.5
120	50	7.5	0-140[3]	Portable	C	VT8F	7	20	35	13.8
120	50	7.5	0-140[3]	VT8F w/gnd. in. and out.	C	VT8FC	7	20	35	13.8
120	50	6.0	0-120/140[3]	Deluxe Portable	C	VT8G	7	20	35	14.2
120	50	6.0	0-120/140[3]	VT8G w/gnd. in. and out.	C	VT8GC	7	20	35	14.2
120	50	8.0	0-120	Fixed Mtg.	B	VT8NE	7	20	35	13.5
120	50	10.0	0-120	Portable	B	VT8NF	7	20	35	13.8
120	50	10.0	0-120	VT8NF w/gnd. in. and out.	B	VT8NFC	7	20	35	13.8
120	50	20.0	0-120/140	Basic Case	C	VT20B	9	45	90	22.5
120	50	25.0	0-120	Basic Case	B	VT20NB	9	45	90	22.5
				TWO-IN-TANDEM ASSEMBLIES[5,10]						
240	60[8]	1.75	0-240/264	Series Conn.[6]	D	VT2-2	5	10	20	5.25
240	60	2.0	0-240	Series Conn.[6]	E	VT2N-2	5	10	20	5.25
240	50	3.5	0-240/280	Series Conn.[6]	D	VT4-2	6	30	60	11.3
240	50	4.75	0-240	Series Conn.[6]	E	VT4N-2	6	30	60	11.3
240	50	7.5	0-240/280	Series Conn.[6]	D	VT8-2	7	45	70	20.6
240	50	10.0	0-240	Series Conn.[6]	E	VT8N-2	7	45	70	20.6
240	50	20.0	0-240/280	Series Conn.[6]	D	VT20-2	9	90	180	45.0
240	50	20.0	0-240/280	Above unit, B case	D	VT20-2B	9	90	180	46.0
240	50	25.0	0-240	Series Conn.[6]	E	VT20N-2	9	90	180	45.0
240	50	25.0	0-240	Above unit, B case	E	VT20N-2B	9	90	180	46.0
480	50	3.0	0-480/560	Series Conn.[6]	D	VT8H-2	7	45	70	20.6
480	50	4.0	0-480	Series Conn.[6]	E	VT8HN-2	7	45	70	20.6
THREE-PHASE										
120	60	1.75	0-120/132	Open Delta Conn.	F	VT2-2	5	10	20	5.25
120	60	2.0	0-120	Open Delta Conn.	G	VT2N-2	5	10	20	5.25
120	50	3.5	0-120/140	Open Delta Conn.	F	VT4-2	6	30	60	11.3
120	50	4.75	0-120	Open Delta Conn.	G	VT4N-2	6	30	60	11.3
120	50	7.5	0-120/140	Open Delta Conn.	F	VT8-2	7	45	70	20.6
120	50	10.0	0-120	Open Delta Conn.	G	VT8N-2	7	45	70	20.6
120	50	20.0	0-120/140	Open Delta Conn.	F	VT20-2	9	90	180	45.0
120	50	20.0	0-120/140	Above unit, B case	F	VT20-2B	9	90	180	46.0
120	60	25.0	0-120	Open Delta Conn.	G	VT20N-2	9	90	180	45.0
120	60	25.0	0-120	Above unit, B case	G	VT20N-2B	9	90	180	46.0
240	50	3.0	0-240/280	Open Delta Conn.	F	VT8H-2	7	45	70	20.6
240	50	4.0	0-240	Open Delta Conn.	G	VT8HN-2	7	45	70	20.6
				THREE-IN-TANDEM ASSEMBLIES[5,10]						
240	60	1.75	0-240[9]	"Y" Conn.	H	VT2-3	5	15	30	8.0
240	60[8]	3.5	0-240/280	"Y" Conn.	H	VT4-3	6	50	85	17.0
240	60[8]	7.5	0-240/280	"Y" Conn.	H	VT8-3	7	80	115	31.0
240	60[8]	6.0	0-240/280	Above unit, E case	H	VT8-3E	7	80	115	40.0
240	60[8]	20.0	0-240/280	"Y" Conn.	H	VT20-3	9	200	300	68.0
240	60[8]	20.0	0-240/280	Above unit, B case	H	VT20-3B	9	200	300	69.5
240	60	25.0	0-240	"Y" Conn.	H	VT20N-3	9	200	300	68.0
240	60	25.0	0-240	Above unit, B case	H	VT20N-3B	9	200	300	69.5
480	60[8]	3.0	0-480/560	"Y" Conn.	H	VT8H-3	7	80	115	31.0

[1] Frequency shown is a minimum—units may be used to well over 400 cps.

[2] VT8H and VT8HN also have taps for 120V input with 280V output for VT8H and 240V output for VT8HN. With use of 120V input the max. current rating applies up to 120V output but reduces to approx. 50% at max. output voltage. Fig. 7.

[3] Connected at factory for overvoltage output—easily reconnected by user for no-overvoltage output. On VT8G, switch selects overvoltage or no-overvoltage.

[4] User wires for desired output. Dial normally calibrated for overvoltage.

[5] Tandem assemblies normally furnished without interconnection between units.

[6] When transformers are series connected, load cannot be grounded.

[7] Includes knob and dial.

[8] May be used at 50 cps if connected for no-overvoltage output.

[9] Overvoltage connection must not be used.

[10] Specify 240 volt dial if desired.

[11] See pages TR2-4 for complete details.

be right with

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resistors

rheostats

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relays

variable transformers

tantalum capacitors

germanium diodes

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TANTALUM CAPACITORS 600

Now! Thirteen Sizes

TAN-O-MITE® SERIES TW *by* OHMITE

WIRE TYPE TANTALUM CAPACITORS

. . the smallest subminiature electrolytic capacitors

Ohmite TAN-O-MITE® Series TW capacitors are tantalum wire, electrolytic type units offering amazingly high capacitance for their small size. The smallest subminiature capacitors available, *they provide microfarads of capacity in less space than that required for micro-microfarads in other units.* In addition to their space saving benefits, they offer excellent performance under temperature extremes, long shelf life and electrical stability superior to aluminum electrolytics.

APPLICATION

Miniaturized or transistorized apparatus where space is a prime consideration. They are intended for coupling, filter and by-pass uses in non-critical, non-resonant, low voltage DC circuits where capacitance values can exceed nominal circuit requirements considerably (see "Capacitance" in "Specifications").

WIDE CAPACITY RANGE

Thirteen case sizes provide sufficient range and flexibility to satisfy virtually any design need. Overall capacitance range of the Tan-O-Mite line is .01 to 150 mfds. The size of the smallest unit "TK", including insulation, is only .150" long by .060" diameter; the largest size "E", including insulation, is only .812" long by .134" diameter. The largest sizes D and E, offer the greatest capacitance of the series, yet remain well within the "subminiature" size designation. They are provided in values formerly available only in foil type units and may be used to replace foil units of the same volt x microfarad product with advantageous savings in space. Maximum capacitance is limited by the size of each case and by the magnitude of the rated D.C. working voltage (see Table, "Max. Mfds.").

CONSTRUCTION

A tantalum wire with specially processed oxide film forms the anode. It is enclosed with an electrolyte solution in a cylindrical silver case which serves as the cathode. The negative lead is connected axially to the end of this case. The "open" end is sealed with a "Teflon" plastic bushing through which the anode wire projects. The positive lead is welded to the anode. A small plastic embedment covers the Teflon bushing, protects the weld and provides an additional seal.

Standard Series TW capacitors are supplied insulated with a tough, Mylar plastic sleeve .002" thick. The capacitors are stocked in certain standard values by Ohmite (see "Stock Values" table). Series TW units, normally have axial leads. Radial leads or other special construction can be furnished to order.

Single End Lead Termination, for example, can be supplied on all Series TW capacitors (see illustration—right). This type of construction facilitates fast assembly into modules and/or into printed circuit boards. Other types of special construction to meet the requirements of certain assembly methods can be supplied. Submit your requirements to OHMITE.

OPERATING TEMPERATURE RANGE

From −55°C to +85°C. See graphs on typical performance data over this range.

Typical Insulated TAN-O-MITE® Capacitor (Enlarged)

OHMITE

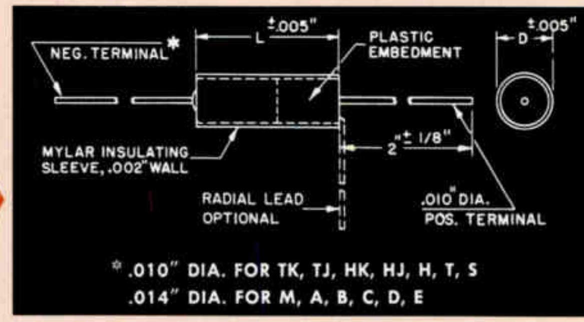
BULLETIN 601

SPECIFICATIONS

Now! 13 Case Sizes to Choose From

CASE SIZE	D ±.005"	L +.015" −.005"	CASE SIZE	D ±.005"	L +.015" −.005"
TK	.060	.150	M	.100	.218
TJ	.060	.190	A	.100	.312
HK	.075	.150	B	.134	.375*
HJ	.075	.190	C	.134	.562*
H	.075	.255	D	.134	.687*
T	.080	.203	E	.134	.812*
S	.080	.234			

* Tolerance is +.025" −.005"



CAPACITANCE—Rated capacitance is determined at 120 cps and +25°C. Standard tolerance is −0, +100%.

In making capacitance measurements, the following precautions should be observed. If a polarizing voltage is used (1) the limits given under "DC WORKING VOLTAGE RATING" must be observed or the capacitor may be permanently damaged; (2) the applied AC voltage should be within the limit given under "120 CYCLE RIPPLE VOLTAGE RATING" otherwise temporary changes in capacitance may occur due to internal heating. If desirable, capacitance may be measured *without a DC polarizing voltage* provided not more than 50 millivolts rms is impressed across the capacitor.

SERIES TW — STOCK VALUES

Mfd.	DCWV†	Case Size	Stock No.
0.1	20	TJ	R1TJ20
	60	M	R1M60
0.2	20	TK	R2TK20
	150	E	R2E150
0.5	10	TK	R5TK10
	16	TJ	R5TJ16
	20	S	R5S20
	80	B	R5B80
1.0	4	TK	1TK4
	8	HK	1HK8
	10	HJ	1HJ10
	20	M	1M20
	60	B	1B60
	80	C	1C80
2	1.25	TK	2TK1R25
	4	HJ	2HJ4
	8	S	258
	40	B	2B40
3	1.25	HK	3HK1R25
	80	E	3E80
	4	HJ	3HJ4
4	3	HJ	4HJ3
	4	S	4S4
	20	B	4B20
5	30	C	5C30
	60	E	5E60
6	1.25	HJ	6HJ1R25
8	1.25	S	8S1R25
	4	M	8M4
10	8	B	10B8
	16	C	10C16
	30	E	10E30
15	1.25	M	15M1R25
20	2	B	20B2
25	6	C	25C6
30	10	E	30E10
50	2	C	50C2
60	4	E	60E4
75	2	E	75E2

†Capacitor may be operated at any voltage less than that shown in table.

POWER FACTOR—50% maximum, but generally substantially less since power factor is roughly related to the volt x microfarad product for a given size. For extremely high capacitance values (50 mfds. and above) the power factor may be somewhat higher than 50%. (All measurements made at 120 cps at 25°C.) To convert power factor to dissipation factor or E.S.R. x C Product (equivalent series resistance x capacity) see scale, page 3.

DC LEAKAGE CURRENT — Less than .09 microamperes/volt-mfd. for units .5 mfd. and up; less than .4 microamperes/volt-mfd. for units under .5 mfd. In any instance, the leakage current is not required to be less than 1 microampere (see table, page 4). Measurement is made at 25°C after 5 minutes of electrification at rated DC voltage applied through a 1000 ohm series resistor to limit charging current.

DC WORKING VOLTAGE RATING — The maximum DC voltage which may be applied to the capacitor continuously. When AC voltage is present, the peak voltage across the capacitor (applied steady state DC voltage plus the positive peak AC voltage) must not exceed the rated DCWV.

DC SURGE VOLTAGE RATING — The DC surge voltage rating is 120% of the DC rated voltage and should never be exceeded. The capacitor will withstand this voltage for 1000 cycles of ½ minute on and 4½ minutes off in an ambient temperature of 65°C.

120 CYCLE RIPPLE VOLTAGE RATING—The peak value of 120 cycle AC ripple voltage should not exceed 10% of the DC working voltage rating. In no case shall the peak ripple voltage exceed the actual applied steady state DC voltage.

CAPACITOR CODING — Catalog numbers of Series TW capacitors are composed as follows—**Example 1A8:**

Cap. in Mfds.	Size	Working Volts
1	A	8

"R" is used to represent a decimal point as in 0.1=R1.

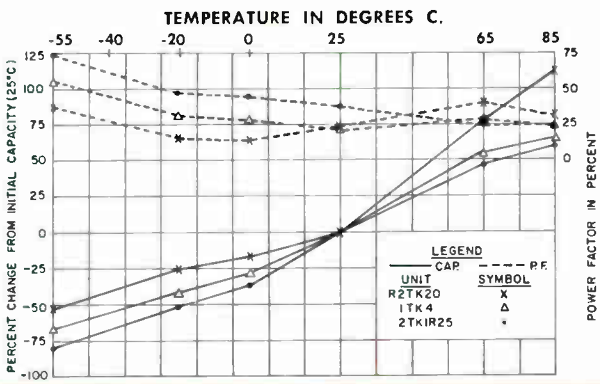
*MAX. MFDS. PERMITTED FOR EACH CASE SIZE FOR TYPICAL RATED WORKING VOLTS D.C.

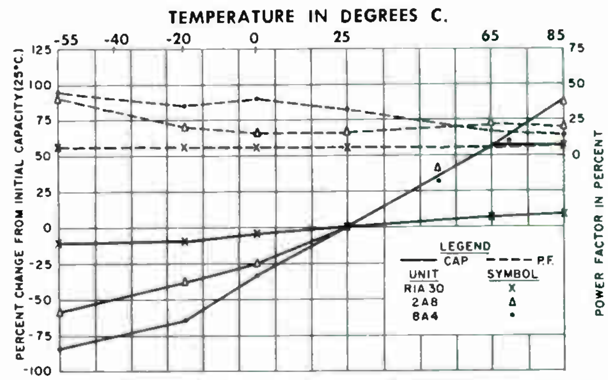
Volts DC†	TK	HK	TJ	HJ	H or S	T	M	A	B	C	D	E
1.25	2	3	3.5	6	10	7	16	20	35	70	110	150
1.5	1.75	2.5	3.0	5.5	9	6.5	14	16	30	60	100	130
2	1.5	2.25	2.5	5.0	7	6.0	10	14	25	55	90	110
3	1.25	2.0	2.25	4	6	5.0	8	12	20	45	75	90
4	1.0	1.5	2.0	3	5	4.0	8	10	17.5	40	60	75
6	.75	1.0	1.5	2	3.5	2.5	4	6	15	25	45	55
8	.6	1.0	1.25	1.5	2.5	2.0	3	5	12	20	35	40
10	.5	.75	.8	1.25	2.0	1.5	2.5	4	10	16	30	35
12	.4	.5	.6	.9	1.5	1.0	2.0	3	8	14	25	30
16	.3	.5	.5	.7	1.25	.75	1.5	2.5	6	12	20	25
20	.2	.3	.4	.4	1.0	.5	1.0	2	5	10	15	20
25			.3	.3	.8	.4	.8	1.25	4	8	12	15
30				.25	.6	.3	.6	1.0	3	6	9	10
40					.4	.25	.4	.7	2	4	7	8
50					.25		.3	.5	1.5	3	5	6
60							.25	.4	1.25	2.5	4	5
70								.3	1.0	2.0	3	4
80									.7	1.5	2	3
150									.04	.08	.1	.2

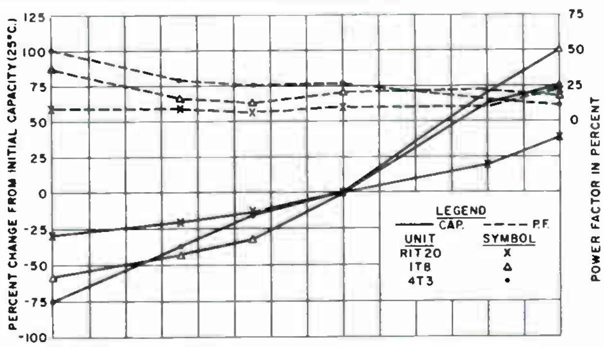
* For unlisted and intermediate values inquire of factory.
†Capacitor may be operated at any voltage less than that shown in table.

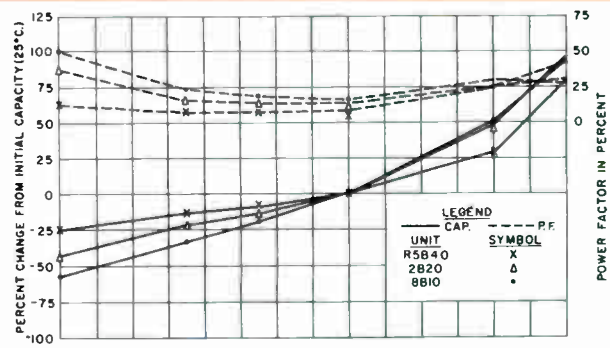
TEMPERATURE CHARACTERISTICS OF SERIES TW CAPACITORS (Capacity, Power Factor)

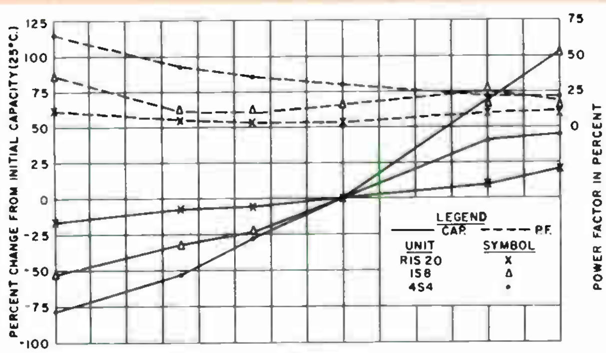
(Measured at 120 cps)

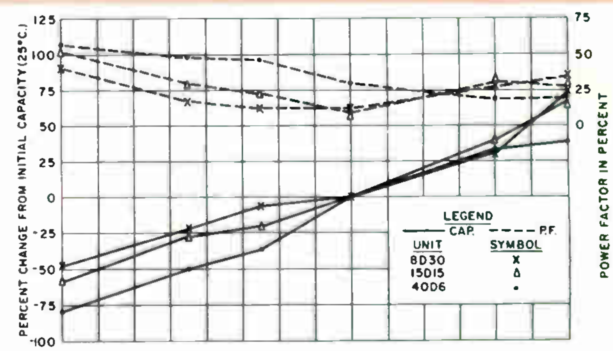


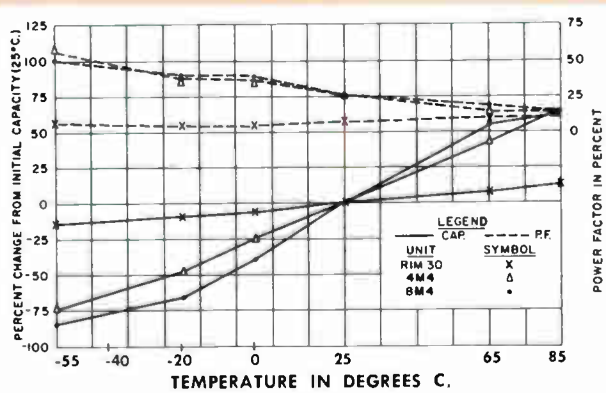


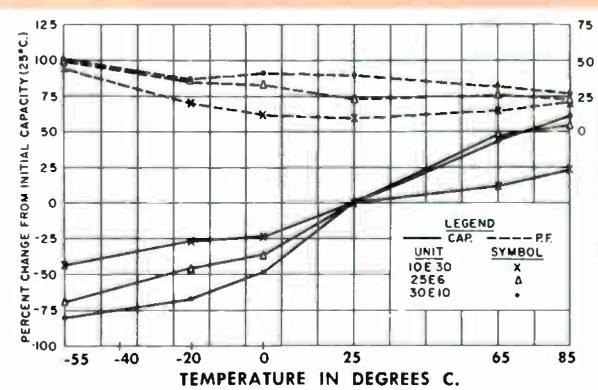


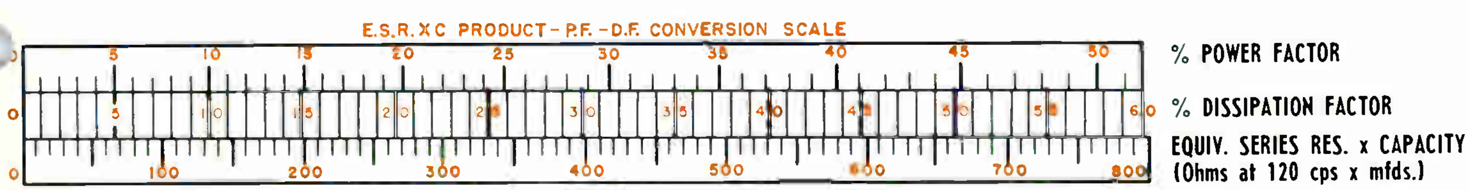






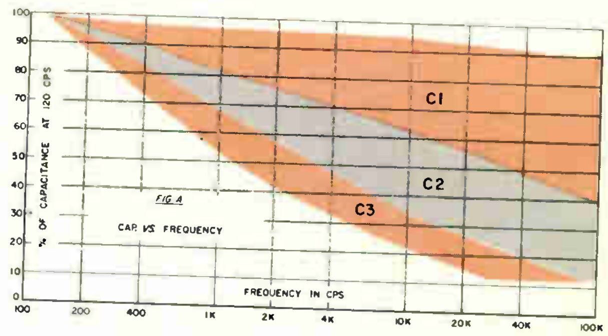


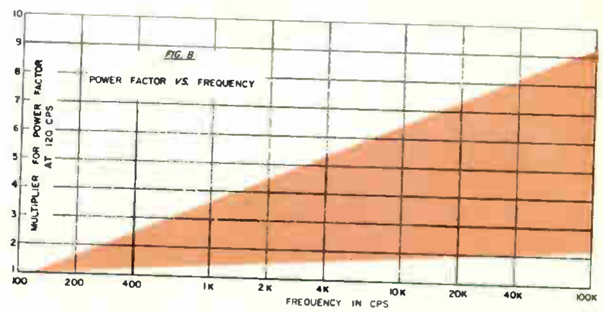




FREQUENCY CHARACTERISTICS

The table below is used in conjunction with Fig. A. "Capacitance vs Frequency". Fig. B shows the possible variance from initial power factor with frequency. The relatively wide spread is due to inherent differences in the metallurgical, chemical and physical characteristics that affect power factor. It should be noted that the effects of higher frequencies on the capacitor parameters are greater for the higher capacitance ratings.





FREQUENCY CHARACTERISTICS DATA

Case Size	DC WV	Cap. μfd.	P.F. % @ 120 cps	Freq. vs. Cap. Fig A
TK	1.25 4 20	2 1 0.2	37 24 13	C3 C2 C2
TJ	4 20	2 0.1	37 7	C2 C1
HK	1.25 8	3 1	39 21	C3 C2
HJ	1.25 10	6 1	33 21	C3 C2
H	2 6 20	8 2 0.5	34 32 10	C3 C2 C1
T	3 20	4 0.1	23 6	C2 C1
S	1.25 4 20	8 4 0.5	24 22 8	C2 C2 C1

Case Size	DC WV	Cap. μfd.	P.F. % @ 120 cps	Freq. vs. Cap. Fig. A
M	1.25 4 60	15 4 0.1	27 16 7	C3 C2 C2
A	2 20	14 0.1	22 3	C2 C1
B	1 20 80	40 4 0.5	26 13 10	C2 C2 C2
C	2 6 80	50 25 1	24 22 11	C2 C2 C2
D	2.5 4 60	100 50 1	44 25 10	C3 C3 C2
E	2 5 150	75 40 0.2	24 16 9	C3 C2 C2

LEAKAGE CURRENT

Case	μfd	Volts	μa/volt-μfd @ 25°C Max.	@ 25°C Avg.	@ 85°C Max.	@ 85°C Avg.
TK	0.2 1 2	20 4 1.25	.059 .003 .004	.055 .003 .004	.122 .015 .012	.115 .010 .008
H	0.5 2 8	20 6 2	.013 .030 .015	.009 .0262 .010	.040 .125 .052	.025 .075 .042
T	0.1 1 4	20 8 3	.099 .0049 .013	.0334 .0043 .010	.414 .075 .068	.183 .0225 .031
S	0.1 1 4	20 8 4	.0020 .0055 .0075	.0019 .0047 .0047	.0020 .0274 .0895	.0019 .0130 .0289
M	0.1 4 8	30 4 4	.0132 .0017 .0054	.0124 .0015 .0035	.0132 .055 .0445	.0124 .0240 .0300

Case	μfd	Volts	μa/volt-μfd @ 25°C Max.	@ 25°C Avg.	@ 85°C Max.	@ 85°C Avg.
A	0.1 2 8	30 8 4	.0146 .0047 .0338	.0134 .0026 .0146	.0393 .0117 .407	.0166 .0039 .258
B	0.5 2 8	40 20 10	.0113 .0012 .0016	.0064 .0008 .0008	.0795 .0600 .0142	.0646 .0179 .0064
C	2 10 40	40 16 4	.0043 .0089 .0049	.0018 .0019 .0021	.0249 .0781 .0236	.0138 .0158 .0123
D	8 15 40	30 15 6	.032 .0015 .0009	.0017 .0006 .0007	.0540 .0116 .0012	.0240 .0051 .0007
E	10 25 30	30 6 10	.0057 .0056 .0427	.0043 .0032 .0277	.0373 .0392 .587	.0312 .0202 .307

SHELF LIFE (at 25°C)

Type	No. Units	Shelf Life Hours	*Avg. % Δ C Less Than
1T8	10	10000	+ 1
R1T20	10	10000	—12
2T4	10	10000	—17
R5T20	10	10000	—15
4T4	13	10000	+ 8
R5B10	6	10000	+ 3
R5B16	6	10000	+18

* Average % change from Initial Capacity (25°C) measured at 120 cps

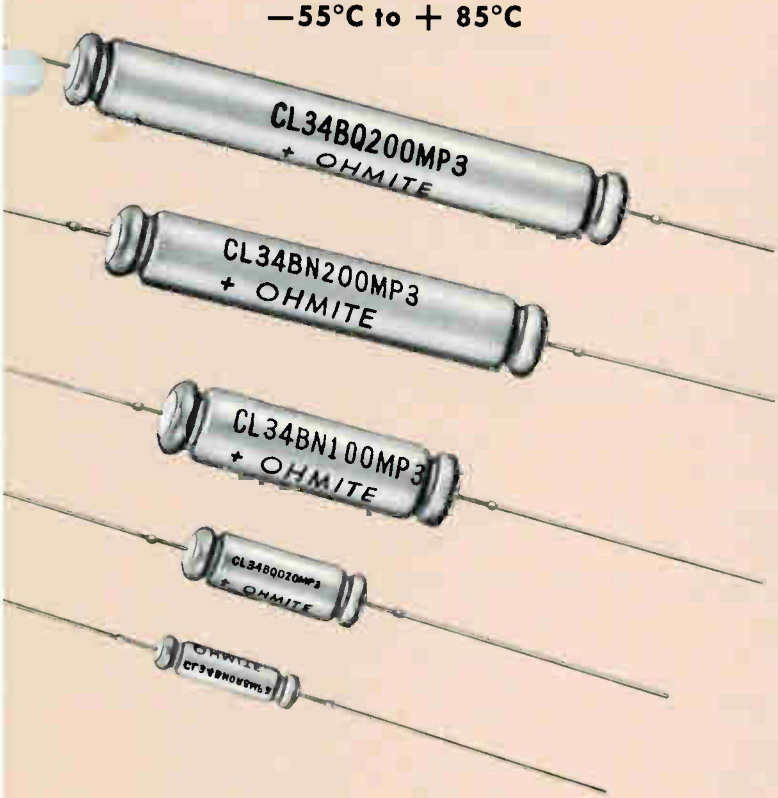
LOAD LIFE TESTS — Measured at 25°C, 120 c.p.s.

TYPE	R1T20		R5T20		1T8		1M8		4M4		1A8		4A4		1B16		10B4		2C16		20C4	
Test. Temp.	85°C	65°C	85°C	65°C	85°C	65°C	85°C	65°C	85°C	65°C	85°C	65°C	85°C	65°C	85°C	65°C	85°C	65°C	85°C	65°C	85°C	65°C
No. Units	20	10	20	10	20	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
HOURS	**AVERAGE % OF INITIAL CAPACITANCE**																					
AFTER 500	95.2	99.4	97.6	108.2	108.7	110.1	98.5	83.9	95.1	132.7	100.7	99.9	97.5	89.4	91.4	93.4	98.7	96.0	98.3	103.0	—	—
1000	95.1	99.8	96.7	106.7	109.4	121.9	102.6	80.7	96.9	136.7	98.6	95.7	98.8	88.6	89.0	89.4	101.7	97.1	95.9	100.2	82.4	93.7
4000	92.9	86.8	91.0	100.3	91.6	114.3	93.7	84.9	70.5	106.0	94.2	86.4	107.3	102.4	86.4	90.9	111.2	105.8	97.5	103.5	81.6	107.8
6000	91.5	91.9	91.5	104.6	89.2	115.4	77.6	68.6	—	67.2	92.6	87.6	93.5	86.1	84.0	82.0	109.2	98.6	93.7	98.1	68.4	82.4
10000	79.7	88.4	79.6	104.8	62.6	111.3	78.2	64.8	—	68.0	93.2	84.8	95.4	83.2	86.0	86.0	108.7	99.3	95.7	91.7	72.9	75.9
HOURS	**AVERAGE POWER FACTOR IN %**																					
AFTER 500	4	3	10	10	16	18	25	17	23	22	12	12	20	17	3	4	11	11	10	8	—	—
1000	5	2	15	7	25	17	29	19	26	28	13	12	21	20	10	11	16	17	15	11	33	31
4000	3	9	16	16	28	5	21	16	19	25	9	10	14	14	8	7	11	10	10	9	27	24
6000	10	9	19	15	40	19	21	16	19	21	8	10	12	12	6	10	12	14	11	12	21	15
10000	11	6	24	16	54	24	24	20	17	20	9	9	14	16	9	11	12	14	12	12	23	21

OHMITE

TAN-O-MITE®
SERIES TF
TANTALUM FOIL CAPACITORS

- Plain & Etched Foil Types
- Polar & Non-Polar Types
- Meets MIL-C-3965C Styles CL20, CL21, CL24, CL25, CL30, CL31, CL34, CL35
- —55°C to + 125°C
  —55°C to + 85°C



Series TF capacitors are tantalum foil electrolytic type units designed for low voltage AC and DC applications. In common with all tantalum capacitors, these units exhibit such characteristics as high capacitance for small size, great stability in use or in storage, long operating and shelf life, operation at wide temperature extremes, small capacitance drop at low temperatures, low leakage current and power factor. In comparison to the wire type of tantalum, wet-electrolytic capacitors, Series TF units have markedly superior leakage current and power factor characteristics. They are the only variety supplied in both polar and non-polar types. Two operating temperature ranges are available; —55°C to +85°C and —55°C to +125°C.

Types and Construction: Series TF capacitors are supplied in plain foil and etched foil varieties. The etched foil type provides higher maximum capacitances for a given case size and, in addition, has somewhat lower leakage current than the plain foil type. All Series TF capacitors are supplied in metal cases (five sizes) and are sealed against atmospheric conditions. Insulation in the form of a plastic sleeve can be provided on all units.

Range: Overall capacitance range for plain foil capacitors, 0.25 to 400 mfds.; for etched foil units, 0.5 to 580 mfds. Working voltages for both types to 150 VDC depending upon capacitance.

POLAR AND NON-POLAR UNITS

Non-Polar units are intended for DC applications where reversal of potential occurs or for AC applications at limited voltage. Consult factory for AC ratings. Non-polar units must have their cases insulated from ground. Insulated types (see "... Construction") can be used here. For the same case size and voltage

(Continued, next page)

OHMITE MANUFACTURING COMPANY
3601 Howard Street • Skokie, Illinois 60076

BULLETIN 602A

rating, the maximum possible capacity for a non-polar unit is generally about half that of a polar unit. In the low voltage range, it is somewhat more than half.

Polar Units are designed for application where reversals of potential do not occur. The cathode (negative) foil is treated to withstand small reversals up to 3.75 volts DC except where the DC rated voltage is less. Cases of polar units must be either insulated or grounded at the same potential as the cathode lead. Polar units are marked "+" on one end.

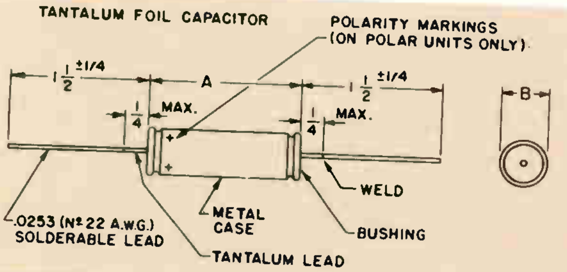
Standard Ratings are shown in tables. All 85°C plain and etched foil listings are carried in stock for immediate shipment. MIL capacitors also carry commercial markings. Other ratings provided on request. Highest capacitance indicated for a given case size and voltage rating is maximum possible for that combination.

Commercial catalog numbers are coded as follows:

Example **6J10**

Cap. in mfd.	Case Size	Working Voltage
6	J	10

A letter "R" is used to represent a decimal point as in 4.5 =4R5; an "E" follows the case size designation in the case of "etched foil" capacitors; a "C" following the case size or the "E" indicates 125°C rating; an "N" following the catalog number indicates "non-polar" unit; an "S" following the catalog number indicates "insulating sleeve."



Case Size* Commercial	MIL		Uninsulated CL20, CL30, CL24, CL34 A ±1/16	B ±1/64	Insulated CL21, CL31, CL25, CL35 A +1/8 −1/16	B ±1/32
J	C1	D1	11/16	3/16	3/4	13/64
K	C2	D2	7/8	9/32	1 5/16	19/64
L	C3	D3	1 7/16	3/8	1 1/2	25/64
N	C4	D4	2 1/8	3/8	2 3/16	25/64
P	C5	D5	2 3/4	3/8	2 13/16	25/64

*Indicated dimensions are within MIL limits

STOCK PLAIN FOIL CAPACITORS (85°C)

MIL Styles CL34, CL35

Mfd.	D.C. Rated Volts	P† or N	Commercial Case Size	Commercial Stock No.‡	MIL-C-3965C Case Size	MIL-C-3965C Type Designation‡
10	3	P*	J	10J3	C1	CL3__BA100MP3
50	3	P*	K	50K3	C2	CL3__BA500MP3
10	3.75	N	J	10J3R75N		
45	3.75	N	K	45K3R75N		
140	3.75	N	L	140L3R75N		
280	3.75	N	N	280N3R75N		
400	3.75	N	P	400P3R75N		
8	6	P	J	8J6	C1	CL3__BB080MP3
30	6	P	K	30K6	C2	CL3__BB300MP3
35	6	P	K	35K6		
100	6	P	L	100L6	C3	CL3__BB101MP3
200	6	P	N	200N6	C4	CL3__BB201MP3
300	6	P	P	300P6	C5	CL3__BB301MP3
7	6	N	J	7J6N		
25	6	N	K	25K6N		
85	6	N	L	85L6N		
175	6	N	N	175N6N		
250	6	N	P	250P6N		
6	10	P	J	6J10	C1	CL3__BD060MP3
25	10	P	K	25K10	C2	CL3__BD250MP3
80	10	P	L	80L10	C3	CL3__BD800MP3
160	10	P	N	160N10	C4	CL3__BD161MP3
220	10	P	P	220P10	C5	CL3__BD221MP3
4	10	N	J	4J10N		
16	10	N	K	16K10N		
55	10	N	L	55L10N		
110	10	N	N	110N10N		
150	10	N	P	150P10N		
4.5	15	P	J	4R5J15	C1	CL3__BE4R5MP3
10	15	P	K	10K15	C2	CL3__BE100MP3
18	15	P	K	18K15	C2	CL3__BE180MP3
55	15	P	L	55L15	C3	CL3__BE550MP3
110	15	P	N	110N15	C4	CL3__BE111MP3
160	15	P	P	160P15	C5	CL3__BE161MP3
2.5	15	N	J	2R5J15N		
10	15	N	K	10K15N		
35	15	N	L	35L15N		
70	15	N	N	70N15N		
100	15	N	P	100P15N		

(Continued left col., next page)

NOTES FOR TABLES

Numbers in [shaded area] are non-polar units.

When selecting ratings, choose voltages equal to or higher than required. A capacitor will always operate satisfactorily at voltages below its rating.

†P = polar; N = non-polar type. A non-polar unit may be used as a polar unit.

‡For insulating sleeve add "S" to commercial stock number. Complete MIL type designation as follows:

For 85°C uninsulated units insert "4" after "CL2__" or "CL3__"; for insulated units insert "5" instead.

For 125°C uninsulated units insert "0" after "CL2__" or "CL3__"; for insulated units insert "1" instead.

MIL Grade 3 vibration test requirement is standard and satisfies requirements of Grades 1 and 2.

*Regardless of polarity indicated, these low voltage units can be used as either polar or non-polar units within their rating.

STOCK ETCHED FOIL CAPACITORS (85°C)

MIL Styles CL24, CL25

Mfd.	D.C. Rated Volts	P† or N	Commercial Case Size	Commercial Stock No.‡	MIL-C-3965C Case Size	MIL-C-3965C Type Designation‡
15	15	P	J	15JE15	C1	CL2__BE150UP3
60	15	P	K	60KE15	C2	CL2__BE600UP3
200	15	P	L	200LE15	C3	CL2__BE201UP3
400	15	P	N	400NE15	C4	CL2__BE401UP3
580	15	P	P	580PE15	C5	CL2__BE581UP3
10	15	N	J	10JE15N		
40	15	N	K	40KE15N		
120	15	N	L	120LE15N		
125	15	N	L	125LE15N		
250	15	N	N	250NE15N		
350	15	N	P	350PE15N		

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STOCK PLAIN FOIL CAPACITORS (85°C) Cont.

MIL Styles CL34, CL35

Mfd.	D.C. Rated Volts	P† or N	Commercial Case Size	Commercial Stock No.‡	MIL-C-3965C Case Size	MIL-C-3965C Type Designation‡
3	25	P	J	3J25		
12	25	P	K	12K25		
35	25	P	L	35L25		
70	25	P	N	70N25		
100	25	P	P	100P25		
1.5	25	N	J	1R5J25N		
6	25	N	K	6K25N		
20	25	N	L	20L25N		
40	25	N	N	40N25N		
60	25	N	P	60P25N		
2.5	30	P	J	2R5J30	C1	CL3_BH2R5MP3
10	30	P	K	10K30		
30	30	P	L	30L30	C3	CL3_BH300MP3
60	30	P	N	60N30	C4	CL3_BH600MP3
85	30	P	P	85P30	C5	CL3_BH850MP3
1.4	30	N	J	1R4J30N		
5.5	30	N	K	5R5K30N		
18	30	N	L	18L30N		
36	30	N	N	36N30N		
45	30	N	P	45P30N		
1.5	50	P	J	1R5J50	C1	CL3_BJ1R5MP3
6	50	P	K	6K50	C2	CL3_BJ060MP3
20	50	P	L	20L50	C3	CL3_BJ200MP3
40	50	P	N	40N50	C4	CL3_BJ400MP3
55	50	P	P	55P50	C5	CL3_BJ550MP3
0.8	50	N	J	R8J50N		
3	50	N	K	3K50N		
10	50	N	L	10L50N		
20	50	N	N	20N50N		
30	50	N	P	30P50N		
1.25	60	P	J	1R25J60		
5	60	P	K	5K60		
17	60	P	L	17L60		
34	60	P	N	34N60		
48	60	P	P	48P60		
0.6	60	N	J	R6J60N		
2.5	60	N	K	2R5K60N		
8.5	60	N	L	8R5L60N		
17	60	N	N	17N60N		
24	60	N	P	24P60N		
1	75	P	J	1J75	C1	CL3_BL010MP3
4	75	P	K	4K75	C2	CL3_BL040MP3
14	75	P	L	14L75	C3	CL3_BL140MP3
28	75	P	N	28N75	C4	CL3_BL280MP3
40	75	P	P	40P75	C5	CL3_BL400MP3
0.5	75	N	J	R5J75N		
2	75	N	K	2K75N		
7	75	N	L	7L75N		
14	75	N	N	14N75N		
20	75	N	P	20P75N		
0.8	100	P	J	R8J100	C1	CL3_BN0R8MP3
3	100	P	K	3K100	C2	CL3_BN030MP3
10	100	P	L	10L100	C3	CL3_BN100MP3
20	100	P	N	20N100	C4	CL3_BN200MP3
30	100	P	P	30P100	C5	CL3_BN300MP3
0.4	100	N	J	R4J100N		
1.5	100	N	K	1R5K100N		
5	100	N	L	5L100N		
10	100	N	N	10N100N		
15	100	N	P	15P100N		
0.5	150	P	J	R5J150	C1	CL3_BQ0R5MP3
2	150	P	K	2K150	C2	CL3_BQ020MP3
4	150	P	L	4L150	C3	CL3_BQ040MP3
7	150	P	L	7L150	C3	CL3_BQ070MP3
8	150	P	N	8N150	C4	CL3_BQ080MP3
12	150	P	N	12N150	C4	CL3_BQ120MP3
14	150	P	N	14N150	C4	CL3_BQ140MP3
20	150	P	P	20P150	C5	CL3_BQ200MP3
0.25	150	N	J	R25J150N		
1	150	N	K	1K150N		
3.5	150	N	L	3R5L150N		
7	150	N	N	7N150N		
10	150	N	P	10P150N		

†‡ See "Notes" page 2

STOCK ETCHED FOIL CAPACITORS (85°C) Cont.

MIL Styles CL24, CL25

Mfd.	D.C. Rated Volts	P† or N	Commercial Case Size	Commercial Stock No.‡	MIL-C-3965C Case Size	MIL-C-3965C Type Designation‡
10	25	P	J	10JE25	C1	CL2_BG100UP3
40	25	P	K	40KE25	C2	CL2_BG400UP3
120	25	P	L	120LE25	C3	CL2_BG121UP3
125	25	P	L	125LE25		
250	25	P	N	250NE25	C4	CL2_BG251UP3
350	25	P	P	350PE25	C5	CL2_BG351UP3
5	25	N	J	5JE25N		
20	25	N	K	20KE25N		
70	25	N	L	70LE25N		
140	25	N	N	140NE25N		
200	25	N	P	200PE25N		
8	30	P	J	8JE30	C1	CL2_BH080UP3
32	30	P	K	32KE30	C2	CL2_BH320UP3
110	30	P	L	110LE30	C3	CL2_BH111UP3
220	30	P	N	220NE30	C4	CL2_BH221UP3
300	30	P	P	300PE30	C5	CL2_BH301UP3
4.5	30	N	J	4R5JE30N		
18	30	N	K	18KE30N		
60	30	N	L	60LE30N		
120	30	N	N	120NE30N		
170	30	N	P	170PE30N		
4.5	50	P	J	4R5JE50	C1	CL2_BJ4R5TP3
18	50	P	K	18KE50	C2	CL2_BJ180TP3
60	50	P	L	60LE50	C3	CL2_BJ600TP3
100	50	P	N	100NE50	C4	CL2_BJ101TP3
150	50	P	P	150PE50	C5	CL2_BJ151TP3
2.5	50	N	J	2R5JE50N		
10	50	N	K	10KE50N		
30	50	N	L	30LE50N		
60	50	N	N	60NE50N		
80	50	N	P	80PE50N		
4	60	P	J	4JE60		
15	60	P	K	15KE60		
50	60	P	L	50LE60		
88	60	P	N	88NE60		
125	60	P	P	125PE60		
2	60	N	J	2JE60N		
7.5	60	N	K	7R5KE60N		
25	60	N	L	25LE60N		
50	60	N	N	50NE60N		
67	60	N	P	67PE60N		
3	75	P	J	3JE75	C1	CL2_BL030TP3
12	75	P	K	12KE75	C2	CL2_BL120TP3
30	75	P	L	30LE75	C3	CL2_BL300TP3
70	75	P	N	70NE75	C4	CL2_BL700TP3
100	75	P	P	100PE75	C5	CL2_BL101TP3
1.5	75	N	J	1R5JE75N		
6	75	N	K	6KE75N		
15	75	N	L	15LE75N		
35	75	N	N	35NE75N		
50	75	N	P	50PE75N		
2	100	P	J	2JE100	C1	CL2_BN020SP3
8	100	P	K	8KE100	C2	CL2_BN080SP3
25	100	P	L	25LE100	C3	CL2_BN250SP3
50	100	P	N	50NE100	C4	CL2_BN500SP3
70	100	P	P	70PE100	C5	CL2_BN700SP3
1	100	N	J	1JE100N		
4	100	N	K	4KE100N		
12	100	N	L	12LE100N		
25	100	N	N	25NE100N		
35	100	N	P	35PE100N		
1	150	P	J	1JE150	C1	CL2_BQ010SP3
4	150	P	K	4KE150	C2	CL2_BQ040SP3
13	150	P	L	13LE150	C3	CL2_BQ130SP3
25	150	P	N	25NE150	C4	CL2_BQ250SP3
36	150	P	P	36PE150	C5	CL2_BQ360SP3
0.5	150	N	J	R5JE150N		
2	150	N	K	2KE150N		
6	150	N	L	6LE150N		
12	150	N	N	12NE150N		
18	150	N	P	18PE150N		

PLAIN FOIL CAPACITORS (125°C) MADE TO ORDER

MIL Styles CL30, CL31

Mfd.	D.C. Rated Volts @ 85°C	D.C. Rated Volts @ 125°C	P† or N	Commercial Case Size	Commercial Cat. No.‡	MIL-C-3965C Case Size	MIL-C-3965C Type Designation‡
4.5	15	10	P	J	4R5JC10	D1	CL3_CD4R5MP3
18	15	10	P	K	18KC10	D2	CL3_CD180MP3
55	15	10	P	L	55LC10	D3	CL3_CD550MP3
110	15	10	P	N	110NC10	D4	CL3_CD111MP3
160	15	10	P	P	160PC10	D5	CL3_CD161MP3
2.5	15	10	N	J	2R5JC10N	D1	
10	15	10	N	K	10KC10N	D2	
35	15	10	N	L	35LC10N	D3	
70	15	10	N	N	70NC10N	D4	
100	15	10	N	P	100PC10N	D5	
3	25	15	P	J	3JC15	D1	CL3_CE030MP3
12	25	15	P	K	12KC15	D2	CL3_CE120MP3
35	25	15	P	L	35LC15	D3	CL3_CE350MP3
70	25	15	P	N	70NC15	D4	CL3_CE700MP3
100	25	15	P	P	100PC15	D5	CL3_CE101MP3
1.5	25	15	N	J	1R5JC15N	D1	
6	25	15	N	K	6KC15N	D2	
20	25	15	N	L	20LC15N	D3	
40	25	15	N	N	40NC15N	D4	
60	25	15	N	P	60PC15N	D5	
1.5	50	30	P	J	1R5JC30	D1	CL3_CH1R5MP3
6	50	30	P	K	6KC30	D2	CL3_CH060MP3
20	50	30	P	L	20LC30	D3	CL3_CH200MP3
40	50	30	P	N	40NC30	D4	CL3_CH400MP3
55	50	30	P	P	55PC30	D5	CL3_CH550MP3
0.8	50	30	N	J	R8JC30N	D1	
3	50	30	N	K	3KC30N	D2	
10	50	30	N	L	10LC30N	D3	
20	50	30	N	N	20NC30N	D4	
30	50	30	N	P	30PC30N	D5	
1	75	50	P	J	1JC50	D1	CL3_CJ010MP3
4	75	50	P	K	4KC50	D2	CL3_CJ040MP3
14	75	50	P	L	14LC50	D3	CL3_CJ140MP3
28	75	50	P	N	28NC50	D4	CL3_CJ280MP3
40	75	50	P	P	40PC50	D5	CL3_CJ400MP3
0.5	75	50	N	J	R5JC50N	D1	
2	75	50	N	K	2KC50N	D2	
7	75	50	N	L	7LC50N	D3	
14	75	50	N	N	14NC50N	D4	
20	75	50	N	P	20PC50N	D5	
0.8	100	60	P	J	R8JC60	D1	CL3_CK0R8MP3
3	100	60	P	K	3KC60	D2	CL3_CK030MP3
10	100	60	P	L	10LC60	D3	CL3_CK100MP3
20	100	60	P	N	20NC60	D4	CL3_CK200MP3
30	100	60	P	P	30PC60	D5	CL3_CK300MP3
0.4	100	60	N	J	R4JC60N	D1	
1.5	100	60	N	K	1R5KC60N	D2	
5	100	60	N	L	5LC60N	D3	
10	100	60	N	N	10NC60N	D4	
15	100	60	N	P	15PC60N	D5	
0.5	150	100	P	J	R5JC100	D1	CL3_CN0R5MP3
2	150	100	P	K	2KC100	D2	CL3_CN020MP3
7	150	100	P	L	7LC100	D3	CL3_CN070MP3
14	150	100	P	N	14NC100	D4	CL3_CN140MP3
20	150	100	P	P	20PC100	D5	CL3_CN200MP3
0.25	150	100	N	J	R25JC100N	D1	
1	150	100	N	K	1KC100N	D2	
3.5	150	100	N	L	3R5LC100N	D3	
7	150	100	N	N	7NC100N	D4	
10	150	100	N	P	10PC100N	D5	

ETCHED FOIL CAPACITORS (125°C) MADE TO ORDER

MIL Styles CL20, CL21

Mfd.	D.C. Rated Volts @ 85°C	D.C. Rated Volts @ 125°C	P† or N	Commercial Case Size	Commercial Cat. No.‡	MIL-C-3965C Case Size	MIL-C-3965C Type Designation‡
15	15	10	P	J	15JEC10	D1	CL2_CD150UP3
60	15	10	P	K	60KEC10	D2	CL2_CD600UP3
200	15	10	P	L	200LEC10	D3	CL2_CD201UP3
400	15	10	P	N	400NEC10	D4	CL2_CD401UP3
580	15	10	P	P	580PEC10	D5	CL2_CD581UP3
10	15	10	N	J	10JEC10N	D1	
40	15	10	N	K	40KEC10N	D2	
120	15	10	N	L	120LEC10N	D3	
250	15	10	N	N	250NEC10N	D4	
350	15	10	N	P	350PEC10N	D5	
10	25	15	P	J	10JEC15	D1	CL2_CE100UP3
40	25	15	P	K	40KEC15	D2	CL2_CE400UP3
120	25	15	P	L	120LEC15	D3	CL2_CE121UP3
250	25	15	P	N	250NEC15	D4	CL2_CE251UP3
350	25	15	P	P	350PEC15	D5	CL2_CE351UP3
5	25	15	N	J	5JEC15N	D1	
20	25	15	N	K	20KEC15N	D2	
70	25	15	N	L	70LEC15N	D3	
140	25	15	N	N	140NEC15N	D4	
200	25	15	N	P	200PEC15N	D5	
4.5	50	30	P	J	4R5JEC30	D1	CL2_CH4R5TP3
18	50	30	P	K	18KEC30	D2	CL2_CH180TP3
60	50	30	P	L	60LEC30	D3	CL2_CH600TP3
100	50	30	P	N	100NEC30	D4	CL2_CH101TP3
150	50	30	P	P	150PEC30	D5	CL2_CH151TP3
2.5	50	30	N	J	2R5JEC30N	D1	
10	50	30	N	K	10KEC30N	D2	
30	50	30	N	L	30LEC30N	D3	
60	50	30	N	N	60NEC30N	D4	
80	50	30	N	P	80PEC30N	D5	
3	75	50	P	J	3JEC50	D1	CL2_CJ030TP3
12	75	50	P	K	12KEC50	D2	CL2_CJ120TP3
30	75	50	P	L	30LEC50	D3	CL2_CJ300TP3
70	75	50	P	N	70NEC50	D4	CL2_CJ700TP3
100	75	50	P	P	100PEC50	D5	CL2_CJ101TP3
1.5	75	50	N	J	1R5JEC50N	D1	
6	75	50	N	K	6KEC50N	D2	
15	75	50	N	L	15LEC50N	D3	
35	75	50	N	N	35NEC50N	D4	
50	75	50	N	P	50PEC50N	D5	
2	100	60	P	J	2JEC60	D1	CL2_CK020TP3
8	100	60	P	K	8KEC60	D2	CL2_CK080TP3
25	100	60	P	L	25LEC60	D3	CL2_CK250TP3
50	100	60	P	N	50NEC60	D4	CL2_CK500TP3
70	100	60	P	P	70PEC60	D5	CL2_CK700TP3
1	100	60	N	J	1JEC60N	D1	
4	100	60	N	K	4KEC60N	D2	
12	100	60	N	L	12LEC60N	D3	
25	100	60	N	N	25NEC60N	D4	
35	100	60	N	P	35PEC60N	D5	
1	150	100	P	J	1JEC100	D1	CL2_CN010SP3
4	150	100	P	K	4KEC100	D2	CL2_CN040SP3
13	150	100	P	L	13LEC100	D3	CL2_CN130SP3
25	150	100	P	N	25NEC100	D4	CL2_CN250SP3
36	150	100	P	P	36PEC100	D5	CL2_CN360SP3
0.5	150	100	N	J	R5JEC100N	D1	
2	150	100	N	K	2KEC100N	D2	
6	150	100	N	L	6LEC100N	D3	
12	150	100	N	N	12NEC100N	D4	
18	150	100	N	P	18PEC100N	D5	

†‡See "Notes," page 2.

TANTALUM FOIL CAPACITORS

SPECIFICATIONS

Capacitance and Tolerance: The rated capacitance is measured at 120 cps and at +25°C. For *plain foil*, the standard tolerance is ±20% (MIL tolerance designation "M"). For *etched foil*, tolerances are as follows:

85°C Rated	125°C Rated	Tolerance
Below 50 Volts	Below 30 Volts	−15 +75% (MIL Desig. "U")
50-99 Volts	30-99 Volts	−15 +50% (MIL Desig. "T")
100-150 Volts	100 Volts	−15 +30% (MIL Desig. "S")

At extremes of operating temperatures, the capacitance change meets the requirements of MIL-C-3965C and is shown in table below:

CHANGE IN CAPACITANCE FROM +25°C RATING

85°C Rated Capacitors

Type		−55°C	+85°C
Plain Foil Polar and Non-polar	Less than 15 Volts 15 Volts and Higher	−30% −20%	+20% +20%
Etched Foil Polar and Non-polar	Less than 50 Volts 50 Volts and Higher	−40% −35%	+20% +20%

125°C Rated Capacitors

Type		−55°C	+125°C
Plain Foil Polar and Non-polar	10 Volts to 39 Volts 40 Volts to 100 Volts	−25% −25%	+25% +15%
Etched Foil P (Polar)	10 Volts to 64 Volts 65 Volts to 100 Volts	−40% −35%	+50% +30%
Etched Foil N (Non-polar)	10 Volts to 64 Volts 65 Volts to 100 Volts	−40% −40%	+45% +30%

Operating Temperature Ranges: Two types of units available; one is designed for operating over the ambient temperature range of −55°C to +85°C, the other −55°C to +125°C.

DC Working Voltage Rating: The DC rated voltage is the maximum voltage for continuous duty. Where AC is superimposed on DC voltage, the sum of the positive AC peak and the DC voltage, must not exceed the DC rated voltage subject to the limitations shown under "120 CYCLE RIPPLE VOLTAGE RATING."

DC Surge Voltage Rating: The DC surge voltage rating is 116% of DC rated voltage and should never be exceeded. The capacitor will withstand this voltage applied for 1000 successive cycles of ½ minute on and 5½ minutes off, at the maximum rated ambient temperature.

Power Factor: When measured at 120 cps and at +25°C, the power factor is substantially below the following limits:

Power Factor in Per Cent

85°C Rated Capacitors

Type		25°C	85°C
Plain Foil Polar and Non-polar	Less than 15 Volts 15 Volts and Higher	15% 10%	20% 15%
Etched Foil P (Polar)	Less than 50 Volts 50 Volts and Higher	15% 10%	20% 15%
Etched Foil N (Non-polar)	Less than 50 Volts 50 Volts and Higher	20% 15%	30% 25%

125°C Rated Capacitors

Type		25°C	125°C
Plain Foil Polar and Non-polar	10 Volts to 39 Volts 40 Volts to 100 Volts	10% 10%	25% 15%
Etched Foil P (Polar)	30 Volts and Less Higher than 30 Volts	20% 15%	30% 20%
Etched Foil N (Non-polar)	30 Volts and Less Higher than 30 Volts	20% 15%	40% 30%

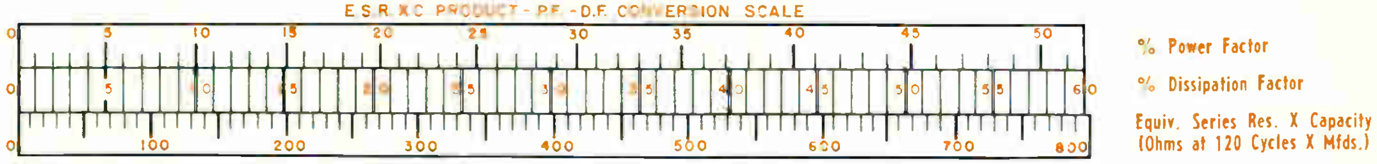
120 Cycle Ripple Voltage Rating: The peak value of 120 cycle ripple voltage should not exceed 10% of the DC rated voltage. For polar capacitors, the applied DC voltage must be sufficient to limit the negative peak to 3.75 volts.

DC Leakage Current: DC leakage current is less than these limits:

Foil Type	Microamperes per volt-mfd. at 25°C	Microamperes per volt-mfd. at 85°C or 125°C
Plain	0.017	0.10
Etched	0.01	0.06

Life Test: Capacitors will withstand a life test of more than 2000 hours at DC rated voltage and a maximum rated temperature, as required by MIL-C-3965C.

E.S.R. X C PRODUCT - P.F. - D.F. CONVERSION SCALE



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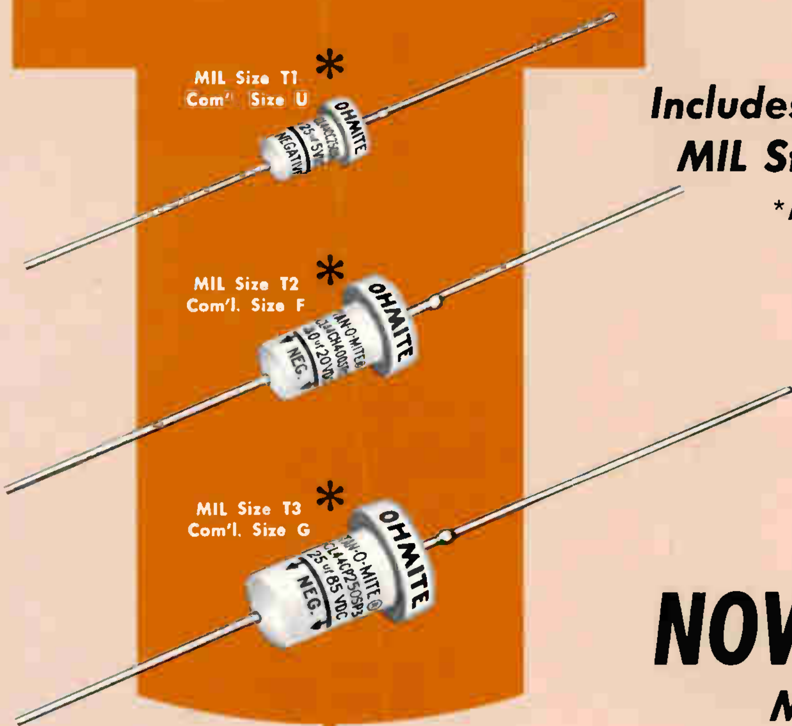
TANTALUM SLUG CAPACITORS



Includes all case sizes for MIL Styles CL44, CL45 *

**MIL-C-3965/4D*

NOW! *All three case sizes for MIL Styles CL64, CL65* †

†MIL-C-3965/4D, 4E

OHMITE MANUFACTURING COMPANY
3601 Howard Street, Skokie, Illinois 60076

BULLETIN 603B

Printed in U.S.A. 11-66

TANTALUM SLUG CAPACITORS

TAN-O-MITE Series TS capacitors, in conjunction with the other types of tantalum wet-electrolytic capacitors, feature high capacitance with small size. In comparison with the other types, however, they offer superiority in most characteristics . . . lower leakage current and power factor (equivalent series resistance) and closer capacitance tolerances. Their stability and long life in operation or in storage are unexcelled and they will withstand extraordinary conditions of high frequency vibration, shock and acceleration.

Construction: These capacitors employ a porous slug of sintered tantalum for the anode. This is sealed into a fine silver case which serves as the cathode and as the container for the electrolyte. Both the anode and cathode leads are solderable. The capacitor can be supplied insulated with a plastic sleeve.

Two physical types are available. The "hat-shaped" type includes commercial case sizes U, F and G which are respectively equivalent to cases T1, T2, T3 supplied under military styles CL44 and CL45 of MIL-C-3965/4D. The "straight-cylindrical" type occupies less space but offers a comparable range of capacitance, voltage and operating characteristics. These are supplied as commercial case sizes SU, SF, SG or sizes T1, T2, T3 under Styles CL64 and CL65 of MIL-C-3965/4D and 4E, a later revision.

"High Capacitance Units" are available in both physical types. Because of specially constructed slugs, the high-capacitance units provide over twice the capacitance of units with the same case size and voltage rating.

Range: Both the hat-shaped and straight-cylindrical types offer a collective range of 1.7 to 560 mfds. Working voltages range to 125 DC depending upon capacitance and temperature rating.

Application: Intended for DC applications, in their indicated polarity only, the capacitors will function in applications where a super-imposed AC ripple is present subject to the limitations in the "Specifications" following.

SPECIFICATIONS

Capacitance Rating and Tolerances—Rated capacitance is measured at 120 cps and at 25° C. Standard tolerances are:

Tolerance	Code Letter
± 5%	J
± 10%	K
± 20%	M

Operating Temperature Range—All capacitors are available in "B" (−55°C to +85°C) and "C" (−55°C to +125°C) characteristics.

DC Working Voltage Rating . . . is the maximum value of voltage for continuous duty at rated temperature. Where AC is superimposed on DC voltage, the sum of the AC peak and the DC voltage must not exceed the DC rated voltage. See "AC Ripple Current."

DC Surge Voltage Rating . . . is 115% of the DC Working Voltage Rating. It is the maximum voltage that the capacitor may be subjected to intermittently under any condition. This peak voltage includes AC ripple that may be superimposed on the DC. The capacitor will withstand this surge voltage applied for 1000 successive cycles of ½ minute on, 5½ minutes off, at the maximum rated ambient temperature.

AC Ripple Current.

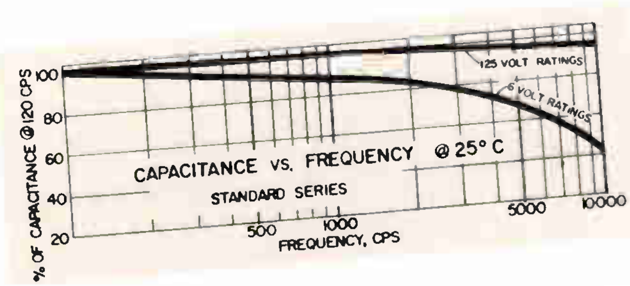
Case Size		Max. Ripple Current in ma	
Com'l.	MIL	−55 +85°C	−55 +125°C
U, SU	T1	50	40*
F, SF	T2	250	200*
G, SG	T3	400	320*

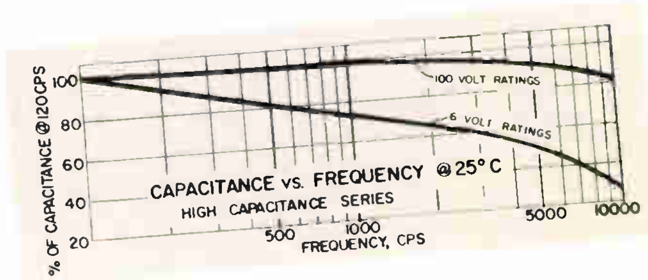
*Not applicable to units with 85°C max. rating.

DC Leakage Current . . . is measured at the applicable ambient temperature after 5 minutes of electrification at DC rated voltage. Voltage is applied through a 1000 ohm resistor in series with each capacitor to limit charging current. The maximum DC leakage currents are shown in the table.

Equivalent Series Resistance . . . in ohms, as determined by measurement at 120 cps and at +25°C, is less than the limits described in MIL-C-3965.

Reduced Pressure—Capacitors will operate at a reduced atmospheric pressure of 0.82 inches of mercury (80,000 feet altitude) exceeding the requirements of MIL-C-3965.





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High Frequency Vibration, Shock, Acceleration—TS units will exceed vibration test requirements of MIL-C-3965, Grade 3, from 5 to 2000 cps with acceleration of 15 g's. They have been successfully tested over this range with an acceleration of 30 g's. They will withstand a 50 g shock test in accordance with MIL Std. 202A, Method 205; also a constant acceleration test of 50 g's.

Shelf & Load Life—Tests have shown that the capacitors exhibit no perceptible change in capacitance over 10,000 hours of storage at 25°C. At rated voltage for 10,000 hours at 85°C ambient, the typical change of capacitance is 2%.

Terminal Strength—Leads will withstand pull test of 3 pounds in an axial direction for 30 seconds as required by MIL-C-3965, will withstand bend test also per MIL-C-3965.

Testing Precautions — Capacity ratings are established at 120 cps. Before measurements are made, it should be carefully determined that the DC bias is sufficiently large to prevent polarity reversal due to the AC component. The peak AC voltage should be limited to 30 percent of the rated DC voltage or 4 volts rms, whichever is smaller.

Parallel or Series Connection—Capacitors may be connected in parallel to obtain greater total capacitance. Capacitors may be connected in series to accommodate higher voltage requirements but shunting resistors are required, maximum values for which are achieved with these formulae*:

Cases U, SU (T1) $R = \frac{3.4}{\sqrt{C}}$ **Cases F, SF, (T2)** $R = \frac{5.2}{\sqrt{C}}$

Cases G, SG (T3) $R = \frac{6.5}{\sqrt{C}}$ **(*R in megohms; C in mfds.)**

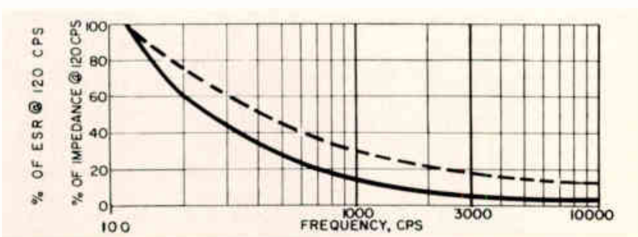
Coding of Commercial Catalog Numbers—Catalog numbers for Series TS capacitors are translated as follows:

Example— **1 R 7 U B 1 2 5** K

Cap. in Mfd.	Case Size	Operating Temp. Range	Volts DC	Cap. Tolerance
1.7	U	B	125	K

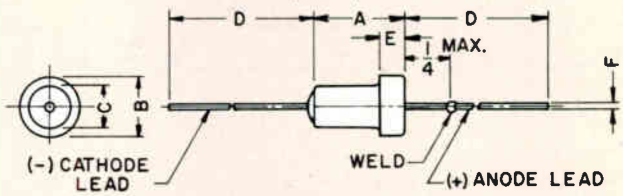
The letter "R" represents a decimal point. Case size designation of "straight-cylindrical" unit would be "SU." Adopting the military coding system, the letter "B" represents an operating temperature range of —55°C. to +85°C. Substitute "C" for —55°C to +125°C range. To specify an insulating sleeve, add "A" as a suffix to the catalog number.

On MIL capacitors, "C" type (125°C) capacitors carry a dual voltage rating, for example, "60/40 VDC." The first number is the rating at 85°C; the second is the 125°C rating.



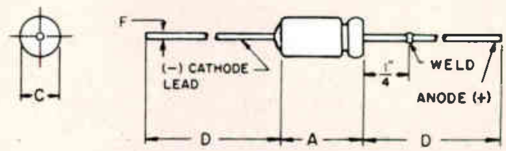
— — — = % equivalent series resistance (ESR) vs frequency;
——— = % impedance vs frequency.

HAT-SHAPE TYPE, CASE SIZES U, F, G
MIL STYLES CL44, CL45, CASE SIZES T1, T2, T3

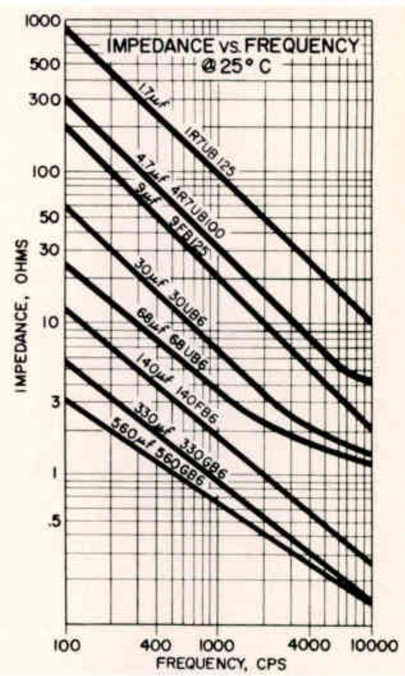


Dim.	Uninsulated Case (CL44) Tol.	U (T1)	F (T2)	G (T3)	Insulated Case (CL45) Tol.	U (T1)	F (T2)	G (T3)
A	+1/64-1/32	15/32	11/16	49/64	±1/32	35/64	49/64	55/64
B	±1/64	5/16	15/32	37/64	max.	3/8	17/32	21/32
C	+1/64-1/32	7/32	9/32	3/8	max.	17/64	11/32	7/16
D	±1/4	1 1/2	2 1/4	2 1/4	±1/4	1 1/2	2 1/4	2 1/4
E	±.008	.125	.150	.165	±.031	.172	.197	.212
F	+.005 −.001	.032	.040	.040	+.005 −.001	.032	.040	.040

STRAIGHT CYL. TYPE; CASE SIZES SU, SF, SG
MIL STYLES CL64, CL65; CASE SIZES T1, T2, T3



Dim.	Uninsulated Case (CL64) Tol.	SU (T1)	SF (T2)	SG (T3)	Insulated Case (CL65) Tol.	SU (T1)	SF (T2)	SG (T3)
A	+1/32-1/64	29/64	41/64	49/64	±1/32	35/64	47/64	55/64
C	±1/64	3/16	9/32	3/8	max.	7/32	5/16	13/32
D	±1/4	1 1/2	2 1/4	2 1/4	1/4	1 1/2	2 1/4	2 1/4
F	+.005 −.001	.025	.025	.025	+.005 −.001	.025	.025	.025



Characteristics shown here for hat-shaped capacitors may also be considered applicable to their straight-cylindrical counterparts in sizes SU, SF, and SG.

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STOCK TANTALUM SLUG CAPACITORS

Commercial Case Sizes SU, SF, SG—MIL-C-3965/4E, Styles CL64, CL65
Commercial Case Sizes U, F, G—MIL-C-3965/4D, Styles CL44, CL45

Stock Slug Capacitors								Capacitor Characteristics						
	D.C. Rated Volts		Commercial			MIL-C-3965		Max. ESR @ 120 cps @ 25°C Ohms	Max. Imp. @ 120 cps @ −55°C Ohms	Max. D.C. Leakage Current, Microamps at Rated Volts		% Max. Capac. Change from Rating at 25°C.		
Mfd.	@ 85°C	@ 125°C	Case§ Size	Stock No. (85°C)*	Stock No. (125°C)*	Case Size	Type Designation†			@ 25°C	@ 85°C & 125°C	@ −55°C	@ +85°C	@ +125°C
30	6	4	U	30___UB6___	30___UC4___	T1	CL_____B300___P3	4	100	0.8	2	−40	+10.5	+12
68‡	6	4	U	68___UB6___	68___UC4___	T1	CL_____B680___P3	4	60	1	2	−40	+14	+16
140	6	4	F	140___FB6___	140___FC4___	T2	CL_____B141___P3	1.8	40	1	3	−40	+14	+16
270‡	6	4	F	270___FB6___	270___FC4___	T2	CL_____B271___P3	2	25	1	6.5	−44	+17.5	+20
330	6	4	G	330___GB6___	330___GC4___	T3	CL_____B331___P3	1.8	20	2	7.9	−44	+14	+16
560‡	6	4	G	560___GB6___	560___GC4___	T3	CL_____B561___P3	3	25	2	13	−64	+17.5	+20
25	8	5	U	25___UB8___	25___UC5___	T1	CL_____C250___P3	4	100	0.9	2	−35	+10.5	+12
56‡	8	5	U	56___UB8___	56___UC5___	T1	CL_____C560___P3	4	59	1	2	−40	+14	+16
220‡	8	5	F	220___FB8___	220___FC5___	T2	CL_____C221___P3	4	30	1	7	−44	+17.5	+20
430‡	8	5	G	430___GB8___	430___GC5___	T3	CL_____C431___P3	3	25	2	13.8	−64	+17.5	+20
20	10	7	U	20___UB10___	20___UC7___	T1	CL_____D200___P3	4	120	0.9	2	−30	+10.5	+12
47‡	10	7	U	47___UB10___	47___UC7___	T1	CL_____D470___P3	3.6	100	1	2	−36	+14	+16
100	10	7	F	100___FB10___	100___FC7___	T2	CL_____D101___P3	2	60	1	4	−36	+14	+16
180‡	10	7	F	180___FB10___	180___FC7___	T2	CL_____D181___P3	4	40	1	7	−36	+14	+16
250	10	7	G	250___GB10___	250___GC7___	T3	CL_____D251___P3	2	30	2	10	−40	+14	+16
390‡	10	7	G	390___GB10___	390___GC7___	T3	CL_____D391___P3	3	25	2	15.6	−64	+17.5	+20
15	15	10	U	15___UB15___	15___UC10___	T1	CL_____E150___P3	5	145	1	2	−24	+10.5	+12
33‡	15	10	U	33___UB15___	33___UC10___	T1	CL_____E330___P3	3.6	90	1	2	−28	+14	+16
70	15	10	F	70___FB15___	70___FC10___	T2	CL_____E700___P3	2.5	63	1	4	−28	+14	+16
120‡	15	10	F	120___FB15___	120___FC10___	T2	CL_____E121___P3	4	50	1	7	−28	+17.5	+20
170	15	10	G	170___GB15___	170___GC10___	T3	CL_____E171___P3	2	35	2	10	−32	+14	+16
270‡	15	10	G	270___GB15___	270___GC10___	T3	CL_____E271___P3	3	30	2	16	−56	+17.5	+20
10	25	17	U	10___UB25___	10___UC17___	T1	CL_____G100___P3	6	190	1	2	−16	+8	+9
22‡	25	17	U	22___UB25___	22___UC17___	T1	CL_____G220___P3	3.6	140	1	2	−20	+10.5	+12
100‡	25	17	F	100___FB25___	100___FC17___	T2	CL_____G101___P3	4	50	1	10	−28	+13	+15
180‡	25	17	G	180___GB25___	180___GC17___	T3	CL_____G181___P3	4	32	2	18	−48	+13	+15
8	30	20	U	8___UB30___	8___UC20___	T1	CL_____H080___P3	7	230	1	2	−16	+8	+12
15‡	30	20	U	15___UB30___	15___UC20___	T1	CL_____H150___P3	5	175	1	2	−20	+10.5	+12
40	30	20	F	40___FB30___	40___FC20___	T2	CL_____H400___P3	4	65	1	4.8	−24	+10.5	+12
68‡	30	20	F	68___FB30___	68___FC20___	T2	CL_____H680___P3	6	60	1	8	−24	+13	+15
100	30	20	G	100___GB30___	100___GC20___	T3	CL_____H101___P3	2.5	40	2	12	−28	+10.5	+12
150‡	30	20	G	150___GB30___	150___GC20___	T3	CL_____H151___P3	4	35	2	18	−48	+13	+15
5	50	33	U	5___UB50___	5___UC33___	T1	CL_____J050___P3	7.2	355	1	2	−16	+5	+6
10‡	50	33	U	10___UB50___	10___UC33___	T1	CL_____J100___P3	5.4	250	1	2	−24	+8	+9
25	50	33	F	25___FB50___	25___FC33___	T2	CL_____J250___P3	4	90	1	5	−20	+10.5	+12
47‡	50	33	F	47___FB50___	47___FC33___	T2	CL_____J470___P3	6	70	1	9	−28	+13	+15
60	50	33	G	60___GB50___	60___GC33___	T3	CL_____J600___P3	3	45	2	12	−16	+10.5	+12
82‡	50	33	G	82___GB50___	82___GC33___	T3	CL_____J820___P3	4	45	2	16	−32	+13	+15
4	60	40	U	4___UB60___	4___UC40___	T1	CL_____K040___P3	8.1	405	1	2	−16	+5	+6
8.2‡	60	40	U	8R2___UB60___	8R2___UC40___	T1	CL_____K8R2___P3	8	275	1	2	−24	+8	+9
20	60	40	F	20___FB60___	20___FC40___	T2	CL_____K200___P3	4.3	105	1	4.8	−16	+10.5	+12
39‡	60	40	F	39___FB60___	39___FC40___	T2	CL_____K390___P3	7	90	1	9	−28	+10.5	+12
50	60	40	G	50___GB60___	50___GC40___	T3	CL_____K500___P3	4	50	2	12	−16	+10.5	+12
68‡	60	40	G	68___GB60___	68___GC40___	T3	CL_____K680___P3	6	50	2	16	−32	+10.5	+12
3.5	75	50	U	3R5___UB75___	3R5___UC50___	T1	CL_____L3R5___P3	9	505	1	2	−16	+5	+6
6.8‡	75	50	U	6R8___UB75___	6R8___UC50___	T1	CL_____L6R8___P3	6.3	300	1	2	−20	+8	+9
15	75	50	F	15___FB75___	15___FC50___	T2	CL_____L150___P3	5	135	1	4.5	−16	+8	+9
33‡	75	50	F	33___FB75___	33___FC50___	T2	CL_____L330___P3	7	90	1	9.9	−24	+10.5	+15
40	75	50	G	40___GB75___	40___GC50___	T3	CL_____L400___P3	4.7	60	2	12	−16	+10.5	+12
56‡	75	50	G	56___GB75___	56___GC50___	T3	CL_____L560___P3	6	60	2	16.8	−28	+10.5	+15
2.5	100	70	U	2R5___UB100___	2R5___UC70___	T1	CL_____N2R5___P3	9.5	710	1	2	−16	+3	+4
4.7‡	100	70	U	4R7___UB100___	4R7___UC70___	T1	CL_____N4R7___P3	9	500	1	2	−16	+5	+6
11	100	70	F	11___FB100___	11___FC70___	T2	CL_____N110___P3	5	200	1	4	−15	+5	+6
22‡	100	70	F	22___FB100___	22___FC70___	T2	CL_____N220___P3	7	100	1	8.8	−16	+5	+6
30	100	70	G	30___GB100___	30___GC70___	T3	CL_____N300___P3	4	80	2	12	−15	+7	+8
43‡	100	70	G	43___GB100___	43___GC70___	T3	CL_____N430___P3	6	70	2	17	−20	+7	+8
1.7	125	85	U	1R7___UB125___	1R7___UC85___	T1	CL_____P1R7___P3	13.5	950	1	2	−15	+3	+4
3.6‡	125	85	U	3R6___UB125___	3R6___UC85___	T1	CL_____P3R6___P3	12	500	1	2	−16	+5	+5
9	125	85	F	9___FB125___	9___FC85___	T2	CL_____P090___P3	5	235	1	4.5	−15	+4	+6
14‡	125	85	F	14___FB125___	14___FC85___	T2	CL_____P140___P3	12	167	1	7	−16	+6	+7
25	125	85	G	25___GB125___	25___GC85___	T3	CL_____P250___P3	5	90	2	12.5	−15	+8	+10
39‡	125	85	G	39___GB125___	39___GC85___									

*Complete commercial stock no. as follows: If straight-cylindrical capacitor is desired, insert an "S" in the middle of the number where the underlined space is provided as in "30SUB6___." If a hat-shape capacitor is desired, write this number without the space as in "30UB6___." Add J, K or M at end of number to indicate tolerance. Add "A" after tolerance letter if insulating sleeve is desired.

†Complete MIL type designation as follows: For hat-shape, uninsulated type, insert "44" after "CL___"; for insulated type insert "45" instead. For straight-cylindrical shape, uninsulated, insert "64" after "CL___"; for insulated type insert "65" instead. After desired style designation ("CL44, CL64" etc.) insert "B" for 85°C or "C" for 125°C characteristic. Insert J, K or M before "P" to indicate tolerance.

‡High capacitance units.

§"S" precedes case letter for straight-sided units.

Tolerances: J = ±5%; K = ±10%; M = ±20%.

RELAYS

CATALOG SEQUENCE 700

RELAYS
700

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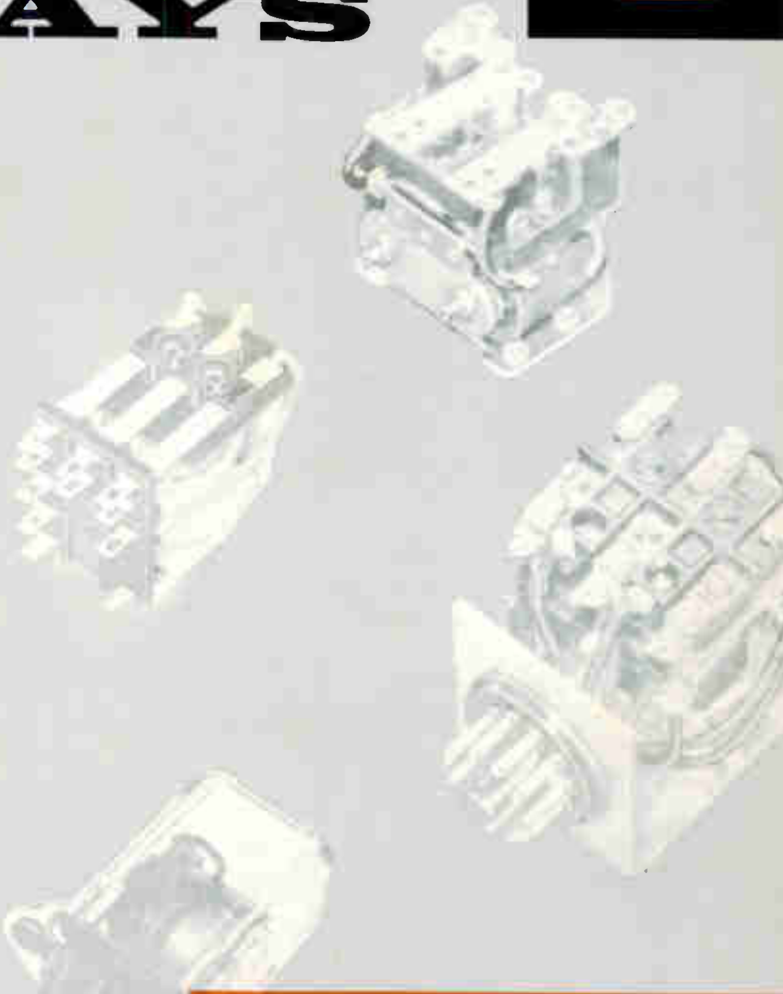
RELAYS

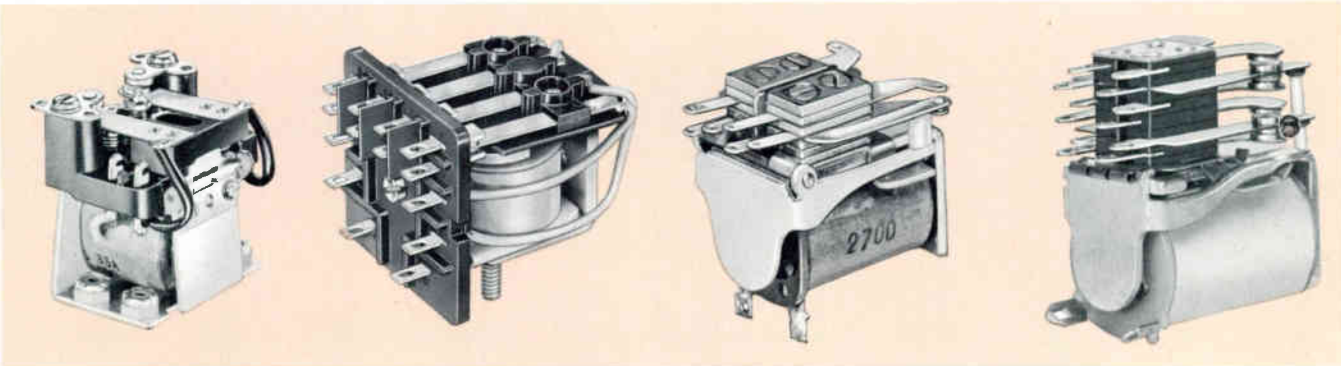
CONTENTS



CATALOG 700C

OHMITE MANUFACTURING COMPANY • 3601 HOWARD ST. • SKOKIE, ILLINOIS 60076

GENERAL PURPOSE



Typical Molded Panel and Pile-Up Type Relays

Introduction: Ohmite relays embody the same careful engineering, strict quality control and generous use of high quality materials for which Ohmite products have become famous. Parts are plated where necessary for corrosion resistance. Springs are of nickel-silver, phosphor-bronze or beryllium copper. Contacts are fine silver except where the catalog description indicates otherwise. (Special contact materials can be supplied.)

Every precaution is taken to assure reliable operation under demanding as well as ideal ambient conditions. Protection against humidity and moisture is paramount and is accomplished in layer-wound coils, through complete sealing with cellulose-acetate. A sheet of this high temperature plastic is placed between each layer of wire. Then, by means of a patented process, the acetate is caused to flow around the ends of the coil to form a completely plastic-sealed unit. Where layer winding is not possible, suitable bobbin construction is used with (optional) vacuum varnish impregnation.

Relay Selection: The Relay Selection Guide on pages 4 and 5 will be useful in making an initial choice of a relay. All the essential data is presented here including the availability of special mountings and enclosures. The Guide also indicates which relays are carried in stock for immediate delivery. Details of each relay and stock listings, where available, will be found in the individual relay descriptions (see Guide, "Described on page . ."). See "Contents" page 1 this section, for other special relays.

The data presented in the Guide is qualified by the factors discussed below and should be considered in making a choice of relays for a particular application.

Coil Operating Voltage or Current: The Relay Selection Guide clearly distinguishes between relays that operate on 60-cycle AC or DC. (Other frequency requirements for AC relays should be stated.) Where a relay must operate on a specific voltage or current, the pull-in and drop-out values should be specified and the allowable variation indicated. Where the variation is not specified, relays will be adjusted to pull in at 80% or less of the nominal voltage for DC relays and 85% or less for AC relays (at normal ambient temperature of 20°C).

Ohmite may be able to furnish relays which will operate on less pull-in power than indicated under "Pull-In Coil Watts" in the Guide, particularly if the desired contact combination is less than the maximum. (Data in the Guide assumes the maximum contact combination unless otherwise indicated.) However, this possibility is affected by the ambient operating temperature and the temperature coefficient of resistance of the coil wire. In applications where shock and vibration are encountered, heavier contact spring pressures may be required to prevent momentary openings. Greater coil power would then be necessary to operate the contacts. Engineering analysis is provided by Ohmite where critical coil requirements arise. The maximum operating voltage for DC relays is 20% above the nominal voltage; for AC relays, 15% above nominal.

Contacts: Contact ratings presented in the Guide and in the individual relay descriptions are conservative and assume that the load is non-inductive. Where extra sets of contacts are available on a relay, "double break contacts", see column "Cont. Rating") the current handling capacity can be increased appreciably. Where the load is non-inductive, it is sometimes possible to switch voltages greater than 115 volts AC. However, current ratings must be reduced—current must be halved as voltage doubles. For voltages over 460 volts AC or 32 volts DC, engineering analysis is required.

For inductive loads, Ohmite can supply silver-tungsten or silver-cadmium-oxide instead of the standard, fine silver contacts. Contact current capacity must also be considered in the light of the duty cycle of the relay. Where a relay is called upon to operate only a few times daily, overloading of the contacts might be permitted. Conversely, where the relay must operate several hun-

AC AND DC RELAYS

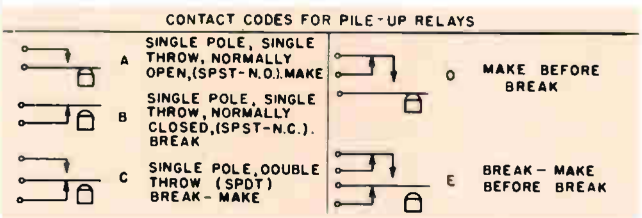
dred times a minute for long periods, it may be necessary to use contacts with capacity greater than that demanded by the load.

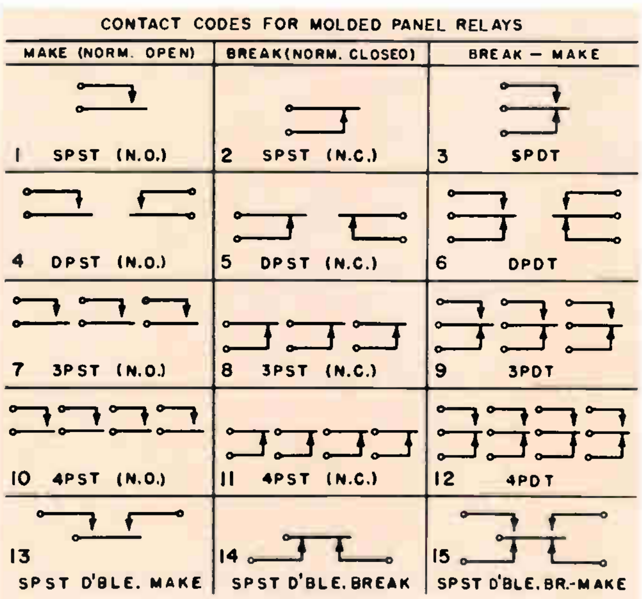
Mechanical Requirements: Where more than one relay satisfies the electrical requirements, the mechanical requirements may be the determining factor. This involves size of the relay and manner of mounting which is particularly important where shock and vibration are encountered. Where protection from ambient conditions is desired, the availability of enclosures is a factor.

Moisture and Tropicalization Treatment: Coil and phenolic parts can be supplied with a fungus-resistant varnish coating.

Contact Arrangements and Ordering Code: Complete contact combinations are made up from simple combinations which are coded by letter for pile-up type relays such as TKL, TO, TT and TS and by number for molded panel type relays* such as GPR, DOS, DOSY, DO, DOY and CR.

Thus, a double-pole, double-throw combination would consist of two "C" combinations in a pile-up type relay or one "6" combination in a molded panel type (see





So called because the base and contact carrying parts are panels of molded plastic.

diagrams below). Because of this difference in contact designation, the ordering codes for molded panel and pile-up relays differ as shown.

Example: Code Designation for Pile-Up Relay with DPDT, SPST-N.O. and SPST-N.C. combination.

TKL — (CC-AB) D — 24V

Model | Left Pile-Up Combination‡ | Right Pile-Up | Coil Power "A" = AC "D" = DC | Coil Volts

‡*As viewed from terminal end with contact springs on top.*

Example: Code Designation for Molded Panel Type Relay with DPDT combination.

DOS — 6 A — 115V

Model | Combination | Coil Power "A" = AC "D" = DC | Coil Volts

Different model codes are assigned to Ohmite relays when they are modified through the addition of plug mountings, dust or hermetically sealed enclosures. The new model codes are obtained through the use of suffixes as described on pages 21-23.

Where enclosures or special mountings are desired, it is necessary to use the modified model code in the code designation. Thus, the simple code designations shown above might appear:

TKLHP-STYLE 2-(CC-AB)D-24V (or)
DOSHP-STYLE 3-6A-115V

See the Guide and individual relay descriptions for available modifications.

Specification Numbers: Relays supplied on an order, and the acknowledgments and invoices pertaining to same, carry the number of the covering specification. This number is unrelated to the code designation and should be used on re-orders instead of the code designation. Specification numbers may be identified by the "X" following the model code as in DOSX-7. Where the item is carried in stock i.e., a "stock item", a "T" follows the number as in DOSX-7T.

When ordering Ohmite Relays, give:

1. The information required in the code designation, or the stock number if the item is carried in stock or the specification number if a non-stock item is being re-ordered.

2. On initial orders, describe the contact load completely; give voltage and current in amperes, type of current—AC or DC and whether the load is inductive or non-inductive.

3. Describe any special requirements in detail such as non-standard mountings.

OHMITE

HELPFUL RELAY

AC RELAYS		DC RELAYS			CONTACT RATING AMPS‡	MAXIMUM CONTACT COMBINATION	UNENCLOSED SIZE			DESC. ON PAGE	STOCK RELAYS	APPLICATION
MODEL	NOM. COIL WATTS	MODEL	COIL WATTS Nom.	COIL WATTS Pull-in			Length	Width	Height			
GPR§	3-Pole 1.6 4-Pole 2.4	GPR§	1.4	0.9	5 and 10	3PDT 4PDT	1 15/16 1 29/32	1" 1 3/8	1 3/16† 1 13/32†	6	✓	General purpose, plate circuit thyratron plate and indicator types
DOS§	3.0	DOS§	2.5	1.6	15 25 with D.B.	DPDT SPDT with D.B.	1 5/8	1 1/2	1 7/8	10	✓	Industrial and mobile
		DOSY	1.0	.64	15 25 with D.B.	DPDT SPDT with D.B.	1 5/8	1 17/32	1 7/8	14	✓	Plate circuit
DO§	6.0	DO§	3.0	1.9	10 20 with D.B.	4PDT DPDT with D.B.	2 1/16 (4 Pole) 1 5/8 (3-Pole)	1 13/16	2 1/4	12	✓	Industrial and mobile
		DOY	1.5	1.0	10 20 with D.B.	4PDT DPDT with D.B.	2 1/16 (4-Pole) 1 5/8 (3-Pole)	1 13/16	2 1/4	15		Plate circuit
		TT		.15 per pole	5	4PDT	1 17/64	51/64	1 17/64‡	16		Aircraft applications
		TS		.25 per pole	10	4PDT	1 17/32	7/8	1 1/2‡	17		Aircraft applications
		TKL	1.25	.8	1 3 with pall. cont.	4PDT or 6PST (6 springs in each pile-up)	1 19/32	31/32	1 17/32*	18		Aircraft applications
		TO		.1 per pole	3	6PDT	2 1/16	1 1/16	1 27/32‡	19		Medium telephone type
QC	5.6	QC	2.75	1.75	25	SPST N.O. D.B. only	1 29/32	1 3/32	1 23/32	20		Miniature contactor
CR	5.6	CR	2.75	1.75	7.5 15 with D.B.	DPST N.O. SPST with D.B.	1 25/32	1 1/32	1 23/32	20		Industrial and mobile, small size

* With 6 springs in each pileup ‡ With max. no. springs in each pileup † Exclusive of mtg. stud ‡ @ 115VAC or 32VDC †Resistive

§ UL versions available; pages 6-9 for GPR, 11 for DOS, 13 for DO.

SELECTION GUIDE

OHMITE

BASIC MODELS**	PLUG-IN MODELS, "__P" PAGE 21	REMOVABLE ENCLOSURE "__EP, __TP, __TA, __TT, __TS" PAGES 7, 23	PLUG-IN, NON-REMOVABLE ENCL. Hermetically Sealed (__HP) Dust-Tight (__CP) PAGE 22	SOLDER TERMINALS, NON-REMOVABLE ENCLOSURES Hermetically Sealed (__H) Dust-Tight (__C) PAGE 22
GPR-3PDT GPR-4PDT	Basic Models Can Plug Into Sockets See P. 7 (SOGPR)	GPRTA GPRTT GPRTS GPRTP	GPRHP	GPRH
	DOSP DOSYP	DOSEP, DOSYEP DOSTP	DOSHP, DOSYHP, DOSCP, DOSYCP Style 1 Style 3	DOSH, DOSYH, DOSC, DOSYC Style 1 Style 2
	DOP DOYP	DOEP, DOYEP	DOHP, DOYHP, DOCP, DOYCP	DOH, DOC, DOYH, DOYC
			TTHP Styles 1, 2	TTH Styles 1, 2 Style 3
			TSHP Style 1 Styles 2, 3	TSH Style 1 Styles 2, 3
		TKLEP	TKLHP, TKLCP Style 1 Style 2	TKLH, TKLC Style 1 Style 2
	CRP			CRH, CRC

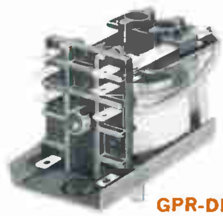
** For variations not shown here, see pages 24-27

OHMITE

MODEL GPR RELAY

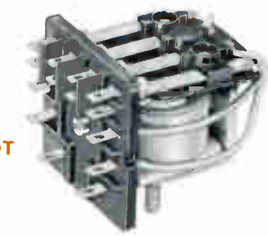
AC or DC OPERATION—STOCK AND MADE-TO-ORDER

GPR-SPDT



GPR-DPDT

GPR-3PDT



GPR-4PDT

Model GPR relays are an extensive and popular series for general purpose use where versatility, ease of replacement and economy are desired. They are capable of handling substantial power for their small size and offer unusual flexibility for making connections and mounting either with or without enclosures. The series includes plate relays for standard vacuum tubes or thyratrons, and "indicator" relays which incorporate lamps to indicate the energized condition of the coil. A large variety of types and ratings are stocked for immediate delivery.

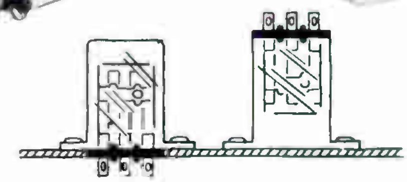
Construction, Terminals and Mounting: A rigid frame helps to assure long retention of adjustments and an adequate magnetic circuit. A 6-32 threaded stud and nut, standard on unenclosed units, permits mounting on panels up to ¼" thick. A hole is also required for the non-turn boss on the relay frame. (A "lug-washer" is employed for 4-pole relays). A 6-32 tapped mounting hole can be supplied in place of the stud on 1 to 3-pole relays.

The coil is wound on a nylon bobbin. All connections terminate on one terminal panel on combination solder—quick-connect (push-on) lugs which accept AMP Series 110 female connectors. Relay contacts are integral inlays on the terminals themselves. With all terminals appearing on one panel, these relays are easily incorporated into printed circuit assemblies. The standard panels (with standard terminals) also can be plugged into Ohmite "SOGPR" sockets as an alternative to mounting by means of the threaded studs (See "Socket" following). To maintain UL spacing requirements for 150 volts, 3- and 4-pole GPR relays are fitted with fiber insulating barriers between the rows of terminals. One, two and three-pole relays have a fiber chassis-insulator also. These barriers and chassis insulators are easily removed to permit plugging of the panel into the SOGPR socket in which case 150 volt spacing is still retained.

Contact Combinations: Up to four-pole double-throw. Also see "GPRLE Latching Relay" page 24 for larger combinations.

GPRTT

GPRTA

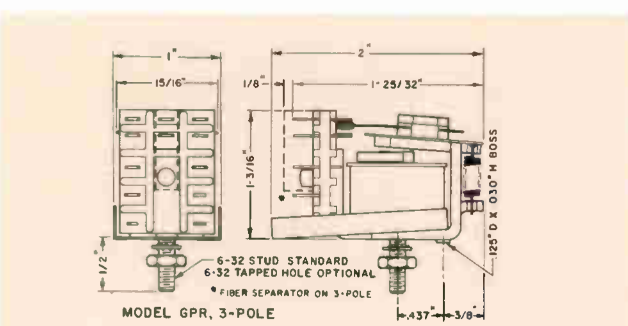


GPRTT GPRTA

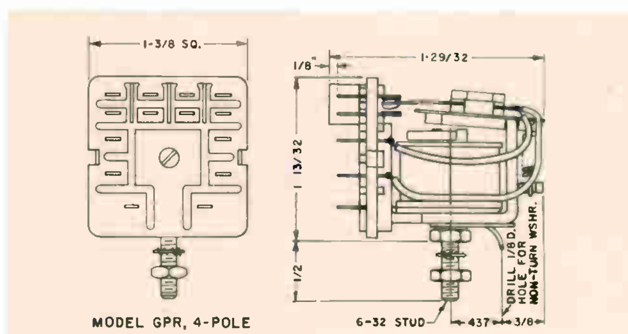
Chassis Mounting of Panel-Type Enclosed Relays

GPRTP

Indicator Type with Neon Bulb



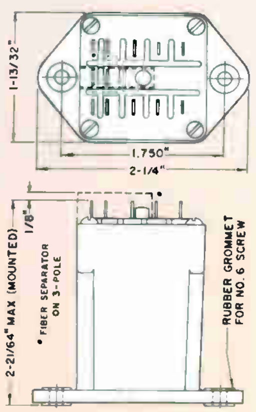
MODEL GPR, 3-POLE



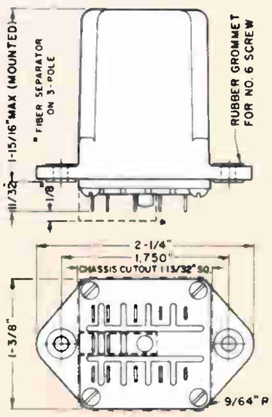
MODEL GPR, 4-POLE

MODEL GPR RELAY (cont.)

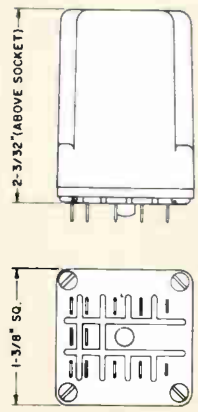
OHMITE



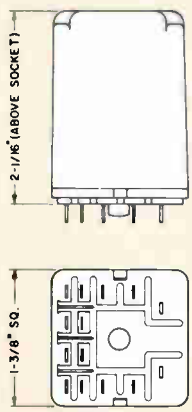
GPRTA Enclosure



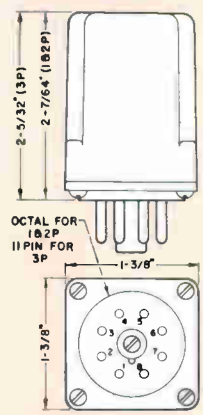
GPRTT Enclosure



GPRTS Enclosure for up to 3-Pole



GPRTS Enclosure for 4-Pole



GPRTP Enclosure

GPRTS Enclosure (up to 3PDT)

Socket (SOGPR-9) for up to 3PDT

GPR and GPRTS Relays in SOGPR Sockets

GPRTS Enclosure (for 4-Pole Relays)

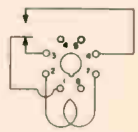
Socket (SOGPR-12) for 4-Pole Relays

SOCKETS FOR GPR and GPRTS RELAYS

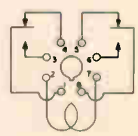
For up to 3PDT: Stock No. SOGPR-9
For 4-pole models: Stock No. SOGPR-12

Std. punches & dies from Ward Machinery Co., Chicago. No. 28, Style 22N, 1¼x1½, for SOGPR-9; No. 28, Style 14R, 1½x1½, for SOGPR-12.

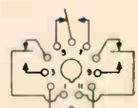
Plug Wiring for GPRTP



SPDT



DPDT



3PDT

Contact Ratings: Two ratings—fine-silver contacts, gold-flashed, 5 amps resistive at 115VAC or 32VDC; silver-cadmium fixed contacts, silver-cadmium-oxide movable contacts, 10 amps.

Coil Operating Voltage Range: Any voltage up to 230 VAC, 60 cycles or 120 VDC.

Coil Wattage: 1.4 watts DC operation; 1.6 watts (2.0 volt-amps) AC except 2.4 watts (3.70 volt-amps) for 4-pole AC relays.

Weights: Figures shown below stock tables are based on three-pole, double-throw relay. Relays with fewer poles weigh slightly less.

Insulation: Tested at 1500 VAC between all terminals and ground.

ENCLOSED GPR RELAYS

Four GPR enclosures afford a liberal choice of mounting arrangements. Four-pole relays are available only in the GPRTS enclosure described below but the GPRTA version can be made-to-order.

Chassis-Mounting Panel Types: "GPRTA" ("Terminals-Above-Chassis" type) has terminal panel opposite mounting flange; "GPRTT" ("Terminals-Through-

MODEL GPR RELAY (cont.)

STOCK "GPR" RELAYS*

Contacts	Coil Data: Volts	Amps.	Ohms	5 Amp Contacts: Unenclosed GPR	Enclosed Above Chassis GPRTA†	Enclosed Thru-Chassis GPRTT†	Enclosure for SOGPR Socket GPRTS‡	Enclosed Plug Base GPRTP	10 Amp Contacts: Unenclosed GPR	Enclosure for SOGPR Socket GPRTS‡	Enclosed Plug Base GPRTP	Indicator Plug Base GPRTP
SPDT	6VAC	.334	4.2	GPRX-3T	GPRTAX-3T	GPRTTX-3T		GPRTPX-3T	GPRX-203T		GPRTPX-203T	
DPDT	6VAC	.334	4.2	GPRX-6T	GPRTAX-6T	GPRTTX-6T	GPRTSX-6T	GPRTPX-6T	GPRX-206T	GPRTSX-206T	GPRTPX-206T	GPRTPX-291T
3PDT	6VAC	.334	4.2	GPRX-9T	GPRTAX-9T	GPRTTX-9T	GPRTSX-9T	GPRTPX-9T	GPRX-209T	GPRTSX-209T	GPRTPX-209T	
4PDT	6VAC	.650	2.5	GPRX-403T			GPRTSX-403T		GPRX-433T	GPRTSX-433T		
SPDT	12VAC	.167	17	GPRX-12T	GPRTAX-12T	GPRTTX-12T		GPRTPX-12T	GPRX-212T		GPRTPX-212T	
DPDT	12VAC	.167	17	GPRX-15T	GPRTAX-15T	GPRTTX-15T	GPRTSX-15T	GPRTPX-15T	GPRX-215T	GPRTSX-215T	GPRTPX-215T	GPRTPX-292T
3PDT	12VAC	.167	17	GPRX-18T	GPRTAX-18T	GPRTTX-18T	GPRTSX-18T	GPRTPX-18T	GPRX-218T	GPRTSX-218T	GPRTPX-218T	
4PDT	12VAC	.309	10	GPRX-406T			GPRTSX-406T		GPRX-436T	GPRTSX-436T		
SPDT	24VAC	.084	65	GPRX-21T	GPRTAX-21T	GPRTTX-21T		GPRTPX-21T	GPRX-221T		GPRTPX-221T	
DPDT	24VAC	.084	65	GPRX-24T	GPRTAX-24T	GPRTTX-24T	GPRTSX-24T	GPRTPX-24T	GPRX-224T	GPRTSX-224T	GPRTPX-224T	GPRTPX-293T
3PDT	24VAC	.084	65	GPRX-27T	GPRTAX-27T	GPRTTX-27T	GPRTSX-27T	GPRTPX-27T	GPRX-227T	GPRTSX-227T	GPRTPX-227T	
4PDT	24VAC	.155	40	GPRX-409T			GPRTSX-409T		GPRX-439T	GPRTSX-439T		
SPDT	115VAC	.0174	1,600	GPRX-30T	GPRTAX-30T	GPRTTX-30T		GPRTPX-30T	GPRX-230T		GPRTPX-230T	
DPDT	115VAC	.0174	1,600	GPRX-33T	GPRTAX-33T	GPRTTX-33T	GPRTSX-33T	GPRTPX-33T	GPRX-233T	GPRTSX-233T	GPRTPX-233T	GPRTPX-294T
3PDT	115VAC	.0174	1,600	GPRX-36T	GPRTAX-36T	GPRTTX-36T	GPRTSX-36T	GPRTPX-36T	GPRX-236T	GPRTSX-236T	GPRTPX-236T	
4PDT	115VAC	.0325	1,000	GPRX-412T			GPRTSX-412T		GPRX-442T	GPRTSX-442T		
SPDT	230VAC	.0087	7,000	GPRX-39T	GPRTAX-39T	GPRTTX-39T		GPRTPX-39T	GPRX-239T		GPRTPX-239T	
DPDT	230VAC	.0087	7,000	GPRX-42T	GPRTAX-42T	GPRTTX-42T	GPRTSX-42T	GPRTPX-42T	GPRX-242T	GPRTSX-242T	GPRTPX-242T	GPRTPX-295T
3PDT	230VAC	.0087	7,000	GPRX-45T	GPRTAX-45T	GPRTTX-45T	GPRTSX-45T	GPRTPX-45T	GPRX-245T	GPRTSX-245T	GPRTPX-245T	
4PDT	230VAC	.0147	4,000	GPRX-415T			GPRTSX-415T		GPRX-445T	GPRTSX-445T		
SPDT	6VDC	.23	26	GPRX-48T	GPRTAX-48T	GPRTTX-48T		GPRTPX-48T	GPRX-248T		GPRTPX-248T	
DPDT	6VDC	.23	26	GPRX-51T	GPRTAX-51T	GPRTTX-51T	GPRTSX-51T	GPRTPX-51T	GPRX-251T	GPRTSX-251T	GPRTPX-251T	GPRTPX-296T
3PDT	6VDC	.23	26	GPRX-54T	GPRTAX-54T	GPRTTX-54T	GPRTSX-54T	GPRTPX-54T	GPRX-254T	GPRTSX-254T	GPRTPX-254T	
4PDT	6VDC	.23	26	GPRX-418T			GPRTSX-418T		GPRX-448T	GPRTSX-448T		
SPDT	12VDC	.114	105	GPRX-57T	GPRTAX-57T	GPRTTX-57T		GPRTPX-57T	GPRX-257T		GPRTPX-257T	
DPDT	12VDC	.114	105	GPRX-60T	GPRTAX-60T	GPRTTX-60T	GPRTSX-60T	GPRTPX-60T	GPRX-260T	GPRTSX-260T	GPRTPX-260T	GPRTPX-297T
3PDT	12VDC	.114	105	GPRX-63T	GPRTAX-63T	GPRTTX-63T	GPRTSX-63T	GPRTPX-63T	GPRX-263T	GPRTSX-263T	GPRTPX-263T	
4PDT	12VDC	.114	105	GPRX-421T			GPRTSX-421T		GPRX-451T	GPRTSX-451T		
SPDT	24VDC	.060	400	GPRX-66T	GPRTAX-66T	GPRTTX-66T		GPRTPX-66T	GPRX-266T		GPRTPX-266T	
DPDT	24VDC	.060	400	GPRX-69T	GPRTAX-69T	GPRTTX-69T	GPRTSX-69T	GPRTPX-69T	GPRX-269T	GPRTSX-269T	GPRTPX-269T	GPRTPX-298T
3PDT	24VDC	.060	400	GPRX-72T	GPRTAX-72T	GPRTTX-72T	GPRTSX-72T	GPRTPX-72T	GPRX-272T	GPRTSX-272T	GPRTPX-272T	
4PDT	24VDC	.060	400	GPRX-424T			GPRTSX-424T		GPRX-454T	GPRTSX-454T		
SPDT	110VDC	.0110	10,000	GPRX-75T	GPRTAX-75T	GPRTTX-75T		GPRTPX-75T	GPRX-275T		GPRTPX-275T	
DPDT	110VDC	.0110	10,000	GPRX-78T	GPRTAX-78T	GPRTTX-78T	GPRTSX-78T	GPRTPX-78T	GPRX-278T	GPRTSX-278T	GPRTPX-278T	GPRTPX-299T
3PDT	110VDC	.0110	10,000	GPRX-81T	GPRTAX-81T	GPRTTX-81T	GPRTSX-81T	GPRTPX-81T	GPRX-281T	GPRTSX-281T	GPRTPX-281T	
4PDT	110VDC	.0110	10,000	GPRX-427T			GPRTSX-427T		GPRX-457T	GPRTSX-457T		
Approx. weight →				2.5 oz.	3.0 oz.	3.0 oz.	3.0 oz.	3.5 oz.	2.5 oz.	3.5 oz.	3.5 oz.	3.5 oz.

*Column heads carry symbols which indicate UL or CSA (Canadian Standards Association) approval. UL approval consists of listing under the UL "components program," so these relays do not carry a UL stamp. (See explanation in "UL and CSA Approval".) Only relays in the grey tinted areas are listed by UL.

†GPRTA and GPRTT types as listed by UL, differ slightly from the stock versions above and consequently, are made to order. These UL versions have a "U" added to the catalog number, such as in "GPRTAU." They also have CSA approval and will carry the CSA stamp.

Chassis" type) has terminal panel on same end as mounting flange, requires chassis cutout; "GPRTS" type ("Terminals for Socket Use") is similar to GPRTT but has no mounting flanges. It is intended strictly for plug-in mounting in Ohmite socket "SOGPR" (see "Socket" below). Terminals are the combination solder—quick-connect type (AMP Series 110) described under "Construction." Mounting holes in the flange have rubber grommets except for UL-approved GPRTA (GPRTAU) and GPRTT (GPRTTU) relays which have holes for No. 10 screws in the flanges.

Pin-Plug Base Type, GPRTP: A modified octal plug (see "UL Requirements") is provided for 1-and 2-pole relays; an 11-pin plug for 3-pole relays. The octal plug base is integral with the relay assembly and meets UL spacing requirements for 150 volts. The cover is held by screws in the corners of the plug base.

Hermetically Sealed GPR Relays: GPRH and GPRHP (plug-base) hermetically sealed relays for up to 3PDT are described on page 22. See illustrations, page 9.

Socket (SOGPR): Unique sockets fit the *standard* terminal panels of all GPR relays and provide over-the-surface spacing to meet UL requirements for 150 volts. Require chassis cut-out to mount. Hold down springs (see illustration) for unenclosed and enclosed relays, are provided with each socket but are not required except under conditions of vibration or shock. Socket solder-terminals will also accept AMP 110 quick-connectors. See socket listings.

MODEL GPR RELAY (cont.)

Indicator Relay: Incorporates lamp which lights to indicate energized condition of coil. Available only in GPRTP enclosures for 1- and 2-pole relays, described above. Stocked only in DPDT, 10 amp type. Neon bulb furnished with coil ratings 70 volts and higher; incandescent bulbs for coil ratings below 70 volts.

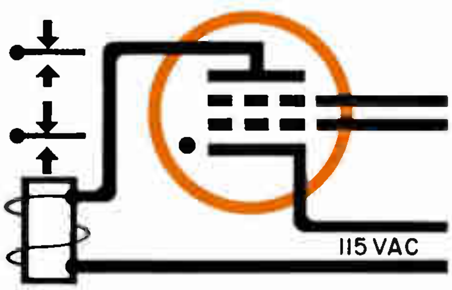
Plate Circuit Relays: GPR plate circuit relays feature the same physical characteristics described under "Construction . . ." They are adjusted for greater sensitivity and are adaptable to a wide range of electronic circuit controls such as signaling attainment of predetermined current levels in the plate circuits of vacuum tubes. GPR plate relays are supplied in the standard GPR enclosures (see tables).

Thyratron Plate Relay: Designed specifically for plate circuit of thyratron tubes 2050 and 2D21 with 115 VAC supply (see diagram). At the nominal 115 AC line voltage, relays draw 17 ma when measured with a DC milliameter placed in series with the relay coil. They are also suitable for operation in series with silicon-controlled rectifiers from a 115 VAC supply. Ready to work, no capacitors or adjustments required, no chatter. Available unenclosed and in all GPR enclosures.

UL and CSA Listings: Column heads in the stock tables carry the UL (Underwriters' Laboratories) and/or CSA (Canadian Standards Association) symbols where listing has been granted. The grey tint in the column indicates those relays which are recognized under the "UL Components Recognition Program" and are listed in the Component Recognition Index. The acceptability of *such* relays by UL depends upon their combination with other equipment such as sockets, etc., and therefore they do not carry the UL stamp. *All* relays with CSA listing carry the CSA stamp. GPRTA and GPRTT relays as listed by UL are made to order and differ slightly from the stock versions by having "Lexan" instead of polystyrene covers and by not having rubber grommets in the mounting flanges. The UL versions add a "U" to the catalog number as in "GPRTAU."

GPRH
Hermetically Sealed

GPRHP
Hermetically Sealed



Showing Relay in Plate Circuit of Thyratron

STOCK "GPR" PLATE CIRCUIT RELAYS—5 Amp Contacts

Contacts	Coil Data: Ohms	Coil Data: Pull-in max. ma.	Unenclosed GPR	Enclosed Above-Chassis GPRTA	Enclosed Thru-Chassis GPRTT	Enclosed for SOGPR Socket GPRTS	Enclosed Plug-Base GPRTP
SPDT	2,500	7.2	GPRX-82T	GPRTAX-82T	GPRTTX-82T		GPRTPX-82T
DPDT	2,500	10	GPRX-83T	GPRTAX-83T	GPRTTX-83T		GPRTPX-83T
3PDT	2,500	12.3	GPRX-84T	GPRTAX-84T	GPRTTX-84T		GPRTPX-84T
4PDT	2,500	15.0	GPRX-463T			GPRTSX-463T	
SPDT	5,000	5	GPRX-85T	GPRTAX-85T	GPRTTX-85T		GPRTPX-85T
DPDT	5,000	7.2	GPRX-86T	GPRTAX-86T	GPRTTX-86T		GPRTPX-86T
3PDT	5,000	8.7	GPRX-87T	GPRTAX-87T	GPRTTX-87T		GPRTPX-87T
4PDT	5,000	11	GPRX-466T			GPRTSX-466T	
SPDT	10,000	3.6	GPRX-88T	GPRTAX-88T	GPRTTX-88T		GPRTPX-88T
DPDT	10,000	5	GPRX-89T	GPRTAX-89T	GPRTTX-89T		GPRTPX-89T
3PDT	10,000	6.1	GPRX-90T	GPRTAX-90T	GPRTTX-90T		GPRTPX-90T
4PDT	10,000	7.5	GPRX-469T			GPRTSX-469T	
Approx. weight →			2.5 oz.	3.0 oz.	3.0 oz.	3.0 oz.	3.5 oz.

STOCK GPR THYRATRON RELAYS

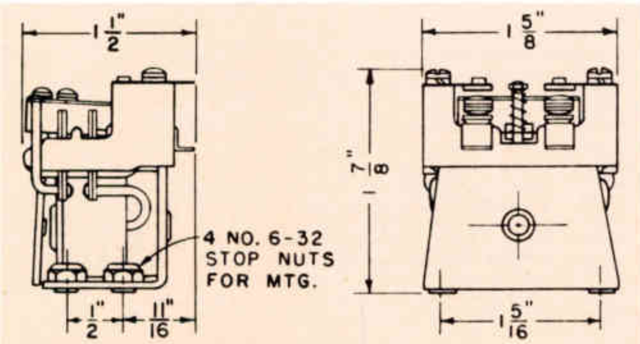
Contacts	5 Amp Contacts: Unenclosed GPR	5 Amp: Enclosed Above-Chassis GPRTA	5 Amp: Enclosed Thru-Chassis GPRTT	5 Amp: Enclosed for SOGPR Socket GPRTS	5 Amp: Enclosed Plug-Base GPRTP	10 Amp Contacts: Unenclosed GPR	10 Amp: Enclosed for SOGPR Socket GPRTS	10 Amp: Enclosed Plug-Base GPRTP
SPDT	GPRX-191T	GPRTAX-191T	GPRTTX-191T		GPRTPX-191T	GPRX-391T		GPRTPX-391T
DPDT	GPRX-192T	GPRTAX-192T	GPRTTX-192T		GPRTPX-192T	GPRX-392T		GPRTPX-392T
3PDT	GPRX-193T	GPRTAX-193T	GPRTTX-193T		GPRTPX-193T	GPRX-393T		GPRTPX-393T
4PDT	GPRX-473T			GPRTSX-473T		GPRX-483T	GPRTSX-483T	

MODEL DOS RELAY

AC OR DC OPERATION—STOCK AND MADE-TO-ORDER

Model DOS

The Model DOS is a general purpose relay with a wide range of applications. It meets the rigorous standards for aircraft relays and industrial needs for a lightweight relay capable of handling loads demanded of much heavier relays. Contact and terminal carrying parts are molded panels of high grade phenolic material.



MODEL DOS

STOCK DOS RELAYS—15 Amp. Contacts*

Cat. No.	Type	Normal Position	COIL DATA Volts	Amps.	D.C. Ohms
Unenclosed					
DOSX-229T	SPST*	Open	6 VAC	.890	1.07
DOSX-230T	DPST	Open	6 VAC	.890	1.07
DOSX-30T	DPDT	—	6 VAC	.890	1.07
DOSX-16T	DPDT	—	12 VAC	.460	4.20
DOSX-231T	SPST*	Open	24 VAC	.269	15.5
DOSX-232T	DPST	Open	24 VAC	.269	15.5
DOSX-162T	DPDT	—	24 VAC	.269	15.5
DOSX-233T	SPST*	Open	115 VAC	.043	450
DOSX-234T	DPST	Open	115 VAC	.043	450
DOSX-7T	DPDT	—	115 VAC	.043	450
DOSX-235T	SPST*	Open	230 VAC	.030	1,450
DOSX-236T	DPST	Open	230 VAC	.030	1,450
DOSX-12T	DPDT	—	230 VAC	.030	1,450
DOSX-158T	DPDT	—	6 VDC	.450	13.4
DOSX-66T	DPDT	—	12 VDC	.210	56.2
DOSX-9T	DPDT	—	24 VDC	.105	230.0
DOSX-237T	SPST*	Open	110 VDC	.022	5,000
DOSX-238T	DPST	Open	110 VDC	.022	5,000
DOSX-59T	DPDT	—	110 VDC	.022	5,000
DOSX-177T	DPDT	—	220 VDC	.013	16,400
With Plug Base**					
DOSPX-1T‡	DPDT	—	115 VAC	.043	450
With Dust Covers**					
DOSEPX-5T‡	DPDT	—	115 VAC	.043	450
In Hermetic Enclosure**					
①DOSHX-40T	DPDT	—	115 VAC	.043	450
②DOSHPX-47T‡	DPDT	—	115 VAC	.043	450
①DOSHX-39T	DPDT	—	110 VDC	.022	5,000
②DOSPHX-46T‡	DPDT	—	110 VDC	.022	5,000

*Except double break contacts—25 amps resistive.
**See text above for pages listing dimensions. Weights: 8 oz. each approx.
‡See right for plug wiring.
①In DOSH style 2 enclosure. ②In DOSHP style 3 enclosure.

Coil Wattage: Normally rated at 2.5 watts for DC operation with a temperature rise not exceeding 45°C. For AC operation, the rating is 3 watts with a temperature rise not exceeding 65°C. Lower wattages are available.

Coil Operating Voltage Range: Coils can be supplied to operate on any voltage up to 220 VDC or 440 VAC 60 cycles. Stock voltages are shown in table.

Insulation: Tested at 1500 VAC.

Contact Combination: Maximum standard, DPDT.

Contact Rating: Nominal 15 amps for 115 VAC or 32 VDC resistive load (see stock table).

Weight: Approximately 4 ounces (114 grams).

Mounting Styles: Standard mounting, Style 1, with stop nuts, as illustrated. Other mountings available as listed. All holes are on same centers as Style 1.

Style 2—4 tapped holes #6-32
Style 3—4 holes .165 dia. (Clearance for #8 screw)
Style 4—4 holes .152 dia. (Clearance for #6 screw)
Style 5—2 holes .1875 dia. on 2¼" centers (permits mounting from front of panel).

Enclosed, Plug-In and Special Terminal DOS Relays: Hermetically sealed relays, DOSH and (plug-base) DOSHP (see stock listings left), Dust-Tight DOSC and (plug-base) DOSCP are described on page 22; Plug-base relay DOSP on page 21; Plug-base with dust-covers DOSEP, DOSTP on page 23; With special terminals, page 26.

DOSP

DOSEP

DOSTP

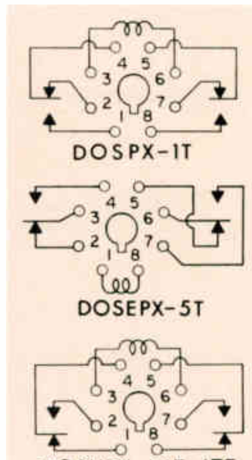
DOSH, DOSC (Style 1)

DOSH, DOSC (Style 2)

DOSHP, DOSCP (Style 1)

DOSHP, DOSCP (Style 3)

Mountings and Enclosures for DOS Relay



DOSPX-1T

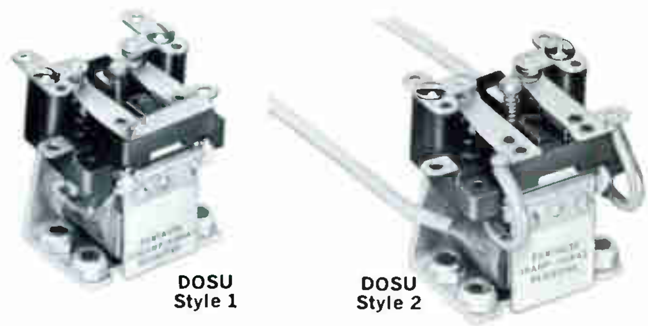
DOSEPX-5T

DOSHPX-46T, 47T

Plug Wiring for Stock Plug-Base DOS Relays

MODEL DOSU RELAY

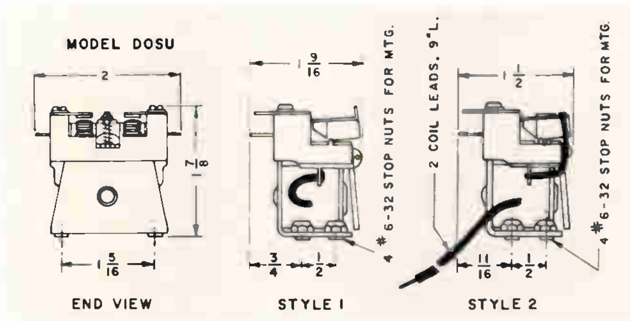
UL LISTED DOS—STOCK AND MADE-TO-ORDER



DOSU Style 1 DOSU Style 2

Ohmite DOS relays listed in the Underwriters' Laboratories Components Recognition Index (see definition page 9, "UL and CSA Listings") are designated "DOSU." Essentially, they are DOS types but incorporate a number of modifications. The modifications consist principally of different coil wrappings to satisfy UL insulation thickness and spacing requirements.

In all other respects—frame size, basic construction and configuration, mounting facilities, etc., DOSU and DOS relays are the same. Both series feature "molded panel" construction where the terminal and contact-carrying parts are panels of high grade phenolic plastic. Operating characteristics and ratings are the same except that Underwriters' Laboratories limits the operating voltage range to 110VDC or 115VAC. Both the DOS or DOSU families of relays have wide general purpose use, meeting industrial needs for a lightweight relay capable of handling the loads demanded of heavier models.



UL APPROVED DOS RELAYS — 15 AMP CONTACTS† — D.B. 22½ AMPS†

Listings in Tinted Areas are In Stock

AC COIL

Cat No.	Contacts	Normal Position	COIL DATA AC Volts	Amps.	DC Ohms	Style
DOSUX-1	SPST	Open	6	.890	1.07	2
DOSUX-2	SPST	Closed	6	.890	1.07	2
DOSUX-3	SPDT	—	6	.890	1.07	2
DOSUX-4	DPST	Open	6	.890	1.07	2
DOSUX-5	DPST	Closed	6	.890	1.07	2
DOSUX-6	DPDT	—	6	.890	1.07	2
DOSUX-7	SPST*	Open	6	.890	1.07	1
DOSUX-8	SPST*	Closed	6	.890	1.07	1
DOSUX-9	SPDT*	—	6	.890	1.07	1
DOSUX-10	SPST	Open	12	.460	4.20	2
DOSUX-11	SPST	Closed	12	.460	4.20	2
DOSUX-12	SPDT	—	12	.460	4.20	2
DOSUX-13	DPST	Open	12	.460	4.20	2
DOSUX-14	DPST	Closed	12	.460	4.20	2
DOSUX-15	DPDT	—	12	.460	4.20	2
DOSUX-16	SPST*	Open	12	.460	4.20	1
DOSUX-17	SPST*	Closed	12	.460	4.20	1
DOSUX-18	SPDT*	—	12	.460	4.20	1
DOSUX-19	SPST	Open	24	.269	15.5	2
DOSUX-20	SPST	Closed	24	.269	15.5	2
DOSUX-21	SPDT	—	24	.269	15.5	2
DOSUX-22	DPST	Open	24	.269	15.5	2
DOSUX-23	DPST	Closed	24	.269	15.5	2
DOSUX-24	DPDT	—	24	.269	15.5	2
DOSUX-25	SPST*	Open	24	.269	15.5	1
DOSUX-26	SPST*	Closed	24	.269	15.5	1
DOSUX-27	SPDT*	—	24	.269	15.5	1
DOSUX-28	SPST	Open	115	.043	450	2
DOSUX-29	SPST	Closed	115	.043	450	2
DOSUX-30	SPDT	—	115	.043	450	2
DOSUX-31	DPST	Open	115	.043	450	2
DOSUX-32	DPST	Closed	115	.043	450	2
DOSUX-33	DPDT	—	115	.043	450	2
DOSUX-34	SPST*	Open	115	.043	450	1
DOSUX-35	SPST*	Closed	115	.043	450	1
DOSUX-36	SPDT*	—	115	.043	450	1

DC COIL

Cat No.	Contacts	Normal Position	COIL DATA DC Volts	Amps.	DC Ohms	Style
DOSUX-37	SPST	Open	6	.450	13.4	2
DOSUX-38	SPST	Closed	6	.450	13.4	2
DOSUX-39	SPDT	—	6	.450	13.4	2
DOSUX-40	DPST	Open	6	.450	13.4	2
DOSUX-41	DPST	Closed	6	.450	13.4	2
DOSUX-42	DPDT	—	6	.450	13.4	2
DOSUX-43	SPST*	Open	6	.450	13.4	1
DOSUX-44	SPST*	Closed	6	.450	13.4	1
DOSUX-45	SPDT*	—	6	.450	13.4	1
DOSUX-46	SPST	Open	12	.210	56.2	2
DOSUX-47	SPST	Closed	12	.210	56.2	2
DOSUX-48	SPDT	—	12	.210	56.2	2
DOSUX-49	DPST	Open	12	.210	56.2	2
DOSUX-50	DPST	Closed	12	.210	56.2	2
DOSUX-51	DPDT	—	12	.210	56.2	2
DOSUX-52	SPST*	Open	12	.210	56.2	1
DOSUX-53	SPST*	Closed	12	.210	56.2	1
DOSUX-54	SPDT*	—	12	.210	56.2	1
DOSUX-55	SPST	Open	24	.105	230.0	2
DOSUX-56	SPST	Closed	24	.105	230.0	2
DOSUX-57	SPDT	—	24	.105	230.0	2
DOSUX-58	DPST	Open	24	.105	230.0	2
DOSUX-59	DPST	Closed	24	.105	230.0	2
DOSUX-60	DPDT	—	24	.105	230.0	2
DOSUX-61	SPST*	Open	24	.105	230.0	1
DOSUX-62	SPST*	Closed	24	.105	230.0	1
DOSUX-63	SPDT*	—	24	.105	230.0	1
DOSUX-64	SPST	Open	110	.022	500.0	2
DOSUX-65	SPST	Closed	110	.022	500.0	2
DOSUX-66	SPDT	—	110	.022	500.0	2
DOSUX-67	DPST	Open	110	.022	500.0	2
DOSUX-68	DPST	Closed	110	.022	500.0	2
DOSUX-69	DPDT	—	110	.022	500.0	2
DOSUX-70	SPST*	Open	110	.022	500.0	1
DOSUX-71	SPST*	Closed	110	.022	500.0	1
DOSUX-72	SPDT*	—	110	.022	500.0	1

*Double break contacts—22.5 amps. †Resistive.

MODEL DO RELAY

AC OR DC OPERATION—STOCK AND MADE-TO-ORDER

DO 3-Pole

The Model DO relay is similar to the Model DOS relay and has the same mounting dimensions. It offers a greater maximum contact combination (4PDT) and is particularly adaptable to aircraft and mobile equipment applications where severe shock and vibration may be encountered.

Coil Wattage: Rated at 3 watts for DC operation with a temperature rise not exceeding 45°C; for AC operation, the rating is 6 watts with a temperature rise not exceeding 75°C. Lower wattages are available.

Coil Operating Voltage Range: For any voltage up to 220 VDC or 440 VAC 60 cycle.

Insulation: Tested at 1500 VAC between all terminals and ground.

Contact Combination: Maximum standard combinations: 3PDT and 4PDT.

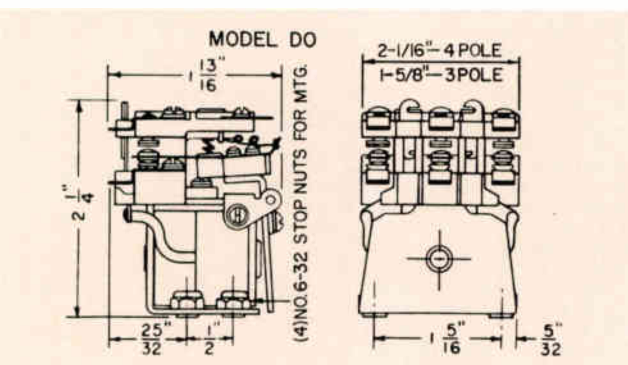
Contact Rating: Nominal 10 amps for 115 VAC or 32 VDC resistive load (see stock table).

Weight: For DO-3 pole approximately 5 ounces (140 grams); for DO-4 pole 6 ounces (168 grams).

Mounting Styles: Standard mounting, Style 1, with stop nuts as illustrated. Others below. Holes for Styles 2, 3 and 4 on same centers as Style 1.

Style 2—4 tapped holes #6-32
Style 3—4 holes .165 dia. (Clearance for #8 screw)
Style 4—4 holes .152 dia. (Clearance for #6 screw)
Style 5—2 holes .1875 dia. on 2¼" centers (permits mounting from front of panel).

Enclosed, Plug-In and Special Terminal DO Relays (Note listings in stock table at right): Hermetically Sealed Relays DOH and (plug-in type) DOHP, also dust-tight relays DOC and (plug-in type) DOCP on page 22; Plug mounted relay with dust cover DOEP on page 23; Plug mounted relay DOP on page 21; Binding-post terminal relay DOB, also DO relay with push-on (AMP style) and screw terminals are shown on page 26.

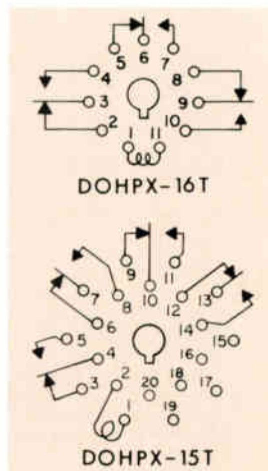


STOCK DO RELAYS—10 Amp. Contacts*

Cat. No.	Type	Normal Position	COIL DATA Volts	Amps.	D.C. Ohms
Unenclosed					
DOX-50T	3PDT	—	6 VAC	2.33	0.36
DOX-183T	4PDT	—	6 VAC	2.33	0.36
DOX-49T	3PDT	—	12 VAC	1.28	1.40
DOX-184T	4PDT	—	12 VAC	1.28	1.40
DOX-181T	3PDT	—	24 VAC	.57	5.50
DOX-185T	4PDT	—	24 VAC	.57	5.50
DOX-226T	DPST*	Open	115 VAC	.110	145.0
DOX-227T	3PST	Open	115 VAC	.110	145.0
DOX-46T	3PDT	—	115 VAC	.110	145.0
DOX-228T	4PST	Open	115 VAC	.110	145.0
DOX-53T	4PDT	—	115 VAC	.110	145.0
DOX-61T	3PDT	—	230 VAC	.070	550.0
DOX-130T	4PDT	—	230 VAC	.070	550.0
DOX-145T	3PDT	—	6 VDC	.487	12.3
DOX-186T	4PDT	—	6 VDC	.487	12.3
DOX-51T	3PDT	—	12 VDC	.231	51.8
DOX-102T	4PDT	—	12 VDC	.231	51.8
DOX-141T	3PDT	—	24 VDC	.105	230.0
DOX-137T	4PDT	—	24 VDC	.105	230.0
DOX-93T	3PDT	—	110 VDC	.022	5,000
DOX-187T	4PDT	—	110 VDC	.022	5,000
DOX-182T	3PDT	—	220 VDC	.014	16,100
DOX-188T	4PDT	—	220 VDC	.014	16,100
In Hermetic Enclosure**					
①DOHPX-16T‡	3PDT	—	115 VAC	.110	145.0
①DOHPX-15T‡	4PDT	—	115 VAC	.110	145.0
②DOHX-22T	3PDT	—	115 VAC	.110	145.0
②DOHX-23T	4PDT	—	115 VAC	.110	145.0

*Except double break contacts—20 amps. **See text above for pages listing dimensions. Weights: 3-pole hermetic relay approx. 14 oz.; 4-pole approx. 15 oz. ‡See below for plug wiring. Plug base for DOHPX-16T mates with Amphenol 77MIP-11 socket. Plug base for DOHPX-15T mates with Amphenol 77MIP20 socket. ①In DOHP enclosure. ②In DOH enclosure.

Mountings and Enclosures for DO Relay



Wiring for Plug-Base Stock DO Relays

MODEL DOU RELAY

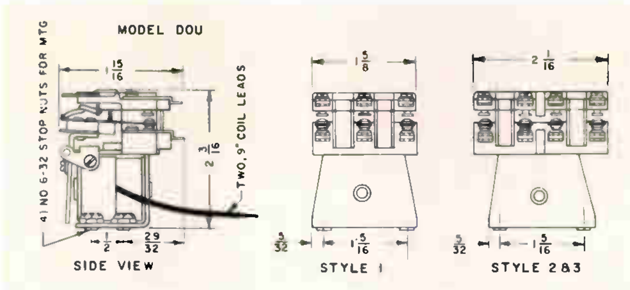
UL LISTED DO—STOCK AND MADE-TO-ORDER

OHMITE

DOU—Style 1 Style 2 Style 3

Model "DO" relays listed in the Underwriters' Laboratories Components Recognition Index (see definition page 9, "UL and CSA Listings") are designated "DOU." Essentially, they are "DO" types but incorporate a number of modifications which consist principally of different terminals, addition of flexible coil leads and different coil wrappings to satisfy UL insulation thickness requirements.

In all other respects—frame size, basic construction and configuration, mounting facilities, etc., DOU and DO relays are the same. Both series feature "molded panel" construction where the terminal and contact-carrying parts are panels of high grade phenolic plastic. Operating characteristics are also the same except that UL limits operating voltage to 220VDC or 230VAC.



UL APPROVED DO RELAYS — 10 AMP CONTACTS† — D.B. 20 AMP*

Listings in Tinted Areas are In Stock

AC COIL

Cat. No.	Contacts	Normal Position	COIL DATA AC Volts	Amps.	DC Ohms	Style
DOUX-1	3PST	Open	6	2.33	0.36	1
DOUX-2	3PST	Closed	6	2.33	0.36	1
DOUX-3	3PDT	—	6	2.33	0.36	1
DOUX-4	4PST	Open	6	2.33	0.36	2
DOUX-5	4PST	Closed	6	2.33	0.36	2
DOUX-6	4PDT	—	6	2.33	0.36	2
DOUX-7	DPST*	Open	6	2.33	0.36	3
DOUX-8	DPST*	Closed	6	2.33	0.36	3
DOUX-9	DPDT*	—	6	2.33	0.36	3
DOUX-10	3PST	Open	12	1.28	1.40	1
DOUX-11	3PST	Closed	12	1.28	1.40	1
DOUX-12	3PDT	—	12	1.28	1.40	1
DOUX-13	4PST	Open	12	1.28	1.40	2
DOUX-14	4PST	Closed	12	1.28	1.40	2
DOUX-15	4PDT	—	12	1.28	1.40	2
DOUX-16	DPST*	Open	12	1.28	1.40	3
DOUX-17	DPST*	Closed	12	1.28	1.40	3
DOUX-18	DPDT*	—	12	1.28	1.40	3
DOUX-19	3PST	Open	24	.57	5.50	1
DOUX-20	3PST	Closed	24	.57	5.50	1
DOUX-21	3PDT	—	24	.57	5.50	1
DOUX-22	4PST	Open	24	.57	5.50	2
DOUX-23	4PST	Closed	24	.57	5.50	2
DOUX-24	4PDT	—	24	.57	5.50	2
DOUX-25	DPST*	Open	24	.57	5.50	3
DOUX-26	DPST*	Closed	24	.57	5.50	3
DOUX-27	DPDT*	—	24	.57	5.50	3
DOUX-28	3PST	Open	115	.110	145	1
DOUX-29	3PST	Closed	115	.110	145	1
DOUX-30	3PDT	—	115	.110	145	1
DOUX-31	4PST	Open	115	.110	145	2
DOUX-32	4PST	Closed	115	.110	145	2
DOUX-33	4PDT	—	115	.110	145	2
DOUX-34	DPST*	Open	115	.110	145	3
DOUX-35	DPST*	Closed	115	.110	145	3
DOUX-36	DPDT*	—	115	.110	145	3
DOUX-37	3PST	Open	230	.070	550	1
DOUX-38	3PST	Closed	230	.070	550	1
DOUX-39	3PDT	—	230	.070	550	1
DOUX-40	4PST	Open	230	.070	550	2
DOUX-41	4PST	Closed	230	.070	550	2
DOUX-42	4PDT	—	230	.070	550	2
DOUX-43	DPST*	Open	230	.070	550	3
DOUX-44	DPST*	Closed	230	.070	550	3
DOUX-45	DPDT*	—	230	.070	550	3

*Double break contacts—20 amps resistive.

DC COIL

Cat. No.	Contacts	Normal Position	COIL DATA DC Volts	Amps.	DC Ohms	Style
DOUX-46	3PST	Open	6	.487	12.3	1
DOUX-47	3PST	Closed	6	.487	12.3	1
DOUX-48	3PDT	—	6	.487	12.3	1
DOUX-49	4PST	Open	6	.487	12.3	2
DOUX-50	4PST	Closed	6	.487	12.3	2
DOUX-51	4PDT	—	6	.487	12.3	2
DOUX-52	DPST*	Open	6	.487	12.3	3
DOUX-53	DPST*	Closed	6	.487	12.3	3
DOUX-54	DPDT*	—	6	.487	12.3	3
DOUX-55	3PST	Open	12	.231	51.8	1
DOUX-56	3PST	Closed	12	.231	51.8	1
DOUX-57	3PDT	—	12	.231	51.8	1
DOUX-58	4PST	Open	12	.231	51.8	2
DOUX-59	4PST	Closed	12	.231	51.8	2
DOUX-60	4PDT	—	12	.231	51.8	2
DOUX-61	DPST*	Open	12	.231	51.8	3
DOUX-62	DPST*	Closed	12	.231	51.8	3
DOUX-63	DPDT*	—	12	.231	51.8	3
DOUX-64	3PST	Open	24	.105	230	1
DOUX-65	3PST	Closed	24	.105	230	1
DOUX-66	3PDT	—	24	.105	230	1
DOUX-67	4PST	Open	24	.105	230	2
DOUX-68	4PST	Closed	24	.105	230	2
DOUX-69	4PDT	—	24	.105	230	2
DOUX-70	DPST*	Open	24	.105	230	3
DOUX-71	DPST*	Closed	24	.105	230	3
DOUX-72	DPDT*	—	24	.105	230	3
DOUX-73	3PST	Open	110	.022	5000	1
DOUX-74	3PST	Closed	110	.022	5000	1
DOUX-75	3PDT	—	110	.022	5000	1
DOUX-76	4PST	Open	110	.022	5000	2
DOUX-77	4PST	Closed	110	.022	5000	2
DOUX-78	4PDT	—	110	.022	5000	2
DOUX-79	DPST*	Open	110	.022	5000	3
DOUX-80	DPST*	Closed	110	.022	5000	3
DOUX-81	DPDT*	—	110	.022	5000	3
DOUX-82	3PST	Open	220	.014	16100	1
DOUX-83	3PST	Closed	220	.014	16100	1
DOUX-84	3PDT	—	220	.014	16100	1
DOUX-85	4PST	Open	220	.014	16100	2
DOUX-86	4PST	Closed	220	.014	16100	2
DOUX-87	4PDT	—	220	.014	16100	2
DOUX-88	DPST*	Open	220	.014	16100	3
DOUX-89	DPST*	Closed	220	.014	16100	3
DOUX-90	DPDT*	—	220	.014	16100	3

†Resistive. On 3-pole relays, rating can be 5 amps at 230 VAC.

MODEL DOSY RELAY

DC OPERATION—STOCK AND MADE-TO-ORDER

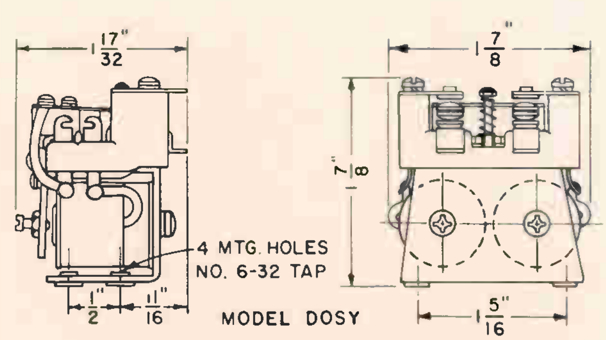
Model DOSY

The Model DOSY relay is similar to the Model DOS relay in construction with the exception that the DOSY relay is equipped with twin coils. This two coil design increases the magnetic efficiency (sensitivity) of the relay by permitting a greater number of ampere-turns. This increased operating sensitivity makes the DOSY adaptable to a wide range of electronic control circuits, such as plate circuit controls or as underload or overload controls in DC circuits to signal attainment of predetermined current levels.

Coil Wattage: The operating coil is normally rated at 1.00 watt for DC operation with a temperature rise not exceeding 45°C. Lower wattages are available on special designs.

Coil Operating Voltage Range: Coils can be supplied to operate on any voltage up to 150 VDC.

Insulation: Tested at 1500 VAC between all terminals and ground.



TYPICAL OPERATING DATA
FOR DC OPERATION

DC Voltage	Total Ohms Resistance for Both Coils	Current Amperes
6	35.6	.170
12	138.0	.087
24	540.0	.045
48	2260.0	.022
110	13600.0	.0081

Contact Combination: Maximum standard contact combination double-pole, double-throw; other combinations available upon request, and as per table.

Contact Rating: 15 amperes at 115 VAC or 32 VDC resistive load.

Weight: Approximately 4½ ounces (128 grams).

Mounting Styles: Standard mounting is shown in dimension diagram. An optional style provides two .1875 dia. holes on 2¼" centers—permits mounting of relay from front of panel.

STOCK DOSY RELAYS

Cat. No.	Type	COIL DATA D.C. Ohms	COIL DATA Max. Pull-in Current	Contact Amps.
DOSYX-67T	DPDT	10,000	8 MA	15
DOSYX-68T	DPDT	5,000	11 MA	15
DOSYX-69T	SPDT	10,000	5 MA	15
DOSYX-70T	SPDT	5,000	7 MA	15

Plug-In, Enclosed and Special Terminal DOSY Relays: Plug-in type relay DOSYP is described on page 21; Hermetically sealed relays DOSYH and DOSYHP (plug-in type), and dust tight relays DOSYC and DOSYCP (plug-in type) on page 22; DOSY relays with push-on (AMP style) or screw terminals are described on page 26.

DOSYP

DOSYEP

DOSYH, DOSYC (Style 1)

DOSYH, DOSYC (Style 2)

DOSYHP, DOSYCP (Style 1)

DOSYHP, DOSYCP (Style 3)

Mountings and Enclosures for DOSY Relay

MODEL DOY RELAY

DC OPERATION—MADE-TO-ORDER

OHMITE

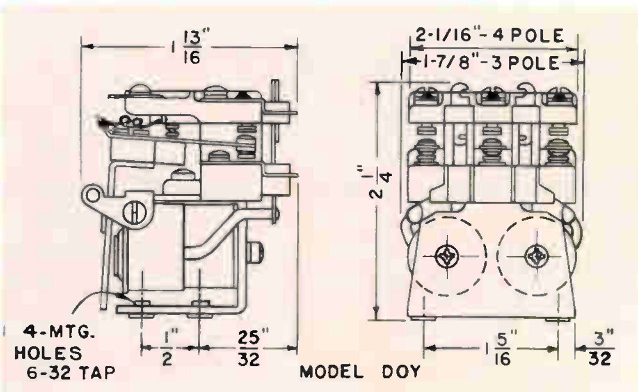
The Model DOY relay is similar to the Model DO relay in construction with the exception that the DOY relay is equipped with twin coils. This two coil design increases the magnetic efficiency (sensitivity) of the relay by permitting a greater number of ampere-turns. The consequent low power requirement coupled with the high load carrying capacity, makes this relay adaptable to a wide variety of industrial applications. It is useful, particularly in electronic circuits as a plate circuit relay, where multiple contact combinations are required.

Coil Wattage: The Model DOY relay is available only for DC operation. The operating coils are normally rated at 1.5 watts DC with a temperature rise not exceeding 45°C. Lower wattages are available on special designs.

Coil Operating Voltage Range: Coils can be supplied for any voltage up to 175 VDC.

Insulation: Tested at 1500 VAC between all terminals and ground.

Contact Combination: Maximum standard contact combination is four-pole, double-throw for the four-pole relay; three-pole, double-throw for the three-pole relay; other combinations available, upon request.



TYPICAL OPERATING DATA
FOR DC OPERATION

DC Voltage	Resistance Ohms	Current Amperes
6	26	.230
12	100	.120
24	380	.063
48	1,380	.035
110	10,000	.011

DOY 3-Pole;

DOY 4-Pole

Contact Rating: 10 amperes at 115 VAC or 32 VDC resistive load.

Mounting Styles: Standard mounting is shown in dimension diagram. An optional style provides two .1875 dia. holes on $2\frac{1}{4}''$ centers—permits mounting of relay from front of panel.

Weight: Approximately 8 ounces (227 grams) for 4-pole relay.

Plug-In, Enclosed and Special Terminal DOY Relays: Plug-In relay DOYP described on page 21; Plug-in type with dust cover DOYEP on page 23; Hermetically sealed relays DOYH and (plug-in type) DOYHP and dust tight relays DOYC and DOYCP (plug-in type) on page 22; DOY relays with push-on (AMP style) terminals and screw terminals on page 26.

DOYP

DOYEP

DOYH
DOYC

DOYHP
DOYCP

Mountings and Enclosures for DOY Relay

MODEL TT RELAY

DC OPERATION—MADE-TO-ORDER

TT-DPDT

TT-4PDT

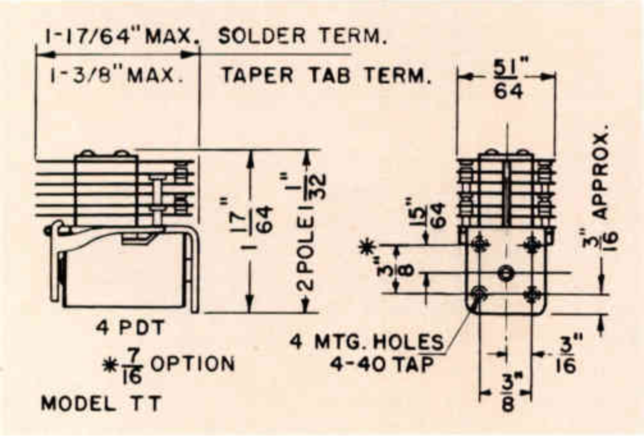
Exceptional sensitivity for a relay of its small size is achieved in the Model TT relay, a high quality miniature telephone type unit. It finds wide application in aircraft as well as in numerous industrial uses (also see Model TS next page). Sensitive performance is the result of several unique design features (described under Model TS Relay, next page).

Military Applications: Model TT relay has been designed to meet the requirements of relay specification MIL-R-5757C (Class A and B) and can be furnished for operation in ambients up to +125°C. Hermetically sealed enclosures for military use are also available—see below.

Coil Wattage: The operating coil is rated nominally at .150 watts per pole at an ambient temperature of +20°C.

Coil Operating Voltage Range: Coils can be provided for operation up to 120 volts DC.

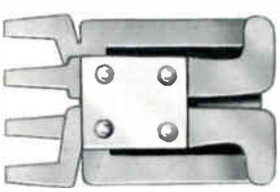
Insulation: Tested at 1000 volts AC between all terminals and ground. Relays intended for operation in ambients up to +85°C are equipped with nylon bobbins. Those intended for operation in ambients up to +125°C are equipped with Kel-F bobbins.



Contact Combinations: Maximum standard combination is 4PDT. Other combinations available on request.

Contact Ratings: Up to 5 amperes at 115 volts AC or 32 volts DC resistive, with standard contact material, palladium. Other materials can be supplied.

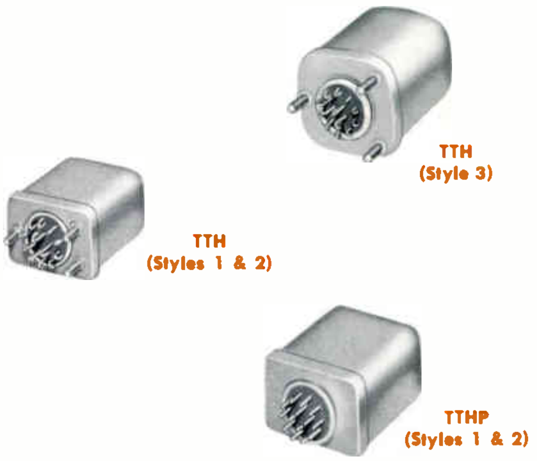
Terminals: Solder terminals are standard. Taper-tab terminals to receive "AMP 78" push-on type female connectors can be furnished upon request.



Taper Tab Terminals

Weight: Approximately 2 ounces for 4PDT unit.

Enclosed TT Relays: Hermetically sealed relays TTH and (plug-in type) TTHP are described on page 23.



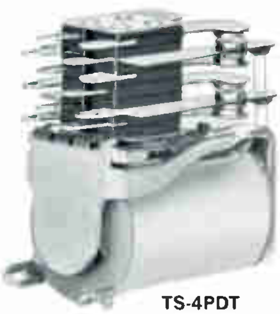
Enclosures for TT Relay

MODEL TS RELAY

DC OPERATION—MADE-TO-ORDER

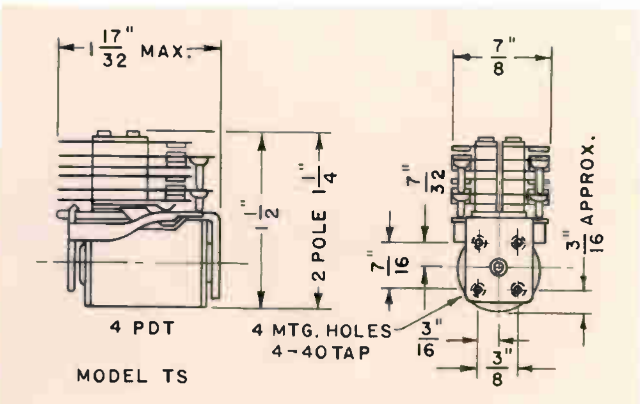
OHMITE

TS-DPDT



TS-4PDT

The Model TS relay is essentially the same type of high quality telephone type unit as Model TT described on the preceding page except that it is somewhat larger and is designed to transfer heavier currents. Like its smaller counterpart, the Model TS relay is exceptionally sensitive for its size and is widely used in aircraft as well as industrial control applications. Sensitive performance is the result of several design features, notable among which is the design of the armature retaining guard which minimizes undesirable heel gap. The resulting manner of assembly, makes it possible to use a staked-in polepiece thereby eliminating an undesirable gap between the frame and polepiece.



Military Applications: Model TS relay has been designed to meet the requirements of relay specification MIL-R-6106C and can be furnished to operate in ambient temperatures up to 125°C. Hermetically sealed enclosures for military use are available—see below.

Coil Wattage: The operating coil is rated nominally at .250 watts per pole at an ambient temperature of +20°C.

Coil Operating Voltage Range: Coils can be provided for operation up to 220 volts DC.

Insulation: Tested at 1000 volts AC between all terminals and ground. Relays intended for operation in ambient temperatures up to 85°C are equipped with nylon bobbins. Those designed for operation in ambients of +125°C are equipped with Kel-F bobbins.

Contact Combinations: Maximum standard combination is 4PDT. Other combinations available on request.

Contact Ratings: Up to 10 amperes at 115 volts AC or 32 volts DC resistive with standard contact material, silver-cadmium oxide. Other contact materials can be supplied.

Weight: Approximately 3 ounces for 4PDT unit.

Enclosed TS Relays: Hermetically sealed relays TSH and (plug-in type) TSHP are described on page 23. Enclosures with AN-type connectors can also be furnished.

TSH (Style 1)

TSH (Styles 2 & 3)

TSHP (Style 1)

TSHP (Styles 2 & 3)

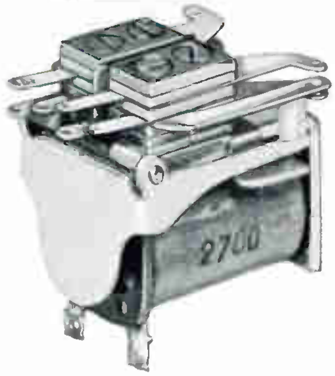
AN-Style

AN-Style

Enclosures for TS Relay

MODEL TKL RELAY

DC OPERATION—MADE-TO-ORDER



TKL-2PDT

TKL-4PDT

Model TKL is a miniature telephone type relay and was designed originally for aircraft control applications. It has high resistance to shock and vibration and finds its widest use when multiple circuit control of small currents is required in a limited space.

Coil Wattage: The operating coil is nominally rated at 1.25 watts DC with a temperature rise not exceeding 45°C. Lower wattages are available.

Coil Operating Voltage Range: Coils can be supplied to operate at any voltage up to 140 VDC.

Insulation: Tested at 750 VAC between all terminals and ground. Special insulation requirements can be met by the use of Mycalex spacers when specified.

Contact Combination: Maximum standard contact combination, four-pole, double-throw; other combinations available upon request.

Contact Rating: 1 ampere at 115 VAC or 32 VDC resistive loads. Contacts with ratings up to 3 amperes are available.

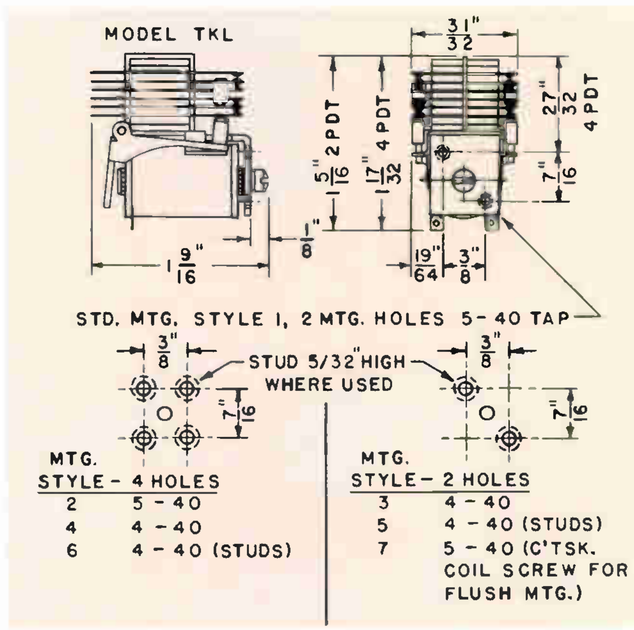
TYPICAL OPERATING DATA
FOR DC OPERATION

DC Voltage	Resistance Ohms	Current Amperes
6	23.6	.26
12	94.0	.128
24	300.0	.080
48	2,080.0	.023
110	10,000.0	.011

Weight: Approximately $1\frac{3}{4}$ ounces, for 4-pole double-throw unit.

Mounting Styles: The frames can be supplied with tapped holes or studs, as shown, instead of the Style 1 mounting which is standard (see below). Styles 1, 2, 3 and 4 require a $\frac{1}{4}$″ dia. clearance hole in the mounting support for the head of the core screw.

Enclosed TKL Relays: Plug-in type relay with dust cover, TKLEP, described on page 23; Hermetically sealed relays TKLH and (plug-in type) TKLHP, also dust tight relays TKLC and (plug-in type) TKLCP, all described on page 22.



TKLEP

TKLH
TKLC
(Style 1)

TKLH
TKLC
(Style 2)

TKLHP
TKLCP
(Style 1)

TKLHP
TKLCP
(Style 2)

Enclosures for TKL Relay

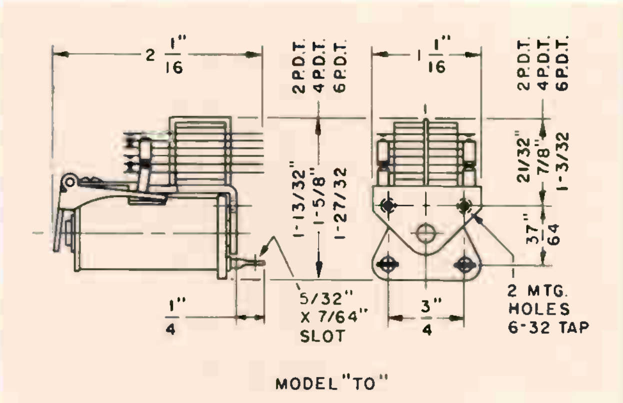
MODEL TO RELAY

DC OPERATION—MADE-TO-ORDER

OHMITE

TO Relay
Terminal End

TO Relay
Armature End



The longer coil of Ohmite's new Model TO relay provides increased operating sensitivity as compared to the Model TKL (miniature telephone type) to which it is similar. Operating voltage range of the Model TO is greater and it can carry a greater number of contacts. The relay features a mounting similar to the standard long telephone types; i.e., terminals project at the mounting end for typical chassis assembly. Model TO incorporates the time-proven hinge-pin armature construction and a staked-in polepiece which eliminates the undesirable air-gap between polepiece and frame, and thereby increases sensitivity.

Coil Wattage: 100 milliwatts per pole at an ambient temperature of 20° C.

Coil Operating Voltage Range: Up to 260 volts DC.

Insulation: Laminated phenolic . . . Tested at 750 volts AC between all terminals and ground. Mycalex insulation can be supplied for special requirements.

Contact Combination: Maximum standard contact combination is six-pole, double-throw.

Contact Rating: 3 amperes at 115 VAC or 32 VDC, resistive with standard palladium contacts. Contacts with ratings up to 5 amperes are available.

Coil Resistance: Maximum resistance is 20,000 ohms.

Weight: Approximately 3.5 ounces for 4PDT unit.

Enclosures: Write for complete information on hermetically sealed or dust-tight enclosures for Model TO relay.

MODEL CR, QC RELAYS

MADE-TO-ORDER

Model CR

MODEL CR RELAY—AC or DC OPERATION

A small, positive action unit with single-pole, single-throw, double-break, normally open or normally closed contacts having high load capacity. Contacts can be supplied as double-pole, single-throw, normally open.

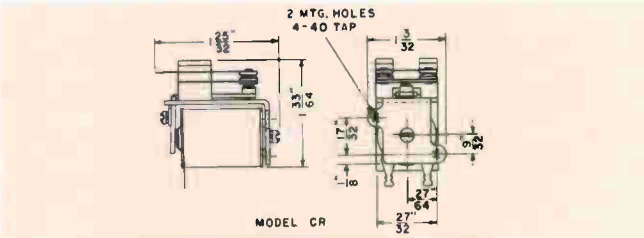
Coil Wattage: 2.75 watts DC with temperature rise not exceeding 45° C; 5.6 watts 60 cycle AC with temperature rise not exceeding 75° C. Lower wattages available.

Coil Operating Voltage Range: Any voltage up to 240 VDC or 440 VAC at 60 cycles.

Insulation: Tested at 1000 VAC.

Contact Combination & Rating: For SPST-N.O. or N.C., double break—15 amperes at 115 VAC or 32 VDC resistive load; for DPST-N.O.—7.5 amperes.

Weight: Approximately 3 ounces (84 grams).



Plug-In, Enclosed and Snap-Switch CR Relays: Plug-in relay CRP described on page 21; Hermetically sealed relay CRH and dust tight CRC on page 22; Snap-switch type CRSA on page 27. See Guide, page 5, for illustrations of enclosures.

TYPICAL OPERATING DATA					
FOR 60 CYCLE AC			FOR DC		
AC Voltage	DC Resistance Ohms	Current Amperes	DC Voltage	DC Resistance Ohms	Current Amperes
6	1.0	1.20	6	15.2	.40
12	4.2	.60	12	63.4	.20
24	15.7	.38	24	238.0	.10
48	61.7	.19	48	858.0	.056
115	380.0	.075	110	5,100.0	.022
230	1,420.0	.046	230	20,600.0	.011

Model QC

MODEL QC RELAY—AC or DC OPERATION

The Model QC relay may be considered a miniature contactor for industrial applications. The contact arms carry screw type terminals.

Coil Wattage: 2.75 watts DC with temperature rise not exceeding 45° C; 5.6 watts AC with temperature rise not exceeding 75° C.

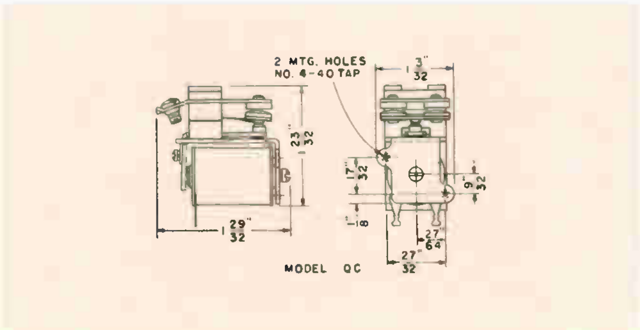
Coil Operating Voltage Range: To any voltage up to 240 VDC or 440 VAC, 60 cycle.

Insulation: Tested at 1000 VAC.

Contact Combination: Single-pole, single-throw, normally open, double break.

Contact Rating: 25 amperes at 115 VAC or 32 VDC resistive loads.

Weight: Approximately 3 ounces (84 grams).

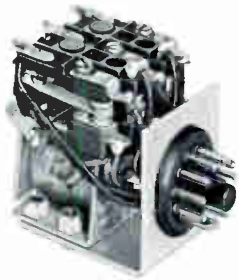


TYPICAL OPERATING DATA					
FOR 60 CYCLE AC			FOR DC		
AC Voltage	DC Resistance Ohms	Current Amperes	DC Voltage	DC Resistance Ohms	Current Amperes
6	1.0	1.20	6	15.2	.40
12	4.2	.60	12	63.4	.20
24	15.7	.38	24	238.0	.10
48	61.7	.19	48	858.0	.056
115	380.0	.075	110	5,100.0	.022
230	1,420.0	.046	230	20,600.0	.011

RELAYS WITH PLUG-IN MOUNTING

OHMITE

DOYP



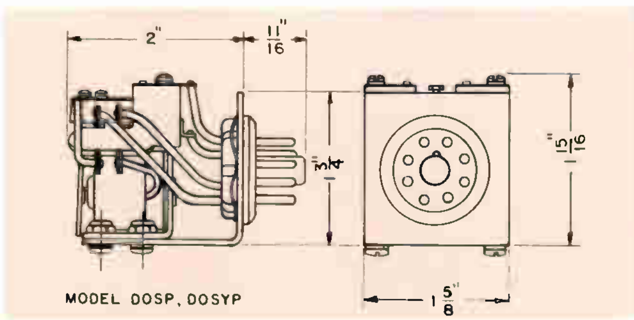
DOP

DOSYP

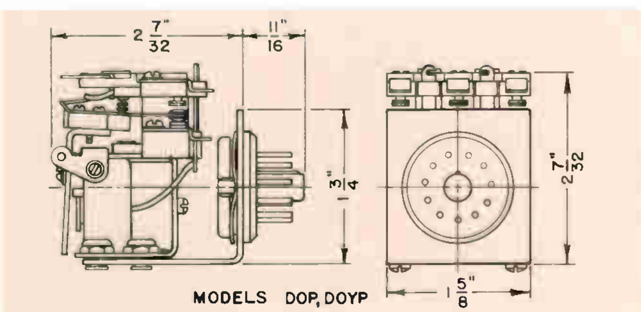
DOSP

CRP

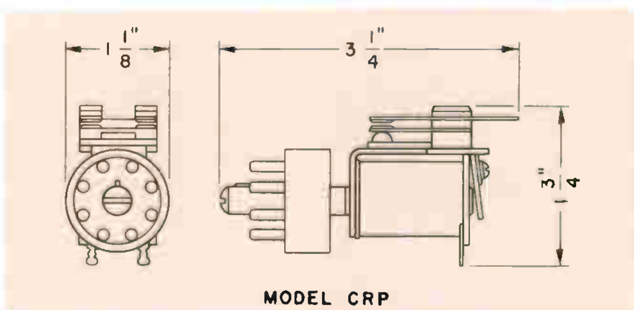
Plug mountings make for virtually effortless replacement of components, and standard Ohmite relays such as DOS, DOSY, DO, DOY and CR can be furnished on plug bases. Where plug mounting is supplied, the suffix "P" is added to the basic model code as in "DOSP" (basic relay DOS). Operating data for these plug-mounted relays is the same as for unmounted relays. See basic relay descriptions for data. Illustrations below give pertinent dimensional data for these units.



Models DOSP and DOSYP: Octal plug standard—allows for DPDT contacts maximum. Mountings for DOSP and DOSYP are identical.



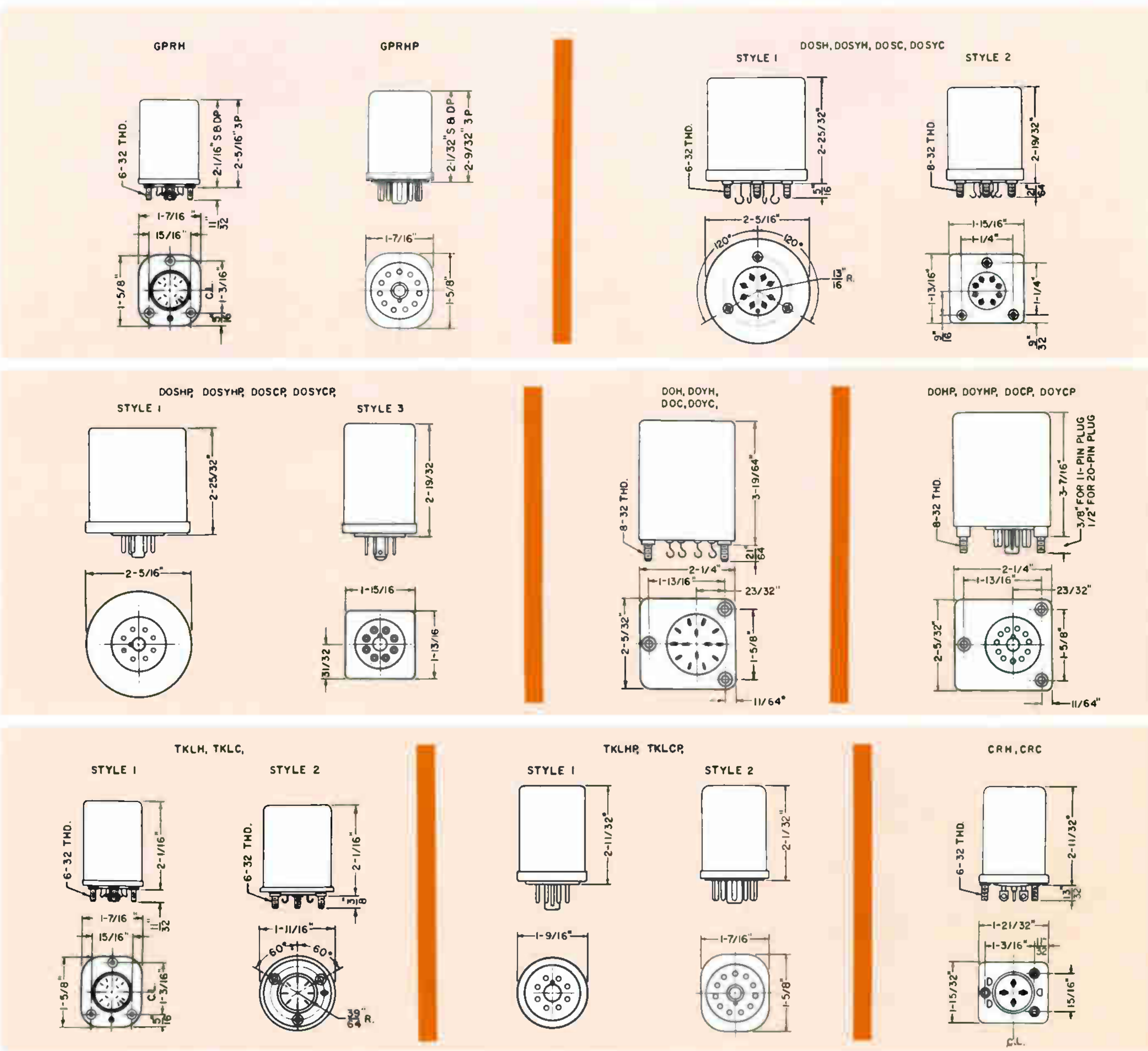
Models DOP and DOYP: Style No. 1 uses an 11 pin, octal style plug; Style No. 2 uses Howard B. Jones industrial plug. Number of pins will be varied to suit specified contact combination.



Model CRP: Octal plug is standard—allows for SPST-N.O. double break contacts.

Hermetically Sealed Relays, protected from ambient conditions have become important to industry and particularly to the Armed Forces where components are called upon for unfailing operation under the most adverse conditions. These non-removable enclosures are exhausted and filled with dry nitrogen or other gas. A trace of helium is added to the gas so that leakage tests can be made by means of the mass spectrometer—the most sensitive device available for this purpose. Ohmite supplies many of its basic relays in hermetically sealed enclosures as illustrated in the Selection Guide and individual relay descriptions. Dimensions for the enclosures are shown below.

Ohmite relays available in hermetically sealed enclosures carry different model designations i.e., letter suffixes are added to the basic relay model depending upon the type of enclosure. Thus, hermetically sealed relays with solder terminal "headers" carry the suffix "H" as in "DOSH" (basic relay DOS). Hermetically sealed relays with plug-in type headers carry the suffix "HP" as in "DOSHP". Where more than one design or size of enclosure is available, it is also distinguished by a "style" number as shown below. For operating data concerning these relays, refer to basic model descriptions in the preceding pages. *Stock hermetically sealed relays are listed on pages for DOS and DO relays. Enclosures other than those shown here can be supplied to order.*



Dimensions of Hermetically Sealed and Dust Tight Enclosures

DUST TIGHT RELAYS

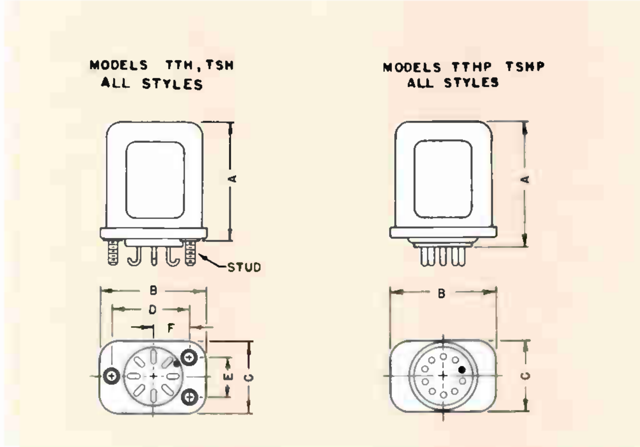
OHMITE

Dust tight relays employ non-removable enclosures identical with the hermetically sealed types except for the absence of a solder seal and the omission of evacuation and gas filling. The suffixes that designate relays so enclosed are "C" for the solder terminal type of enclosure as in "DOSC" (DOS basic relay) and "CP" for the plug-in type of dust tight enclosure as in "DOSCP". Dust tight relays have the same dimensions as their hermetically sealed counterparts and the drawings below consequently carry both model designations.

Terminals and Headers: The number of solder terminals or pins in the headers of hermetically sealed or dust-tight units is varied to fit the size of the relay contact combination.

Finish: Enclosures have a durable, light grey finish. The circuit diagram is printed on each can or provided on drawings where small quantities are involved.

Military Enclosures: Hermetically sealed units in AN-type enclosures and/or with AN-type connectors can be provided.



Dimensions of Hermetic Enclosures for TT and TS Relays

MODEL TTH									
Contact Comb.	Style Enc.	A	B	C	D	E	F	Studs	Term.
1 C or 2 C	1	1 21/32	1 21/64	15/16	1	1/2	15/32	21/64 x 4-40	8
3 C or 4 C	2	1 21/32	1 27/64	1	1	1/2	15/32	21/64 x 4-40	14
3 C or 4 C	3*	2 1/32	1 5/8	1 7/16	1 3/16	15/16	1/2	3/8 x 6-32	14

*Same as enclosure used for AN3304-1

MODEL TTHP					
Contact Comb.	Style Enc.	A	B	C	Pins
1 C or 2 C	1	1 23/32	1 21/64	15/16	7 & 9 Resp.
3 C or 4 C	2	1 23/32	1 27/64	1	14

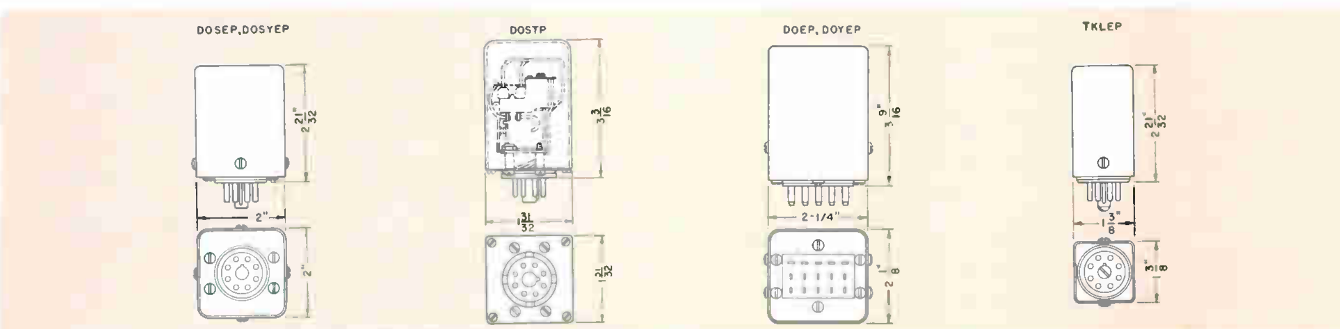
MODEL TSH									
1 C or 2 C	1	2 1/32	1 21/32	1 15/32	1 3/16	15/16	31/64	13/32 x 6-32	8
3 C or 4 C	2	2 1/8	2 7/64	1 19/32	1 5/8	1	13/16	13/32 x 6-32	14

MODEL TSHP					
1 C or 2 C	1	2	1 5/8	1 7/16	8
3 C or 4 C	2	2 3/32	2 7/64	1 19/32	14

PLUG MOUNTED RELAYS WITH DUST COVER

Ohmite relays equipped with plug base and removable covers. Covers are attached with screws. Metal (drawn aluminum) covers are indicated by the suffix "EP" as in "DOSEP" (for DOS relay). A transparent enclosure is shown (below) only for the DOS relay* and is indicated by the suffix "TP." *Important: Highly versatile transparent enclosures for GPR type relays are described on page 6.* **PLUGS**—All enclosures described below incorporate a standard octal plug termination except enclosures for DOEP or DOYEP which feature a 15 prong Jones Industrial Plug. For 3-pole, double-throw combinations, DOEP or DOYEP can be provided with an 11-point, octal-style plug.

*Contacts of the DOSTP relay are rated at 15 amperes also, provided the switching rate does not exceed one per minute. Contacts should be derated to 10 amperes when the switching rate is more than 1 and not more than 4 per minute.

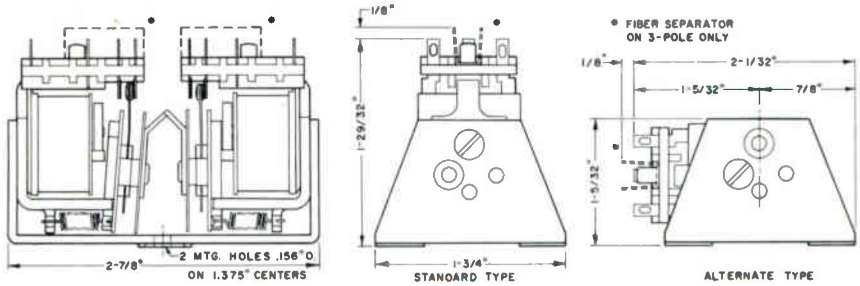


Dimensions of Plug-Mounted Relays with Dust Covers

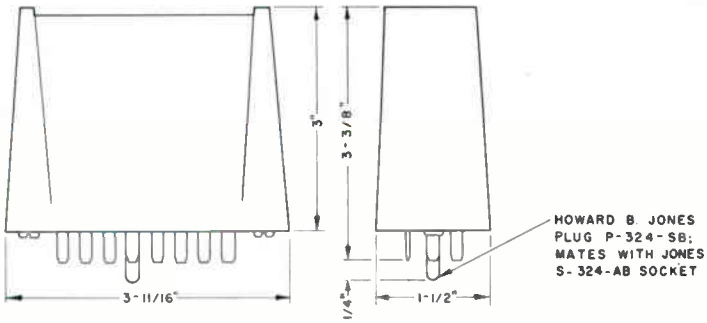
LATCHING RELAYS– ELECTRICAL RESET

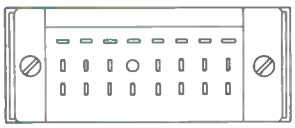
MODELS GPRLE, GPRLETP

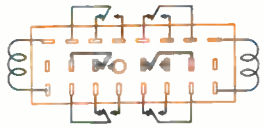
6PDT Latching Relay (GPRLE)



Dimensions — Unenclosed Latching Relay (GPRLE)
("Standard" configuration is furnished on stock units)







PLUG WIRING FOR 6PDT, GPRLETP RELAY. ON 4PDT, TERMINALS IN GREY AREA WOULD NOT BE WIRED.

Enclosed Latching Relay (GPRLETP)

◀ Dimensions — Enclosed Latching Relay (GPRLETP)

Latching relays consisting of two GPR relays, each with any number of contacts up to the maximum (3PDT). The armatures of both relays are so linked that the normally open contacts of one relay are mechanically latched in the closed position when the relay is energized. It remains latched even after the energizing current is removed until the other relay is energized. The second relay remains closed after de-energizing until the first relay is pulsed again. GPR latching relays thus make it possible to switch up to 6 circuits and hold for long periods without continuous relay coil current and with resetting accomplished remotely. Coils of AC Latching Relays are rated 3.7 volt-amperes. Operating characteristics are otherwise as described on page 6.

"GPRLETP" Enclosed, Plug-Base Type: This is the same relay assembly as the unenclosed GPRLE described above but supplied in a clear plastic enclosure with a Jones P-324-SB Plug. See stock tables.

UL and CSA Approval: GPR latching relays (except for 230 VAC ratings) are listed in the UL "Components Recognition Index." See "UL and CSA . .", page 9.

STOCK "GPR" LATCHING RELAYS
5 Amp Contacts

Total Contacts	COIL DATA—(Each Coil) Volts	Amps.	Ohms	UL CSA Unenclosed GPRLE †	UL Enclosed CSA Plug-Base GPRLETP †
4PDT	6 VAC	.650	2.5	GPRLEX-1T	GPRLETPX-1T
6PDT	6 VAC	.650	2.5	GPRLEX-2T	GPRLETPX-2T
4PDT	12 VAC	.309	10.0	GPRLEX-3T	GPRLETPX-3T
6PDT	12 VAC	.309	10.0	GPRLEX-4T	GPRLETPX-4T
4PDT	24 VAC	.155	40.0	GPRLEX-5T	GPRLETPX-5T
6PDT	24 VAC	.155	40.0	GPRLEX-6T	GPRLETPX-6T
4PDT	115 VAC	.0325	1,000	GPRLEX-7T	GPRLETPX-7T
6PDT	115 VAC	.0325	1,000	GPRLEX-8T	GPRLETPX-8T
4PDT	230 VAC	.0147	4,000	GPRLEX-9T	GPRLETPX-9T
6PDT	230 VAC	.0147	4,000	GPRLEX-10T	GPRLETPX-10T
4PDT	6 VDC	.23	26	GPRLEX-11T	GPRLETPX-11T
6PDT	6 VDC	.23	26	GPRLEX-12T	GPRLETPX-12T
4PDT	12 VDC	.114	105	GPRLEX-13T	GPRLETPX-13T
6PDT	12 VDC	.114	105	GPRLEX-14T	GPRLETPX-14T
4PDT	24 VDC	.060	400	GPRLEX-15T	GPRLETPX-15T
6PDT	24 VDC	.060	400	GPRLEX-16T	GPRLETPX-16T
4PDT	110 VDC	.0110	10,000	GPRLEX-17T	GPRLETPX-17T
6PDT	110 VDC	.0110	10,000	GPRLEX-18T	GPRLETPX-18T
	Approx. weight ⟶			7.0 oz.	11.3 oz.

†Column heads carry symbols to indicate UL or CSA (Canadian Standards Association) approval. The grey tint indicates that relay is listed in the UL "Components Recognition Index." See explanation in "UL and CSA Approval," page 9.

LATCHING RELAYS—ELECTRICAL RESET

OHMITE

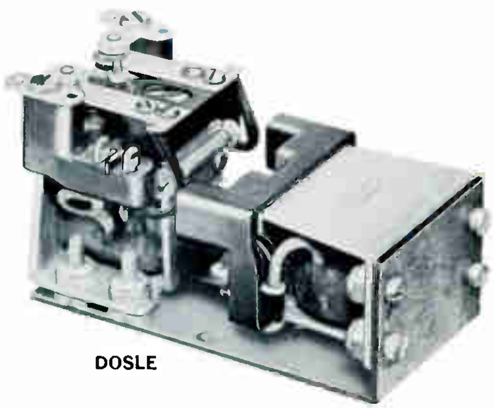
MODELS DOSLE, DOLE

Latching relays incorporating Model DOS (DOSLE) or DO (DOLE) relays. The armature is mechanically latched to the armature of a reset magnet so that the normally open contacts of the relay close when the coil is momentarily energized and remain closed after the coil energizing voltage has been removed. The armature is released and the contacts are returned to the normal position by impulsing the reset coil. Thus, the contacts may be maintained in closed position for long periods of time without continuous coil current and resetting is accomplished remotely.

The Model DOSLE and DOLE latching relays differ from the Model GPRLE and GPRLETP (on the opposite page) in that their reset magnets function strictly as latching and release devices and carry no contacts of their own. The DOS and DO relays used here, have the same operating characteristics as their counterparts described in the preceding pages.

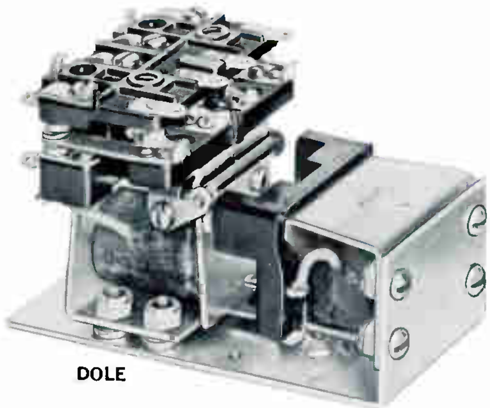
For made-to-order units specify operating voltage for both the relay and reset coils and indicate AC or DC operation. Stock DOSLE and DOLE relays are shown in the tables below.

MODEL DOSLE

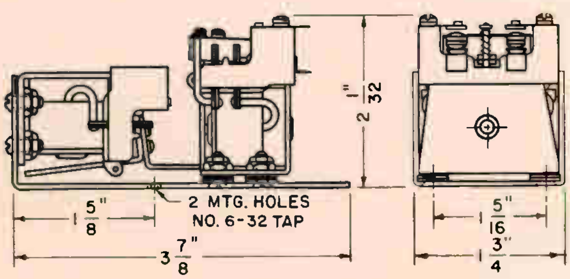


DOSLE

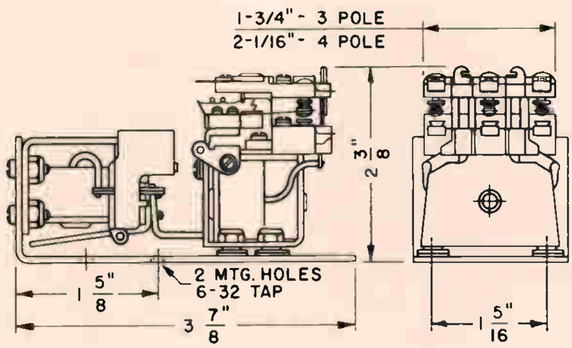
MODEL DOLE



DOLE



MODEL DOSLE



MODEL DOLE

STOCK DOSLE LATCHING RELAYS
15 Amp Contacts

Cat. No.	Type	Normal Position	COIL DATA†		
			Volts	Amps.	DC Ohms
DOSLEX-1T	DPDT	—	115 VAC	.043	450

†Coil data applies to relay part of latching assembly. Reset magnet operates on 115 VAC, 60 cycle also.

STOCK DOLE LATCHING RELAYS
10 Amp Contacts

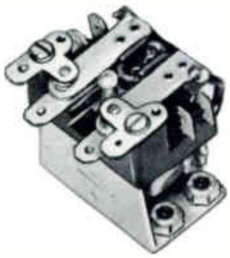
Cat. No.	Type	Normal Position	COIL DATA†		
			Volts	Amps.	DC Ohms
DOLEX-3T	3PDT	—	115 VAC	.110	145
DOLEX-5T	4PDT	—	115 VAC	.110	145

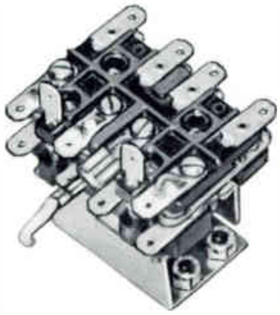
†Coil data applies to relay part of latching assembly. Reset magnet operates on 115 VAC, 60 cycle also.

RELAYS WITH SPECIAL TERMINALS OR SPECIAL CONSTRUCTION

RELAYS WITH PUSH-ON OR SCREW TERMINALS

Model DOS, DOSY, DO, or DOY relays can be supplied with solderless "push-on" type terminals which will receive a female connector similar to AMP, "Faston" No. 41202 or a corresponding ARK-LES connector. The same relays can also be supplied with screw-type terminals. Operating characteristics for these relays are the same as indicated in the individual relay sections for DOS, DOSY, DO and DOY relays. To order units with these terminals, specify "push-on" or "screw" terminals in addition to the proper ordering code (see Introduction). For relays with other types of push-on and tab terminals, see pages 6 and 16.


DOS — Push-On;

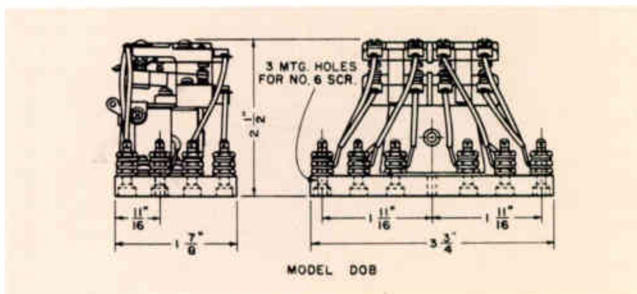

DO — Push-On;


DOS — Screw;


DO — Screw

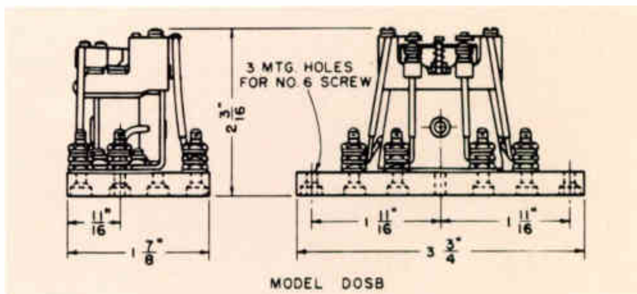
RELAYS WITH BINDING-POST TERMINALS

Models DOSB and DOB are used where screw type binding posts are preferred to solder type terminals. The DOSB and DOB are actually the standard Model DOS and DO relays mounted on a heavy laminated plastic base. Operating data for the standard Models DOS and DO, applies to the DOSB and DOB. Approximate weight of the DOSB and DPDT contact combination is 8 ounces; the approximate weight of the DOB with four pole, double throw contact combination is 12 ounces.



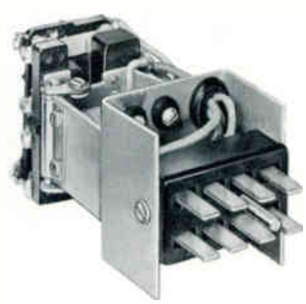

DOB


DOSB



"SPECIALS" MADE TO YOUR SPECIFICATIONS

Where quantities warrant, Ohmite will manufacture relays with special features. Ohmite can furnish not only special terminals, special contact combinations, contact materials, and coils, but special enclosures, connectors, impregnation, or frames. For example, the illustration shows a DOS relay with special black bakelite base and enclosure and banana plug that meets Underwriters' Laboratories spacing requirements, and a standard DO relay with special mounting employing a Jones industrial plug.



Typical Custom-Made Relays

RELAYS WITH SNAP-ACTION SWITCH CONTACTS

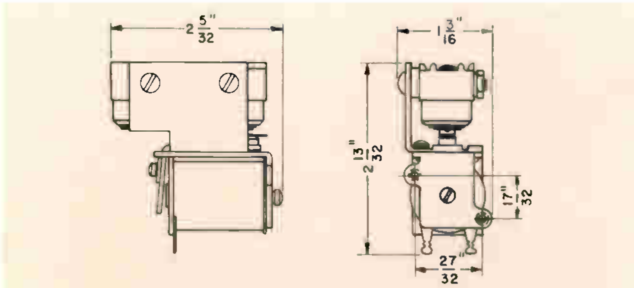
CRSA

To obtain sensitive relay operation with heavy duty contacts, the CR relay is available with snap-action switch contacts. These switches have a high current rating and are available in a variety of contact combinations and sizes. The switch-equipped CR relay is called Model CRSA.

Switch Contact Combinations: Standard combinations—SPST, N.O.; SPST, N.C.; and SPDT. DPDT and DPST switches can sometimes be supplied.

Contact Ratings: 10 amperes at 115 VAC non-inductive load. Switches of higher rating are available.

Coil Operating Data: Refer to the operating data for the Model CR on page 20.

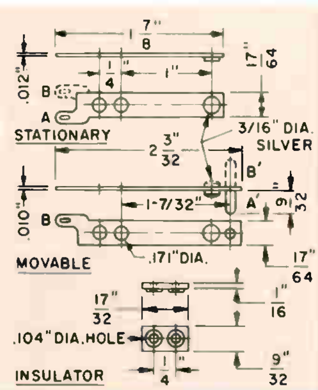


MODEL CRSA

LEAF SWITCH

Leaf Switch

Virtually hundreds of different switch assemblies can be made. Illustrated is a typical example of a leaf switch assembly. The drawing shows the most commonly used parts. Ohmite engineers welcome your inquiry.



TERMINAL	CONTACT	STUD	CAT. Nº
STATIONARY CONTACT ARM			
AT A	SINGLE	—	LS100
AT B	SINGLE	—	LS101
MOVABLE CONTACT ARM			
AT B	DOUBLE	—	LS102
AT B	DOUBLE	AT A'	LS103
AT B	SINGLE	—	LS104
AT B	SINGLE	AT A'	LS105
AT B	SINGLE	AT B'	LS106
INSULATOR-SEPARATOR			LS107

Model LS Leaf Switch Parts

COIL WINDINGS

Coil

Ohmite can supply coils to meet individual specifications. Layer-wound coils have a sheet of high temperature cellulose-acetate between each layer of wire and by means of heat and pressure, the acetate is caused to flow around the ends of the coil, forming a completely plastic-sealed coil. This process affords maximum protection from ambient conditions, particularly moisture and humidity. Bobbin wound coils can also be supplied. Your inquiries are invited.

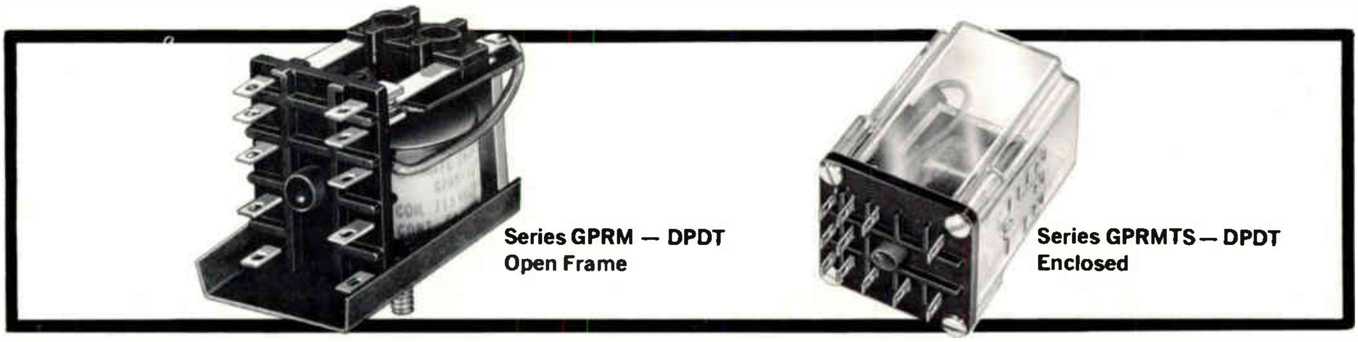
OHMITE has another new answer

DATA SHEET 701-1

March 25, 1968 / Supplement to Catalog 701

Magnetic Latching Relays

Series GPRM



Series GPRM — DPDT Open Frame

Series GPRMTS — DPDT Enclosed

same size as standard general-purpose relays . . . economical cost.

Latching functions of the new Series GPRM relays are performed magnetically; no mechanical latching levers required. Unlike conventional latching relays, the Series GPRM magnetic latching relays are less susceptible to shock and vibration, and do not require critical lever adjustments.

Principle of Operation

The latching function of the new Series GPRM magnetic latching relay is accomplished by using a magnet structure made from a steel having high "remanence". This means that once the coil has been energized and the relay armature has closed, it will remain in the closed position indefinitely even after the coil energizing voltage has been removed.

Advantages

Small size. Because the new GPRM magnetic latching relay uses standard size relay frames and only one coil, you can now design latching functions into the same space required of general purpose relays. On the other hand, mechanical latching relays are usually twice the general purpose relay size and are available only in large contact configurations.

Long Life. Magnetic latching relays have no mechanical latching levers to wear or go out of adjustment.

Reliable. Magnetic latching relays work in any position. Unlike mechanical latching relays, Ohmite's GPRM relay accommodates moderate shock and vibration and will not inadvertently unlatch.

Positive Action. The GPRM relay does not require expensive safeguards against subsequent power or circuit failure. It cannot be locked-in manually.

Low Power Consumption. In the Ohmite GPRM relay remanent magnetism keeps the relay latched without continuous coil energization.

Economical Price. Conventional mechanical latching relays require latching mechanisms and dual coils and frames. Because Ohmite's Series GPRM magnetic latching relays do not have extra mechanisms, coils or frames, the price of these relays is less than conventional mechanical latching relays.

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General Characteristics

Mechanical

Series GPRM magnetic latching relays are available in a variety of packages offering flexibility in mounting and termination. Series GPRM is available in open frame and enclosed models.

Construction. A rigid frame assures long retention of adjustments. The coil is wound on a nylon bobbin for long life. All connections terminate on one terminal panel for easy wiring.

Multiple Use Terminals. Four termination possibilities are offered: the universal terminals can be used as solder lug, quick-connect (push-on) which accept Amp series 110 female connectors or to plug into standard Ohmite SOGPR sockets; the pin plug type is designed for octal base sockets.

Variety in Mounting. Open frame models mount on panels up to ¼ inch using a 6-32 threaded stud and nut. A hole is also required for the non-turn boss on the relay frame.

A 6-32 tapped mounting hole can be supplied in place of the stud. Open frame models also can be mounted using the Ohmite SOGPR socket as an alternative to stud mounting.

Enclosed models are offered in four mounting styles: through-chassis flange (TT style), above-chassis flange (TA style), socket (TS style, for use with SOGPR-23 socket), and octal pin-plug (TP style.)

Electrical

Series GPRM magnetic latching relays have one coil with two windings; a "latch" winding and a "release" winding. Specific operating voltages are shown in the table at right. Relay contacts are integral inlays on the terminals.

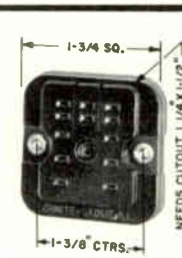
Contact Configurations. Up to double-pole, double-throw contact forms are available in the Series GPRM magnetic latching relay as standard. Contact the factory for other contact forms.

Contact Ratings. There are two ratings. Relays with fine-silver contacts, gold flashed are rated 5 amps resistive at 115 VAC or 32 VAC. Relays with silver-cadmium oxide gold flashed movable and silver-cad gold flashed fixed contacts are rated 10 amps.

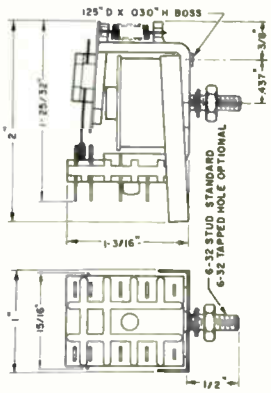
Coil Operating Voltages. Any voltage up to 230 VAC, 60 Hertz or 110 VDC. See table of coil data for listing of standard operating voltages.

Insulation. All relays tested at 1500 VAC between all terminals and ground.

Socket Model SOGPR-23 for one and two pole magnetic latching relays.
Unique sockets fit the standard terminal panel of GPRM and GPRMTS styles and provide over-the-surface spacing to meet UL requirements for 150 volts. Require chassis cut out to mount. Hold down springs for open frame and enclosed relays are provided but are only required under conditions of vibration or shock. Socket terminals accept Amp 110 quick connectors or soldering.

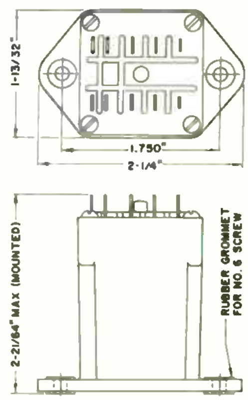


Open Frame Style

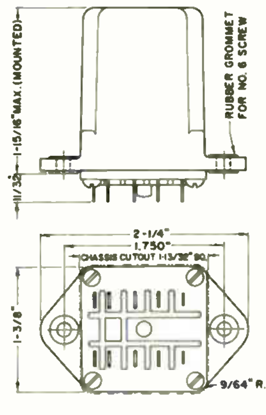


Enclosed Styles

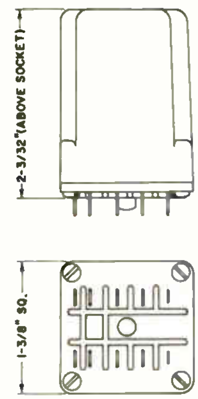
Type TA — Above chassis mount



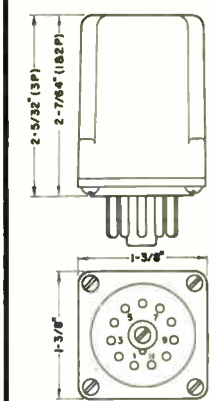
Type TT — Thru chassis mount



Type TS — For socket mount

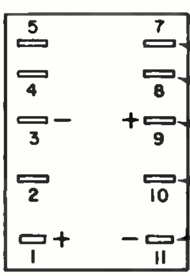


Type TP — Plug base socket



Relay Wiring Panel

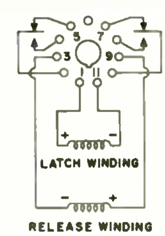
Front View of Panel with coil down



- N.C. Contacts (5 and 7)
- N.O. Contacts (4 and 8)
- Release Coil* (3 and 9)
- "Movable" Contacts (2 and 10)
- Latch Coil* (1 and 11)

*Polarity as shown for the latch and release coils applies only if windings are for DC operation. It is not applicable for AC operation.

PLUG WIRING FOR OCTAL PIN PLUG



Ordering Information

ALL RELAYS ARE DPDT CONTACT CONFIGURATIONS. CONTACT FACTORY FOR SPDT AND OTHER CONTACT ARRANGEMENTS.

Coil Data			5 Amp Rated Contacts					10 Amp Rated Contacts		
			Open	Enclosed				Open	Enclosed	
Volts	DC Coil Resistance ±10% Latch Winding	Release Winding	Frame GPRM Style	Thru-Chassis GPRMTA Style	Above Chassis GPRMTT Style	For SOGPR-23 Socket GPRMTS	Plug Base GPRMTP Style	Frame GPRM Style	For SOGPR-23 Socket GPRMTS	Plug Base GPRMTP Style
6 VAC	3.64	8.77	GPRMX-6	GPRMTAX-6	GPRMTTX-6	GPRMTSX-6	GPRMTPX-6	GPRMX-206	GPRMTSX-206	GPRMTPX-206
12 VAC	14.7	34.5	GPRMX-15	GPRMTAX-15	GPRMTTX-15	GPRMTSX-15	GPRMTPX-15	GPRMX-215	GPRMTSX-215	GPRMTPX-215
24 VAC	56.2	135	GPRMX-24	GPRMTAX-24	GPRMTTX-24	GPRMTSX-24	GPRMTPX-24	GPRMX-224	GPRMTSX-224	GPRMTPX-224
115 VAC	865	1350	GPRMX-33	GPRMTAX-33	GPRMTTX-33	GPRMTSX-33	GPRMTPX-33	GPRMX-233	GPRMTSX-233	GPRMTPX-233
230 VAC	3460	1350	GPRMX-42	GPRMTAX-42	GPRMTTX-42	GPRMTSX-42	GPRMTPX-42	GPRMX-242	GPRMTSX-242	GPRMTPX-242
6 VDC	14.7	34.5	GPRMX-51	GPRMTAX-51	GPRMTTX-51	GPRMTSX-51	GPRMTPX-51	GPRMX-251	GPRMTSX-251	GPRMTPX-251
12 VDC	56.2	135	GPRMX-60	GPRMTAX-60	GPRMTTX-60	GPRMTSX-60	GPRMTPX-60	GPRMX-260	GPRMTSX-260	GPRMTPX-260
24 VDC	222	540	GPRMX-69	GPRMTAX-69	GPRMTTX-69	GPRMTSX-69	GPRMTPX-69	GPRMX-269	GPRMTSX-269	GPRMTPX-269
110 VDC	3460	1350	GPRMX-78	GPRMTAX-78	GPRMTTX-78	GPRMTSX-78	GPRMTPX-78	GPRMX-278	GPRMTSX-278	GPRMTPX-278

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RELAY CROSS REFERENCE

This cross reference deals only with Ohmite's new versatile MODEL GPR general purpose relays and the equivalents produced by other manufacturers. The relays produced by other manufacturers are listed in alpha-numerical order along with the Ohmite equivalents.

5 AMP CONTACTS — POTTER & BRUMFIELD (P&B) vs OHMITE

P&B	OHMITE	P&B	OHMITE
KA5AY-6V	GPRX-3T	KB23D-6V	GPRLEX-12T
KA5AY-115V	GPRX-30T	KB23D-12V	GPRLEX-14T
KA5AY-230V	GPRX-39T	KB23D-24V	GPRLEX-16T
KA5D-6V	GPRX-48T	KB23D-110V	GPRLEX-18T
KA5D-24V	GPRX-66T	KCP5-3.6MA	GPRTPX-88T
KA5D 110V	GPRX-75T	KCP5-5MA	GPRTPX-85T
KA11AY-6V	GPRX-6T	KCP5-7.2MA	GPRTPX-82T
KA11AY-12V	GPRX-15T	KCP11-5MA	GPRTPX-89T
KA11AY-24V	GPRX-24T	KCP11-7.2MA	GPRTPX-86T
KA11AY-115V	GPRX-33T	KCP11-10MA	GPRTPX-83T
KA11AY-230V	GPRX-42T	KCP14-6.1MA	GPRTPX-90T
KA11D-6V	GPRX-51T	KCP14-8.7MA	GPRTPX-87T
KA11D-12V	GPRX-60T	KCP14-12.3MA	GPRTPX-84T
KA11D-24V	GPRX-69T	*KRP5A-6V	GPRTPX-3T
KA11D-110V	GPRX-78T	*KRP5A-115V	GPRTPX-30T
KA14AY-6V	GPRX-9T	*KRP5A-230V	GPRTPX-39T
KA14AY-12V	GPRX-18T	*KRP5D-6V	GPRTPX-48T
KA14AY-24V	GPRX-27T	*KRP5D-24V	GPRTPX-66T
KA14AY-115V	GPRX-36T	*KRP5D-110V	GPRTPX-75T
KA14AY-230V	GPRX-45T	*KRP11A-6V	GPRTPX-6T
KA14D-6V	GPRX-54T	*KRP11A-12V	GPRTPX-15T
KA14D-12V	GPRX-63T	*KRP11A-24V	GPRTPX-24T
KA14D-24V	GPRX-72T	*KRP11A-115V	GPRTPX-33T
KA14D-110V	GPRX-81T	*KRP11A-230V	GPRTPX-42T
KB17AY-6V	GPRLEX-1T	*KRP11D-6V	GPRTPX-51T
KB17AY-12V	GPRLEX-3T	*KRP11D-12V	GPRTPX-60T
KB17AY-24V	GPRLEX-5T	*KRP11D-24V	GPRTPX-69T
KB17AY-115V	GPRLEX-7T	*KRP11D-110V	GPRTPX-78T
KB17AY-230V	GPRLEX-9T	*KRP14A-6V	GPRTPX-9T
KB17D-6V	GPRLEX-11T	*KRP14A-12V	GPRTPX-18T
KB17D-12V	GPRLEX-13T	*KRP14A-24V	GPRTPX-27T
KB17D-24V	GPRLEX-15T	*KRP14A-115V	GPRTPX-36T
KB17D-110V	GPRLEX-17T	*KRP14A-230V	GPRTPX-45T
KB23AY-6V	GPRLEX-2T	*KRP14D-6V	GPRTPX-54T
KB23AY-12V	GPRLEX-4T	*KRP14D-12V	GPRTPX-63T
KB23AY-24V	GPRLEX-6T	*KRP14D-24V	GPRTPX-72T
KB23AY-115V	GPRLEX-8T	*KRP14D-110V	GPRTPX-81T
KB23AY-230V	GPRLEX-10T		

*Also KAP Series

5 AMP CONTACTS — ELGIN-ADVANCE (E-A) vs OHMITE

E-A	OHMITE	E-A	OHMITE
GHA1C-6VAC	GPRX-3T	GHP1C-6VAC*	GPRTPX-3T
GHA1C-6VDC	GPRX-48T	GHP1C-6VDC*	GPRTPX-48T
GHA1C-24VDC	GPRX-66T	GHP1C-24VDC*	GPRTPX-66T
GHA1C-110VDC	GPRX-75T	GHP1C-110VDC*	GPRTPX-75T
GHA1C-115VAC	GPRX-30T	GHP1C-115VAC*	GPRTPX-30T
GHA1C-230VAC	GPRX-39T	GHP1C-230VAC*	GPRTPX-39T
GHA2C-6VAC	GPRX-6T	GHP2C-6VAC	GPRTPX-6T
GHA2C-6VDC	GPRX-51T	GHP2C-6VDC	GPRTPX-51T
GHA2C-12VAC	GPRX-15T	GHP2C-12VAC	GPRTPX-15T
GHA2C-12VDC	GPRX-60T	GHP2C-12VDC	GPRTPX-60T
GHA2C-24VAC	GPRX-24T	GHP2C-24VAC	GPRTPX-24T
GHA2C-24VDC	GPRX-69T	GHP2C-24VDC	GPRTPX-69T
GHA2C-110VDC	GPRX-78T	GHP2C-110VDC	GPRTPX-78T
GHA2C-115VAC	GPRX-33T	GHP2C-115VAC	GPRTPX-33T
GHA2C-230VAC	GPRX-42T	GHP2C-230VAC	GPRTPX-42T
GHA3C-6VAC	GPRX-9T	GHP3C-6VAC	GPRTPX-9T
GHA3C-6VDC	GPRX-54T	GHP3C-6VDC	GPRTPX-54T
GHA3C-12VAC	GPRX-18T	GHP3C-12VAC	GPRTPX-18T
GHA3C-12VDC	GPRX-63T	GHP3C-12VDC	GPRTPX-63T
GHA3C-24VAC	GPRX-27T	GHP3C-24VAC	GPRTPX-27T
GHA3C-24VDC	GPRX-72T	GHP3C-24VDC	GPRTPX-72T
GHA3C-110VDC	GPRX-81T	GHP3C-110VDC	GPRTPX-81T
GHA3C-115VAC	GPRX-36T	GHP3C-115VAC	GPRTPX-36T
GHA3C-230VAC	GPRX-45T	GHP3C-230VAC	GPRTPX-45T
GHE1C-2500*	GPRTPX-82T		
GHE1C-5000*	GPRTPX-85T		
GHE1C-10000*	GPRTPX-88T		
GHE2C-2500	GPRTPX-83T		
GHE2C-5000	GPRTPX-86T		
GHE2C-10000	GPRTPX-89T		
GHE3C-2500	GPRTPX-84T		
GHE3C-5000	GPRTPX-87T		
GHE3C-10000	GPRTPX-90T		

5 AMP CONTACTS — LINE ELECTRIC (L-E) vs OHMITE

L-E	OHMITE	L-E	OHMITE	L-E	OHMITE
MK1A-6V	GPRX-3T	MK3D-12V	GPRX-63T	MKP1A-115V	GPRTPX-30T
MK1A-12V	GPRX-12T	MK3D-24V	GPRX-72T	MKP1A-230V	GPRTPX-39T
MK1A-24V	GPRX-21T	MK3D-110V	GPRX-81T	MKP1D-6V	GPRTPX-48T
MK1A-115V	GPRX-30T	MKC-1-2500	GPRX-82T	MKP1D-12V	GPRTPX-57T
MK1A-230V	GPRX-39T	MKC-1-5000	GPRX-85T	MKP1D-24V	GPRTPX-66T
MK1D-6V	GPRX-48T	MKC-1-10000	GPRX-88T	MKP1D-110V	GPRTPX-75T
MK1D-12V	GPRX-57T	MKC-2-2500	GPRX-83T	MKP2A-6V	GPRTPX-6T
MK1D-24V	GPRX-66T	MKC-2-5000	GPRX-86T	MKP2A-12V	GPRTPX-15T
MK1D-110V	GPRX-75T	MKC-2-10000	GPRX-89T	MKP2A-24V	GPRTPX-24T
MK2A-6V	GPRX-6T	MKC-3-2500	GPRX-84T	MKP2A-115V	GPRTPX-33T
MK2A-12V	GPRX-15T	MKC-3-5000	GPRX-87T	MKP2A-230V	GPRTPX-42T
MK2A-24V	GPRX-24T	MKC-3-10000	GPRX-90T	MKP2D-6V	GPRTPX-51T
MK2A-115V	GPRX-33T	MKF-1-2500	GPRTPX-82T	MKP2D-12V	GPRTPX-60T
MK2A-230V	GPRX-42T	MKF-1-5000	GPRTPX-85T	MKP2D-24V	GPRTPX-69T
MK2D-6V	GPRX-51T	MKF-1-10000	GPRTPX-88T	MKP2D-110V	GPRTPX-78T
MK2D-12V	GPRX-60T	MKF-2-2500	GPRTPX-83T	MKP3A-6V	GPRTPX-9T
MK2D-24V	GPRX-69T	MKF-2-5000	GPRTPX-86T	MKP3A-12V	GPRTPX-18T
MK2D-110V	GPRX-78T	MKF-2-10000	GPRTPX-89T	MKP3A-24V	GPRTPX-27T
MK3A-6V	GPRX-9T	MKF-3-2500	GPRTPX-84T	MKP3A-115V	GPRTPX-36T
MK3A-12V	GPRX-18T	MKF-3-5000	GPRTPX-87T	MKP3A-230V	GPRTPX-45T
MK3A-24V	GPRX-27T	MKF-3-10000	GPRTPX-90T	MKP3D-6V	GPRTPX-54T
MK3A-115V	GPRX-36T	MKP1A-6V	GPRTPX-3T	MKP3D-12V	GPRTPX-63T
MK3A-230V	GPRX-45T	MKP1A-12V	GPRTPX-12T	MKP3D-24V	GPRTPX-72T
MK3D-6V	GPRX-54T	MKP1A-24V	GPRTPX-21T	MKP3D-110V	GPRTPX-81T

RELAY CROSS REFERENCE (Continued)

10 AMP CONTACTS POTTER & BRUMFIELD (P&B) vs OHMITE

P & B	OHMITE
KA5AG-6V	GPRX-203T
KA5AG-12V	GPRX-212T
KA5AG-24V	GPRX-221T
KA5AG-115V	GPRX-230T
KA5AG-230V	GPRX-239T
KA11AG-6V	GPRX-206T
KA11AG-12V	GPRX-215T
KA11AG-24V	GPRX-224T
KA11AG-115V	GPRX-233T
KA11AG-230V	GPRX-242T
KA14AG-6V	GPRX-209T
KA14AG-12V	GPRX-218T
KA14AG-24V	GPRX-227T
KA14AG-115V	GPRX-236T
KA14AG-230V	GPRX-245T
*KRP5AG-6V	GPRTPX-203T
*KRP5AG-12V	GPRTPX-212T
*KRP5AG-24V	GPRTPX-221T
*KRP5AG-115V	GPRTPX-230T
*KRP5AG-230V	GPRTPX-239T
*KRP5DG-6V	GPRTPX-248T
*KRP5DG-12V	GPRTPX-257T
*KRP5DG-24V	GPRTPX-266T
*KRP5DG-110V	GPRTPX-275T
*KRP11AG-6V	GPRTPX-206T
*KRP11AG-12V	GPRTPX-215T
*KRP11AG-24V	GPRTPX-224T
*KRP11AG-115V	GPRTPX-233T
*KRP11AG-230V	GPRTPX-242T
*KRP11AN-6V	GPRTPX-291T
*KRP11AN-12V	GPRTPX-292T
*KRP11AN-24V	GPRTPX-293T
*KRP11AN-115V	GPRTPX-294T
*KRP11AN-230V	GPRTPX-295T
*KRP11DG-6V	GPRTPX-251T
*KRP11DG-12V	GPRTPX-260T
*KRP11DG-24V	GPRTPX-269T
*KRP11DG-110V	GPRTPX-278T
*KRP11DN-6V	GPRTPX-296T
*KRP11DN-12V	GPRTPX-297T
*KRP11DN-24V	GPRTPX-298T
*KRP11DN-110V	GPRTPX-299T
*KRP14AG-6V	GPRTPX-209T
*KRP14AG-12V	GPRTPX-218T
*KRP14AG-24V	GPRTPX-227T
*KRP14AG-115V	GPRTPX-236T
*KRP14AG-230V	GPRTPX-245T
*KRP14DG-6V	GPRTPX-254T
*KRP14DG-12V	GPRTPX-263T
*KRP14DG-24V	GPRTPX-272T
*KRP14DG-110V	GPRTPX-281T

* Also KAP Series

GUARDIAN vs OHMITE *

GUARDIAN	OHMITE
1200-G6	GPRX-206T
1200-G12	GPRX-215T
1200-G24	GPRX-224T
1200-G115	GPRX-233T
1200-GC6	GPRX-209T
1200-GC12	GPRX-218T
1200-GC24	GPRX-227T
1200-GC115	GPRX-236T
1210-G6	GPRTPX-206T
1210-G12	GPRTPX-215T
1210-G24	GPRTPX-224T
1210-G115	GPRTPX-233T
1210-GC6	GPRTPX-209T
1210-GC12	GPRTPX-218T
1210-GC24	GPRTPX-227T
1210-GC115	GPRTPX-236T
1210N-G115	GPRTPX-294T
1215-G6	GPRTPX-251T
1215-G12	GPRTPX-260T
1215-G24	GPRTPX-269T
1215-GC6	GPRTPX-254T
1215-GC12	GPRTPX-263T
1215-GC24	GPRTPX-272T

*Ohmite relays have 10 ampere contacts; Guardian 8 ampere contacts.

10 AMP CONTACTS ELGIN – ADVANCE (E–A) vs OHMITE

GHB1C-6VAC	GPRX-203T
GHB1C-12VAC	GPRX-212T
GHB1C-24VAC	GPRX-221T
GHB1C-115VAC	GPRX-230T
GHB1C-230VAC	GPRX-239T
GHB2C-6VAC	GPRX-206T
GHB2C-12VAC	GPRX-215T
GHB2C-24VAC	GPRX-224T
GHB2C-115VAC	GPRX-233T
GHB2C-230VAC	GPRX-242T
GHB3C-6VAC	GPRX-209T
GHB3C-12VAC	GPRX-218T
GHB3C-24VAC	GPRX-227T
GHB3C-115VAC	GPRX-236T
GHB3C-230VAC	GPRX-245T

10 AMP CONTACTS LINE ELECTRIC (L–E) vs OHMITE

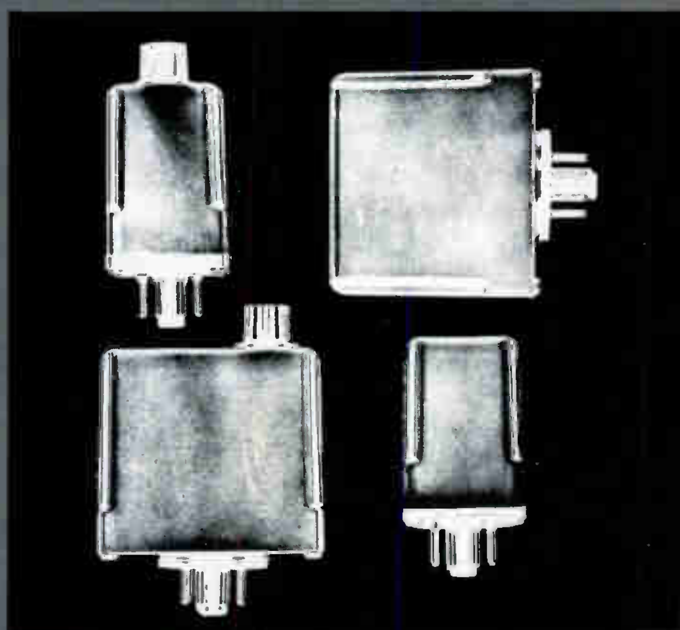
L–E	OHMITE	L–E	OHMITE
MKH1A-6V	GPRTPX-203T	MKH3D-6V	GPRTPX-254T
MKH1A-12V	GPRTPX-212T	MKH3D-12V	GPRTPX-263T
MKH1A-24V	GPRTPX-221T	MKH3D-24V	GPRTPX-272T
MKH1A-115V	GPRTPX-230T	MKH3D-110V	GPRTPX-281T
MKH1A-230V	GPRTPX-239T		
MKH1D-6V	GPRTPX-248T	MKO1A-6V	GPRX-203T
MKH1D-12V	GPRTPX-257T	MKO1A-12V	GPRX-212T
MKH1D-24V	GPRTPX-266T	MKO1A-24V	GPRX-221T
MKH1D-110V	GPRTPX-275T	MKO1A-115V	GPRX-230T
MKH2A-6V	GPRTPX-206T	MKO1A-230V	GPRX-239T
MKH2A-12V	GPRTPX-215T	MKO2A-6V	GPRX-206T
MKH2A-24V	GPRTPX-224T	MKO2A-12V	GPRX-215T
MKH2A-115V	GPRTPX-233T	MKO2A-24V	GPRX-224T
MKH2A-230V	GPRTPX-242T	MKO2A-115V	GPRX-233T
MKH2D-6V	GPRTPX-251T	MKO2A-230V	GPRX-242T
MKH2D-12V	GPRTPX-260T	MKO3A-6V	GPRX-209T
MKH2D-24V	GPRTPX-269T	MKO3A-12V	GPRX-218T
MKH2D-110V	GPRTPX-278T	MKO3A-24V	GPRX-227T
MKH3A-6V	GPRTPX-209T	MKO3A-115V	GPRX-236T
MKH3A-12V	GPRTPX-218T	MKO3A-230V	GPRX-245T
MKH3A-24V	GPRTPX-227T		
MKH3A-115V	GPRTPX-236T		
MKH3A-230V	GPRTPX-245T		

SOLID STATE TIME DELAY RELAYS

OHMITE

CATALOG 709

NOVEMBER, 1969



SOLID STATE TIME DELAY RELAYS

Ohmite Solid State Time Delay Relays, are designed to achieve delays in the closing and opening of the output contacts of an electro-mechanical relay. This delay occurs from the time a switch is operated i.e. closed or opened. Also, time delay relays are supplied for closing or opening a set of relay output contacts for a finite period upon the momentary closing of a switch. (See Table I.) Delays up to 180 seconds are possible.

Utilization of a solid state timing device, a unijunction transistor triggered by a resistance-capacitance timing network, means greater timing accuracy and repeatability and exceedingly long life. The difficulties sometimes encountered with electro-mechanical timing devices such as bulk due to gears, motors, plus the wear common to such devices, are eliminated.

The Ohmite Time Delay Relay offers the finest solid state elements and circuitry for the timing portion of this device along with long-life Ohmite electro-mechanical relays as the power switching portion.

INTERNAL OR EXTERNAL RELAY

As indicated above, Ohmite Time Delay Relays consist of a solid state timing network and an electro-mechanical relay which is energized by the timing network. For the "Delay on Operate" type of relay, the electro-mechanical relay can be supplied in the same enclosure as the timing network or can be external to it. The internal electro-mechanical relay has DPDT contacts rated at 10 amperes. Where an external relay is required, Ohmite GPR, DOS or DO relays can be used. See paragraph, "Recommended External Relays."

USES OF TIME DELAY RELAYS

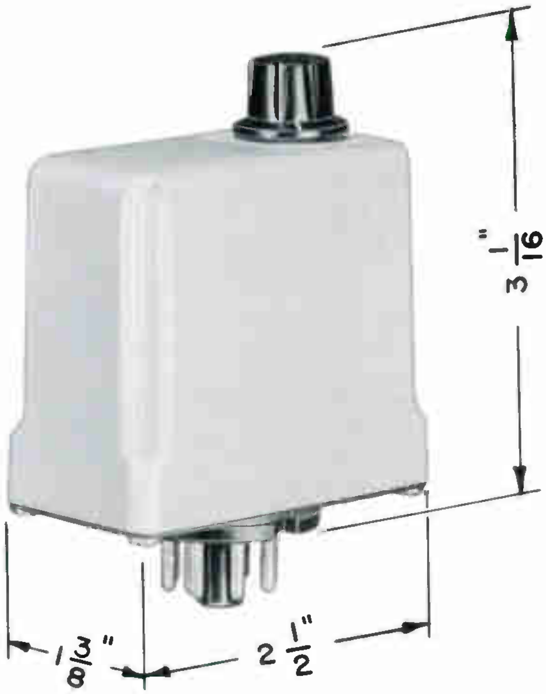
Time delay relays find application where delays must be introduced as a safety factor for the protection of equipment such as motors, or where certain machine sequences must be established. They may also be used for timing and sequencing certain operations as in welding or photographic developing. Thus time delay relays are found in motor starting circuits, injection molding and die casting machines, warm-up controls in radio transmitters or X-ray machines, in automatic elevator systems, dispensing or vending machines and in all types of automated equipment systems.

TABLE I—CHARACTERISTICS OF OHMITE TIME DELAY RELAYS

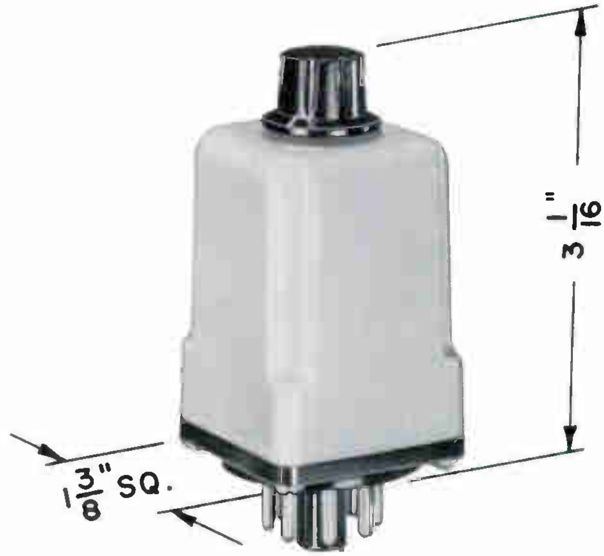
TYPE OF RELAY	SERIES DESIGNATION	TIMING CYCLE INITIATED BY	CAN PERFORM THESE FUNCTIONS	EXTERNAL OUTPUT RELAY OPTION	OUTPUT RELAY: AT START OF CYCLE	OUTPUT RELAY: AT END OF CYCLE	TO RE-SET FOR NEXT CYCLE
"Delay on Operate"	"SO ___ ___"	Sustained closing of a switch in supply circuit.	(1) Switch "on" a device upon expiration of the pre-set delay. (2) Switch "off" a device upon expiration of the pre-set delay. (3) Switch "on" a device for a pre-set interval.	Yes	Remains De-Energized	Becomes Energized	Open Initiating Switch
"Delay on Release"	"SRI ___"	Sustained opening of a switch in "Control Circuit" (Supply circuit always connected.)	(1) Switch "off" a device upon expiration of the pre-set delay. (2) Switch "on" a device upon expiration of the pre-set delay. (3) Switch "off" a device for a pre-set interval.	No	Remains Energized	Becomes De-Energized	Close Switch in "Control Circuit"
Momentary Actuation	"SMI ___"	Momentary closing of a switch in Supply Circuit.	(1) Switch "on" a device for a pre-set interval. (2) Switch "off" a device for a pre-set interval.	No	Becomes Energized	Becomes De-energized	No re-setting necessary

SOLID STATE TIME DELAY RELAYS

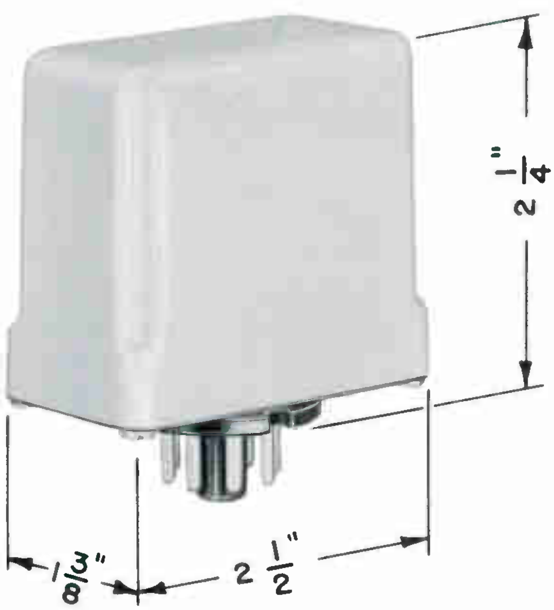
OHMITE



A
Variable Delay
with Internal Relay



B
Variable Delay Module
Requiring External Relay



C
Fixed Delay
with Internal Relay

D
Fixed Delay Module
Requiring External Relay

DELAY AND DELAY ADJUSTMENTS

Variable — The Ohmite Time Delay Relay, designated as "variable" incorporates a knob (on top of the case) which permits adjustment of the time delay over a range as indicated in the table on pages 6 and 8. Three ranges are offered as follows:

0.1 to 10 seconds
0.6 to 60 seconds
1.8 to 180 seconds

Fixed Maximum and Remote — This type is supplied with a factory set time delay. However, it incorporates provisions (terminals) for connecting an external resistor for reducing the time delay from the maximum. Alternatively, a variable resistance may be used to adjust the delay over the range down from nearly the maximum to the minimum. The minimum delay is obtained when a short circuit is placed across the delay circuit terminals. The delay adjusting resistance can be located remotely providing still another element of flexibility in the use of these relays.

Standard "Fixed Maximum Delay" values are shown in Table II:

Operating Voltage Ratings: Ohmite Time Delay Relays can be supplied to operate from the following voltages:

AC: 24, 115
DC: 24, 48, 110

Contacts and Rating of Internal Relay: DPDT, 10 amperes at 115 VAC, 32VDC resistive.

Recommended External Relays: For "Delay on Operate" relays SOEV, SOEF; see Table III. Descriptions of recommended external relays are provided in Catalog 700 available on request.

TABLE II — FIXED MAXIMUM DELAYS & RESISTANCE VALUES* (OHMS) FOR REDUCING DELAYS FROM FIXED MAX. TO . . .

FIXED MAX. †DELAY (Sec.)	(MODELS SOIF, SOEF) ¼	½	¾	(MODEL SRIF) ¼	½	¾	(MODEL SMIF) ¼	½	¾	SHORT CKT. DELAY (Sec.)
1	3300	9100	20K	18K	56K	160K	5100	10K	56K	0.1
5	27K	75K	220K	110K	330K	910K	27K	82K	270K	0.1
10	56K	150K	430K	240K	750K	2 meg.	51K	160K	510K	0.1
30	56K	180K	510K	240K	750K	2 meg.	51K	150K	470K	0.6
60	120K	360K	1.1 meg.	510K	1.6 meg.	6.2 meg.	110K	330K	1.3 meg.	0.6
120	240K	680K	2.2 meg.	910K	3 meg.	12 meg.	180K	560K	1.8 meg.	1.8
180	330K	1 meg.	3.3 meg.	1.3 meg.	4.3 meg.	20 meg.	820K	910K	3 meg.	1.8

*Resistances designated were selected to correspond to standard E.I.A. values so that the reduced delays are approximate only.
†Where a remote variable resistance (control) is employed, the longest delay obtainable will generally be 90% of the stated "fixed maximum" delay and this is obtainable with the use of a potentiometer having a resistance equal to approximately 10 times the resistance shown in the "½" columns above.

ORDERING CODES

The catalog numbers listed in the tables of Types and Ratings are really descriptive codes based on the following schemes:

SOIV - 115A - O

Relay Type | Internal or Ext. Relay | Variable or Fixed Delay | Supply Voltage | Delay Range or Value

Relay Type:
SO — Delay on Operate
SR — Delay on Release
SM — Momentary Actuation

Internal or External Relay:
Internal = I
External = E

Variable or Fixed Delay:
Variable = V
Fixed = F

Supply Voltage:
24 VAC = 24A
115 VAC = 115A
24 VDC = 24D
48 VDC = 48D
110 VDC = 110D

Delay Range or Value:

Range or Value (Seconds)	Code	Range or Value (Seconds)	Code
0.1–10	0	10	5
0.6–60	1	30	6
1.8–180	2	60	7
1	3	120	8
5	4	180	9

TABLE III — RECOMMENDED EXTERNAL RELAYS*

Relays in Tint areas are Enclosed Types

External Relay Model		External Relay Cat. No. Prefix	24VAC	115VAC	24VDC	48VDC	110VDC
		For Time Delay Models	SOEV—24A— SOEF—24A—	SOEV—115A— SOEF—115A—	SOEV—24D— SOEF—24D—	SOEV—48D— SOEF—48D—	SOEV—110D— SOEF—110D—
			External Relay Cat. No. Suffixes				
GPR—5 Amp. Contacts	SPDT	GPRX—		—191T	—66T		—75T
		GPRTAX—		—191T	—66T		—75T
		GPRTTX—		—191T	—66T		—75T
		GPRTPX—		—191T	—66T		—75T
	DPDT	GPRX—		—192T	—69T		—78T
		GPRTAX—		—192T	—69T		—78T
		GPRTTX—		—192T	—69T		—78T
		GPRTSX—			—69T		—78T
		GPRTPX—		—192T	—69T		—78T
	3PDT	GPRX—		—193T	—72T		—81T
		GPRTAX—		—193T	—72T		—81T
		GPRTTX—		—193T	—72T		—81T
		GPRTSX—			—72T		—81T
		GPRTPX—		—193T	—72T		—81T
	4PDT	GPRX—		—473T	—424T		—427T
		GPRTSX—		—473T	—424T		—427T
GPR—10 Amp. Contacts	SPDT	GPRX—		—391T	—266T		—275T
		GPRTPX—		—391T	—266T		—275T
	DPDT	GPRX—	—329	—392T	—269T	—326	—278T
		GPRTSX—			—269T		—278T
		GPRTPX—	—335	—392T	—269T	—333	—278T
	3PDT	GPRX—	—330	—393T	—272T	—327	—281T
		GPRTSX—			—272T		—281T
		GPRTPX—	—336	—393T	—272T	—334	—281T
	4PDT	GPRX—	—331	—483T	—454T	—328	—457T
		GPRTSX—	—119	—483T	—454T	—118	—457T
DOS[1]	DPDT	[1]DOSX—	—631	—632	—9T	—633	—59T
DO[2]	3PDT	[2]DOX—	—459	—460	—141T	—248	—93T
	4PDT	[2]DOX—	—461	—462	—137T	—384	—187T

[1]15A Contacts [2]10A Contacts

*See Catalog 700 for description of External Relays

TABLE IV — DELAY ON OPERATE — INTERNAL RELAY (DPDT 10A CONTACTS): VARIABLE DELAY — "SOIV"

Delay Range*	Dimen. P. 3	Wiring P. 7	SUPPLY VOLTAGE 24VAC	115VAC	24VDC	48VDC	110VDC
0.1—10			SOIV—24A—0	SOIV—115A—0	SOIV—24D—0	SOIV—48D—0	SOIV—110D—0
0.6—60	A	A	SOIV—24A—1	SOIV—115A—1	SOIV—24D—1	SOIV—48D—1	SOIV—110D—1
1.8—180			SOIV—24A—2	SOIV—115A—2	SOIV—24D—2	SOIV—48D—2	SOIV—110D—2

*Seconds

TABLE V — DELAY ON OPERATE — INTERNAL RELAY (DPDT 10A CONTACTS): FIXED DELAY — "SOIF"

Delay*	Dimen. P. 3	Wiring P. 7	SUPPLY VOLTAGE 24VAC	115VAC	24VDC	48VDC	110VDC
1			SOIF—24A—3	SOIF—115A—3	SOIF—24D—3	SOIF—48D—3	SOIF—110D—3
5			SOIF—24A—4	SOIF—115A—4	SOIF—24D—4	SOIF—48D—4	SOIF—110D—4
10			SOIF—24A—5	SOIF—115A—5	SOIF—24D—5	SOIF—48D—5	SOIF—110D—5
30	C	B	SOIF—24A—6	SOIF—115A—6	SOIF—24D—6	SOIF—48D—6	SOIF—110D—6
60			SOIF—24A—7	SOIF—115A—7	SOIF—24D—7	SOIF—48D—7	SOIF—110D—7
120			SOIF—24A—8	SOIF—115A—8	SOIF—24D—8	SOIF—48D—8	SOIF—110D—8
180			SOIF—24A—9	SOIF—115A—9	SOIF—24D—9	SOIF—48D—9	SOIF—110D—9

*Seconds

TABLE VI — DELAY ON OPERATE — EXTERNAL RELAY: VARIABLE DELAY — "SOEV"

Delay Range*	Dimen. P. 3	Wiring P. 7	SUPPLY VOLTAGE 24VAC	115VAC	24VDC	48VDC	110VDC
0.1—10			SOEV—24A—0	SOEV—115A—0	SOEV—24D—0	SOEV—48D—0	SOEV—110D—0
0.6—60	B	C	SOEV—24A—1	SOEV—115A—1	SOEV—24D—1	SOEV—48D—1	SOEV—110D—1
1.8—180			SOEV—24A—2	SOEV—115A—2	SOEV—24D—2	SOEV—48D—2	SOEV—110D—2

*Seconds

TABLE VII — DELAY ON OPERATE — EXTERNAL RELAY: FIXED DELAY — "SOEF"

Delay*	Dimen. P. 3	Wiring P. 7	SUPPLY VOLTAGE 24VAC	115VAC	24VDC	48VDC	110VDC
1			SOEF—24A—3	SOEF—115A—3	SOEF—24D—3	SOEF—48D—3	SOEF—110D—3
5			SOEF—24A—4	SOEF—115A—4	SOEF—24D—4	SOEF—48D—4	SOEF—110D—4
10			SOEF—24A—5	SOEF—115A—5	SOEF—24D—5	SOEF—48D—5	SOEF—110D—5
30	D	D	SOEF—24A—6	SOEF—115A—6	SOEF—24D—6	SOEF—48D—6	SOEF—110D—6
60			SOEF—24A—7	SOEF—115A—7	SOEF—24D—7	SOEF—48D—7	SOEF—110D—7
120			SOEF—24A—8	SOEF—115A—8	SOEF—24D—8	SOEF—48D—8	SOEF—110D—8
180			SOEF—24A—9	SOEF—115A—9	SOEF—24D—9	SOEF—48D—9	SOEF—110D—9

*Seconds

TABLE VIII — DELAY ON RELEASE — INTERNAL RELAY (DPDT 10A. CONTACTS): VARIABLE DELAY — "SRIV"

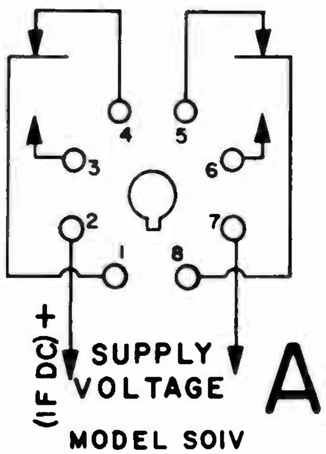
Delay Range*	Dimen. P. 3	Wiring P. 7	SUPPLY VOLTAGE 24VAC	115VAC	24VDC	48VDC	110VDC
0.1—10			SRIV—24A—0	SRIV—115A—0	SRIV—24D—0	SRIV—48D—0	SRIV—110D—0
0.6—60	A	E	SRIV—24A—1	SRIV—115A—1	SRIV—24D—1	SRIV—48D—1	SRIV—110D—1
1.8—180			SRIV—24A—2	SRIV—115A—2	SRIV—24D—2	SRIV—48D—2	SRIV—110D—2

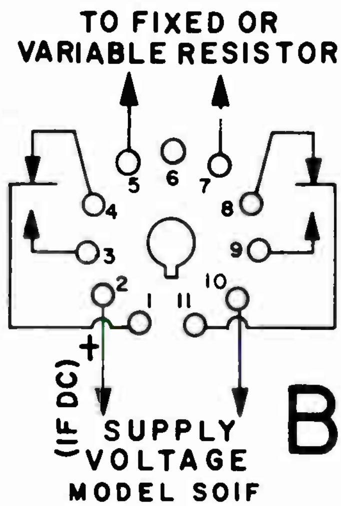
*Seconds

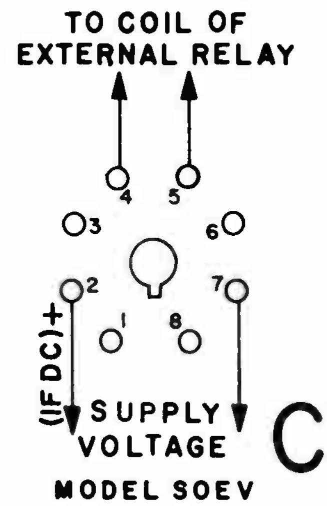
(Continued on back page)

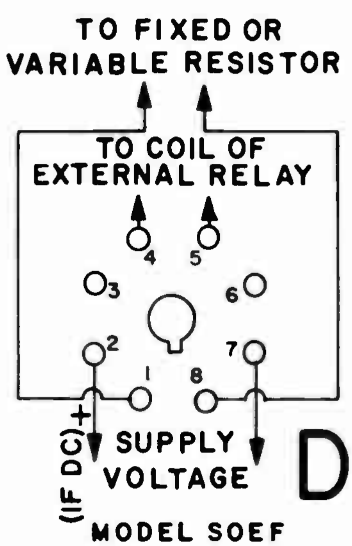
PLUG WIRING DIAGRAMS

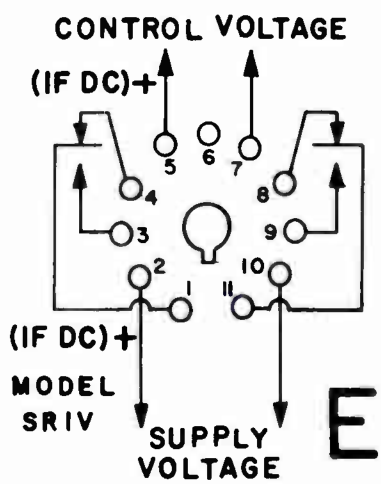
Time Delay Relays

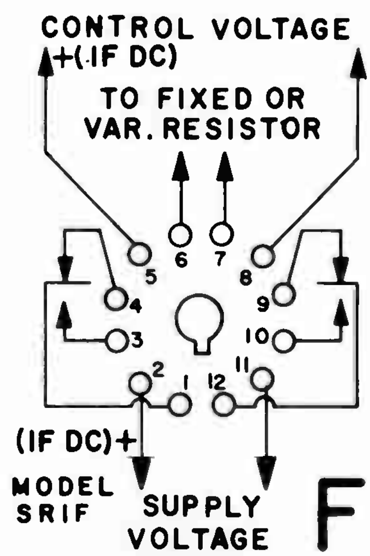


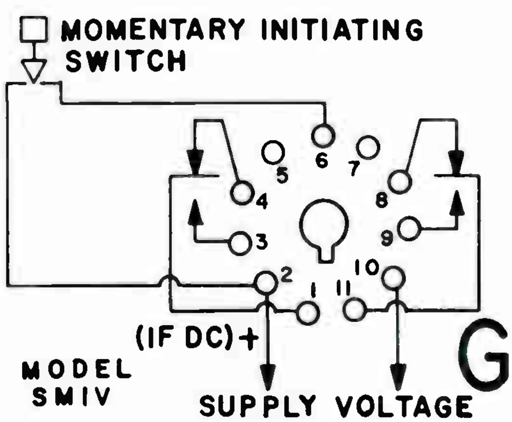


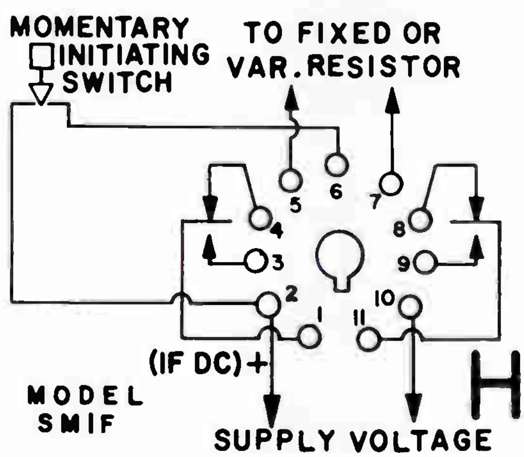












TYPES AND RATINGS

Time Delay Relays...(Continued)

TABLE IX — DELAY ON RELEASE — INTERNAL RELAY (DPDT 10A. CONTACTS): FIXED DELAY — "SRIF"

Delay*	Dimen. P. 3	Wiring P. 7	SUPPLY VOLTAGE 24VAC	115VAC	24VDC	48VDC	110VDC
1	C	F	SRIF—24A—3	SRIF—115A—3	SRIF—24D—3	SRIF—48D—3	SRIF—110D—3
5			SRIF—24A—4	SRIF—115A—4	SRIF—24D—4	SRIF—48D—4	SRIF—110D—4
10			SRIF—24A—5	SRIF—115A—5	SRIF—24D—5	SRIF—48D—5	SRIF—110D—5
30			SRIF—24A—6	SRIF—115A—6	SRIF—24D—6	SRIF—48D—6	SRIF—110D—6
60			SRIF—24A—7	SRIF—115A—7	SRIF—24D—7	SRIF—48D—7	SRIF—110D—7
120			SRIF—24A—8	SRIF—115A—8	SRIF—24D—8	SRIF—48D—8	SRIF—110D—8
180			SRIF—24A—9	SRIF—115A—9	SRIF—24D—9	SRIF—48D—9	SRIF—110D—9

*Seconds

TABLE X — MOMENTARY ACTUATION — INTERNAL RELAY (DPDT 10A. CONTACTS): VARIABLE INTERVAL — "SMIV"

On or Off Interval Range*	Dimen. P. 3	Wiring P. 7	SUPPLY VOLTAGE 24VAC	115VAC	24VDC	48VDC	110VDC
0.1—10	A	G	SMIV—24A—0	SMIV—115A—0	SMIV—24D—0	SMIV—48D—0	SMIV—110D—0
0.6—60			SMIV—24A—1	SMIV—115A—1	SMIV—24D—1	SMIV—48D—1	SMIV—110D—1
1.8—180			SMIV—24A—2	SMIV—115A—2	SMIV—24D—2	SMIV—48D—2	SMIV—110D—2

*Seconds

TABLE XI — MOMENTARY ACTUATION — INTERNAL RELAY (DPDT 10A. CONTACTS): FIXED INTERVAL — "SMIF"

On or Off Interval	Dimen. P. 3	Wiring P. 7	SUPPLY VOLTAGE 24VAC	115VAC	24VDC	48VDC	110VDC
1	C	H	SMIF—24A—3	SMIF—115A—3	SMIF—24D—3	SMIF—48D—3	SMIF—110D—3
5			SMIF—24A—4	SMIF—115A—4	SMIF—24D—4	SMIF—48D—4	SMIF—110D—4
10			SMIF—24A—5	SMIF—115A —5	SMIF—24D—5	SMIF—48D—5	SMIF—110D—5
30			SMIF—24A—6	SMIF—115A—6	SMIF—24D—6	SMIF—48D—6	SMIF—110D—6
60			SMIF—24A—7	SMIF—115A—7	SMIF—24D—7	SMIF—48D—7	SMIF—110D—7
120			SMIF—24A—8	SMIF—115A—8	SMIF—24D—8	SMIF—48D—8	SMIF—110D—8
180			SMIF—24A—9	SMIF—115A—9	SMIF—24D—9	SMIF—48D—9	SMIF—110D—9

*Seconds

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has the answer

in products for today's & tomorrow's circuitry

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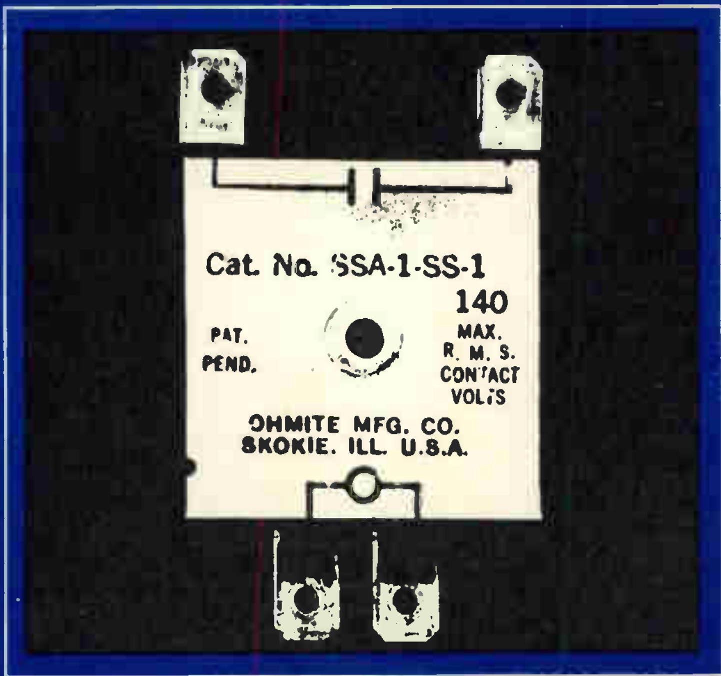
OHMITE

SOLID STATE RELAYS

CATALOG 750A

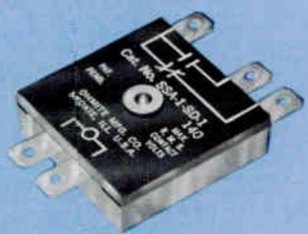


OHMITE
has another
new answer

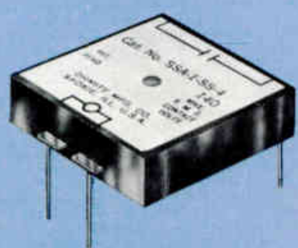
MODELS SSA & SSB SOLID STATE RELAYS

OHMITE

"Coil" and "Contacts"
The models SSA and SSB relays are all solid state and therefore do not employ conventional coil and contacts. However, in describing the functional parameters of the relays, the terms "coil" and "contacts" are used in the analogous sense to aid understanding.



3-Way Terminals
Quick Connect—Solder—Screw
Styles 1 and 3



Printed Circuit Terminals
Style 4

Octal Pin Plug
Style 5

Octal Pin Plug With
Integral Heat Dissipator
Style 6

Ohmite Models SSA and SSB relays are completely solid state; there are no moving parts, nothing to wear or fall out of adjustment. Being all solid state, these relays perform excellently under extreme environmental conditions such as severe shock and vibration, dust and high rates of actuation. They are true relays in the functional sense because the input is completely isolated from the switching elements.

Hi-Rel, Long Life

Ohmite solid state relays provide the ultimate in reliability, long life and trouble-free service. Expected electrical life is over 10^8 operations. There are no contacts to bounce and there is little chance for erratic operation under abnormal conditions.

Opens New Applications

Although SSA and SSB relays can be used to replace electro-mechanical relays in critical applications where exceptional life and reliability are paramount or where reduction of maintenance is desired, the unusual flexibility and sensitivity of the relay enables it to be used in highly specialized applications where electro-mechanical relays cannot be applied successfully. For instance, the predictable threshold voltage (pull-in/drop-out) and other design features enable the relay to be applied in level detectors, go/no-go differentials and servo applications, to name a few.

Predictable DC Threshold Voltage (Pull-in/Drop-out)

These relays have a predictable low DC threshold voltage with low hysteresis (typically 175 millivolts), something not offered in electromechanical or other solid state relays. The "contacts" will always close when the threshold voltage is applied to the "coil' and will always open when the voltage is reduced below the threshold. The threshold voltage is in the range of 2.5 to 4.5 VDC depending upon model.

Highly Sensitive

SSA and SSB relays will operate on as little as six milliwatts and will not draw more than two milliamps independent of the "coil" voltage level. They are capable of being operated directly from integrated circuit generated logic signals. They can serve as an interface between linear or digital systems and power circuits.

Basic model
8/15-28
based on
Quan

MODELS SSA & SSB SOLID STATE RELAYS

OHMITE

Wide "Coil" Voltage Range

Any one Model SSA catalog number operates on any input voltage within the nominal range of 4.5 to 140 VAC (to 25 KHz) or 4 to 200 VDC, a unique feature not normally associated with relays. Likewise, any one Model SSB catalog number operates on any input voltage within the range of 4 to 50 VAC or 2.75 to 50 VDC. When specifying an Ohmite SSA or SSB relay, the coil voltage need not be specified as long as the relay will be operated from a source voltage within the stated ranges.

Transient Protection

The relay is protected from transient voltages. The extent of protection from **damage** of either the "coil" or "contacts" is shown in Figure 1.
Also inherent in the design is protection from **false actuation** resulting from transient voltages. Both false actuation and damage due to transients is characteristic of other solid state switching devices.

Surge Current Handling

The relay is capable of withstanding current surges of at least 10 times rated current within the limits shown in Figure 2. Surge current overloads within these limits should not be repeated more than once per minute.

Load Current/Temperature Derating

Temperature measurement is made near the center of the metal mounting for styles 1, 3 and 4. Ratings for styles 5 and 6 (octal base) shown in the "Types and Ratings" table are not intended to be derated based on the curves shown in Figure 3.

Standard or Synchronous Switching

All relays switch 50/60 Hz AC power. Drop-out ("turn-off") occurs at the zero current crossing point.

Standard models turn on at any point in a half cycle and turn off at any half cycle zero crossing point. **Synchronous** models turn on only at a zero crossing point and turn off only at a full cycle zero crossing point. See Figure 4. The synchronous option provides the switching function free of radio frequency interference, a very important consideration in meeting EMI requirements in computer and military systems.

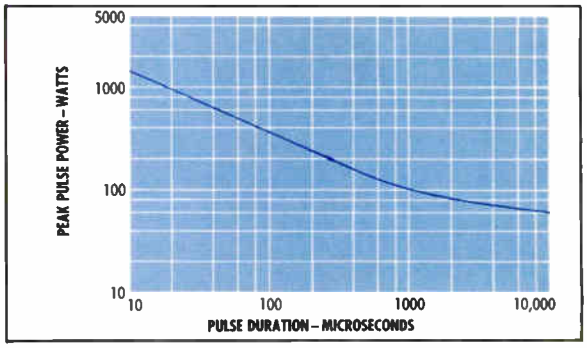


FIG. 1. TRANSIENT PROTECTION

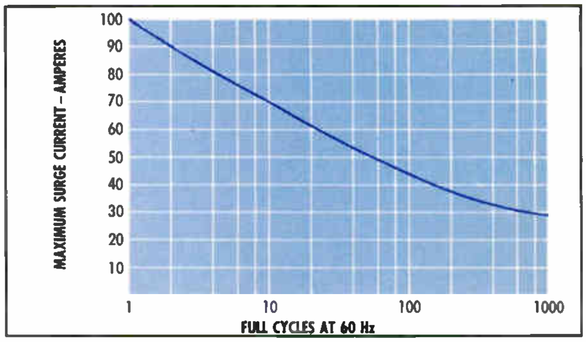


FIG. 2. SURGE CURRENT HANDLING

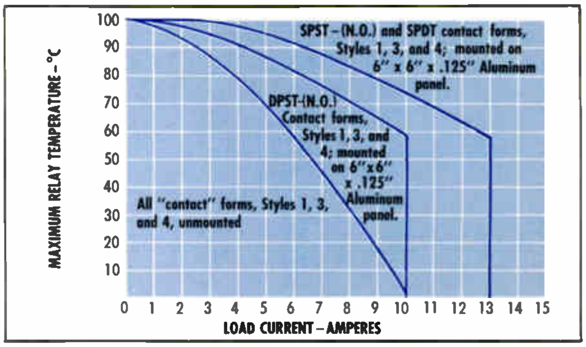


FIG. 3. LOAD CURRENT/TEMPERATURE DERATING

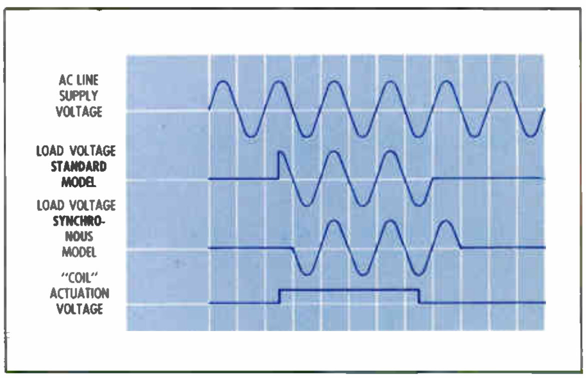


FIG. 4. STANDARD AND SYNCHRONOUS "TURN-ON" SEQUENCE

MODELS SSA & SSB SOLID STATE RELAYS

OHMITE

FIG. 5. TYPICAL MARKINGS FOR WIRING.

"Contacts" and Ratings

Models SSA and SSB relays are available in SPST (N.O.), DPST (N.O.) and SPDT "contact" configurations. They are intended for switching AC power—50/60 Hertz. For 400 Hz models, consult factory.

The AC currents these relays are capable of switching depend on the physical style and/or the manner in which the relay is mounted. For example, the basic SSA or SSB relay (Styles 1 and 3) unmounted, can switch currents of 2 amperes at 40°C ambient (3 amperes at 25°C). Mounted on a metal panel of sufficient size, the same relay will switch 10 amperes at 40°C (13.0 amperes at 25°C). Relay styles such as octal base styles which cannot readily transfer heat to the mounting surface, are rated on the same basis as the basic, unmounted styles. The various models, catalog designations and current ratings are shown in the table, "Types and Ratings," page 6.

Rugged, Compact Construction

Tough transfer molded plastic package completely encloses the all solid state circuitry. Impervious to environmental conditions. Metal mounting surface assures efficient heat transfer.

Safety

The relay is incapable of producing any arcing which, under abnormal conditions, could supply ignition to potentially explosive atmospheres.

Military Specifications

The relay is designed to meet the requirements of MIL-STD-202 in respect to shock, vibration, altitude, acceleration, salt spray and humidity.

SPECIFICATIONS

ELECTRICAL

"CONTACTS"

Forms: SPST—(N.O), DPST—(N.O.), SPDT. Standard models switch 50/60Hz AC only.

Ratings: **Maximum:** 10A, @ 40°C (13A @ 25°C) depending on model and mounting. See Fig. 2 and Fig. 3, page 3 for temperature derating and surge current data.
Minimum: 10mA.
Voltage: 140 or 260 VAC. maximum depending on model.

Resistance: **Closed ("On"):** 75 milliohms minimum, typically 1 to 1.5V. drop.
Open ("Off"): 55K ohms typical.

Isolation: 500 gigaohms—"coil" to "contacts," "contacts" to mounting plate, mounting plate to "coil"

Dielectric Strength: 1500 V RMS—"coil" to "contacts," "contacts" to mounting plate, mounting plate to "coil."

Transient Protection: See Figrue 1, page 3.

Speed of Operation:

Standard Model. **Pull-in ("Turn-on":** 5 microseconds for all voltages, AC or DC.
Drop-out ("Turn-off") 100 microseconds to 8.3 milliseconds (60Hz).

Synchronous Option: **Pull-in ("Turn-on")** 100 microseconds to 8.3 milliseconds (60Hz)
Drop-out ("Turn-off"): 135 microseconds to 16.6 milliseconds (60Hz)

"COIL"

Input Voltage: Any voltage in the range of 4.5± .75 to 140 VAC (to 25 KHz) or 4± .5 to 200 VDC, for model SSA. Also, any voltage in the range of 4± .75 to 50 VAC or 2.75± .25 to 50 VDC, for model SSB. Lower pull-in/drop-out voltages are available.
Operate-Realease Voltage: DC hysteresis typically 175 millivolts.
Current: 2 milliamps maximum, independent of voltage.
Transient Protection: See Figure 1, page 3.

MECHANICAL

Ambient Temp. Range: —55°C to +85°C
Shock/Vibration: Meets requirements of MIL-STD-202.
Mounting: For full "contact" ratings for styles 1 and 3, mount basic models on an aluminum panel 6" x 6" x ⅛" or equivalent. See dimensional drawings for mounting method data.
Terminals: Styles 1 and 3 offer quick-connect and solder, or screw termination, respectively. Styles 5 and 6 provide octal pin base mounting/termination.
Weight: 31 grams (1.1 oz.)

MODELS SSA & SSB SOLID STATE RELAYS

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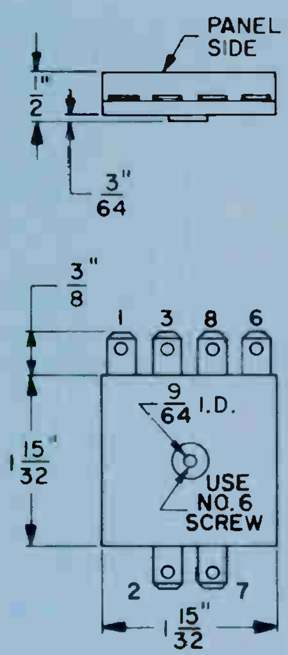
DIMENSIONS

Style 1
Style 3

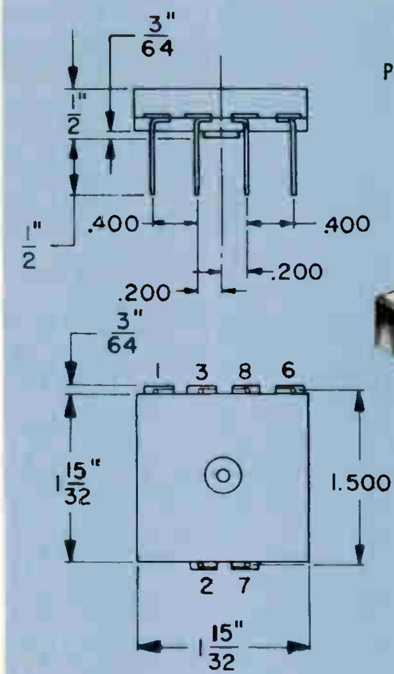
Style 1: quick-connected terminals—mates with AMP ¼" FASTON—tinned solderable (replaces old sty. 2).

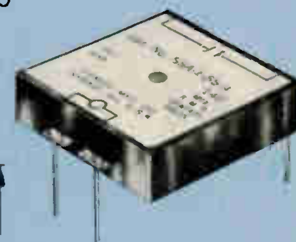
Style 3: screw terminals



Style 4

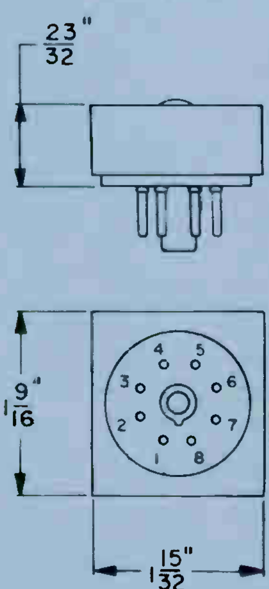
Printed Circuit Board Mounting





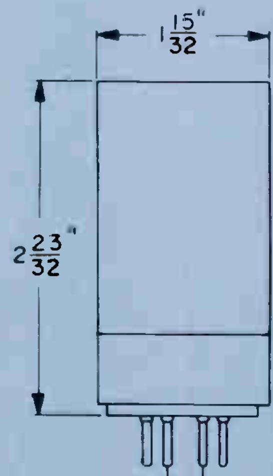
Style 5

Octal base mounting.



Style 6

Octal base with heat dissipator.



TYPES & RATINGS

"CONTACT" FORM	MAX. VOLTS R.M.S. 50/60 Hz	CATALOG NUMBER [1]	"CONTACTS" RATING (AMPS-AC) @ 40C° NOT MTD.	@ 40C° MTD. [2]	@ 25°C NOT MTD.	@ 25°C MTD. [2]	TERM-INAL [3] NOS.	NORMAL POSITION	"COIL" INPUT VOLTS DC	"COIL" INPUT VOLTS AC TO 25 KHz	"COIL" TERM-INALS [3]
SPST—N.O	140	SS*-1-SS-1 SS*-1-SS-3 SS*-1-SS-4	2	10	3	13	1,6	Open	4 to 200 for model SSA 2.75 to 50 for model SSB	4.5 to 140 for model SSA 4 to 50 for model SSB	2, 7
		SS*-1-SS-5 SS*-1-SS-6	2 6	2 6	3 7	3 7					
	260	SS*-2-SS-1 SS*-2-SS-3 SS*-2-SS-4	2	10	3	13					
		SS*-2-SS-5 SS*-2-SS-6	2 6	2 6	3 7	3 7					
DPST—N.O.	140	SS*-1-DS-1 SS*-1-DS-3 SS*-1-DS-4	2	7	3	10	1,3 8,6	Open			
		SS*-1-DS-5 SS*-1-DS-6	2 4	2 4	3 6	3 6					
	260	SS*-2-DS-1 SS*-2-DS-3 SS*-2-DS-4	2	7	3	10					
		SS*-2-DS-5 SS*-2-DS-6	2 4	2 4	3 6	3 6					
SPDT	140	SS*-1-SD-1 SS*-1-SD-3 SS*-1-SD-4	2	10	3	13	1,8 – 1,6	N.O.-N.C.			
		SS*-1-SD-5 SS*-1-SD-6	2 6	2 6	3 7	3 7	1,6 – 1,3	N.O-N.C.			
	260	SS*-2-SD-1 SS*-2-SD-3 SS*-2-SD-4	2	10	3	13	1,8 – 1,6	N.O.-N.C.			
		SS*-2-SD-5 SS*-2-SD-6	2 6	2 6	3 7	3 7	1,6 – 1,3	N.O.-N.C.			

[1] The last digit or suffix (-1, -3 etc.) represents different terminal styles as described on page 5. The optional synchronous switching feature is indicated by adding an "S" at the end of the catalog number. See "Ordering Codes" below for catalog number formula explanation.

* Insert an "A" or "B" depending on model desired.

[2] Rating when mounted to an aluminum panel 6" x 6" x .125 or equivalent.

[3] See page 5, "Dimensions", for terminal or pin designations.

Multiple Poles: To obtain multiple pole combinations such as DPDT, "coils" of multiple units can be connected in parallel.

Caution: Paralleling "contacts" to increase rating is not recommended.

ORDERING CODES

The catalog numbers shown in the table of "Types and Ratings" are descriptive codes based on the following formula:

SSA-1-DS-5S

I. Model — II. Max "Contact" Volts — III. "Contact" Form — IV. Terminal/ Mounting — V. Synchronous (option)

I. Model: SSA = all solid state—Type A
SSB = all solid state—Type B

II. Max. Contact Volts: 1 = 140 volts RMS
2 = 260 volts RMS

III. "Contact" Form:

SS = Single pole, single throw, normally open
DS = Double pole, single throw, normally open
SD = Single pole, double throw

IV. Terminal/Mounting

Describes the physical construction and/or mounting arrangements of the relay as follows:

Style 1. Basic model with tinned quick-connect terminals, suitable for soldering.

3. Basic model with screw terminals.

4. Printed circuit board mounting.

5. Octal base mounting.

6. Octal base with heat dissipator.

V. Synchronous: Add "S" to the catalog number when synchronous switching feature is desired.

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in relays for today's and tomorrow's circuitry

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GPR—GENERAL PURPOSE

- 5 and 10 amp capacity
- Up to 4PDT
- Open frame and enclosed models
- Multiple use terminals
- Over 300 models in stock

DO—DOS—INDUSTRIAL

- 15 and 25 amp capacity
- Long life
- Heavy duty construction
- Single and dual coils

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- Fail-safe—shock resistant
- No levers to adjust
- Small—same size as general purpose relay
- Positive action
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- 5 Amp Capacity
- 4PDT and 6PDT
- Plug-in, solder or quick-connect terminal
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- Fixed or variable
- Delays to 180 seconds
- Delay on operate or release
- Momentary action

Variable Delay with internal relay

Variable Delay Module — requires external relay

Fixed Delay with internal relay

Fixed Delay module — requires external relay

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SOLID STATE RELAYS

CATALOG 750

September, 1968/Supersedes Bulletin 710

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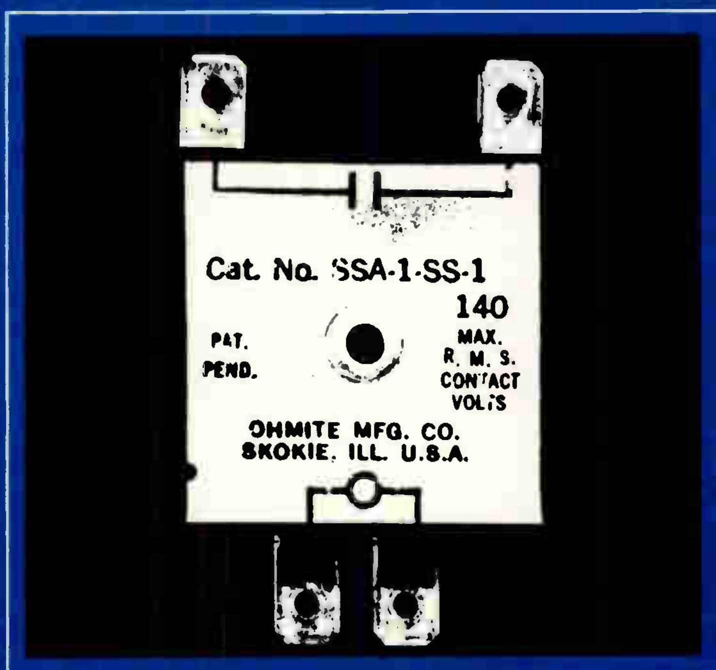


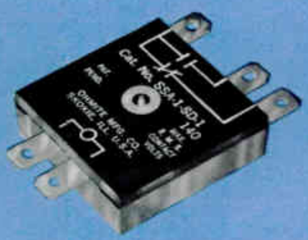
Patent Pending

OHMITE
has another
new answer

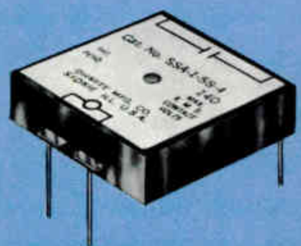
MODEL SSA SOLID STATE RELAYS

OHMITE

"Coil" and "Contacts"
The SSA relay is all solid state and therefore does not employ conventional coil and contacts. However, in describing the functional parameters of the SSA relay, the terms "coil" and "contacts" are used in the analogous sense to aid understanding.



3-Way Terminals
Quick Connect—Solder—Screw
Styles 1, 2, 3 respectively



Printed Circuit Terminals
Style 4

Octal Pin Plug
Style 5

Octal Pin Plug With
Integral Heat Sink
Style 6

Ohmite Model SSA relays are completely solid state; there are no moving parts, nothing to wear or fall out of adjustment. Being all solid state, model SSA relays perform excellently under extreme environmental conditions such as severe shock and vibration, dust and high rates of actuation. Model SSA relays are true relays in the functional sense because the input is completely isolated from the switching elements.

Hi-Rel, Long Life

Ohmite Model SSA relays provide the ultimate in reliability, long life and trouble-free service. Expected electrical life is over 10^8 operations. There are no contacts to bounce so there is not chance for erratic operation under abnormal conditions.

Opens New Applications

Although SSA relays can be used to replace electro-mechanical relays in critical applications where exceptional life and reliability are paramount or where reduction of maintenance is desired, the unusual flexibility and sensitivity of the SSA relay enables it to be used in highly specialized applications where electro-mechanical relays cannot be applied successfully. For instance, the predictable threshold voltage (pull-in/drop-out) and other design features of the SSA enable the relay to be applied in level detectors, go/no-go differentials and servo applications, to name a few.

Predictable Threshold Voltage (Pull-in/Drop-out)

The Model SSA relay has a predictable low threshold voltage with low hysteresis, something not offered in electro-mechanical or other solid state relays. The "contacts" will always close when a minimum of 3 volts is applied to the "coil" and will always open when the voltage is reduced to less than 3 volts.

Highly Sensitive

SSA relays will operate on as little as six milliwatts and will not draw more than two milliamps regardless of the "coil" voltage level. They are capable of being operated directly from integrated circuit generated logic signals. They can serve as an interface between linear or digital systems and power circuits.

MODEL SSA SOLID STATE RELAYS

OHMITE

Wide "Coil" Voltage Range

Any one Model SSA catalog number operates on any input voltage within the range of 3 to 140 VAC (to 25HKz) or 3 to 200 VDC, a unique feature not normally associated with relays. When specifying an Ohmite SSA relay, the coil voltage need not be specified as long as the relay will be operated from a source voltage within the stated ranges.

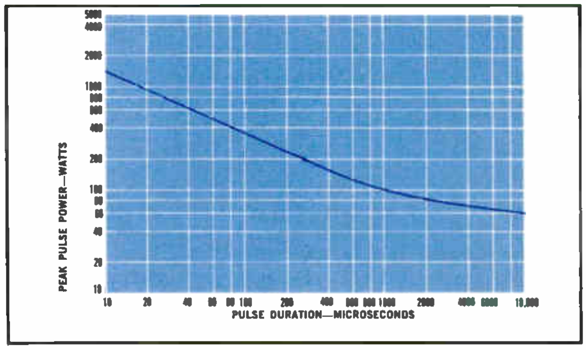


FIG. 1. TRANSIENT PROTECTION

Transient Protection

The SSA is protected from transient voltages. The extent of protection from **damage** of either the "coil" or "contacts" is shown in Figure 1.

Also inherent in the SSA design is protection from **false actuation** resulting from transient voltages. Both false actuation and damage due to transients is characteristic of other solid state switching devices.

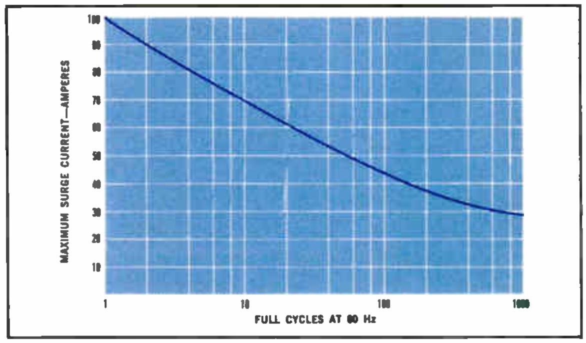


FIG. 2. SURGE CURRENT HANDLING

Surge Current Handling

The SSA relay is capable of withstanding current surges of at least 10 times rated current within the limits shown in Figure 2. Surge current overloads within these limits should not be repeated more than once per minute.

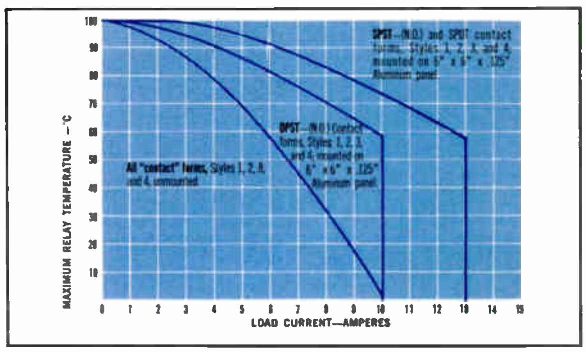


FIG. 3. LOAD/CURRENT TEMPERATURE DERATING

Load/Current Temperature Derating

Temperature measurement is made near the center of the metal mounting plate for styles 1, 2, 3 and 4. Ratings for styles 5 and 6 (octal base) shown in the "Types and Ratings" table are not intended to be derated based on the curves shown in Figure 3.

Standard or Synchronous Switching

All Model SSA relays switch 50/60 Hz AC power. Drop-out ("turn-off") occurs at the zero current crossing point.

Standard models turn on at any point in a half cycle and turn off at any half cycle zero crossing point. **Synchronous** models turn on only at a zero crossing point and turn off only at a full cycle zero crossing point. See Figure 4. The synchronous option provides the switching function free of radio frequency interference, a very important consideration in meeting EMI requirements in computer and military systems.

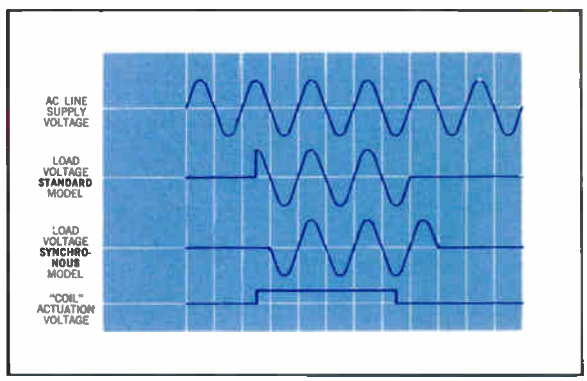


FIG. 4. STANDARD AND SYNCHRONOUS "TURN-ON" SEQUENCE

OHMITE

MODEL SSA SOLID STATE RELAYS

FIG. 5. TYPICAL MARKINGS FOR WIRING.

"Contacts" and Ratings

Ohmite SSA relays are available in SPST (N.O.), DPST (N.O.) and SPDT "contact" configurations. They are intended for switching AC power—50/60 Hertz. For 400 Hz models, consult factory.

The AC currents these relays are capable of switching depend on the physical style and/or the manner in which the relay is mounted. For example, the basic SSA relay (Styles 1, 2, and 3) unmounted, can switch currents of 3 amperes at 40° C ambient (4 amperes at 25° C). Mounted on a metal panel of sufficient size, the same relay will switch 10 amperes at 40° C (13.0 amperes at 25° C). Relay styles such as octal base styles which cannot readily transfer heat to the mounting surface, are rated on the same basis as the basic, unmounted styles. The various models, catalog designations and current ratings are shown in the table, "Types and Ratings," page 6.

Rugged, Compact Construction

Tough transfer molded plastic package completely encloses solid state circuitry—all silicon devices. Impervious to environmental conditions. Metal mounting surface assures efficient heat transfer.

Safety

Underwriters Laboratories listing can be obtained on a specific application basis.

The SSA relay is incapable of producing any arcing and/or sparking and contains no energy storage circuits which, under abnormal conditions, could supply sparking to potentially explosive atmospheres.

Military Specifications

The SSA relay is designed to meet the requirements of MIL-STD-202 in respect to shock, vibration, altitude, acceleration, salt spray and humidity.

SPECIFICATIONS

ELECTRICAL

"CONTACTS"

Forms: SPST—(N.O.). DPST—(N.O.), SPDT. Standard models switch 50/60Hz AC only.

Ratings: **Maximum:** 10A, Resistive or Inductive @ 40°C (13A @ 25°C) depending on model and mounting. See Fig. 2 and Fig. 3, page 3 for temperature derating and surge current data.
Minimum: 10mA.
Voltage: 140 or 260 VAC. maximum depending on model.

Resistance: **Closed ("On"):** 100 milliohms, typically .75 to 1.0V. drop.
Open ("Off"): 1.5 megohms typical.

Isolation: 500 Kilomegohms—"coil" to "contacts," "contacts" to mounting plate, mounting plate to "coil"

Dielectric Strength: 2000 V RMS-"coil" to "contacts," "contacts" to mounting plate, mounting plate to "coil."

Transient Protection: See Figure 1, page 3.

Speed of Operation:
Standard Model. **Pull-in ("Turn-on"):** 5 microseconds for all voltages, AC or DC.
Drop-out ("Turn-off") 100 microseconds to 8.3 milliseconds (60Hz).
Synchronous Option: **Pull-in ("Turn-on"):** 100 microseconds to 8.3 milliseconds (60Hz)
Drop-out ("Turn-off"): 135 microseconds to 16.6 milliseconds (60Hz)

"COIL"

Input Voltage: Any voltage in the range of 3 to 140VAC (to 25KHz) or 3 to 200VDC.

Operate-Release Voltage: Predictable pull-in/drop-out threshold of 3 volts, AC or DC.

Current: 2 milliamps maximum, independent of voltage.

Impedance: Below 3 volt threshold: 15 megohms
Above 3 volt threshold: 100K ohms, minimum, and constant over entire voltage range.

Transient Protection: See Figure 1, page 3.

MECHANICAL

Ambient Temp. Range: —55°C to +85°C

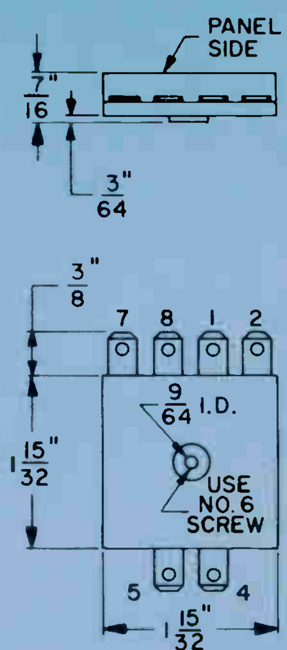
Shock/Vibration: Meets requirements of MIL-STD-202.

Mounting: For full "contact" ratings for styles 1, 2, and 3, mount basic models on an aluminum panel 6" x 6" x ⅛" or equivalent. See dimensional drawings for mounting method data.

Terminals: Styles 1, 2, and 3 offer quick-connect, solder or screw termination, respectively. Styles 5 and 6 provide octal pin base mounting/termination.

Weight: 31 grams (1.1 oz.)

DIMENSIONS

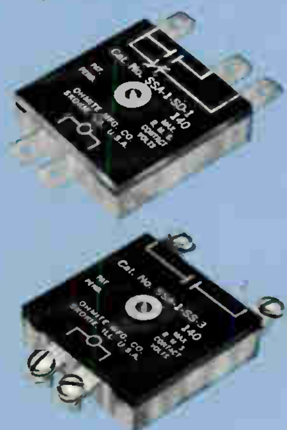


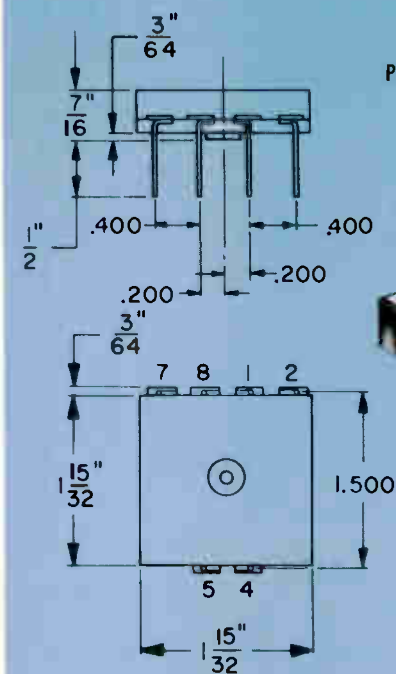
Styles 1 and 2
Style 3

Style 1: quick-connect terminals—mates with AMP ¼" FASTON.

Style 2: tinned solderable terminals

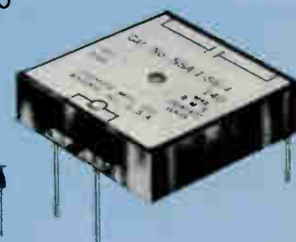
Style 3: screw terminals

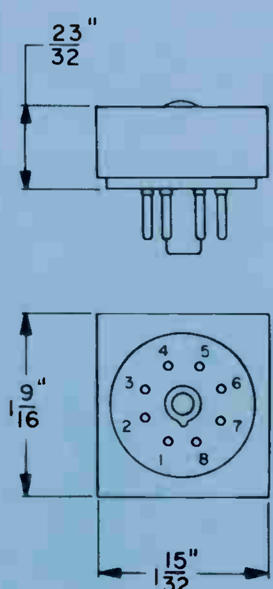




Style 4

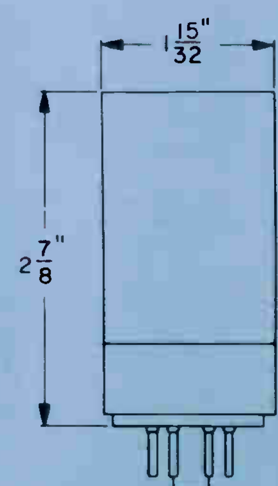
Printed Circuit Board Mounting





Style 5

Octal base mounting. Pin numbers correspond with terminal number of Style 1.



Style 6

Octal base with heat sink. Pin numbers correspond with terminal number of Style 1.

TYPES & RATINGS

"CONTACTS"									"COIL"		
"CONTACT" FORM	MAX. VOLTS R.M.S. 50/60 CPS.	CATALOG NUMBER [1]	RATING (AMPS-AC) @ 40C° NOT MTD.	@ 40C° MTD. [2]	@ 25°C NOT MTD.	@ 25°C MTD. [2]	TERMINAL [3] NOS.	NORMAL POSITION	INPUT VOLTS DC	INPUT VOLTS AC TO 25 K	TERMINALS [3]
		SSA-1-SS-1									
		SSA-1-SS-2	3	10	4	13					
		SSA-1-SS-3									
	140	SSA-1-SS-4					2, 7				
		SSA-1-SS-5	3	3	4	4					
SPST—N.O		SSA-1-SS-6	6	6	7	7					
		SSA-2-SS-1						Open			
		SSA-2-SS-2	3	10	4	13					
		SSA-2-SS-3									
	260	SSA-2-SS-4					2, 7				
		SSA-2-SS-5	3	3	4	4					
		SSA-2-SS-6	6	6	7	7					
		SSA-1-DS-1									
		SSA-1-DS-2	3	7	4	10					
		SSA-1-DS-3					7, 8				
	140	SSA-1-DS-4					1, 2				
		SSA-1-DS-5	3	3	4	4					
DPST—N.O.		SSA-1-DS-6	4	4	6	6					
		SSA-2-DS-1						Open	3 to 200	3 to 140	4, 5
		SSA-2-DS-2	3	7	4	10					
		SSA-2-DS-3					7, 8				
	260	SSA-2-DS-4					1, 2				
		SSA-2-DS-5	3	3	4	4					
		SSA-2-DS-6	4	4	6	6					
		SSA-1-SD-1					7, 1	Open			
		SSA-1-SD-2	3	10	4	13					
		SSA-1-SD-3									
	140	SSA-1-SD-4									
		SSA-1-SD-5	3	3	4	4	7, 2	Closed			
SPDT		SSA-1-SD-6	6	6	7	7					
		SSA-2-SD-1									
		SSA-2-SD-2	3	10	4	13	7, 1	Open			
		SSA-2-SD-3									
	260	SSA-2-SD-4									
		SSA-2-SD-5	3	3	4	4					
		SSA-2-SD-6	6	6	7	7	7, 2	Closed			

[1] The last digit or suffix (-1, -2, -3 etc.) represents different terminal styles as described on page 5. The optional synchronous switching feature is indicated by adding an "S" at the end of the catalog number. See "Ordering Codes" below for catalog number formula explanation.

[2] Rating when mounted to an aluminum panel 6" x 6" x .125 or equivalent.

[3] See page 5, "Dimensions", for terminal or pin designations.

Multiple Poles: "Coils" of multiple units can be connected in parallel.

Caution: Paralleling "contacts" to increase rating is not recommended.

ORDERING CODES

The catalog numbers shown in the table of "Types and Ratings" are descriptive codes based on the following formula:

SSA-1-DS-5S

I. Model — II. Max "Contact" Volts — III. "Contact" Form — IV. Terminal/ Mounting — V. Synchronous (option)

I. Model: SSA = all solid state—Type A

II. Max. Contact Volts: 1 = 140 volts RMS
2 = 260 volts RMS

III. "Contact" Form:

SS = Single pole, single throw, normally open
DS = Double pole, single throw, normally open
SD = Single pole, double throw

IV. Terminal/Mounting

Describes the physical construction and/or mounting arrangements of the relay as follows:

Style 1. Basic model with untinned quick-connect terminals.
2. Basic model with tinned terminals (will also accept quick-connectors).
3. Basic model with screw terminals.
4. Printed circuit board mounting.
5. Octal base mounting.
6. Octal base with heat sink.

V. Synchronous: Add "S" to the catalog number when synchronous switching feature is desired.

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FORM 15

OHMITE

BULLETIN 751

SUPERSEDES CATALOG 750A

ORIGINATORS OF THE HIGH POWER SOLID STATE RELAY

Model SSB Solid State Relay is the "MISSING LINK" between Mini Computer Logic and Power Devices

Model SSB

SOLID STATE RELAY

JAN 16 197

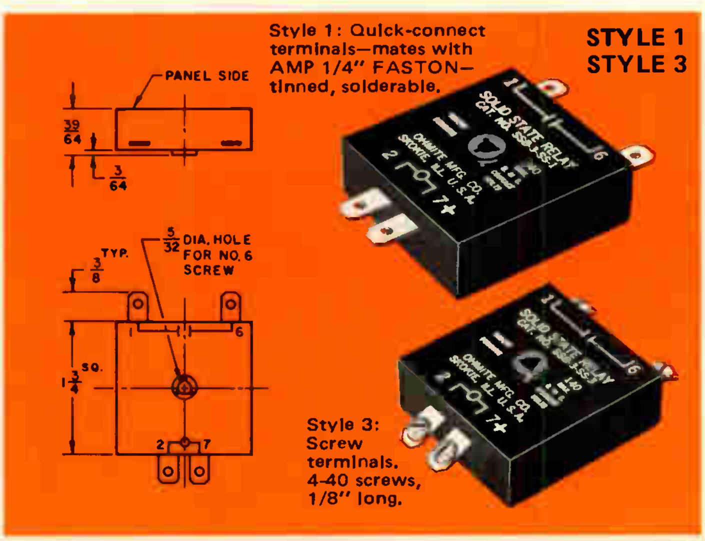
With the advent of linear and digital mini-computers for use in process control applications, interfacing the computer's 3 to 5 volt logic signals with power devices such as contactors, solenoid valves, etc. has been somewhat a problem. The SSB relay is the "missing link" between the computer logic and power devices.

Replacing op-amps and mechanical relays, the Model SSB solid state relay provides compact and complete interfacing while increasing reliability and simplifying design and installation. Full isolation between the output of the computer and the input to power devices is maintained, safeguarding against any interaction between the power and logic circuitry.

Immunity to false actuation is a primary design feature and insures reliable operation in critical systems. This feature is especially important in "missing link" applications where power devices have a history of generating spurious signals. A bogus signal could cause an unsafe personnel environment or spoil a process operation. Particular attention to safe-guarding against this possibility is incorporated in the Ohmite SSB relay.

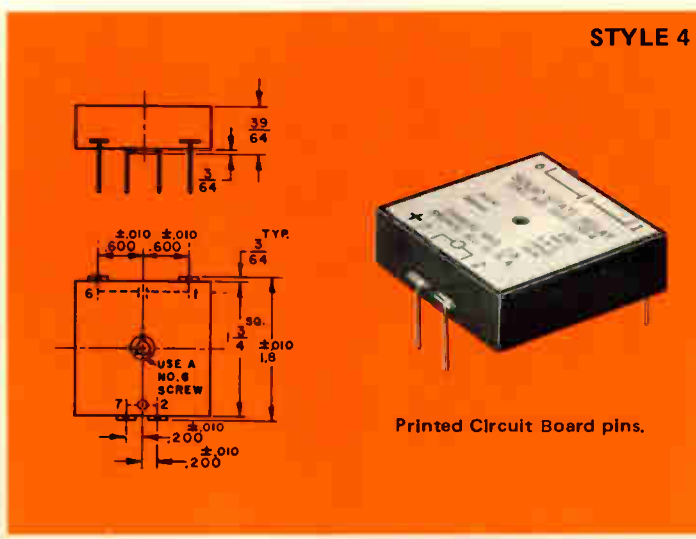
MODEL SSB FEATURES

- Direct interface with low-level logic signals.
- Immunity to false actuation.
- Less than 0.2 V. hysteresis (on-off differential).
- Speed: Pull-in ("on") and Drop-out ("off") is 1/2 cycle load current.
- Highly Sensitive: Draws less than 2 milliamps, independent of input voltage; will operate on as little as 3 milliwatts.
- "Contacts" handle up to 13A, 120V or 240V AC.
- Choice of four types of terminations: Solder/quick-connect, screw, p.c. pins, and octal socket.

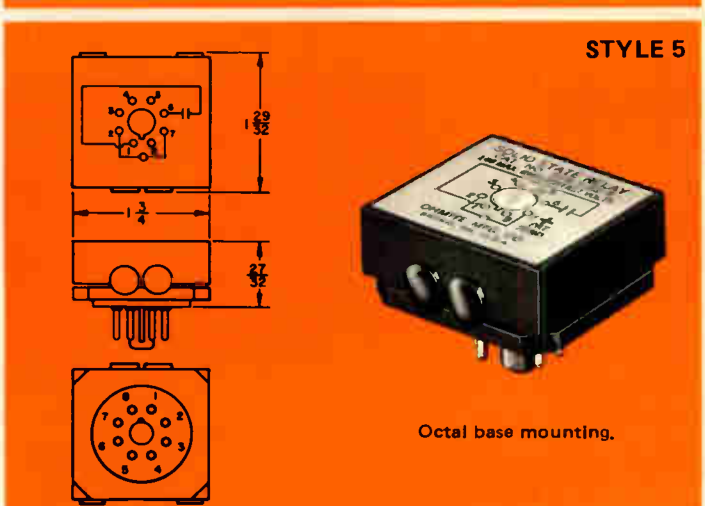


Style 1: Quick-connect terminals—mates with AMP 1/4" FASTON—tinned, solderable.

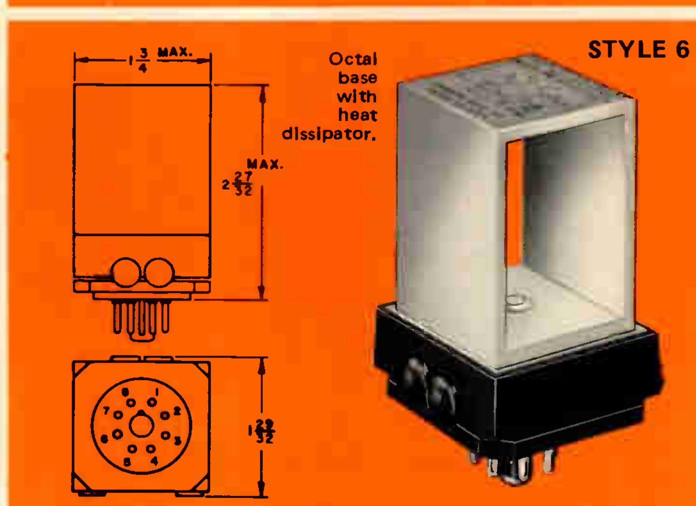
Style 3: Screw terminals. 4-40 screws, 1/8" long.



Printed Circuit Board pins.



Octal base mounting.



Octal base with heat dissipator.

Model SSB

"Coil" and "Contacts"
Model SSB relays are all solid state and therefore do not employ conventional coil and contacts. However, in describing the functional parameters of the relays, the terms "coil" and "contacts" are used in the analogous sense to aid understanding.

SPECIFICATIONS

"COIL"

Input Voltage: Any voltage within the range of 2.5 to 32 volts D.C. maximum.

Threshold Voltage: 3.5 V. maximum, 2.5 V. minimum. (Specific threshold voltages between 2.5 and 3.5 V. available on special order.)

Operate-Release Voltage: D.C. hysteresis maximum is 0.2 volts.

Input Current: 2 milliamps, maximum; 1.7 milliamps, typical, independent of voltage. Requires 7 milliwatts maximum, 5 milliwatts, typical.

"CONTACTS"

Form: SPST-N.O., form A, 50/60 Hz, A.C. only.

Ratings: Maximum: 13 Amperes at 25°C (10 A. @ 40°C) mounted to an aluminum panel 6" x 6" x .125" or equivalent. 3 Amperes at 25°C (2 A. @ 40°C) unmounted, depending on model.

Minimum: 100 milliamps.

Voltage: 120, 240 VAC, RMS, depending on model.

Surge Current: Withstands at least 10 times rated current for 1 cycle of load current.

Voltage Drop: Closed ("ON"), 1 to 1.5 Volts, typical.

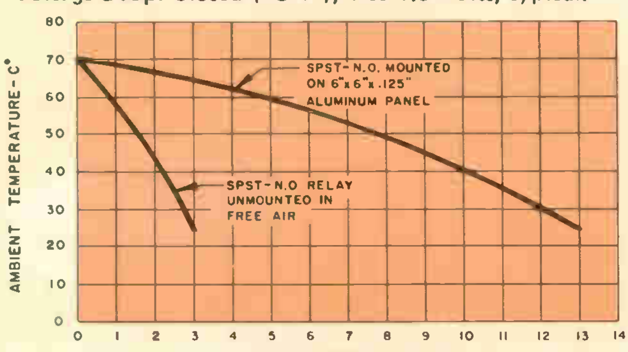


Fig. 1. LOAD CURRENT/TEMPERATURE DERATING

Impedance: Open ("Off"), 26K ohms, typical.

Isolation: 500 gigaohms — "coil" to "contacts", "contacts" to mounting plate, mounting plate to "coil."

Dielectric Strength: 1500 V RMS — "coil" to "contacts", "contacts" to mounting plate, mounting plate to "coil."

Transient Protection: The relay is protected from transient voltages in both the "coil" and "contact" circuitry, to the extent shown in Fig. 2.

Protection from **false actuation** resulting from transient voltages is a primary design feature.

External transient protection devices are not only unnecessary, they are undesirable.

Speed of Operation: Pull-in: 1/2 cycle load current.
Drop-out: 1/2 cycle load current.

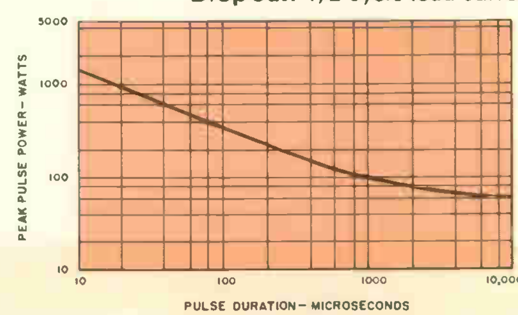


Fig. 2. TRANSIENT PROTECTION

MECHANICAL

Ambient Temp. Range: Storage −55°C to +100°C. Operating 0°C to +70°C.

Mounting: For full "contact" ratings for styles 1 and 3, mount basic models on an aluminum panel 6" x 6" x 1/8" or equivalent. See dimensional drawings for mounting method data.

Terminals: Styles 1 and 3 offer quick-connect and solder, or screw termination, respectively. Style 4 offers pins for printed circuit board mounting. Styles 5 and 6 provide octal pin base mounting/termination. **Weight:** 2 oz. approximately.

TYPES and RATINGS

All relays are SPST-N.O. Contact Factory for SPDT and DPST-N.O. "contact" forms.

Catalog Number	Termination Style	Volts (RMS) 50/60 Hz	Ratings (Amperes, A.C.) @ 25°C		@ 40°C	
			Mounted	Free Air	Mounted	Free Air
SSB-3-SS-1	Quick-connect					
-3	Screw		13	3	10	2
-4	P.C. pins	120				
-5	Octal base		3	3	2	2
-6	Octal base w/heat dissipator		7	7	6	6
SSB-4-SS-1	Quick-connect					
-3	Screw		13	3	10	2
-4	P.C. pins	240				
-5	Octal base		3	3	2	2
-6	Octal base w/heat dissipator		7	7	6	6

Ohmite Manufacturing Company a North American Philips company
3601 Howard Street, Skokie, Illinois 60076/Phone (312) 675-2600/TWX: 910-223-0805/Telex 72-4433

OHMITE

BULLETIN 752

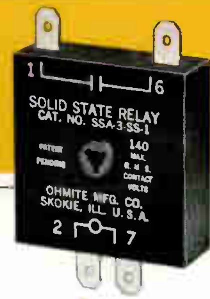
SUPERSEDES CATALOG 750A

ORIGINATORS OF THE HIGH POWER SOLID STATE RELAY

Model SSA Solid State Relays . . . for Interfacing AC or DC Logic With Power Devices

Model SSA

SOLID STATE RELAY



JAN 16 1971

Model SSA relays are all solid state, designed to control power devices (solenoids, contactors, etc.) where logic signals of either AC or DC voltage are available. Highly sensitive, Model SSA's draw less than 2 milliamps, independent of input voltage.

Complete isolation between input and output is maintained, safeguarding against any interaction between the power and logic circuitry.

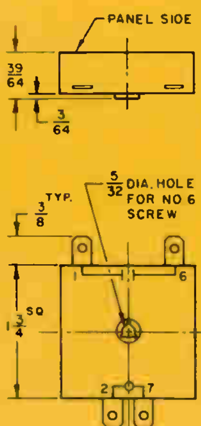
Immunity to false actuation is a primary design feature and assures reliable operation in critical systems. This feature is especially important in applications where power devices could possibly generate spurious signals. A bogus signal could cause an unsafe personnel environment or spoil a process operation. Particular attention to safe-guarding against this possibility is incorporated in the Ohmite SSA relay.

MODEL SSA FEATURES

- Input: 15 to 120 VAC; 10 to 185 VDC (non-polar).
- Highly Sensitive: Draws less than 2 milliamps, independent of input voltage.
- Immunity to false actuation.
- Direct interface with logic signals.
- Complete isolation between input and output.
- Speed: Pull-in ("on") and Drop-out ("off") is 1/2 cycle load current.
- "Contacts" handle up to 13 A, 120V. or 240V AC.
- Choice of four types of terminations: solder/quick-connect, screw, p.c. pins, and octal socket.

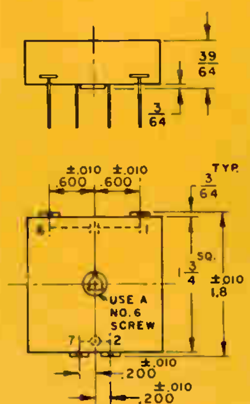
STYLE 1
STYLE 3

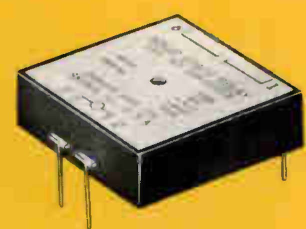
Style 1: Quick-connect terminals—mates with AMP 1/4" FASTON—tinned, solderable.



Style 3: Screw terminals, 4-40 screws, 1/8" long.

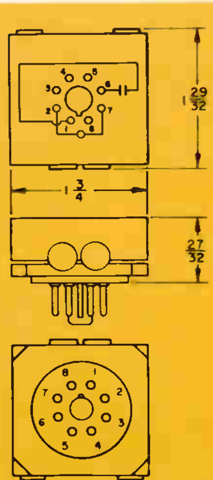
STYLE 4





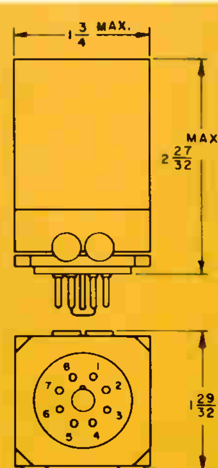
Printed Circuit Board pins.

STYLE 5



Octal base mounting.

STYLE 6



Octal base with heat dissipator.

Model SSA

"Coil" and "Contacts"
Model SSA relays are all solid state and therefore do not employ conventional coil and contacts. However, in describing the functional parameters of the relays, the terms "coil" and "contacts" are used in the analogous sense to aid understanding.

SPECIFICATIONS

"COIL"

Input Voltage: Any voltage within the range of 15 to 120 volts A.C. RMS or 10 to 185 volts D.C. maximum (non-polar).

Drop-out Voltage: 3 volts A.C. or D.C.

Input Current: 2 milliamps, maximum; 1.7 milliamps, typical, independent of voltage. Requires 7 milliwatts maximum to actuate; 5 milliwatts, typical.

"CONTACTS"

Form: SPST-N.O., form A, 50/60 Hz, A.C. only.

Ratings (Max.): 13 Amperes at 25°C (10 A. @ 40°C) mounted to an aluminum panel 6" x 6" x .125" or equivalent. 3 Amperes at 25°C (2 A. @ 40°C) unmounted, depending on model.

Minimum: 100 milliamps.

Voltage: 120, 240 VAC, RMS, depending on model.

Surge Current: Withstands at least 10 times rated current for 1 cycle of load current.

Voltage Drop: Closed ("ON"), 1 to 1.5 Volts, typical.

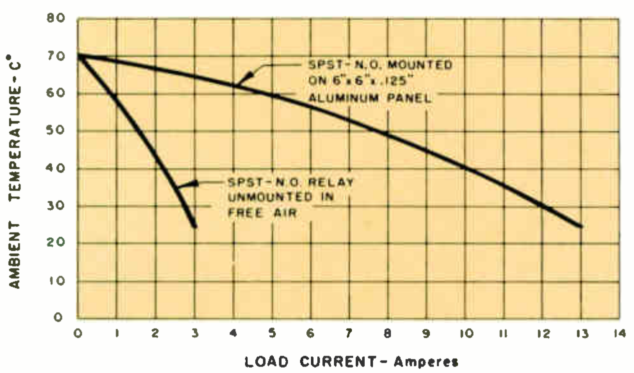


Fig. 1 LOAD CURRENT/TEMPERATURE DERATING

Impedance: Open ("Off"), 26K ohms, typical.

Isolation: 500 gigaohms — "coil" to "contacts," "contacts" to mounting plate, mounting plate to "coil."

Dielectric Strength: 1500 V RMS — "coil" to "contacts," "contacts" to mounting plate, mounting plate to "coil."

Transient Protection: The relay is protected from transient voltages in both the "coil" and "contact" circuitry, to the extent shown in Fig. 2.

Protection from **false actuation** resulting from transient voltages is a primary design feature.

Speed of Operation: **Pull-in:** 1/2 cycle load current.
Drop-out: 1/2 cycle load current.

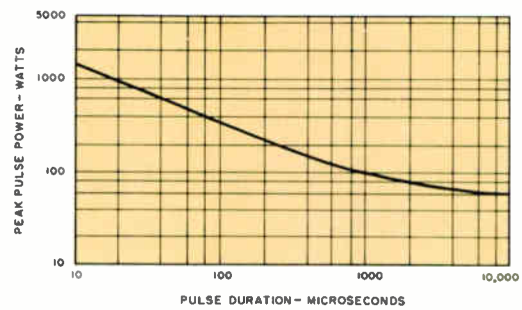


Fig. 2. TRANSIENT PROTECTION

MECHANICAL

Ambient Temp. Range: Storage −55°C to +100°C. Operating 0°C to +70°C.

Mounting: For full "contact" ratings for styles 1 and 3, mount basic models on an aluminum panel 6" x 6" x 1/8" or equivalent. See dimensional drawings for mounting method data.

Terminals: Styles 1 and 3 offer quick-connect and solder, or screw termination, respectively. Style 4 offers pins for printed circuit board mounting. Styles 5 and 6 provide octal pin base mounting/termination. **Weight:** 2 oz. approximately.

TYPES and RATINGS

All relays are SPST-N.O. Contact Factory for SPDT and DPST-N.O. "contact" forms.

Catalog Number	Termination Style	Volts (RMS) 50/60 Hz	Ratings (Amperes, A.C.) @ 25°C ambient Mounted	@ 25°C ambient Free Air	@ 40°C ambient Mounted	@ 40°C ambient Free Air
SSA-3-SS-1	Quick-connect	120	13	3	10	2
-3	Screw					
-4	P.C. pins					
-5	Octal base		3	3	2	2
-6	Octal base w/heat dissipator		—	7	—	6
SSA-4-SS-1	Quick-connect	240	13	3	10	2
-3	Screw					
-4	P.C. pins					
-5	Octal base		3	3	2	2
-6	Octal base w/heat dissipator		—	7	—	6

Ohmite Manufacturing Company a North American Philips company
3601 Howard Street, Skokie, Illinois 60076/Phone (312) 675-2600/TWX: 910-223-0805/Telex 72-4433

OHMITE

BULLETIN 753

FROM THE ORIGINATORS OF THE HIGH POWER SOLID STATE RELAY . . .

Model SSH Solid State Hybrid Relays . . . for Interfacing DC Logic with Power Devices

Model SSH

HYBRID RELAY

Model SSH relays are hybrid units employing a reed type input with a solid state output. Designed for industrial control applications, these relays interface directly with low power DC logic signals and control power devices (solenoids, contactors, etc.) with loads to 15 amperes. Six models handle logic signals of 6, 12 or 24 volts DC and draw less than 160 milliwatts.

SSH relays are used in applications such as machine and process control, automatic assembly operations and other applications using logic to control a multitude of programmed monitoring and operating activities performed by power devices.

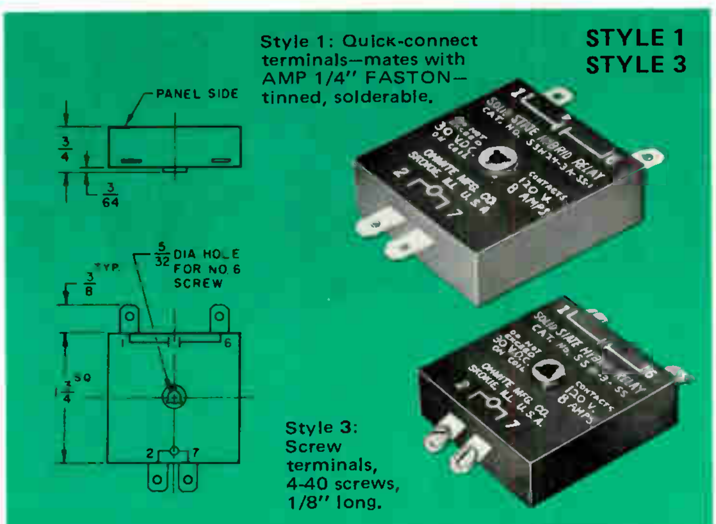
Complete isolation between input and output of the relay is maintained, safeguarding against any interaction between the logic and power circuitry.

High immunity to false actuation is provided by special commutation circuitry. When controlling inductive loads, this circuitry limits the dv/dt seen by the relay and assures turn off.

MODEL SSH FEATURES

- Direct interface with D.C. logic signals.
- High immunity to false actuation.
- Complete isolation between input and output.
- Power handling to 15 amperes.
- Choice of three (3) input ranges: 6, 12 and 24 VDC.
- Speed: Pull-in ("on") less than 1 millisecond.
- Choice of four (4) types of termination/mounting: solder/quick-connect, screw, p.c. pins and octal socket.
- Rugged molded package.

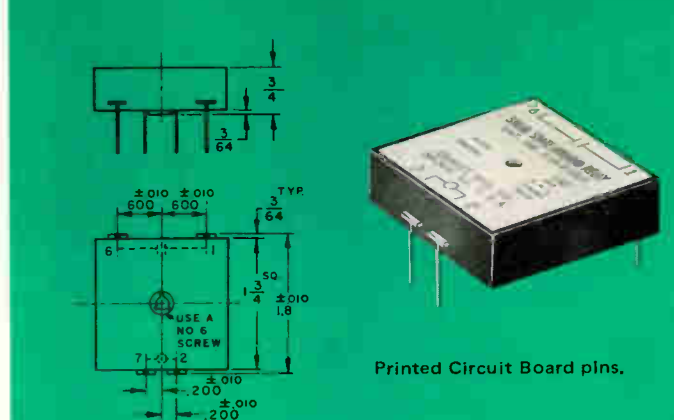
STYLE 1
STYLE 3



Style 1: Quick-connect terminals—mates with AMP 1/4" FASTON—tinned, solderable.

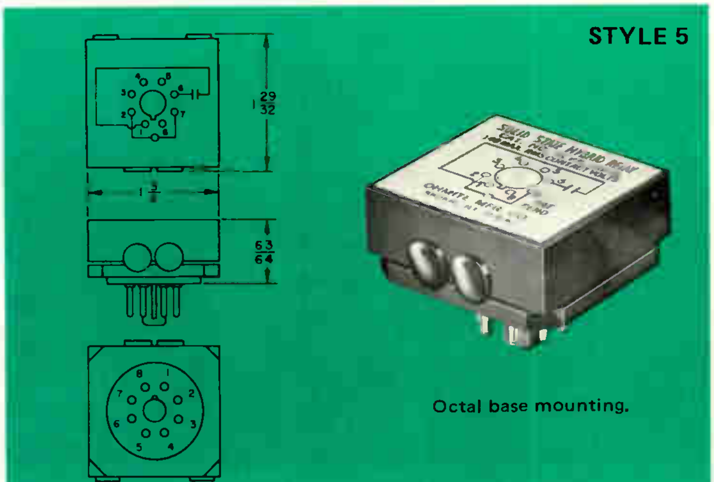
Style 3: Screw terminals, 4-40 screws, 1/8" long.

STYLE 4



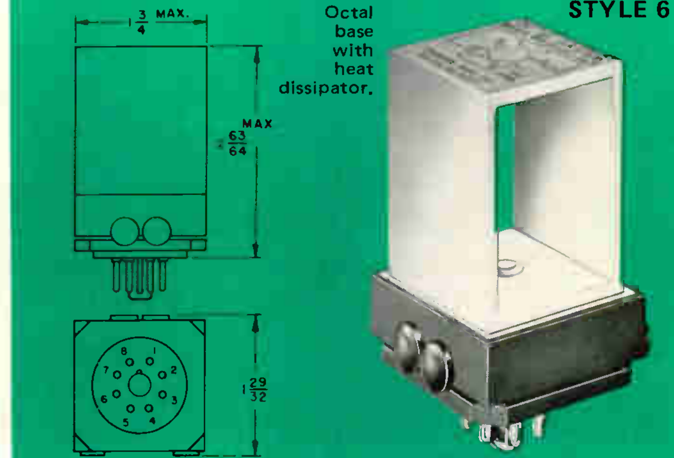
Printed Circuit Board pins.

STYLE 5



Octal base mounting.

STYLE 6



Octal base with heat dissipator.

Complete detailed specifications are stated on the reverse side.

"Coil" and "Contacts"
Model SSH hybrid relays are a combination of a reed input and solid state output and therefore do not employ conventional coil and contacts. However, in describing the functional parameters of the relays, the terms "coil" and "contacts" are used in the analogous sense to aid understanding.

Model SSH HYBRID RELAY

SPECIFICATIONS

"COIL"

Input Voltage: 5 to 30 volts DC, depending on Model.

Input Current: 10 to 33 milliamps, nominal, depending on Model.

"CONTACTS"

Form: SPST-N.O., form A, 50/60 Hz, 120 VAC.

Rating: See table for maximum ratings.

Surge Current: Withstands at least 10 times rated current for 1 cycle of load current.

Voltage Drop: Closed ("on"), 1.6 volt, typical.

Impedance: Open ("off"), 26K ohms, typical.

Isolation: 500 gigaohms between "coil" and "contacts", coil and case and contacts and case.

Dielectric Strength: 1500 V RMS.

Transient Protection: Components used in both the "coil" and "contact" are self-protecting devices. Protection from false actuation provided. Special commutator circuitry assures turn off under inductive loads.

Speed of Operation: Pull-in: Less than 1 millisecond. Drop-out: ½ cycle of load current.

MECHANICAL

Ambient Temp. Range: Storage −55°C to +100°C. Operating 0°C to +70°C.

Mounting: For full "contact" ratings for styles 1 and 3, mount basic models on an aluminum panel 6" x 6" x 1/8" or equivalent. See dimensional drawings for mounting method data.

Terminals: Styles 1 and 3 offer quick-connect and solder, or screw termination, respectively. Style 4 offers pins for printed circuit board mounting. Styles 5 and 6 provide octal pin base mounting/termination. **Weight:** 2 oz. approximately.

TYPES AND RATINGS

All relays are SPST-N.O., 120 VAC, RMS, 50/60 Hz

Catalog Number	Termination/Mounting Style	"COIL" Input Volts (D.C.)	Input Current milliamps	Threshold Voltage	Dropout Voltage	Impedance	"Contact" Ratings (Max. Amperes @120 VAC) @ 25°C ambient Mounted*	@ 25°C ambient Free Air	@ 40°C ambient Mounted*	@ 40°C ambient Free Air
SSH6-3A-SS-1	Quick-Connect/Solder									
-3	Screw						8	3.5	8	2.5
-4	P.C. pins	5 to 9	33 ma.	5 V. max.	0.5 V.	150 Ω				
-5	Octal base		nominal	1 V. min.		nominal	—	3.5	—	2.5
-6	Octal base w/heat dissipator						—	5.0	—	4.0
SSH6-3C-SS-1	Quick-Connect/Solder									
-3	Screw						15	3.5	10.5	2.5
-4	P.C. pins	5 to 9	33 ma.	5 V. max.	0.5 V.	150 Ω				
-5	Octal base		nominal	1 V. min.		nominal	—	3.5	—	2.5
-6	Octal base w/heat dissipator						—	7.5	—	5.0
SSH12-3A-SS-1	Quick-Connect/Solder									
-3	Screw						8	3.5	8	2.5
-4	P.C. pins	10 to 18	17 ma.	10 V. max.	1 V.	600 Ω				
-5	Octal base		nominal	3 V. min.		nominal	—	3.5	—	2.5
-6	Octal base w/heat dissipator						—	5.0	—	4.0
SSH12-3C-SS-1	Quick-Connect/Solder									
-3	Screw						15	3.5	10.5	2.5
-4	P.C. pins	10 to 18	17 ma.	10 V. max.	1 V.	600 Ω				
-5	Octal base		nominal	3 V. min.		nominal	—	3.5	—	2.5
-6	Octal base w/heat dissipator						—	7.5	—	5.0
SSH24-3A-SS-1	Quick-Connect/Solder									
-3	Screw						8	3.5	8	2.5
-4	P.C. pins	20 to 30	10 ma.	20 V. max.	2 V.	2000 Ω				
-5	Octal base		nominal	5 V. min.		nominal	—	3.5	—	2.5
-6	Octal base w/heat dissipator						—	5.0	—	4.0
SSH24-3C-SS-1	Quick-Connect/Solder									
-3	Screw						15	3.5	10.5	2.5
-4	P.C. pins	20 to 30	10 ma.	20 V. max.	2 V.	2000 Ω				
-5	Octal base		nominal	5 V. min.		nominal	—	3.5	—	2.5
-6	Octal base w/heat dissipator						—	7.5	—	5.0

*Mounted to an aluminum panel 6" x 6" x .125" or equivalent.

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OHMITE

MANUFACTURER'S PRICE SCHEDULE

Minimum charges exclusive of transportation charges are:
1. STOCK ITEMS—$15.00 per order
2. MADE-TO-ORDER ITEMS—$25.00 per item
Terms: 1%, 10th & 25th, net 30 days, F.O.B. our factory
Prices subject to change without notice.

JANUARY 1, 1971

SOLID STATE RELAYS

	1-9	10-24	25-49	50-99
SSA-3-SS-1	38.10	36.20	34.29	32.39
-3	39.60	37.62	35.64	33.66
-4	38.90	36.96	35.01	33.07
-5	43.60	41.42	39.24	37.06
-6	45.90	43.61	41.31	39.02
SSA-4-SS-1	41.30	39.24	37.17	35.11
-3	42.80	40.66	38.52	36.38
-4	42.40	40.28	38.16	36.04
-5	46.10	43.80	41.49	39.19
-6	48.60	46.17	43.74	41.31

	1-9	10-24	25-49	50-99
SSB-3-SS-1	32.90	31.26	29.61	27.97
-3	34.20	32.49	30.78	29.07
-4	33.60	31.92	30.24	28.56
-5	38.40	36.48	34.56	32.64
-6	41.10	39.05	36.99	34.94
SSB-4-SS-1	36.50	34.68	32.85	31.03
-3	38.00	36.10	34.20	32.30
-4	36.80	34.96	33.12	31.28
-5	41.40	39.33	37.26	35.19
-6	43.90	41.71	39.51	37.32

SOLID STATE HYBRID RELAYS

	1-9	10-24	25-49	50-99
SSH6-3A-SS-1	16.40	15.58	14.76	13.94
-3	18.20	17.29	16.38	15.47
-4	17.60	16.72	15.84	14.96
-5	22.20	21.09	19.98	18.87
-6	24.80	23.56	22.32	21.08
SSH6-3C-SS-1	19.40	18.43	17.46	16.49
-3	21.50	20.43	19.35	18.28
-4	20.90	19.86	18.81	17.77
-5	25.60	24.32	23.04	21.76
-6	28.10	26.70	25.29	23.89
SSH12-3A-SS-1	16.40	15.58	14.76	13.94
-3	18.20	17.29	16.38	15.47
-4	17.60	16.72	15.84	14.96
-5	22.20	21.09	19.98	18.87
-6	24.80	23.56	22.32	21.08

	1-9	10-24	25-49	50-99
SSH12-3C-SS-1	19.40	18.43	17.46	16.49
-3	21.50	20.43	19.35	18.28
-4	20.90	19.86	18.81	17.77
-5	25.60	24.32	23.04	21.76
-6	28.10	26.70	25.29	23.89
SSH24-3A-SS-1	16.40	15.58	14.76	13.94
-3	18.20	17.29	16.38	15.47
-4	17.60	16.72	15.84	14.96
-5	22.20	21.09	19.98	18.87
-6	24.80	23.56	22.32	21.08
SSH24-3C-SS-1	19.40	18.43	17.46	16.49
-3	21.50	20.43	19.35	18.28
-4	20.90	19.86	18.81	17.77
-5	25.60	24.32	23.04	21.76
-6	28.10	26.70	25.29	23.89

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SOLID STATE CONTROLS

CATALOG SEQUENCE 800

OHMITE

SOLID STATE CONTROLS • 800

OHMITE ®

"METERSAVER" PROTECTS SENSITIVE METERS

JAN 16 1971

The Ohmite "Metersaver," OMC7111, is a semiconductor device used for the protection of sensitive meter movements. Some typical applications follow:

- Production meters of all types up to 100 μa
- VOM's (Volt-Ohm-Milliammeters)
- Wheatstone & Kelvin Bridge indicators
- Laboratory type meters during setup
- Student setups awaiting instructor's okay
- During experimental setups where sensitive dc meters are involved.

Theory: To understand the theory and application of the "Metersaver" consider a 0 to 50 microamp meter with a representative value of internal resistance of the order of 4000 ohms. The meter requires about 200 millivolts for full scale deflection, but will usually stand an overload 10 times that amount for short periods of time. To protect this meter, we place an OMC7111 across it. This unit contains two silicon diodes back to back; in effect, one of the diodes is always across the meter in the forward direction. The "Metersaver" is provided with two lugs which slip over the present terminals of the meter. When operating normally, there are 200 millivolts or less across the meter and the effective diode then represents a shunting resistance greater than ½ megohm. The other diode across the meter is in the reverse direction and represents a completely negligible shunt path.

A ½ megohm resistor shunted across 4K ohms will shunt out $\frac{4k}{500k} = \frac{1}{125}$ of the current, and introduce an error of .8%, entirely tolerable for an average 2% instrument.

The device applies the characteristic of silicon diodes that before the forward voltage reaches about 500 mv, the current is quite small. After 500 mv, however, the current rises very rapidly and as it does the resistance of the diode drops. Near 1000 mv, (1V) the resistance may be of the order of a few ohms.

If you try to peg the meter on a 10 times overload or 500 μa, (.5 ma) the diode begins to conduct and shunts out most of the overload current.

In an actual circuit, using an OMC7111, the system settled down so that the meter current was 145 μa and the by-passed current 355 μa; in effect, then, a 10 times overload was converted into a 3 times overload. Most standard meters will tolerate a 3 times overload continuously. At a circuit current of 10 ma, representing an overload of $\frac{10000}{50} = 200$, the meter sees only 155 μa, the balance of (10,000 − 155) microamperes going thru the shunting diode.

The curves show how the shunting effect of the protector behaves for different types of meters and different degrees of overload.

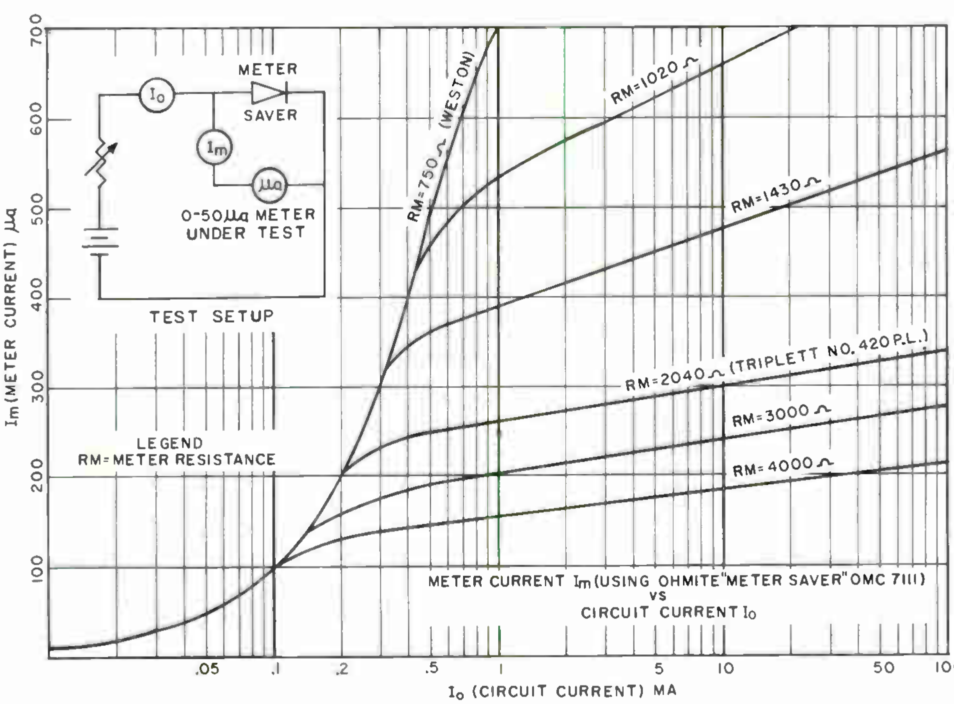
The protection is most effective for meters of relatively high internal resistance. For meters of low internal resistance, a resistor can often be installed in series with the meter for improved performance.

Use of the meter protection diode enables you to use more economical fuses. For example, if the overload is so severe that 125 ma flows in the circuit, the meter will see only 220 μa, and the 125 ma, in effect, flows thru the diode. Hence, a ⅛ amp. fuse will suffice here. Lower rating fuses are more expensive.

The reason for having 2 diodes back to back is that even if you connect the meter with reverse polarity, and with a serious overload, it will be protected from burning out in the same way as it would have been if you had connected it with the correct polarity.

Installation: To install, take off the two nuts which now hold the lugs on the back of your meter and place the OHMITE "Metersaver" across the two terminals and put back the 2 nuts securely. Do not worry about polarity. The meter is now protected in the manner described above and shown on the curves on this page. There is nothing more to do.

METERSAVER OMC7111 .... Net Price (1-99) $1.98



OHMITE MANUFACTURING COMPANY
3601 Howard Street, Skokie, Illinois 60076

BULLETIN 806

RESISTORS • RHEOSTATS • TAP SWITCHES • RELAYS • VARIABLE TRANSFORMERS
TANTALUM CAPACITORS • SEMICONDUCTOR DIODES • R. F. CHOKES

JAN 16 1971

OHMITE

SOLID STATE CONTROLS

BULLETIN 810 D
Supersedes Bulletin 810C

- SAVE SPACE, SAVE POWER, SAVE $$
- SMALLEST 1 & 2 KW CONTROL
- LONG LIFE
- AC & DC OUTPUT TYPES
- INTEGRAL TRIMMER ADJUSTS CONTROL RANGE FOR DIFFERENT APPLICATIONS
- INCORPORATES ON-OFF SWITCH

USE IT TO CONTROL

POWER MODEL PCA AC OUTPUT	MOTOR SPEED MODEL PCD DC OUTPUT
Shaded pole motors	Shunt wound motors
Permanent split capacitor motors	Series wound motors
Universal motors	Permanent magnet motors
Heaters—both resistive and infra-red	Magnetic clutches and brakes

Now, for the first time, a Solid State Power Control is available which is adaptable to a wide variety of applications by a simple turn of a screwdriver!

An internal trimmer allows the starting point of the control voltage of the Ohmitrol to be set anywhere within the stated trimmer voltage range. (This adjustment can be preset at the factory at small additional cost).

From the starting point to full line voltage, infinitely smooth control is obtained by means of the control knob. An "on-off" line switch actuated at the counterclockwise end of the control knob rotator is provided on all models.

Ohmite solid state power controls are the smallest 1 or 2 KW controls available and offer the advantages not only of convenient size, but also of power savings, long life and low initial cost.

Two styles are available: the component style for panel mounting in equipment, and the lightweight, self-contained portable style. Portable units are completely self contained with grounded line cord and standard grounded AC receptacle.

Ohmitrol Controls are available with AC output and with two kinds of DC output delivered simultaneously. One kind consists of rectified DC, at approximately full line voltage; the other is the variable or controlled DC. This double output is useful, for example, for controlling shunt wound motors. Two-way terminals at the rear of the controls accept quick-connectors (push-on connectors), or can be soldered.

PORTABLE STYLE

Catalog No.
PCA-1001,
PCD-1001,
PCA-1021,
PCD-1021

SPECIFICATIONS AND ORDERING INFORMATION

	120 Volt Types	240 Volt Types
LOAD RATING PCA Models	1 KW, 8.3 Amps. AC	2 KW, 8.3 Amps
PCD Models	3.5 Amp DC Motorload 6.0 Amp DC Resistive	3.5 Amp DC Motorload 6.0 Amp DC Resistive
INPUT	120v AC, 60 Hz†	240v AC, 60 Hz†
OUTPUT	0-120v AC(PCA), DC(PCD)	0-240v AC (PCA), DC(PCD)
TRIMMER VOLTAGE RANGE	0-50 Volts	0-100 Volts

Mounting (Component Style) ⅜"-32 Bushing, Non-Turn Projection on ½" centers with shaft.
Knob (not included) Recommend Catalog No. 5150.
Terminals (Component Style) Two-way Accept ¼" Faston connectors or soldering.
† 50 Hz also available. Contact factory.

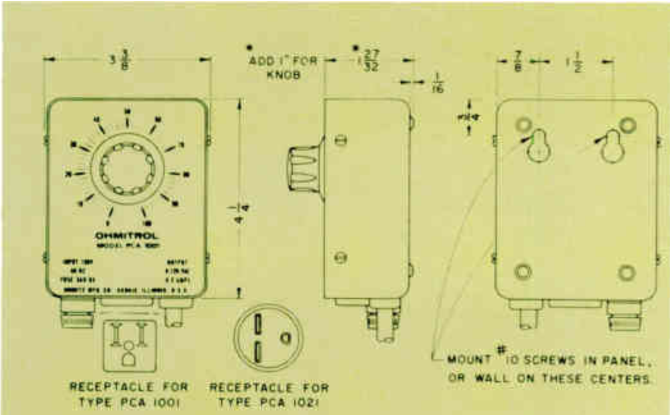
COMPONENT STYLE*

Catalog No.
PCD-1000,
PCA-1000,
PCA-1020,
PCD-1020

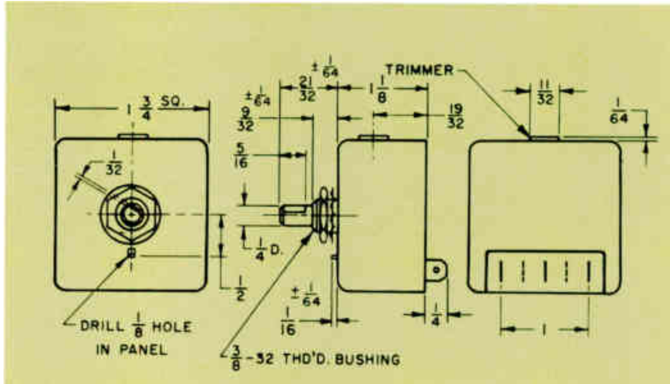
* Knob not included

Catalog No.	Input	Output
PCA-1001	120 VAC	0-120 VAC
PCD-1001	60 Hz	Pulsating 0-120 VDC and Full 120 VDC
PCA-1021	240 VAC	0-240 VAC
PCD-1021	60 Hz	Pulsating 0-240 VDC and Full 240 VDC

Catalog No.	Input	Output
PCA-1000	120 VAC	0-120 VAC
PCD-1000	60 Hz	Pulsating 0-120 VDC and Full 120 VDC
PCA-1020	240 VAC	0-240 VAC
PCD-1020	60 Hz	Pulsating 0-240 VDC and Full 240 VDC



Mounting Dimensions Portable Style

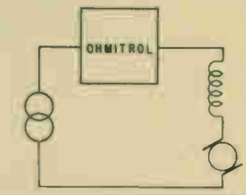
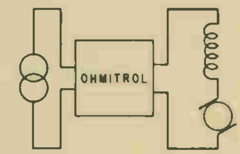
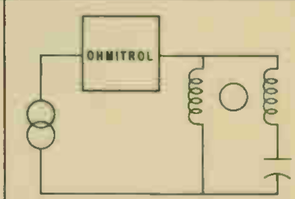
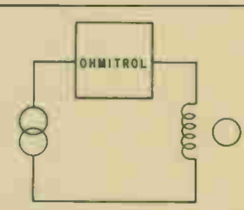
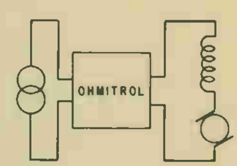
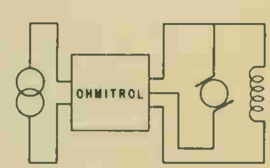
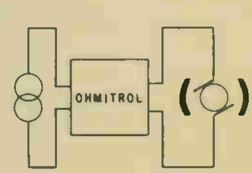
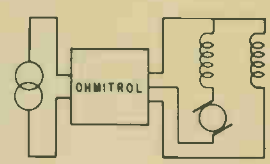


Mounting Dimensions Component Style

Ohmite Manufacturing Company a North American Philips company
3601 Howard Street, Skokie, Illinois 60076 Phone: (312) 675-2600 TWX: 910-223-0805 Telex: 72 4433

PRINTED IN U.S.A.
PUBLICATION 195A

OHMITROL® SOLID STATE SPEED CONTROLS FOR MOTORS

Type of Motor	Current	Reversibility	Braking	Characteristics		Circuit Diagram	Type of Ohmitrol Control
				Motor Only	Motor with Control		
Universal (Series)	AC	Yes, if armature and field connections are brought out of motor, or motor may be provided with split field.	Yes; Dynamic. Requires Switch.	High Speed, High Starting torque. Speed varies widely with load.	Same as motor only. Full speed range.		PCA
	DC			High Speed, High Starting torque. Increased speed & improved torque over Universal motor operated on A.C.	Increased speed and greatly improved torque, i.e., speed vs. load characteristic, due to feedback circuitry in Ohmitrol.		PCD
Permanent Split Capacitor	AC	Yes	Yes, Dynamic. Requires additional circuitry.	Speed fairly constant with load. Starting torque approximately same as full load torque.	Speed fairly constant with load. High slip motor design will yield better low speed performance.		PCA
Shaded Pole	AC	No. Unless designed for reversing service.	Yes; Dynamic. Requires additional circuitry.	Speed fairly constant with load but poorer than PSC. Starting torque less than full load torque.	Speed fairly constant with load. Speed control range somewhat limited.		PCA
Series	DC	Yes, If armature and field connections are brought out of motor, or motor may be provided with split field.	Yes; Dynamic. Requires Switch.	High Speed, High Starting torque, speed varies widely with load.	High Speed, High Starting torque, much improved speed vs. load characteristic due to feedback circuitry in Ohmitrol.		PCD
Shunt	DC	Yes, reverse armature or field connections, preferably armature	Yes; Dynamic. Requires Switch.	Speed fairly constant with load. Starting torque higher than full load torque.	Speed vs. load characteristic improved over that of bare motor, due to feedback circuitry in Ohmitrol.		PCD
Permanent Magnet	DC	Yes. reverse armature connections.	Yes; Dynamic. Requires Switch.	Same as Shunt.	Same as Shunt.		PCD
Compound	DC	Yes, reverse armature or field connections, preferably armature.	Yes; Dynamic. Requires Switch.	Same as Shunt but has improved starting torque.	Same as Shunt.		PCD

Ohmite Manufacturing Company
3601 Howard Street, Skokie, Illinois 60076 Phone: (312) 675-2600 • TWX: 910-223-0805 • TELEX 72 4433

obsolete? 12/70

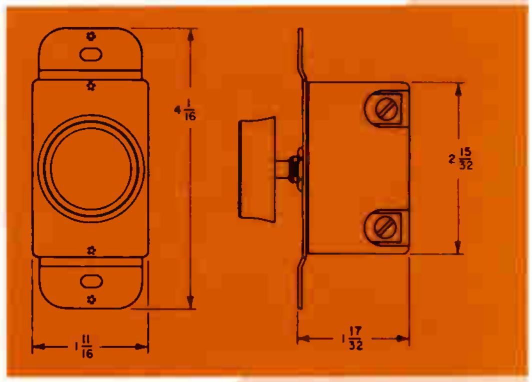
OHMITE

ELECTRONIC (Solid State) DIMMERS for INCANDESCENT LIGHTING

600 Watts

Replace Any
2 or 3-Way
Switch

Made by OHMITE
Famous Producer of
Quality Components



CONTINUOUSLY VARIABLE DIMMING by means of silicon symmetrical switch—a modern semiconductor device.

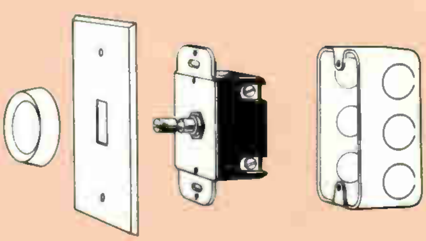
PUSH-PUSH KNOB for ON/OFF at *any* light setting.

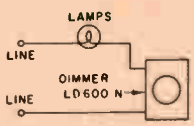
CONSERVES POWER — Draws only the power needed by the circuit at the light level desired.

SCREW TERMINALS for convenient wiring without splicing or wire fastening nuts—eliminates space consuming leads—permits use of dimmer even in shallow boxes.

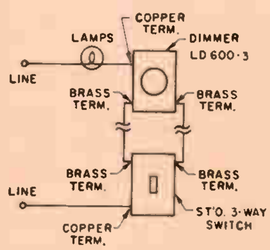
NO RADIO OR TV INTERFERENCE due to special filter.

GUARANTEED for 1 year against defects in materials and workmanship provided units have been properly installed and operated.





CONNECTIONS—DIMMER LD600



CONNECTIONS—DIMMER LD600-3

INSTALLATION NOTES

Maximum Ambient—120°F.

Use only 1 dimmer for each lighting circuit.

Install dimmer with power OFF.

Ganging—Several dimmers may be installed in a common box provided units are derated as follows: two units, 500 watts each; three or more units, 400 watts each.

ORDERING INFORMATION

Cat. No.	UL Listed	Description	Net $
LD600 N	—	Single-Pole Push-Push Switch	7.00
LD600	Yes	600 Watts, 120 Volts, 60 Cycle	9.30
LD600-3 N	—	3-Way Push-Push Switch	9.50
LD600-3	Yes	600 Watts, 120 Volts, 60 Cycle	11.30

BULLETIN 809A

OHMITE MANUFACTURING COMPANY 3601 Howard Street, Skokie, Illinois 60076

RESISTORS • RHEOSTATS • TAP SWITCHES • RELAYS • VARIABLE TRANSFORMERS
TANTALUM CAPACITORS • SOLID STATE CONTROLS • R. F. CHOKES

#1967

Printed in U.S.A.—4-67

Obsolete?
12/70

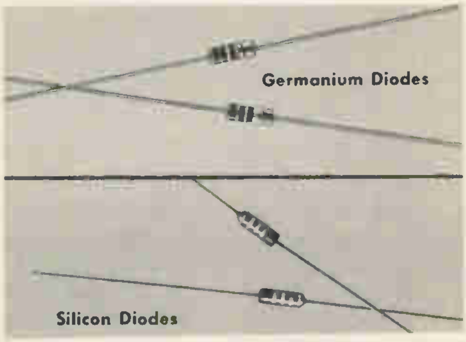
OHMITE

STOCK DIODES

Germanium and Silicon

SUPERSEDES LISTINGS IN STOCK CATALOG 30K!!

Also "Metersaver" Meter Protector



A wide choice of popular characteristics in low power germanium and silicon diodes is available immediately from Ohmite stock. Both the germanium and silicon types are supplied in the subminiature, hermetically sealed glass envelope (see diagram). The silicon envelope is light-shielded.

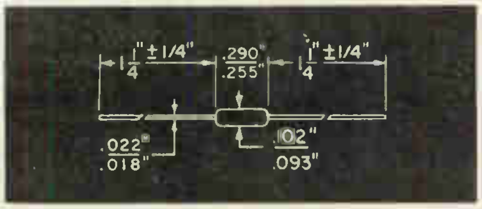
High stability is achieved through temperature cycling and aging. All units must meet severe environmental, electrical and mechanical requirements with a liberal safety factor.

GERMANIUM DIODES — Ohmite supplies the gold-bonded variety. Power rating is 80 mw at 25°C except where otherwise indicated. Operating temperature range is −65°C to +90°C.

SILICON DIODES — Employ either the alloy or diffusion method of junction formation. Power rating is 400 milliwatts at 25°C except where otherwise indicated. Operating temperature range is −65°C to +150°C.

STOCK GERMANIUM DIODES

Stock No.	PIV	Max. Rev. µa at 25°C	Min. Fwd. ma at 1V	Net 1/99
1N34	100	800@ 50V	8.5	$ .22
1N34A	75	500@ 50V	5	.24
1N38A	120	500@100V	4	.50
1N48	85	833@ 50V	4	.28
1N51	50	1677@ 50V	4	.30
1N54A	75	100@ 50V	5	.42
1N56	40	300@ 30V	15	.38
1N56A	50	300@ 30V	15	.38
1N58A	120	600@100V	4	.55
1N60	30	67@ 10V	—	.29
1N63	125	50@ 50V	4	.52
1N64	20	100@ 10V	—	.27
1N66	60	800@ 50V	5	.36
1N67	100	50@ 50V	4	.49
1N67A	100	50@ 50V	4	.28
1N68A	130	625@100V	3	.63
1N69	75	850@ 50V	5	.34
1N69A	75	500@ 50V	5	.62
1N87	23	30@ 1.5V	1⑥	.39
1N90	75	800@ 50V	5	.32
1N95	75	800@ 50V	10	.40
1N96	75	800@ 50V	20	.53
1N98	100	100@ 50V	20	.31
1N99	100	50@ 50V	10	.45
1N99A	100	50@ 50V	20	.45
1N100	100	50@ 50V	20	.31
1N191①	90	25@ 10V⑤	5	.34
1N198	100	250@ 50V③	4	.34
1N270	100	100@ 50V	200④	.31
1N273	40	200@ 20V	100	.46
1N276	100	100@ 50V	40	.31
1N277	120	250@ 50V③	100	.34
1N279	40	200@ 20V	100	.29
1N281	75	500@ 50V	100	.31
1N294	70	10@ 10V	5	.34
1N295	50	200@ 10V	—	.32
1N295A	40	200@ 10V	—	.32
1N497	30	20@ 20V	100	.38
1N695②	20	20@ 10V③	100	.29



STOCK SILICON DIODES

Stock No.	PIV	Max. Rev. µa at 25°C	Min. Fwd. ma at 1V	Net 1/99
1N456	25	.025@ 25V	40	$ .35
1N456A	25	.025@ 25V	100	.35
1N457	60	.025@ 60V	20	.35
1N457A	60	.025@ 60V	100	.35
1N458	125	.025@125V	7	.45
1N458A	125	.025@125V	100	.45
1N459	175	.025@175V	3	.50
1N459A	175	.5 @175V	100	.50
1N461	25	.5 @ 25V	15	.35
1N462A	60	.5 @ 60V	100	.35
1N463	175	.5 @175V	1	.45
1N645	225	.2 @225V	400	1.30

FOOTNOTES FOR ALL DIODE TABLES

①0.5 µsec.
②0.3 µsec.
③75°C.
④Duty cycle must be adjusted in testing at these high forward currents so that average power dissipated does not exceed 80 mw.
⑤55°C.
⑥At 0.25 volts.

DIODE METERSAVER PROTECTS METERS

Designed to protect sensitive (high internal resistance) meters against burnout due to overload even where potential is reversed. Introduces negligible error. Consists of 2 silicon diodes in compact case with leads and lugs. Connects across meter terminals without regard for polarity. Shunts excess current around meters—for example, can convert 200 times overload to 3 times overload. Allows use of less expensive meter fuses. Can be used with meters of low internal resistance but use of series resistor is then recommended.

Stock No. OMC7111....Net (1-99) $1.98

BULLETIN 811

OHMITE MANUFACTURING COMPANY • 3601 HOWARD ST. • SKOKIE, ILLINOIS 60076

RESISTORS • RHEOSTATS • TAP SWITCHES • RELAYS • VARIABLE TRANSFORMERS
TANTALUM CAPACITORS • SEMICONDUCTOR DIODES • R. F. CHOKES

PRINTED IN U.S.A. 6-66

R. F. CHOKES

CATALOG SEQUENCE 900

OHMITE

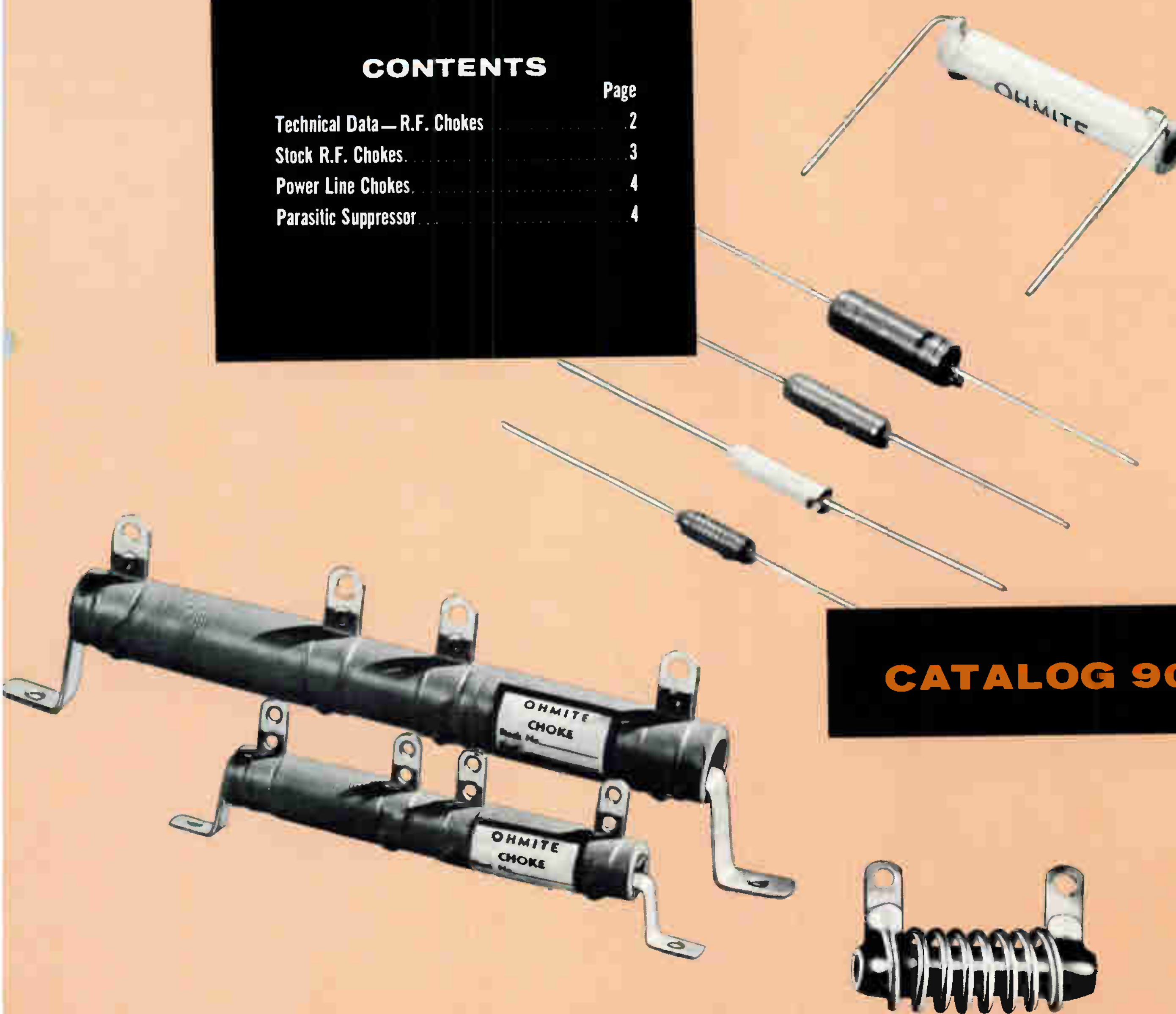
R. F. CHOKES
900

obsolete 12/70

OHMITE

RADIO FREQUENCY AND POWER LINE CHOKES

CONTENTS



CATALOG 900B

OHMITE MANUFACTURING COMPANY • 3601 HOWARD ST. • SKOKIE, ILLINOIS 60076

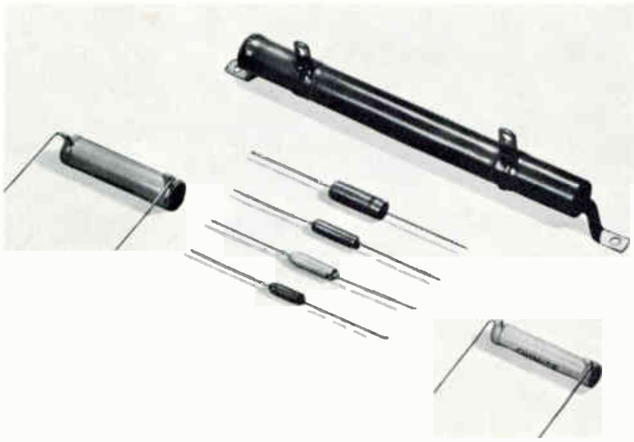


Figure 1: Stock R. F. Plate Chokes

The series of seven Ohmite single layer wound solenoid radio frequency plate chokes covers the entire frequency range of 3 to 520 megacycles. The catalog number corresponds to the approximate frequency at which maximum efficiency will be obtained. The chart, Figure 2, gives the position and width of the amateur bands for convenience, but the chokes obviously may be used at any other frequencies within their operating ranges.

The four highest frequency chokes are wound on low power factor plastic cores while the other three units are wound on steatite tubes. Windings are insulated and protected by a moisture-proof coating. The single layer winding is designed to avoid adverse harmonic effects within the recommended operating range and also prevents breakdown from high r.f. potentials. The Z-14 and Z-28, have wire leads welded to lug type terminals; the Z-50, Z-144, Z-235 and Z-460 have axial type wire leads.

The Ohmite line offers a series of *engineered* chokes, any one of which may be selected for a particular frequency within the recommended operating range with the knowledge that it will give excellent performance at the desired frequency. By means of the chart shown in Figure 2, which gives the recommended operating frequency range for each of the seven stock sizes of chokes, it is only necessary to select a choke whose operating range spans the frequency band of intended use.

The true inductance of a choke, as measured at a sufficiently low frequency, differs appreciably from and is considerably lower than the *effective* parallel inductance at frequencies within the operating range but below the natural resonant frequency indicated as f_0 in Figure 3. At frequencies above f_0 but within the operating range, the effective reactance of the choke is actually capacitive! This, of course, is in accordance with the

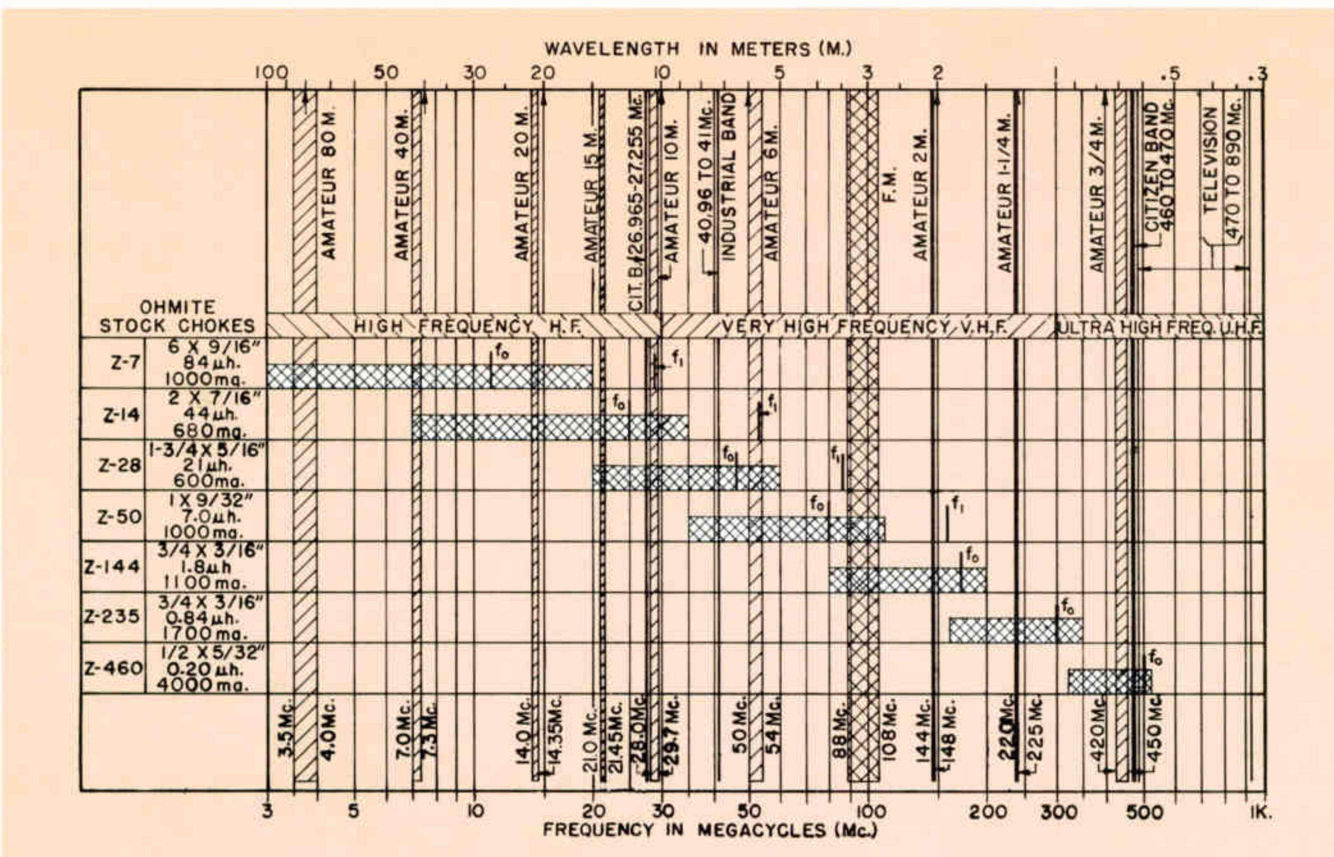


Figure 2: Recommended Operating Frequency Ranges of R.F. Plate Chokes.

inherent properties of parallel resonant circuits, the general characteristics of which are exhibited by the choke over its operating range of frequencies.

Figure 3 shows the frequency characteristics of the Z-28 choke over a broad range of frequencies. This graph is typical of all the chokes, and shows the basis which was used to determine limits of recommended operating frequency ranges.

The inherent frequency characteristics of these chokes, as well as those of all single layer chokes, are such that they exhibit optimum performance when used at or near their natural resonant frequency. However, since the effective parallel resistance of these chokes remains sufficiently high over a broad range of frequencies both below and above the natural resonant frequency, f_0, the chokes have good efficiency up to the limits of the recommended operating frequency ranges. This is illustrated for the Z-28 choke in Figure 3. Within the frequency limits shown, the apparent parallel resistance of the chokes, designated as R_p, is appreciably in excess of 200,000 ohms; this arbitrary minimum figure is the criterion for the lower limit of operating frequency for all chokes except the Z-235 and Z-460. For these two chokes, the minimum value of R_p is approximately 100,000 ohms at the lower frequency limit.

Referring to Figure 3, the value of R_p, rapidly drops to a very low value at the first overtone frequency. This frequency is designated as f_1 in both Figures 2 and 3, and occurs near the second harmonic frequency of the chokes.

At this critical frequency, f_1, the chokes behave in a manner similar to that of a *series* resonant circuit as contrasted to a *parallel* resonant circuit at f_0. Consequently, at the frequency f_1, the choke presents a low impedance path to ground for the r.f. currents. Therefore, the chokes should never be used at or near the frequency f_1. Any single layer choke used at this critical frequency will not only render the circuit in which it is used extremely inefficient, if not inoperative, but may destroy itself from heat as a result of the high energy absorption due to sectional series resonant effects.

Since the LC product determines the values of f_0 and f_1, it is evident that neither the inductance nor distributed capacity value for a choke is, in itself, an adequate indication of performance. The true indices of performance are the critical frequencies of f_0 and f_1 and their proximity to the desired operating frequency of the choke. *Both inductance and distributed capacity*, as well as any small capacity existing between the choke and ground as a result of mounting conditions and wiring, will affect the frequency response of the choke.

All measurements on these chokes were made with the chokes positioned remotely with respect to ground, that is, with minimum capacity to ground. When the chokes were mounted physically close to a grounded plane (or chassis) the effect was to shift the critical frequencies f_0 and f_1 and, therefore, also the recommended operating frequency range downward by as much as 20%, depending of course on the actual proximity to ground.

For this reason it is generally advisable to select a choke whose resonant frequency f_0 is slightly higher than the desired operating frequency since any additional capacity to ground will tend to shift the resonant frequency lower. Also, for this reason, the frequency designated by the chokes' catalog number is lower then the natural resonant frequency.

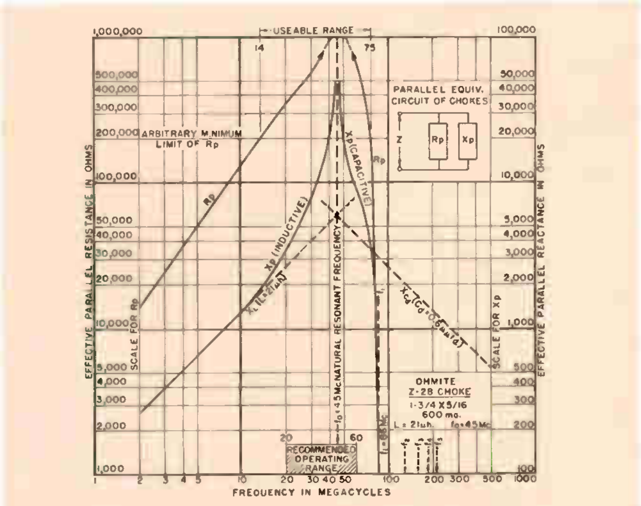


Figure 3: Frequency Characteristics of a Typical Plate Choke.

STOCK CHOKES

Cat. No.	Operating Range Megacycles	Micro-henries	Rated Current Amps.	D.C.* Res. Ohms	Core Dimensions	Weight Pounds
Z-7	3 to 20 Mc.	84.0	1.0	4.7	6" x 9/16"	.106
Z-14	7 to 35 Mc.	44.0	0.68	2.6	2" x 7/16"	.026
Z-28	20 to 60 Mc.	21.0	0.60	2.7	1 3/4" x 5/16"	.011
Z-50	35 to 110 Mc.	7.0	1.0	0.98	1" x 9/32"	.005
Z-144	80 to 200 Mc.	1.8	1.1	0.33	3/4" x 3/16"	.002
Z-235	160 to 350 Mc.	0.84	1.7	0.14	3/4" x 3/16"	.002
Z-460	320 to 520 Mc.	0.20	4.0	0.034	1/2" x 5/32"	.001

Specify Non-magnetic Brackets No. 9B for use with Z-7, when desired.
***At 100 ma. in 25°C ambient.**

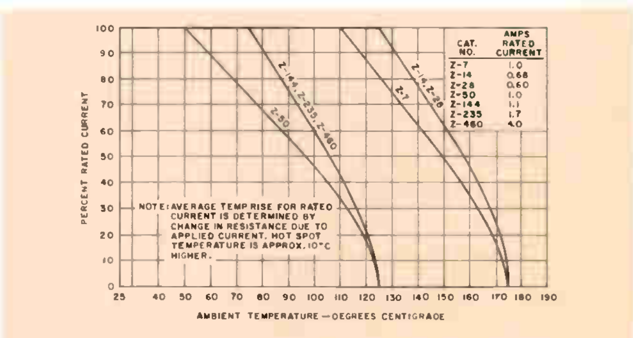


Fig. 4: Current Derating Curves

POWER LINE CHOKES–PARASITIC SUPPRESSOR

POWER LINE CHOKES

Figure 5: Stock Power Line Chokes

Cat. No.	Total Micro-henries	Amps.	Total D. C. Ohms	Dimensions	Weight Pounds	Mounting Bracket No.
Z-20	14	5	0.15	4" x 5/16"	.11	9B
Z-21	15	10	0.07	6½" x ¾"	.31	12B
Z-22	18	20	0.045	8½" x 1⅛"	.73	18B
*Z-30	104	20	0.085	8½" x 1⅛"	1.45	18B

Specify brackets on order if desired.
*One section is wound as a second layer over the other.

APPLICATION: To prevent radio or TV interference which may be caused by the inadvertent transmission of r.f. energy over common power lines from such equipment as r.f. generators for induction or dielectric heating, amateur radio transmitters, diathermy machines etc. Used in conjunction with 0.1 μf paper-type capacitors rated at approximately twice line voltage to filter out interference at the source.

DESCRIPTION: Two single layer windings on a single ceramic core insulated and protected by Ohmicone® silicone-ceramic coating. In an ungrounded 240 V system, the windings are connected as in Figure 6a. A choke is shown connected in a 120 V grounded system in Figure 6b. For higher inductance, on the Z30 choke one coil is wound as a second layer over the first. It is connected as shown in Figure 6c. Special chokes can be made to order.

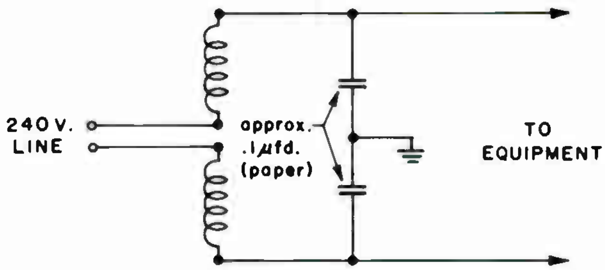


FIG. 6a

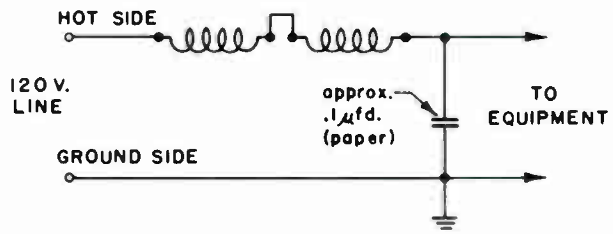


FIG. 6b

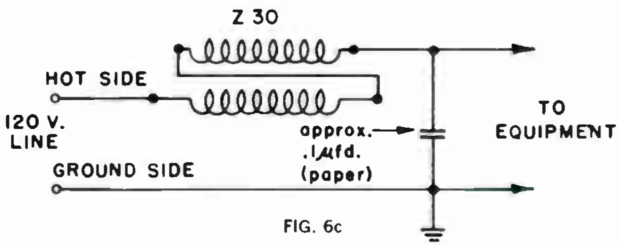


FIG. 6c

Figure 6: Connection Diagrams

PARASITIC SUPPRESSOR

APPLICATION: For the suppression of unwanted ultra-high frequency parasitic oscillations due to incidental resonance between tube plate and grid circuit of push-pull and parallel-operated transmitting radio amplifiers. Also used to suppress "hash" in plate circuit of mercury vapor rectifiers.

DESCRIPTION: Consists of a 50 ohm vitreous enameled non-inductive resistor which supports (in parallel) a choke of 0.3 microhenries and .003 ohm D. C. resistance. Dimensions are 1¾" by 21/32". The parasitics are suppressed, without loss of driving power, by inserting the Model P-300 in the grid lead, next to the tube socket, of one or both tubes. Suppressors of special resistance and inductance can be supplied also.

Figure 7

Parasitic Suppressor . . . . Cat. No. P-300

ENGINEERING MANUAL

CATALOG SEQUENCE 1100

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MANUAL OF ENGINEERING INFORMATION

CONTENTS

GEORG SIMON OHM
1787-1854

In 1827, Dr. Georg Simon Ohm mathematically demonstrated the relation between resistance, voltage and current in electrical circuits. Ohm's Law is fundamental in all resistance calculations.

BULLETIN 1100

OHMITE MANUFACTURING COMPANY • 3601 HOWARD ST. • SKOKIE, ILLINOIS 60076

HOW TO MAKE RESISTANCE CALCULATIONS

OHM'S LAW

The fundamental law of the electric circuit is Ohm's Law which has been stated as follows: *The current in a circuit is directly proportional to the E.M.F. (Electromotive Force) in the circuit and inversely proportional to the resistance.* In formula form it is:

$$I = \frac{E}{R} \text{ or } R = \frac{E}{I} \text{ or } E = IR$$

The following formula, also used in connection with resistor calculations, expresses the basic fact that the power in watts is equal to the product of the volts and amperes:

$$W = IE$$

Because $E = IR$ this can be written:

$$W = I \times IR \text{ or } W = I^2R \text{ or } W = \frac{E^2}{R}$$

The power formula is known as Joule's Law.

Ohm's Law can be expressed in several different forms, all of which are conveniently tabulated below. Note that in working out any problem, all terms must be reduced to volts, amperes and watts when used in any of the formulas. For example, 30 milliamperes must be written as 0.030 amperes, 2.5 K.W. must be written as 2500 watts, 1 megohm as 1,000,000 ohms, and so forth.

W = Watts	EI	I^2R	$\frac{E^2}{R}$			
E = Volts		IR		$\sqrt{WR}$		$\frac{W}{I}$
I = Amperes			$\frac{E}{R}$	$\sqrt{\frac{W}{R}}$	$\frac{W}{E}$	
R = Ohms	$\frac{E}{I}$				$\frac{E^2}{W}$	$\frac{W}{I^2}$

Fig. 1: Table of Ohm's Law Formulas for Direct Current Circuits.

OHM'S LAW FOR ALTERNATING CURRENT

Ohm's Law in the forms given in Fig. 1 applies to direct current circuits. However, the same formulas can be used for alternating current circuits, provided the amount of inductance (because of coils) or capacitance (because of capacitors or distributed capacitance) in the circuit is negligible. Thus, for commercial frequencies (25 or 60 cycles) Ohm's Law can be used for the calculation of circuits involving heaters, lamps, vacuum tube filaments, etc., which for all practical purposes may be considered as pure resistance.

Even in circuits which have reactance, the direct current form of Ohm's Law still applies so far as the resistor itself is concerned (even at frequencies at the high end of the audio frequency range), because the reactance of the resistor, in that frequency range, is generally negligible when compared to the resistance. This is not true, however, at radio frequencies. Non-inductive type resistors are used at the radio-frequencies in order to minimize the changes due to frequency (see "Non-Inductive Resistors" in "Resistor" catalog).

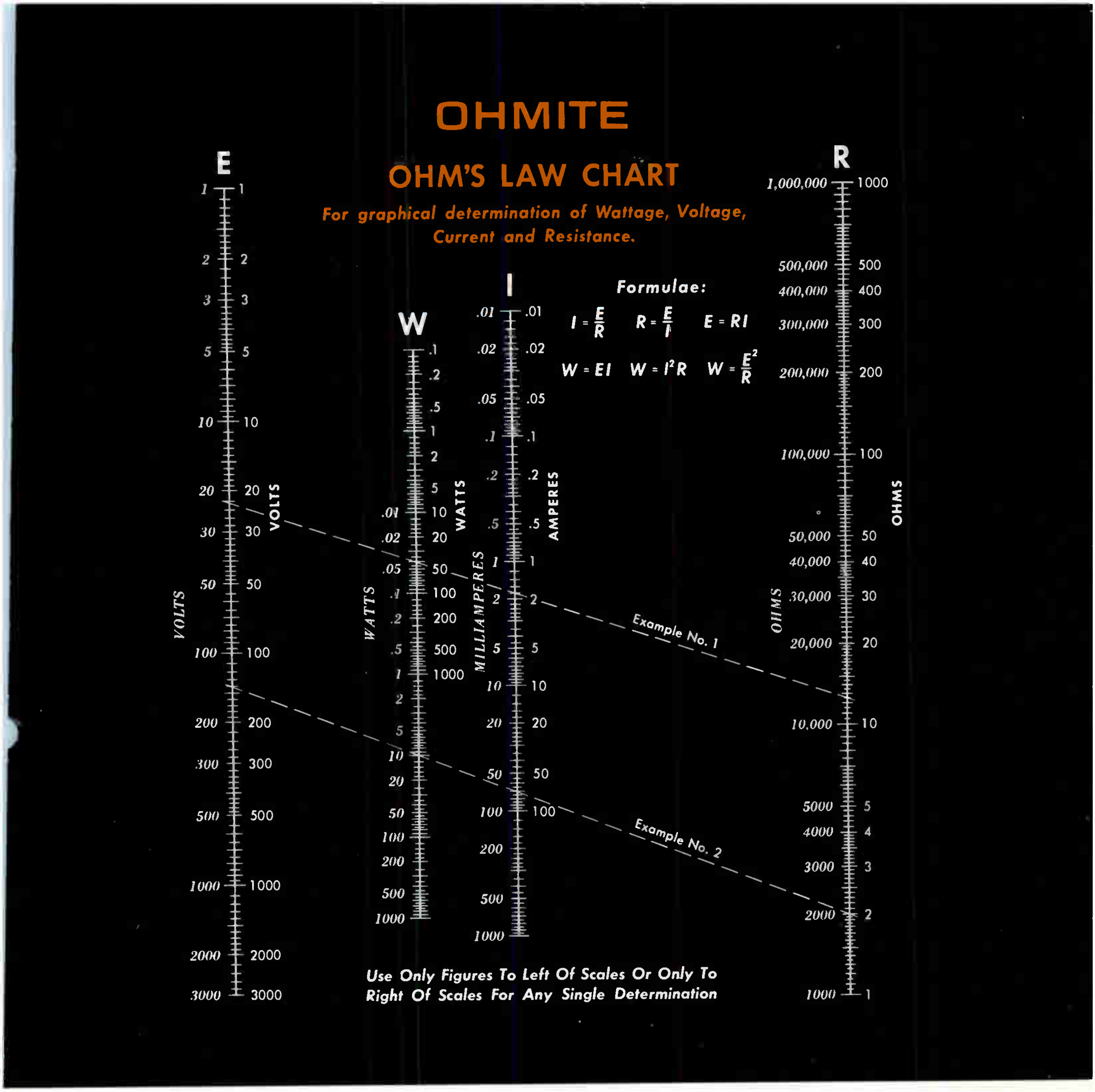
The formulas given in Fig. 2 apply to single-phase alternating current circuits containing reactance, such as circuits involving relays, magnets, solenoids, motors, chokes and filter circuits. It can be noted that these formulas reduce to the same form as the direct current formulas when the reactance is zero and cosine θ thereupon becomes equal to 1.

E = Volts		$\frac{W}{I \cos\theta}$	IZ	$\frac{\sqrt{WR}}{\cos\theta}$	$\sqrt{\frac{WZ}{\cos\theta}}$	
I = Amperes	$\frac{W}{E\cos\theta}$		$\frac{E}{Z}$	$\sqrt{\frac{W}{R}}$	$\sqrt{\frac{W}{Z\cos\theta}}$	
Z = Ohms	$\frac{E}{I}$	$\frac{W}{I^2\cos\theta}$		$\frac{R}{\cos\theta}$	$\frac{E^2\cos\theta}{W}$	$\sqrt{R^2+X^2}$
R = Ohms	$\frac{E^2\cos^2\theta}{W}$	$\frac{E}{I}\cos\theta$	$Z\cos\theta$		$\frac{W}{I^2}$	$\sqrt{Z^2-X^2}$
W = Watts	$\frac{E^2\cos\theta}{Z}$	$EI\cos\theta$	$I^2Z\cos\theta$	I^2R		
$\cos\theta$ = (Power Factor)	$\frac{IR}{E}$	$\frac{W}{I^2Z}$	$\frac{WZ}{E^2}$	$\frac{R}{Z}$	$\frac{W}{EI}$	$\frac{R}{\sqrt{R^2+X^2}}$
X = Ohms	$(X_L - X_C)$		$\left(2\pi fL - \frac{1}{2\pi fC}\right)$			$\sqrt{Z^2-R^2}$

Z = Impedance
X_L = Inductive Reactance
X_C = Capacitive Reactance
f = Frequency in cycles per second
L = Inductance in henries
C = Capacitance in farads
θ = Angle of lead or lag
ω = Angular velocity = $2\pi f$

Note: Power Factor is often expressed as a percentage.

Fig. 2: Table of Ohm's Law Formulas Modified for Alternating Current, Single Phase Circuits.



HOW TO USE THIS OHM'S LAW CHART

This alignment chart enables graphical solution of Ohm's Law problems. To use, place a ruler across any two known values on the chart; the points at which the ruler crosses the other scales will show the unknown values. The *italic* figures on the left of the scales cover one range of values and the figures on the right of the scales cover another range. For a given problem, all values must be read on the left set or right set of numbers only, as required.

Example No. 1: The current through a 12.5 ohm resistor is 1.8 amperes. What is the voltage across it? The wattage? Answer: Dotted line No. 1 through $R = 12.5$ and $I = 1.8$ shows E to be 22.5 volts and W to be 40.5 watts.

Example No. 2: What is the maximum permissible current through a 10 watt resistor of 2000 ohms? Answer: Dotted line No. 2 through $W = 10$ and $R = 2000$ shows I to be 70 milliamperes.

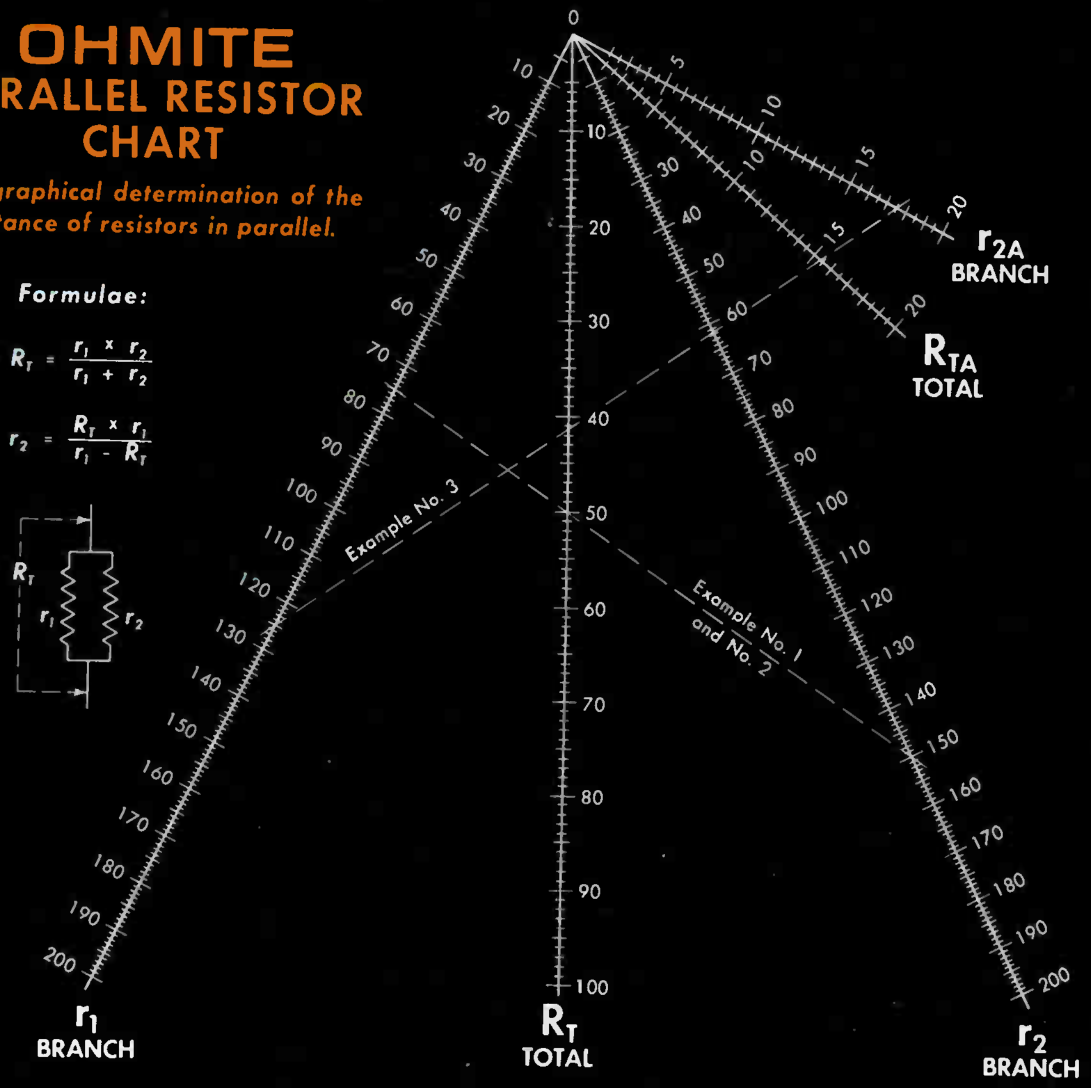
OHMITE PARALLEL RESISTOR CHART

For graphical determination of the resistance of resistors in parallel.

Formulae:

$$R_T = \frac{r_1 \times r_2}{r_1 + r_2}$$

$$r_2 = \frac{R_T \times r_1}{r_1 - R_T}$$



HOW TO USE THIS PARALLEL RESISTOR CHART

This alignment chart enables graphical solution of problems involving resistances connected in parallel. The values of the parallel resistors r_1 and r_2 and of the total effective resistance R_T must be read on the scales marked with the corresponding letters. To use, place a ruler across the two known values; the point at which the ruler crosses the third scale will show the unknown value. Pairs of resistances which will produce a given parallel resistance can be obtained by rotating a ruler around the desired value on scale R_T. The range of the chart can be increased by multiplying the values on *all* the scales by 10, 100, 1000, etc., as required. Scales r_{2A} and R_{TA} are used with scale r_1 when the values of r_1 and r_2 differ greatly.

Example No. 1: What is the total resistance of a 75 ohm resistor and a 150 ohm resistor connected in parallel? Answer: From dotted line No. 1, R_T is 50 ohms.

Example No. 2: What resistance in parallel with 750 ohms will give a combined value of 500 ohms? Answer: From dotted line No. 1, r_2 is 1500 ohms.

Example No. 3: What is the combined resistance of 1750 ohms and 12,500 ohms? Answer: Scales r_1 and r_{2A} are used and from dotted line No. 3, R_{TA} is 1535 ohms.

Example No. 4: What is the combined resistance of 400, 600 and 800 ohm resistors in parallel? Answer: First find R_T for 400 ohms and 600 ohms. Then set the 240 ohms thus found as a new r_1 and 800 ohms as r_2 and the final answer is found to be 185 ohms.

CURRENT, VOLTAGE AND POWER IN THREE-PHASE CIRCUITS

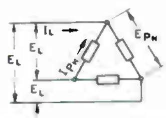
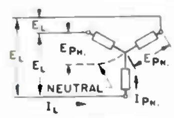
	3 PHASE CONNECTIONS (BALANCED LOAD)	
	DELTA	STAR—(Y)
		
E_L =	E_{Ph}	$\sqrt{3}\, E_{Ph} = 1.73\, E_{Ph}$
E_{Ph} =	E_L	$E_L/\sqrt{3} = E_L/1.73 = 0.577\, E_L$
I_L =	$\sqrt{3}\, I_{Ph} = 1.73\, I_{Ph}$	I_{Ph}
I_{Ph} =	$I_L/\sqrt{3} = I_L/1.73 = 0.577\, I_L$	I_L
Total Volt-Amperes =	$3 \times E_{Ph} \times I_{Ph} = \sqrt{3}\, E_L \times I_L = 1.73\, E_L I_L$	$3 \times E_{Ph} \times I_{Ph} = \sqrt{3}\, E_L \times I_L = 1.73\, E_L I_L$
Total Watts =	*PF* × *Total Volt-Amperes* or $PF \times 1.73\, E_L I_L$	
Power Factor (PF) =	*Cosine of angle by which E_L leads or lags I_{Ph}*	*Cosine of angle by which E_{Ph} leads or lags I_L*
	$\dfrac{\text{Total Watts}}{\text{Total Volt-Amps.}} =$	$\dfrac{\text{Total Watts}}{\sqrt{3}\, E_L I_L}$

Fig. 3: Table of Three Phase Relationships.

RESISTANCES IN SERIES

Total Resistance $R_T = R_1 + R_2 + R_3 \cdots + R_N$ *Ohms*

RESISTANCE OF PARALLEL CONNECTIONS

For resistances in parallel:

$$\text{Total Resistance } R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_n}} \text{ Ohms}$$

For two resistances in parallel:

$$\text{Total resistance } R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

When one of the resistances and the total are known the formula is conveniently written:

$$R_2 = \frac{R_T \times R_1}{R_1 - R_T}$$

When the resistances are all equal, the total parallel resistance is equal to the value of one resistance divided by the number of units. For example, the total resistance of two equal resistances in parallel is one-half that of one, the parallel resistance of three equal resistances is one-third that of one.

The handy chart on page 4 can be used for quickly determining the approximate resistance of two resistors in parallel.

The resistance of any number of resistors in parallel can be determined readily by calculating the current in each resistor, adding the currents and dividing the voltage across the resistors by the total current.

KIRCHHOFF'S LAWS

Kirchhoff's laws are extremely useful for the calculation of circuits containing more than one source of voltage or containing parallel paths.

First Law: *"The algebraic sum of the potential drops around every closed circuit is always equal to zero."*

Note that one direction is assumed positive for voltages and currents, and that opposing voltages, or circuits which are traversed in the opposite direction, take negative signs. A resistance drop is always negative with respect to the direction of the impressed voltage.

$$E_1 \pm E_2 \cdots \pm E_n - IR_1 - IR_2 \cdots - IR_n = 0$$
$$\text{or } E = \Sigma IR$$

Second Law: *"The algebraic sum of the currents at any junction of the conductors is always zero."*

That is, the total current flowing towards a junction point of several conductors must be equal to the sum of the currents flowing away from the point.

DISSIPATION AND STORAGE FACTORS—ADMITTANCE PARAMETERS

*D = Dissipation Factor	$\frac{R}{X}$	$\cot\theta$	$\frac{1}{Q}$	$\frac{G}{B}$
*Q = Storage Factor	$\frac{X}{R}$	$\tan\theta$	$\frac{1}{D}$	$\frac{B}{G}$
Y = Mhos Admittance	$\frac{1}{Z}$			
G = Mhos Conductance	$\frac{1}{R}$ (For $X = 0$)	$\frac{R}{Z^2}$		
B = Mhos Susceptance	$\frac{1}{X}$ (For $R = 0$)	$\frac{X}{Z^2}$	*D and Q are numbers	

Fig. 4: Table of Terms Used for Capacitors, Coils and Circuits.

SECTION I. BY CALCULATION

When the current through, and the voltage across a resistor are known from the given conditions of a circuit, the resistance can be readily calculated by Ohm's Law. Cases which are calculable, rather than determinable only by test, are most often those in which the resistance is used as a voltage dropper to operate a low voltage device from a higher voltage source, or to limit the amount of current passing. Typical cases are: operation of low-voltage lamps or devices from 110 or 220 volt lines; dropping or bias resistors in radio circuits; current limiting heater control.

Example 1: It is desired to operate a 6 volt, 15 C.P. lamp drawing 2.02 amperes from the 115 volt power line. What resistance is required?

Method: Volts across resistor $= (115\text{-}6) = 109$

By Ohm's Law: $R = \frac{E}{I} = \frac{109}{2.02} = 54$ ohms

Also Watts $= EI = 109 \times 2.02 = 220$ *watts*

Note: If the lamp were to be operated at less than 6 volts, the fact that the lamp resistance is not a constant would have to be taken into account.

The lamp resistance can be calculated by reference to the graph, "Average Curves for Tungsten Filament Lamps" in the "Lamp Dimming" portion of the "Rheostat" catalog.

Selecting a Resistor: (a) Using Stock Units. A total resistance of 54 ohms can be made up of two Catalog No. 0701 fixed resistors of 25 ohms each, connected in series with a Catalog No. 0362 Dividohm Adjustable Resistor of 5 ohms, which is to have the adjustable lug set at 4 ohms.

(b) *Using Made-to-Order Units.* A single unit 1⅛" x 11¼", Code: 11¼ P46 F-54, of 54 ohms and operating at 94% load could be used; or two units 1⅛" x 8½", Code: 8½ P46F-27, each of 27 ohms and connected in series to operate at 63% of rated watts, might be chosen.

Example 2: It is desired to control a 500 watt, 115 volt heater by means of a rheostat so that the amount of heat (number of B.T.U. per hour) may be reduced 50%. What rheostat resistance is required?

Calculation:

Maximum current $I = \frac{W}{E} = \frac{500}{115} = 4.35$ *amperes*

Heater resistance is $\frac{E}{I} = \frac{115}{4.35} = 26.4$ *ohms*

Because the amount of heat produced is directly proportional to the watts, the heater watts must be reduced to 250. The current is then:

$$I = \sqrt{\frac{W}{R}} = \sqrt{\frac{250}{26.4}} = \sqrt{9.47} = 3.08 \text{ amps.}$$

$$R_{Total} = \frac{115}{3.08} = 37.4 \text{ ohms.}$$

$$R_{Rheostat} = R_{Total} - R_{Heater} = 37.4 - 26.4 = 11.0 \text{ ohms.}$$

Selecting a Rheostat: (a) From Stock.

The smallest rheostat available from stock for this particular case (see "Rheostats"), is a Model N, 300 watt unit of 15 ohms, Catalog No. 0657. This rheostat is selected because it is the nearest stock unit that has a current rating (4.47 amps.) greater than the 4.35 amperes maximum required for this application.

(b) *Made-to-Order.*

A Model P with uniform winding can be used for this application.

TAPPED RESISTORS—VOLTAGE DIVIDERS—POTENTIOMETERS

The procedure for calculating a typical voltage divider is given in Example 3. The same method can be extended to cover a voltage divider of any number of sections. When a rheostat or "Dividohm" adjustable resistor is used as a potentiometer, it is in effect a voltage divider with variable sections and can be calculated in the same way.

Example 3: To find the resistance and wattage of each section of a voltage divider for a radio transmitter. *Conditions:* Rectifier voltage (maximum across bleeder) = 1000 volts. To be provided with taps at 750 volts, 40 milliamperes, and 500 volts, 20 milliamperes. Bleeder current to be 40 milliamperes.

Method: The first step is to make a sketch similar to Fig. 5 showing the voltages and currents. Commence with Section A, which carries only the bleeder current I_A. By Ohm's Law:

$$R_A = \frac{500}{.040} = 12{,}500 \text{ ohms}$$

$$W_A = 500 \times .040 = 20 \text{ watts}$$

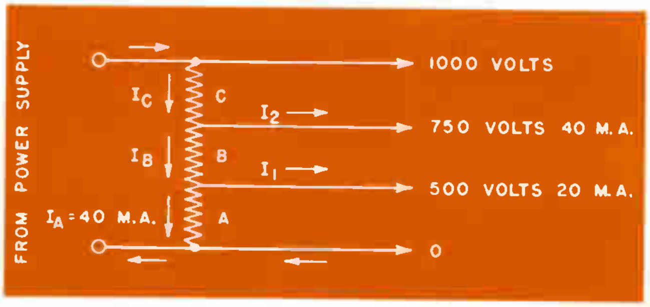


Fig. 5: Voltage Divider Diagram for Example 3.

Section B carries the bleeder current I_A plus the current I_1, drawn at the 500 volt tap or

$$I_B = 40 + 20 = 60 \text{ milliamperes}$$

$$R_B = \frac{250}{.060} = 4{,}166 \text{ ohms}$$

$$W_B = 250 \times .060 = 15 \text{ watts}$$

Section C carries the current in Section B plus the current drawn at the 750 volt tap.

$$I_C = I_B + I_2, \text{ or } I_C = 60 + 40 = 100 \text{ milliamps. or } 0.1 \text{ amp.}$$

$$R_C = \frac{250}{.1} = 2500 \text{ ohms}$$

$$W_C = 250 \times .1 = 25 \text{ watts}$$

$$R_{Total} = 12500 + 4166 + 2500 = 19{,}166 \text{ ohms}$$

$$W_{Total} = 20 + 15 + 25 = 60 \text{ watts.}$$

Note that the voltage between the taps of a voltage divider will change if the currents drawn from the various taps change, and that the bleeder current (section A) is increased under no-load conditions and is then equal to supply voltage divided by total bleeder resistance. All sections should be designed to carry the maximum current which would occur under the different conditions of use.

Selecting the Resistor (a) from Stock.

The total resistance required is 19,166 ohms; hence a Dividohm adjustable resistor of 20,000 ohms can be used. Three adjustable lugs will be needed to form the divider. The current rating of the Dividohm must not be exceeded in any section regardless of the watts to be dissipated in that section. Hence, a Dividohm with a rating equal to, or larger than, the maximum current (0.1 amp.) must be selected. This is Stock No. 1367, equipped with two lugs No. 2158 in addition to the one regularly supplied with the resistor.

The divider could be assembled also by using one of No. 0208, No. 0382 and No. 0583 resistors in series.

(b) *From Made-to-Order Sizes.* A tapped resistor on a ¾" x 6½" core would be suitable. The winding space allowed for each section and the wire size would be determined by us according to the wattage and resistance.

SECTION 2. BY TRIAL OR SUBSTITUTION

When the amount of control or change to be produced by a resistance unit is not or cannot be known without trial, a temporary or substitute resistance and suitable meters must be connected in the actual circuit; then the resistance is varied until the desired results are secured and the amount of resistance and current noted.

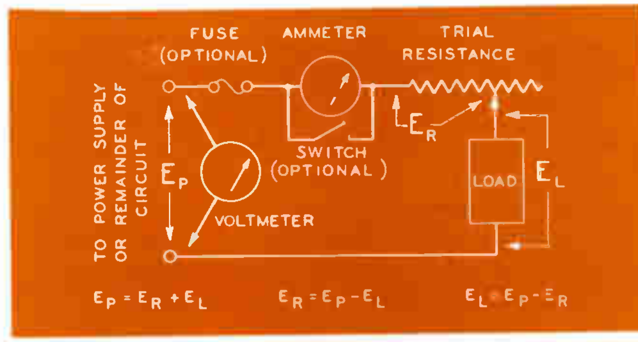


Fig. 6: Typical Test Circuit for Use in Determining Resistance and Current.

Circuit: Fig. 6 illustrates a typical test circuit (which may be only part of a larger circuit). The power supply may be the commercial 115 V. or 230 V. outlet, batteries or a generator. The load may be any device such as a motor, generator field, lamp, or heater. The adjustable trial resistance may be an Ohmite rheostat, or it may consist of a number of Ohmite fixed resistors, or one or more Ohmite adjustable Dividohm resistors. Fig. 7 illustrates a convenient way of inserting the trial resistance and ammeter by means of a series plug (such as Hubbell No. 7772).

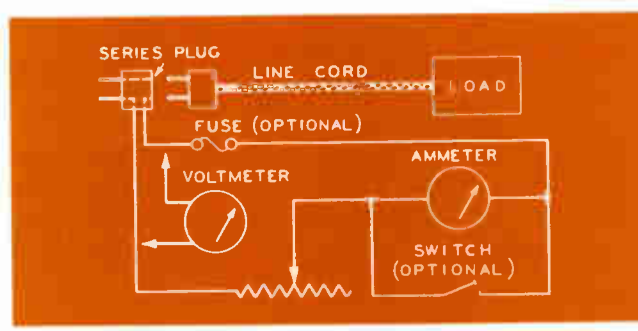


Fig. 7: Typical Test Circuit Using a Series Plug for Connection.

PRACTICAL POINTS ON SELECTING METERS AND WIRING

Before connecting any meter to a circuit, the meter range should be compared with the maximum current or voltage expected, to make sure that the meter range exceeds the values which are to be measured. The expected values can be obtained from the name plate data of the apparatus under test or by calculation from the wattage and voltage. It is well to include a fuse in the circuit to protect the meters and apparatus against accidental overload.

When possible, select meters on which the indications will occur in the upper half of the scale in order to obtain the most accurate reading. When the range between maximum and minimum current is very great, it may be necessary to substitute a lower range ammeter for the minimum values.

HOW TO DETERMINE REQUIRED FOR

Because of the non-uniform calibration of the scale, alternating current instruments generally cannot be used below approximately 20% of full scale value (except for rectifier type instruments). Small direct current meters commonly have an accuracy of 2% of full scale readings. Alternating current meter accuracy varies (in descending order) according to the type as follows: electro-dynamometer, iron vane and rectifier (5%).

When the load current amounts to several amperes, as in most power applications, the effect of the current drawn by the voltmeter (when connected across the resistance or the load) generally can be ignored. But as alternating current voltmeters are quite generally of low resistance, the amount of current drawn by the meter should be considered whenever the load currents are small. In the case of high resistance, low current circuits (as in radio apparatus), high resistance rectifier type voltmeters or vacuum tube voltmeters must be used to avoid upsetting circuit conditions.

Pulsating Direct Current: Conventional permanent magnet (D'Arsonval) direct current meters read average values. When used on pulsating D.C., the average value indicated is not the true measure of the heating effect or power. For battery charging circuits, the average values are used, but for lighting or heating circuits, the R.M.S. (root-mean-square) value must be used. For unfiltered half-wave rectification, this is 1.57 times the average value; for unfiltered full-wave rectification, it is 1.11 times the average. For filtered circuits where the amount of ripple is less than one-third of the maximum, the difference between the average and R.M.S. is less than 1%.

Wiring: Copper wire of large enough gauge to carry the current without appreciable heating should be used so that the resistance of the connecting wires can be neglected.

MEASUREMENTS REQUIRED

The number of measurements necessary to determine the required resistor depends upon whether the control resistance is to be fixed or adjustable and upon the nature of the load (i.e., of constant or varying resistance). Fig. 8 shows the measurements to be taken for each of the different possibilities. The intermediate tests for Type 3 Control are taken to obtain a curve showing how the current varies between the maximum and minimum.

Over-Voltage: If there is any possibility of operating voltages exceeding the test voltages, it is well to consider the effect on the current rating and resistance required to be certain of obtaining the desired amount of control under the most adverse operating conditions.

TYPE 1. FIXED RESISTOR CONTROL

Example 4: An A.C. relay intended for operation on 110 volts is to be operated from a 220 volt line. The operating current is unknown. What resistance is required?

Method: The relay, a trial resistance (Ohmite "Dividohm" or rheostat) and a meter are connected in series as in Fig. 6. The resistance is then varied until the relay operates satisfactorily, with the voltage measured across the relay checking at 110V. Typical measured data might be as follows:

Measured Data for Example 4

I	E_P	E_R	$R_{Res.}$
.105 Amp.	220 V.	110 V.	$\frac{110}{.105}$ = 1045 ohms

Wattage in Resistor $= EI = 110 \times .105 = 11.55$ *watts.*

Selection of Resistor: A Stock No. 0375B, 1250 ohm "Dividohm" or 1000 ohm 20 watt Brown Devil.

Type of Control and Load			Conditions for Each Test		Measure Any Two (or Three to Provide a Check)			Measure in Each Case	Measure or Calculate
Type 1	*Type 2	*Type 3			E_P	E_R	E_L	I	R
Fixed Resistance Control—Any Load	Rheostat Control—Constant Resistance Load	Rheostat Control—Varying Resistance Load		For Type 3 Loads, More Than 5 Tests Are Often Taken to Obtain More Detailed Information.	Line Volts	Volts Across Resistance	Volts Across Load	Amps. Current	Ohms Control Resistance
Minimum Tests Required									
	√	√	1	Resistance = 0 Current = $I_{Max.}$ = Maximum					
√	√	√	2	Res. = Max. Value Used. Current = $I_{Min.}$ = Minimum		Your test data may be arranged in tabular form similar to this.			
		√	3	Res. = 3 or more Intermediate Values					

*Measurements for Type 2 Loads are sufficient for Type 3 Loads if a uniformly wound rheostat is to be used.

Fig. 8: Table of Tests and Data Required for Different Types of Controls and Loads.

TYPE 2: RHEOSTAT CONTROL OF A CONSTANT RESISTANCE LOAD

Typical Applications: The temperature control of heaters, such as drying ovens, solder pots, glue pots, electric furnaces, machine spot-heaters, soldering irons, etc.; field control of generators, balancing of control circuits; etc.

Example 5: A drying oven of 500 watts, 115 volt rating, is to be controlled between its maximum temperature and some lower value (to be determined during the test).

Method: From $I = \frac{W}{E} = \frac{500}{115} = 4.35$ *amperes*, it can be seen that a 5 ampere meter will handle the maximum current. The trial rheostat, of course, should be rated to carry this current or more.

Assuming that the temperature will fall at a somewhat lesser rate than the wattage, and that the desired minimum temperature is approximately 75% of the maximum, select a trial rheostat which will reduce the wattage by about one half.

Calculations similar to those given in Example 2, show that approximately 10 ohms will be needed The circuit in Fig. 6 or Fig. 7 can be used. The trial resistance is increased step by step and time allowed for the oven temperature to stabilize itself until the desired operating temperature is reached.

Data as called for in Fig. 8, Conditions 1 and 2, are taken.

Conditions	I Amps.	E_P Volts	E_R Volts	R Ohms
Maximum	4.35	115	0	0
At Desired Temperature	3.5	115	22.4	$\frac{22.4}{3.5} = 6.4$ ohms

Selecting a Rheostat: Proceed as given under Example 2. Stock Rheostat: Model L, Cat. No. 0529, 7.5 ohms, 150 watts, 4.47 amps. maximum current.

TYPE 3. RHEOSTAT CONTROL FOR A VARYING RESISTANCE LOAD

Typical Applications: Lamp dimming, motor speed control, etc.

Example 6: A ventilating fan is directly driven by a 1/6 H.P., 115 Volt D.C. series motor. It is desired to control the speed of the fan from the maximum down to a value determined by trial. From the chapter, "Rheostat Control of Motor Speed" in the "Rheostat" catalog, it is ascertained that a series rheostat will provide satisfactory control.

Test Must Be Made With Motor Loaded: All tests on motors must be run while they are connected to their normal loads.

Circuit: Fig. 6 or 7. Meters: From the name plate data on the motor, it is found that the full load current is 1.5 amperes.

The ammeter should be shorted while the motor is being started so as to protect the meter against the starting surge.

Procedure: From Fig. 8 it can be seen that for complete data, measurements must be taken under at least five different conditions. The first condition is that of full speed, when the load current is at maximum and the control resistance is at zero.

The temporary resistances for the test should be selected so that their maximum current ratings are equal to, or greater than the load current when they are in the circuit. Therefore, the first adjustable resistance to be inserted in the circuit should have a current rating of more than 1.5 amps.

Measured Data for Example 6

Condition	Speed R.P.M.	E_P Line Volts	E_R Volts Across Rheostat	I Amps.	R (Calculated) Ohms
1	1725	115	0	1.50	0
2	1500	115	22.0	1.29	17.1
3	1300	115	39.0	1.11	35.1
4	1100	115	51.8	0.96	54.0
5	900	115	66.7	0.82	81.2

Your test data, including complete name plate description of the motor should be sent to us to permit calculation of the taper-wound rheostat best suited for the application.

Selecting a Rheostat: Proceed as given under Example 2. Stock Rheostat: Model N, Stock No. 0661, 100 ohms, 1.73 amps. maximum current. Tapered Rheostat: A Model L of 82 ohms can be used.

ENVIRONMENTAL FACTORS— POWER RATING

All the components of an electrical apparatus—resistors, rheostats, capacitors, transformers, chokes, wiring, terminal boards, rectifiers, transistors, electronic tubes, etc.—have their own limitations as to the maximum temperature at which they can reliably operate. The attained temperature in service is the sum of the ambient temperature plus the temperature rise due to the heat dissipated in the apparatus. The temperature rise of a component is affected by a number of factors as explained in some detail in Resistor Catalog 100 and Rheostat Catalog 200. Maximum operating temperatures are given also in all of the other catalogs.

The graphs and discussions which follow, amplify and supplement the data previously referred to.

Note that the Multiplying Factors given on the Short Cut Chart, in the "Resistor" catalog, are the reciprocals of the "Percent Load Ratings" shown on the graphs in this section. The percent figures are, of course, expressed as decimals before finding the reciprocals.

AMBIENT TEMPERATURE DERATING

Fig. 9 shows the percent of full load which power resistors can dissipate for various high ambient temperatures. Curves for Rheostats, Riteohm Precision Resistors, and VT Variable Transformers are given in their respective catalogs.

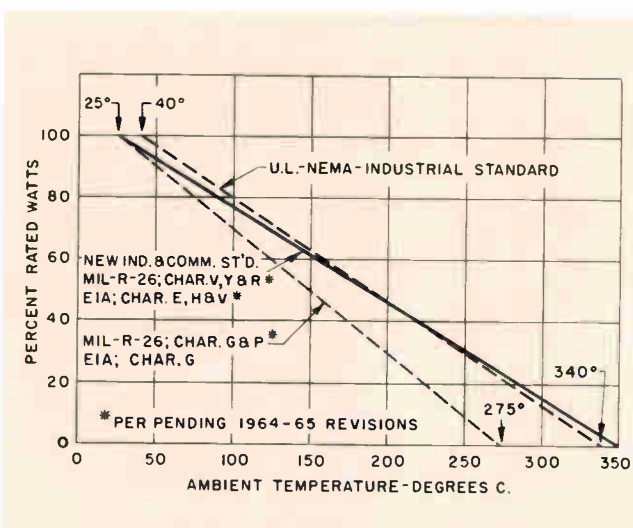


Fig. 9: Derating of Resistors for High Ambient Temperatures.

DERATING DUE TO ENCLOSURE

The amount of derating required, if any, because of enclosure is affected by a number of factors, most of which are hard to determine accurately. The watts per square inch of surface, size, shape, orientation, wall thickness, material, finish and amount and location of ventilating openings all play a part. Fig. 10 serves to indicate for a particular set of conditions how the temperatures varied with the size of enclosure for a moderate size power resistor.

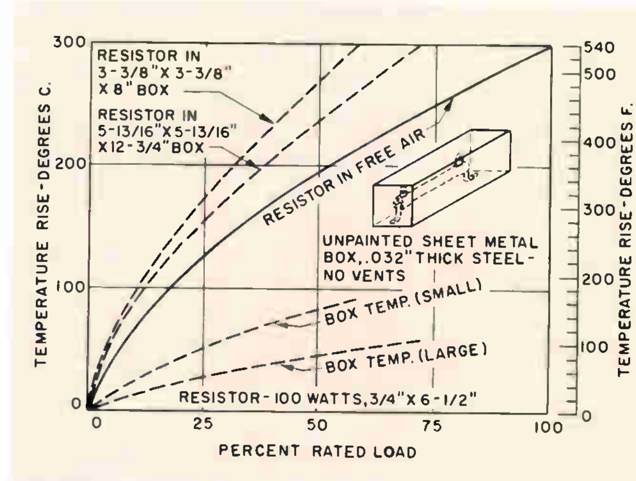


Fig. 10: Example of Effect of Size of Enclosure on Temperature Rise of An Enclosed Resistor.

DERATING DUE TO GROUPING

The temperature rise of a component is affected by the nearby presence of other heat-producing units, such as resistors, electronic tubes, etc. The curves in Fig. 11 show the power rating for groups of resistors with various spacings between the closest points of the resistors, assuming operation at maximum permissible hot spot temperature. If resistors are to be operated at lower hot spot temperatures, the amount of derating for grouping can be reduced.

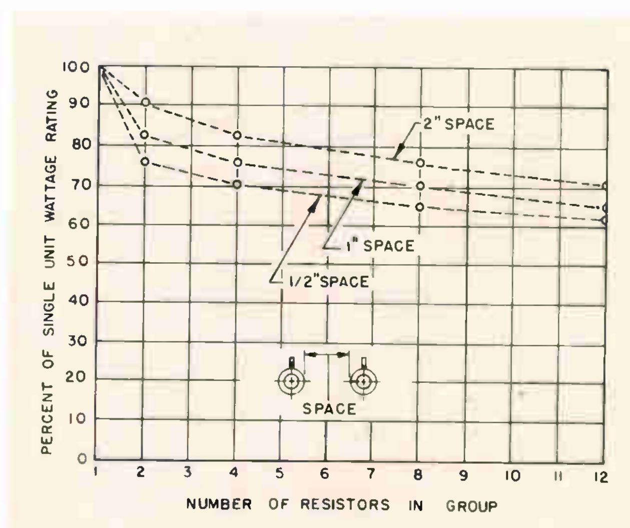


Fig. 11: Derating of Resistors to Allow for Grouping.

DERATING FOR ALTITUDE

The curve in Fig. 12 shows the proportional watts for various altitudes, assuming standard atmospheric conditions.

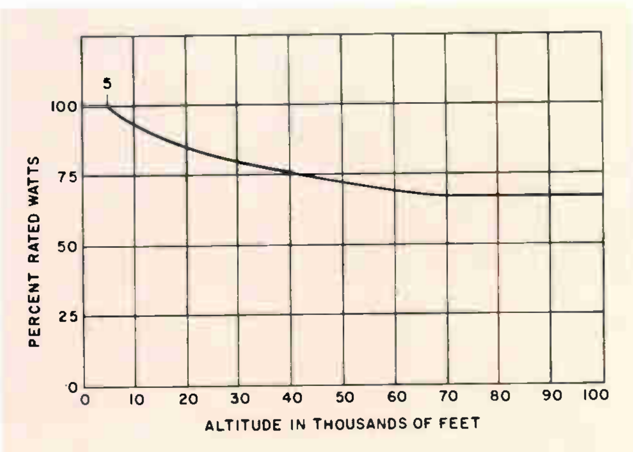


Fig. 12: Derating for Altitude.

PULSE OPERATION

Unlike the environmental factors, which result in reduction of the watt rating, pulse operation may permit higher power in the pulses than the continuous duty rating.

The NEMA has set up certain standard duty cycles for motor control resistors and the resistor ratings for some of these conditions are shown in Fig. 13.

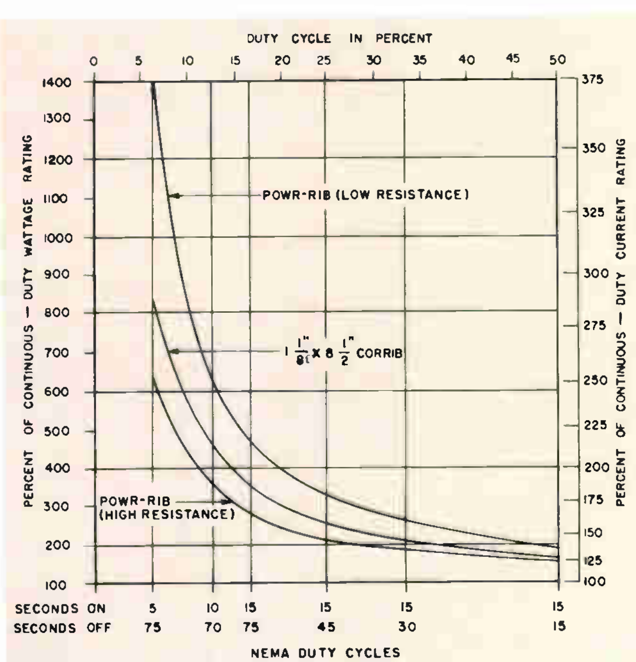


Fig. 13: Percent of Continuous Duty Rating for Resistors for Typical NEMA Duty Cycles.

The curves in Figures 15, 16, 17 and 18 illustrate the more general case of various combinations of on and off time for specified loads up to 1000% for a continuous series of pulses. Intermediate loads can be approximated by interpolation. The "on-time" at which each curve flattens out also indicates the maximum on-time for single pulses (with enough off-time for cooling to ambient). Additional data on single pulses is given by Fig. 14. Resistors will reach about 75% of the rated maximum temperature rise in approximately 5 to 8 pulses and level off at maximum rise in another 10 to 20 cycles, depending on percent load, size, type, etc. Any curve passing above the intersection of the designated on and off-times indicates a percent load which can be used. A resistor operated at the rating of an interpolated curve through the point of intersection would operate at maximum rated temperature rise.

The *exact* temperature rise, of course, varies with each resistor, depending on size, ohms winding, etc. The curves shown indicate the approximate rise for *typical*

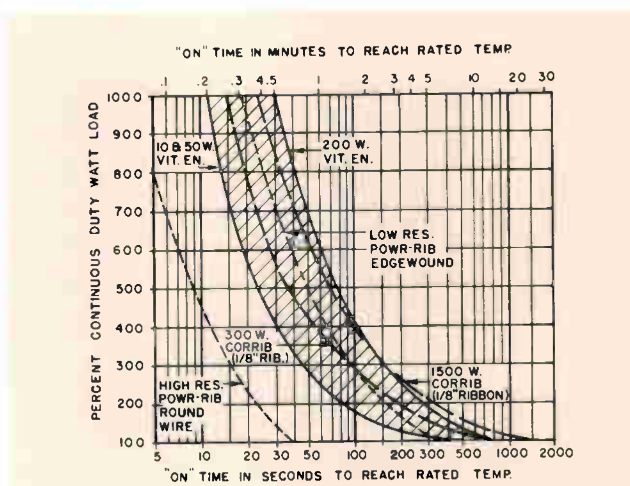


Fig. 14: Time Required for Typical Resistors to Reach Rated Operating Temperature at Various Watt Loads.

units only, as a band or range of values actually exists for each percent load.

Ratings at over 1000% are not recommended except for POWR-RIB resistors. Curves for intermediate size resistors can be roughly estimated by comparison with the sizes given.

Ratings for single pulses in the milli-second range (and up to 1 to 2 seconds) require individual calculation. This is because the ratings vary greatly with the resistance, or more specifically with the actual weight and specific heat of the resistance alloy used. Calculation is based on the assumption that all of the heat generated in the pulse goes to raise the temperature of the resistance wire.

PULSE OPERATION—COOLING—LIMITED TEMPERATURES

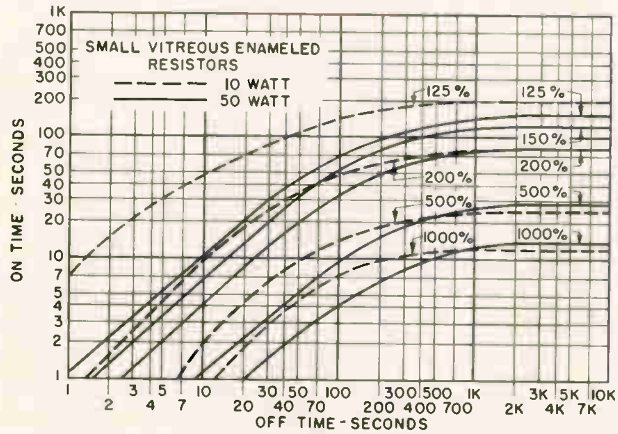


Fig. 15: Percent of Continuous Duty Rating for Pulse Operation of Small to Medium Size Vitreous Enameled Resistors.

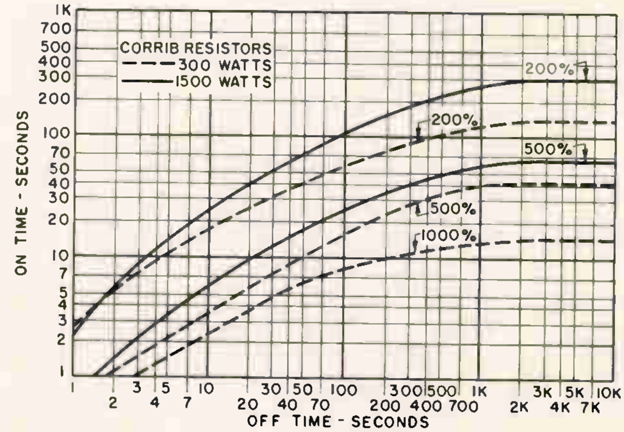


Fig. 17: Percent of Continuous Duty Rating for Pulse Operation of CORRIB, Corrugated Ribbon Resistors.

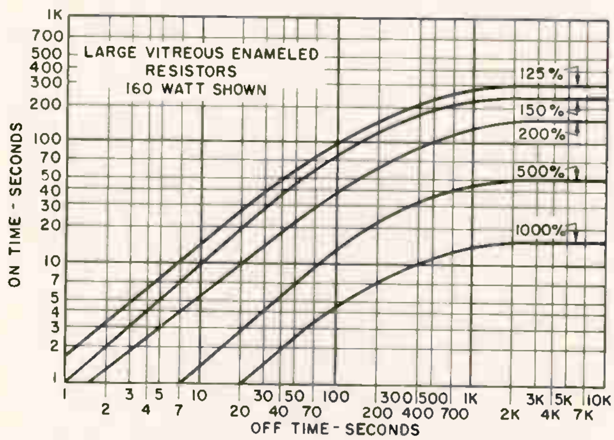


Fig. 16: Percent of Continuous Duty Rating for Pulse Operation of Large Vitreous Enameled Resistors.

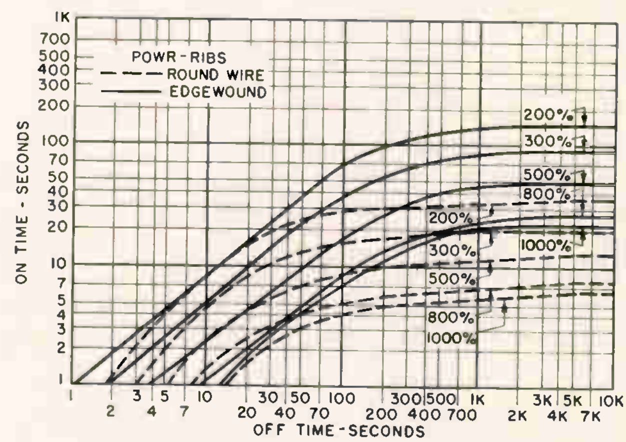


Fig. 18: Percent of Continuous Duty Rating for Pulse Operation of POWR-RIB, Bare Resistors.

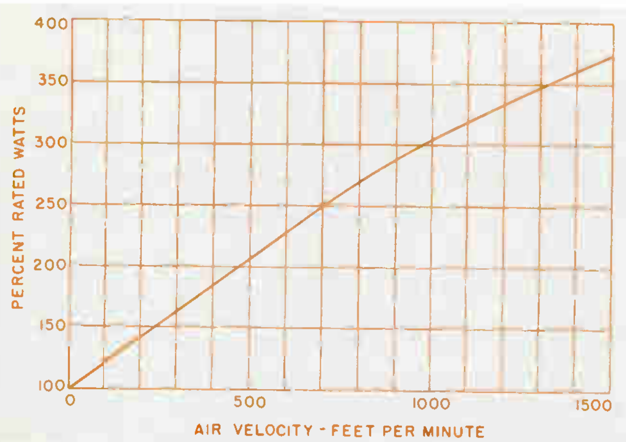


Fig. 19: Percent of Free Air Rating for Typical Resistor or Rheostat Cooled by Forced Air Circulation.

COOLING AIR

Resistors, rheostats and other components can be operated at higher than rated wattage when cooled by forced circulation of air. A typical curve is illustrated in Fig. 19. The curve tends to level off at higher velocities as excessive hot spots develop where the air flow does not reach all parts uniformly.

LIMITED TEMPERATURE RISE

When it is desired to operate a resistor or rheostat at less than maximum temperature rise, the percent watts for a given rise can be read from "Temperature Rise vs. Load" graphs in each catalog.

RESISTOR DESIGN
Resistance Alloys and Uses

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A number of different resistance alloys are used in winding resistors and rheostats as shown in Fig. 20. The general use for each alloy is indicated by the column headed, "Resistance Range for Which Used." Whether a particular alloy can be used on a specific resistor can be estimated by dividing the given resistance by the area of the given winding space and determining whether the quotient falls within the limits given hereafter. The "high resistance" alloys cover the range from approximately 10 to 25,000 ohms per square inch of winding area, the "low to medium" type from 5 to 400 ohms and the "very low resistance" alloys from less than an ohm to 250 ohms. It should be noted that the "Ohms per Square Inch" ranges overlap considerably, indicating that in many instances a given resistor could use any of several alloys. Both the upper and lower limits of the ranges are only approximate and in general can be extended somewhat when necessary.

The actual temperature coefficient of a complete resistor is generally greater than the nominal for the wire alone. The approximate change in overall resistance at full load is shown in the table.

Other Alloys: In addition to the alloys tabulated which show small changes in resistance with temperature, there are others which sometimes have to be used for very low resistance units. These alloys have higher temperature coefficients, which limit their use to applications where the change in resistance with load is not important. An example is No. 60 alloy, which has a resistance of 60 ohms per circular-mil-foot and a temperature coefficient of +700ppm/°C.

Ballast Wire: There are other alloys which are selected especially for their high temperature coefficient of resistance. These are used for so-called "ballast" resistors where a large change in resistance is desired with a change in load. A typical ballast wire is Nickel, which has 58 ohms/cmf and a temperature coefficient of +4800ppm/°C. Others are "Hytemco" and "Balco" at 120 ohms/cmf and a TC of +4500ppm/°C.

ASTM Alloy Class*	Alloy Composition (Approximate)	Ohms per CMF	Trade Names	Mean Temperature Coeff. of Res. ppm/°C	Temperature Range for TC °C	Resistance Range for Which Used	†Average Resistance Change at Full Load
1a	Nickel base, non-magnetic Ni 75%, Cr 20% plus Al, Cu, Fe, etc.	800	Evanohm Karma Moleculoy Nikrothal L	0 ± 20	−65 to +250	Very high, medium and up, for low temp. coeff.	Under ±1% to ±2%
1b		800		0 ± 10	−65 to +150		
2a	Iron base, magnetic Fe 73%, Cr 22.5%, Al 4.5% (plus Co in one alloy)	800	Alloy 815-R Kanthal DR Mesoloy	0 ± 20	−65 to +200	Alternate sometimes for Class 1	Under ±1% to ±2%
2b		800		0 ± 10	0 to +150		
3a	Nickel-Chromium 80%—20%	650	Chromel A Nichrome V Nikrothal B Protoloy A Tophet A	+80 ± 20	−65 to +250	High and medium	+4 to +6%
3b		675		+60 ± 20			
4	Nickel—Chromium—Iron 60%—16%—24%	675	Chromel C Electroloy Nichrome Nikrothal 6 Tophet C	+140 ± 30	−65 to +200	High and medium	+5 to +8%
5a	Copper-Nickel 55%—45%	300	Advance Copel Cupron Cuprothal 294 Neutroloy	0 ± 20	−65 to +150	Low and low to medium for low temp. coeff.	Under ±1% to ±2%
5b				0 ± 40			
6	Manganin 13% Mn, 87% Cu	290	Manganin	0 ± 15	+15 to +35	Low and low to medium for low TC near 25°C	Under ±1% to ±2%†
7	Copper-Nickel 77%—23%	180	180 Alloy Cuprothal 180 Midohm	+180 ± 30	−65 to +150	Very low	+5% to +8%
9	Copper-Nickel 90%—10%	90	90 Alloy 95 Alloy Cuprothal 90	+450 ± 50	−65 to +150	Very low	+5% to +10%

*American Society for Testing Materials, Tentative Specification B267-60T. †—For resistor with 300°C hot spot rise from 25°C ambient except 54°C rise for Manganin.

Fig. 20: Table of Resistance Alloys Generally Used for Resistors and Rheostats.

TAP SWITCH CONSIDERATIONS

Few problems arise in the choice of a tap switch to be used within its normal, published rating. Questions are frequently asked, however, about applications in which one of the normal factors has been altered. Typical variations involve standstill currents higher than rated load-break values, high current surges, operation on 400 cycles, higher voltages, operation of switches in parallel, operation in instrument type applications involving very low currents and voltages, DC ratings and operation at high altitude or high ambient temperature.

Other variations involve mechanical problems such as rotation at many RPM or life when subjected to an abnormally high number of operations.

Only a few of these questions have general answers, such as that switches can be operated on 400 cycles. Practical answers to the other questions depend on the circumstances. Ohmite engineers will be glad to answer specific requests as completely as possible. In many cases an actual trial is necessary to evaluate the suitability of a particular switch.

RELAY APPLICATIONS

Relays are used as basic parts of such a limitless variety of control circuits that many relay types have evolved to handle the different needs. In many cases several different types of relays can be used and the designer's task is to select the one which provides the best balance of performance, mechanical convenience and cost.

Coil operating characteristics constitute one set of conditions, contact load another and mechanical or environmental conditions yet another. AC or DC operation and the amount of power required are the essentials to be considered for the coil. In pulse circuits the operate and release times may be important.

Contact loads and "dry circuit" operation set the requirements on the contacts although expected life (number of operations) is also a factor.

Mechanical considerations include method of mounting, desirability of plug-in connection, dust proof enclosures, hermetic sealing, and special requirements (generally according to military specifications) as to ability to withstand vibration, acceleration and shock, etc. Humidity and ambient temperatures are still other factors.

Ohmite engineers will make recommendations of relays for specific applications upon receipt of full information.

TANTALUM CAPACITOR CONSIDERATIONS

All tantalum capacitors are "electrolytic capacitors" and therefore differ in some characteristics from the "classical" capacitor consisting of two plates (or sets of plates) separated by air or a solid dielectric. In a tantalum capacitor (regardless of type—wire, slug or foil) the dielectric is the thin oxide-layer formed on the tantalum. This layer acts as a dielectric or insulator only as long as the surface it is formed on is electrically positive (the anode).

The following basic formulas apply:

$$\text{Capacitance } C = 0.224 \frac{KA}{d \times 10^6} \textit{ microfarads}$$

K = Dielectric constant　　A = Area of one plate in inches
d = thickness in inches

$$\text{Charge } Q = CE \times 10^{-6}$$

Q = Coulombs　　C = Capacitance in microfarads
E = Volts　　Coulombs = Amperes $\times$ seconds

$$\text{Stored Energy} = \frac{CE^2}{2} \times 10^{-6} \textit{ joules}$$

$$\text{Joules} = \textit{Watts} \times \textit{seconds}$$

In the application of tantalum capacitors to circuits, the differences between electrolytic and other capacitors must be taken into consideration. Basically, tantalum capacitors are used in typical electrolytic capacitor applications in filter and by-pass circuits where the capacitors are subjected to a constant DC bias and a small AC ripple voltage. This comes about because electrolytic capacitors are generally polar, i.e., act as capacitors only when the voltage does not reverse across them. However, foil type tantalum capacitors (Ohmite Tan-O-Mite Type TF) are also available as non-polar types and can be used on AC within their rating.

All types of capacitors show some changes in capacitance and power-factor or leakage current with temperature, frequency, voltage and time. All of these factors should be considered in the application of tantalum capacitors. Tantalum capacitors which are to be connected in series, require special consideration. On DC, the voltage will divide according to the ratio of leakage currents rather than the capacitances. Also, a series combination of polar and non-polar types on AC shows differences on each half-cycle. Instruments particularly suited for the purpose must be used for measuring tantalum capacitors as the relative amount of AC compared to the DC bias may affect the observed measurement results.

VARIABLE AUTOTRANSFORMER USES

Variable autotransformers provide a convenient means of voltage control of AC operated devices. As applied in Ohmite "*v.t.*" Transformers, they enable control of voltage from zero to 110% or 117% of line voltage (depending on the model). Apparatus requiring 240 volts can also be operated from a 120 volt source, by use of the transformers.

Where no step-up of voltage is required, a rheostat or potentiometer can generally be used, rather than a variable transformer, to do the same control job and the question therefore arises as to what determines the choice between them. A survey of each type of control discloses that transformers and rheostats each have their own advantages such that the details of the application determine the choice.

Variable autotransformers are of course limited to alternating current use, have excellent regulation under changing load, have high efficiency, produce little heat, and are fairly universal in application within their current rating. Current ratings (in general) go hand in hand with physical size, so that large currents require large transformers.

Rheostats can be connected as potentiometers or voltage dividers so as to be able to control the load from zero to line voltage, like the transformer. They are more generally used as series resistances however. Unlike the transformers, rheostats work on DC as well as AC and can be provided to handle large currents on any size rheostat. They can also operate at higher ambient temperatures than the transformers. In a large percentage of applications, especially where the current or voltage does not have to be reduced to less than 25 to 50%, the rheostat provides the desired amount of control and is smaller, lighter and cheaper.

Tapered windings can also be provided on the rheostats so as to obtain special relationships between the angle of rotation and the controlled effect.

Special circuit arrangements with the load permit variable transformers to be used also for such purposes as providing a variable load of constant power factor, or to provide controlled phase shift.

RADIO FREQUENCY CHOKE PROBLEMS

Problems involving the application of radio-frequency chokes become too involved in radio theory to permit adequate treatment in this manual. Suffice it to say, that while the standard series of Ohmite R.F. "plate" chokes covers a wide range of frequencies, it is of course possible to design chokes to fit other requirements. Recommendations for special chokes will be made by Ohmite engineers upon receipt of full information as to circuit and other considerations.

REFERENCE DATA

PROPERTIES OF VARIOUS METALS AND ALLOYS

MATERIAL	Ohms Per Circular-Mil-Foot At 20° C. (68° F.)	Relative Resistance With Copper = 1	Approximate Temperature Coefficient 20° C.	Approximate Melting Point Degrees Centigrade	Maximum Working Temperature Degrees Centigrade	Specific Heat	Specific Gravity	Weight in Pounds Per Cubic Inch
Silver	9.796	0.95	.0038	960		.057	10.5	.379
Copper	10.37	1.00	.00393	1085		.10	8.89	.321
Aluminum	17.0	1.64	.00446	660		.23	2.70	.096
No. 30 Alloy	30.00	2.89	.00118	1100	350	.092	8.92	.322
Brass (Spring)	36.30	3.50	.0020	965		.10	8.55	.309
Beryllium Copper (Heat Treated)	41.5 to 57.6	4.0 to 5.55		955		.10	8.21	.297
Phosphor Bronze—5% (Grade A)	56.5	5.45	.0018	1050		.09	8.88	.320
Nickel	58.0	5.60	.0048	1445	500	.11	8.90	.321
Iron	61.1	5.90	.0062	1575		.11	7.7	.278
Lohm Alloy	60.0	5.78	.0008	1100	350	.092	8.9	.321
Platinum	63.8	6.15	.0030	1755		.032	21.45	.775
No. 90 Alloy	90.0	8.68	.00045	1100	400	.092	8.96	.324
Lead	132.0	12.7	.0039	327		.031	11.4	.412
Everdur No. 1010	155.0	15.0	.00034	1019		.09	8.52	.308
No. 180 Alloy	180.0	17.3	.00018	1130	400	.092	8.95	.323
18% Nickel Silver	190.0	18.3	.00019	1110	260	.09	8.50	.307
Monel	256.0	24.7	.00145	1360	500	.127	8.9	.321
Manganin	290.0	28.0	±.00002	1020	100	.09	8.39	.303
Copper-Nickel (55%-45%)	294.0	28.4	±.00002 or'4	1290	500	.094	8.9	.321
Stainless Steel—Type 416	343	33.1	.0014	1500	677	.11	7.75	.280
Stainless Steel—Type 302 or 303	433	41.8	.0011	1410	760	.12	8.03	.290
Nickel-Chromium (80%-20%)	650	62.7	.00008	1400	1150	.104	8.412	.304
Nickel-Chromium-Iron (60%-16%-24%)	675	65.0	.00014	1350	1000	.107	8.247	.298
Stainless Steel—Type 1-JR	720	69.4	.00015	1400	870	.11	7.34	.265
Nickel-Chromium-Al-Cu (74.5-20-2.75-2.75)	800	74.5	±.00002 or'1		300	.104	8.10	.293

OHMITE

REFERENCE DATA

TABLE OF WIRE SIZES

American Wire Gauge (B&S)

Gauge A. W. G. (B&S)	Diameter Inches	Area Circular Mils	Gauge A. W. G. (B&S)	Diameter Inches	Area Circular Mils
1	.28930	83,700.0	21	.02846	810.0
2	.25763	66,400.0	22	.02535	642.0
3	.22942	52,600.0	23	.02257	510.0
4	.20431	41,700.0	24	.02010	404.0
5	.18194	33,100.0	25	.01790	320.0
6	.16202	26,300.0	26	.01594	254.0
7	.14428	20,800.0	27	.01420	202.0
8	.12849	16,500.0	28	.01264	160.0
9	.11443	13,100.0	29	.01126	127.0
10	.10189	10,400.0	30	.01003	101.0
11	.09074	8,230.0	31	.00893	79.7
12	.08081	6,530.0	32	.00795	63.2
13	.07196	5,180.0	33	.00708	50.1
14	.06408	4,110.0	34	.00630	39.8
15	.05707	3,260.0	35	.00561	31.5
16	.05082	2,580.0	36	.00500	25.0
17	.04526	2,050.0	37	.00445	19.8
18	.04030	1,620.0	38	.00397	15.7
19	.03589	1,290.0	39	.00353	12.5
20	.03196	1,020.0	40	.00315	9.9

Wire Table Relations

The following approximate relations are convenient for rapid mental computations:

Increase in AWG No. By	Multiplies Resistance By
1	1.25
2	1.6
3	2.0
10	10.

To find the resistance per foot of any size wire of any alloy: *OHMS/FOOT=OHMS per CMF/CM*

To find the weight per 1000 feet of any bare wire of any alloy:

$$POUNDS/1000\ FEET = .003 \times CM \times SP.\ GR./.321$$
$$= .000342 \times CM \times SP.\ GR.$$

ALLOWABLE CURRENT‡ FOR COPPER WIRE

From National Electric Code 1962

AWG or B&S	Rubber or Plastic 1 Cond.* Amps	Rubber or Plastic To 3 Cond.† Amps	Asbestos 1 Cond.* Amps	Asbestos To 3 Cond.† Amps
18	—	7	—	10
16	—	10	—	15
14	20	15	30	25
12	25	20	40	30
10	40	30	55	40
8	55	40	70	50
6	80	55	100	70
4	105	70	135	90
3	120	80	155	105
2	140	95	180	120
1	165	110	210	140
0	195	125	245	155

*—In free Air. †—In raceway or cable.
‡—Ratings apply only to certain wire insulation systems. Consult N.E. code for details.

TEMPERATURE CONVERSION

To convert degrees Fahrenheit (F°) into degrees Centigrade (C°):

$$C^\circ = \frac{5}{9}(F^\circ - 32) \text{ or } C^\circ = .555\,(F^\circ - 32)$$

To convert degrees Centigrade into degrees Fahrenheit:

$$F^\circ = \frac{9}{5}C^\circ + 32 \text{ or } F^\circ = 1.8\,C^\circ + 32$$

When a temperature rise (not the temperature attained) is to be converted from one system to the other, the 32° terms in the above formulae are omitted.

OTHER USEFUL DATA

Inches to Centimeters and Millimeters

1 inch = 2.54 cm. = 25.4 millimeters

Pounds and Ounces to Grams

1 pound = 454 grams 1 ounce = 28 grams

SCREW SIZES

No.	Dia.	No.	Dia.	No.	Dia.
0	.060	4	.112	10	.190
1	.073	5	.125	12	.216
2	.086	6	.138		
3	.099	8	.164		

DECIMAL EQUIVALENTS

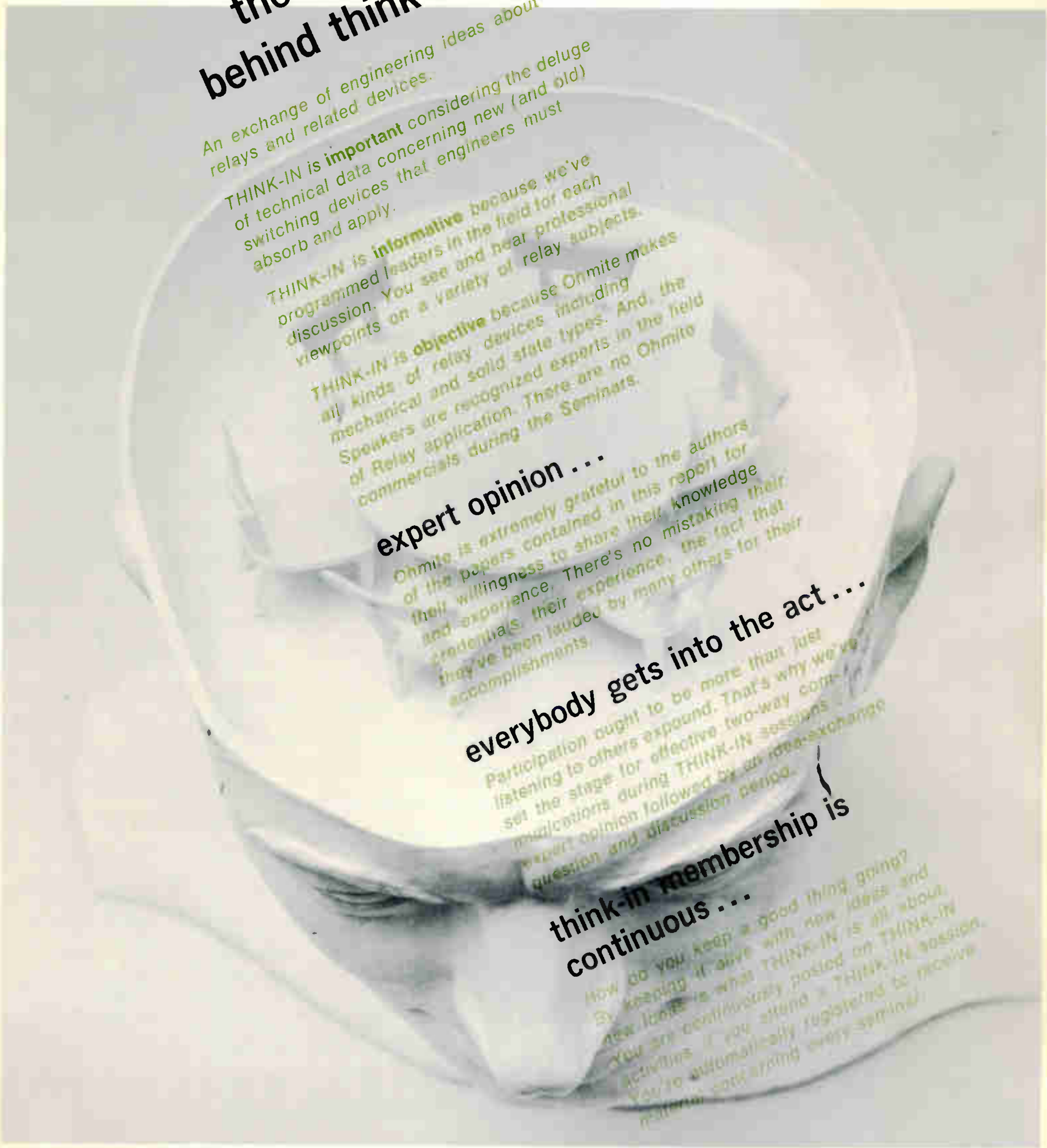
Fraction	Decimal	Fraction	Decimal
1/64	.015625	33/64	.515625
1/32	.03125	17/32	.53125
3/64	.046875	35/64	.546875
1/16	.0625	9/16	.5625
5/64	.078125	37/64	.578125
3/32	.09375	19/32	.59375
7/64	.109375	39/64	.609375
1/8	.125	5/8	.625
9/64	.140625	41/64	.640625
5/32	.15625	21/32	.65625
11/64	.171875	43/64	.671875
3/16	.1875	11/16	.6875
13/64	.203125	45/64	.703125
7/32	.21875	23/32	.71875
15/64	.234375	47/64	.734375
1/4	.25	3/4	.75
17/64	.265625	49/64	.765625
9/32	.28125	25/32	.78125
19/64	.296875	51/64	.796875
5/16	.3125	13/16	.8125
21/64	.328125	53/64	.828125
11/32	.34375	27/32	.84375
23/64	.359375	55/64	.859375
3/8	.375	7/8	.875
25/64	.390625	57/64	.890625
13/32	.40625	29/32	.90625
27/64	.421875	59/64	.921875
7/16	.4375	15/16	.9375
29/64	.453125	61/64	.953125
15/32	.46875	31/32	.96875
31/64	.484375	63/64	.984375
1/2	.5	1	1.

an exchange of ideas about
Relays and Related Devices

OHMITE

think-in report

Seminar II SHERATON INN
at LaGuardia
EAST ELMHURST, N.Y.
SEPTEMBER 10, 1969



the thought behind think-in . . .

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RELAY RELIABILITY — A TRIPLE EDGED SWORD

By **Arthur Siegel**, Switching Devices Engineer, RCA Corp.

Relays are reliable parts. That must be our basic premise. Now I didn't use the term "Hi-Rel" or "Established Reliability" because these terms do not relate to an application. They merely relate to the part itself when supplied to a given set of parameters. To those who demand "Hi-Rel" relays I ask, "How high is high?." To those who purchase to Established Reliability Specifications I ask, "Can you afford the single failure you are forecasting by your failure rate and secondly can you accept the buyers risk inherent in your confidence level.

No, Reliability, especially in the relay category is not just a specification or a High Reliability document. Gentlemen (and ladies), Relay Reliability is a triple edged sword. I know this may sound flamboyant but I could find no more suitable analogy. You ask why a sword.

A weapon can kill as well as protect. Knowing how to use it can save a life, a battle, or a war. Not knowing is synonymous to signing a death warrant. Just as overtesting can destroy a relay's life without providing the necessary assurance of quality and capability, undertesting will not project the information required. The proper test procedures performed for the optimum number of operations and at the most revealing levels will prevent the relay failure which can produce catastrophic results.

The sword for relay reliability has three edges - Selection, Quality Assurance and Analysis. The acceptability of any relay is only as good as the capability of the weakest of the three links.

Let us examine the techniques that should be used in the selection of a relay for an application. I assume the basic electrical parameters are known but in many cases, the size is not specified at first, but must be selected based upon other factors. Let us examine these.

Don't make a "Spectacular" out of your application. Use a unit with the most experience at your application levels. If possible, use a Military Standard model or version, thereof, don't choose state of the art relays just for the sake of being a pioneer. Crusaders receive a great deal of applause when they are correct but they stand a good chance of sitting in a "hot seat."

If, however, you are backed into a corner and have to use a relay with very little backup information, tread very carefully and don't skip any steps in your evaluation of the manufacturer or his part. After size and application requirements are finalized, you now have the task of selecting the Vendor or Vendors, as the case may be. If possible, a trip to each potential supplier's manufacturing facility should be the first order of business. On this trip, don't be impressed by clean rooms, fancy offices, and all the rest of the fittings that some people believe are synonymous with reliable relays. Not that they are not important and useful. Many years ago in school, I learned that "Walls do not a prison make nor iron bars a jail." The same can be said for a component plant.

Clean rooms do not automatically produce reliable units nor does fancy test equipment on the production line assure a good product. It is your job to ascertain that full advantage is being taken of all these capital improvements. Do the personnel know what they are doing? Are there sufficient quality checks on the line? Who does the QC Manager report to? If his boss is the head of manufacturing you might have a problem. Does the factory have a training program for the people? Do they provide their personnel with a neat lunch room? This last factor may not seem important but take it from me, it is.

Alright, you have visited the two potential vendors and, in your estimation, their production facilities are acceptable. The next step is to sit down with the manufacturer's engineering departments and tell them of your complete application. Within the limits of security, hold nothing back. These men are there to help you. They may show you some areas you haven't thought about. Remember: someone may have had an almost identical application before and the fellow you would be speaking to has the job of knowing of it and determining how he could best meet it. Don't keep secrets from your supplier. He should have test data available to indicate meeting your requirement, or he may have to interpolate between the data on two tests. Now you are in a position to write the requirements specification for your application; getting approval from each of the potential supplies.

Your next step is to sit down with your projects office and purchasing group and find out just what dollar value has been allowed for the relay. If they figured on using a \$6 unit, and your requirements indicate a TO-5 size relay, somebody has to shift.

In many cases, this is done prior to the initial step so all that will come out of this meeting is a target price; you know you are in the ballpark but the determination of the amount of Quality Assurance testing that can be performed will be decided. Many factors will enter into this Quality Assurance program. Is the program one where down time can be tolerated or are we talking about a space venture. If the relay is in the latter category, how critical is its operation to the mission. Another factor would be past history on the relay type, the vendor, and the price you are paying. If the relay is one which has been on the market for many years you can be pretty certain that a large percentage of the "bugs" have been removed. It is a state-of-the-art relay, where very little usage information is available you must leave nothing to doubt. If the manufacturer over the past few years has had an excellent reputation at your plant or company, especially in this basic type of unit, you can relax somewhat. If the converse is true be on your guard especially if the unit is in a critical application.

The first question to be faced is the area of qualification. Is the testing necessary? If so, who will do it? Do you have confidence that the manufacturer has the capability to perform or at least monitor the testing if it is done at an outside test lab. Do you have a facility that is adequate to evaluate the unit? Possibly a combination of testing by the vendor and yourself might be best. I usually try to get the manufacturer to do most of the testing leaving only those portions I consider most critical for my own lab. This keeps me from spending all of my time in the lab yet permits me to keep a sharp eye on the entire qualification program.

If the manufacturer is going to perform the entire evaluation you might ask for his proposed test schedule and ask him to advise you of any changes in the dates for specific tests due to slippage. You also should request a call within 24 hours of any failure, no matter how unimportant he may believe it is. The schedule will permit you to arrive at his plant to monitor what you feel are the critical tests. The calls keep him on his toes with regard to a daily review of the data. In many cases, companies have Field Quality Assurance personnel available who can "look-in" on the testing and make certain that things are proceeding as expected. Now I know what all you relay experts are going to say. What does a Field QA representative know about relay testing. I can only give you my experience and I think my company is representative of most. These field people may not know precisely how to test a relay but they do know how to test and they have a remarkable amount of "savvy." If your procedures have been set up properly it will take them only a few minutes to get into the swing of the test and they can spot a problem much easier than many knowledgeable relay people. The reason is that they look at the test as merely that and do not go down to the "nitty gritty" of whether relays or transformers are being evaluated. The field people can be a valuable asset to you and should be used wherever possible.

So far, we have decided on our qualification test sample, based on the criticality of the part, decided who will perform the test, written or approved the test procedure and we now have received a test report indicating that the relay is qualified. For many, they would feel their job is done. I believe your job is just beginning. Why do I say that? Well first, we must examine my definition of Qualification Approval. A few years ago, actually more years than I care to state publicly, I taught a company course at GE on the proper application of parts in Military Equipment. For 14 weeks, I pounded a statement into the head of the pupils and I was rewarded on the final exam, when they were asked what does QPL mean, and they all answered "that at sometime and someplace a required number of samples of a particular part were able to demonstrate that they had the capability of meeting a set of requirements." By the way, just for getting that right no one failed the course. The important word in the statement is capability. And what does that mean! To put it bluntly it says that the design and materials are such that if the necessary precautions are taken and the proper workmanship utilized there is a good chance that acceptable relays may result. Bear in mind, that relays are built and adjusted by human beings hence relays coming off the line a day apart are not like peas in a pod. On Monday the adjuster received his income tax refund check so that he is a happy fellow on Tuesday but Tuesday night his girl friend tells him she's marrying Bill. I hope my relays are not among those being adjusted on Wednesday but are in the Tuesday lot. With the ultimate in Q.C. this will be picked up and potentially the Wednesday reject rate will rise but if examination for electrical parameters alone are made, I am sure marginal and unacceptable units can get through.

Before any manufacturer starts to get bleeding ulcers, maybe I had better explain what I mean by marginal and unacceptable relays. For general purpose applications where the contacts close on a 1/2 ampere 28 volt circuit just about any properly designed and manufactured relay will operate satisfactorily, especially when there are no environmental requirements of significance. But lets look at an application that "can try men's souls"; an airborne or aerospace requirement where the current is about 100 milliamperes or even worse where it will randomly cycle between dry circuit and this intermediate current level. Units which will offer high resistances when their contacts are mechanically closed are barely acceptable and I call these relays marginal. Those that have electrically open contacts are unacceptable. Now the question is how do you keep these relays from finding their way into your plant and into your production material bins.

The technique, I believe, to be used has two parts; acceptance and screening. The first type of tests merely examines the relays to determine whether they meet the parametric requirements of the specification. The only heavy thought that must be given in this category is with regards to the precise tests and whether the testing should be done on a statistical sample. When considering the test procedures to be utilized bear in mind that testing costs money. Wherever possible use a vendor's past performance with the relay type in question as a basis for your decision. As an example, if a specific manufacturer has had no history of Dielectric problems on his relay you might be wise, if cost is a critical item, and I'd like to see when it isn't, to perform this testing on a very small sample. Any problem would be the result of faulty adjustment or setup tooling and the sample would highlight this difficulty. This might be especially true if this vendor did have a history of contact resistance problems. Then you would want to concentrate most of your acceptance test dollars in this known problem area.

When it comes to the Destructive acceptance tests a recent situation by the Military makes it imperative that a great deal of thought be given to the precise procedure and their frequency. Previously MIL-R-5757D required that these tests be done on a lot basis, therefore, it was necessary for an engineer to specify which tests he **didn't** want or the time gap **between** evaluation, if it were not to be done or a weekly lot basis. This all required thought and therefore. cut down on the possibility of something "slipping by." With the issuance of MIL-R-5757E destructive testing is done every 24 months as a requalification. Hence, a problem in a relay's capability in vibration that occurred six months after qualification would not be discovered under the Military system for 18 months; long after your first relays were shipped, installed in equipment, shipped to the field and failed in the field. So my hint for today is to reinstitute the old Group B Acceptance Tests of MIL-R-5757D, even if only on a once a month basis if you don't have the utmost confidence in the Vendor's product and especially if the manufacturer doesn't run destructive quality audits on his environmental capabilities.

We now come to the testing that separates the men from the boys. Some call it burn-in but I call it screening. The reason is simple. The basis of these tests is completely different from any of the other testing previously performed. During other procedures we apply certain loads to the relay contacts, operate them certain ways, expose the units to certain environments and then check certain specific parameters outlined on the specification sheet for the part. As an example, we load the relay contacts with rated load, place the relays in an ambient equivalent to its maximum operating temperature, cycle it 20 times a minute and maintain other factors within certain limits. Before this test the maximum contact resistance allowable was 50 milliohms. After 100,000 cycles of operation the maximum allowable contact resistance is 100 milliohms. No cognizance is taken of the percentage of change between the pre-life and post life values. Normal exposures were used. Screening looks beyond absolute values and tries to interpret what is taking place and whether the changes occurring are forecasting incipient failures. As an example, using the criteria from Group B Acceptance Testing of MIL-R-5757D for Life Testing if a relay had an initial constant resistance of 15 milliohms and a post life resistance of 75 milliohms it would have been considered acceptable. I personally would question a contact set whose resistance rose to five times the initial value. Another criteria for screening is that the testing must not remove much of the useful life of the relay therefore complete life tests cannot be run but results must be forecast. That last word is the key. A screening test must forecast future problems with a particular unit. The testing must be of relatively short duration, not remove more than about 10% of the relays rated life, and accelerate problems. Its criteria for failure need not be a catastrophic occurrence within the relay nor even parameter values in excess of those specified on the procurement document. One method of forecasting with data, and the one used by RCA/DEP is the parameter drift method whereby certain drift limits are set up for each parameter after specific exposures. Should a relay have measured values that exceed these drifts it would be rejected. We know that some of these rejected relays are good but can't determine which of these are in this category, hence, all units failing screening are not used for applications requiring ultra-reliability. They are used in future bread boards or for ground equipment. If your screening procedures are optimum you will also note many actual failures in the few operations you put in the relay. These units, of course, must be scrapped.

Some people believe a simple run-in for relays or a short time overload for resistors will cure all ills. It is better than nothing but surely a far cry from the program I will outline which is RCA/-DEP's screening technique for relays. By the way, the reason this type of testing is commonly called burn-in is because resistors, capacitors and other components which have no moving parts were first screened by burning them in. Today those industries as well as ours, know that a burn-in or run-in is only part of the task.

Now let us examine one method of screening relays. All relays used in the last eight Tiros satellites, the camera portions of Nimbus and many controls assemblies on the Lunar Excursion Module as well as, all the VHF Communications for the entire Apollo Mission including the Astronauts Back Pack Radio, were screened by a modification of the following technique.

All relays are examined for their electrical parameters. One additional procedure is a coil current waveform in which the coil current oscillogram is photographed. In many cases this trace indicates a bearing hangup or other difficulties which will never be found by other methods.

The relays are then exposed to a vibration scan in the most critical plane and at a high level; at least the level at which the relay is specified but not necessarily the application level. Contacts are monitored during the scan. One twenty minute sweep should suffice. Those electrical parameters chosen from those performed initially, which you feel would be most revealing and which are most affected by vibration should be measured. The relays would then be exposed to the maximum storage temperature, if it is different from the maximum operating temperature, for about 1/2 hour after which the relays would be cycled at a rate of 10 per minute with a 50% duty cycle. The precise load would depend upon the application requirements. The contacts would either be checked for each closure or every 500 cycles. Each 500 cycles the relays would have their positions changed so that the cycling would take place with the units equally in all 6 positions. At the conclusion of the sequence and while the relays are still at the maximum temperature their coils are energized and maintained at this state while the units are cooled to minimum temperature. They are then individually deenergized and checked immediately upon deenergization for contact resistance. A relay whose interior contains gas with a high dew point will have iced normally closed contacts. The contact resistance measurements must be made with a current of 10 milliamperes or less to prevent melting of the ice. Ice will forecast all the other problems which moisture causes and that Win Crawford of Autonetics and Charlie Schneider of Bell Labs have been talking about for years.

After the last relay has been examined for icing, the relays are then cycled exactly as they were at the high temperature extreme. At the conclusion of these 3000 cycles all initial measurements with the exception of the coil current waveform are repeated. After these measurements the units are placed on a monitored run-in at room ambient conditions where regardless of how the contacts were checked previously, the contacts are examined for a specific dynamic contact resistance with automatic cutoff when this value is exceeded. Any failure occurring can then be verified since the entire setup stops. No confirmed misses are tolerated. I'm not going to go into the mechanics of the monitoring apparatus since there are an unlimited number of ways that it can be built; all of them correct. Only the results are fixed.

After the run-in all initial measurements are repeated. Just what was accomplished by this involved procedure? The exposure stressed all parts of the relay so that any problem areas would show up. Any insulation which out-gasses would cause difficulty during the cycling especially after the hot and cold exposure. The icing test would signal a problem in the manufacturer's bake-out equipment or technique. In addition, at the conclusion of all testing the values obtained for a given parameter for each relay are compared with regard to the initial reading, post-vibration value, post thermal measurement and final reading with only certain percentage change permitted. We call this Allowable Parameter Drift. We feel that any unit whose values exceed this allowable limit must have a weakness hence, it is not the relay for an application where only the best is good enough.

Other screening methods are available but most look only for one type of problem. Since the most prevalent mechanism of relay failure is particle contamination two new methods have been developed to isolate relays with loose particles enclosed within their chamber. The first was developed by Raytheon. Further instrumentation was developed and it is presently being used by the Grumman Aerospace Engineering Corporation. This technique vibrates the relay in a plate at right angles to the motion of its contacts when operating. The acceleration to the sample is of the random type and of low frequency. During the vibration exposure the relay is slowly cycled and its contacts monitored for closure. Since the random vibration has the tendency to make the particles hop in the contact gap, they will insulate the contacts and show up as a miss. In some cases, they are squashed against the contact resulting in a permanent open. This procedure is an excellent one but does depend upon particle being in the right place at a precise time. Obviously a relay with many particles will surely fail.

A second method is one where a very accurate crystal is used to listen for particles as small as one thousandth of an inch. The technique is new and was developed by Lockheed at Sunnyvale, California. I personally have never seen it used but Ed Friera, one of the mentors behind it assures me that it has had excellent results. He has been able to open each relay where a particle was suspected and find something.

The Grumman method also checks for metallic particles by putting a voltage between pins and case. In the event of a piece of metal, such as weld flash, a broken spring, piece of solder, or any other assorted loose metallic material, a very small current is permitted to flow thereby doing no damage.

The screening techniques I have outlined are but a few. New methods are being developed daily. As long as you are sure they will isolate a major failure mechanism of the relay and do not impress upon the unit any load or environmental requirement which is damaging to a good unit, use it. I'm going to repeat that last phrase because it is the crux of the whole philosophy. You may overstress a relay but the stress should be such that it will not damage a **good** relay.

Well, now you've written the specification, selected the vendor, qualified the unit, decided on the acceptance testing, and screened the relay as required and the units are now going into equipment. Is your job done? Not by a long shot! A very critical part of your job still remains; the third edge of the sword.

Many times during the design of equipment certain facts are overlooked or not known. You can be sure if these little problem areas didn't come up before and they affect the capability of the relay they will show up in your failure reports, both from your factory and the field. The first relay failures isolated must be sent to you for your analysis. Even though the engineering design group may think that somebody "zapped" the relay you should see it. You might uncover unknown problems before they really become a panic. Carefully analyze each of these relays not only in the area where the problem is reported but in its entirety. This will be easier at the beginning when the failures are occurring at your plant. Once the equipment goes out in the field it gets more difficult. With a little luck and the proper care you may avert this situation by "nipping in the bud" any shortcomings of the relay. If you come up against a transient which is damaging coils or contacts it might be best to add other parts to your equipment to limit this spurious voltage. It is better to know about it and retrofit equipment before it is shipped. If the relay must be changed you must start this game all over again except that you do not pass go and you do not collect $200. If all things are considered and the proper inputs are supplied this should rarely be the case. To preclude starting from scratch each time you might design an application form which you fill out as you start each job. Later on you will have all the facts if a trade-off is required.

Well there is your triple edged sword. One which when used properly can guarantee victory in the war against unreliable equipment. Keep your weapon well honed by learning of the latest test techniques, reading about the proper methods of analysis and staying on a good technical base with all of your suppliers. Every once in a while you will make an error of judgment; we all do. This will result in a coat of tarnish forming on your sowrd. The best polish to use is the knowledge that you did your best and that you will profit from the mistake.

I now put my battered but sharp Triple Edged sword in its scabbard awaiting its next battle.

THE GENERAL PURPOSE RELAYS
0 to 2 Amperes for Ground Support Equipment

By Barhyt Bonnell, Consulting Engineer, Sudbury, Mass.

My discussion on this subject will, I hope, give you something to think on. I am essentially a mechanic with practical mechanical ideas. I once worked for a rather remarkable man. He, also, was a mechanical man and although Vice President in charge of manufacturing of an electronic facility, he insisted that if he had an electrical design that was correct functionally, then all failures would be mechanical in origin. Even a dielectric test failure is definitely a mechanical failure.

For purposes of this discussion I would like to limit Ground Support Equipment to electronic systems or subsystems for use in support of navigation, fire control or other major radar or communication systems. These are usually installed in an air conditioned building or shelter for use by the Military or some other Government agency. This indicates that the operating environment would be benign; however, the non-operating environment, including storage and transportation, would be typical of the Military; that is, anything that could be encountered anywhere will be. (Another application of Murphy's Law.)

Because of this we are mainly concerned with an hermetically sealed relay or at least a sealed contact chamber with suitable coil protection. This type of relay is covered by Military Specification Mil-R-5757 and I would like to show you some of the relays that are available from Mil-R-5757 approved sources for these applications.

The following are typical relays:

Mil-R-5757/1 6 PDT Low-Level and 2 Amperes
Subminiature, panel mounted

Mil-R-5757/9 2 PDT Low-Level and 2 Amperes
One half crystal can–can be PCB mounted

Mil-R-5757/10 2 PDT Low-Level and 2 Amperes
Crystal can–requires support besides pins

Mil-R-5757/21 2 PDT Low-Level to 2 Amperes (latching)
Crystal can–requires support besides pins

Mil-R-5757/30 or /19 2 PDT Low-Level and 0.5 Ampere
One sixth crystal can–can be PCB mounted

Mil-R-5757/37 2 PDT Low-Level to 1 Ampere
.15 inch grid pin spacing–can be PCB mounted

Mil-R-5757/40 2 PDT Low-Level to 1 Ampere
For PCB mounting primarily

These specifications must be treated individually and with extreme care since we cannot expect even one small improvement in practice over and above the specified capabilities. Because these specifications are of necessity general in nature and since they attempt to be all things to all designers it becomes the problem of the circuit designer to apply his switching devices with this in mind, and if his particular type of load or method of operation is not included he must go into the "Special Relay" category and thoroughly evaluate his selection. There are many switching problems connected with this type of electronic hardware. Some of the more common usages will be discussed here.

To drive indicators:
These indicators are usually of the moderately low DC voltage variety, typically 28 volt incandescent lamps mounted, often in pairs for redundancy, in a housing behind a legend plate which may or may not change color and/or legend when energized. Due to the characteristics of incandescent tungsten filament lamps the turn-on surge is ten to eleven times the steady state current. For this reason the number of lamps controlled by one set of contacts must be closely controlled. For instance, two midget flange-based 28 volt lamps will draw 800 to 900 milliamperes on cold turn-on. There are, of course, ways to cut down on the surge. One is to keep the filaments warm by energizing in parallel with a suitable resistor with your driving contacts. Another is by means of a voltage dropping resistor which will result in a voltage divider when "on." This will cut down the voltage across the lamp and will reduce the light output but will also increase the lamp life inversely as the twelfth power of the voltage ratio.

To turn on power:
By this is meant to supply current to a device, small subsystem or assembly within the power capabilities of the relay contacts. There is not too much difficulty with this application as long as possible surges on turn-on or turn-off are considered. These could be RFI filters, inductances such as transformer coils, other relay coils or others.

At this point I would like to mention derating of relay contacts. This is more applicable to this type of load than either lamp loads or signal switching. I would recommend for switching power that a 2 ampere relay be used to switch, reliably, no more than 35% of the rated power, this is, if the contact rating is 2 amperes at 28 volts DC or 56 watts, then the actual load switched should not be more than 20 watts with 2 amperes and 28 volt as maximums. This should result in more reliable switching for more operations with the contacts in better condition to switch at a lower voltage drop.

To switch signals:
(These signals can be of many forms from continuous direct current, pulses, various codes to Radio Frequency up to the low megahertz range.) In this case the contacts are often asked to switch current of the order of ten to one hundred milliamperes at voltages from two to three to as high as twenty-eight volts direct current. This is in the "Minimum Current" range that has received so much attention lately. The capability of switching this level of load is a firm requirement in many of the Mil-R-5757 individual specifications for the so-called high level relays. Before asking a particular relay to switch this type of load, investigate its capabilities thoroughly. If the signals you are switching are truly "Low Level," then a low level relay should be chosen. When applying a low level relay properly good performance and long life will be the result, BUT do not make a hybrid of a low level relay by switching power with one set of contacts. If this is done carbonaceous material will be formed and sooner or later the low level set of contacts will miss.

To maintain information (Fail Safe):
It is sometimes necessary or advisable to secure a piece of information, a yes or no, in the form of a bit and this can be done, even in the event of a power failure by a magnetic latch relay which when once set in one position will remain there until ordered away.

Relays as a means of obtaining redundancy:
By command, either manual or automatic by means of a sensing circuit, a failed operating device, sub assembly or unit can be replaced by a "Stand-By" device, etc., by means of a group of re-

lays. In this type of operation the individual switching contacts must be break before make or Form C. They must make and break with an extremely low failure rate. The contact that makes must make with a voltage drop that is acceptable and since the defective module is isolated from the now operating "Stand-By" module the isolation between the closed and open contacts must be sufficient to block any spurious signal or circuit noise.

Only a relay of proven capabilities should be used for this type of switching. These contacts could be in one position for extended periods of time where equipment is of a continuous use type, and then be asked to switch without failure.

These are some of the more common usages of this type of relay, with cautions supplied as to their application.

Now to consider some failure modes. In our discussion of applications we have cautioned about overloading and watching out for dangerous surges on both turn-on and turn-off. Some other failures will be discussed.

A circuit designer selects a relay to be operated within his circuit but to supply energizing power to a portion of another circuit controlled by a second designer. They discuss the application and both are satisfied. But the interconnection designer was not considered and he decided on a RFI filter as this particular line entered the second cabinet. The relay failed due to capacitance in the circuit that was not properly considered. So we will have to add intercommunication between affected design areas and those engineers responsible as another item necessary to satisfactory application.

Environment: We have only briefly discussed the assumed benign environment in an air conditioned building or shelter. But electronic equipment does not perform work with no losses, so temperatures sometimes exceed a nominal relay capability in a section of a cabinet not properly ventilated.

"ELECTRICAL MAKE AND BREAK CONTACTS - ARE THEY SAINTS OR SINNERS?"

By C. B. Gwyn, Jr., Director of Engineering, Contacts Incorporated
Alloys Unlimited Inc., Wethersfield, Conn.

For our Seminar we will define an electrical make and break contact as any body of material intentionally used under controlled limits to physically engage with or separate from an opposing mating surface - thereby establishing and/or terminating the flow of an electrical current - preferably this will be accomplished in a minimum time interval with a modicum of change in body physical dimensions and/or the controlled circuit characteristics.

Our present basic knowledge of contact behavior or rather misbehavior originated through gradual accumulation of individually obtained observations made during operational trials and failures. Frequently this resultant know-how was treated as a jealously guarded trade secret. Erratic service or outright functional failures often reflected inaccuracies in properly interpreting, recording and applying these empirical results to other service usages.

Since random choosing of a material found to be best for a thought to be similar application was often a prelude to failure, far-sighted manufacturers, engineers, designers, metallurgists and physicists began to form groups to collectively "pool" their primary efforts. (You might call this recognizing the need of an initial "think in.")

Grouped intellect quickly showed proper electrical contact selection was not a simple problem with sharply defined parameters. Instead their individual and collective efforts definitely showed their factual information nadir - repeatedly emphasized the urgency and need to openly and collectively discuss and analyze their findings, theories, progress and/or inexplicable failures. Such collective efforts initiated the necessary integration of electrical, mechanical, metallurgical and physical factors. Through international publishing and freely interchanging research results the "X" factor denoting unknown, unpredictable or unresolved reasons for contact malfunctionings has been greatly reduced, but not yet zeroed. Issuance of some 700 U.S. and 280 foreign patents comprising contact materials compositions, processing, polarized (dis-similar) materials combinations, plus publication of some 630 papers, research articles, associated text books, data shown and developments detailed during various U.S. and international contact seminars, relay conferences, etc. evidence the tremendous "plus" developments being made in electrical contact know how.

This knowledge, plus the necessary added factors of availability, workability, economy, have combined to normally pick our initial make and break electrical contact choice or recommendation in pure, alloyed, admixed or sintered forms or combinations of the following elements:

> Silver, copper, gold, platinum family group, tungsten, molybdenum, rhenium, nickel, cobalt, graphite or carbon, cadmium, iron, mercury, manganese.

How then do we choose from among these 14 elements for successful make and break contact applications in order to ameliorate or overcome the effects of the 21 major variables affecting contact performance?

PRIMARY MATERIAL.
If we use a pure elemental form, for example highest purity fine silver–we have no way of altering its inherent electro-physical properties. We determine these, taking maximum advantage of their more valuable properties. We have no choice other than to stay within these maximums.

ALLOYED MATERIALS(S)
Through proper alloying of two or more materials we can synergistically combine their more desirable "plus" features. We can now control hardness–alter corrosion resistance, polarize to advantage, retard or prevent welding together–often lower materials costs, etc. As a typical example, a certain automotive cutout relay originally used fine silver contacts. These sometimes welded under overloading. Tests proved coin silver 90 Ag 10 Cu to resist welding. Through further electro-metallurgical deduction and confirming tests we developed the now widely used Conmet #4 alloy comprised of 75% silver, 24.5% copper, .5% nickel - much lower in materials costs and virtually weld-proof in this application.

ADMIXTURES.
These are characterized by having two or more materials intimately mixed mechanically or chemically but not altered otherwise. As examples: silver and carbon, silver and cadmium oxide, silver and nickel. When desirable these mixtures may advantageously be mechanically compacted, hot compressed, sintered, oxidized, etc. A new and novel method of producing admixtures is to impinge the proper percentages of the desired compositions against a baffle plate at extremely high velocities. This produces a cold bonding type of surface coating or amalgamation.

INFILTRATED MATERIALS.
Basically these are comprised of a skeleton or sponge of a high melting point material infilatrated with or bonded together by a lower melting point, higher electro-thermal capacity material. Typically this may be tungsten-silver, the tungsten being the skeleton or support, the silver cementing and bonding the individual tungsten particles together, simultaneously enhancing the electrical and thermal characteristics of the resultant contact body.

As engineers we all know that surfaces which are sufficiently dirty and/or have an extremely high melting point are difficult to solder, fuse braze or spot weld together. We deliberately achieve this same non-sticking or non-welding surface action on the working face surfaces of our available Contact materials by some type of controlled surface "Dirtying" - through alloying, admixing, sintering, impregnating, mechanically or electro-chemically altering the surfaces, etc. In accomplishing this we of course must keep their electrical and/or thermal properties as high as possible. We have outlined our metallurgical preferences for producing our electrical make and break contacts with specific characteristics. How then do we use their proven metallurgical properties in overcoming or satisfactorily limiting the deleterious individual or cumulative effects of our recognized 21-plus variables? What are these 21-plus variables? For our convenience - and therefore not necessarily in the order or degree in which they influence contact operation and life, we group these 21 or more factors as follows:

A. Electrical Variable Factors, Primarily

(1) Normal and peak (maximum) currents in amperes through and/or across the contact working faces.

(2) Normal and maximum peak voltages through and across the contact working faces.

(3) Is the circuit which we make and/or break AC or DC?

If D.C. can the contacts be definitely and permanently polarized?
If A.C. at what cycle (frequency)?

(4) Are the circuits major characteristics in effect resistive-capacitive, inductive?

(5) How often must the contacts make or break the circuit - for example once a second, 100 times a second - once an hour - a-day - a year.

(6) When not operating, will the contacts be in a normally open or normally closed position?

(7) What type(s) of arc suppression or other contact protective means will be provided?

(8) Will the contacts have the same closed circuit capacity as the other portions of the circuit - This is an often overlooked and very important "must."

B. Mechanical Variable Factors

(1) What is the maximum pressure exerted on the working faces of the contacts in their closed (conducting) position - expressed in ounces or grams.

(2) Is there any no load fritting (dry interfacial-vibrational or rubbing action) between the contiguous areas on the mating closed contacts?

(3) Is there any wiping or interfacial rubbing action produced when the mating contact surfaces are brought together and/or separated?

(4) Will these contacts be subjected to strong bounce or chatter conditions?

(5) In reaching their closed position(s) will the contacts rorate, slide, rock or butt together?

(6) At what speed (rate) will the contacts physically close and/or separate (break apart)?

(7) Maximum separational distance in the open position?

(8) What means will be used to physically close and/or open the mating contacts - solenoid - magnetic materials, spring purely mechanical etc.?

(9) Will the mating contacts be subjected to mechanical cohesion (interlocking) from rough or pitted surfaces - and if so will the separational forces be strong enough to overcome this interlocking?

C. Physical Variable Factors

(1) What is the permissible ambient operational range - minimum - maximum in degrees F. or C.?

(2) What comprises the atmosphere surrounding the contacts - or do they operate in a vacuum or a liquid?

(3) What - if any - is the ambient atmosphere pressure?

(4) Will these contacts operate in an open, a closed or a sealed container?

(5) How will the contact working face and body materials be assembled into their normal operational positions?

(6) What physical dimensions were allowed for the contact materials themselves and/or, when assembled to supports? How were these dimensions obtained?

D. Metallurgical Factors:

(1) Availability of chosen materials.

(2) Calculated and/or allowable material(s) cost.

(3) Assurance of uniformity of materials compositions on succeeding lots of these chosen, tested and approved contacts.

HOW DO THE ABOVE PRIMARY ELECTRICAL, MECHANICAL, PHYSICAL AND METALLURGICAL VARIABLE FACTORS CAUSE OR CONTRIBUTE TO FUNCTIONAL DEVIATIONS OF MAKE AND BREAK CONTACTS?

(In the same order as listed above)

A. Primarily Electrical Factors

A-1. **Normal** and **peak** currents. Insufficient area and/or body volume, electrical, thermal capacity produces welding, fusion, flashover, contact materials migration (D.C.) rapid dimensional changes.

Electrical welding can be broken down into three main forms: fusion bonded, welded, and tack welded.

Fusion bonding is a result of a molten metal being established between the mating or interface portions of the contacts creating an alloying of or brazing together of these contact faces if they are closed together while this condition exists. Normal corrective steps are changes in compositions and dimensions of the contacts, plus removing or ameliorating the causative peak electromechanical or surge conditions.

Welded contacts are just what their name implies, joined together by a resistance or projection weld, the same as any parts electrically welded by the I^2R heating action, while they were in a closed or substantially closed position - remedy, change in contact composition, use of polarized or dissimilar contact compositions change in contact dimensions, and limitation of the surge of maximum current through the contacts.

Tack welding is usually produced with lower than the contact maximum currents, but still sufficient, however, to produce localized welding on limited contiguous areas of the contacts or by the welding of some external contaminant to the surfaces of both mating contacts, or under contact bounce or chattering conditions. Tack welded parts usually separate readily or without a severe application of force. Remedy, dissimilar materials in mating contacts, or changes in compositions, stronger opening and closing forces, better contact alignments, amelioration or elimination of bounce or chatter, keeping out foreign metal particles.

A-2. Normal and maximum peak voltages working surface and inherent resistances of materials must be and remain sufficiently low to maintain a minimum allowable voltage drop across the contacts. Not doing this promotes early circuit continuity failures. Surge or peak voltages may bridge the space between open contacts, forcing (continuing) current flow. Assuming the applied voltage across the contacts is sufficient to obtain a normal operation, the most frequent causes of contact open circuits or high voltage drops causing variations in cycling are: Face contaminants: with contacts comprised of silver and certain other contact materials, humidity and ambient atmosphere contaminants causing chemical and/or so called battery actions - examples sulfides, nitrides, oxides, salts varying with the types and degree, the resultant surfaces may be nonconductive, highly resistive, or rectifying in character so that they will carry currents readily in one direction, block or limit currents in the reverse direction. Other surface contaminants include silicones, fungus growths, solder fluxes, oils, dusts, perspiration, plating materials or flakes from them.

A-3. **Is the circuit which we make and break A.C. or D.C.?**
For general use contact diameters for D.C. voltages in the range of 6 to 28 volts are the same as those for 120/230 volts A.C. 60 cycle, however on the higher D.C. voltages such as 120 the safe contact operational current carrying capacity is approximately 1/4 that of 120 volts A.C. and for 230 volts D.C. approximately 1/5.

If AC at what cycle (frequency) per second?
On 400 cycle AC the safe contact current carrying capacity is only 70% that at 60 cycles. For further details refer to the "Current VS Contact Diameter Selector" which will be given to those attending Ohmite's THINK-IN Number II on Sept. 10, 1969.

If the circuit is D.C. can the mating contacts be definitely and permanently polarized?
The use of mating contacts of different compositions is frequently necessary to prevent migration or buildup and control contact surface resistance rise, alternately to secure lower per pair contact costs, and to lower the effects of wear and/or erosion factors.

In general, on D.C. applications operating in the lower operational cycles per second range (1 to 120), transfer or migration is found to be from the positive contact to the negative. (This action is frequently abbreviated to P.P.T.N.)

In some other instances reverse direction D.C. transfers have occured - particularly in an operational cycle range of, for example, 150 to 300 per second. The use of dissimilar (different) contact compositions has shown to have marked advantage in overcoming or limiting these materials transfers. As examples, fine silver to fine silver transferred rapidly on a certain D.C. relay. Changing to a composition of 90 silver 10 iron-conmet #68-positive and 97 silver 3 palladium-conmet #30-negative not only eliminated transfer but also stabilized the resistance drop across the contact. Strangely, perhaps, dissimilar contact compositions are also often found advantageous for A.C. use. For example, a pump motor control relay manufacturer first tried coin silver contacts for controlling a 60 cycle 110 volt split phase motor. Inrush currents occasionally hit a 100 ampere R.M.S. peak for 2 milliseconds duration followed by 50 amps R.M.S. at .8 power factor for one second, followed by 10 amps R.M.S. at .65 power factor and life requirements were set at 50,000 operational cycles. Coin silver failed repeatedly at around 20,000 cycles.

In this particular contacts application case, the unsatisfactory coin silver contacts were successfully replaced with a dissimilar metals composition of Conmet #72 (90 silver 10 cadmium oxide) against a mating contact of Conmet #62 (85 silver 15 nickel). Repeated life tests exceeded 75,000 cycles of successful operation with the contacts still remaining in excellent service condition. A combination of 85% silver 15% cadmium oxide against 60% silver 40% tungsten carbide successfully met the A.C. life and service requirements for an automatic elevator control relay – also for an aircraft relay used to operate the cabin air pressure controls.

A-4. **Are the circuits major characteristics in effect resistive, capacitive, inductive?**
In general, a **resistive load** such as lamps, the usual electric range elements, etc. are subject to high peak (cold) inrush currents. These are often up to 10 times the normal operating current. This produces a fusion effect similar to that obtained in standard resistance type welders – to prevent this fusion we use high conductivity contact materials having compositions chosen to offset the interfacial surface fusion forces. The most widely used composition is 90 Ag 10 Fe (Conmet #68) operating against Conmet #68. In other instances the dis-similar compositions of 77 Ag 22.8 Cd 0.2 Ni (Conmet #12) against 85 Ag 15 Ni (Conmet #62) are preferable.

Capacitive loads may produce momentary peak currents up to several thousand times normal currents. In such instances it is preferable to use mating contacts of pure refractory materials such as tungsten, molybdenum, carbon or infiltrated refractories such as 35 silver, 65 tungsten (Conmet #83).

Inductive Loads. Typical of these are motors, solenoids, etc. Dependent on closing pressures, operational speeds, normal (closed) operational currents and the severity of peak current and voltage values of the induced "surge," our preferred compositions for mating contacts may comprise 85/90 Ag 10/15 Cd O, or 75 silver - 25 carbon or refractories such as 50/80 W - 20/50 Ag.

A-5. **How often do the contacts make and/or break the circuit?**
For example, once a second, 100 times a second, once a day, etc. The rate of mechanical wear overall heat capacity, electrical erosion and/or materials migration (transfer), allowable resistance rise materials compositions, etc. are all factors determined thereby.

A-6. **When not operating will the contacts be in a normally open or normally closed position?**
In an open position, non-shielded contacts are exposed to surface contaminations from many sources unless firmly held together in their closed position, on contacts subjected to high frequency mechanical vibrations, creating a rubbing action, fritting or cohesion (mechanical welding) may result.

A-7. **What type(s) of arc suppression or other contact protective means will be provided?**
Such protection is extremely effective where high voltage and/or current transients may occur. Typical protectors include parallel resistors, half wave rectifiers, condensers, glow discharge tubes, etc. For D.C. services, polarized dissimilar materials contacts may suffice.

A-8. **Will the contacts have the same closed circuit capacity as the other portions of the circuit?**
The short-time, current-carrying capacity of all contacts is, of course, heavily influenced by one or more of these factors:

(a) Ambient temperatures and maximum operational contact temperatures.

(b) The condition (cleanness and freedom of surface films) of the contact surfaces.

(c) The maximum and short-time, current-carrying capacity of the wires, etc. connecting the various component parts of the circuit, particularly including the load and those to the power supply and contacts. Under short-circuit conditions, all contacts are, of course, subjected to extreme electrodynamic forces. The ratio of the maximum circuit-current capacity to the contact diameter is, therefore, quite an important contact life factor as the degrees of arc erosion and contact welding are generally found to be in direct ratio to the amount of electrical energy passing through and interrupted by the contacts themselves. From a satisfactory performance standpoint using too small a contact size is comparable to putting a Honda motor into a Cadillac. Correctional steps are obvious.

B. Mechanical variable factors
B-1, B-2, B-3. What is **maximum pressure** exerted **on the** working faces of the contacts in their closed (conducting) position? The optimum pressure would of course be that at which the mechanical wear would just equal the electrical erosion, thereby maintaining constantly clean contact interfaces. Factually the pressure must be sufficient to prevent false openings, provide a little wiping action but not fritting.

B-4. **"Bounce or chatter"**
This is generally defined as a nondesirable series of rapid make and break contact actions usually brought about through me-

chanical malfunctioning forces induced in the supports being transferred to the contact body members. These cause rapid erosion of the electrical contact materials and may lead to pitting or welding. Remedial steps frequently used are the use of a plastic coating on one of the support members or springs, changes in contact shapes, making openings in, ribbing or corrugating the springs or supports, using a dampener spring in parallel with the main contact spring, or a return spring having a cone helix with a smaller diameter at one end than the other. Other dampening or resonance methods include use of porous powdered metal supports, multi-layer contact supports, hollow contacts (some of which contain metallic powders), and magnets.

B-5. **In reaching their closed (conducting position) will the contacts roll (rotate) slide, butt together – have a heel and toe action?**
Properly used all of the above motions except abutting will assist in cleansing the contact surfaces from operational or other types of detrimental coatings. The contact working faces should be properly shaped to utilize one of these motions advantageously.

B-6. **At what linear speed (rate) will the contacts physically close and or separate?**
It is usually thought preferable to have the contacts move into their closed (conducting) position at the fastest rate possible without producing chatter or bounce. In most cases a fast break (circuit opening) time is best: However, for certain AC frequency cycles a slower rate is preferred to prevent opening at the peak load position.

B-7. **Maximum separational distance in the open position?**
Provided it is not so large as to unduly delay closing, wide contact surface separation is insurance against voltage spill-over, arc continuance, etc. It should not be large enough to cause severe mechanical wear or to lower heat sink capacity obtained from support members.

B-8. **What means will be used to physically open and/or close the mating contacts?**
In general solenoid or magnetic force is found somewhat faster than mechanical spring or thermostatic opening forces. Sometimes the magnetic forces can be simultaneously used to achieve a "blow out" action for arc suppression. Silver-Iron and Silver plus Nickel contact materials are magnetizable and this property can be utilized to advantage for make or break purposes.

B-9. **Will the mating contacts be subjected to mechanical cohesive forces from action produced rough or pitted faces or alternately from highly polished faces?**
Such conditions may be brought about by severe vibration, mechanical wear, by too fast electrical wear, by the use of too small surface engagement areas in the mating contacts, or from foreign matter or materials coating the contact working faces. Separational forces should be sufficient to overcome these conditions.

C. Physical variable features.

C-1. **What is the permissible ambient operating range in degrees F. or C.?**
These temperatures should never exceed those at which changes in contact composition or contact contamination (metallurgical) will occur. They must be kept below temperatures at which "out gassing" of insulating materials etc. occur, also lower than those producing "tack welding" or fusion together of contacts.

C-2. **What comprises the ambient atmosphere around the contacts? Could they operate better in vacuum or a liquid?**
The majority of make and break contacts operate in air and are therefore subject to humidity, airborne chemical, etc. contaminants and/or the metallurgical effects of oxygen, nitrogen at arcing, sparking, electrostatic temperatures. It is felt it will be best to discuss case remedial methods individually rather than to summarize such protective steps. Some contact materials transfer rapidly in a vacuum through sputtering etc. actions. Others function best in neutral gas mixtures such as helium, argon. Other than mercury type contacts, contacts operating in or as a liquid are not widely used in the relay industry.

C-3. **What is the effect of the ambient atmospheric pressure on contact operation?**
Recent investigations have shown that many of the contact materials which function well in air at sealevel pressures failed rapidly in high altitude service in planes, etc. Refractory based contacts appear to be best for high altitude operation.

C-4. **Will these contacts operate in open, closed or sealed containers?**
Make and break contacts function well under controlled conditions in all three types of containers. Lack of time presently prevents summarizing the salient features of each type.

C-5. **How will the contact working face materials be assembled into their normal operational positions?**
This might best be restated as "What's the best and most economical assembly method for my particular contact application?"
The majority of contacts used for relay assembly are produced in the form of:

(a) Rivets (including eyelets)
(b) Welded parts
(c) Brazed parts
(d) Clad materials - inlays, overlays, etc.
(e) Staked (interfering fit) or, hot upset contact assemblies
(f) Plated contacts - electroplated, vacuum plated, sprayed metals, etc.
(g) Spring parts (comprised of solid contact materials).
(h) Screws

These can be best discussed as individual applications since each type has its particular field of application. Improper assembly will of course obviate successful contact functionings.

C-6. **When designing your relays what physical dimensions were allowed for the contact materials themselves and/or when they were assembled to supports?** How were these dimensions obtained? The Current VS Contact Diameter Selector" which will be supplied to you at the Sept. 10 "Think In" was developed from data supplied by and through the cooperation of over 300 electronic, electrical and metallurgical engineers. We suggest you try it out "for size" and advise us your findings.

D. Metallurgical Factors.

D-1. Availability of chosen contact materials.
Most of the generally used contact materials are presently available in desired quantities. However, silver, cadmium, the platinum family group, tungsten and molybdenum are becoming increasingly difficult to obtain. Since this situation will continue, it is recommended that relay manufacturers check with contact suppliers on replacing some types of these contact materials with bonded or composite (Uniclad) types and/or some of the newly developed contact replacement materials.

D-2. Calculated and/or allowable contact materials costs. Closer liaison between relay and contact engineers and designers can produce worthwhile savings in assembly, materials, and testing costs. Since these projects are on specific applications, it is felt that they should be individually discussed rather than covered by my paper.

D-3. Assurance of uniformity of materials compositions on succeeding lots of tested and approved contacts.

(a) Request a certification of analysis with your purchase orders.

(b) Your contact supplier has carefully processed and packaged your contacts. Be sure that your inspection and storage before use prevents contamination from any source.

In conclusion:
Personally, I feel that electrical make and break contacts are neither "saints" nor "sinners," but servants; if used properly they will serve you well. If improperly used, they cannot in themselves solve the service complexities jointly introduced by our above outlined 21 variables plus our ignorance factor in improperly using them.

Regardless of their dimensions and compositions, electrical contacts cannot overcome the effects of faulty designs, slipshod assembly, improper service ratings if these exist in the relays into which they are incorporated. Provided your electrical contacts are correctly selected with regard to compositions, dimensions, and your circuits actual service requirements, plus proper assembly, they will have the same basic capabilities for service reliability as any other relay or controls component. Your progressive relay and controls manufacturers frequently re-evaluate your relays and controls on the basis of developments in and availability of new materials, competition, production improvements, automation, redesigns, field and laboratory service reliability history, changes in circuiting and terminal applications.

Are you simultaneously giving your electrical contacts a similar careful analysis? If not, why not? Yesterday's contacts may also become obsolete! Typical of these application questions is the "controversy" over when and where to use silver tungsten–when and where to use the silver cadmium oxide.

SILVER-CADMIUM OXIDES vs. SILVER-TUNGSTEN CONTACTS WHICH-WHEN-WHERE-WHY?

I have been asked to comment on the silver-cadmium oxides versus Silver-tungsten contact application controversy.

Actually although each type of these materials has its own optimum application field, they do have overlapping service parameters in which either material will give satisfactory service, and choice is dictated by preference.

Silver cadmium oxide achieves its chief purpose–non-welding–and a low erosion rate through a momentary "blasting action" or spreading out of the arc plasma, plus its unique inherent ability to absorb enormous amounts of heat energy during the temporary reduction of some of the contained cadmium oxides to metallic cadmium. This process arrests itself when the contact body is sufficiently cooled and the nascent cadmium so formed readily re-oxidizes to cadmium oxide.

In tungsten-silver, the tungsten body or matrix material has an extremely high melting point–3370°C, boiling point 5900°C and will therefore not readily weld to the similar tungsten matrix in the opposite or mating tungsten-silver contact. Since tungsten does oxidize readily it forms a natural surface "dirtying" agent which tends to dust or coat the silver surface(s). The silver contact portion may therefore reach or even exceed its melting point without resultant fusing to the silver in the mating tungsten silver contact surfaces.

We have cross checked our application test results and conclusions on both Ag Cd 0 and Ag W contact materials with Dr. W. A. Merl, Manager of contact research for "Durrwachter Doduco K.G." in Pforzheim, Germany and find that we are in close agreement in the following:

1. Generally preferred for contactors or relays rated for handling around 400 ampere currents–90 Ag 10 Cd 0, for higher currents such as 600 ampere ratings 85 Ag 15 Cd 0.

2. For breakers or relays up to 230 volts A.C. and perhaps to 100 amperes maximum rating, 60W 40 Ag–alternately 50 Ag 50 Mo–performs well if ample heat sink capacity is provided. For these same applications the erosion rate is usually higher on Ag Cd 0 than on Ag W.

It is interesting to note that in Germany and on the continent, many of their 100 ampere medium voltage breakers and relays use a preferred dis-similar materials combination of Ag 95/C5 against 70/80 Ag 20/30 Ni. The operational life of these combinations is somewhat below Ag W but less overall heating is experienced.

3. However we both find in 10 to 50 ampere ratings when using a strong magnetic force which produces fast opening speeds, the resultant arc is rapidly blown away and/or quickly extinguished, using 90 Ag 10 Cd 0 is preferable.

4. Where the arc suppression takes longer and the opening speed is slower the Ag Cd 0 erosion rate is too high. Provided the contacts are closed under higher applied pressures Ag W (alternately Ag Mo) will give superior overall service. It is interesting to note that in our recent tests dis-similar material(s) combinations of Ag Cd 0 against a mating Ag W or Ag Mo contact has been surprisingly effective in heat reduction and obtaining enhanced overall service life.

5. For D. C. service European practice is generally to use Ag Cd 0 for quickbreak contacts widely separated after break and closed under lighter pressures.–Ag W, Ag Mo–against themselves, alternately 90/95 Ag 5/10 C against 85/90 Ag 10/15 Ni are preferred under higher closing pressures and slower opening speeds.

6. Some of our recent D.C. tests have indicated that using 85 Ag 15 Cd–cadmium and not cadmium oxide–polarity negative against 90/95 Ag 5/10 Cd 0 positive polarity often improves overall service life.

7. Summarizing:

(a) Ag Cd 0 for quickbreaking contacts widely separated in open position and held closed under moderate pressures.

(b) Ag W (also Ag Mo) for slower opening speeds, minimal separations in open positions, contacts subjected to severe mechanical wear and/or high closing pressures.

GUIDELINES FOR RELIABLE RELAY APPLICATION AND SELECTION

By **L. W. Wendling**, Naval Air Systems Command Hdq., Washington, D.C. and **E. U. Thomas**, Grumman Aerospace Corp., Bethpage, L.I., New York.

PREFACE

Messrs. L. W. Wendling (Naval Air Systems Command) and E. U. Thomas (Chairman of the SAE A-2R Relay Committee) stressed the point that all too many military and aerospace relay failures are directly traceable to misapplication — misapplications that are not readily recognized by many, yet can be used to predict eventual field failures. Their published paper contains a wealth of information regarding proper selection and common sources of failures. These latter included first various types of loads (resistive, inductive, motor, lamp, and minimum current). Coupled with the load considerations is the power source and switching modes — e.g., single phase off-on, poly-phase off-on, and load transfer between unsynchronized power sources. Each switching mode is progressively more demanding upon relays' capability. Recent revisions and amendments to the general purpose specifications now provide adequate test requirements for each area. It is not necessary to use a relay with greater capabilities than the application requires, but it certainly is inviting trouble to use one with less than the capabilities required.

Besides the paper handed out (essentially the same as presented by the two men in April at Oklahoma State University) and now in the 1969 Proceedings (available from NARM Box 1649, Scottsdale, Arizona 85252 at $5) with some addenda, additional circuit design help can be obtained by writing the Superintendent of Documents, General Printing Office, Washington D.C. 20402 and requesting copy of Section XI **only**, "Relays, Electromechanical" of NAVAIR 01-1A-514 "Design of Electric Systems for Naval Aircraft and Missiles." Section XI has been assigned Catalog Number D217,14:EL2/CH at $2.75 and is highly recommended by Mr. Wendling as an adjunct to the present paper.

Because the printed paper contains much too much data to be orally presented, the authors presented their theme on reliability by way of proper selection by showing colored slides of failed relays and explained why; provided selection data tables; showed that newer relays are smaller and lighter with greater capability than older ones; illustrated circuits where voltage sensors failed to detect phase loss; etc. Recently cancelled relays were also listed.

One of the items in their paper indicated that some surplus relay houses have reworked relays, changed the name tags and represented the reworks as updated relays to later revisions of the specifications and marked them as qualified MS parts when even the manufacturer using better materials than his early models is not qualified. Users who are victims should notify the FBI.

Although primary emphasis dealt with electromechanical relays, Mr. Wendling is responsible for the NAVAIR "SOSTEL" program — (Solid State Electronic Logic) for contactless aircraft electric systems.

ABSTRACT: With the assistance of the SAE A-2R subcommittee for relays, the representatives of the various military activities have been successful in incorporating necessary requirements directly into relay and equipment specifications. However, the ever increasing complexity of aircraft system designs, the demands on electric power, and the continual need for miniaturizing have, and continue to collectively cause design engineers to misapply relays. By acknowledging the problems which exist during the system paper design phase, it is hoped engineers and designers, upon recognizing these limitations, will more effectively utilize relays for the purposes intended. In order that relays will be accepted for their known basic reliability, these "guidelines" are presented and apply not only to military but to relay applications and selection in general.

The original material was first presented at Oklahoma State University at the 17th OSU/NARM National Relay Conference, 22/23 April 1969.

INTRODUCTION

Relays are trustworthy devices. Were they not, they would not be so widely used in so many fields, nor for so many years by so many people. When they do fail, however, quite often no attempt is made to determine the cause. But, even when a diagnosis is made, frequently it is incorrect. In most instances, the relay is merely replaced – only to fail once more at a later date. Replacement is easier than admitting to an engineering systems design deficiency. The time to deal with misapplication is prior to the hardware design stage, a point reached long before corrective action becomes unduly expensive. Misapplication can and must be avoided.

Most engineers instinctively believe that once proper terminal voltage is applied to an electromechanical relay, it will switch and transfer its contacts in the manner the circuit designer intended. To do so is the axiomatic function of a relay. Surprisingly, this simple concept often turns out to be the very cause of many equipment failures because misapplication causes relays to **"fight rather than switch."** They are deterred from completing their appointed rounds in many ways, but seldom is it the fault of the relay. For example, if a circuit malfunction causes a contact failure, it is the relay that is blamed. When called upon, relays may make contact mechanically but not electrically in the **"minimum current"** area; contacts may weld; they may wearout; or the relay may literally blow up – all from being misapplied. Sometimes relays do fail, yet **"were they properly understood, better standardized, less abused and less misused,"**[6] the incidence of failure would be greatly diminished.

Different conditions impose entirely different requirements upon the switching device capabilities. These differences must be understood, recognized and dealt with. The components selected must be "technically suitable,"[9] which means meeting **all combinations** of **all** of the specific application requirements. To meet the requirements they must all be stated for they are all part of any switching action. The ever increasing complexity of aircraft electric system design, the demands on electric power, and continued need for miniaturization, collectively cause design engineers to misapply electromechanical relays. These factors and the apparent lack of definition of characteristics of the relays selected, contribute to failures affecting the reliability of aircraft and their related systems such as support and checkout equipment. As design deficiencies are recognized, military specifications, military standards, handbooks and detail specification sheets are continually being revised by both the Military and Industry to more clearly define the performance requirements and to establish methods to assure that these requirements will be constantly met. Not only must requirements for intended usage be adequately covered, but the known limitations must likewise be identified in the military documents. These procedures generally increase relay capabilities and reduce the possibilities for misapplication (the choice of improper though qualified component for a specification application). For relays to be technically suitable and properly applied, the engineer must recognize both a relay's capabilities and its limitations. He must also recognize all his application's requirements and see that they and the relay's capabilities correspond. Neither its QPL status nor the mention of a military specification establishes a preference **ipso facto** for a relay. It is the contractor's responsibility to meet specification requirements and stand behind trouble-free system operation. Correction of defects may well be at the contractor's own expense[9] where engineering design deficiency exists. The granting of QPL does not bestow mystic properties on a relay, nor does it implicity imply a "quality" item.

To assist an engineer in recognizing merits and some of the problems of misapplication, such as: the areas of minimum current (or intermediate switching area); paralleling contacts; grounded relay cases; arc-over (between contacts or contacts to the case); catastrophic flash over failures; effects of various load types; effects of frequency; and source characteristics under which load switching commonly occurs; and whether switching be on-off; polyphase; load transfer; etc.: including slowly changing coil power upwards or downwards or just plain partial coil energization contribute to "relay failures", all of these topics are included in this discussion. Much has been written individually on each of these topics, but little has been accomplished to prepare a single digest presenting the combined overall problems and various considerations for deliberation at an industry wide conference such as the OSU/NARM Annual Relay Symposium. Distribution of this paper as a part of NARM proceedings should meet certainly both the users' and the manufacturers' approval.

DISCUSSION

The transfer of electric loads between unsynchronized power sources has been one major cause for misapplications due to inadequate information and understanding. Using two position rather than three position relays to select between power sources, is becoming more prevalent in aircraft electric power systems than in the past. In a highly competive industry in which unnecessary component size and weight are costly, those safeguards such as extra internal insulation are not included inside relays primarily intended for the control of 28 VDC loads or single phase AC from a single source. In military aircraft electric systems hermetically sealed relays are mandatory[4, 10] unless otherwise stated. The design engineer must select a relay to handle his specific requirements - it must be "technically suitable"[9] to the particular application. A relay may be "highly reliable" in one application and not in another. Where relay reliable operation is needed at all locations it may be logistically expedient to use a single style relay throughout an electric system even though the more expensive version is needed at one or two locations. In an original system design MS27218 could be used not only to switch three phase circuits for which it was designed but also "single phase circuits only" for which the similarly sized MS25267 was designed. The MS27218 can be used everywhere the MS25267 is used, but not vice versa. The importance of this consideration will become more apparent as switching details are discussed. Therefore, let us start with the simplest switching requirements and progress through a variety of commonly encountered switching applications. At the request of the Navy, SAE A-2R subcommittee accepted the task to prepare a draft of a relay applications manual for triservice military considerations ––– a task that has not been completed, but is still being pursued.

Some Factors Affecting Switching Performance

Tables I through VII list various switching considerations such as type of load, power, contacts, load level, and the switching function itself (on-off, load trasnfer, reversal, etc.). These concepts bear directly upon the typical basic circuits that follow and these in turn bear on ultimate system reliability and trouble free life. Relay selection must satisfy the switching requirements and not the other way around. Sometimes the circuit must be modified to fit existing relays while still retaining the basic circuit logic. In addition to the above, of course, must be added environmental considerations, gas pressures, contaminants, shock vibrations, etc., but only the "electrical" aspects will be treated at this time.

Typical Switching Circuits and their required relay design capability:

The simplest circuit is shown in Figure 1, ON-OFF DC control from the same source whether relay is single or multipole.

CAUTION

THE TYPE OF LOAD (TABLE I) CAN MATERIALLY AFFECT THE RELIABILITY OF THE RELAY OPERATION. TUNGSTEN LAMP LOADS FOR EXAMPLE, MAY BE RESISTIVE BUT THEY ARE ALSO NON-LINEAR AND SUBJECT THE CONTACTS TO HIGH INRUSH CURRENTS (12 TO 16 TIMES THE STEADY STATE VALUE) THAT MAY WELD IMPROPERLY SELECTED RELAY CONTACTS BECAUSE CONTACTS BOUNCE UPON CLOSING JUST WHEN CURRENT IS MAXIMUM. TO UTILIZE A RELAY TO SWITCH TUNGSTEN LAMP

TABLE I

Types of Load

- Resistive
- Inductive
- Capacitive
- Motor
- Lamp

TABLE II

Type of Power

- DC
- AC - (Frequency)

TABLE III

Loading Factor (Percent of Contact Rating)

- Low Level (Dry Circuit)
- Intermediate Loading (minimum current)
- Full rated load
- Rupture (Fail-Safe requirement)

TABLE IV

Contact Type

SINGLE BREAK CONTACTS

Form A	Normally Open
Form B	Normally Closed
Form C	Transfer (break-before-make)
Form D	(make-before-break)
Form K	(Center-Off)

DOUBLE BREAK CONTACTS

Form X	Normally Open
Form Y	Normally Closed
Form Z	Transfer (break-before-make)
Form	(make-before-break)
Form	(Center-Off)

FACTORS AFFECTING SWITCHING PERFORMANCE

TABLE V

ON-OFF Switching

DC Power Source	Single
DC Power Source	Multiple (e.g., different voltages)
AC Power Source	Single Phase
AC Power Source	Single Source
AC Power Source	Polyphase, single source (single and/or polyphase loads)
AC Power Source	Polyphase, two sources (not transfer) Same Frequency Different Frequency
AC Power Source	Six Phase uncontrolled frequency

TABLE VI

Load Transfer

Grounding DC load when off
Grounding AC load when off
    Single Phase
    Polyphase
Transfer of load between two DC sources
Transfer of load between two AC phases of some AC source
Transfer of load between unsynchronized single phase AC sources
Transfer of load(s) between two unsynchronized polyphase AC sources

TABLE VII

Motor Reversal

Reversing DC motor
Reversing one phase of 2 Ø motor
Reversing input of two winding capacitor phase shift motor
Reversing two phase of three phase motor

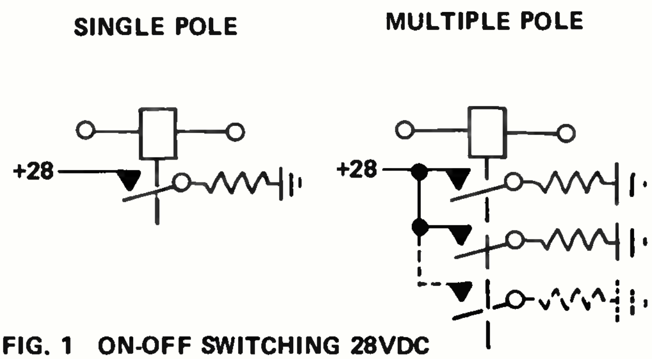


FIG. 1 ON-OFF SWITCHING 28VDC
TABLE V

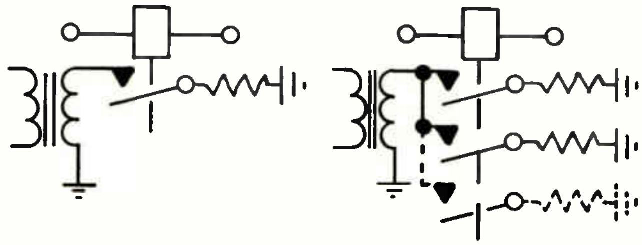


FIG. 2 ON-OFF SWITCHING 115VAC
Single Phase, Single Source
TABLE V

LOADS, THE DETAIL SPECIFICATION SHEET MUST SPECIFY THE CURRENT VALUE OF APPROXIMATELY ONE-EIGHTH THAT OF THE RELAY RESISTIVE CURRENT VALUE. SIMILAR DERATING APPLIES TO MOTORS WHICH NOT ONLY HAVE HIGH IN-RUSH, BUT ARE INDUCTIVE WHEN DISCONNECTED. FIGURE 1A SHOWS ONE METHOD TO SAVE CONTACTS WHEN SWITCHING LAMP LOADS.

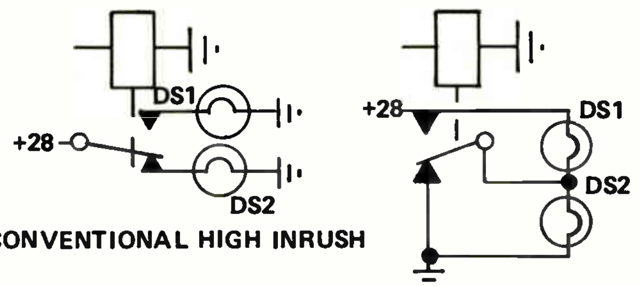


FIG. 1a RECOMMENDED LOW INRUSH CIRCUIT

Figure 2 shows circuitry for ON-OFF switching from a single-phase, single AC source, but introduces "something else".

WARNING AND CAUTION

IN ACCORDANCE WITH REQUIREMENT 1 OF MIL-STD-454 (AS NOW SPECIFIED IN MIL-E-5400, FOR EXAMPLE) PERSONNEL MUST BE PROTECTED FROM THE FATAL ELECTRIC SHOCK RESULTING FROM INTERNAL FAULTING IN A RELAY. THE RELAY CASE MUST EITHER BE GROUNDED OR BE INACCESSIBLE TO PERSONNEL WHENEVER EQUIPMENT IS IN OPERATION. THIS INCLUDES TESTING AND SERVICING. THAT GROUNDING THE CASE IMPOSES NEED FOR ADDITIONAL RELAY CAPABILITY (e.g., ADDITIONAL INSULATION) TO PREVENT ARC-OVER TO THE CASE (INTERNAL FAULTING) DURING SWITCHING IN THE PRESENCE OF AN ARCING CONTACT HAS BEEN COVERED AT OSU/NARM CONFERENCES SEVERAL TIMES SINCE THE HAZARD WAS FIRST RECOGNIZED BY MR. D. SAEWERT OF MOTOROLA IN 1958.[2] CONSIDERING THAT MANY RELAYS BECOME AUTOMATICALLY GROUNDED WHEN MOUNTED, MOST DETAIL SHEETS SHOW GROUNDED CAPABILITIES. CAUTION MUST BE EXERCISED WHEN SELECTING RELAYS FROM CATALOGS LISTING VALUES WITH CASES UNGROUNDED, WHICH PRACTICE LEADS TO RELAY MISAPPLICATION AND NEEDLESS CATASTROPHIC FLASH OVER FAILURES. THE MILITARY HAVE ADDED THE AC RATINGS WITH GROUNDED CASES AND IT IS UPON THESE VALUES THAT THE LATEST SERIAL NUMBERS MEANT FOR EQUIPMENT DESIGNS THAT QPL IS GRANTED. NEW MILITARY REQUIREMENTS **ONLY** ESTABLISH THE NEED OF DESIGNS TO EXCEED THE EXISTING MILITARY STANDARDS; SUITABLE DETAIL SHEETS WILL FOLLOW. IMPROVED DESIGNS PERMIT INTERNAL INSULATION TO BE ADDED TO THE EXISTING RELAY CONFIGURATIONS THUS PREVENTING ARC OVER BOTH BETWEEN POLES AND TO CASE. FOR EXAMPLE, MS27218 IS ESSENTIALLY SIMILAR TO MS25267 EXCEPT THAT INSULATION BARRIERS HAVE BEEN ADDED BETWEEN CONTACTS, THEREBY ISOLATING THE POLES OF A POLYPHASE CIRCUIT. IT WILL DO ALL THAT THE FORMER WILL DO AND NOT FAIL WHEN SWITCHING POLYPHASE **"115/200 VOLT"** CIRCUITS.

WARNING

SWITCHING GROUND – PLACING THE RELAY CONTROL CONTACT IN THE GROUND LEAD IS A VIOLATION OF REQUIREMENT 1 OF MIL-STD-454.[9] GRANTED IT IS STANDARD TELEPHONE PRACTICE TO SWITCH GROUND WHERE THE VOLTAGES DO NOT EXCEED 48 VOLTS, AND THEREFORE PERMISSIBLE UNDER THE NATIONAL ELECTRICAL CODE, **BUT THIS DOES NOT APPLY TO HIGHER VOLTAGES.** EVEN 28 VOLTS ON A WET AIRCRAFT CARRIER DECK CAN BE HAZARDOUS. BESIDES BEING A PERSONNEL HAZARD AT THE HIGHER VOLTAGES, SWITCHING GROUND CAN CAUSE MANY A MALFUNCTION. IN HIGH IMPEDANCE CIRCUITS, FALSE OPERATION OCCURS BECAUSE OF LEAKAGE TO GROUND AND THIS ACTION CAN BE PERILOUS IN A WEAPONS RELEASE SYSTEM WHERE CONTROL LEADS PASS THROUGH MANY CONNECTORS OR MAY BECOME GROUNDED THROUGH WEAR AND TEAR OR ENEMY ACTION. THEREFORE, ONLY

"HOT-LEAD", FAIL-SAFE SWITCHING CIRCUITS ARE CONSIDERED IN THIS DISCUSSION.[4]

Polyphase ON-OFF Switching

In addition to the different types of leads (Tables I and III), it has been long recognized in certain areas but not in others, that polyphase switching imposes additional pole to pole stresses. Conditions will only become more severe as higher voltage aircraft systems emerge, e.g., 240/416V. Military relay specifications and drawings include the polyphase requirements and so, too, should the relay manufacturers' drawings. These often list a current value without reference to voltage or type of load. In many instances this value is for 28 VDC resistive loads and is greater than for other conditions. Table V lists some of the more typical applications of relays for which Figure 3

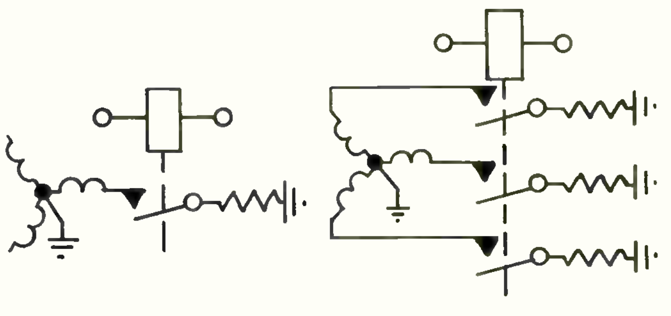


FIG.3 ON-OFF SWITCHING 115/200VAC
Single Source, Polyphase
TABLE V

is one, covering **ON-OFF** switching of a polyphase circuit, where the voltages between poles require that the poles be isolated whether by insulation or adequate spacing. The dielectric test voltages on the detail specifications are so rated when polyphase application is intended.

CAUTION

THREE SINGLE PHASE LOADS ON DIFFERENT PHASES OF THE SAME SOURCE REQUIRE THE SAME ISOLATION AND THREE PHASE CAPABILITIES AS A SINGLE THREE PHASE LOAD.

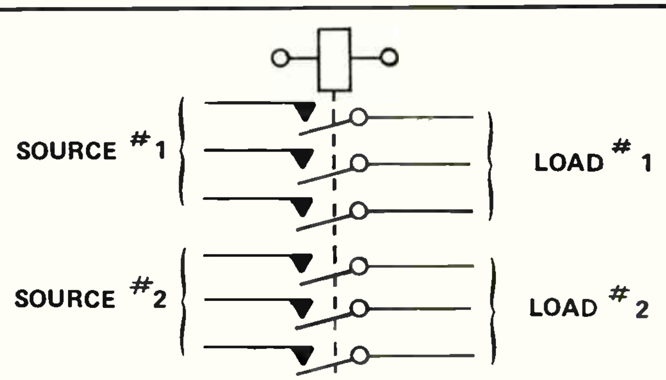


FIG.4 ON-OFF SWITCHING
Polyphase loads, Dual Source
TABLE V

Figure 4 illustrates another potential relay stress condition. Even if there should be sufficient dielectric spacing between contacts to handle each three phase power source separately on adjacent contacts, two unsynchronized sources can be directly out of phase where two adjacent contacts in the relay are supplied by different sources. At the time of this writing no QPL'd military standard six pole relay rated for 115/200 volts exists. MS25269, for example, is intended for single phase 115 volt switching and must not be used for polyphase. Although both MS27420 and MS21987 have been cancelled for lack of QPL sources, the use of polyphase on relays rated for single phase, is Russian Roulette. When the firing conditions become coincident, catastrophe strikes. Both MIL-R-5757E and MIL-6106F recognize this potential failure mode.

Transfer Switching, General (Table VI)

"Transfer switching" can take several forms. It can involve (a) the transfer of a power source between different loads, or (b) the transfer of loads between different sources. The transfer of power between different loads is discussed first, being the less demanding.

Transferring power between loads is essentially "ON-OFF" switching. Where one load current is near the contact rated value and the other load is in the intermediate area **(minimum current)**, switching failure problems (Table III) arise. These are explained under that heading.

Polarity Changing

Another common use of the transfer contacts that creates

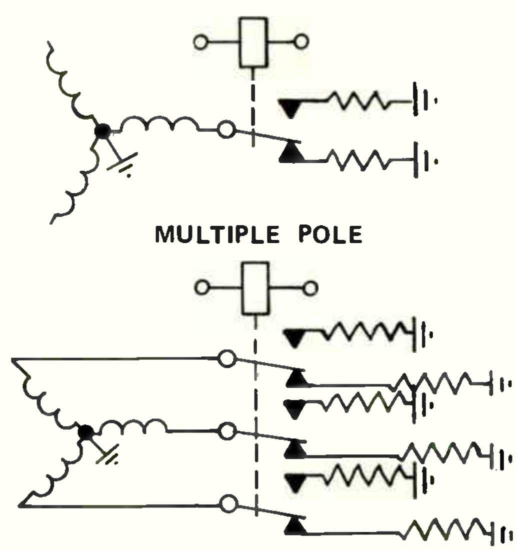


FIG. 5 POWER TRANSFER BETWEEN LOADS
Single Source
TABLE V

commonly unrecognized switching problems[3] is the reversal of connections or polarity to a load as in Figure 6B, and 6A and 7B. Many small light, fast acting relays have a lower

TABLE VIII

Some Common Misconceptions Regarding Relays

1. **Dielectric test voltages do not "specify the relay's ability to withstand rated voltages and transient voltages that may be imposed during switching."** Dielectric tests are conducted under static conditions in the absence of both switching and arcing.[13]
2. **Catalogs list AC voltages and currents for relays with ungrounded cases.** Such usage does not comply with Requirement 1 of MIL-STD-454, nor is it in accordance with Military detail specifications.
3. **"Operate values" may be determined properly at 25°C** - Military specifications require **compliance over entire specified temperature** range for **pickup, dropout, operate** and **release times** with nominal coil voltages. Even the specification values are not worst case values.
4. **Water bubble test if "one of three hermetic seal tests".** It is not sensitive enough by itself (1 x 10^{-5} cc/sec) and is intended to detect gross leakers only. Additional tests must be imposed. See Myths.

specified dielectric test voltage across the open contact than between poles - e.g., crystal can relays are tested at **1000 volts pole to pole,** but **only 500 volts across open contacts,** and **TO-5** relays are tested at **a mere 125** volts. These lower values should suggest to the engineer that the internal air

SINGLE POLE

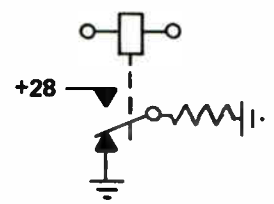


FIG. 6A LOAD TRANSFER 28VDC

TABLE VI

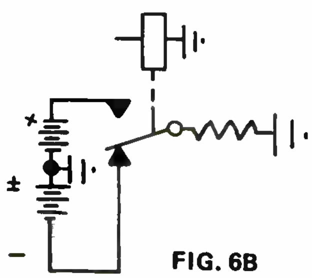


FIG. 6B

MULTIPLE POLE

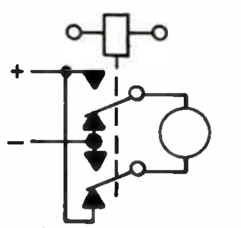


FIG. 7A TABLE VII

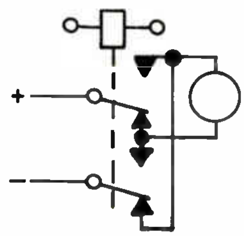


FIG. 7B TABLE VII

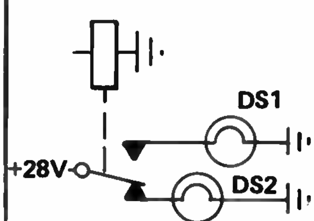


FIG. 6C HIGH INRUSH LAMP TRANSFER

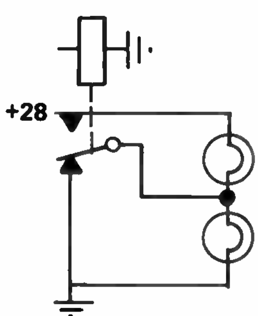
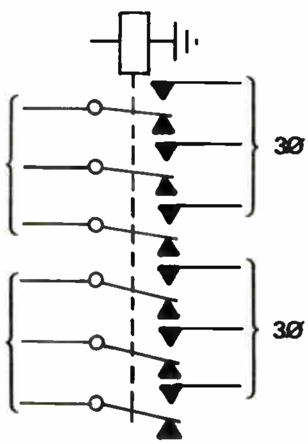


FIG. 6D LOW INRUSH

gap or amount of travel is short, and it is this short distance that cuases many transfer problems. The smaller the relay, the less the dielectric test voltage and the smaller the gap. TO-5 relays, for example, have extremely small air gaps and even at 28 volts under load switching, an arc can be drawn across the contacts where both stationary sides are connected. Despite what has been said and written at this symposium in the past, **the dielectric test voltages do not " 'specify' the relay's ability to withstand rated voltage and transient voltages that may be imposed during switching."**[13] The dielectric test voltages are static test voltages applied in the absence of both contact motion and arcing. Uncontrolled flash over without current limiting resistance can be devastating, the same as flash over to



Misapplication, unless relay is rated "115/200 VAC" i.e., 3 Phase (Relays rated "115 VAC" are for 1 phase only) e.g. MS25269 or MS25329

grounded case. Small multipole relays with tight tolerances and short contact travel can actually transfer one set of contacts before another with the result that one set will make before the other breaks. This results in a condition that can short circuit the power input of Figure 7B. (See also paralleling contacts.) Circuit designers must recognize that it is neither practical to adjust and maintain contacts to make and break simultaneously nor do the specifications require it. One contact set will be ahead of the other and the relative amount of displacement depends a great deal on the size and configuration of the relay as well as the intended use and amount of armature travel. The smaller the relay the more difficult it is to adjust and maintain operation during the useful life of the relay.

SINGLE POLE **MULTIPLE POLE**

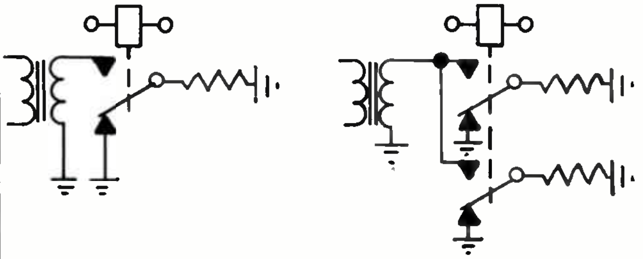


FIG. 8 LOAD TRANSFER 115VAC
Single Source, Single Phase
TABLE VI

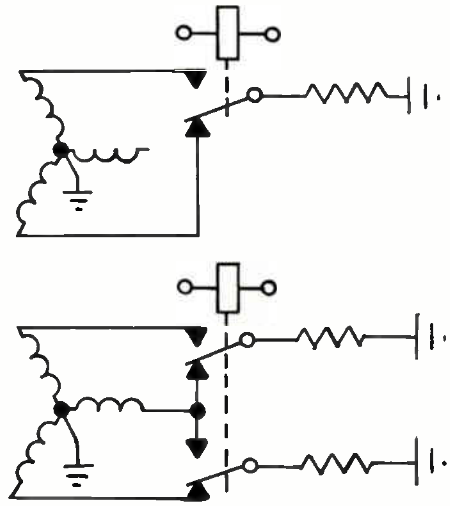


FIG. 9 LOAD TRANSFER BETWEEN PHASES 115/200VAC
Single source, Polyphase
TABLE VII

Load Transfer Hazards (Table VI)

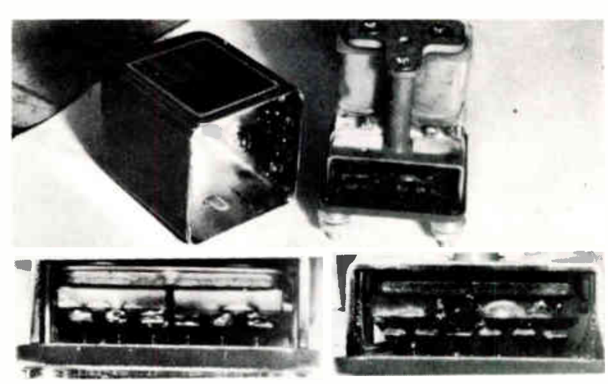
Figure 8 illustrates a common typical switching hazard. When an inductive current wave form is interrupted at the right point, an arc can ionize the gas in the air gap and if air gap is small the arc will be sustained. Where the frequency exceeds the ionization decay time, and the voltage wave rises, the arc may continue and with no means for self-extinguishment such as in a horn gap lighting arrestor. In a horn gap, the heat of the arc causes it to rise and as the electrodes diverge the arc is extended until it goes out. Once an arc is broken it does not restrike because the original dielectric breakdown resistance has been restored as soon as the air is de-ionized. Relays are not built to be so fortunate.

Figures 9 and 10 are variations of Figure 8, but the voltage potentials are greater and so are the number of relay failures. Failures that are predictable as going to happen eventually but as in Russian Roulette the particular occasion is not. It occurs everytime the AC voltage waves are interrupted at the right point, and in some instances, half the chambers are loaded.

MISAPPLICATION CATASTROPHIES

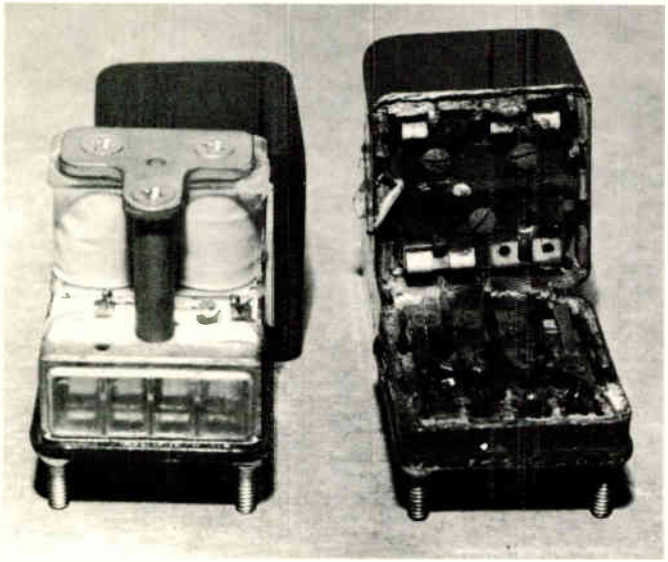
"Technically Unsuitable" for the Application
Failure of 1Ø Relays for On-Off Control of 3Ø

MIL-R-5757 Design After Being Used to Switch 115/200 Volts 3Ø (On-Off Control) for which Service It was Neither Designed nor Tested.



MS25269 6 PDT Relay Rated "115" Volts Used To Switch 115/200 Volts 3Ø (On-Off Control) For Which It Was Neither Designed Nor Tested.

FAILURE OF 3Ø RELAY FOR LOAD TRANSFER



MS25271 Type "before and after" three phase power selection (load transfer between ac sources)

Relay rated "115/200" volts or 200 volts pole to pole (see barrier strip) but only 115 volts across open transfer contacts.

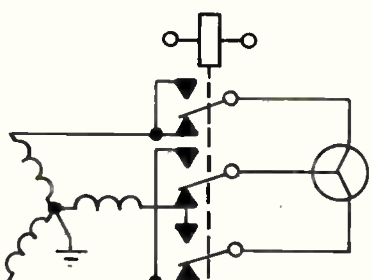


FIG. 10 MOTOR REVERSAL
Single Source, 3 Phase
TABLE VI&VII

Load Transfer Between Different Sources (Table VI) Figure 11 shows DC sources.

In the preceding AC figures, transfer was between different phases of the same source. Figures 12 and 13 show individual two-position relays used to transfer between different sources. In the case of AC supplies, whether single or polyphase, if the source voltages are 180° out of phase, **twice** the phase to neutral voltages may appear across the transfer contact. Once again it is Russian Roulette with loaded chambers. When the arcing starts between supplies, insulation destruction can cause shorting between phases of the same supply. The contact air gaps and the speed of operation during transfer must be great enough not to transfer the arcs.

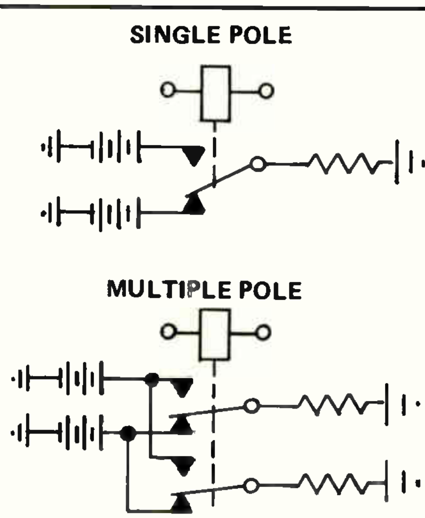


FIG. 11 LOAD TRANSFER BETWEEN SOURCES 28VDC
TABLE VI

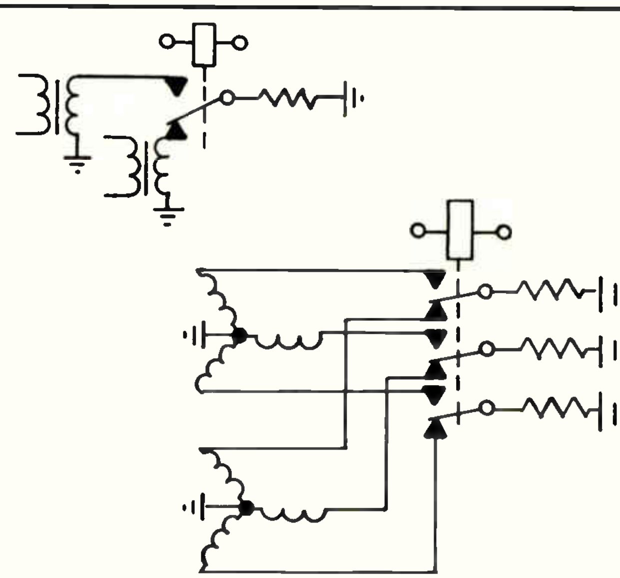


FIG. 12 LOAD TRANSFER BETWEEN SOURCES
Dual, 3 Phase 115/200VAC
TABLE VI

Neutral vs. Polarized Bistable Relays

The diagrams show single coil two-position neutral relays, but the contact gap and other isolation problems are the same for **polarized bistable,** double biased, relays (or "magnetic latch" types as they are commonly called.)

Two-Position vs. Three-Position Relays

In the past, aircraft power source selection was frequently done with two-coil center-off transfer relays. Here two air gaps exist between the different power sources and flash-over has not been a problem.[3] With the increase of electric power and the number of aircraft systems, the use of two position relays for load transfer between power sources has multiplied, especially in the smaller relay

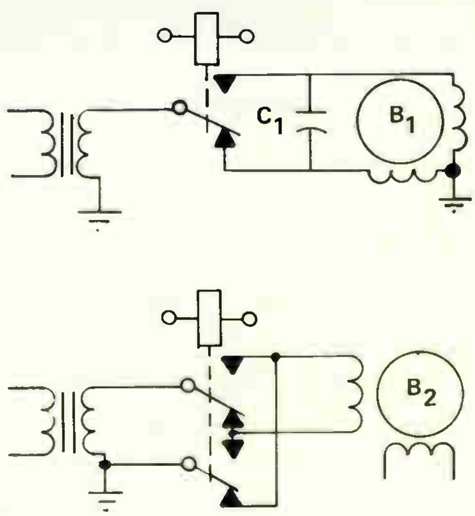


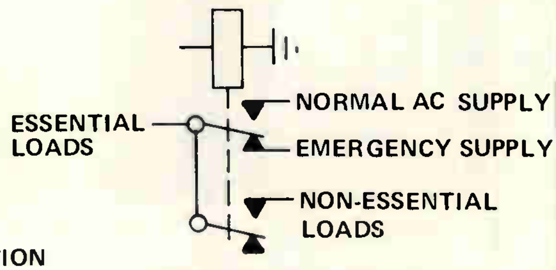
FIG. 13 PHASE WINDING REVERSAL
TABLE VII

sizes. Such applications have become of more and more concern to the Naval Air Systems Command, particularly where flash over occurs between unsynchronized AC power sources. Where such applications are contemplated, both MIL-R-5757E and MIL-R-6106F include testing provisions to demonstrate that relays are technically suitable, and the MS sheets to the letter specification have been recently revised to show the transfer rating if it exists. (See Fail-Safe.)

Closed Circuit (Fail-Safe) Principal

The closed circuit principal relates to fail-safe operation. In other words, a circuit must be closed and continuously energized for **normal** operation. If either the control circuit or if one of the contacts controlled thereby, fails, then the emergency condition should be established. Thus, if power fails, and it is necessary to remember what circuit condition existed before the failure, a latch relay may be suitable for the memory feature only, but not for transfer to emergency configuration because it requires electrical power to "unlatch" a latching relay and this circuit may malfunction. If a relay is electrically latched over its own normally open contact, however, any circuit interruption to the relay coil releases the relay and it will not pickup until the proper sequence of events take place to re-establish its self-holding condition. The "fail-safe" criterion has been met by means of the closed circuit principle.

FIG. 14 RECOMMENDED FAIL-SAFE CIRCUIT



CAUTION

Contacts must be rated for "load transfer" between unsynchronized ac scources. (Both supplies may be on before relay picks up to assume normal conditions.)

NOTE:

3Ø loads should be treated similarly.

Latch-Relay (Not fail-safe)

Latch relays whether they be mechanical or magnetic require control power to "unlatch" or "reset" the relay. Whether the relay coil shorts, or opens, or whether the external coil circuit opens or shorts, the results are the same; namely, the relay cannot be released from its latched condition. Therefore, as a safety-of-flight requirement, **circuits involving flight operation must not use latch relays.** For example, primary power circuits should use energized neutral relay to establish the normal configuration and must relax into the emergency configuration.

Fail-Safe Transfer

It is common "fail-safe" closed circuit railway signaling practice to transfer highway grade crossing signal controls from the normal AC power sources to the DC standby batteries in event of primary power failures. In other words the fail-safe concept is to **apply energy** to a neutral two position relay **under normal** operating **conditions** and to make the transfer to standby power in the emergency configuration without power on the relay coil. The same reasoning should apply to aircraft. Most general purpose relays are not designed for this type service but sometimes are erroneously used in this manner. Both the military and industry are now using special wide gap relays where the isolation between sources is adequate. (See photographs.)

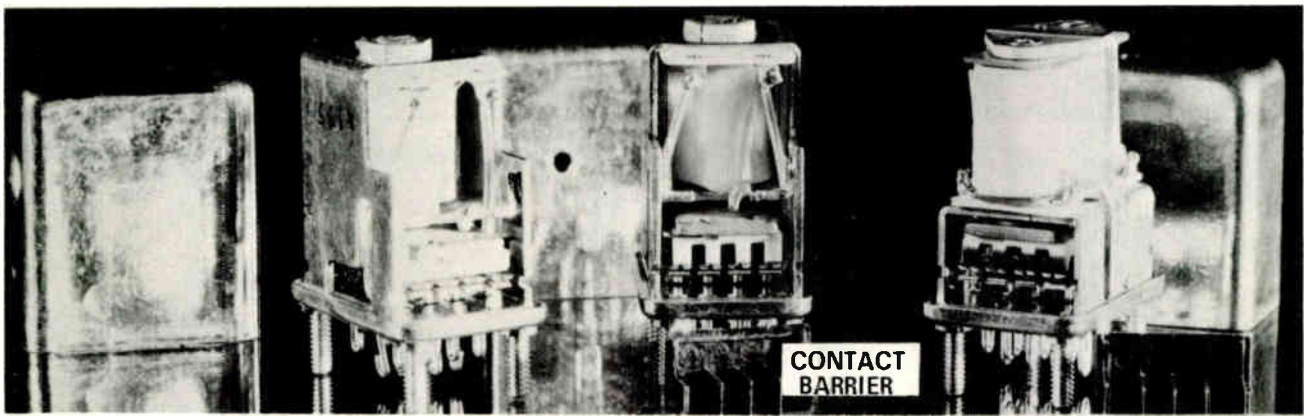
Switched Energy

If the energy is low, ionization and arcing may not occur. This means that the relays have resisted failures and switched as required even where the voltage may have been higher

FIG. 15 4 PDT 5 AMP RELAYS

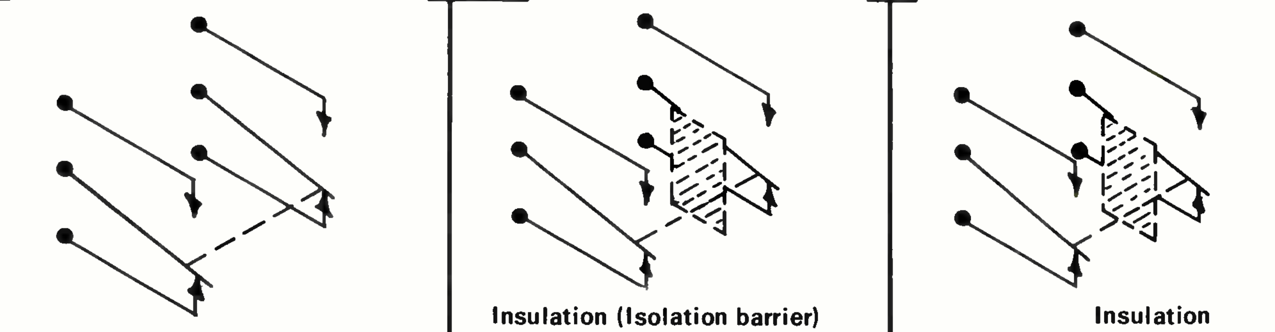
	SINGLE PHASE SINGLE SOURCE	SINGLE SOURCE POLYPHASE	LOAD TRANSFER DUAL SINGLE POLYPHASE

PHOTOGRAPHS

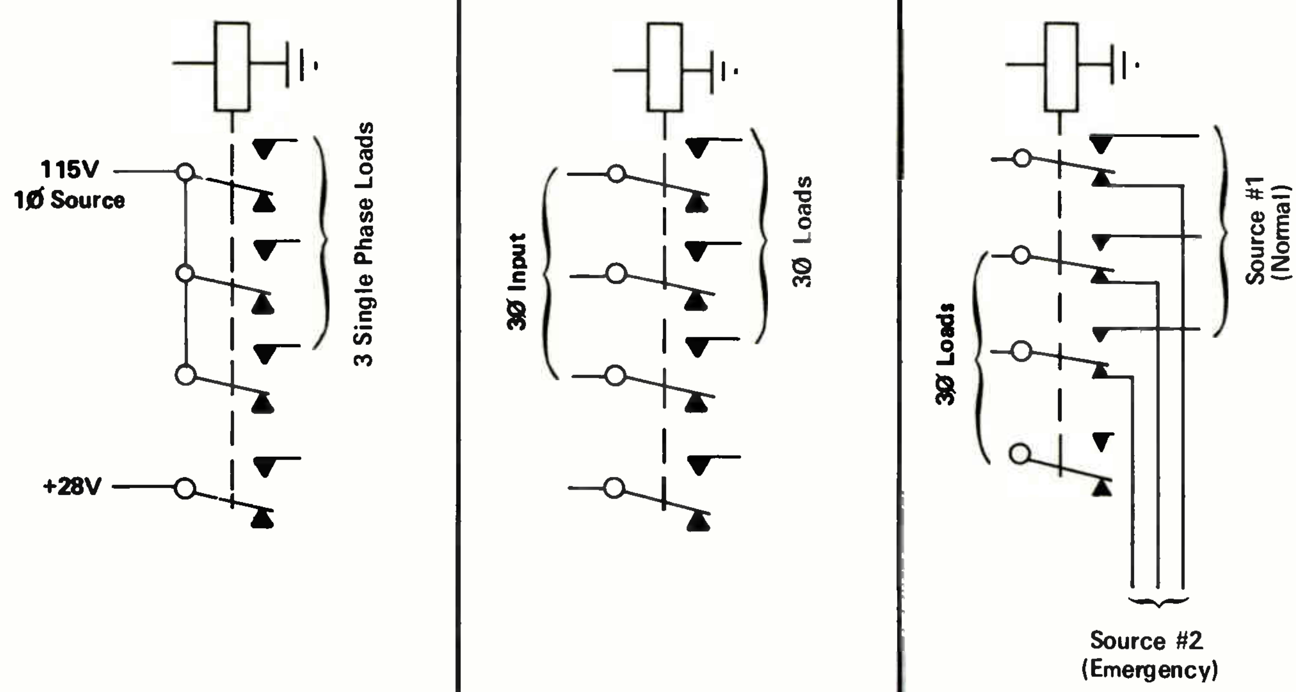


	MS25267	MS27218	SPECIAL WIDE GAP (MONOSTABLE POLARIZED)

CONTACTS



TYPICAL APPLICATIONS
(Intended Usage)



than the intended application design. Success is based on the currents being exceedingly small and therefore, so is the total energy. At the other end, where the currents may have been large while the voltages were low catastrophic arc over has not occurred because once again the total energy has been low. In fact three phase 115/200 volts circuits have been switched successfully by some relays that did not incorporate barriers, but once again the current and energy levels were low. The margin of safety before failure, however, is not known and only the fact the energy is low explains why there have not been more failures when switching three phase. It is not, however, to be recommended – certainly not without exhaustive testing under operating conditions.

Still another aspect of switched energy involves the law of conservation of energy – see Arc Suppression.

Frequency Effects

With DC, once an arc is established across contacts that are no longer in motion, there is nothing to extinguish the arc until parts of the relay are destroyed. With AC, as the frequency increases from zero, some interesting effects occur. Assuming the contacts separate at a reasonable speed and open sufficiently far enough, then at sixty hertz as the voltage goes through zero, arc interruption can take place. Inductive loads at this frequency are usually more severe than at 400 hertz. Frequently therefore, contacts are rated at lesser current values for inductive loads than for resistive loads and at lower values for 60 Hz than for 400 Hz inductive loads. Both 400 and 60 Hz inductive load values are now being added to the detail sheets for both MIL-R-5757 and MIL-R-6106. The problem, however, is not as simple as the above might be interpreted. As the frequency increases, the voltage may build up again within the same contact movement so that before the ionization decay is exceeded, restrike occurs as a result of the current to voltage phase lag. Once again the contacts suffer and once again as conditions change, so do the results. An ironclad rule regarding frequency and load cannot be made, but the effects of contact separation speed must not be overlooked.[5, 15]

Arc Suppression

Aside from "rfi" considerations, there are other reasons for arc suppression as indicated under "Switched Energy" where the law of conservation of energy was mentioned. Lenz's law follows indicating that a voltage will develop of sufficient magnitude so as to maintain the current flow that existed the instant the contacts start to open. The energy must be dissipated somewhere. If arc suppression is not permitted then the energy is dissipated across the contacts, and they suffer. In the past for inductive loads MIL-R-6106 relays were rated at 1/5 the resistive operations. Where possible, inductive loads should have arc suppression added, but a compromise may become necessary in the case of contacts controlling relay coils. Arc suppression tends to lengthen the relay's release time while the energy dissipates through the coil resistance and the suppression circuit.

Some applications cannot tolerate a delay in release time. Also contact life may suffer from delay in extinguishing an arc as contacts separate more slowly.

Minimum Current and Contact Contamination

"Minimum current" switching problems have been recognized by the military for more than a decade[16] and many military relays have had the long standing test requirement as applicable. At nearly dry circuit conditions energy and voltage are too low to create arcing problems in an hermetically sealed environment. In most cases the contact resistance at microamperes does not represent an intolerable voltage drop. What is acceptable at dry circuit, however, is definitely not at the intermediate or "minimum current" levels, and users must learn to appreciate this distinction.

At full rated contact loading there is sufficient arc energy to carbonize or depolymerize the absorbed hydrocarbons on the contact faces, especially in hermetically sealed relays. While arcing contributes to the information of contaminants, at full load the energy is also sufficient to burn them away. One application survey concluded that 85% of contact loads were at less than rated values and most of these in the so called minimum or intermediate current area of switching.

At the intermediate levels, – 50 MA to 300 MA more or less, – the story is different. The critical level of current varies somewhat with the type of load, but essentially arcing in an enclosed atmosphere carbonizes or depolymerizes the absorbed hydrocarbons on the contact faces and these contaminate the contacts. Because of the low current levels there is insufficient energy to clean the contacts and so relays that worked in the breadboard stage may fail in service after repeated operations have allowed these contaminations to build up. Failures increase with time and the number of operations which frequently fail in the range of 5,000 to 10,000 operations.

The reliable sealed relays are built with materials that will not off-gas and pains are taken during their fabrication to see that none is introduced. These relays may cost a bit more to make, but their ability to give reliable switching over prolonged periods of time is a military must and a contractor's responsbility to incorporate in his equipment.[9]

Non-Standard Relays and New Potential Sources for Standards

Military standards for relays provide the minimum acceptable design requirements of quality and workmanship to encourage maximum competition and eliminate, insofar as it is possible, restrictive features which might limit potential producers. Before new designs are considered for any application, available data, tables, charts, etc., such as those contained here (see Appendix) should be reviewed. A manufacturer's claim of **"complete interchangeability"** with existing designs should always be verified before inclusion in military equipment as "technical suitable". An MS part can be misapplied, so if the application dictates it, a non-standard relay may be the order of the day. If it is, however, then the procuring agency's permission should be obtained for the specific application and should be properly documented thereto.

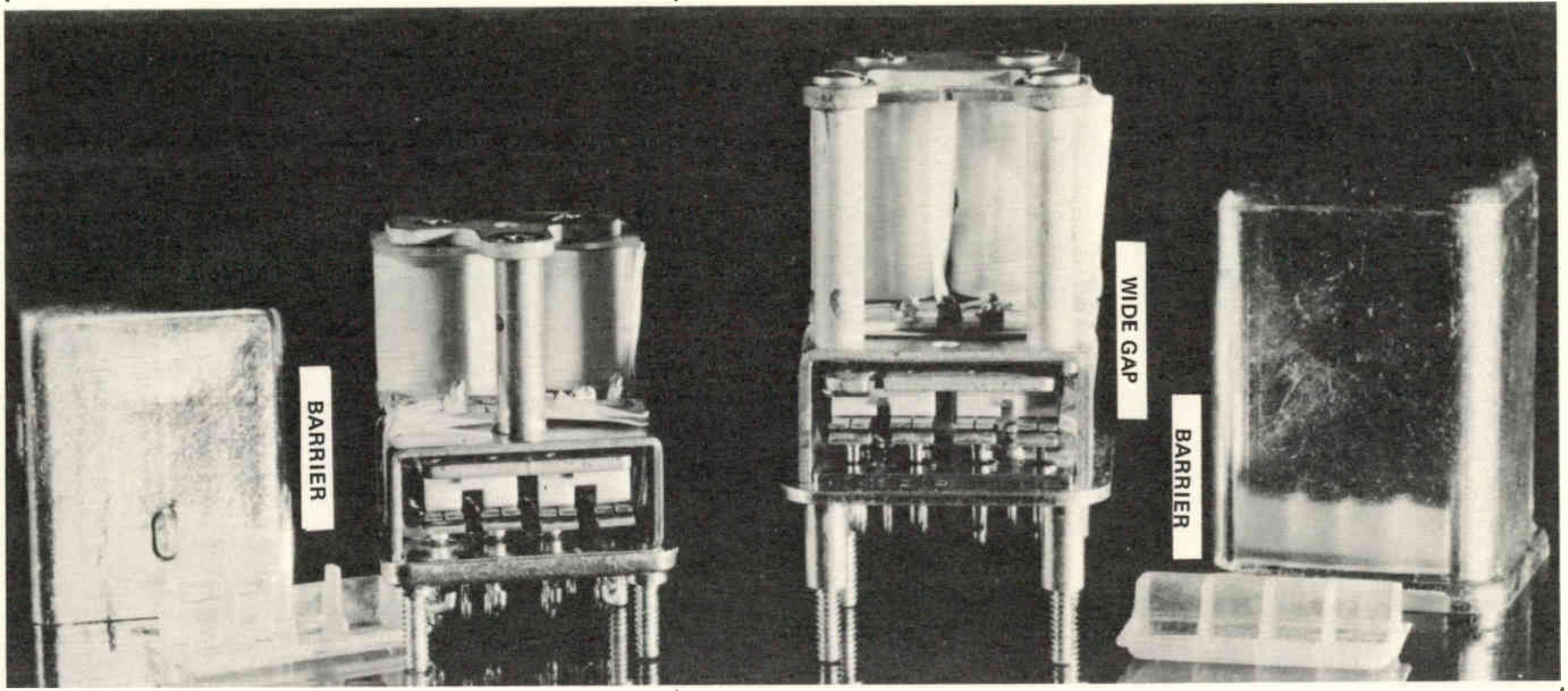
Paralleling Contacts

Paralleling contacts can be beneficial under special conditions, but under other conditions it can prove just the opposite and defeat the very purpose for which paralleling was undertaken.[11]

a. **Relay contacts should not be paralleled for the**

FIG. 16 4 PDT 10 AMP RELAYS

SINGLE SOURCE: POLYPHASE	DUAL SOURCE: POLYPHASE



MS25271	MS INCREASED WINDING SPACE	(AS) WIDE GAP RELAY

purpose of increasing the switching capacity. One contact will invariably make before other(s) and bear the full brunt of input surge, and one contact will also suffer under interruption conditions. Progressively, one contact will fail and then another. Adequate contacts must be used in the first place.

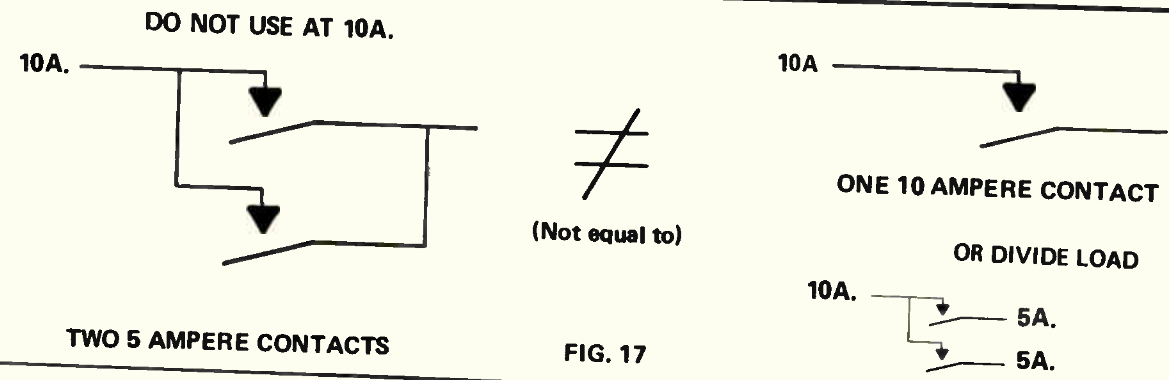


FIG. 17

CAUTION

MORE THAN ONE MILITARY SPECIFICATION IS RESTRICTED TO 10 AMPERES MAXIMUM AND CONTACTS SHOULD NOT BE PARALLELED FOR GREATER LOADS. USE THE PROPER RELAY SPECIFICATION.[12, 9]

b. **Relay contact should not be paralleled for redundancy on the assumption that they will work in unison.** The contacts will not make and break simultaneously and for small relays such as crystal can relays where contact travel is small, one contact may easily transfer before the other breaks. Instead of a break-before-make (form C) operation, a make-before-break contact (form D) operation will result. Allowance for contact operation changes due to wear, shock, vibration, and temperature effects must be considered.[11]

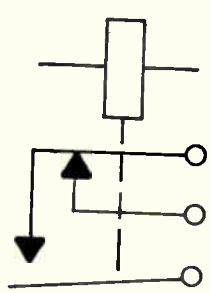


FIG. 18 FORM D MAKE–BEFORE–BREAK

c. **Relay contacts may be paralleled, however, for redundancy,** e.g., in minimum current applications where contact integrity is important. **BUT** contacts must not be paralleled if the circuits are critical and must maintain break-before-make operations (see step b). Bifurcated contacts are frequently used so as to provide for reliable restrained non-synchronized operation, i.e., unwanted make-before-break (form D) action. (NOTE: Not all relays QPL'd to the same drawing have identical contact structure and the difference could be all important to some applications.) For instance, some crystal can relays have bifurcated contacts and others do not, even from the same manufacturer in the same housing.

d. **Relay contacts may be paralleled to reduce the effects of contact bounce and vibration, BUT** the same cautions expressed above apply. Where, contacts have different natural vibration frequencies the net effect during contact bounce is for less total open circuit time than for each contact separately. Some relays are designed having bifurcated contacts of unequal widths just so that the resonant frequencies will be different and, therefore, have different critical vibration frequencies.

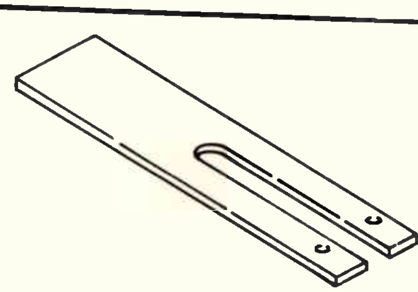


FIG. 19 BIFURCATED CONTACT

Military Specifications and Standards - Changes To:

Minimum current, and grounded relay case requirements have been a part of a number of military relay specifications and drawings for some time. Greater emphasis is now being applied to the details of these requirements for reasons of clarity and to avoid misinterpretation. **For replacement purposes only,** old designs are retained. For new systems designs wherever possible requirements are being standardized and made specific. Both the military specifications, MIL-R-5757 and MIL-6106 and their related drawing titles, are being or have already been changed to incorporate the requirements of the foregoing circuits and the features of Table I through VIII. Thus wide gap relays for load transfer applications are now being processed as Military Standards and will appear shortly. Meanwhile, non-standard relays should be used where application dictates.

Suitable Relays

When the wrong relay is used, it fails as shown in the attached illustrations. What then are the correct relays for some of the foregoing circuits? Typical are the following 4 pdt 5 and 10 ampere relays showing their features and intended usage. As mentioned before the relay with added features can be used in place of the one with lesser features but not vice versa. In some cases, retrofit should be considered. In the future, retrofit may become mandatory. (Pages 10 & 11).

Misapplication Circuit Correction, · Example of

Crystal can relays have limited switching capability for AC because of the arc over to case problems.[2] They are not assigned motor ratings by the military, yet are often so used and fail from welded contacts. Therefore, on two counts the use of crystal can relays to reverse one of the two phases of a motor as shown, is bound to result in failures. Instead of putting the phase shifting amplifiers ahead of the relays and motor field, the crystal can control relays should be at the input of the amplifier while the output is now continuously connected to the motor field. The relays now operate within their design capabilities and without change in the components. Fig. 21.

Form D Contacts

The "make-before-break" contact feature of Form D contacts is attractive for missiles and similar situations where the equipment must be transferred from external (ground) supply to its internal power without circuit interruption. This can be done on DC with ease by using series blocking devices in the lead of each power source so that excessive currents will not flow where power sources are paralleled. In the case of AC, transfer is not so easy. The sources must be synchronized and be in phase, otherwise there will be all manner of fire works. Proper selection includes proper circuit design. Fig. 20.

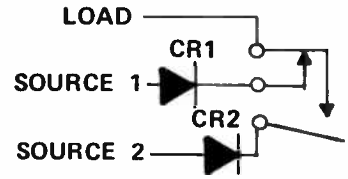


FIG. 20 CONTINUITY OF TRANSFER—
FORM D CONTACT

IDEP (Data Availability Through IDEP Center)[7]

One way of reducing relay failures is the use of IDEP, Interagency Data Exchange Program. Users, for example, can review what other users have found that contributed to relay failures and further they can determine what relays were subjected to which tests and to what extent by other users. In addition, they can pick up useful information as to what not to use certain relays for and what may lead to

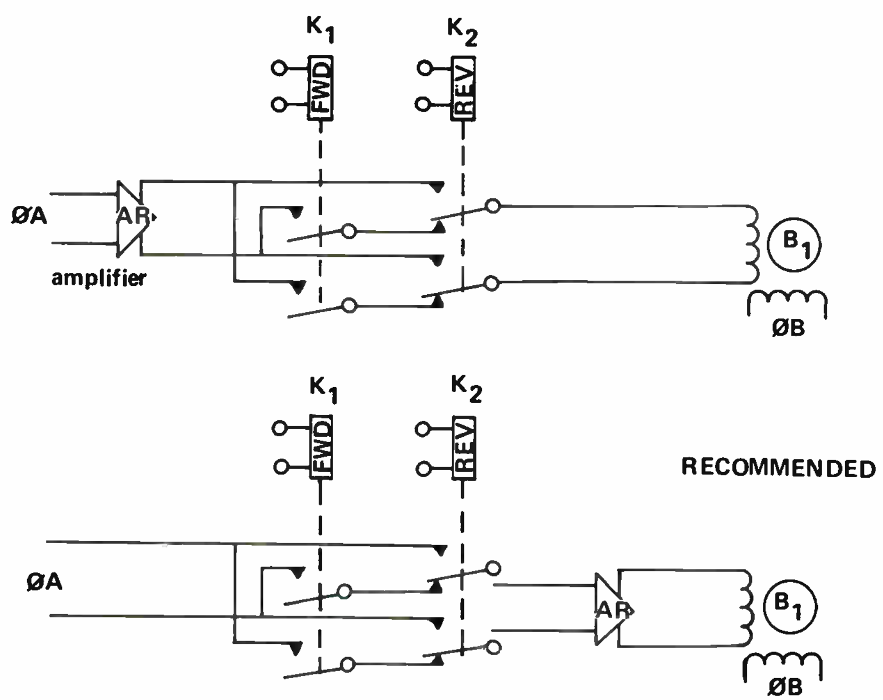


FIG. 21 MISAPPLICATION CIRCUIT CORRECTION

failures through misapplications which are to be avoided at all costs. Information for IDEP is compiled from private industry contractor members and government agencies such as Air Force, Navy [7], Army, NASA and CAMESA (Canadian). See Appendix for addresses and explanation.

Hazards of Surplus Relays

The use of relays from surplus houses may appear attractive from the standpoint of quick delivery and price, but prove disastrous in the end. First, many government contracts prohibit the use of surplus relays, and with good reason. To become surplus, relays are usually of older designs many of which are INACTIVE FOR NEW DESIGN. They were built before the minimum current requirement was mandated. Consequently, they have lain on the shelf and become self-contaminated from off gassing. In all probability, they are to an older version of the relay specification when requirements were less stringent. And last but not least, they may have been reworked and had "forged" nameplates added to represent them as updated devices.[17] FBI should be notified.

Graphical Symbols

Relays should be shown graphically in accordance with United States Standard Y32.2 (1967) which has superseded MIL-STD-15-1 as of 1968. **Contacts should be shown so as to be attracted towards the coil symbol when energized.** System Wiring Diagrams should show relays in de-energized positions unless noted contrarywise (i.e., 3 position relay contacts should be centered and two position contacts should not.)[19]

Polarized Relays

Polarized relays should also follow Y32.2 practice as was extensively treated at last year's relay conference[18] by the military.

RECOMMENDATIONS

To reduce the possibility of misapplication and thereby increase the reliability of any electric system, be it for military aircraft, missiles, or support systems the authors make the following recommendations:

1. Consider the whole system requirements as to (a) environment, (b) worst possible conditions, (c) power failures, (d) overloads, (e) types of loads, (f) switching functions, (g) etc. The last thing to think of is a particular specification and equally to be avoided is a preconceived idea as to size and shape of a relay.[12] A relay must be "technically" (i.e., functionally) suitable and should be selected from a qualified source. Anything less will compromise performance.

2. Use the attached list in your checking (Table IX).

3. Consult the selection charts in the Appendix as a starting guide and develop your own to maintain current data as new requirements evolve. (The military specifications (e.g., MIL-R-6106F) are scheduled to include selection guides as a part of the document.)

4. Consult such SAE documents as AIR 875 – "Comparison of Government Relay Specification".[8] (This document will be updated and reissued to reflect specification changes such as "F" revision to MIL-R-6106 and the "E" revision to MIL-R-5757.

5. When in doubt consult with reliable relay manufacturers who will provide relays supported by suitable test data to assure that items produced will satisfy the requirements for the specified applications.

6. Avoid wishful thinking. Verify that the relay fits the application. Do not assume that contact ratings are universal in nature. They vary with loads.

7. Do not accept the first solution that may work. INVESTIGATE further. There may be a simpler, better and more reliable way of accomplishing the switching function.

CONCLUSIONS

All too many relay failures result from misapplication. Misapplication often results from the design engineer's failure to appreciate the nature of the application switching requirements. Another fault is the engineer's attempt to save space and weight by using smaller relays without suitable safeguards such as proper circuit design or necessary internal isolation. The laws of physics do not change just because a relay acquires a military association. To select the proper relay circuit designers and component selectors must be familiar with the following: (a) the different relay specifications; (b) the significant features of the detail sheets; (c) minimum current; (d) parallel contacts; (e) relay case grounding; (f) predictable catastrophic failures; (g) arc-over; (h) effects of load types; (i) effect of frequency; and (j) the switching mode to assure that the item used will not be applied in a manner for which it was not intended. Appendix data should prove most useful towards these goals. To do otherwise is like discovering that sirlion steak was available from the kitchen after you've finished eating the hamburger you ordered from the menu. (The steak may cost more, but you know what you are getting without embarrassing after effects.) Some aircraft have power plants comparable in capacity to those of a destroyer. If the skipper of a destroyer loses power through some relay fault, he loses headway and hence steerage and thereby becomes what is known in the vernacular as "dead in the water". The pilot of the aircraft overhead who loses power from a misapplied relay might find himself and all his passengers and crew "dead in the water". Surely such relay misapplication penalizes the skippers disproportionately.[14]

SUMMARY

More than a decade ago Oklahoma State University Professors C. F. Cameron and D. D. Linglebach as consultants to the Air Force's "Electronics Components Handbook"[6] opened the section on relays as follows:

"Of all the component parts employed in electronic equipment, relays are probably the least understood, least

TABLE IX
Military Contract Requirement Check List

1. MILITARY STANDARD PARTS SHOULD BE USED WHERE TECHNICALLY SUITABLE – (MIL-STD-143). THEY MUST BE LISTED ON A QUALIFIED PRODUCTS LIST (QPL); BE SUPPORTED WITH CERTIFIED DATA AS EVIDENCE, (SEE APPENDIX EXAMPLE), THAT ITEMS PRODUCED WILL MEET THE REQUIREMENTS OF THE SPECIFICATION.[9]
2. THE USE OF MILITARY STANDARD PARTS DOES NOT GUARANTEE GOVERNMENT ACCEPTANCE – (MIL-STD-143). When misapplied or unsuitable for the application, the user is held responsible.[9]
3. STANDARDIZATION FOLLOWS SUCCESSFUL APPLICATION. Normally a Military standard or detail specification sheet should never be issued where a requirement has been justified and met. This establishes a source. Once established, the military document can be issued. Unfortunately, MS's and detail specification sheets do exist without a qualified source. Therefore, verify QPL source before committing design. Military specification documents when issued specify the **minimum** requirements that must be met by prospective producers. e.g. MS27420 has been cancelled July 1969.
4. CLAIMS MADE BY PRODUCERS THAT ITEMS "MEET" or "EXCEED" MILITARY SPECIFICATION REQUIREMENTS ARE NOT TO BE CONSIDERED AS GOVERNMENT APPROVAL. Only Government issued letters of certification to a producer, stating specific items qualified, are authenic approval. It is not permissible to use these letters for advertisement. However, as verification that a producer is currently approved, when soliciting quotations, the prospective bidders should be requested to forward with the quotation a copy of the Government letter of approval. Since the Government issues Qualified Products Lists users should consult these publications for possible sources of items to be procured. Current Qualified Products Lists can be obtained by request from the Government activity referenced in the procurement specification. The user must also be aware of what the specification revision letter and amendment number represents, and remember there are different degrees of compliance, e.g., some crystal can relays are suitable for low level, others are not, yet both may bear QPL's to different serial numbers. (Not all serial numbers are for new design.) – Revised August 1969, see note. *
5. QUALIFICATION APPROVAL COVERS **ONLY THE ITEMS SUBMITTED** BY THE PRODUCER FOR QUALIFICATION. Appearance of a producer's name on a Qualified Products List is not to be construed that other items, being produced by the same manufacturer, are Government approved. See catagory II of MIL-R-5757E.
6. IT IS THE USER'S RESPONSIBILITY TO ASSURE THAT THE SYSTEM DESIGN MEETS ALL THE REQUIREMENTS – (MIL-STD-143). The Governmental contracting agency can insist on replacement and correction of engineering deficiencies at the contractor's expense. (Caveat Emptor and Venditor).[9]
7. WHEN IT BECOMES NECESSARY TO USE NON-STANDARD PARTS TO MEET EQUIPMENT REQUIREMENTS, APPROVAL TO DO SO MUST BE OBTAINED FROM THE PROCURING AGENCY (WR-62). A justification requires supporting evidence to substantiate the selection in accordance with the the order of precedences specified in MIL-STD-143.[9]
8. USE OF MILITARY STANDARD PARTS IN NEW EQUIPMENT. The fact that a part has been used in initially procured equipment does not mean that it should be used for subsequent procurements. As long as form, fit and function are assured a review of military specifications and standards, due to new documents or revisions to existing documents, make available interchangeable items for use in new procurements and new design – (see Appendix).
9. PERIODICALLY MILITARY STANDARD PARTS BECOME OBSOLETE FOR NEW EQUIPMENT DESIGN. Some military standard parts qualified in an older revision of the specification become obsolete and are superseded by new military standard items. When superseded the obsolete documents should include the appropriate status note (MIL-STD-32). Only the current military approved standards containing the new requirements should be used for new design – (see Appendix). e.g. M5757/10-151.
10. APPROVAL OF NON-STANDARD PART DOES NOT CONSTITUTE APPROVAL OF A SIMILAR ITEM BY ANOTHER MANUFACTURER. Although multisources are preferred each source item authorized must be documented and approved separately.
11. SIMILAR RELAYS WITH DIFFERENT MS NUMBERS ARE NOT INTERCHANGEABLE FOR ALL APPLICATIONS. Example, MS27218 can be used instead of MS25267 but not vice versa, MS27255, MS27400, MS27709, and MS27725, have significant differences even though all three are basically 4 pdt, 10 ampere relays with interchangeable mounting configurations available. (See Appendix.)

A NOTE OF CAUTION. Users should not accept unsubstantiated assurances that a product is undergoing QPL testing. There are cases on record where such claims have been made and two years later there was still no test data and no qualified source. Information related to current QPL status should be obtained from activity responsible for qualification shown on the Military Specification. CLAIMS BY PRODUCERS THAT PRODUCTS THEY MANUFACTURE BUT ARE NOT ON A QUALIFIED PRODUCTS LIST ARE "COMPLETELY INTERCHANGEABLE," WITH OTHER ITEMS BEING USED BY THE MILITARY, IS NOT ALWAYS TRUE. –ipso facto. Users must verify such statements with supporting data.

***Note:** As of August 1969, M4120.3 Standardization Manual has been revised. Advertising that product (relay) is QPL'd is permissible provided there is no implication that it is sole item QPL'd or that it is endorsed by U.S. Government.

standardized, least controlled by specification and most abused. Although there is no doubt that they come under the general heading of troublesome components, it is remarkable that their reliability record in military equipment is as good as it is."*

These statements have been repeated several times since at OSU/NARM symposia and elsewhere. Unfortunately, they are still true. We hope, however, that this paper will help reduce some of the **abuse** and aid in the **understanding** of relays.

A failed relay contact is often only the symptom and not the cause of the malfunction.

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*The "Standards Engineering" Dec/Jan '69, disagrees, saying data is available. True, but unless data is read, and followed relays will continue to be "least understood. etc."

REFERENCES

1. NAVAIR 01-1A-514 Technical Manual - **"Design of Electric Systems for Naval Aircraft and Missiles"** (Available to those with "need-to-know" from Commanding Officer, U.S. Naval Supply Depot, 5801 Tabor Avenue, Philadelphia, Pa. 19120). **Section XI only - "Relays, Electromechanical"** is available from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402, as catalog Number D217.14: EL2/CH @ $2.75.

2. "A study of Discharge Transients in Relays with Grounded Cases." - C.P. Nunn, Sr., and R. Halbeck - 1961 NARM Proceedings.

3. "Hazards in the use of Double-Throw Contacts" P.N. Martin, 1963 NARM Proceedings.

4. MIL-E-5400 Electronic Equipment, Aircraft.

5. "AC Contact Ratings, Effect of Power Frequency and Type of Load" - P.N. Martin - 1961 NARM Proceedings.

6. "Electronic Components Handbook" Volume 1 Electronic Components Laboratory, Wright Air Development Center (McGraw-Hill) 1957.

7. IDEP - Interagency Data Exchange Program - Navy - Commanding Officer (Code E-6) Naval Fleet Missile Systems Analysis and Evaluation Group, Corona, California, 91720, Attention: IDEP. Office Phone - 714–736-5388.

8. SAE - Society of Automotive Engineers - Aerospace Equipment Division - J.G. Lippert - 2 Pennsylvania Plaza, New York, New York 10001 - Phone 212–594-5700. (**NOTE:** SAE A-2 Aerospace Electrical Electronic Equipment Committee (Chairman B.F. Varney, North American Rockwell) is American ISO (International Standardization Organization) representative for aircraft electrical equipment including relays.)

9. MIL-STD-143. Specifications and Standards, Order of Precedence for the Selection of:

   "1.1 PURPOSE: . . . Requirements for . . . the use of documents stating applicability of specifications and standards for special applications are subject to contract provisions.

   "4.1.1 TECHNICAL SUITABILITY: Items shall be selected from standards where such exist, but in every case must be technically suitable in every respect for their application . . . The use of a specification does not, in itself, assure the suitability of an item for any specific application.

   "5.2 USE OF SPECIFICATIONS, STANDARDS, OR DRAWINGS: Satisfactory operation of equipment procured under any specification, standard, or drawing is the responsibility of the contractor, and the use of such specifications, standards, or drawings listed for use by the Government requiring activity is in no way to be considered as guaranty of Government acceptance of the finished product" - **Electromechanical Design,** June 1963 (Relay Facts).

10. MIL-STD-454. Standard General Requirements for Electronic Equipment.

11. IDEP Alert Number S6-68-01 (Paralleling Contacts) Applied Physics Lab, John Hopkins University Silver Springs, Maryland.

12. "A Systems Approach to Relay Specification" E.U. Thomas and J.V. Iverson, 1961 NARM Proceedings.

13. "Anatomy of a Relay Specification for Military Application" C.B. Knox, Jr., 1967 NARM Proceedings.

14. "Relay Facts" **Electromechanical Design,** June 1963.

15. Holm, Ragnar. "Electric Contacts Theory and Application".

16. Amendment 1 to MIL-R-1606B, April 1956.

17. IDEP Alert Number SMD-036 covers forged relays from a number of surplus houses. You are requested to notify the FBI if you encounter any. (See Appendix.)

18. "Relay Industry Savings Resulting From Polarized Bistable Crystal Can Relay Header Standardization" - George E. Fogleman (preparing activity for MIL-R-5757 and MIL-R-39016) and E.U. Thomas - 16th Relay Conference 1968.

19. Viz. Cover sheet "Basic Principles and Application of Relays" - Pollack (Rider Publications). 1962

APPENDIX

Popular Myths Dispelled

1. **The water bubble test is not the criterion for hermetic seal.** It is too insensitive to be suitable.[13]
2. **A dielectric test does not "specify the contact capability under transient switching conditions".** — It is a static test in the absence of both switching and arcing.[13]
3. **Switching AC in the ground lead may save a relay,** but it also constitutes a personnel hazard violating the National Electrical Code, MIL-B-5087 and requirement 1 of MIL-STD-454.

APPENDIX

Index to Tabular Relay Data

TABLE	SUBJECT MATTER
I	MIL-R-5757 Development (History)
II	MIL-R-6106 Development (History)
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IV	MIL-STD-454, Requirement 57 Relays
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TABLE I — MIL-R-5757 DEVELOPMENT

MIL-R-5757→MIL-R-5757A(USAF)→MIL-R-5757B→MIL-R-5757C
1951 1952 1955
Amend. 1→ MIL-R-5757D
1956 1960
MIL-R-25018(USAF) Amend. 1
1954 1963
Notice 1 Amend. 2
1958 1963
Amend. 1 Amend. 3
1958 1964
Amend. 2 → Amend. 4→MIL-R-5757E
1958 1965 1968
Amend. 1
MIL-R-21093(SHIPS) MIL-R-21093A(SHIPS) → 1968
1958 1960
MIL-R-83722(USAF)→SEE TABLE
1968

SPECIFICATION	DATE	TITLE
MIL-R-5757		
MIL-R-575A(USAF)	26 Oct. 1951	
MIL-R-5757B	8 May 1952	Relays, Armature (For Electronic and Communication Equipment)
MIL-R-5757C	26 July 1955	Relays, Armature (For Electronic and Communication Equipment)
Amend. 1	6 Sept. 1956	
MIL-R-5757D	20 Sept. 1960	Relays (Electrical [Excluding Thermal], for Electronic and Communication - Type Equipment.) General Specification
Amend. 1	14 Jan. 1963	
Amend. 2	26 April 1963	
Amend. 3	1 April 1964	
Amend. 4	18 March 1965	
MIL-R-25018(USAF)	9 Dec. 1954	Relays, Miniaturized, Hermetically Sealed, Airborne Equipment
Notice 1	21 Feb. 1958	
Amend. 1	12 Feb. 1958	
Amend. 2	14 Nov. 1958	
MIL-R-21093(SHIPS)	10 March 1958	Relays, Armature, General Purpose
MIL-R-21093A(SHIPS)	11 March 1960	Relays, Armature, General Purpose
MIL-R-83722 (USAF)	12 April 1968	Relay, Telegraph, Electro-Mechanical
MIL-R-5757E	15 Nov. 1968	Relays, Electrical (for Electronic and Communication-type equipment), General Specification
Amend. 1	30 Dec. 1968	

TABLE II — MIL-R-6106 DEVELOPMENT

AN-R-20a→AN-R-20b
1945 1946
Amend. 1→MIL-R-6106
1946 1950
Amend. 4→
1953
→MIL-R-6106A(ASG)→MIL-R-6106B(ASG)
1954 1955
AN-R-27 MIL-R-6742 Amend. 1
1948 1950 → 1956
Amend. 2→MIL-R-6106C(ASG)
1956 1957
Amend. 1→MIL-R-6106D(ASG)→MIL-R-6106E(ASG)
1959 1963 1964
Amend. 1→MIL-R-6106F(ASG)
1964 1967

SPECIFICATION	DATE	TITLE
AN-R-20a	4 April 1945	Relays, Direct Current
AN-R-20b	4 March 1946	Relays, Direct Current
Amend. 1	19 Sept. 1946	Relays, Direct Current
AN-R-27	28 July 1948	Relay, Aircraft 115/200 AC or 120 volts DC
MIL-R-6742	14 Jan. 1950	Relay, Aircraft 115/200 volts AC
MIL-R-6106	14 April 1950	Relays, Direct Current
Amend. 1		
Amend. 2		
Amend. 3	7 Aug. 1952	
Amend. 4	13 Jan. 1953	
MIL-R-6106A(ASG)	16 Feb. 1954	Relays, Electric, Aircraft
MIL-R-6106B(ASG)	20 Sept. 1955	Relays, Electric, Aircraft
Amend. 1	10 April 1956	
Amend. 2	27 June 1956	
MIL-R-6106C(ASG)	15 May 1957	Relays, Electric, Aircraft
Amend. 1	14 Dec. 1959	
MIL-R-6106D(ASG)	23 Aug. 1963	Relays, Electric, AEROSPACE
MIL-R-6106E(ASG)	30 March 1964	Relays, Electric, Aerospace
Amend. 1	15 Oct. 1964	Relays, Electric, Aerospace
MIL-R-6106F(ASG)	25 Aug. 1967	Relays, Electric

TABLE III

MIL-R-5757E	15 November 1968	Salient Features
Superseding MIL-R-5757D and MIL-R-83722 (USAF) 1968		

Title	–	Relays, Electrical (for Electronic and Communication-type equipment), General specification for.
Scope	–	Up to and including 10 amperes for use in electronic communication.
Shock	–	Addition of and revisions to shock methods 50G, 75G, 100G, method 213 replacing 15g, 30g, and 50g to former test methods.
Relay categories	–	I. Those completely defined by slash sheet (from QPL source). II. Those with minor differences (must be from category I source). III. Non-standard relays.
Telegraph relays	–	(MIL-R-83722)
Contact Arrangments	–	Addition of contact forms and terminal designations the same as in MIL-R-6106. Plug-in contacts to be gold-plated — solder terminals shall not. **Cases** shall be **welded** for hermetic seal.
Seal Tests	–	Changed I = Bubble test - enclosed relay (non-hermetic). II = Mass spectrometer or equivalent - (not bubble test for hermetic).
Minimum current	–	Level I and Level II Multiple loads simultaneously on multi-pole relay.
Magnetic Inter-reaction	–	Adjacent similar relays.
Load Transfer	–	(3Ø) unsynchronized power sources Grounded relays during life testing Coil grounded directly - (negative or neutral).
Contact Bounce	–	Rated voltage and rated current.
Cross Talk	–	Reed Relays.
Loads	–	Different types. {Resistive, Inductive, Lamp, Motor, Low-level} {Includes ratings for} {dc; ac → {single phase, poly phase, load transfer}}
Notes	–	Intended use. Definitions.

TABLE IV

MIL-STD-454B Standard General Requirements For Electronic Equipment 1968 - June

. . . EXCERPTS

5. **DETAIL REQUIREMENTS**

Requirement	1	Safety (Personnel Hazard)
Requirement	10	Electric Connectors
	25	Electrical Power Source
	57	Relays
	58	Switches
	60	Sockets, Tube Shields, Parts, and Tube Clamps

MIL-STD-454B

REQUIREMENT 57
RELAYS

1. Purpose. The purpose of this requirement is to establish criteria for the choice application of relays.

2. Documents applicable to Requirement 57:

*MIL-R-5757	Relays (Electrical - Excluding Thermal - for Electronic and Communication - type Equipment), General Specification for
MIL-R-6106	Relays, Electric, General Specification for
MIL-S-12883	Socket, for Plug-In Electric Components, and Accessories, General Specification for
MIL-R-19648	Relays, Thermal, Time Delay, Hermetically Sealed, General Specification for
MIL-R-39016	Relays, Electromagnetic, Established Reliability, General Specification for

3. Low current relays (up to 10 amperes). Low current relays up to 10 amperes shall conform to MIL-R-5757. However, relay applications requiring high in-rush current capabilities (e.g., motor and controller functions) may be in accord with MIL-R-6106, as applicable.

4. High current relays. Relays used in high current applications shall conform to MIL-R-6106.

5. Time delay relays. Thermal time delay relays shall conform to MIL-R-19648.

6. Solid state electromagnetic relay assemblies. Solid state electromagnetic relay assemblies with an electromagnetic relay output shall conform to MIL-R-5757.

7. Established reliability relays. Established reliability relays shall conform to MIL-R-39016.

8. Reed relays. Reed relays shall conform to MIL-R-5757.

9. Relay sockets. When relay sockets are required, they shall conform to MIL-S-12883.

NOTE: Requirement 57 was prepared under Uniformity Project Group Task 71 of Aerospace Industries Association of America - Mr. L. T. Miller (BTL) EIA Coordinations inconjunction with ASG (Aeronautical Standards Group).

*E Revision title now reads, "Relays, Electrical (For Electronic and Communication Type Equipment), General Specification For." - November 1968.

TABLE V

Miscellaneous Information

1. **Existence of a military detail sheet or military standard does not imply existence of a qualified source. Before specifying a unit obtain current certification that a qualified source exists.** NOTE: MS27420 drawing was released in 1965 but as of February 1969 no QPL source existed. (The MS was cancelled July 1969.)

2. Unless a Government certification of qualification can be produced MS Part Numbers should not be specified. Invariably quotations specify "MS" Part Numbers when they should have specified a non-standard part.

3. The use of non-standard parts requires approval from the procuring agency. User approval must be supported with sufficient data to insure that the requirements have been met to satisfy the specified application.

4. The practice of relay manufacturers quoting AC relay ratings, based on ungrounded relay case, without so stating, is common practice, but it is not in accordance with **any** of the general purpose relay specification requirements. **Relay cases must be grounded to protect personnel from the fatal electric shock.** (MIL-B-5708, MIL-STD-454, et al.)

5. **Polyphase** loads **should not be used** with multi-contact relays that are rated only "115" volts. A "115/200" volt rated relay must be used, e.g., MS27218 should be used for polyphase applications and not MS25267 (4 pdt, 5 amperes). (Nor MS25325 - the plug-in version.)

6. Transferring AC loads between different phases or between different power sources can lead to catastrophic failures. Only relays which specify power transfer ratings should be used.

7. Paragraph 3.1.1.3 (MIL-E-5400J) **"Unauthorized use of Government designations.** Parts which require qualification approval but have not received such approval, shall not be identified by MIL-type numbers or AN-part numbers."

8. "It has been reported that surplus relays have been offered and sold to the Military Aerospace Industry by relay wholesale houses with original labels removed and replaced by new labels indicating incorrectly that the relays were new and to the latest revision of the Military drawing and governing Military spec. In addition, instances have been uncovered where reworked used relays have been sold as new without the original manufacturer's knowledge or consent. Several manufacturer's relays are involved. A court order has been obtained restraining at least one wholesale relay house from relabeling as new surplus relays built to earlier versions of applicable specifications." – A-2R minutes of meeting January 1969.

9. A QPL'd item does not guarantee the purchaser a good product nor a "quality" product. It indicates that manufacturer at a given facility has made a product meeting specification requirements.

10. MIL-R-5757D, Part II, no longer valid. - of Catagory II of MIL-R-5757E.

TABLE VI

	STD SPECIFICATION	ESTABLISHED RELIABILITY
10 amperes and less	MIL-R-5757	MIL-R-39016
5 amperes and up	MIL-R-6106	"ER versions

Contrary to some catalog data implication **MIL-R-5757 does not deal with reliability.**

TABLE VII
Dash Numbers for MIL-R-6106 "MS" Detail Drawings

Over the years there have been a number of recommended systems for assigning dash numbers to individual detail sheets. In some cases the overall policy regarding detail dash numbers especially where items become computerized have over ridden the individual specification procedures which had evolved so that the system had to be abandoned for those. A few examples of the variations that may be expected are listed in the table below. The only safe procedure is to consult the applicable detail in every case.

PART NUMBER	REV & DATE	6106 1950	6106A 1954	6106B 1955	6106C 1957	6106D 1963	6106E 1964	6106F 1967		FEATURES: AC Coil	DC Coil	Hook Lugs	Screws	Plug-In	Auxiliaries	Date of Issue	REMARKS
AN's (1)		←	→	→							X				prior to 1957		All superseded or canceled as of 1957
MS24143-1 (2)				X							X					54	
MS24143-2 (2)				X							X				X	54	
MS24143-D1 (2)					X						X					57	
MS24143-D2 (2)					X						X				X	57	
MS24143-A1										X						57	
MS24143-A2										X					X	57	
MS25467-D1 (3)					X						X	X				63	Two coils both DC
MS25467-A1					X					X		X				63	Two coils both AC
MS25467-AD1					X					X	X	X				63	Two coils one AC, one DC
MS27255-1 (4)						X					X	X				64	
MS27255-2						X				X		X				64	
MS27400-1 (4)						X				X		X				64	Polarized, Monostable.
MS27400-2						X				X				X		64	
MS27418-1A (4)							X			X		X				65	
MS27418-1B							X				X	X				65	
MS27418-2A							X			X			X			65	
MS27418-2B							X				X		X			65	

NOTES:
1. See individual AN sheets for superseding part (if there is one).
2. MS24143-D1 superseded MS24143-1, and MS24143-D2 supersedes MS24143-2. The new may be used in place of older design, but not vice versa.
3. Two Coils.
4. Detail sheets must be consulted to determine features.
5. Class "O" relays to 6106B or earlier.
6. Where Military contracts are let, contractors need only use items meeting the specification in effect at date of contract, because a contractor can not be obligated to meet requirements that do not exist at time of negotiation. It is, however, perfectly permissible for the contractor, at a subsequent date, to use superseding parts on his own volition, e.g., If the basic design called for MS24143-1, the contractor might well consider using MS24143-D1 as a superior interchangeable superseding relay, and may be available at no increase in cost.

TABLE VIII
Ground Support Power Supply Connections

MS17793A (1968) Schematic Wiring Diagram (External AC Power Connector, Aircraft) (FSC5935) supersedes AND10462 and MS24441 (cancelled). This drawing shows external wiring of plug and indicates aircraft components with greatly simplified wiring. Preparing Activity - Naval Air Systems Command. Custodians: Army and Air Force. Drawing is marked "International Interest".

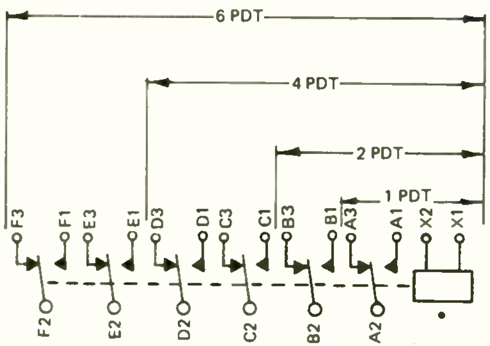
TABLE IX

LEGEND
- ● AVAILABLE
- X DO NOT USE
- \- VALUES NOT ASSIGNED
- ○ SEE NOTES BELOW

RELAY SELECTION CHART 1
10 AMPERES AND LESS-HERMETICALLY SEALED TYPES
FOR USE AS A GUIDE IN DESIGN OF NEW EQUIPMENT
NOTE: CONSULT LATEST ISSUE OF MS DETAIL PRIOR TO FINAL SELECTION

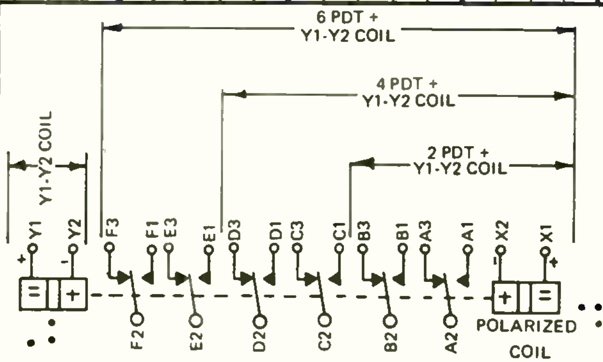
(5) Paragraph 66 of MIL-STD-15-1: The proper poling of a polarized relay (+/−) is shown by the use of (+) and (-) designations applied to the winding leads. The current in the direction indicated is to be interpreted to move or tend to move, the armature toward the contact shown nearest the coil on the diagram. If the relay is equipped with numbered terminals, proper numbers should be shown. (6) Contact operation cycles vary

Contacts Form C: Amperes (Resistive)	Contacts Form C: Number Poles Double Throw	Military Standards (2)	Circuit Diagram	Coil Voltage: 28 VDC	Coil Voltage: 115 v/60 Hz	Coil Voltage: 115 v/400 Hz	Coil Voltage: 1 Each AC & DC (4)	28 VDC: Resistive	28 VDC: Inductive	28 VDC: Motor	28 VDC: Lamp	28 VDC: Min Current	400 Hz 115 v/1 ϕ: Resistive	400 Hz 115 v/1 ϕ: Inductive	400 Hz 115 v/1 ϕ: Motor	400 Hz 115 v/1 ϕ: Lamp	400 Hz 115 v/200 v 3 ϕ: Resistive	400 Hz 115 v/200 v 3 ϕ: Inductive	400 Hz 115 v/200 v 3 ϕ: Motor	400 Hz 115 v/200 v 3 ϕ: Lamp	60 Hz 115 v 1 ϕ: Resistive	60 Hz 115 v 1 ϕ: Inductive	60 Hz 115 v 1 ϕ: Motor	60 Hz 115 v 1 ϕ: Lamp	60 Hz 115 v/200 v 3 ϕ (3): Resistive	60 Hz 115 v/200 v 3 ϕ (3): Inductive	60 Hz 115 v/200 v 3 ϕ (3): Motor	60 Hz 115 v/200 v 3 ϕ (3): Lamp	Times Rated Load: Overload	Times Rated Load: Rupture	Terminal Style: Potted Leads	Terminal Style: Solder Hook	Terminal Style: Plug-In	Type Mtg.	Remarks
1U	4	MS24568	1	●		●		10	10	6	3	YES	15	10	6	3	15	10	6	3	-	-	-	-	-	-	-	-	6	8				"L" Shaped Bracket	Screw Terminal
		MS25271	1	●		●		10	6	4	2	YES	10	6	4	2	10	6	4	2	-	-	-	-	-	-	-	-	4	5		●		Stud	
		MS25272	1	●		●		10	6	4	2	YES	10	6	4	2	10	6	4	2	-	-	-	-	-	-	-	-	4	5	●			Stud	
		MS25200	2	●				10	6	4	2	YES	10	6	4	2	10	6	4	2	-	-	-	-	-	-	-	-	4	5		●		Top Bracket	Magnetic Latch DB Bistable
		MS25327	1	●		●		10	6	4	2	YES	10	6	4	2	10	6	4	2	10	6	4	2	10	6	4	2	6	8			●	Socket	
		MS25461	2	●		●	●	10	6	4	2	YES	10	10	4	2	10	10	4	2	10	10	4	2	10	10	4	2	6	8			●	Socket	Magnetic Latch DB Bistable
		MS25468	2	●		●	●	10	6	4	2	YES	10	10	4	2	10	10	4	2	10	10	4	2	10	10	4	2	6	8		●		Stud	Magnetic Latch DB Bistable
		~~MS25919~~	1	●				~~10~~	~~7~~	~~6~~		~~YES~~	~~10~~						4												●	●		~~Stud~~	~~Not~~ for New Design
		MS27254	1	●		●		10	10	5	3	YES	10	10	5	3	10	10	5	3	10	10	5	3	10	10	5	3	4	5			●	Socket	(6)
		MS27255	1	●		●		10	10	5	3	YES	10	10	5	3	10	10	5	3	10	10	5	3	10	10	5	3	4	5		●		Bracket	(6)
		MS27400	3	●		●		10	8	4	2	YES	10	8	4	2	10	8	4	2	10	8	4	2	10	8	4	2	6	8		●	●	Socket Bracket	Polarized Monostable (5)
		MS27709	1	●				10	8	4	2	YES	10	8	4	2	10	8	4	2									4	5		●	●	Socket Bracket	(6)
		~~MS27402~~	~~1~~	●				~~10~~	~~6~~	4		~~YES~~																	~~4~~	~~6~~		●		~~Stud~~	Not for ~~New Design~~



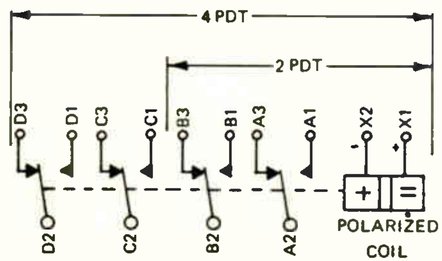
CONTACT FORM "C" - i.e., Transfer Single break before make.

CIRCUIT DIAGRAM 1



CONTACT FORM "C" - i.e., Transfer Single break before make

CIRCUIT DIAGRAM 2 - (Double Biased) BISTABLE (DB)



CONTACT FORM "C" - i.e., Transfer single break before make

CIRCUIT DIAGRAM 3 - MONOSTABLE (P)

TABLE X

Similar 4 PDT, 10 Ampere Relays

CAUTION: Detail differences can be significant for particular applications even though interchangeable mountings may be available.

Examples of Some of the Differences in Operating Parameters **Attribute**	MS27254 MS27255 (USAF) **Neutral**	MS27400 **Polarized Monostable**	MS27709 (USAF) **Neutral**	MS27725 (USAF) **Neutral**	MIL-R-5757/72 **Neutral**
Max operate times	.010	.015	.015	.015	.020
Max release time	.010	.015	.101	.015	.020
AC coil available	yes	yes	no	yes	no
60 Hz load ratings listed	no	no	no	yes	yes
400 Hz Rupture	5x	8x	5x	8x	– –
Overload	4x	6x	4x	6x	2x
Shock	25g	100g	50g	100g	50g
Vibration (1)	20g to 2000 Hz	30g to 3000 Hz	20g to 2000 Hz	30g to 3000 Hz	30g to 3000 Hz
NOTES:					
1. Plug-in units are rated for lower g values than the bracket mounted units.					
2. Inductive ratings 1/5 the resistive operations.		(2)			
3. NC contacts 50,000 operations instead of 100,000.	(3)		(3)		

TABLE XI

Conditions Under Which Qualification Is Granted

"Qualified Products Lists (QPL) listing does not guarantee acceptance of the product(s) in any future purchase.

"QPL listing does not constitute a wavier of any requirements of the specification or of the provisions of any contract.

"Qualification of the product applies **only to the product manufactured at the plant which produced the sample tested.** If extension of qualification is desired to the product as manufactured at any other of your plants, request for such extension should be made to this Headquarters with reference to this notification.

"New qualification tests will be required if changes are made in the materials or construction of the approved product unless previous notification has been received indicating that such changes have been approved by the activity responsible for qualification.

"The QPL, the notification of qualification, the results of tests, or other information relating to qualification, the results of tests, or other information relating to qualification shall not be circulated or referred to for publicity, for advertising, or for sales other than those leading to ultimate use of the product by an agency of the Federal Government. Violation is cause for removal of the product from the list by the Government activity concerned. (It must be understood that the Department of Defense takes no issue with advertisements indicating that the manufacturer's product conforms to the requirements of a specification, on the assumption that the determination of such **conformance is a responsibility of the purchaser.** However, there is objection to reference in an advertisement to a statement of Government approval, or to the listing of a product on a Qualified Products List issued by a Government activity. To the public, such statements connote endorsement by the Department of Defense, which is contrary to departmental policy.)"

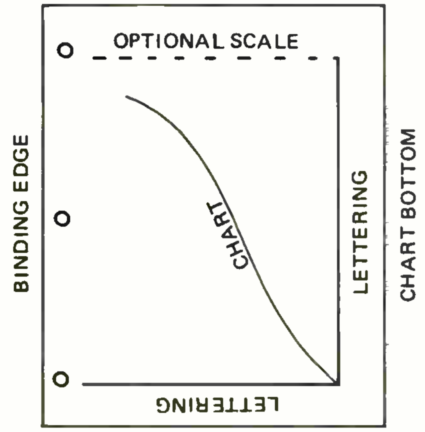
APPENDIX

TABLE XII

MIL-STD-831
28 August 1963

Military Standard Test Report, Preparation of

". . . Full page tables, illustrations, etcetara, shall be arranged so that the **bottom of the table or illustration will be either at the bottom or at the right hand edge of the bound document."**



SHEET

TABLE XIII

MIL-R-6106 MS Sheet New Format Data - Partial

		RATED CONTACT LOAD (AMPERES PER POLE) CASE GROUNDED													
TYPE OF LOAD	LIFE OPERATING CYCLES x 10^3	28 VDC				115 VAC, 1 PHASE				115/200 VAC, 3 PHASE (2)					See Appropriate Notes
		MAIN		AUX		MAIN		AUX		MAIN		AUX		
		NO	NC	NO	NC	400Hz	60Hz	400Hz	60Hz	400Hz	60Hz	400Hz	60Hz	
RESISTIVE	100	10	10			10	5			10	5			
INDUCTIVE	20	8	8			8	2.5			8	2.5			
INDUCTIVE	100	4	4			4	1			4	1			
MOTOR	100	4	4			4	2			4	2			
LAMP	100	2	2			2	1			2	1			
TRANSFER, LOAD														(3)
MECHANICAL LIFE REDUCED CURRENT	400	2.5	2.5			2.5				2.5				
MIN CURRENT		APPLICABLE PER SPECIFICATION												

NOTES, APPLICATION (Note provision for two inductive values.)

(1) Over temperature range.
(2) 115/200 VAC for 60 Hz ratings, absence of value indicates relay is not rated for 3 phase applications.
(3) Transfer load indicates relay suitable for transfer between unsynchronized AC power supplies at rating indicated.
(4) Dielectric rating may be improved by suitable insulation of terminals and wiring after installation.

TABLE XIV

Example of Official Specification QPL*

QPL-5757-00
SUPERSEDING (DATE)
QPL-5757-00
(DATE)

QUALIFIED PRODUCTS LIST

OF

PRODUCTS QUALIFIED UNDER MILITARY SPECIFICATION

MIL-R-5757

FSC 5945
(FEDERAL STOCK CLASSIFICATION)

RELAYS
ELECTRICAL (FOR ELECTRONIC
AND COMMUNICATION-TYPE EQUIPMENT)
GENERAL SPECIFICATION FOR**

This list has been prepared for use by or for the Government in the Procurement of Products covered by the subject specification and such listing of a product is not intended to and does not connote endorsement of the product by the Department of Defense. All products listed herein have been qualified under the requirements for the product as specified in the latest effective issue of the application specification. This list is subject to change without notice; revision or amendment of this list will be issued as necessary. The listing of a product does not release the supplier from compliance with the specification requirements. Use of the information shown herein for advertising or publicity purposes is expressly forbidden.

THE ACTIVITY RESPONSIBLE FOR THIS QUALIFIED PRODUCTS LIST IS THE NAVAL ELECTRONIC SYSTEMS COMMAND.

Government Designation	Manufacturer's Designation Or Type Number	Test or Qualification Reference	Detail Specification	Manufacturer's (Address On Last Page)
M5757/1-000	X1Y2Z3	5757-000-00	/1	XYZ Corporation

***NOTE**: Copies of specifications and QPL's may be obtained from Commanding Officer, Naval Supply Depot, 5801 Tabor Avenue, Philadelphia, Pa. 19120. Military Specification numbers are unique - i.e.. There is only one 5757 or 6106, therefore, QPL heading does not need to include the letter "R" (relay). The dash numbers are assigned consecutively as required. QPL's can be amended to avoid reprinting the whole lists. It is the contractor's responsibility to verify that item is currently QPL'd. (Items that have been QPL'd can be removed.) Between QPL issues, interim letters affirming QPL status are issued to the qualifying supplier and users should request same before acceptance of product as QPL'd.

**MIL-R-5757E title.

APPENDIX

TABLE XV
SAE Relay Committee

The SAE Cooperative Engineering Program assists in preparation and acts as advisors to the military for their specifications.

The A-2 parent committee is the American Representative to the ISO (International Standardization organization) for Aircraft Electronic and Electric Equipment and as such includes relays.

At the request of the military, the SAE brought into being the A-2R relay subcommittee in 1956. Because the membership is comprised of men acting as individuals and not representatives of their employers, but who come from both user and manufacturing areas, the military have been able to implement considerable meaningful revisions to MIL-R-6106 and MIL-R-5757.

E.U. Thomas, Chairman	Grumman Aircraft Engineering Corp.	Bethpage, N.Y.
R.L. Harrison, Vice Chairman	Hartman Electrical Mfg. Co.	Mansfield, Ohio
N.L. Hug, Recording Secretary	McDonnell-Douglas	Huntington Beach, California
M.G. Nelsen, Corresponding Sec.	Leach Relays	Los Angeles, California
J.B. Bergenthal	AC Spark Plug	Milwaukee, Wisc.
D.M. Bowdish	McDonnell-Douglas	St. Louis, Mo.
A.P. Boylan	Allied Control	New York, N.Y.
W. Crawford	Autonetics (NAR)	Anaheim, California
J.E. Davies	Cutler-Hammer	Milwaukee, Wisc.
L.D. Dickey	LTV	Dallas, Texas
H.L. Gossler	Boeing Company	Seattle, Wash.
O. Hrynewycz	Guardian Electric	Chicago, Ill.
J.S. Jordan	Struthers-Dunn	Pitman, N.J.
W.F. Lewis	Northrup	Hawthorn, California
H.P. Lynch	General Electric	Philadelphia, Pa.
G.A. Marshall	North American Rockwell Corp.	Downey, California
P.N. Martin	SCM	Stamford, Conn.
J.J. McGorray	Westinghouse	Baltimore, Md.
G.W. Niotta	Lockheed, California	Burbank, California
J.L. Ridings	Westinghouse	Lima, Ohio
M.J. Sakatos	General Reed	Clark, N.J.
C. Wegenka	Babcock	Columbus, Ohio
	LIAISON REPRESENTATIVES	
I. Carol	Army Electronics Command	Fort Monmouth, N.J.
G. Fogleman	Naval Electronics Systems Command	Washington, D.C.
W.J. Fontana (deceased)	Army R & D	Fort Monmouth, N.J.
R.J. Gangenie	Picateny Arsenal	Dover, N.J.
F.J. Kelly	Frankford Arsenal	Philadelphia, Pa.
R.V. Leyden	Naval Air Engineering Center	Philadelphia, Pa.
G. Neyhouse	DESC-EMD	Dayton, Ohio
W.J. Shockley, Jr.	NASA Marshall	Huntsville, Ala.
I.J. Soper	AFLC	Dayton, Ohio
J.L. Swyler	NASA Goddart	Greenbelt, Md.
J.D. Triola	Naval Development Center	Johnsville, Pa.
L.W. Wendling	Naval Air Systems Command	Washington, D.C.
R.E. Young	Naval Avionics Facility	Indianapolis, Ind.
C.N. Zillotti	ASG	Silver Springs, Md.
	CONSULTANTS	
C.F. Camerson	OSU	Stillwater, Oklahoma
L. Flenner	—	Dayton, Ohio
N. Kronstadt	—	Washington, D.C.
J.V. Roughan	NARM	Scottsdale, Ariz.
C. Schneider	EIA	Holmdel, N.J.
H. Steinback	NARM	Chicago, Ill.

TABLE XVI
A Summary of the Interagency Data Exchange Program (IDEP)

– EXCERPTS –

"The Interagency Data Exchange Program (IDEP) is a cooperative Government activity whose task is to provide automatic interchange of parts/components test data among Government contractors and agencies, thereby reducing duplicate expenditures for parts testing and improving system reliability.

"IDEP has created a constantly expanding and up-to-date file of documents dealing with all phases of parts testing. These documents are primarily test reports on "off-the-shelf" hardware likely to be available among participants (see page iii). In addition to normal laboratory-controlled tests, there are included general technical data when of particular significance to parts using activities; high reliability contractor specifications on parts; accounts of planned or in-process parts testing activity, and other specifically related documents of mutual value.

"The participants listed on page iii are either Government Agencies, or prime or major subcontractors engaged in parts testing activities under the Air Force, Navy, Army, and NASA. They are parts **users** rather than parts manufacturers or vendors.

"Distribution of data is automatic among all participants, "A" participants receiving the entire file and "B" participants receiving summaries only with complete reports available on request. The IDEP Offices microfilm, reproduce and distribute documents to participants without charge. Documents are reproduced in their entirety, not edited or abstracted by the IDEP Office.

"The IDEP data is transmitted to participants on 16 mm roll-film reels or cartridges. The microfilmed text can be reviewed or reproduced in easily readable size in a matter of seconds.

"Summary cards of test data accompany the roll-film for distribution to cognizant design engineers, and a visual coincidence card (VC) system for searching specific test environments is also available to the IDEP user.

"The documents listed herein are for the contractors' use as supporting evidence in parts-use justifications as well as in the following specific ways:

1. Selection of most reliable parts in designs avoids possible system failures.
2. Earlier parts information promotes improved performance; shortened delivery schedules.
3. Improved test reporting quality promotes higher output per test dollar.
4. Use of IDEP information reduces test duplication; more efficient information retrieval.
5. Broader access to current parts information permits more realistic bid proposals.
6. IDEP guidelines accelerate parts specification writing and test planning, expediting eventual introduction of standardized improved parts.
7. Provides channels for direct intercontractor inquiries in urgent cases.
8. Alternate vendor sources are suggested.
9. IDEP files are a source of general advice, confirmation, and general education at early program development stages.

Despite variations from exact data desired, reports which partly cover requirements yield savings proportionate to the degree of confidence or similarity. If a test cannot be eliminated entirely, it often can be shortened, or guided in sequence, method, or sample size from failure modes demonstrated by others. Many retests and tests on obviously inadequate parts, are avoided."

Government IDEP Offices

ARMY/NASA
Hq Army Missile Command
Redstone Scientific Information Center
Redstone Arsenal, Alabama 35809
Attn: B.W. Barnett, AMSMI-RBP

Phone: 205–876-0851
Autovon: 266-0851, 6088

AIR FORCE
Hq SAMSO (SMSDI)
Los Angeles Air Force Station
Air Force Unit Post Office
Los Angeles, California 90045
Attn: IDEP Office

Phone: 213–643-1021
Autovon: 833-1021

NAVY
Commanding Officer (Code E-6)
Naval Fleet Missile Systems
Analysis & Evaluation Group
Corona, California 91720
Attn: IDEP Office

Phone: 714–736-5388
Autovon: 933-5388

CAMESA (ASSOCIATE IDEPO)
Canadian Military Electronics
Standard Agency
Department of National Defense
Ottawa, Ontario, Canada
Attn: Mr. G. Seabrook

Phone: 613–996-2356, 26604

TABLE XVII

Defense Standardization Manual 4120.3M † Standardization Policies Procedures and Instructions

GLOSSARY – EXCERPTS

1-106 **Activity, preparing.** The military activity, or the activity in a Federal civil agency (for Federal documents only), responsible for document and study projects and for maintenance of the resultant Standardization Documents.

1-122 **Custodian.** The activity responsible for effecting coordination and other related functions for its own department in the DoD.

1-123 **Department.** The Department of the Army, the Department of the Navy, or the Department of the Air Force.

1-444 **Qualified Products List.** A list of products qualified under the requirements stated in the applicable specification, including appropriate product identification and test reference with the name and plant address of the manufacturer and distributor, as applicable. (Source: Department of Defense Directive 4120.3)

6-212 **Activity symbols.** The following symbols are used to identify the preparing activity, custodians, and review/user interest on Federal and military standardization documents, and to identify the issuing activity on limited, coordination documents (see Figures VI-1, 5 and 6).

ARMY*

Electronics Command	EL
Missile Command	MI
Munitions Command	MU
Weapons Command	WC

NAVY*

Naval Air Systems Command	AS
U.S. Coast Guard	CG
U.S. Marine Corps	MC
Office of Management Information	OM
Naval Ordnance Systems Command	OS
Naval Ship Engineering Center	SH
Naval Electronics Systems Command	EC

AIR FORCE*

Hq U.S. Air Force Standardization Group	01
Rome Air Development Center (AFSC)	17
Quality & Reliability Assurance Branch (AFLC)	23
Hq, AFLC, Standardization Branch	26
Interchangeability & Substitution Systems Branch (AFLC)	85

DEFENSE SUPPLY AGENCY*

Headquarters, Defense Supply Agency	DH
Defense Electronics Supply Center	ES

OTHER

Other - If the issuance is applicable only to the Naval Air Systems Command and the Department of the Air Force, in the aeronautical field, use the symbol "ASG."

*Partial listing.
†Formerly M200B.

TABLE XVIII

Pertinent Relay Specifications and Documents

1.	**MIL-STDS**	
	MIL-STD-12	Abbreviations (for panels)
	MIL-STD-454	Standard General Requirements for Electronic Equipment
	MIL-STD-456	Electronic Parts, Data and Source Coding for
	MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
	MIL-STD-143	Specifications and Standards, Order of Precedence for the Selection of
	MIL-STD-XXX	Relays, Selection and Application (to be issued 1969)
	MIL-STD-704	Electric Power Aircraft, Characteristics and Utilization of
	MIL-STD-831	Test Reports, preparation of
2.	**DOD MANUAL**	
	4120.3-M	Defense Standardization Manual, Standardization Policies, Procedures, and Instructions (formerly M200B)
3.	**MILITARY SPECIFICATIONS**	
	MIL-B-5087	Bonding, Electrical, and Lightning Protection for Aerospace Systems
	MIL-E-5400	Electronic Equipment, Aircraft
	MIL-R-5757	Relays, Electrical for Electronic and Communication Type Equipment
	MIL-R-6106	Relays Electric
	MIL-R-19648	Relays, Thermal, Time Delay, Hermetically Sealed
	MIL-R-39016	Relays Electromagnetic, Established Reliability
4.	**NAVAIR**	
	01-1A-514	Technical Manual "Design of Electric Systems for Naval Aircraft and Missiles." - FSN 0701-010-0160
5.	**SAE** Society of Automotive Engineers*	
	AIR 875	Comparison of Government Relay Specifications (To be updated by military whenever specifications are revised)
	AIR 904	Polarized Relay Conventions
	ARP 909	Electric and Electronic Relays and their applications
6.	**UNITED STATES STANDARDS (Formerly ASA)**	
	Y32.16	Electrical and Electronic Reference Designations (Supersedes MIL-STD-16)
	Y32.2	Graphical Symbols for Electrical and Electronic Diagrams (Supersedes MIL-STD-15-1)
	Y10.5 (IEEE No. 280)	Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering
	Y10.19 (IEEE No. 260)	Letter Symbols for Units Used in Electrical Science and Electrical Engineering
	Y14.15	Drafting Manual Electrical Diagrams
	C42	Series - Definitions and Electrical Terms
	C83.16	Relay Definitions and Terminology
	C83.25	Testing Procedures for Relays
7.	**NARM**	
	"Engineers' Relay Handbook" - Revised Edition.	

*Automotive = self-propelled (land, sea, air, or space)

APPENDIX

TABLE XIX

DoD 1969 Military Relay Program (Department of Defense)

Representatives from the U.S. Air Force (AFLC), Naval Air Systems Command (AS), U.S. Army Electronic Command (EL), Defense Electronics Supply Center (DESC-EM) and Naval Electronic Systems Command (EC) in a show of **solid unification** announced **at** a SAE/A2R Relay meeting held in Washington, D.C. 14 Jan. 1969, **the 69/70 DoD Military program for FSC 5945.**

1. Development/coordination for General Relay Specifications covering the following:

    a. Photo-Sensitive Devices
    b. Hybrid Relays/Assemblies
    c. Solid State Relays
    d. Vacuum Relays
    e. Time Delay Relays (Excluding Solid-State & Thermal Devices).

2. Development/Coordination of MIL-STD's for the following:

    a. Preferred Relays and Circuit Application
    b. Standard Test Procedures.

3. Revisions G & F to MIL-R-6106 and MIL-R-5757 based on completion of work outlined in 2(b).

4. Revisions of MIL-R-39016 to include "ER" requirements applicable to control relays covered under MIL-R-5757 and MIL-R-6106 as selected.

5. Agreement to nomenclature all future relay documentation for 60 Hz electrical loading ratings for standardization and convert previous documentation as applicable where loads at 400 hertz only were specified.

Military Representatives: (Project Engineers Assigned)

U.S. Army Electronic Systems Command (EL) (I. Carol)
U.S. Air Force Logistic Commani (AFLC) (I. Soper)
Naval Air Systems Command (AS) (L. Wendling)
Naval Electronic Systems Command (EC) (G. Fogleman)
Defense Electronic Supply Center (DESC-EM) (G. Neyhouse)

TABLE XX

Classification and Descriptions

The government tries to define items so that adequate standards assure that components can be produced, procured, cataloged and maintained. To this end, Federal Handbook H6-1 covers Federal Item Identification (abbreviated FII). Supplementing this is Federal Handbook H4-1 which covers Federal Supply Classification (abbreviated FSC). Under this arrangement, various types of relays and other Government classes of items are identified. From these descritpions the Federal Supply Classifications are set up to cover relatively homogeneous areas of commodities. Accordingly, FSC 5945 covers Relays, Contactors and Solenoids. FSC 5930 covers Switches and FSC 5925 Circuit Breakers. Unfortunately, despite the best laid plans, classification problems do arise and both users and manufacturers should be aware that such problems do arise and both users and manufacturers should be aware that such problems do exist. For example, if a device for selecting different electrical circuits is manually operated, classification as a switch under FSC 5930 appears reasonable. If the same device has an electrical actuator mechanism added should the basic specification and classification change? Or let's start at another point. Take a solenoid - FSC 5945. Now add contacts. Is it a relay? Suppose the solenoid is the electrical actuation mechanism for the first switching item is FSC 5930 not reasonable? Attention is invited therefore to the situtations as they can and have developed so that one will not find it incomprehensible as to why a **"Relay, Stepping"** falls under FSC 5945 and the nearly identical item by the same manufacturer appears under FSC 5930 as a **"switch, stepping".** Our suggestion is that if you do not find an item under a particular classification, it may not necessarily mean that the item does not exist under another Federal Supply Classification.

TABLE XXI
Some Abbreviations and Symbology Conventions

ITEM (SELECTED FOR INFORMATIONAL PURPOSES)	MIL-STD-12C ABBREVIATIONS (FOR USE ON DRAWINGS) 1968	NASA	(MIL-STD-16) SUPERSEDED USA STD Y32.16 LETTER DESIGNATIONS	MIL-STD-15-1 SYMBOLS SUPERSEDED BY USA STD Y32.2 GRAPHICAL SYMBOLS	NASA MSFC DRAFTING MANUAL 15	AAR ASSOCIATION OF AMERICAN RAILROADS
Battery (Electrical)	BAT	BATT	BT		BT	
Switch Electrically op Manually op	SW		 K S			
Ground Chassis Earth	GND*	GND				
Relay	REL		K			
Circuit	CKT	CIRC				
Capacitor ''Condenser'' is not a preferred term	CAP		C		or outside foil. i.e. curved side.	

NOTES: 1. Battery polarity symbols vary
2. Ground symbols are not consistent
3. **Capacitors should always be shown with one side curved** (US Std as of 1943) e.g.

*Revised 1968 from "GRD" after 19 years.

TABLE XXII
Standards

SUBJECT	MIL-STD	USA STD(1)	EXAMPLES
Abbreviations (for use on drawings)	MIL-STD-12C 1968	None	SW = Switch on panel GND = Ground (not GRD) after 1968
Graphical Symbols (for use on wiring diagrams)	Superseded Aug. 1968 (MIL-STD-15-1)	Y32.2(1967)	= Capacitor **(one side ALWAYS curved)** on and after 1943
Reference Designations	Superseded (MIL-STD-16)	Y32.16(1967)	S = Switch (wiring diagram) Q = Transistor CR = Rectifier DS = Lamp
Letter Symbol for Units used in electrical science and electrical engineering		Y10.19(1967)	Hz = hertz (cycles/sec) dB = deciBels MW = MegaWatts oC = Celsius – (not "centigrade" as of 1949)

NOTES: 1. United States of America Standards Institute which superseded ASA (American Standard Association) – 10 East 40th Street, New York, N.Y. 10016

TABLE XXIII

Aircraft Electric Systems - Design Manuals (Use of Hermetically Sealed Relays)

1. **"Guidance for Designers of Airborne Electronic Equipment"** - ARINC, INC., Report No. 403-1955/64. ARINC (Aeronautical Radio, Inc.) is a corporation in which U.S. scheduled airlines are principal stockholders. Address: 2551 Riva Road, Annapolis, Md. 210401. **"Manual recommends against the use of hermetically sealed relays in any size".** Fifth printing 1964. Reaffirmed 1964 (ARINC Report No. 414.)

2. **"Design Manual of Aircraft Electrical Installation"** - Aircraft Industries Association - June 1958. AIA now "Aerospace Industries Association. Document is out of print. **Hermetic sealed relays** are not mentioned.

3. "**Technical Manual - Design of Electric Systems for Naval Aircraft and Missiles**" - Naval Air Systems Command - NAVAIR 01-1A-514, FSN 0701-010-0160 - Issued June 1964, Revised August 1967. Section XI Catalog No. D217.14: EL2/CH @ $2.75 Relays, Electromechanical is available from Supt. of Documents, General Printing Office, Washington DC 20402. Section XI devotes 170 pages to relays and their application. Most types are military qualified hermetically sealed types for military aircraft.

   a. **MIL-E-5400J (1966) Military Specification, Electronic Equipment Aircraft,** paragraph 3.1.18" . . . . **Only hermetically sealed relays** shall be used."

   b. Early "hermetically" sealed relays, circa 1950, were for piston aircraft and were largely comprised of telephone type relays that were enclosed before the contamination of contacts from off-gassing was recognized. Relays were not immune to shock and vibration as well as being imperfectly sealed. Military specifications for hermetically sealed relays have undergone extensive revisions to avoid early problems.

NOTES:

1. **Sealing**

   a. **Hermetic Sealing (Military vs. Commercial):** The military require hermetically sealed relays for aircraft (e.g., MIL-STD-454). The commercial airlines on the other hand vehemently recommend against their usage.*

   b. **Hermetic Sealing:** Many relays are designated, "hermetically sealed," yet only a water bubble test is used and this is not sensitive enough to detect 1×10^{-8} cc/sec leak rate. Relays calling for **"seal test I of MIL-R-5757D - (paragraph 4.7.2.1)** alone have been considered or termed "hermetic". Relays meeting the bubble test only have been considered hermetically sealed, erroneously, and when used, developed contact contaminations and excessive moisture and contact failures. Reference: "Hermetic Seal, Leak Rate, and Vacuum Terminology" - J. Cittadini and E. U. Thomas, 1967 IEE/EIA Electronic Components Proceedings.

2. **The Hazards of Surplus Relays:** Relays that were built years ago were not required to meet the same requirements that have been added to military specifications in recent years. The leak rate requirements have changed. Older relays that have had a long shelf life when used, developed contact failures in the minimum current area. In fact, relays produced to early versions of specifications, having only Class A insulation have "forged" name plates added. The part numbers were also changed, to indicate a part that has a higher temperature range, yet the relay insulation was unchanged. In at least one case the forged name plate contained an MS number yet no qualified source for this part ever existed. Reference: IDEP Alert SMD 68036, 27 August 1968, 601.00.00.00.B2.1.

3. **Common Catalog Errors:** Catalogs frequently do not reflect the true military relay specification requirements and should not be used in lieu of actual military detail specification sheets of Military Standards. The following are typical examples:

   a. **Temperature Range:** Military relay specifications specify that the pickup, dropout, and operate and release times apply **for entire temperature range.** Catalogs frequently list the maximum values of the military items and state **"at 25^{o}C".**

   b. **Minimum Dropout:** Aircraft relays must release when coil power is removed. One common detail requirement is that the relay release at 1.5 volts minimum. This means **1.5 volts over the temperature range,** i.e., at -70^{o}C with maximum current for a given terminal voltage. This is absolutely essential where transistor leakage currents may hold relay in picked up condition. Some catalogs in the past have indicated compliance with QPL for crystal can relays yet printed to a dropout value of "0.8 volts at -65^{o}C." The values do not tally.

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*ARINC Reports 403 and 414.

TABLE XXIV

Partial List of Organizations Contributing to Military Relay Standards

AIA	AEROSPACE INDUSTRIES ASSOCIATION
EIA	ELECTRONIC INDUSTRIES ASSOCIATION
NARM	NATIONAL ASSOCIATION OF RELAY MANUFACTURERS
SAE	SOCIETY OF AUTOMOTIVE ENGINEERS
IEEE	INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS
AACC	AMERICAN AUTOMATIC CONTROL COUNCIL
AAR	ASSOCIATION OF AMERICAN RAILROADS
ISA	INSTRUMENT SOCIETY OF AMERICA
AIAA	AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS
USASI	UNITED STATES OF AMERICA STANDARDS INSTITUTE
ASQC	AMERICAN SOCIETY FOR QUALITY CONTROL
IDEP	INTERAGENCY DATA EXCHANGE PROGRAM
NAS	NATIONAL AEROSPACE STANDARDS
NEMA	NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

TABLE XXV

Phase Loss Detection

Instantaneous phase loss detection involving rotating equipment requires a current **(not voltage)** sensor. The current in the open phase reverses, but the voltage does not, nor does it materially decrease immediately.

TABLE XXVI

Circuit Tips (Reliable Operation)

a. Do not pickup relays over their own back contacts. They will "doorbell" unless they are form D which is not available as a military standard general purpose relay.

b. Use the relay contacts to verify the relay armature position and not whether coil terminals do or do not have voltage.

TABLE XXVII

(DoD Mandatory)

Letter Symbols - USA Standard Y10.19 (1967)

1. Do Not Use — **Use**

Do Not Use	Use
Megamega = MM	Tera = T
Micro micro = μμ	pico = p

2. Correct letter symbols

A	ampere
dB	decibel
kHz	kilohertz
V	volts
^{o}C	degree Celsius **(do not use "centigrade")**
C	coulomb
F	farad
GHz	gigahertz
H	henry
mH	millihenry
MHz	megahertz
μF	microfarad
Ω	ohm
pF	picofarad
VA	voltampere
W	watt

TABLE XXVIII

Relay Terminology Comparison Showing PREFERRED Practice

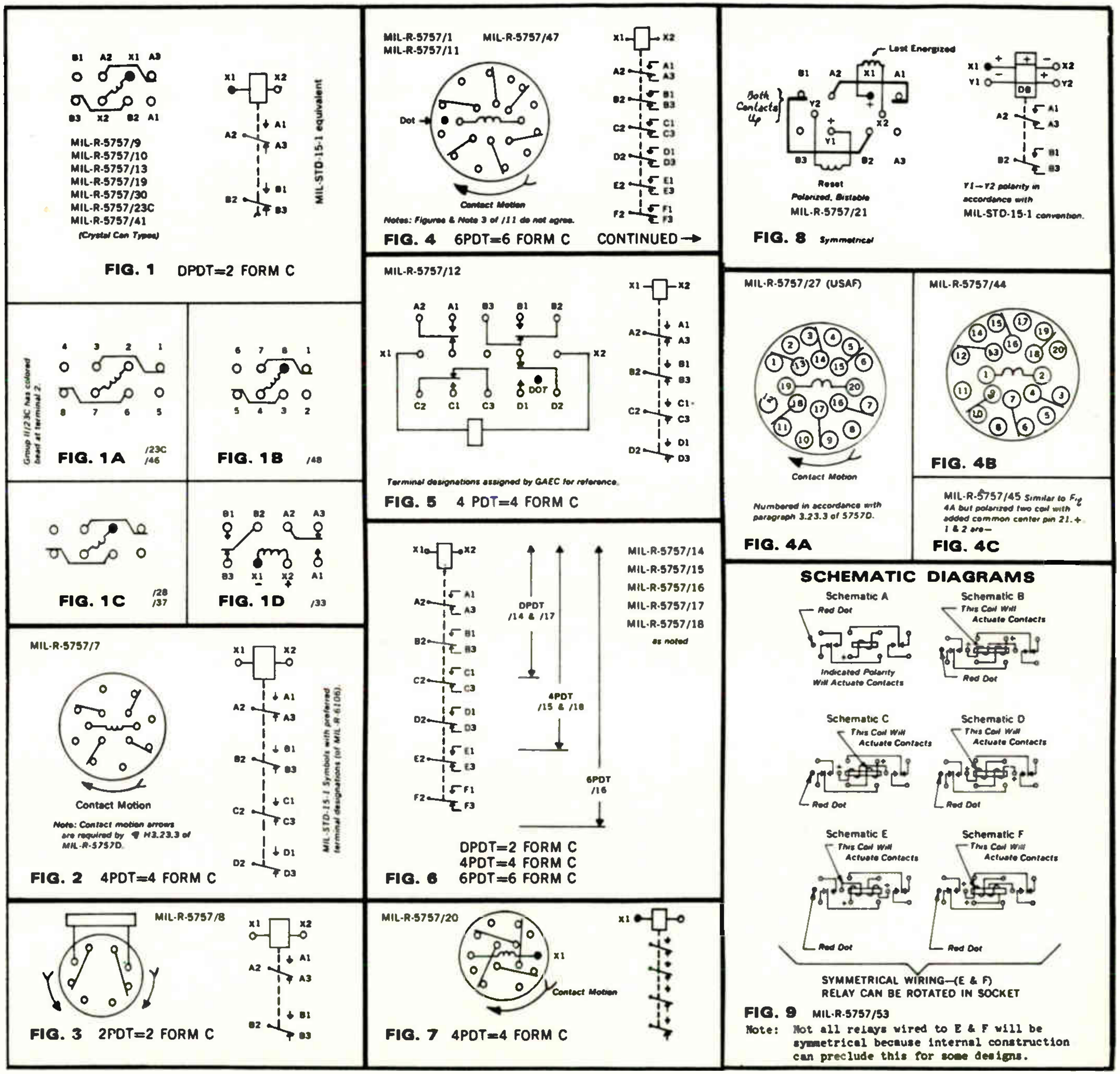
MILITARY			NASA			NARM		USASI		NAS (7)
MIL-R-5757D	MIL-R-6106F	MIL-R-39016	MSFC-SPEC-339A	GSFC-S-601.100	ST-R-001	PREFERRED	NON-PREFERRED	C83.16	C83.25	728
Pickup*	Pickup*	Pickup*	Operate	Pickup and Pull-in	Pickup	PICKUP	**Pull-in**	Operate Time	Pickup	Pickup*
Dropout*	Dropout*	Dropout*	Release	Dropout	Dropout	DROPOUT	Release	Dropout-Release	Dropout	Dropout*
Operate Time*	Operate Time*	Operate Time*	Operate Time	(MIL-R-5757)*	Operate Time	OPERATE TIME	Pickup Time	Operate Time	Operate Time	Operate* Time
Release Time*	Release Time*	Release Time*	Release Time	(MIL-R-5757)*	Release Time	RELEASE TIME	Dropout Time	----	Release Time	Release* Time
Contact Bounce Time**	Contact Bounce Time**	Contact Bounce Time**	(Contact-Bounce)***	(Contact-Bounce)***	Contact Bounce**	CONTACT BOUNCE	------	Contact Bounce	----	Contact Bounce?

NOTES:
1. Marshall Space Flight Center, Huntsville, Ala.
2. Goddard Space Flight Center, Greenbelt, Md.
3. NASA MSC, Houston, Texas
4. Engineers' Relay Handbook (Hayden) 1966
5. USASI (United States of America Standards Institute, formerly ASA) C83.16 (1959) Relay Definitions
6. USASI C83.25 (1962)
7. † NAS (National Aerospace Standard) 728 - "Test Methods for Electro-mechanical Relays (1962)
8. **10 Ampere Maximum.** For higher values do not parallel contacts. Go to another specification.
9. 5 Amperes Minimum (main contacts).

* OVER ENTIRE TEMPERATURE RANGE, and not at 25°C only!
** EXCLUDED FROM OPERATING TIMES
*** INCLUDED IN OPERATION TIMES
† To be revised - AIA and A-2R

TABLE XXIX
TYPICAL MIL-R-5757 WIRING DIAGRAMS

CONTACTS		MIL-R-5757 SLASH NO.	WIRING DIAGRAM FIGURE NUMBER
CONTACT CURRENT (AMPS RESISTIVE)	NO. OF POLES DT		
0.125	12 ST	MIL-R-5757/43	Reed
0.25	4	MIL-R-5757/34	
0.5	1	MIL-R-5757/6A MIL-R-5757/39A	
	2	MIL-R-5757/19B MIL-R-5757/30 MIL-R-5757/40A	1 1
	4	MIL-R-5757/29B	
1.0	1	MIL-R-5757/38A MIL-R-5757/50	
	2	MIL-R-5757/37 MIL-R-5757/51	1C
1.5	2	MIL-R-5757/46	1A
2	2	MIL-R-5757/8A MIL-R-5757/9C MIL-R-5757/10C MIL-R-5757/13B MIL-R-5757/21B MIL-R-5757/22B MIL-R-5757/41 MIL-R-5757/48 MIL-R-5757/53	3 1 1 1 8 1B 9
	4	MIL-R-5757/3 MIL-R-5757/7A MIL-R-5757/12A	 2 5
	6	MIL-R-5757/1C MIL-R-5757/11A MIL-R-5757/44 MIL-R-5757/45	4 4 4B 4C
3	1	MIL-R-5757/32A	
	2	MIL-R-5757/33	1D
	4	MIL-R-5757/20	7
5	1	MIL-R-5757/24	
	2	MIL-R-5757/14A MIL-R-5757/49	6
	4	MIL-R-5757/5 MIL-R-5757/15	 6
	6	MIL-R-5757/16A MIL-R-5757/47	6
10	2	MIL-R-5757/17 MIL-R-5757/28	6 1C
	4	MIL-R-5757/18A MIL-R-5757/23C	6 1 to 1A
15	1	MIL-R-5757/35	
25	1	MIL-R-5757/36	



ADDENDUM

GUIDELINES FOR RELIABLE RELAY APPLICATION AND SELECTION

L. W. Wendling and E. U. Thomas

Additional Applications Tips

In the interim since the time when the ''guidelines'' paper was first presented at the 17th Annual Relay Conference in April at Oklahoma State University, the authors have considered that additional information would prove useful to relay users and circuit designers towards successful trouble free relay application.

1. **Terminal Polarities and Designations** (Military Practice)
Terminal X_1 should nominally be considered as positive or high side of an ac circuit. If glass beaded headers are used, X_1 should be blue. If a common terminal is used for two coils, the common terminal should be designated as X_2 Y_2 and connected to ground (negative or neutral). **Note 1**

2. **Phase Loss Detection – False Sense of Security**
The use of voltage sensors to detect phase loss is not a universal panacea. When voltages are induced or generated in rotating machinery or wye-delta transformer circuits, voltage detectors may malfunction. Other methods such as current direction (phase angle) sensors should be considered e.g., for gyro compasses. **Note 2.**

3. **More Against Practice of Switching Ground Leads**
Switching grounds with relays where arc-over to grounded case may occur, does not eliminate the arc-over. It will limit discharge current to magnitude of load current, but arc-over can still occur and generate ''rfi.'' Switching grounds leaves loads ''hot'' when relay contact is open. The National Electrical Code indicates loads should be solidly grounded and the hot side switched unless both sides are simultaneously opened.

4. **''Simultaneity'' of Relay Contacts** — (impractical adjustment)
Simultaneous opening and closing of relay contacts is an almost impossible requirement and even more difficult to maintain in service once wear and tear sets in. Reed relay contacts are each independent with no mechanical connection between them. The closing of one changes the magnetic flux distribution and affects the pick-up value of all others. Where separate relay mechanisms are contained in same housing, MIL-R-6106 requires that the writing diagrams show the units as separate relays. Screening relays for simultaneous contact action is questionable practice and not recommended. What passed for simultaneous action one day, may not the next, and is even less likely after wear sets in. If circuits are critical to overlap or ''make-before-break'' (form D) action, a single contact may well prove more reliable than the mathematics used for redundant (paralleled) contacts.

5. **Design Manual Availability**
Section XI ''Relays, Electromechanical'' of NAVAIR 01-1A-514'' Design of Electric Systems for Naval Aircraft and Missiles'' is now available at $2.75 a copy from the Superintendent of Documents, General Printing Office, Washington, D.C. 20402 as catalog item D217.14:EL/CH.

6. **Bifilar Winding Arc Suppression Adverse Effects of**
Bifilar wound relay coils, where one winding is short circuited to provide arc-suppression without coil polarization, does provide arc suppressions, but at a price: Lost active winding space (less power for given size); slows pickup; slower release, slower contact motion (which can drag out arcs and shorten contact life); possible armature rebound (with extra contact opening and closings); shorter contact life; higher cost; loss of hammer blow to break contact films; and the increase in reliability as claimed in some quarters is subject to question.

7. **Coil Interaction**
The design of relays can materially affect their operation in a circuit. For example, if one winding of a concentrically wound pair is shunted by a divide for arc suppression, the induced current when the other winding is energized may well be in the forward direction of the other winding's shunt diode. This will slow down pickup. If all the reset windings of a bank of magnetic latch relays are paralleled for instant reset, malfunction may occur from the induced circulating currents when any ''operate'' coil is energized. Again armature speed and possible rebound may occur from coil interaction either between windings on the same relay or paralleled windings of different relays.

ADDENDUM NOTES

Note No.

1. **Terminal designations**
   a. MIL-R-5757E specifies X_1 positive with blue bead.

   b. Section XI, Relays, Electromechanical, NAVAIR 01-1A-514 ''Design of Electric Systems for Naval Aircraft and Missiles,'' indicates X_1 should be positive.

   c. SAE A-2R has recommended X_1 be shown as positive in Figure 1 of MIL-R-6106 and X_2 Y_2 be the common negative terminal.

2. **Phase Loss Detectors**
   a. MIL-R-5757/68.

   b. Oral presentation 17th Annual Relay Convention 1969 at Oklahoma State University.

3. **Ground Switching**
   a. National Electrical Code – section 310.

   b. NAVAIR 01-1A-514 handbook – Section XI.

   c. ''Guidelines for Reliable Relay Application and Selection'' – L. W. Wendling and E. U. Thomas.

   d. SAE Aerospace Recommended Practice (ARP 909) Relays.

   e. ''Relay Facts'' Electromechanical Design – 1962-1965.

   f. ''Transient Discharges in Relays with Grounded Cases'' – C. Nunn.

   g. Requirement 1, Personnel Safety – MIL-STD-454.

4. **''Simulaneity of Contact Operations''**
   a. Ohmite ''Think-In'' – February, 1969 discussion notes.

   b. MIL-R-5757E and MIL-R-6106F.

   c. IDEP ''alert'' on failures resulting from contact transfer overlap.

   d. 3.7.1.1 of MIL-R-6106F.

5. **Design Manual**
   a. Reference 1 of ''Guidelines'' paper.

   b. To be basis for MIL-STD- for relays.

   c. Recommended by military at Oklahoma State University as a comparison piece to go with ''Guidelines'' paper.

6. **Bifilar Arc-Suppression Disadvantages**
   a. ''Inductive Transient Suppression of Relay Coils'' – J. Schuessler, Leach Relays (1968)

7. **Coil Interaction**
   a. ''Twenty ways to wreck a relay'' EDN 1966.

   b. ''Inductive Transient Suppression of Relay Coils'' – J. Schuessler, Leach (1968).

THE AUTHORS

By L.W. WENDLING
Naval Air Systems Command Hdq.
Washington, D.C.

Mr. Leonard W. Wendling is the engineer responsible for design of aircraft electric control equipment. His most recent publication (U) "Controlling Aircraft Electric and Integrated Avionics Systems with Semiconductor Devices," appeared in the September 1968 issue of the Naval Air System News. This article discusses the development of a Solid State Electric Logic (SOSTEL) system which utilizes semiconductor devices as power controllers, signal sources and logic to control the performance of aircraft electric power. He is a liaison representative to the Society of Automotive Engineers (SAE) Aerospace Electrical Equipment subcommittee for relays A-2R, contributing to the preparation of military specifications.

E.U. THOMAS
Grumman Aerospace Corp.
Bethpage, L.I., New York 11714

Mr. Edward U. Thomas is an engineer in the Components Applications Group of Grumman Aerospace Corporation's Vehicle Electronic Design Engineering Section. He authored the monthly column "Relay Facts" in Electromechanical Design; is a member of the Society of Automotive Engineers (SAE); and chairman of their Aerospace Electrical Equipment subcommittee for relays A-2R and thereby a party to the ISO program for aircraft relays. He has presented six papers at NARM/OSU relay conferences beginning with 1961 and was the innovator of SAE document AIR875. He is a senior member of Institute of Electrical and Electronics Engineers, Instrument Society of America and a member of American Ordnance Association, Society of American Military Engineers, American Association for the Advancement of Science; American Institute of Aeronautics and Astronautics, Standards Engineers Society, Toastmasters International and a member of EIA S 48 TC Switch Committee for International Standardization. He has also authored articles on circuit breakers and holds a patent for railway signaling control without line wires.

TRANSCRIPT OF A THREE-HOUR QUESTION AND DISCUSSION PERIOD

QUESTION: MR. SIEGEL

If, in a screening for contact resistance, an increase of five times is considered excessive, what percentage increase is considered reasonable?

ANSWER:

There is no rule of thumb that can be used for all relays across the board. We have figures which we use, determined by the contact material and the size of the relay. For example, a 1/6th size crystal can relay would have different contact pressure than a full size crystal can relay; therefore contact pressures come into bearing.

A relay with gold contacts would have different results from a relay with silver contacts.

So before we work out a screening technique and allow for parameter drifts, we must know everything about the relay. This is why some of the vendors get calls from me and we ask, "We are not going to put it in a drawing, but what is your contact material and what do you consider your maximum limits of pressure?"

RCA is not going to get into the relay business, but we are trying to find out what they use, and we have found pretty good correlation for certain materials, from vendor to vendor, the allowance for parameter drift remains the same if the materials remain the same, and the allowance for pressure remains constant. Any relay that exhibits a contact resistance rise of five times on a 2 amp life test, I would not accept.

QUESTION: MR. THOMAS

In your 100 per cent inspection analysis, how many failures do you usually find, percentagewise?

ANSWER:

I am sorry, I am not on the incoming inspection quality assurance program. I have a paper here which was delivered out at Oklahoma State University a year ago by J. J. Lombardi, Jr. I will look it up and see if he had any details but I can tell you that the percentage is a lot higher than you might think.

He does not discuss relay failure rate analysis figures. However, apparently, the program paid off; we made it to the moon.

If you would like to get a copy of the paper, entitled, **Relay Failure Analysis Techniques,** I suggest you get in touch with J. J. Lombardi, Jr., Quality Assurance, Plant Number 10, Grumman Aerospace Corporation, Bethpage, New York 11714; telephone is 516-575-7906.

They found the strangest things inside a so-called inspected and delivered, hermetically sealed relay which presumably was sent to us to put in a lunar module. But for the lunar module, we had 100 per cent incoming inspection by Vidicon, as it is called, and they put them in the chamber, where the device is so oriented that they can turn it all around and examine it.

The inspector has instantaneous view on the television monitor to see what is or is not there, and if he sees something as an abnormality, he lowers the Polaroid camera and photographs it. So we do not take records that we do not need, but only to show those things which have faults in them.

QUESTION: MR. WENDLING

Could you define electrically what you mean by transfer? This was on one of the slides that you presented, and we would like to see the slide again, if you have it.

ANSWER:

Are you talking about power transfer?

COMMENT: INTERLOCUTOR

Power transfer, yes. The comment here, beyond the question, is in electric power engineering you neither parallel nor transfer power lines unless the sources are in synchronism. There are two commercially available synchronoscopes to do this. Connecting sources out of synch will not only damage the relay but the load as well.

ANSWER:

That is inherently designed in the relay itself. In other words, the capability of the relay to transfer power successfully, is generally dependent on the contact design and switching capability with protection under dynamic load.

COMMENT: MR. THOMAS

I think we ought to point out number one, primarily I think Mr. Wendling and my association is in the aircraft area and with ground support. Now in ground support there usually are no restrictions on size, weight, et cetera. A great many aircraft are built and have separate power supplies.

However, they are not paralleled, and they only make a transfer between one power unit and the other. The word power is very deceiving, because there are people who think that 5 amperes, 115 volts is power because they have a "power supply" to feed their electronics.

It is this latter group that are really the electronic geniuses who have been studying solid state phhysics and who have not been exposed to electro-mechanical relays, because I doubt if there are any colleges other than Purdue University which has a course on relays.

However, with a great many aircraft power supplies, if you lose one primary source, you need a standby to provide power.

COMMENT: MR. WENDLING

Without interruption.

COMMENT: MR. THOMAS

The electronics, because of the digital codes or bits of electronic information – at one time they could absorb the slight interruption and the aircraft did not tumble down because of that. A great many of the original power transfer devices were center-off so they had two coils, one to go to one side and one to the other.

In this case, the air gaps between the contacts gave sufficient isolation. Primarily, people who are dealing with power as power are interested in power and they know a little bit about it. The people who deal primarily with electronics find that they need, as Mr. Wendling said, a continuity in power. They want to go from something else in a hurry to something else, such as if a missile is primarily tested out on the ground and as it takes off, they want to transfer to the internal power supply, which they can save up to the last minute and when they transfer, they want to do so without even missing a beat.

So there are two things: number one, a lot of people try to make a transfer between power with a relay with a single coil such as shown on the slide, because it has multiple poles. And unfortunately the small relays that are put in aerospace equipment very frequently have a lower dielectric across the open contacts than they do between adjacent poles. And they do not have the capability. And the second one is that the boys want to transfer without loss of power, in which case sometimes it is necessary to put two relays in parallel, such, that one acts faster than the other, so they do temporarily parallel the power supply.

But an awful lot of people seem to forget about this fact that the utility companies, for years, have known what you have just said, that you have to synchronize AC sources before you parallel them, or you are going to have an awful transient reaction or peak value.

COMMENT: MR. WENDLING

These transients, of course, affect the relay operation and its inherent function determines the reliability of the system. If you do not have this capability, you have catastrophic failures, and we are speaking not only in the electronics field, but we know there is power transmission in aerodynamics and the flight system cannot afford these power failures.

Consequently, those things that relate to 3-phase transfer – and we are talking of primary power – cannot afford this interruption which could be catastrophic.

COMMENT: MR. THOMAS

One of the things I forgot, to get back to the second question I was asked to answer, one of the other things is to use a magnetic latch relay which has two coils, but they go bistable from one position to another, and this is where people are trying to get a fast shift between one power supply and the other power supply. And when they do so, they overlook that the air gap in the transfer is very small. The dielectric test voltage, as I said before, is a static test, in the absence of arcing, and without contact movement. When the contacts are asked to shift while drawing power they are apt to be arcing because the contacts are apt to move, changing the air gap. And if the power supplies are out of synchronism, the voltage can go to double or nothing.

On the other hand, certain relays can be used with a single coil or a bistable magnetic latch, in which case invariably you will find that the transfer rating, when the transfer rating is provided, is considerably less than for on-off switching. The total switched energy is down low enough that the transfer distance is adequate for the amount of energy switched.

COMMENT: MR. WENDLING

Mil standard 704-A defines the parameters of utilization and power requirements for equipment, and this defines relatively what must occur in transfer of power. And it is available and I speak now from what which is called the prime mover, which in the airborne system initiates the continuity electric power.

QUESTION: MR. GWYN

I have four questions concerning contacts for industrial limits which is Double Pole-Double Throw-10 amperes-120 volts AC.

Are laminated contacts, silver over copper, acceptable for this service?

ANSWER:

In a nominal case, yes. It depends on whether they have clearance by Underwriters', and in most cases they have approved so long as there is sufficient material to withstand all of your load requirements for the length of time you have to use it.

QUESTION: MR. GWYN

What are the causes of separation of laminated contacts, copper and silver?

ANSWER:

It depends on the method in making them. Sometimes they are cold bonded, using no brazing material; other times they are brazed; sometimes they are forced fitting procedures.

It would depend on the method you use in making them. But under normal conditions, they ought to carry any load that the solid contact would carry without separation, in some cases even more because the copper backing may have more conductivity and thermal capacity than does the contact material itself, if it is a solid contact.

QUESTION: MR. GWYN

Will shock, caused by the force of the contacts mating, affect the laminated joint?

ANSWER:

Not normally, if it has been made propertly it will not, because as a general rule, your shear tests are about the same, or even over that of a solid contact. There again, it depends on the method used in putting the two parts together.

QUESTION: MR. WENDLING

Would you qualify the difference between minimum life and the term established reliability?

ANSWER:

I think that the considerations of ER were well defined by Mr. Siegel this morning in his relationship. Minimum life is that parameter which can be defined as that which is normal in acceptance of the minimum requirements for that particular relay.

An ER relationship is that which is very specific in its requirement as regards, its application such as space. I know of very few components other than that specifically defined as specials that can meet the ER relationships with the exceptions of resistors or capacitors. In this area where you have the longevity of data defined to substantiate the capability of an ER relationship.

ER is costly. There is a definite need, but its need is predicated upon a specific suitability to a reliability capability, and I think the two are very relative.

When I say ER, established reliability, because at one time I think they started out calling it some other factor, but then they had to look at the facts and say that the only thing we can do is determine, by usage values, a statistical need of a basis of a capability of a particular component. And these factors can only be assured through usage in time.

There are new elements coming into being which are awfully hard to devise the parameters of the reliability factors, until such time as you have enough data substantiated to govern its process, its limitations and its values.

QUESTION: MR. WENDLING

Can established reliability ultimately save money for the user, even though its initial cost is greater for ER ratings?

ANSWER:

Again, depending upon the application. If it were a moon shot, yes; if it were a ground piece of equipment, I would question that.

ANSWER: MR. SIEGEL

Can I answer that question? I would like to answer both parts.

Let us take that first question considering minimum life and established reliability. We are dealing with apples and oranges. Minimum life is a generic term. You design a relay for a minimum life, and that means when a designer built that relay, he designed it so that if you statistically laid out all the relays, you would find out all the ones that were properly produced should go at least 100,000 operations. Some will go a million, but they all should go 100,000.

Established reliability is a statistical analysis of a lot. Here you have an actual number, because you are taking a number of units from a particular lot and testing them. You are also coming up with a buyer's risk.

Now, you are saying you buy an ER relay, you are buying it at a sixty per cent confidence level which means you are taking a forty per cent risk that the relays will not meet established reliability that you are buying it to. That is why we do not believe in ER. You are also forecasting a failure.

The other problem is you do not forecast if the failure is going to happen in the first operation or the 999 thousandth operation. You just forecast a failure because all the others have to be put in a computer, and you come out with .01 per cent for 10,000 operations. One is a statistical figure based on data, and one is a purely generic term.

As far as your second question goes, when is it economically feasible to buy an ER relay, assuming the established reliability holds up, if you have to run preventive maintenance, if you have a piece of gear that lands airplanes, where this piece of equipment must operate and you have established preventive maintenance so that every thirty days you are going to change that relay, then you buy a standard relay. An established reliability relay is used in a space shot where obviously cost is the secondary objective and reliability is the primary one, with success in a mission the prime objective.

But each application must be examined within its own zone. You cannot just make a general statement about anything.

The problem with relay misapplication throughout the years has been that people have been using general terms and general techniques to select relays. That is our biggest problem in this business. Whenever you say, "it is a 2 amp relay, let us use it for 100 mils," that is where all of us get into trouble.

Look at the over-all picture. Is it established reliability or is it minimum life? Try to establish where you are using them.

COMMENT: INTERLOCUTOR

You spoke about the missile shots. On the other end of the spectrum, what you are saying is that you are wasting your money buying an established reliability relay for a coffee vending machine.

ANSWER: MR. SIEGEL

I do not know. It depends – have you ever stood at a coffee vending machine and put a dime in and did not get a cup of coffee? If I am standing there and angry, that is one thing; but if the president, who is going to install 10,000 of these machines, happens to be standing there, you just lost a lot of money. It depends on who is going to be putting the dime in the coffee machine.

QUESTION: MR. THOMAS

What mil spec for relays provides the best general purpose capability and why?

ANSWER:

That is a very nicely loaded question. As I was telling the people this morning coming in in the car, I get called up on the phone and the man says, "I want a relay. They tell me you are a relay expert."

Then there is a pause, and I say, "Keep talking. What do you want?"

"I want a 28-volt relay. Can you give me the military part number."

"Well, tell me how many poles you want, do you want transfer, what is the type of load, are you going to have motors or 3-phase?"

He says, "Contacts. I want 28 volts."

I say, "What current?"

"28 volts."

I wish it were not so, but this is the way it is. You ask a question that is so broad. What is your application? Then we can guide you! There is an overlap between relays that are built to MIL-R-6106F, because that begins at 5 amperes and up. MIL-R's to 5757 are 10 amperes and down. However, you get the same size relay to two different relay specifications.

If you have an application which is a safety in flight, for example, a parameter known as rupture, which I think more correctly should be called interrupting capacity, to open a circuit because you do not want things to burn up, that is not included in 5757.

So if you want my telephone number, I can give you that. But you have to tell me your complete problem and not a generalization. I want loads, environments, life, etc.

QUESTION: MR. SIEGEL

How do you know when exceeding a spec in testing a relay will not affect its expected life?

ANSWER:

This takes about $18,000 and a year of my time. We have developed test techniques over the years. I have not been at RCA for eight years for nought. We have been developing these techniques and changing the parameter drifts coming up with the various allowable parameter drifts based on changes as designs change.

And we have found that the techniques that we are using, the techniques that we have outlined, in fact, in a paper I wrote in 1963, are still the same techniques we are using today. We are always looking into new ones, and when we find that it is degrading to the relay, we drop it. We have spent thousands testing, and I hope a lot of smarter people than I come up with something over what we have today. But what we are using now is the best we have found so far.

ANSWER: MR. WENDLING

Let me add as we start to establish requirements and consider a need in military relays, there are times when we ask for that which is probably above the state-of-the-art. And once defined and realized that we cannot get it, it does not necessarily mean we won't change that document to reflect today's state-of-the-art. It is not that we do not need it, but it is a matter of how far can we go and are we willing to compromise to accept a given margin of effort to do today's job.

It does not mean that we will not get there tomorrow, but it does mean that just because we have a stated need, we do not always get it.

ANSWER: MR. THOMAS

I wanted to add to what Mr. Wendling just said, and tie into it. There will be more connected with what I am saying. But the former branch chief of the Bureau of what was then known as the Bureau of Aeronautics which is the department of which the Naval Air Systems Command has now become, and the gentleman said in the business of military relays even the most conscientious supplier may not recognize all of the field requirements under which the military has to operate.

So the military is tied into the business of making relay specifications. They also obviously are the last word on it at the time of issuance of a detailed sheet. What they put down, as Mr. Wendling has said, is the minimum requirements that they hope will be consistently met by any of a plurality of sources because they would like to be able to, logistically, have more than one source. And they would like to be able to count on it. There is a specified set of parameters and conditions, as I said, like shock vibration above and beyond what a conscientious supplier may think he needs, but not recognize the corrosion problems that the military happens to know about and insists on taking into consideration.

One of the things now in MIL-R-5757, under contact springs, is the prohibition of cadmium plate because it grows whiskers.

ANSWER: MR. WENDLING

One little adjunct to the statement that Mr. Thomas just made; many times a requirement exists for a single service entity and one is factually given and extended to all the services the utilization by that particular service to eliminate all other documents. The need to compromise and extend its value to where multiple sources ecist by defining specific requirements. Industry can provide relays to satisfy the total military program. Now, we have extended its value, looking at it on the broad aspect, optimumly we have utilized the requirements extending its value and worth.

ANSWER: MR. THOMAS

To go on with that: This morning Mr. Wendling gave an example where a manufacturer had a commercial relay line which could be qualified if the manufacturer would shave a thirty-second inch off the height. The manufacturer could then change his present 5 ampere-4 pole relay to comply with the existing military and also use that design to revise his commercial line. (Ed. Note-MS-25267 and MS-27218)

Logistically, the military, for years, has stocked drilled filister-head screws because they can use them anywhere so that can use a non-drilled filister head screw. They have to stock only one complete set of screws and the drilled head costs like mad. The manufacturer who uses screws can use a plain filister head initially, but for the military replacement of supplies and repairs, it is cheaper for them to pay more and have less varieties.

I think what you have said, is true, that you could extend the capability of a unit to that of a tri-service capability and answer all of them. Sure, each individual service may pay a little bit more, but in the over-all, there is less confusion and fewer parts for the government as a whole.

QUESTION: MR. GWYN

What problems are encountered when a relay must switch low levels and high levels alternately or randomly across the same contact? Comment on applications requiring application of high level current after switching.

ANSWER:

It all depends on the general parameter in which it will work. I think I had better tell you a little story. These two medical students were worrying about whether smallpox was infectious or contagious. They decided to bet their whole lunch money for a week and asked the first person they saw for an answer, and they would accept this.

They walked up to this woman and asked her. She said, "Damned if I know, but it's powerful catching and killing."

You would have to study each case and application, because there are overlapping points for both voltage and current through the contact, below and above, when they do not function properly. There is no such thing as a universal contact material, unfortunately.

QUESTION: MR. GWYN

Would you comment on the level of current after switching? In other words, if the relay is closed on a low level and then increased, is there any effect on the contact?

ANSWER: MR. GWYN

You mean closed on the light amperage, and then carried on the heavier current? Not unless there was some overheating, because in general, if you break through the surface to conduct a low current, it will also conduct a high current without much problem.

QUESTION: DIRECTED TO ALL PANELISTS

What trade-offs are involved in using solid state relays versus mechanical type relays?

ANSWER: MR. THOMAS

What is the application? Define the parameters.

ANSWER: MR. GWYN

They did not have a P.S. on that question saying who built the natural bridge, did they?

QUESTION: DIRECTED TO ALL PANELISTS

Would you feel that the application is more critical with solid state than mechanical relays?

ANSWER: MR. THOMAS

You have to give me the parameters – load, environment, speed, life, etc.

ANSWER: MR. SIEGEL

I will give you a perfect example of this. Quite a few years ago I entered the relay application business and an engineer friend of mine said, "You have to be crazy to get into the relay business. Solid state is really moving. You're on a dead horse."

That horse is still running, and I have a wife and a daughter going to college, all on this dead horse that is still running. It seems that as long as people will misapply solid state relays, the electromechanical relay business is going to be here for a long time, plus the fact that there are many applications where the electromechanical is really superior to solid state.

It is like saying: What is better, a racing car that won the 500 or my little air conditioned Fairlane? I would look like a fool on the Jersey Turnpike with Mario Andretti's car. Certain applications have certain limitations where the electromechanical relay will really work. You have to look at the job.

The biggest problem, I think, in misapplication is that fools rush in where angles fear to tread, and I get about forty calls a day on my phone from various divisions at RCA, and everybody is looking for a quick answer. I sit back and try to ask questions and they say, "Why are you asking all these questions?" And my only answer is, "To try to keep you out of trouble."

And if you say you want to go solid state or you want to go mechanical, you are looking for trouble. You cannot make a general rule. You can set up general guidelines and you have to read between the lines of these guidelines in order to determine where you should be.

ANSWER: MR. WENDLING

Since I can only talk from the viewpoint of the airborne systems, I would like to ask the initiator of the question: Does he have any knowledge where a solid state relay has been used in an airborne system or has anybody who can tell me where a solid state relay, airborne, has been used?

I get complete silence. How can you ask me to determine the value of a solid state relay versus electromechanical at this point, when I speak of airborne systems, when nobody can tell me they have it in being?

COMMENT: THE AUDIENCE

There are other systems besides airborne systems.

QUESTION: MR. WENDLING

I only spoke for my end of that particular question.

ANSWER: MR. THOMAS

Before you jump at the conclusion that I have an answer to that, I do not. But, what Mr. Siegel said earlier, in 1964 the Bureau of Weapons had a symposium down in Washington in which I was a speaker and Mr. Wendling's boss, Mr. Binderman, introduced me with, "I am going to put you out of business because you are the chairman of the A-2R committee for electromechanical relays, SAE."

As Mr. Wendling says, he is hoping to get to it, but it is taking time to go. He just illustrated that he does not yet know, although he asked for and inquires hopefully that somebody will give him a prime example of solid state relays in airborne equipment. So the dead horse is still dying, slowly.

QUESTION: MR. BONNELL

I think probably the best answer to that question is that an electromechanical relay and a solid state relay are not necessarily the same thing and will not necessarily do the same job. I think just one quick look at the semiconductor will give you the answer.

If you are in solid state, you have one set of parameters and one set of problems in order to do your switching. And when you are in an electromechanical, you have a different set of problems. I do not think you can take one out of here and put one in its place.

COMMENT: INTERLOCUTOR

You have unanimous agreement with the rest of the board.

COMMENT: THE AUDIENCE

Doesn't it depend on the end function of the problem? Doesn't the transfer function between the input or output depend on whether you want to use a solid state relay.

COMMENT: MR. SIEGEL

That is one of the factors.

COMMENT: THE AUDIENCE

But in ninety per cent of the cases you can go solid state, because all you are looking for is results. It does not matter what kind of results so long as you achieve your function and you can do the solid state much more easily than with electromechanical relays.

QUESTION: MR. THOMAS

Why do coils on some one-sixth size relays open at nominal voltage, room temperature, no shock or vibration? This occurs after about fifty hours.

ANSWER:

That is an interesting question. I wish I knew. I am not a relay manufacturer, but as a user, I would stay away from the manufacturer that has that sort of trouble. He must probably have to overhaul the production facilities. (Ed. Note: Nylon bobbins with potassium bromide for deembrittlement have caused copper wire corrosion according to a recent IDEP "Alert.")

QUESTION: MR. THOMAS

How do you feel about postlife test internal visual examination?

ANSWER:

Again I want to know what the application is. It is one thing to go look and say that is very nice. And as a French chief engineer I used to work with said: "That is very interesting. But what does it prove?" You have to be able to interpret the results as to whether it is informative and constructive and does it assist you in doing what the gentleman just said, that ninety per cent of the switching problems he could do with solid state devices. I believe there are a few electromechanical manufacturers who would take issue with that.

But the point is, you have to know what you are after. You have to define the problem.

One of the hardest things to do is to get an engineer to define his problems. He does not want to think, he wants you to give him an answer, and he has not told you what he wants to know. And he does not know what he wants to know, and he has not taken the time to find out. He is wasting your time. When you find out precisely and define, as Mr. Wendling said in his paper this morning, define the problem and completely, then we know what we are after.

ANSWER: MR. SIEGEL

If that life test is part of a "qualification examination," I would not consider it a life test unless I opened the door. The qualification test is done on a limited number of units to prove capability. Just because four or five relays went 100,000 operations does not mean it has the capability. Maybe we were lucky. I want to open those relays and see just what condition they are in at the end of 100,000 cycles.

COMMENT: MR. THOMAS

I think an illustration of that case is when I was working for a railway signaling company. They had incandescent lights and they would start with 100 per cent of the lamps burning at zero time, and at the end of so many hours only eighty per cent of the lights would be burning. And after that, the rate of failures increased very rapidly. And yet you would find, where the eighty per cent knee of the curve came down. It may occur at 500 hours, yet at the end of 3,000 hours you would find two or three light bulbs still working.

You cannot project on limited sample as Mr. Siegel just pointed out, because supposing you had tested the lights that worked for 3,000 hours on the qualification test, you do not have a statistical sample. As a result of a statistical sample, when they have enough items, you can benefit. The Pennsylvania Railroad years ago, when the crews would go from one signal locale to another, changing all the light signals at that locale on a rotational basis, right on time. But they knew that most of the lights might still be lighted, but they were going to fail, or enough of them were going to fail that it behooved them to have the track team go down the line, one right after the other, and come back and catch this location on the next scheduled inspection or replacement schedule.

QUESTION: MR. SIEGEL

During the analysis phase, what things do you look for when these first failed relays are examined?

ANSWER:

Presuming these are the first factory failures that hit my desk, the first thing we see is a failure report along with them and it is usually loaded with information: "Relays don't work."

The first thing we have to do is run every electrical test. Here is another tip I will give you people: Run system electrical tests efficiently, and this is necessary on these first failures because once you open the relays, any tests you run are not fully qualified tests. Certainly you are adding things and substracting things in the opening of a relay, so you try to get as much information as you can.

Obviously, if the relay blew up inside, you are not going to get much information. I run a little puzzle with myself; I try to say, what is this thing going to look like when I open it up? And my technician very carefully opens up the relay and about ninety per cent of the time we find exactly what we expect to find.

But we unwrap all coils, we examine everything. If the thing failed immediately, that does not mean that there was not other failures coming along; if the contacts welded, that does not mean that something is not going to happen to the coils in another five or six hours. So you make certain that nothing has been overlooked, that there has not been any powerful transients going through the coils.

Many times we have found, by examining contacts we are able to determine – that something else that was operating caused the failure, the contact pressure went up. We could tell them they were using the wrong dial on some other piece of equipment. We try to forecast what was the cause of the failure as well as analyzing the failure within the relay.

But if you examine the relay very quickly, just don't examine by saying: "The contact looks like it was overloaded, someone must have zapped it," and you put it away. After all we have gone through, and the program is going for a year and a half and we get something back, we mark it as zapped and throw it in the garbage can.

QUESTION: MR. SIEGEL

Are there any corrective type procedures recommended rather than start again from scratch, presuming you find no errors in your application?

ANSWER:

I tried to explain this morning that I hate to start over from scratch and therefore what you try to do is work backwards. If you have an application sheet and you find where your failure mechanism is, you can go back to that area. If someone told you he is handling 100 mils in the contacts and you open up three relays and find no contaminating film then somebody is fooling somebody.

Many times you go to the vendor and ask for a change in contact material. But I really detest going back and starting from scratch. I thank the Lord I have never had to.

I have always gone back to the beginning, but never from the very start. Again, it is extremely difficult for me to try to tell you everything I have learned in many, many years. It is a matter of collecting your thoughts and if you have more than one problem, don't look at all the problems at once. It is like trying to see the apples and oranges and pears and trees at one time. If you look at them all, all you are going to see is fruit.

QUESTION: MR. BONNELL

In power switching, would you please elaborate on thirty-five per cent switch in power? This was in part of your lecture and I missed your point.

ANSWER:

We have a pair of contacts in a relay that were built and manufactured to switch a maximum of two amperes for 100,000 operations. This means that they will be capable of carrying a certain amount of power through the contacts, they will be able to dissipate a certain amount of heat through the leads and through the case, and if they are built correctly and if the design is proper, then you can normally expect 100,000 operations from that relay. You cannot expect an awful lot more than 100,000.

Of course, after 100,000 operations, if you figure on a 100,000 operation life, before failure of this relay, however many you have, you have ten relays or 10,000, no matter, it will have a random failure rate, provided that there are no catastrophic early failures. This random failure rate that you have will determine how many failures you have over the life of the relay and the life of the equipment.

If you reduce the load on the contacts, you will reduce the heat necessary to be dissipated by the contacts, by the leads and by the case. And at least theoretically you will increase the life of the relay. And because you will increase the life, you will undoubtedly decrease the failure.

This is the purpose of reducing the load, to decrease the failure rate, not to increase the life, necessarily, because most equipment where you use this type of relay specified for 100,000 operations, they will not even approach the 100,000 level because the equipment is obsolete and discarded.

QUESTION: MR. BONNELL

Would you recommend paralleling contacts to share current such as two paralleled, two-ampere relays to switch four amperes?

ANSWER: MR. THOMAS

I would not.

ANSWER: MR. BONNELL

No?

ANSWER: MR. THOMAS

Because obviously the contacts do not operate together; and one of them has to switch four amperes.

ANSWER: MR. BONNELL

One of them, and the same one will always operate first.

ANSWER: MR. THOMAS

It has been written in books, the MIT "radiation series" that were published in 1946 specifically state, "Do not parallel relay contacts for the purpose of increasing the contact handling capability, but select properly designed contacts." The papers that you are going to get a copy of, have said this. I do not know how many times, or in how many places I have seen this, and why it takes so long to sink in I do not know. I would like to see that some of the editors here today repeat that for the benefit of those who are not here with us today.

QUESTION: MR. BONNELL

What does the interconnection designer have to guard against to prevent failures? You hinted at capacitive coupling causing problems.

ANSWER:

All I can say is that the designers on both ends of the system and the interconnection engineer have to, of necessity, work together in order to assure themselves that a design is going to work. As far as to what he has to watch out for, he just has to make sure that if there are three involved, that all three of them are thinking along the same lines and know the whole story.

COMMENT: INTERLOCUTOR

Do you have any comment about the capacitive problem?

ANSWER: MR. BONNELL

If you are going to put a capacitor in the line, you have to have a relay that is going to handle that capacitor.

ANSWER: MR. THOMAS

And if the line is long enough, you have capacity whether you realize it or not. The Telephone Company will tell you plenty about that, and I think you will find, in the case of large aircraft, that there is enough intercapacity from the cabling that they have capacity switching problems.

QUESTION: MR. GWYN

Can contacts which have developed a high resistance through use, be efficiently cleaned by passing high current through the contacts?

ANSWER:

It is much better cleaned by passing a low current and a high voltage, because you want to break through any film that is formed on it, and if you are going to pass a high current, you may additionally affect the contact surface.

QUESTION: MR. SIEGEL

If one manufacturer has a record of little trouble in dielectric withstanding voltage, and another manufacturer has a good reputation on contact resistance, how should these factors be handled where each manufacturer is objectively qualifying relays for military specifications?

ANSWER:

You have posed a difficult question. This is a good example: One vendor had a problem in dielectric and the other in contact resistance. I would not even go to the vendor with the contact resistance problem. Let us assume we must have two vendors. We would then have to, because of contractual obligations, put both requirements in the acceptance testing. You cannot make a drawing up for one vendor unless you are going to make a dash-1 for one vendor and a dash-2 for another, and this gets a little hairy.

I would either advise you select your vendor more carefully or, number 2, you just have to pay the additional cost of going to both vendors and calling out both tests.

QUESTION: MR. BONNELL and ALL PANEL MEMBERS

What is the panel consensus regarding the exclusion of contamination (minimum) current testing in favor of the internal icing test?

ANSWER: MR. SIEGEL

Let me give you a little background on the icing test. This was developed by RCA. It was originally in the paper I presented and to be very honest, the icing test came about as a result of technician error. The technician made a boo-boo and energized a coil while it was at maximum temperature and brought it down to minimum temperature while still energized, and he came running to me – "We made a terrible mistake. What do I do now?"

And I said, "If worse comes to worse, we blow the load. Run a test by de-energizing the contacts." And lo and behold we found ice.

For a year I tried to figure out why, if we did it the other way, if we brought the relays down de-energized and energized the relay at cold, we would not find the ice. We did not find out. And a year after I presented my paper in 1964, General Electric presented a paper where they explained to me why my system worked.

It seems that sixty-five per cent of the moisture in a relay is in the coil and by heating you drive it down to the coolest portion of the relays which are the contacts and it forms ice on the contacts.

Let us examine contamination of relays. I am going to forget about particulate contamination. I am only going to talk about gaseous contamination. There is outgassing in every relay of the Teflon and other insulating materials that are used throughout the insulating chamber. This material flies all over the relay and we have found it needs a catylist and this catylist is moisture. I have yet to find a relay that has moisture in the case that will pass this relay test one hundred per cent, bar none.

Not only that, but we have even been able to tell you approximately how many cycles of moisture occur, because it forms a lamination. You will find a lamination of a whitish-gray material, and it seems to be gaseous contamination. I call it a colloid suspension of the contamination that forms on the contacts. And yet when the contacts cool down, it solidifies, and no matter what you do after that, you do not seem to be able to get it to evaporate again.

If you do this again and again, you will finally build up enough of this contaminated plating that no matter what your pressure is, you will not be able to pass a 10 mil current, regardless of your pressure. Therefore we feel that the internal moisture test is probably one of the most critical tests in relays at this minimum current level.

ANSWER: MR. THOMAS

I think there are two things: Number 1, the minimum current test runs about 34 days to do it complete whereas, as Mr. Siegel said, if you run the moisture test you can do it in one day. Second, Mr. Robert Holcomb of GE is, of course, the gentleman who explained to Mr. Siegel what it was, and as a result Mr. Robert Holcomb was immediately nominated to the College of Relay Engineers at Oklahoma State University for the annual award.

As Mr. Holcomb pointed out in that paper, if they had crystal can relays and at 3:00 o'clock in the afternoon the plant whistle ble and an assembler had the relay assembled except she left the tip off the hole overnight, when she came back the next morning the coil would have absorbed enough moisture overnight, despite the fact that the moisture would have to creep through that small seal-off hole, the ice was there when Mr. Siegel received the relay.

ANSWER: MR. SIEGEL

I might add that vendors have come up with new and very unusual methods of getting that moisture in there. For example, they have bake-out chambers which are designed to vacuum bake-out 500 relays at a time, and when business gets too good, they put 800 in and if you are the first one in and the last one out, you are full of water.

QUESTION: MR. WENOLING and MR. THOMAS

Section XI of the NAVAIR advises against 3-phase load transfer, using relays with form C contacts, without interlocking. Has the state of the art advanced to the point where this classically accepted method can be discarded?

ANSWER: MR. THOMAS

I think the question was answered to the effect that if you can synchronize the devices so that the AC relays are not out of phase, then you can make the transfer make-before-break contact. Let us go back and find out what the utility companies learned when they got into power switching – and an aircraft is nothing but a miniature utility company with the same types of switching problems. What the power companies learned over the years is certainly available, if the engineers would take the trouble to look at the literature. The answers have all been solved long ago.

ANSWER: MR. WENOLING

Provided the relay is properly designed. I say that from the standpoint of barriers, et cetera.

ANSWER: MR. THOMAS

What Section XI properly cautions us against is just going about that without thinking and being very certain that you have the proper monitoring equipment. And pick a relay that has the 3-phase capability between poles and that there is provision for synchronizing the sources so that across the contacts they see no voltage differential for potential differences.

COMMENT: THE AUDIENCE

For unsynchronized forces you would not use the form C.

ANSWER: MR. THOMAS

Form C is a transfer which has a break. In other words, it is a break-before-make. I think it depends on what the application is.

If the man can stand the interruption of power – besides that, I have yet to find a military relay as a standard general purpose relay, with a continuity of transfer of contacts or Form D if the fact is worth anything. So they are bound to use form C or else they are going to use center-off or with two coils or some other variation. But they have to be sure that the relay in question has been tested adequately for the application in the manner in which it is going to be employed and for a sufficient number of cycles that it can be established that that relay has that capability.

If the capability is not listed on the detail sheet, it should not be used for applications for which adequate additional testing has not been conducted either by the manufacturer or by the user in his application. Just because it works on a breadboard for a couple of hours is no criterion that this will work beautifully from there on in.

ANSWER: MR. WENOLING

I think what Mr. George Neyhouse is essentially asking is that: Will the form C design relay perform the functions of power transfer? (Ed. Note: Mr. Neyhouse is with Defense Electronic Supply Center, Dayton, Ohio and was a principal speaker at THINK-IN NO. 1.)

ANSWER: MR. THOMAS

There are relay companies who are making it.

ANSWER: MR. THOMAS

There are a set of relays which are commercial at the moment, but I think the military is considering some where they have spread the normally open contacts far enough apart that even when the power supplies are out of synchronism, it will transfer. This is one of the reasons that transfer rating has been added to the detail sheet of the MS drawings and that is why 5757 has included the transfer test. But as yet, I do not believe there are any detail sheets that are proposed; are there, Mr. Neyhouse, that you know of?

But at least 5757 included the test both for 3-phase in the E Revision and the transfer between unsynchronized AC sources. They are now alerted, hopefully, and I hope the press members here will take this down, that this is a potential problem and that if you are going to have that type of application, be sure that you have adequate test data either of your own or the manufacturer's and hopefully he did not make it up at his desk, that a relay will do at the voltage and power factor that you want to use.

QUESTION: MR. GWYN

Running a 2 ampere load, we have encountered a black carbonaceous growth (feathery bridging) between contacts or contacts and case after 60,000 plus operations at 50° Centigrade.

Do you have any idea of the origin of this problem and corrective measures that may be taken? This does not exhibit a problem at loads less than 1/2 ampere.

ANSWER:

I think the person who addressed that has already talked with me. I told him if they send me a contact that has this on it, plus the circuit conditions, I think we can pretty well tell him what has caused it and what it is. There are so many different blackings, particularly for silver-based contacts, it might be sulfided or produced by half-a-dozen different agents.

In many cases we have found that there are solder fluxes that have been vaporized and deposit materials on the contact that you do not normally see, but show up under operation.

ANSWER: MR. THOMAS

MIL-R-5757 E is requiring, for the new designs, that they all be welded construction and include the tip-off and the reason is to avoid the contamination from solder flux.

ANSWER: MR. GWYN

I might add to that we have seen so many cases of solder flux contamination, even when people have used exhaust to remove the fumes and think they are not getting them on or between the contacts, the prevention of it is really something that should be of prime consideration either by using Coben solution or by mechanical means, et cetera. And some of the better relay manufacturers know it exists but are somewhat lax in taking corrective measures.

QUESTION: MR. BONNELL

What are the common arc-quenching methods for AC and DC relays?

ANSWER:

For DC, the commonest that I have seen used is just a simple diode with the proper PIV. This means that the coil terminals have to be polarized.

Some AC relays have coils which are essentially DC coils with a rectifier built into the relay. There is another solution for true AC coils; putting zeners back to back and this is about the best way to approach this. On DC, there are a good many cases where a capacitor/resistor network is used, but in this case the capacitor/resistor network would have to be tailored to the coil where a diode, as I have seen used, a standard diode for every 28 volt coil, and if the PIV is high enough so that any of the surges you would get from the diversity of coils would not break down the diode, then you are on safe ground, and you have satisfactory protection for your contacts.

QUESTION: MR. GWYN

Does bifurcation aid in prolonging contact life? If so, how much?

ANSWER:

I think that subject has been pretty well covered by statements made by our speakers today. About the only thing we can do is if one contact has a little higher resistance than the other, it might help by passing current more readily to the paralleled surface with the higher resistance.

ANSWER: MR. WENDLING

Again it depends on the design of the bifurcating contact. In reference to frequencies, for instance, as related to vibration and shock.

ANSWER: MR. THOMAS

There is one relay company that specifically makes aerospace relays where they have a bifurcated contact is such where the resonant frequencies of the two halves are different, and if they get a critical resonance for one, the other will be closed. But each half is rated for the full load. This is a case of redundancy for the sake of bridging this resonant frequency, but not for increasing its contact capability. It is for an increase in current continuity. All it does is give you a little more assurance that over the whole frequency span, one of those two halves will be closed all the time, so at least you have contact continuity throughout the frequency span.

QUESTION: THE AUDIENCE

Aren't these bifurcating contacts used in telephone circuitry rather than power circuitry?

ANSWER: MR. THOMAS

Let us define power circuitry. When I went to work for a railway signal company, I can tell you they were switching 115 volts for some years with bifurcated contacts and still do.

QUESTION: MR. SIEGEL

Could you provide more information on the Lockheed Crystal detection system for foreign particle contamination detection?

ANSWER:

The process is called PIND and you write to Sunny Valley, California. I have spoken to Mr. Ed Freiria about it numerous times. Lockheed is one of my customers so we are obliged to, if possible, use the technique. This is the reason I investigated it. I found it is useful and since they want it as part of the contract, and we like the business, we do what they want.

Write to Mr. Ed Freiria and he will send you all the information he has about the system.

There are a number of manufacturers that are implementing the PIND system right now. One of them is Teledyne on the TO-5 relay. There are a few other vendors that are implementing. We have found it looks good, so we will use it.

QUESTION: MR. BONNELL

In general purpose relays from 0 to 2 amps, is there any range of load currents that are definitely detrimental to contact life?

ANSWER:

Let us keep to resistive currents. As far as detrimental to life, I again would like to see a definition of what we mean as being detrimental. If a relay is called upon to operate in a minimum current area and it is not satisfactory for that area, there will be misses occurring, but this will not necessarily limit contact life, per se, because it depends on how you define life.

If life is to the first failure, then it has been definitely limited. But if life is over the period of usability of the relay contacts, then it will not be affected. If the relay is properly selected for the load used, I would say there is no particular low level load that is detrimental to the life of the contact.

QUESTION: MR. BONNELL

What is the lowest value of contact resistance that can be obtained in general purpose relays in a 0 to 2 ampere range?

ANSWER:

That is a good question. Right now the general purpose relay, about the only one where you can get a really low level is in a common, ordinary button, round contact surface with the proper materials. And there you can expect nothing less in a new relay than 50 milliohms.

If some manufacturer would build a good wire spring relay, we might be able to do some business with them in a hermetically sealed case for the military usage, I might add.

QUESTION: MR. GWYN

How useful will the Contact Analyzer presently being manufactured by 3M be in contact evaluation? This instrument was developed by Burndy, and is capable of separating the real contact resistance from the bulk resistance.

ANSWER:

I have to admit I know nothing of it.

ANSWER: MR. SIEGEL

I was going to use that as a basis to answer the question that Mr. Bonnell answered. The actual contact resistance that you get, for example, in a crystal can relay where you could measure 16 or 18 milliohms, the actual contact resistance is very small. It is in the neighborhood of 4 or 5 milliohms. The balance is in the bulk resistance, the resistance is the contact to your arm, the arm coming down through your glass.

Burndy has come up with the system. They bring it up to the point where there is a weld taking place, and at that point, whatever their reading, is the exact contact resistance. They have actually negated all the bulk resistance and they are only reading the resistance at the interface and it is amazing.

Yet, if you take the same relay and run it up, and if you try to do things to carbonize the contacts and you run it back on the Burndy tester – (originally Burndy had given a contact to the George Risk Company to make the first five units) and if you took it and put it back on this checker, you found that your contact resistance was now up to about 14 milliohms, and if you measure, you add 14 to the 11 and you still get the same contact resistance.

The bulk resistance is a majority of the initial contact resistance that you measure. At a failure, it is not, assuming that you have not had any mechanical break between a contact and a pin internally, when you measure a contact resistance, it is a misnomer, it is actually the entire resistance of the terminal line, the junction to the contact, the contact interface, the junction to the contact and the terminal line again.

QUESTION: MR. GWYN

What are typical materials used in Reed switches where contacts provide mechanical spring action for separation of contacts and magnetic attraction for closing actions? What kinds of problems have been experienced, particularly in relation to welding of contacts in low current applications?

ANSWER:

Let us take the first part of that. Here again it would depend on the maximum current and the voltage, if you are going to handle interrelays. The normal use of the materials will vary depending on the partular type of relay from fine silver up through soft gold and precious metals, or whether they are going to handle some types of surge currents, they even use tungsten which has been given electrolytic cleaning.

QUESTION: MR. GWYN

What kinds of problems have been experienced, particularly in relation to the welding of contacts in low current applications?

ANSWER:

Most of it may be welded by fritting actions such as what is shown on the slide or somehow vibrations that were set up to cause the fases of the materials to interlock. You will not get a welding unless you mean a full electrical welding where you might get it through shorting.

QUESTION: MR. WENDLING or MR. THOMAS

Is an RC suppression network across a set of contacts a suitable and economical means of reducing transients developed by a 115 VAC or 230 VAC, 500 W inductive load? Are there any good general formulas for determining the resistor and capacitor values used in a suppression network described above?

ANSWER: MR. THOMAS

I do not know, myself. I think Mr. Charles Schneider (Bell Telephone Laboratories, Holmdel, N.J.) made an awful lot of studies about RC. Prior to the diodes, RC, for the telephone industry, was the only way they know how to make arc suppression and the Telephone Company does have formulae for making calculations.

QUESTION: MR. SIEGEL

What is the most widely used and most reliable method of nondestructive relay testing?

ANSWER:

They are not compatible. Most people specify electrical parameter group "A" to make sure that garbage does not get through their front door. Let us say it does increase the reliability because there are certain safety factors inherent in your own specifications for initial parameters, and even if there is no degradation in your initial equipment, this will probably operate and therefore you have inherent safety factors when you do check for initial specifications.

I do not consider this reliability testing. Most manufacturers will give you test date for $.50 or $.40 a relay so that is why most people ask for it. Once you jump the gap from there to any reliability testing, you are talking money, and unless your program should warrant the expenditure, most people do not do it.

The next type of test would be a run-in, but do not be fooled in running-in of a relay at dry circuit, unless you have a dry circuit application. Every vendor will try to sell you this because they have loads and loads of dry circuit testers. But if you have a minimum current application and he runs them in for you at dry circuit, he is telling you you have a better chance of passing than if you did not run them in; but that is not the guarantee that you think you are paying for.

If you have a minimum current test, let him run it at minimum current; and if you have a dry circuit application, run it at dry circuit.

ANSWER: MR. THOMAS

Just to go on with that, proof of being able to run it full load and at minimum load is no indication of a capability at the intermediate load which is what Mr. Siegel just said. So the manufacturer says, "We have the most beautiful set of 'mistest' data and we have the most beautiful test data at 2 ampere loads."

And he says, "Yes, sir, what about minimum current?" They do not have any data, and they cannot pass it.

QUESTION: DIRECTED TO ENTIRE PANEL

What is present availability of solid state relays? What performance can be expected from available SSR's with respect to "off" resistance, acceptable contact voltage range, throw to throw isolation in SPDT devices, and RFI generation?

ANSWER: MR. WENDLING

First of all, I think I clarified the question in the relationship as with respect to the Naval Air Systems requirements at this point. I cannot divulge or discuss that which may be beyond the Naval Air Systems' requirements or Airborne Systems. I know of none at this point utilized and available to us. They may be in a subsystem relationship, but I speak only from the electrical viewpoint, because my primary responsibility is directed to and a part of electrical systems.

I can say that I am working toward the utilization of solid states in aircraft electric systems which is known as the SOSTEL program. To expound on that, and if I get started, it can last for two solid hours as happened last evening. I would be glad to discuss the subject with anyone. The items being developed, as we recognize them, are not solid state relays. They will be multifunctional units called power controllers, because they will be located in this system between the utilization equipment and the power control centers, between the subsystem interface, and the bus. These will function as multifunctional power, solid state devices to perform as we know it today to function as protective devices, known as today's relays, relays, circuit breakers, and current limiters. We are in the process of developing these items. The program is still in the exploratory state. We hope, if successful, to go into advanced development in the '71 fiscal period.

But other than that, to imply that there is a development of solid state relays, per se, for airborne use at this time, I can only say there is a project to develop a general specification for solid state relays. The preparing activity for this project is the Naval Electronics Systems Command. Mr. George Neyhouse at DESC (Defense Electronic Supply Center) has been designated agent for the formulation and coordination of this document. I think the intent here is to identify these relays to perform the functions which today's multipole relays perform.

COMMENT: INTERLOCUTOR

I suggested that if anyone wishes to contact Mr. Neyhouse, he do so after this meeting or call (513) 252-6551, ext. 5830. Are there any more questions.

ANNOUNCEMENT:

We thank you for attending THINK-IN #2, here at the Sheraton Inn at LaGuardia.

Before we bring this seminar to a close, Mr. Thomas has provided us with a 20 minute movie on the Interagency Data Exchange Program (IDEP) and how it works for military parts. We will now view this movie.

Please Note: Mr. L. W. Wendling's comments and opinions are solely his own and should not be construed as official U.S. Government information.

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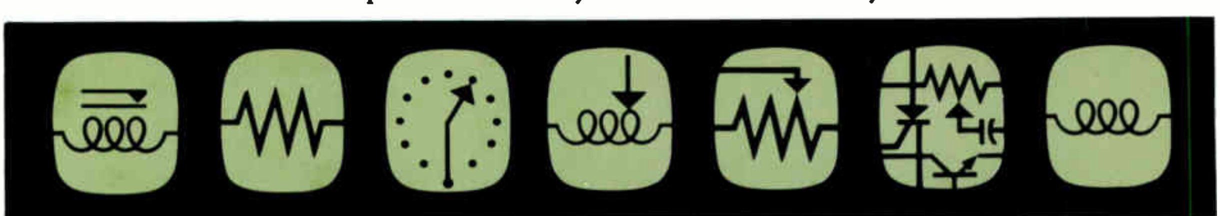

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an exchange of ideas about
Relays and Related Devices

OHMITE

think-in report

Seminar III
International Hotel
Los Angeles, California
February 18, 1970

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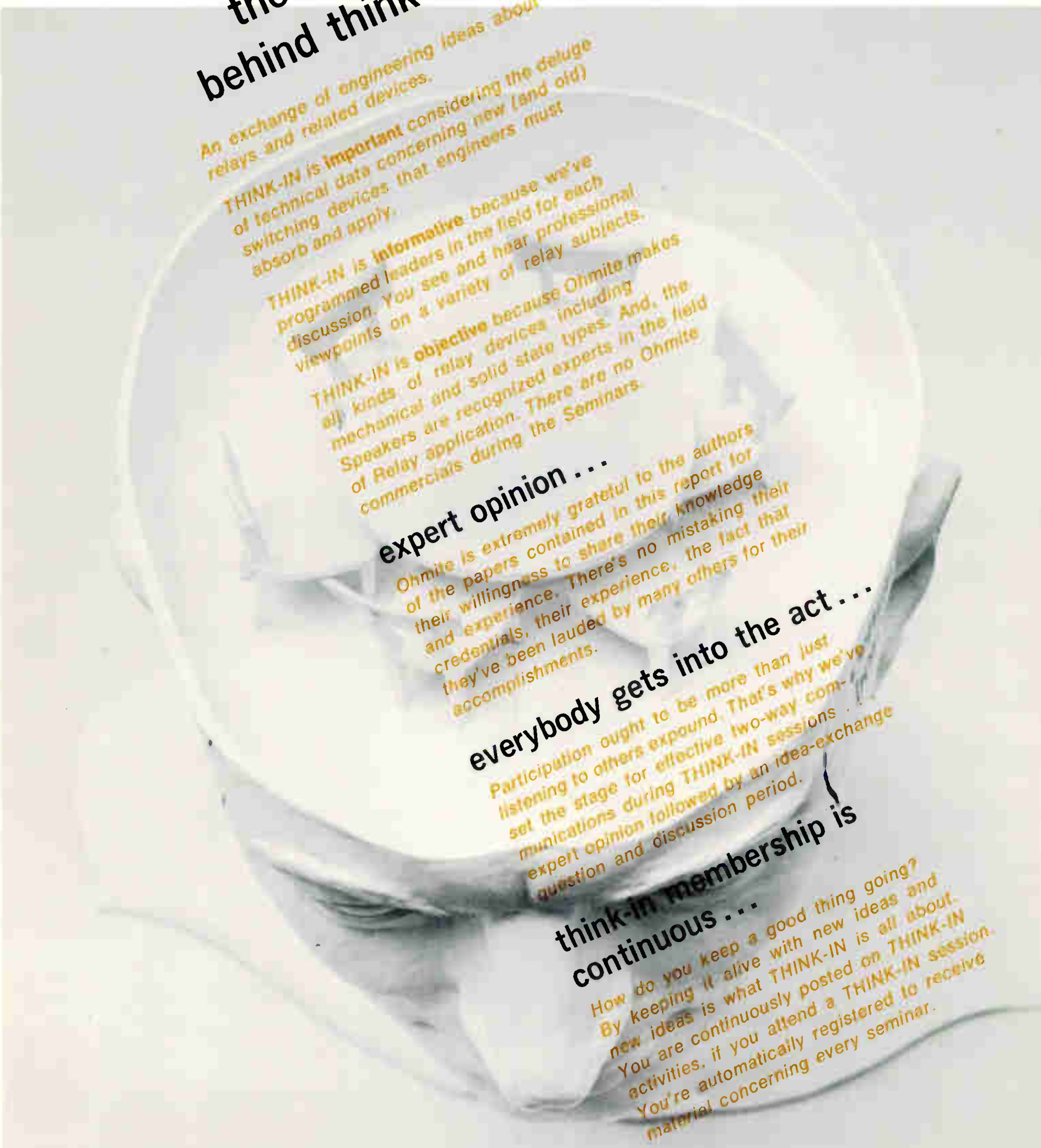

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BASIC RELAY CONSIDERATIONS

By Rudolf Steiner, Member of the Technical Staff, Space Division
of North American Rockwell Corporation, Downey, California

ABSTRACT

Because of the apparent need for continued improvement in relays, especially electromagnetic relays, the history and present situation of relay operations are reviewed. With the objective of determining realistic performance requirements, a discussion is presented of relay contacts, terminals, structures, and enclosures. Particular emphasis is placed upon the basic considerations and natural laws which are expected to govern sound design. In addition to specific recommendations for performance improvement, various future actions are compared with the advantages that may be gained.

INTRODUCTION

It is reasonable to assume that the first need for a relay and the first construction of such a device occurred at the time of the first long-distance telegraph operation, approximately 100 years ago. Mounted firmly on a sturdy support, these relays had to meet only two requirements: to close a local circuit when energized and to open a local circuit when de-energized.

Since that time, requirements have changed considerably. Contemporary relays are expected to perform as contact switching circuits, directional sensors, timers, circuit breakers, and other devices. In contrast to these ever-increasing demands, relay construction has changed but little and the applicable physical laws not at all.

This paper reviews the basic relay concepts, discusses the extent of change between modern requirements and the earlier basic ones, and offers an opinion on the merit of these changes.

CHANGING REQUIREMENTS

The relay requirements that have undergone considerable change include the following:

1. A tremendous increase in relay usage; relay types; and relay operating speed, cycling, and life requirements
2. Mass production
3. Size reduction and miniaturization
4. An increase of contact loads toward heavy power
5. Reduction of contact loads to "dry circuit conditions"

6. Response level requirements

7. Sensitivity

8. Resistance to environments

Most seriously affected by these new demands, although not necessarily in this order, were the following relay elements: contacts, terminals, structures, and enclosures. These elements will be discussed in the following paragraphs.

SELECTED RELAY ELEMENTS

CONTACTS

The contacts are expected to make, break, or maintain an open or closed circuit dependably and for a specified number of operations.

Contact Design

Contact operation, especially contact separation on circuit breaking, constitutes a transfer of electric energy from the formerly closed circuit to the opened contacts. This requires that the contacts be in a position to absorb and dissipate this energy without ill effects to themselves or to the circuit. This necessitates contact points having the adequate coefficient of heat transfer and, especially, the correct mass to absorb, temporarily, the energy in the form of heat until it is dissipated through convection and radiation. The coefficient of heat transfer is given when the contact material is selected, and the mass can be readily calculated from the basic equation of heat transfer. Any reduction in this mass will result in contact destruction. Modern design trends toward miniaturization produced contact dimensions incapable of the required heat transfer. This resulted in unsatisfactory contact performance. To compensate for these deficiencies, relay manufacturers attempted to determine the capabilities of these undersigned contacts through extensive and costly testing. It is obvious that several contact configurations passed these tests successfully. It may not be obvious, however, that a marginal performance situation resulted which is responsible for failures experienced in actual service.

It is remarkable that the contacts continue to present considerable problems, because a widely recognized book, **Electrical Contacts** by Ragnar Holm, appears to offer cures for all of the evils. The fact that the problems have not been solved indicates that additional efforts are required if dependable contact performance is to be attained.

Contact Condition

Experience has shown that contact wear and contamination cannot be prevented even when the greatest care and precautions are taken during relay manufacture. The sealed relays required by most specifications preclude observation of contact deterioration. Contacts are usually expected to perform satisfactorily in varying amounts through several million cycles. No other piece part is required to accomplish this without the benefit of periodic inspection or servicing. Sealed relays make this impossible.

Another requirement, not yet fully recognized, is that specific contacts shall work only once and then after an extended period of relay inactivity. There are also numerous relay applications where the relay contacts may never be called upon to operate although they are connected to an otherwise active system (for example, those in a fire alarm circuit if no fire occurs). The contact condition at the time of need is of equal significance in these two cases.

Contact Rating and Data

The customary contact data include information on resistive, inductive, motor, and lamp-load parameters required for the testing of contacts. These tests are scheduled in that order. In actual service, however, these conditions may occur at the same time in a random sequence, or starting with the most severe service variety. Each of these possibilities can seriously affect the relay contacts and their performance in an unpredictable manner with respect to the subsequent contact operation types

Contact Capacity

The designation "relay" may be applied to a wide variety of devices ranging from miniaturized versions to heavy-duty types. No official, nationally standardized line has yet been drawn between the two rating extremes. Although the heavy-duty relays are sometimes correctly called "contactors," the dividing line is not distinct. The question arises: will a differentiation contribute anything to relay identification? In the author's opinion, it will not.

TERMINALS

Relay terminals of conventional relays, especially those of multipole relays, can easily occupy more space than the relay itself. In the interest of saving space, therefore, many relay terminals are of marginal design and size. The miniaturization requirement imposed new restrictions on the size of terminals. The requirement was met by combining relay terminals with members carrying precisely positioned relay contacts on the other side of a fragile glass bead. Any excessive force or temperature applied to the terminals was transmitted to the relay interior, disturbing the delicate parts adjustment and causing operational failure.

In present practice, the wires are usually attached directly to the coil and contact terminals. This may be of concern with open-type relays having solder lug terminals, because the applied soldering heat may damage relay members.

Other relay types have terminals positioned on a relay base plate, remote from the respective current-carrying member and connected to it through flexible leads. This is a more desirable terminal construction.

Perhaps the most widespread relay terminal variety is that using a post within and bonded to an insulating bead. The bead, in turn, is bonded within a relay header opening. This type of terminal provides a simplified construction, especially for miniaturized relays. The unfavorable heat transfer characteristics of this terminal construction were discussed previously.

Specific miniaturized relays have become so small that relay sockets combined with terminals of practical dimensions have been made available. Since the space occupied by these sockets exceeds that of a conventional relay, all advantages of miniaturization are eliminated.

STRUCTURES

Various new operational requirements resulted in relay structures of greatly increased complexity. This converted the formerly rugged relay into a precision instrument demanding extremely careful handling during manufacture, shipment, storage, installation, and operation. Any negligence in these repsects usually results in relay shortcomings. If relay structures are to be functionally sound, they must occupy much of the space that is badly needed for the operationally required relay parts.

ENCLOSURES

General Practices

Relay enclosures serve primarily as containers for the relay structure and any gas that may have been used for its internal atmosphere. The vast majority of relay enclosures offer no protection or shielding against the electric or magnetic fields emanating from the so-energized relay members. This causes electric and magnetic interference among relays positioned adjacent to each other. In addition, the relays are adversely affected by the electromagnetic field radiations of equipment and cables located near them. Conditions of this kind can easily be misinterpreted as relay failures, because the factors causing these failures no longer act once the relays have been removed from the affected installation.

Present Practice

Frequently, the enclosures are used to carry the relay-mounting provisions, namely, a flange or one or more mounting studs. If the surface of the support to which the relay will be mounted is not flat, or if the binding nut for the studs does not have a true face, the relay enclosure may become warped. Internal clearances and other tolerances are very small (especially in miniaturized relays) and even those spaces are occupied with structural and insulating material. Consequently, any enclosure distortion is transmitted to the operational relay parts. This results in relay malfunctions which were not possible when the relay was tested in an unmounted position. Although failures of this kind cannot be attributed to the relay proper, the relay designer is definitely obligated to provide an adequate mounting provision.

Suggested Practices

For stud mounting, only one stud should be provided. In addition, at least one positioning pin should be provided to register with a corresponding recess in the support.

For flange mounting, the flange should be so designed that differential forces are compensated within the flange without being transmitted to the relay enclosure.

ELECTRICAL RELAY CHARACTERISTICS

This discussion is limited to the following electrical relay characteristics: pickup voltage, dropout voltage, minimum operating cycles, operate time, and release time. The general question applicable to all of these characteristics is: how essential are these requirements to the vast majority of relay operations?

Assuming that these five characteristics are associated with relays of conventional construction, one will observe that any one parameter value of one relay does not vary much from the corresponding value of another relay. The reason for this "togetherness" may be found in the fact that these values are the expressions of physical laws and conditions inherent in each such relay construction. Conversely, it seems absurd to toy with these physical factors merely for the sake of obtaining stricter requirements at tremendous cost.

Most relay applications require operation at or near the nominal system voltage and a dropout upon the completed circuit opening. Because both of these levels are far beyond the present pickup and dropout range, including its generous tolerances, a painstaking test for superficial values would contribute little. Comparable views can be taken of the operate and release time periods. The tricks required to alter these response periods usually result in only small changes which are not commensurate with the effort expanded.

The greatest extravagance or luxury is probably afforded the specification of minimum operating cycles. As was mentioned earlier, countless relays are expected to operate only once or twice, or perhaps not at all, during their useful lives. Nevertheless, they are required to pass tests in excess of tens of thousands of cycles. This appears unwarranted for such applications.

MINIATURIZATION

Several effects of miniaturization on the performance of relays were mentioned earlier. The remaining major consequences of miniaturization are the following:

1. Excessive heat development and emission
2. Reduced insulation distances and spacings
3. Loss of structural strength
4. Lack of marking spaces
5. Complexity of manufacture
6. Performance

HEAT DEVELOPMENT

The reduced surface of miniaturized relays offers a smaller cooling area than that of conventional relays. This, in turn, increases the development of hot spots and the possibilities of coil damage and material outgassing, followed by contact contamination.

INSULATION DISTANCES AND SPACINGS

Insulation distances and spacings have been reduced to such an extent that their insulating capabilities can no longer be determined by means of calculation. The suitability of the design can be verified only through testing.

STRUCTURAL STRENGTH

The reduced structural strength is of particular importance during transit and storage when the relays are handled by untrained personnel.

MARKING SPACES

Small marking spaces or the absence of such spaces requires separate labels, which may become lost. This can cause misapplications or erroneous connections.

COMPLEXITY OF MANUFACTURE

Relays have always been delicate devices. Miniaturization has increased the difficulty of manufacture, assembly, quality control, and inspection.

PERFORMANCE

Obviously, a miniaturized relay cannot be expected to negotiate electric loads in the manner of a rugged contactor. Further, it is not evident why a delicate relay should be expected to manage loads of undue complexity, such as inductive, capacitive, motor, or lamp loads. With but few exceptions, methods and arrangements exist which can rid circuits of the disturbing characteristics of inductive, capacitive, and inrush manifestations and reduce the load effect to that of a resistive type. It should be noted that the aforementioned principle can and should be considered in combination with relays of conventional dimensions.

CONCLUSIONS AND RECOMMENDATIONS

Relay contacts continue to cause concern. Serious consideration must be given to performance improvement in possible combination with the establishment of realistic contact load requirements and an operationally clean, transient-free system. Attention should also be given to dependable dry-circuit operation and to the possibility of contact servicing. Catalog information on contact ratings should be simplified to preclude both misinterpretations and misapplications.

Relay terminals appear to be vulnerable elements. They should not be exposed to excessive stresses of any kind when the relay is to be connected to the electric system. Comparatively long, flexible leads appear preferable to other methods, especially for miniaturized relays.

Because relay structure dimensions are limited to the space remaining between the functional parts and the standardized relay enclosure, the structures are adequate only for the operational stresses. They are usually not capable of withstanding abusive handling or the like. This situation should be indicated through a precautionary note attached to each such relay, and customer education programs should be conducted.

Relay enclosures should be adapted to function also as magnetic and electric shields. Enclosures should not be a part of the mounting bracketry. If this is unavoidable, any enclosure flexure upon the binding of mounting screws should be avoided.

The electrical relay characteristics given in conventional catalogs should be stated in a manner that will realistically present both the capabilities of the relay and the requirements of the user. Specialized relay characteristics should only be presented when requested, or when they contribute to the relay selection.

Once the desirability or necessity of relay miniaturization has been established, little can be done to adjust any adverse factors without the addition of new elements occupying additional volume or a reduction in test standards. For example, reduction of test standards contributed to the commercial success of electric watt-hour meters and small appliances. If these devices were designed to established standards, their dimensions would be prohibitive. The only other alternative would be to eliminate testing completely.

RUDOLF STEINER
Member of the Technical Staff
Space Division of North American Rockwell Corporation
Downey, California

Rudolf Steiner has been with North American Rockwell's Space Division since 1963. At present, he is a member of the technical staff of the Reliability and Safety Department. Before joining the Space Division, he was associated with the Electrical Division of the U.S. Naval Air Development Center, Johnsville, Pennsylvania; Struthers-Dunn, Inc., Philadelphia, Pennsylvania; and Heinemann Electric Company, Trenton, New Jersey. In the course of these activities, he acquired 13 domestic and several foreign patents on electro-magnetic relays and other electric system control and protection devices.

Mr. Steiner received a Master of Science degree in electrical engineering from the Technical State University of Vienna, Austria, and is a registered professional engineer of the State of New Jersey. He is a member of the Institute of Electrical and Electronics Engineers (IEEE) and the Austrian Institute of Electrical Engineers and president of the Aerospace Electrical Society of Los Angeles.

GUIDE LINES FOR THE APPLICATION OF SEMICONDUCTOR TECHNOLOGY TO ELECTRIC POWER DISTRIBUTION SYSTEMS

By Lee D. Dickey and Clyde M. Jones, Vought Aeronautics Division
LTV Aerospace Corporation, Dallas, Texas

SUMMARY

This paper presents an approach for applying solid state switching to aircraft electric systems. The systems approach presented separates signal switching requirements from power switching requirements and utilizes semi-conductor devices to perform the functions of switches, relays and circuit breakers. During the past ten years, these concepts have undergone laboratory and flight test evaluations to establish the feasibility of the systems approach. Recent studies have investigated the application of multiplexing techniques to the signal area.

INTRODUCTION

The trend in advanced high performance aircraft is toward more sophisticated missions which require much more complex electric and electronic systems. This complexity has exponentially increased the quantity of switches, relays, circuit breakers and wire required in the aircraft. Complex digital avionics systems require clean (transient free) electric power, thus adding emphasis for electro-magnetic compatibility and interface compatibility between all signal systems and digital computers. This increase in complexity and requirements for compatibility cannot be compensated for or fully met by existing electromechanical devices. Present electromechanical devices are the result of two decades of development toward miniaturization. This miniaturization without a comparable reduction in system voltage has resulted in electrical stress levels so high that it is extremely easy to misapply the devices. It is felt that major advancements must be made to achieve the progress that is necessary to optimize future aircraft, and these advancements cannot be made by use of conventional approaches and techniques. Therefore, a new approach must be developed to increase performance and reliability. The approach must simplify circuitry, combine functions, separate signal and power switching requirements and eliminate unreliable features of switching control and protection devices and circuit techniques.

Since very rapid advances have been made in the electronics field, especially in digital computers through the development and application of solid state switching techniques utilizing semiconductors or devices, it is evident that investigations should be made to determine the applicability of similar techniques to aircraft electric systems. The application of this technology to aircraft electric distribution systems, however, has been slow to catch on. The slow start can be attributed to the application approach that has generally been made. A number of solid state devices (relays and circuit breakers) have been placed on the market with the idea of providing a solid state device to replace an electromechanical device on a part-for-part basis. This approach has some obvious drawbacks when it is considered that in most aircraft electric control circuits, the switching logic is performed at the power level. Because of the voltage drop and power dissipation characteristic of semiconductor devices, this approach results in a very inefficient system and makes it impossible to meet the voltage drop requirements of MIL-W-5088 (Aircraft Electric Distribution System Specification) in many circuits. At this point many have concluded that solid state switching for power distribution systems is not practical; and if there were no other factors to be considered, this might be the proper conclusion. However, semiconductor devices have advantages such as high reliability, long life and small size which, if properly applied, can provide the urgently needed improvements in aircraft electric distribution systems.

Work was initiated in January, 1960, specifically directed toward the development of an advanced electric system for aircraft. This development effort has continued since that time through programs sponsored by the NAVY, AIR FORCE, NASA, and INDUSTRY. During these studies, a new systems concept and component specifications were developed. The list of references (page 31) gives the reports and previous papers presented on various aspects of this development effort.

DISCUSSION

The overall development effort toward an advanced electric system for aircraft has been given several names, such as "Contactless Switching," Solid State Switching, and SOSTEL (**SO**lid **ST**ate **E**lectric **L**ogic), but they all represent an application of semiconductor technology to the management and control of aircraft electric systems. The electric system gathers and displays information and distributes the flow of power to equipment. Figure 1 is a block diagram of an aircraft electric system showing the primary area of concern during this development effort. Figure 2 is representative of present electric systems and is presented to highlight the fact that logic functions are performed at the power level. The present systems are inherently heavy, require complex harness routing, and are growing larger and heavier with each new requirement. These systems require large quantities of power-handling, electro-mechanical devices which are subject to wear, create large voltage transients, have limited cycle life, and have low cycling rate. These systems do not lend themselves to automated checkout, thus creating complex checkout and maintainability problems.

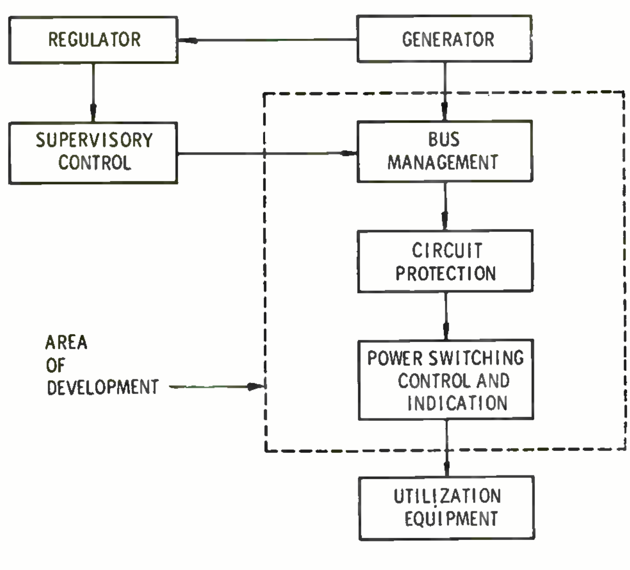


FIGURE 1 BLOCK DIAGRAM AIRCRAFT ELECTRIC SYSTEM

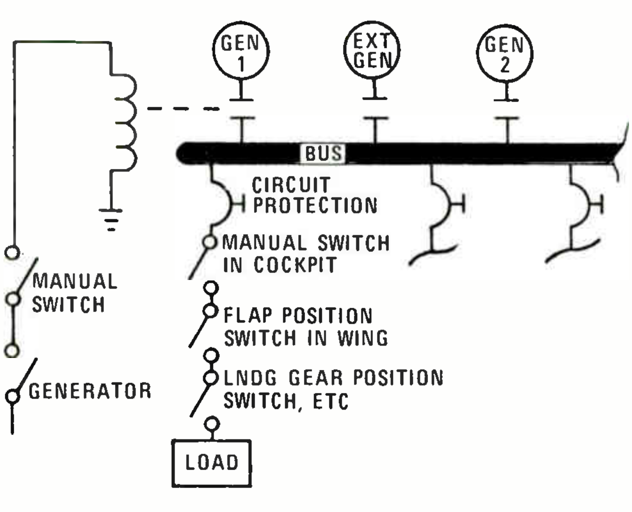


FIGURE 2 PRESENT ELECTRIC SYSTEM

The inherent advantages of the semiconductor devices and technology are high reliability, long life, high cyclic rate and small size. The major disadvantage associated with semiconductor components when used as power switches is the high voltage drop across the device even when operating in deep saturation. A voltage drop of 0.5 volt in silicon power transistors and 1.5 volts in silicon controlled rectifiers can be expected. This limits the number of components that can be connected in series if MIL-W-5088 is to be compiled with or if high power control efficiency is to be obtained. Since the complexity of many aircraft power control circuits requires the use of several relay contacts in series, the use of solid state relays in these circuits is not permissible. Also, electromechanical circuit breakers cannot protect solid state switching devices. Admittedly, the purpose of circuit breakers in the airplane is to protect the wiring only; but solid state relays, flashers, timers, etc., are much more likely to be destroyed as a result of an overload or fault condition than their electromechanical counterpart when operating under the same conditions. The objective of the development work was to determine how solid state switching techniques could be applied to aircraft power control systems to exploit the advantages of this technology. Studies werecentered on separating power switching from signal switching, and on switching power through a minimum number of semiconductor devices. This not only minimizes the voltage drop between the source of power and utilization equipment but also provides efficient power control, since power dissipation is held to a minimum. Low power dissipation means that less heat sinking is required and, therefore, size and weight are reduced.

A concept was developed which separates power and signal switching and utilizes solid state devices to perform all of the switching and circuit protection functions presently performed by electromechanical switches, relays and circuit breakers. This concept makes maximum usage of the advantages of semiconductor devices and minimizes their disadvantages. The solid state electric system shown in Figure 3 is composed of three basic building blocks, namely: (1) signal sources, (2) control logic (including bus monitoring and built-in test) and (3) power controllers (bus switching and load controllers). Signal sources are transducers which provide a digital output. They are used to sense controlling functions, such as temperature, pressure, mechanical motion, etc. Their output signals are fed into the control logic unit where they are correlated in a prescribed manner to provide a signal to control the power controllers. The logic switching is performed by standard integrated circuit NAND/NOR gates to provide maximum reliability with minimum space and weight.

The fan-out capability provided by multiple pole switches and relays is provided by the integrated circuits and is peformed at the signal level instead of the power level. This reduces considerably the number of wires needed to gather intelligence from the various controlling functions. Since the intelligence is gathered at the signal level, small size wire may be used, which further reduces system weight. The flow of power from the power sources to the bus and from the bus to the loads is controlled by power controllers. Separation of power switching and signal switching provides high system efficiency and makes it possible to meet the voltage drop requirements of MIL-W-5088 in all circuits.

Bus Monitoring

The flexibility of the system permits the incorporation of an automatic bus monitoring system which permits optimum loading on the source applying power. The limited capacity of any aircraft emergency source offers an excellent application for automatic bus monitoring. By assigning priorities to various loads in the airplane, it becomes possible to operate the emergency source at its optimum capacity. The emergency source must have the capacity to supply power to all the emergency loads, but in many instances the operation of an emergency load is not required. During these instances, automatic bus monitoring permits the pilot to operate some lesser priority load. If the emergency source is operating at full capacity with low priority loads operating, the selection of a higher priority load will automatically disconnect a lower priority load. Since automatic bus monitoring is performed by the control logic section, the system can be added with little size and weight penalty.

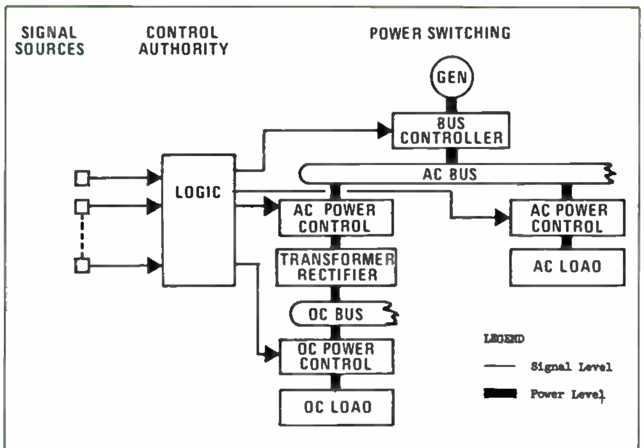


FIGURE 3 SOLID STATE ELECTRIC SYSTEM

Built-in-Test

A technique was developed to perform a preflight GO/NO-GO test on the low level portions of the system which are made up of the signal sources and data handling equipment. Bus controllers and power controllers are not checked by the built-in-test and are actually inhibited while the built-in-test is in operation. However, they are checked as part of subsystem functional checks.

The test is divided into four parts: logic, input buffer, signal source short and signal source open. These tests correspond to four positions of the rotary selector switch on the BITE control panel shown in Figure 4. When the control switch is in the FLY position, the BITE circuits are disabled and the bus power and load power controllers are enabled. Before each test is performed the reset button is depressed. At the start of each test both the GO and NO-GO lights illuminate. One of them will be switched off at the conclusion of each test. A digital indicator identifies the faulty signal source during the short and open tests and the faulty input buffer card during the input buffer test.

The logic test checks the logic circuits within the logic unit through all possible input combinations to see that they will perform their logic functions when required to do so. The input buffer test checks the input buffers to see that a signal will pass through them. The signal source short test checks for short circuits between the signal leads and the power and ground leads both in the signal sources and the logic unit. The signal source open test checks the signal sources output circuits. The built-in-test circuits are packaged as a part of the logic unit.

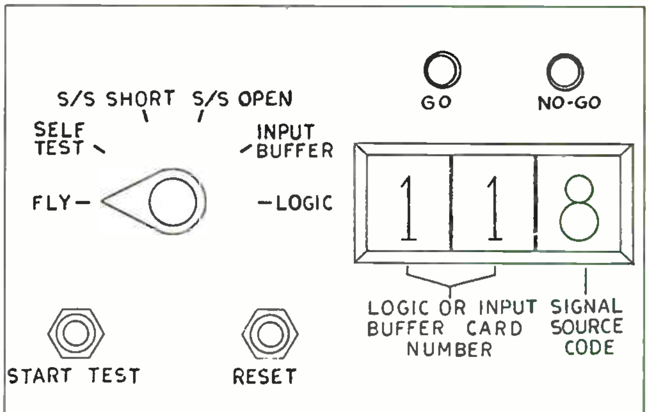


FIGURE 4 BITE CONTROL PANEL

Advanced Control Logic

Recent investigations have been directed toward the development of an advanced solid state electric system as shown in Figure 5. The control signal sensing and the power switching approach remain essentially unchanged. The change occurs in the method of handling and processing the control data. Under the advanced system concept, remote multiplexing input terminals are located in close vicinity to large groups of signal sources, thus allowing a significant reduction in the length of wires required to gather control information. These terminals monitor each signal source and upon command from the master control unit (MCU), code and serially transmit the status of each signal source through the multiplexing transmission data line. The MCU decodes the data from the input terminals, solves the Boolean switching equations according to instructions permanently stored within the memory and then transmits the coded output data over the multiplex data transmission line to the properly addressed remote output terminal. At each remote output terminal, the data are decoded and routed to the particular channel addressed by the MCU. The output of this channel is then hard-wired to a particular bus, load, or indicator power controller. The output signal remains constant, either high or low, until the next up-dating of that output by the MCU.

The MCU is the heart of the data handling system and controls the entire data handling process. It contains a non-destruct read only (NDRO) memory in which are stored all control instructions and the switching equation associated with the control of power to each individual load. The control instructions and equations are programmed into the MCU through a software program. Thus,

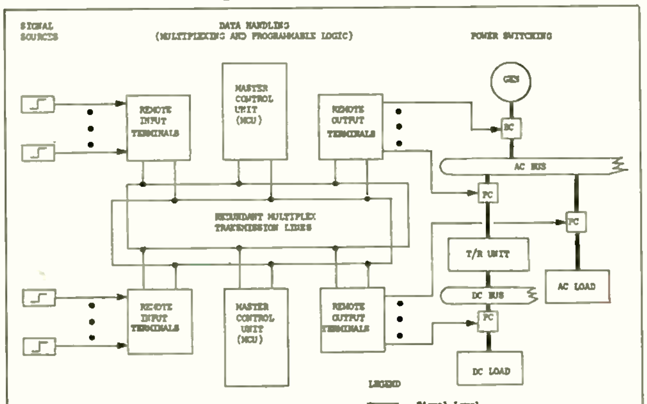


FIGURE 5 ADVANCED SOLID STATE ELECTRIC SYSTEM

changes in control logic can be accomplished by reprogramming the MCU with a paper or magnetic tape, thereby eliminating the need to make any wiring changes on the aircraft. For reliability, two (2) MCU's are to be used per system with one operational and the other in standby. Upon malfunction of the operating unit, the standby MCU is automatically switched into operation. The two MCU's are interchangeable. Parity check and monitor circuits are utilized within the MCU, thus providing a continuous built-in-test capability.

The remote terminals are totally redundant, circuit-wise, in each package. The remote terminals have been optimized at 64 channels each. The package configuration and circuitry of the remote input terminals are identical, thus these units are interchangeable. The same standardization and interchangeability exist for the output terminals.

The multiplex data transmission line consists of two pair of twisted shielded wires each forming a closed loop. Redundant transmission lines are used and routed separately from each other to improve system survivability and decrease system vulnerability. Each transmission line can operate either shorted or open. Under this concept, one transmission line could be totally disabled and the remaining line open or shorted, and the system would still be in operation.

The solid state electric system as previously shown in Figure 5 is composed of three basic building blocks, namely: (1) signal sources, (2) control logic (including combinational logic and programmable logic with multiplexing for load control and built-in test) and (3) power controllers (bus switching and load switching). The signal sources and control logic can be implemented by use of solid state circuitry that is in general use today with minimal development effort required. Requirements for the power controllers, however, are many times more severe and make the job of applying semiconductor technology a difficult one. Therefore, the remainder of this paper will be confined to the requirements and characteristics of power controllers.

Power Controllers

These devices must be capable of switching electric power in a system exhibiting MIL-STD-704 characteristics and be controlled on by a 5 volt 10 ma DC signal supplied by the control logic unit. The load switching power controllers are used between the bus and the utilization equipment to provide control, current limiting and circuit protection, while the bus switching controllers are used only to connect power sources to the bus.

These power controllers have the following operating characteristics:

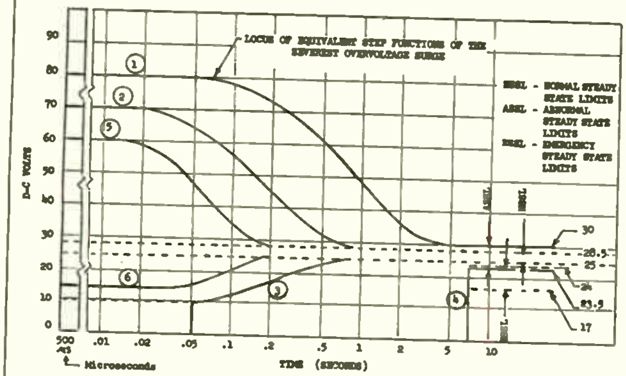
- Isolation between the control and the power circuits
- Operating efficiency of 95% minimum
- Voltage drop .5V Max DC, 1.5V Max AC
- Leakage current: Device rating X 10^{-4} amp at max temp
- Operating temperature range of -54°C to +85°C
- Require no external power supply

Providing the capability for the power controller to operate with variations in the aircraft bus voltage level is the major problem. Notice in Figure 6 that the voltage level is allowed to swing between 10 vdc and 80 vdc and in Figure 7 that the AC voltage is allowed to swing between 60 vrms and 180 vrms. The AC units must also control loads with a power factor between zero lagging and .4 leading as shown in Figure 8.

DC Load Power Controller

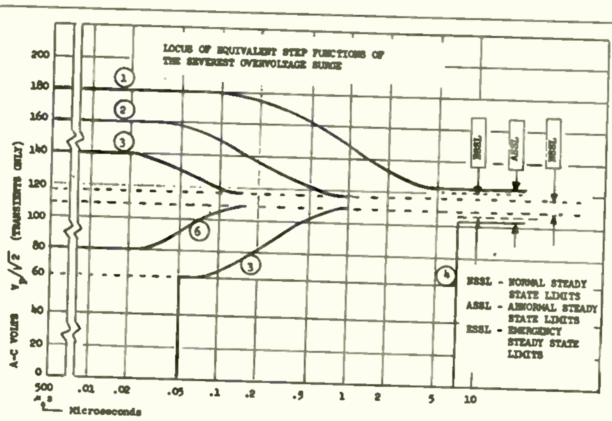
The DC power controller contains a power switch, a regulator, a driver and circuitry for current limiting and circuit protection as shown in Figure 9.

Power Switch - The power switching element is an NPN silicon power transistor. This power transistor must have sufficient voltage rating to withstand MIL-STD-704 voltage transients and sufficient power dissipation capability to provide low thermal gradient during normal operation.



TRANSIENT SURGE DC VOLTAGE STEP FUNCTION LOCI LIMITS FOR CATEGORY A EQUIPMENT
FIGURE 6

NOTE: THIS IS THE SAME AS FIGURE 8 IN MIL-STD-704A, DATED 9 AUG 1966.



TRANSIENT SURGE AC VOLTAGE STEP FUNCTION LOCI LIMITS FOR CATEGORY A EQUIPMENT
FIGURE 7

NOTE: THIS FIGURE REPRODUCES THE INFORMATION IN FIGURE 2, MIL-STD-704A, DATED 9 AUG 1966.

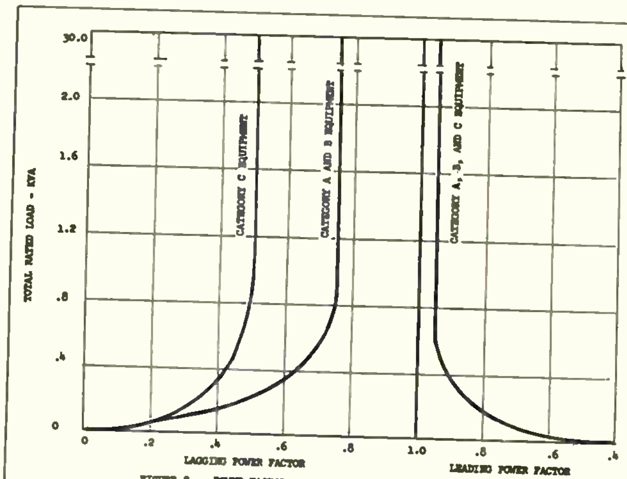


FIGURE 8 POWER FACTOR LIMITS FOR UTILIZATION EQUIPMENT

NOTE: THIS IS THE SAME AS FIGURE 12, MIL-STD-704A, DATED 9 AUG 1966.

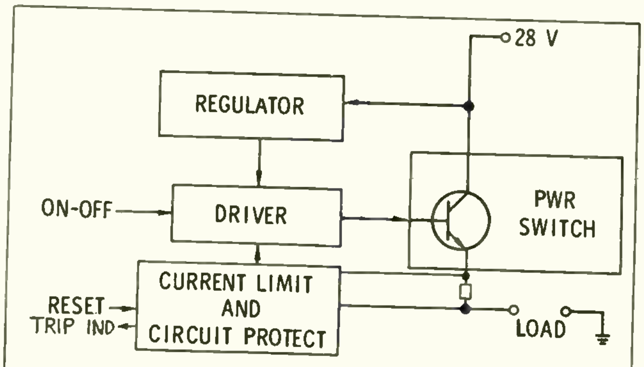


FIGURE 9 DC LOAD SWITCHING POWER CONTROLLER

Regulator - The internal regulator is used to provide a buffer effect so that the voltage to the internal circuitry is independent of the bus voltage variations. A zener diode and resistor may be used for low current power controllers, but a shunt regulator consisting of a zener diode, transistor and resistor must be used to provide better packaging efficiency for the higher current units.

Drive Circuit - The power transistor must be driven deep into saturation if the voltage drop and power dissipation are to be held to a minimum. This requires a large base current which typically is one tenth the load current value. Also, the base-to-emitter and base-to-collector junctions must be forward biased for saturation. A DC to DC converter is used to provide signal to load isolation and the voltage necessary for saturating the transistor. This concept will permit switching power to the load at efficiencies in excess of 95%.

Current limit and circuit protection - There are two reasons for incorporating these features into the unit: (1) to protect the unit itself and (2) to protect the circuit it is controlling. The power dissipated in the switching transistor is held to a minimum during normal operation by providing the proper base drive current to cause the transistor to be saturated and thus have a small voltage drop across it. During overload, short circuit, or voltage transients, the load current tries to increase, thus causing the transistor to fall out of saturation and increase the power dissipation. Since the input voltage cannot be controlled by this device, current limiting provisions must be incorporated to hold the power dissipation within limits that will prevent the temperature of the semiconductor junction from rising above its rated value under conditions of maximum voltage on the input and short circuit on the output. Figure 10 shows the current limiting characteristics specified for the DC power controllers. Notice that at rated voltage (29 vdc) the current is limited to 100% rated for a short circuit on the device output and to 130% rated for an overload $\frac{R1}{R_{Rated}} \geq .667$. This characteristics is called fold back and is incorporated to provide current values greater than

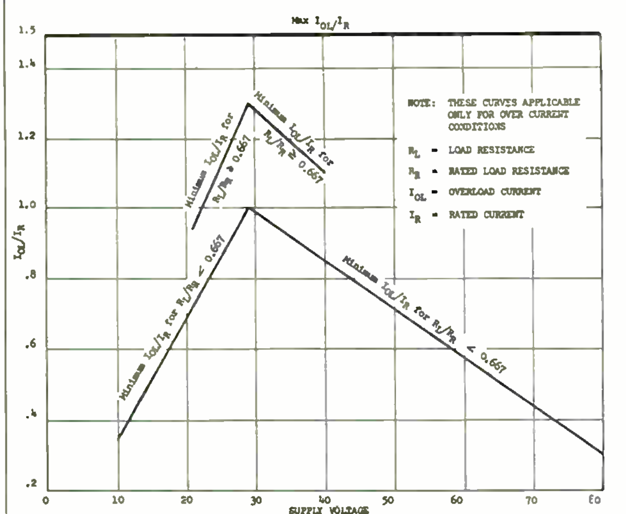


FIGURE 10 OVERLOAD CURRENT LIMITING CHARACTERISTICS OF DC POWER CONTROLLERS

rated for starting surges, yet allow current reduction to protect the switching transistor during circuit protection action (current limit and trip out). Since it would be impractical to design the power controller to be able to dissipate this large amount of power on a continuous basis, a trip-out circuit is provided. The trip-out time must be long enough to prevent nuisance tripping when using a MIL-STD-704 power source (see Figure 11). When a transient condition exists for a period longer than the trip-out time, the power switch is turned off and a trip indication signal is provided. Remote reset is accomplished by application of a 5 volt 10 ma signal (reset) from an external source. Notice that at 29 vdc, the trip-out time may be between 1.0 and 3.0 seconds.

One other difficult requirement to meet is that of the ±600 vdc spike voltage of MIL-STD-704 (Figure 12). This requires special attention to both input and output terminals of the device.

AC Load Power Controller

The AC power controller contains a power switch, a power supply, a driver, circuitry for zero crossover turn-on, current sensing and circuit protection as shown in Figure 13.

Power Switch - The power switching elements are back-to-back silicon controlled rectifiers (SCR's). SCR's are ideally suited for this application since they are automatically commutated "off" by the alternating line voltage. The voltage drop of SCR's is higher than that of saturated power transistors, but this is not serious where the supply voltage is 115 volts. The primary requirements of the SCR are that it has sufficient voltage rating to meet MIL-STD-704 voltage characteristics and an I^2t rating to withstand the high fault current that can be obtained in the generating system. As an example, in a typical 20 KVA system, fault currents with 350 Amp sec. valves per phase have been recorded.

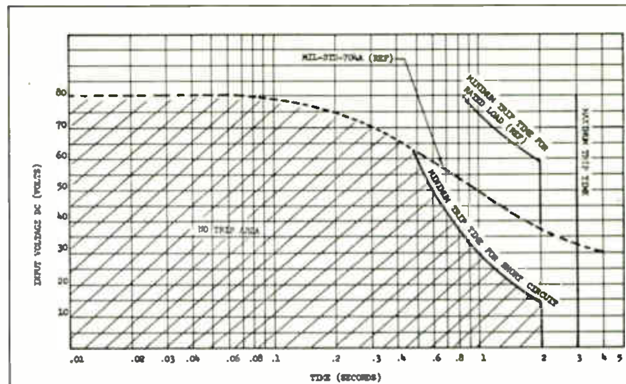


FIGURE 11 TRIP CHARACTERISTICS FOR SHORT CIRCUIT AND/OR OVERVOLTAGE FOR DC POWER CONTROLLERS

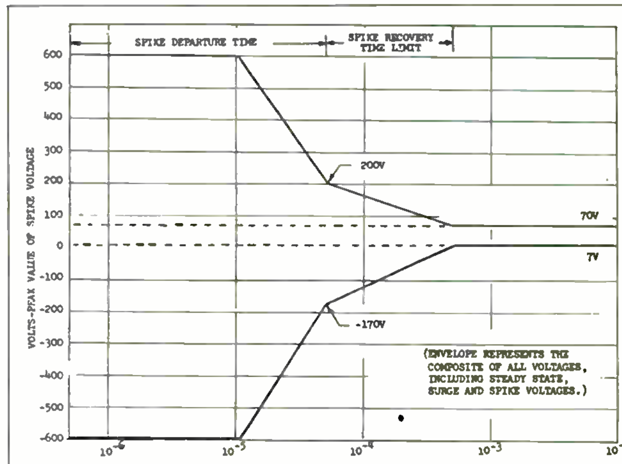


FIGURE 12 ENVELOPE OF SPIKE VOLTAGES FOR DC EQUIPMENT

NOTE: THIS FIGURE REPRODUCES THE INFORMATION IN FIGURE 17, MIL-STD-704A, DATED 9 AUG 1966

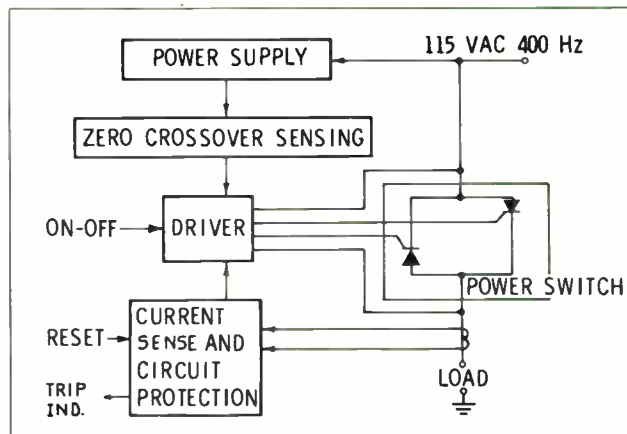


FIGURE 13 AC LOAD SWITCHING POWER CONTROLLER

SCR;s rated for 35 Amps rms, have an I^2t rating of approximately 85. Therefore, very large chips must be used or external protection provided by a device such as a crowbar on each phase of the bus. The present plan calls for a crowbar circuit which will sense bus current and turn on when the current approaches 200 Amps, peak, and divert the excess current to ground; thereby allowing the use of an SCR chip rated at 35 Amps, rms, in the load power controllers. SCR's also have low leakage currents (1.0 milliamp and less) in the off condition which enhances their usefulness for power switching circuits.

Application of AC power controllers is limited by the one half cycle current rating, particularly in systems using conventional generators because of their high transient current capacity. Use of these devices with variable speed constant frequency (VSCF) systems is not limited because the amplitude of transient current is readily controllable.

Power Supply - A power supply is required to provide regulated DC excitation for the driver, current limit and circuit protection circuitry. The power supply consists of a transformer, full wave rectifier, filter and series regulator. This power supply prevents line transients from affecting the internal circuitry.

Drive Circuit - To provide isolation between the control circuit and load circuit as well as power transfer efficiency, a DC to DC converter is used. This concept also provides a continuous gate signal to the SCR's, thereby ensuring SCR triggering for any load power factor during steady state operation.

Zero Crossover Sensing - Zero crossover sensing is required for zero crossover turn-on. The output of this circuit commands the driver circuit to turn-on at zero crossover for starting loads that are within the rating of the device.

Circuit Protection - As in the DC load controller, circuit protection must be incorporated into the unit to protect itself as well as the external circuit. SCR's do not inherently limit current as do power transistors; therefore, it is essential that circuitry be incorporated to provide time current sensing and trip out to protect the SCR's and to switch incandescent lamp loads which have very high starting currents. The time duration should be long enough to prevent nuisance tripping as a result of line transients (see Figure 14) or turning "on" into rated lamp loads. This can be accomplished by sensing load current, actuating a control circuit which determines the time before trip-out. Once tripped out, the device can be reset by applying a reset signal.

Bus Switching Power Controller

The bus switching controller performs the function of a relay only. Transformer rectifier units are used to provide DC power in many systems; therefore, only AC units will be presented. The AC bus switching power controller block diagram is identical to that shown in Figure 13 except it does not contain the current limiting and circuit protection circuitry, but it does include a lock-out feature that is not included in the AC load controller. High current SCR's are used; therefore, I^2t ratings will not present a problem. Circuit protection need not be incorporated since circuit protection is provided by the load controllers which are connected between the bus and the loads. The system concept utilizes a single bus which makes it imperative that no two unsynchronized sources be connected to the bus simultaneously. This feature can be designed into the logic, but a latching circuit within the bus power controller provides added protection. The design concept for low distortion and zero voltage crossover turn-on is basically the same as for the AC load power controller.

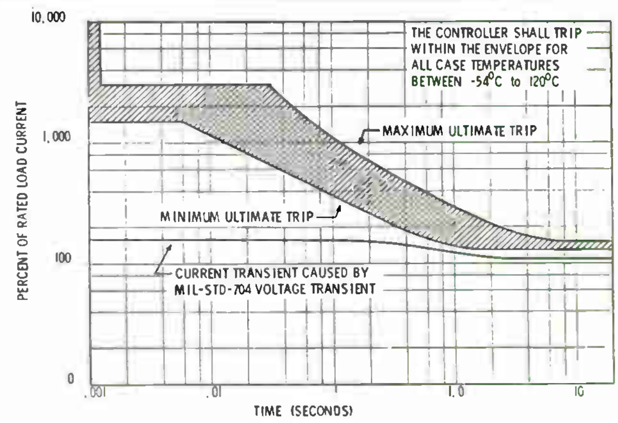


FIGURE 14 TRIP CHARACTERISTICS FOR AC POWER CONTROLLERS

Package Design

Although packaging efficiency is an important factor in determining the size of the power controller module, the power dissipated within the module is of utmost importance. To prevent the junction temperature of the devices within the module from exceeding their maximum ratings, the heat generated within the module must be conducted away. The low current ratings will present no problem, but the high current devices must be attached to an external heat dissipator. Since the junction of the main switching device (power transistor and SCR) is most critical, the

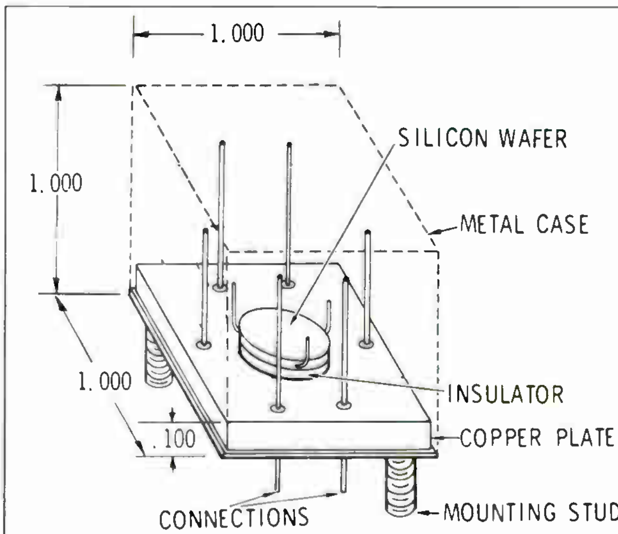


FIGURE 15 LOAD SWITCHING POWER CONTROLLER

thermal resistance between this device and the module surface must be low. To obtain a small package size, integrated circuits, transistor and SCR wafers, and thin-film techniques must be used (as shown in Figure 15). The objective is to minimize weight by letting the system designer handle the power controllers as he would a power transistor and provide heat sink as required for the particular application. Since most of the controllers will be used for loads which require current values less that the rating of the device, the heat sink may be sized according to the load.

CONCLUSION

Aircraft electric systems designed utilizing the advanced solid state system approach offers many advantages over those designed utilizing conventional approaches. Some of these are: higher reliability, longer life, lower maintenance, environmentally rugged, higher versatility, lower weight and volume, simplified system design, electromagnetic compatability, improved fault clearing capability and lower cost. These advantages are emphasized by the results of a study made for the A-7 in which conventional and solid state systems approaches were compared. It is evident from the data shown in Table I that the solid state system provides significant improvements to aircraft electric systems.

TABLE I

COMPARISON OF ELECTRIC SYSTEMS
(A-7 AIRCRAFT)

	CONVENTIONAL	SOLID STATE	CHANGE
WEIGHT	576 LB	315 LB	45% REDUCTION
VOLUME	2756 CU IN	1500 CU IN	45% REDUCTION
RELIABILITY (FAIL/10^6 HR)	498	116	77% REDUCTION
MAINTAINABILITY (MMH/FLT HR)	.01407	.0028	80% REDUCTION

CLYDE M. JONES
Senior Specialist, Electrical Electronics System
Vought Aeronautics Division, LTV Aerospace Corp.
P.O. Box 5907
Dallas, Texas 75222

Mr. Jones is responsible for all R & D activities of the Electrical and Electronic Design Group. Vought has been engaged in study and development programs for applying solid state switching technology to aircraft electric systems since 1960. During these programs which have been sponsored by Vought, Naval Air Systems Command Air Force Aeropropulsion Laboratory, system concepts and proposed military specifications have been developed. The Electric Power Management System defined for advanced aircraft utilizes solid state bi-level switches, data handling (including electrically reprogrammable memory and multiplexing) and solid state power controllers.

Mr. Jones is a member of the A-2K Multiplexing Committee of SAE and consultant to the Power Distribution, Conditioning and Control subcommittee of IEEE.

L. D. DICKEY
Supervisor, Electrical and Electronic Design
LTV Aerospace Corporation
Unit 2-51727
P.O. Box 5907
Dallas, Texas 75222

Since 1963, Mr. Dickey has been responsible for the supervision and technical management of all design and research and development activities of the Electrical and Electronic Design Group.

Between 1951 and 1963, Mr. Dickey was responsible for the design, coordination and installation of electrical and electronic systems for the F-8 (Crusader) airplane. He was Lead Design Engineer responsible for the electrical design effort on an advanced space glider. For four years, he was Lead Design Engineer for R & D programs and had technical responsibility for all research and development programs of Product Design. Mr. Dickey earned his B.S. in Electrical Engineering from Texas Technological College, 1951. He is a member of the A-2R Relay Committee of SAE; Chairman: Power Distribution, Conditioning and Control Sub-committee of IEEE.

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SCREENING RELAYS FOR CONTAMINATION

By **Howard V. Rode**, Member Technical Staff, Space Division
North American Rockwell Corporation

ABSTRACT

There is now no single universal method for detection of all contaminants within the container of a hermetically sealed relay.

Several available methods are described briefly, and results of a study, Programmed Random Vibration Testing for Particle Detection, are presented.

Finally, the most efficient solution to the problem is recommended to be a combination of two methods: X-ray and programmed vibration testing.

INTRODUCTION

There is a need for a comprehensive inspection procedure, or procedures, to detect particulate contaminants within the sealed containers of relays. This paper describes various methods available and presents results of an investigation into programmed vibration testing (PVT). In PVT, components are classified according to size and complexity, and a program is established for each classification so that the greatest possible excitation is imparted to particulate contaminants. The purpose of PVT is to cause loose-particle migration into critical areas which results in a detectable malfunction. Of course, the magnitude and duration of testing must be nondestructive and nondetrimental to service life.

Observation and experience have disclosed a great array of contaminants including: chips, filings, weld splatter, solder splatter, lint, and eyelashes. Anything used in the component assembly area, or in construction of the component itself, is a candidate particulate contaminant. The question is, then, with the large number of types and sizes of contaminants potentially present, how does one provide nondestructive methods to detect a failure-prone unit after it is sealed?

METHODS OF DETECTION

The principal methods of detecting relay contamination are photographic processes–X ray and N ray–and various dynamic techniques. In the latter category is the "miss test," wherein a relay is operated for a specific number of cycles, usually 5000. Also there are programs using sinusoidal or random vibration of short duration, accompanied by the use of miss detection means such as oscilloscopes or solid-state switching devices. A recently developed method identifies contamination by the detection of sound resulting from the impingement of loose particles against the walls of the container during low level vibration stimulation. Under investigation at North American Rockwell is a method wherein the relay is vibrated at a predetermined critical frequency and amplitude to adequately stimulate loose particles. The rationale for this type program is based upon the physical characteristics of various relays. Since no two relays are identical, no two relays have the same dynamic response characteristics. A single uniform test profile would not be realistic for a variety of designs. Therefore, individual vibration test programs must be developed for each relay model to ensure optimum detection capability. On this premise a study was conducted and yielded acceptable results.

X-RAY PHOTOGRAPHY

Radiographic inspection is fast and low in cost and provides a permanent record. However, it requires a skilled equipment operator and photographic interpreter. Also, X rays will not detect particles less dense than the relay container nor show the presence of extraneous nonmetallic particles amidst the high density of internal metallic mechanisms.

N-RAY PHOTOGRAPHY

Neutron radiography is a recently introduced inspection technique. N-ray photography complements the X ray because it can distinguish among materials of similar density but different chemical composition. N rays are good for locating light materials (nonmetals) within heavy materials (metals) and for examination of radioactive specimens. However, this technique is just now emerging from the experimental stage and it will be some time before equipment and operating costs are low enough to make the technique economically justifiable for the production line. Although the N-ray process will detect many nonmetallic particulates, it will remain a selective process, requiring specialized equipment and operator skill.

DYNAMIC DETECTION

Random vibration closely approximates the vibration environment in which the relays will ultimately function. It is logical, therefore, to expose relays to a simulated operating environment before installation. If there are no failures during simulation, the possibility of a failure in the final application can be considered remote.

North American Rockwell engineering postulated that a single fixed or universal test spectrum does not adequately stimulate particulate contaminant in every switching device. This is because of variations in geometry, size, weight, complexity, and materials. It was reasoned that components could logically be categorized according to size and construction details. This would be entitled programmed vibration testing.

PROGRAMMED VIBRATION TESTING

An evaluation test program was formulated to determine the validity of the postulation. Sixty relays, four each of 15 types from nine different manufacturers, were subjected to sine wave and random vibration, with visual or electrical circuit monitoring. The primary objective was to establish vibration parameters that would most effectively stimulate the migration of loose particulate contaminants and result in a detectable open-circuit or short-circuit condition as a mode of failure. The data accumulated would be analyzed, with the goal of classification being a secondary objective.

First, two samples of each relay specimen were prepared by having a window cut in the enclosure and a controlled sample of particles inserted. The window was then sealed with a piece of Lucite. The relays were subjected to sine wave vibration over a narrow low-frequency band and at various g levels. During this operation, the migration of loose particles was observed and photographed.

On an additional sample of each relay the container was punctured in a noncritical area, and an identical group of contaminants was introduced before the hole was sealed. The group was subjected to random vibration while the relays were electrically cycled at the rate of 90 Hertz, and with the contacts carrying 100 milliamperes (ma) at 26.5 vdc. Levels of acceleration spectral density from 0.10 g^2/Hz to 0.20 g^2/Hz were used. Each operation of the relay contacts was monitored for contact voltage drop in excess of 100 ma. The monitoring was done with a Visicorder in conjunction with circuitry that would detect an open- or short-circuit condition.

The remaining relay sample was used as a control sample and subjected to the random vibration test noted.

RESULTS OF TESTS

All except one of the relays with introduced contaminant particles exhibited one or more malfunctions during one-minute test periods. Malfunctions included open-circuit contacts, shorted contacts, and shorts to the case.

(At this point a film was shown that depicts the vibration of particles within relay enclosures.)

This is a lucite window which covers the relay enclosure. We cut an opening in the side of the relay to introduce the contaminants, and then we sealed it up with a lucite window so that we could observe the contaminants.

These are the fiber optics which we use to illuminate the parts and also to photograph the excitation of contaminants – a typical test setup showing the illumination capability of the fiber optics.

This is our control console changing the amplitude and magnitude of the excitation. The operator is making such a change right now. It is interesting to note that of the 15 varieties of relays which we used in this evaluation program, we tentatively concluded that we could classify them in three different classes based on size and configuration.

This is the strobe light which was operating at the same frequency as the excitation of the shake table. The operator is adjusting the camera.

Now we are actually vibrating a test specimen. Specimens were taped to this heavy block. The specimens were light enough so that they didn't require mounting through the usual mounting techniques. It is vibrating now at 20 hertz. That is not a bad picture. Those are contaminants bouncing around inside it.

So those have been introduced. They were previously shown in a test tube.

To the right is what appears to be a piece of teflon lodged on the contact going at 30 hertz. These films vary in frequency of excitation from 20 hertz up to 200 hertz. You will notice now that the armature is starting to oscillate as well as the particulates. They just keep changing frequency; getting higher and higher. Later on when we get up to about 180 or 200 cycles, you will find that the particles all tend to colonize or gather in one isolated group and stay in that area. They are starting to do it now, which indicates that that is not a good frequency to use during vibration of testing with the presence of contaminants.

In the lower left they are starting to colonize at the bottom of the case near the header. I wonder if they shouldn't isolate it from the vibration.

Now, we have a good colony down there at the lower left; nothing is moving, see. It is a very bad frequency for detection of particulates. We ran two types of vibration: One was for the evaluation of particle migration at certain fixed frequencies as you are witnessing now, and then later on we ran a vibration spectrum which we feel more closely resembles what you see in true light. True light is rarely depicted.

This is a different configuration, and it appears to be going at about 20 hertz. This is another configuration. All told we had 15 different configurations and a total of 60 relays were tested. The misses were detected in each and every case, and we feel we have substantiated our hypothesis and have established a technique for detecting particles within sealed relay enclosures using this dynamic approach. We have imposed this method of inspection on our various suppliers, and in the future we will make procurement for additional space programs.

(End of Film)

Table 1. PVT Profiles and Test Results

Sample No.	Failure Axis		Remarks
	NC Contacts	NO Contacts	
51			A
52	-X, +Y	+Y	B, C
53			A
54	-X	-X	B, E
55			A
56			A
57			A
58	-X	-X, +X	B
59	+Y		C
60	-X		B
61			A
62	-X, +X, -Y, +Y		B
63			A
64	-X, +X, +Y	-X, +X, -Y, +Y	B, D
65			A
66	-X, +X, +Y	-X, +X,	B, D
67			A
68	-X, +X, +Y	-X, +X, -Y, +Y	B, D, E
69			Severe contact chatter during
70			transfer, no failures
71			A
72	-X		B
73			A
74	-X, +X, -Y, +y	-X, +X, -Y, +Y	B, D
75			A
76	+X, +Y	-X, n+X, -Y, +Y	B, D
77			A
78	-Y, +Y	+X, -Y, +Y	B
79			A
80	-X, +X, -Y	-X, +X, -Y	B, D

Note: Odd-numbered samples had no contaminants introduced.

A - no failures
B - open contacts
C - case short
D - shorted contacts
E - misses

See Figure 1 for diagram of test axes.

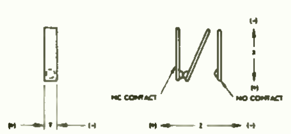

Figure 1. Diagram of Test Axes

Each and every relay will be exposed to this type of inspection procedure.

In addition to using the dynamic approach for particle detection, we feel that a static approach is necessary, and, therefore, we recommend the use of X-rays to screen the enclosure for contaminants.

The sum total of the inspection procedures that we use is a combination of static and dynamic testing, static being X-rays and dynamic being low-level random vibration.

It is estimated that the data accumulated in this brief test program, although limited, is adequate to support the original postulation. It was possible, through observation of contaminated relays under varying sinusoidal vibration levels, to establish effective random vibration profiles for PVT. Table 1 presents the PVT sample numbers, failure axes, and test results.

RECOMMENDATIONS

While it is recognized that the contaminante introduced into the test samples was far in excess, in most cases, to what would be discovered in production, it is recommended the PVT program become an integral part of product acceptance testing. Furthermore, it is recommended that the X-ray technique be used to augment PVT. In this manner, particulate contaminants will be screened in both static and dynamic conditions. A by-product of the final assembly test plan is the detection of gross mechanical defects in the X-ray process.

CONCLUSION

The combined method of X ray and PVT has been introduced and invoked on suppliers at North American Rockwell. A method for establishing profiles for each new component assembly has been established. It remains for enough data to be accumulated and collated to establish the uniform classes of assemblies mentioned previously.

HOWARD V. RODE
Member Technical Staff
Space Division of North American Rockwell Corp.
12214 Lakewood Boulevard
Downey, California 90241

Mr. Howard V. Rode is responsible for electrical equipment and components engineering for the past eight years at the Space Division. In all, he has 25 years experience in electromechanical design engineering.

Mr. Rode has earned his BSME and is a registered Professional Engineer in the State of California.

THE EVOLUTION OF GENERAL PURPOSE RELAYS AND APPLICATION VARIABLES CONCERNING THE USE OF BIFURCATED CONTACTS

By Mr. R. P. Sykes, Member Technical Staff, Redcor Corporation

THE EVOLUTION OF GENERAL PURPOSE RELAYS

If you can picture an evolutionary tree with roots somewhere in the distant past, maybe telegraph sounders and relays evolving out of this telegraph sounder with contacts on them and so on with the dry reeds and mercury relays being the limbs of the tree for specialized applications, then the general purpose relay probably was something with a phenolic base screwed down with woodscrews to a breadboard, back in the late 1800's! It seems to me that the evolution of relays from that time to the present has followed the prevailing packaging technology for packaging the equipment for which the relay is a part.

To go back to those earlier beginnings, we had leather cable clamps, fahnstock clips woodscrewed to a breadboard, coming up to the present where we have wire wrapped dual-inline packages on printed circuit boards. The packaging technology has come a long way.

The relays that were used on those original breadboards had no requirement to be fast or to be small; for that matter to be particularly inexpensive, because they were performing a major function, and they were a relatively complex component for the day. Then those breadboards were mounted vertically between two side rails, and we called them panelboards – power distribution type panelboards. Still basically the same relay mounted on a breadboard with straight runs of wire. You know, big. Remove the breadboards from between those vertical side rails and replace them with horizontal relay mounting bars to permit getting more relays in a given space, and the result was called a "relay rack."

The telephone company then worked that one to its ultimate, getting the maximum number of relays in the minimum amount of floor space. Here the relay had to evolve from something that was woodscrewed down to panelboards to something that was mounted on a single screw to a bar whose contact terminals were exposed for wiring on the back, not unlike our wire wrapped dual terminals that stick out on one side.

Then, say before the second world war, packaging technology evolved using metal chassis with vacuum tubes and big replaceable components on the top and the wiring underneath; and again the general purpose – the mainstream of relay technology – involved taking relays that had been designed for mounting on these bars and relay racks, and mounting them on holes in the chassis.

So the point I am making is that at each step of the evolution the packaging technology has led the way, and the relays have followed. At each step we use the relays from the former packaging technology and adapt it to the present packaging technology until the usage becomes great enough to pay for the changes to the relay that make it more optimum.

For example, it was very difficult to replace a relay that was bolted to a chassis with a screw and hard wired, so this led to the evolution of relays that would fit into sockets, which had already been designed for making vacuum tubes easy to replace. This sort of thing prevailed pretty much all the way through the second world war. By the end of the war, the general purpose relay gained its name.

A general purpose relay was defined as something costing about $4.00 for a form 4C, at the thousand piece level. It was a big and slow general purpose relay.

Now, since the second world war, which has been a while, in my view the trunk of this evolutionary tree hasn't grown. We still have general purpose relays and all the catalogs list it at about $4.00 for form 4C, available to plug into octal sockets and mounted by a single screw to the chassis or relay rack. But the packaging technology has undergone two or three flip-flops until we are at the point now of printed circuit boards mounted either in card cages on four-tenths to seven-tenths of an inch centers, limited by the connectors that they plug into, or daughter boards plugged into mother boards, or soldered into mother boards, with the means of interconnecting things with printed wiring rather than hard wiring or soldering individual leads.

In my view the packaging technology isn't quite at the point where the components are interconnected with wire wrap. Although that is done, I don't see that as the mainstream. I am staying back from that a little bit; I think that may come, but at the moment I think I might stop with the level of circuit boards as the main thing, as in TV sets, radios, washers, and dryers. I think that defines where the mainstream of packaging technology is at the moment.

Now, as I said, in the past, each time packaging technology advanced a notch, it was possible to adapt relays from the former packaging technology to work the new one. I think we have reached the limit; the original hasn't adapted very well to right-angle sockets, and we have PC pins, but it is the inherent large bulk of the think that is its downfall. Yet if we go to subminiature relays, these are by definition not general purpose relays. They are several orders of magnitude more expensive. Hence, I say the trunk hasn't grown; the limbs are growing.

The new types of relays are all peripheral to the main – where the main market ought to be, and I suspect that (you know I am not a relay manufacturer and I would be the last to be able to prove this –) the volume of business in the relay industry as a whole is declining because the manufacturers have failed to serve the general purpose relay market in this day and age. Now they have stopped the trunk, and they are only growing limbs.

It seems to me that the hypothetical general purpose relay that ought to exist today ought to have four poles – form 4C – sell for $4.00, and it ought to fit a printed circuit board without being subminiature. In other words, be quite wide in both directions and not very thick. I don't think it should plug into a right-angle socket; that implies to me a relay that is intended to plug-in upright that has been laid on its side. I am looking for a relay that is designed from scratch to mount on a printed circuit board more the way a mercury relay is constructed with pins coming out of the molded base to plug right into the p.c. board. It would be a telephone derivative relay with fair sized springs driven by a motor armature.

A number of relay manufacturers have taken a crack at this thing to use existing tooling, existing contact spring pileups and existing coils and to rearrange them so that they will lay side by side and make for the low, low height, and yet not require subminiature construction with varying degrees of success. I don't think we have really seen the answer yet, and I just leave it there.

This is a proposition to the representatives of relay manufacturers who are interested in entering the commercial general purpose high-volume, low-cost market: Let's make a PC relay, and adapt it for other uses by, for example, mounting it on a little PC board just its size – two-inch square relay, two-inch square PC board with some edge fingers out to the side, – and this could be sold to distributors for experimenters to plug into available printed circuit card sockets. It would be the more expensive way because it is adapted for the unusual application, but in its basic raw form for use in printed circuit boards is where it would be cheapest because it doesn't need any extra adaptation for that use.

BIFURCATED CONTACTS

This is simply an attempt to reduce the variables affecting the choice of whether to use bifurcated contacts or not to a form where we can, say, refer to a checklist, and if we have an application for relays, we can check off against these pros and cons that I will give you and decide: 1) why bifurcated contacts are definitely the thing to do; The reasons are as follows – (expected improvement and performance is as follows). – You can maybe not prove it, but you can make a very convincing argument!

I would have sworn there was something on this in some book or some article or some application information from some relay manufacturer; but if there is I haven't found it, and I made quite a search for it. So we can say that bifurcated contacts have been the subject of considerable controversy in the relay industry simply because they have never been defined. Very little mention is made of the effects of bifurcation in texts on contact theory, because individual contacts are treated regardless of their means of support: you have books on the interface between two pieces of metal. It might be a switch; it might be a connector; it might be a relay. So relay manufacturers have some very influential customers who prefer bifurcated contact springs, and the manufacturers are consequently reluctant to publicize information that might cast aspersions on their customers' designs. In other words, for example, a customer comes to a relay manufacturer and says, "I will buy a large number of your relays if you will bifurcate the springs (slit the existing springs and put two contacts on the ends instead of one)!" Naturally you will do that. It has nothing to do with whether it is good or whether it is bad or whether it is better or whether it is worse. If that is what he wants, fine. And it isn't bad enough that it's going to make your production line look bad, so there is no risk in doing it. Actually it is more appropriate to speak of "bifurcated contact springs" because the contacts themselves are not changed by the decision to bifurcate. We con't cut contacts in half; we cut the spring that supports them in half.

BIFURCATED CONTACT SPRINGS

The concept of contact spring bifurcation may take the form: "If a given contact in a given environment has a reliability R, then two contacts in parallel will have a reliability of 2R." Probability theory takes a more rigorous view of two paths in parallel. If you say P_a is the probability of contact "A" conducting and P_b is the probability of contact "B" conducting, then P_s is the probability of Success, when either "A" or "B" conducts satisfactorily. P_s is equivalent to $(P_a + P_b) - (P_a \times P_b)$.

For example, take a contact with a probability of conducting as .8, and then (.8 + .8) – (.8 x .8) is (1.6 – .64) = .96. In other words, the parallel combination has a probability of .96 against the single contact probability of .8 which isn't twice at all. It is about a 20 percent improvement. So that is just by way of debunking 2R: Purely on the basis of probability argument, the maximum improvement that you could possibly get if there were no deteriorating factors would be a 20 percent improvement in the reliability of the system all other things remaining unchanged; no compensation.

The concept of parallel redundancy is sound. The problem with applying it to relay contacts is that the "reliability" or "probability of success" of the individual contacts on a bifurcated spring is no longer the same as for a single contact. You see, you can't say "everything is the same."

1) The first contact of the pair to close takes all the erosion due to voltage breakdown. The closed contact reduces the voltage on the second contact prior to its closing.

2) The two closed contacts, sharing a single bifurcated spring, each have a fraction of the total spring force. In the optimum case, each would have one half the force of the single contact they replace.

3) The last contact of the pair to open, which is usually the first to close as in No. 1 above, takes all the erosion due to current supported arcing.

So these are three ways in which the bifurcated combination doesn't perform. The environment around the individual contact is differed by the decision to bifurcate. So we have to explore these things one at a time and try to make some sense out of this because it is getting more complicated; it is not getting simpler.

Contact Life Under Eroding Circuit Conditions

Since only one of the two contacts on a bifurcated spring does all the "making and breaking," its life under eroding conditions of voltage and current is not influenced by the second contact. So the only improvement in practice will occur when the contact that "makes first and breaks last" becomes so vaporized that the remaining contact starts making and breaking the circuit. Thus, the prediction of greater "reliability" should be replaced by a prediction of "longer life" at the "lower reliability" induced by lower contact pressure, where life is limited by voltage and current erosion.

Contact Life and Non-Eroding Circuit Conditions

Under non-eroding circuit conditions, the only wear on the contacts is due to sliding, and the reduction in force on each contact due to bifurcation results in less wear-per-operation; so life may be doubled on that account. Circuit making reliability, however, is now only a function of mechanical breakdown of films and the reduction in force would therefore reduce reliability. Since films tend to be broken down by a specific force (one gram won't do it; two grams won't do it, and suddenly three grams and anything higher will do it) and we will give the designer credit that the device that we are talking about is designed to apply contact force greater than that required to breakdown films of the type anticipated by the design, then reduction of force to half the design value may well result in no breakdown of films at all, and consequent loss of function.

Immunity to Dust

This is where the pro-bifurcationists make their biggest point; Since the occurrence of a particle of dust large enough to prevent a contact from conducting is some sort of a totally random function that I won't attempt to define, the probability of dust obstructing both contacts on a bifurcated spring would seem to be about half of that for a single contact. The same $P_s = P_a + P_b - P_a \times P_b$: for example, about 20 percent improvement for individual contact P = .8 should result. Again, the theory is sound, but the problem with applying the theory is that the probability of a given particle of dust preventing a contact from conducting is inversely proportional to contact pressure. If contact pressure is high enough to smash the particle under consideration, reducing the pressure to half will greatly increase the probability of failure.

Now, I am not saying all dust is smashed in half by contact. I am saying some dust is too sticky to push out of the way. That is a mode of dealing with dust, but not the only one.

In a relay, where the power available to deflect the springs is limited by the heat rise of the coil, the bifurcation of contact springs cannot be accompanied by a proportional increase in spring force.

Immunity to Film Formation

Many contact failures attributed to dust are actually due to a non-conducting film that has accumulated from vapors in the air. "Cleaning off the dust" may in fact remove the accumulated film and restore the contact to operation.

The three mechanisms which may normally destroy films as they form are:

1) voltage breakdown on make;
2) vaporization in the arc on break;
3) mechanical breakdown due to contact force and wipe.

Voltage Breakdown and Arc Vaporization of Films

As discussed above, one contact of a bifurcated pair will always "make first" and break last." It will therefore breakdown and vaporize films as they form, if operated often enough. The twin contact, however, gains no advantage from this relationship and will suffer film formation unimpeded.

When the first contact finally does fail from carrying the whole load on both make and break, the second may well fail to "take over" as the theory promised because it has not been kept clean by arcing and sparking.

The consequence is:

1) Under eroding circuit conditions, exposed to air and therefore film formation, bifurcation will result in shorter life at reduced reliability.

2) Under eroding circuit conditions in an hermetically sealed dry gas environment, bifurcation will give longer life at reduced reliability due to lower force.

Mechanical Breakdown of Films

As stated above, the efficiency of the process of mechanical breakdown of films due to a combination of contact force and wipe will suffer severely from the reduction in force due to bifurcation of the contact spring.

If the spring force of each half can be built up to equal that of the original spring, then mechanical breakdown will occur as with the original single contact.

That tends to be possible on manually operated switches and tends not to be possible in relays because they are heat limited.

Current Carrying Capacity of the Device — With or Without Bifurcated Contact Springs

One final effect of bifurcation is that the first contact to make establishes a higher conductivity contact, due to voltage breakdown and localized contact melting, than the last contact to make.

This results in a low-resistance path through one half-spring and a parallel higher-resistance path through the other half-spring. Consequently almost all the current will flow through the spring of the first contact to "make."

Since its width is half that of an unbifurcated spring, its cross-sectional area is half, so the blade resistance - exclusive of contact resistance - is doubled, doubling its heat rise for a given current.

Since the spring blade is also the principal means of dissipating heat from the contacts, and its efficiency as a radiator is directly proportional to its surface area, when the area is halved the temperature rise will double for a given heat input from the contacts.

These two separate effects add to increase blade temperature four times and reduction of the maximum current rating of the device to half its unbifurcated value is required to restore the original heat rise limit.

So in conclusion:

1) If you have a voltage and current eroding circuit:
   a) With film formation present - (in other words, not hermetically sealed), bifurcation will result in reduced reliability and shortened life.
   b) With no film formation (sealed in a dry gas environment), you will still suffer reduced reliability, but you will have longer life.

2) In a non-eroding circuit - and I am trying to avoid defining dry circuit:
   a) With a film formation present as exposed to the air, then you suffer reduced reliability, but you have a longer physical life of the contacts due to bifurcation.
   b) With no film formation present in a non-eroding circuit, you have the same reliability and longer wear life and mechanical life.

3) Last, in terms of resistance to dust, regardless of what kinds of voltage you have to the circuit, bifurcation results in a slight improvement in reliability and shorter life.

Finally, I am glad that the proceedings of this Seminar are going to be published because I find this very difficult to remember. It is not easy to remember because it is not a simple cause and effect relationship. I have to keep referring to it to draw a conclusion. I can't always presume the right answers, so I propose that you refer to the table that I have just summarized as each application arises.

R. P. SYKES
Member Technical Staff
Redcor Corporation
7800 Deering Avenue
P.O. Box 1031
Canoga Park, California 91304

At REDCOR Mr. Sykes has recently assumed responsibility for the management of component parts application, from selection, application derating and package design through procurement, assembly and test on to field performance in all of REDCOR products.

A 17 year background of jobs involving component part theory preceded his employment at REDCOR. He was employed by Scientific Data Systems since 1965; there he specialized in all types of component characterization and application information to the various circuit design groups. He has had three papers on components published, with a fourth in preparation.

Mr. Sykes has been a Member of the IEEE since 1955.

A TRANSCRIPT OF A THREE-HOUR QUESTION AND DISCUSSION PERIOD

QUESTION: MR. JONES AND MR. DICKEY

MIL-STD-704 was written with the conventional distribution system in mind. When using solid state distribution, is it still necessary to follow MIL-STD-704?

For example, it was shown that a solid state switch will reduce the system voltage transient significantly. If so, why should the solid state switch be designed for the large voltage excursion given by MS-704, which will not exist?

To obtain optimum solid state distribution components, a new standard tailored for solid state systems must be prepared. Do you agree?

ANSWER: MR. JONES

Yes, we agree wholeheartedly. The problem is that if we go to an aircraft manufacturer and say, "I have a piece of equipment I would like to sell you," and he asks you, "Does it meet MIL-STD-704?" you say, "No."

He says, "Well, come back when you can bring a part that does pass."

That is the characteristics of the system we now have, so we really have a chicken-or-egg situation here – which is first? If these components are not compatible with MIL-STD-704, we cannot have acceptance of them.

Now, when we put together a complete electrical system using solid state components, granted we expect system performance to be much improved, and our next phase is to develop a new specification to replace MIL-STD-704 for solid state systems; but until we have such a system, we are still stuck with MIL-STD-704.

QUESTION: MR. DICKEY

What are some of the risks of this Semi-Conductor System?

ANSWER:

The risk at this time is the availability of production hardware in time to meet your need. If you start designing a system, you depend on having these devices because you have planned on a system with the reduced weight and volume and not allowed yourself the luxury of being able to go back to the electromechanical approach. Then you run into trouble if you can't get the production hardware. So this is the risk that management sees in making decisions to go into proposals for the production of aircraft.

QUESTION: MR. SYKES

Have you any test or statistical data to support or refute your analytical conclusions?

ANSWER:

Well, as I said, the subject of whether to use bifurcated contacts or not hasn't been treated in papers attempting to prove as a result of testing whether they are good or not.

So I don't know of any references to such information that I could refer you to. I have used these guidelines in selecting relay and switch contacts for a variety of applications over a number of years and never felt that the results of the application indicated the necessity for reappraisal of these guidelines. That is about all I can say.

Most of the points that I have made I believe are obvious. For example, the first contact to make takes all the load. I don't think that sort of thing needs testing. I think it is intuitively obvious if you have two contacts, one must make before the other. They can't possibly make simultaneously, so that sort of thing isn't involved.

The testing that I think you are referring to is under a given set of load conditions. Does a relay with bifurcated contacts last longer than another relay without bifurcated contacts? And that is a generalization that I purposely avoided in my talk because these relays aren't necessarily identical.

If the one with the bifurcated contacts is truly identical to the other relay, the only difference being a split contact spring, then the result of the test would indicate whether bifurcation was good or not.

If the bifurcated relay consumes double the power to overcome double the spring force, which has been correctly designed in to compensate for the effect of bifurcation, then that by itself does not disprove anything I have said.

Does that answer the question?

ANSWER: AUDIENCE

Yes.

QUESTION: MR. JONES

Is there any development of a transducer to replace the synchro? This is needed for compatibility with solid state data transmission systems.

ANSWER:

Specifically, I don't know of a transducer that is being developed to replace a synchro. I know that a number of shaft-angle encoders are being developed at the present time which could be used to replace the synchro for shaft-angle measurements, and the digital information from this encoder could be transmitted over the transmission system that is used for the other data in the power management system.

Does that answer your question?

ANSWER: AUDIENCE

Yes. Thank you.

QUESTION: MR. DICKEY

What heat sinking is available in the aircraft?

ANSWER:

Well, part of the basic structure is available in some areas. Of course, if we go to composite structures, we lose that capability. The only other place to get rid of heat is to do it artificially with forced air cooling which means putting in an air conditioning load.

QUESTION: MR. JONES

You only discussed single pole, single throw. Do you need 3 pole, single throw, single pole, double throw, and 3 pole, double throw?

ANSWER:

These devices are used for on-off control of electrical power loads. To control three-phase loads, we will use three, single-phase devices, one for each phase.

Now, for other applications – double throw applications – as might be in a motor reversing circuit – (you relay people will probably shudder when you think of using a relay like that) you would use a single-pole device for each set of contacts presently required in that circuit. If a double-pole double-throw relay is replaced with power controllers, four power controllers are required to replace that one component.

So when you start trading off power controllers vs electro-mechanical relays on a part-for-part basis, you have some problems. But when you look at the total system, you come up with improvements not only in the system performance, but also in weights.

In most applications relays are used to perform logic and isolation functions at the power level. Since these functions are performed at the signal level, the number of power controllers required is smaller than the number of power contacts required in a conventional system. Right now we see no real need for the double throw type of power controller.

QUESTION: MR. RODE

How much better – life and reliability – were the relays that passed your vibration screening?

Were vendors screened for cleanroom facilities and procedures?

ANSWER:

To answer the question – second question first – the vendors were screened for cleanroom facilities and all were found to be acceptable. The answer to the first question is I can't answer it because they all failed. We didn't have any pass.

QUESTION: MR. STEINER

For 50 to 150 volt switching, did you imply that no mechanical switch or relay should be permitted whose contacts have less than one-eighth inch spaching? If so, what do you suggest as an alternative?

ANSWER:

I hope I understood it correctly. This question should be answered in two parts, I believe.

First of all, There are no rules at all now for anything from zero to 50 volts, which makes the second part of the answer even more difficult. I believe that the industry should get together and establish standards of minimum requirements like the power people did 75 and maybe 100 years ago to give a springboard for relay designers. Otherwise it would result in what I said during the morning session – in testing and testing and perhaps testing to death. I hope that this is an answer – one possible answer.

COMMENT: AUDIENCE

I would like to ask a question of Mr. Steiner. When you said "industry gets together," do you mean manufacturers as well as users such as ourselves?

ANSWER: MR. STEINER

I am sorry; it was a slip of my tongue. I meant the relay designers and manufacturers who establish relay design standards.

QUESTION: MR. JONES

In view of all the problems and malfunctions involved in the use of electromechanical relays, would you recommend that new AC and DC control systems be designed on the basis of using solid state devices where possible?

ANSWER:

Amen. Certainly; yes. That is the basis of our whole program, to provide a capability to eliminate the make and break contacts which are the source of many troubles in aircraft.

QUESTION: MR. RODE

Are the details of your random vibration study available in published form, for example, in IDEP?

ANSWER:

No, they are not. At the present time this information has not been published. What we anticipate doing is running further tests in the near future and then publishing a report which could be an IDEP item.

QUESTION: MR. JONES

Am I correct in understanding that you suggest the elimination of fuses or other traditional protective devices and substitute solid state logic in a solid state power distribution system?

ANSWER:

The intention here is to allow the solid state power controller to perform the function of circuit protection as well as on-off control of the power circuit.

If you have reference to the normal concept of fuse application, the answer is yes, we want to eliminate them. We are requiring that there be a back-up fuse element in the solid state power controller that will open in case the semi-conductor fails in the shorted condition and you have a fault in the aircraft wiring. Under these conditions, you want to clear this device off the line, so there will still have to be some sort of fusing element; but this fuse is never expected to operate as long as the semi-conductor device functions properly.

QUESTION: MR. DICKEY OR MR. JONES

What are the expected random transients or spikes accepted on the AC bus line?

ANSWER: MR. DICKEY

I don't guess I know what transients we are expecting. MIL-STD-704 doesn't specify the voltage transient – short duration transient – on AC lines. However, the device specifications require that they will be good for 600-volt applications, not to be applied to a 600-volt system, but able to withstand 600 volts.

ANSWER: MR. JONES

Might I add a point to that. Particularly for the bus controllers, the device must remain open when exposed to unsynchronized sources. If you have a bus energized from one source and another source has been energized, but not connected to the bus, these two sources may be unsynchronized and 180 degrees out of phase. It is also possible in a split bus arrangement in the aircraft – for the buses to not only be 180 degrees out of phase, but for both of them to be at 180 volt point allowed by MIL-STD-704.

So all of this adds up to the requirement for a 600-volt standoff with the device in the open state.

QUESTION: MR. JONES

What is the ratio of cost between the conventional and solid state?

Do you recommend peak or average sensing on over-under voltage devices?

Read relay handbook written by NARM.

ANSWER: MR. JONES

When you start talking about costs, you are comparing a Volkswagen and a Cadillac, so which would you rather have? Which are you willing to pay for? The performance of the system with the solid state components is certainly going to be much better than the performance of the system with electromechanical contacts. The electromechanical system has lower initial cost but the performance leaves much to be desired. With the solid state components you improve performance of a system at an increase in cost.

Now, our projections are that the initial cost of a complete system will be somewhere around four to five times that of a conventional system. However, because of the improvements in reliability, maintainability, and so forth, we are projecting the life cycle cost of the aircraft with the solid state system to be considerably less than with the conventional system. The total ownership cost to the customer is much less over the life of the airplane.

Question No. 2. I really have no thoughts whether you should sense peak or average values in over-under voltage devices. I would have to think about that awhile.

QUESTION: MR. STEINER

Do you favor having the transient suppression device be placed inside the relay enclosure? Pros and cons.

ANSWER:

This question again includes another question. It presupposes that we are talking about sealed relays. Well, in that case, I am inclined to say the protection device should be within the relay enclosure, but there are many applications where we use open-type relays and the protection device may be at the exterior part of the harness. It has to be in the proximity, though, for electrical reasons as has been established in many cases.

Sometimes the users will have requirements, but I would say if in doubt and all else being equal, the recommendations of the relay manufacturers should govern.

ANSWER: MR. RODE

I would like to add to that question to which Mr. Steiner just gave an answer. If you use a coil with bi-filar winding, you don't add a suppression device inside the enclosure. This was borne out in a study conducted by Marshall Space Flight Center.

ANSWER: MR. STEINER

I am grateful for that comment, yes. It is built in; but then, of course, necessarily inside the relay.

COMMENT: AUDIENCE

Mr. Rode, in using a bi-filar winding coil, don't you have to sacrifice many things such as time, pick up, voltage, and things of that nature?

ANSWER: MR. RODE

To some degree, yes, you do. Pick up, voltage, and drop-out time do change.

COMMENT: AUDIENCE

I was under the impression that compared to a diode suppression of your coil, you have approximately 40 to 50 percent arc reduction. Now, is 40 percent enough? In other words, it is a compromise when you go to bi-filar wound coils. You lose your various parameters.

ANSWER: Mr. RODE

I can't answer that too well; but in the report I read from Marshall, the bi-filar winding suppresses the arc better than the diode or the capacitor across the coil.

ANSWER: MR. STEINER

Well, I would like to do two things with this gracious opportunity here.

To begin with, Howard, by answering something that you asked him about, then by adding another factor here that is true in life: you cannot get anything for nothing. You will gain advantages with bi-filar winding, with diodes, with other means, and lose other things. So there is no great difference between bi-filar and other devices. As far as bi-filar goes – by the way, we could talk now eight hours just on that subject alone, you realize, but with bi-filar winding you have only DC applications. If you use it on AC, then you and the system have had it.

So that is another disadvantage that you get for using bi-filar, although it has many advantages.

I believe I had better stop here.

QUESTION: MR. RODE

Was lint the major cause of contaminants? Reason – film showed cotton glove used in handling relay.

ANSWER:

No. Our experience has shown that the major cause for contamination is teflon, which is used in coil spools and in tape for wrapping the coil after it is wound. The presence of lint and eyelashes and fingernail polishes is usually very remote.

QUESTION: MR. DICKEY

Can you explain further the risks involved in placing "SOSTEL" into operation, and what are the exact impediments to implementing this concept? What time in the future will these be under control? Will your slides be made available to us?

Do you foresee a future need for conventional switching or relays at either the power or signal level?

ANSWER:

Well, we, in our investigations, have not run across any risk other than the unavailability of production hardware to meet the spec requirements. Until we get hardware that is qualified to the refined spec requirements, there is a certain amount of risk involved; and the impediments, of course, are the normal resistance to change and educational activities required to get acceptance for the first time. We see no technical risks other than those that were pointed out in the presentation which include half-cycle surge current capacity in the AC devices. There will be research and development work done to get semi-conductors for AC devices to provide compatibly with fault currents of large generators.

ANSWER: MR. JONES

May I add something to that, Lee.

If you use a solid state system with a VSCF generator, we don't see the problem that we have with a rotating machine because you do have continuous control of the current and you can limit to some prescribed value that is compatible with the SCR chip that you are using. With the rotating machine, of course, you have no control until you can remove field current which takes many cycles – not what you need to protect the chip.

QUESTION: MR. DICKEY

What time in the future will these be under control?

ANSWER:

I guess this depends on how much money is put into it – trying to get them under control. I would guess just offhand we are talking a couple of years, yet before they are fully under control and production hardware can be qualified for requirements.

QUESTION: MR. DICKEY

Do you foresee a future need for conventional switching of relays at either the power or signal level?

ANSWER:

Not if you can get a full solid state switching system incorporated and be able to take advantage of removing the bulk out of your generating system, which now has to supply fault current, and removing the power switching and protection out of the utilization equipment. Than I can't see going back to electromechanical components either at the signal or power level, but it is going to be quite a while before we can achieve the advantages offered by the complete system.

QUESTION: MR. DICKEY

Will your slides be made available to us?

ANSWER:

Copies of all slides that were pertinent are available in the THINK-IN Report publication. There are a couple of slides which were stated in words in the publication, but they were simple enough that you don't need an actual picture.

QUESTION: MR. JONES

In your concept of a one-cubic inch solid state relay, you specify a heavy copper heat sink. Are there any lower weight materials that can accomplish the same objective?

ANSWER:

There may be – not that I know of. You are primarily interested here in the thermal capacitance of the material, and copper has about the best thermal capacitance that we know of.

QUESTION: MR. STEINER

Do you feel that the present TO5 size relay is as reliable as the half-size crystal can relay in the proper application?

ANSWER:

I seem to be very fortunate to get those questions which contain at least one other question. If relays are reliable the size doesn't matter. I have nothing against TO5 or half-size crystal can, and I mentioned TO5 in the morning. It was merely to compare that its overall size is less than the minimum spacing required by Underwriters Laboratories for comparable devices in the power family.

But there is no bias against any of these devices in our area provided they are exactly what the gentleman asked that they are – reliable. I hope I am not deviating too much with my answer from the spirit of the question, or did I?

QUESTION: MR. DICKEY

Was the LTV system mocked up with discrete components first?

ANSWER:

Yes. We actually breadboarded the concepts for the entire system back as early as around 1962, '63. The prototype hardware was packaged and evaluated in the lab and actually flight tested in an F-8 airplane before arriving at the final spec requirements to go out to industry for production.

QUESTION: MR. JONES

Will a paper be written concerning the solid state power switching for the A-7 mockup when completed, and if so, how may one obtain a copy?

ANSWER:

I don't know if there are any plans to write a paper. There will be a final report on the Air Force contract which will be available through the Air Force Aero Propulsion Lab, Wright-Patterson Air Force Base, Dayton, Ohio. If you wish to be on distribution for that report, you may contact the Technical Monitor, Lt. Charles Lane, APIE-3.

QUESTION: MR. RODE AND MR. STEINER

Have you ever encountered a carbonaceous black growth in relays evaluated after life testing of sealed relays at loads of one and a half amperes or more? This growth appearing on contacts and other internal parts in the contact area.

ANSWER: MR. RODE

No, I haven't seen that growth. We have seen black deposits, but they were not carbonaceous. They were derivatives of teflon.

QUESTION: MR. RODE

What is your opinion on the cleanroom assembly of relays versus, A, non-cleanroom assembly with extensive cleaning of relay versus, B, non-cleanroom assembly with minimum cleaning of relay prior to hermetic sealing as a means of minimizing contamination?

ANSWER

That is a hard question to answer. The two relays fit into separate categories. One we would call "high reliability." The cleanroom relay would fit in this category. It is monitored for cleanliness throughout its entire assembly life. In another product line, the relay is just cleaned periodically; and it is possible for contamination to exist without realizing that it is there.

QUESTION: MR. RODE

What vibration screen test will North American impose on its relay vendors, and what will be the criteria for success for each device and the lot?

ANSWER:

The criteria for success is no failures, naturally. We can't tolerate failures in our programs; so if there is one failure in the lot, the entire lot is rejected back for re-work. This has been our policy in the past and will continue to be so.

Criteria for vibration testing is established as a result of this test program by procedures which we documented wherein the manufacturer must essentially go through the same type of test program we did and establish a vibration profile which is critical for his particular configuration. When that is established, then all of his relays are tested to those parameters.

COMMENT: AUDIENCE

It was my question. When you contract with a particular vendor, do you levey this as a requirement and establish a signature for his device?

ANSWER: MR. RODE

That's correct. Yes, we do.

QUESTION: MR. RODE

Mr. Rode, I noticed in your movie that you did not monitor the relays. You had no wires connected to them. Did you actually power the relay?

ANSWER: MR. RODE

The particular phase that was shown in the movie was the establishment of the vibration spectrum which would exist for the particles. The actual test was a random vibration test monitoring the contact while cycling at the rate of 90 hertz, so that particles would be captured between the contacts.

In every case we had a failure.

QUESTION: MR. JONES

Mr. Jones, you spoke of crowbar protection for your solid state switches. How is this accomplished or integrated into your system?

Do you use resistor-capacitor, or Zener diodes across your solid state switches at 400 hertz?

ANSWER:

We did not use any resistors or capacitors across the SCR's or across the switches.

The crowbar will be installed on the AC bus and will monitor the current. At some prescribed level, the crowbar will be turned on. We have not yet set the turn-on value.

(Ed. Note. See p. 12 of Mr. Jones and Dickey's paper for specific details.)

Let's investigate this just a little bit further. If we have a fault on the load side of one AC power controller, the voltage to that phase is going to be zero during the remainder of the half-cycle, or for all practical purposes, zero. So it really doesn't make any difference whether you are pumping the current out through the load controller or sharing part through the crowbar. The main thing you want to do is minimize or hold the current through the power controller to a safe value so that the SCR can recover its blocking capability at the end of that half-cycle, or when the current goes through zero.

So by adding the crowbar to the bus, you could shunt the excess current through the crowbar. The crowbar would be a very large SCR-type device capable of handling much more current than your normal power controller. Therefore you could protect the controller by shunting this excess current to ground and having the whole system recover at the end of the first half-cycle.

QUESTION: PANEL

A question to all you gentlemen. Have any one of you gentlemen thought of using high-rel relays to MIL-R-39016? Military specifications on high-rel relays established by approved filters and allied; and since we are discussing relay reliability, has this been thought of?

ANSWER: MR. STEINER

Again two or three answers to that question.

Number one, two months ago in a two-day committee meeting in Washington, the opinion was expressed that the tendency of the public and the military is getting away from ER specifications.

So whatever we are saying today may be short-lived. By the time we form an opinnion, the ER specifications may have lost quite a bit of their glory.

Number two, the answer is that the fact that something is made according to extra reliability specifications does not make an extra reliability product.

Number three, it depends on what the user specifies. At North American Space Division we do have ER references, and in other instances we do not lean too heavily on ER. As a rule they were preferred for a longer period of time.

Does that answer your question, or do you wish to add more to it?

COMMENT: AUDIENCE

In part it does.

ANSWER: MR. STEINER

Would you mind then asking what part I overlooked.

COMMENT: AUDIENCE

Here you gentlemen are talking about building two systems: one with conventional relays, and the other with solid state components. These are devices strictly for reliability, correct?

ANSWER: MR. DICKEY

Not necessarily. Performance characteristics, getting rid of EMI transients is a large part, also.

COMMENT: AUDIENCE

The point I am making here – there have been relay committees establishing high rel.-type components and many dollars have been spent to do this. From what I see here, it could be a waste of all these dollars going down the drain. I am not a manufacturer of relays, but I do use the relays and I see much dollars being wasted because of this. This is my own opinion; I am not sure whether anyone agrees with me or disagrees with me.

ANSWER: MR. DICKEY

We have not had a need for high reliability relays in our economical aircraft system that we design. Space applications perhaps have the requirement for high rel. relay devices. We in the Aircraft Division don't require that kind of reliability.

ANSWER: MR. STEINER

Maybe what should be underscored is that we are playing with expressions. We probably need a definition. What do you mean by "extra reliability"; and what I mean and the general public. In essence in daily work that I am doing, it now means two or three additional applications like burn-in, particular careful screening, and things like this, which is, of course, resulting in expenses which I expressed in dollars and cents, naturally.

But there is nothing of a miracle or mystery about it. It is just extra care, extra time which probably should have been expended in the first place at the time we didn't have the ER specs. So that is all we can ask for: extra careful screening and delivery.

COMMENT: AUDIENCE

And this is borne out with relay specification MIL-R-39016?

ANSWER: MR. STEINER

In essence, yes. Burn-in, screening, and other precautionary measures, in addition to a few more points which we haven't even discussed here today.

ANSWER: MR. SYKES

I would like to add a footnote to that.

In my opinion a high rel. relay is any relay being properly applied; a low rel. relay is any relay being improperly applied. Reliability of the relay is less inherent in the device than relay specs would lead us to believe. In other words, the inference is that high rel. relay specs result in a relay that will be reliable no matter how you use it, and this is the reason for the trend away from the established reliability relays as a mandatory thing. It is much more to do with the way the relay is used. The telephone company uses relays that we in the aerospace would classify as low reliability, crude relays. They last for 40 years! They work very well **because** they are properly applied.

COMMENT: AUDIENCE

We have been deeply involved in all the established reliability specifications, either using them or avoiding them because of cost. MIL-STD-785, which is becoming a contractual requirement on most new systems requests that you use them. You play the contract; maybe you can get out from under it, but some parts run an order of magnitude more than the standard part, and we have to decide whether they are worth the money or not.

In fact, just maybe in the last few months we have become extremely conscious with the real world, and I should say extremely first-cost conscious; the first cost in the contract. Most contracts are written just for cost, not for total cost over their life. So in order to stay in business you get a little cagier than you used to be when contracts were easier to get.

We have looked at the ER specifications. They apply to relays, capacitors, resistors. Right now we are looking at many one-line capacitors. Your Tantalum capacitors have made the grade – readily available – done a lot of good for the industry. Industry has accepted them and the cost is about the same for the normal first grade of ER.

By the way, I should explain ER means "established reliability," not "extra reliability," or anything like this. You in your first level of reliability have really got the same part, maybe just slightly better. That is a long story, but, anyway, that means established reliability; so if you are looking for reliability theoretically you can take an ER spec and pick the reliability you need. There are several orders of magnitude; a number of ways you can play with the numbers than the standard part which is also available in the same specification.

I just wanted to clarify this point of the ER's.

ER carbon resistors are the same cost, exact same prices as non-ER's in their best level because that is all they make. They have made them for so long the same way they know exactly what they have and they are darn good.

As you come to develop mechanical items, it costs too much money to establish reliability. You just can't do it; and some parts are not prone to ER, and that is what we are seeing in the relay business because we don't have a standard enough product to test the department to know exactly what test to get.

There are some slight advantages, Mr. Steiner, in in-burn, and screening, and so forth, and we should all get together in the specification and do this.

But going back to what this other gentleman asked, if you are going into an established reliability program and then compare this to your solid state which is supposed to give us more reliability, or one of the reasons they use it – we are wondering why we don't compare an ER, even if it costs a lot of money in the first system. Say this electromechanical versus – has a certain value – a certain number does this and our solid state does this, and the inference I get is that you are not looking as much for reliability although that will be a gain. You are looking for the other performance advantages in the EMI weight savings, things like this.

That was a long answer, but is that what you really mean?

ANSWER: MR. JONES

May I answer that. The comparisons that were shown this morning were based upon conventional relays in aircraft as we use them today. These are not high rel. relays, switches, and circuit breakers. Now, for space shuttle applications, the comparison that you mention of the high rel. components versus solid state systems certainly must be made.

COMMENT: AUDIENCE

That answers it. I work in all components, not only relays, and I made a mistake in the last few years and I have read the contracts. I found that if you really read the contract you may find that you are supposed to be using these ER parts and don't know it, and may not be using them because someone isn't enforcing the contract on you.

But I understand what you are saying. You are saying that in your case you didn't need this reliability so you weren't going to pay for it. So you are not involved in that phase.

ANSWER: MR. DICKEY

I might add that in establishing the specs for the solid state hardware, the customer did not want to specify any established reliability because they feel that relays and solid state devices did not lend themselves to having established reliability like semi-conductor devices themselves and resistors and capacitors, et cetera.

So established reliability for complicated components may be short-lived.

COMMENT: AUDIENCE

Yes. As Mr. Steiner said, a few months ago you attended a meeting that said this, and we have got rumors back that way, too, that ER specs have already been developed completely and have QPL suppliers and are available.

It looks like they are going to die.

QUESTION: MR. SYKES

Mr. Sykes, you said: "reliability is either a relay as properly applied or misapplied." I have to disagree 50 percent.

Application-wise it is very important. If the relay is properly applied it is a proven fact that some relays are very good; but from what I gather from your conversation is that I can get a relay from Brand X as equally good as from Brand Y, and that is not true.

ANSWER: MR. SYKES

It is possible to misapply a high rel. established reliability relay so it wouldn't work well. It is not inherently guaranteed to give you success.

It is possible to devise a circuit under which any relay made will work well for a long time if you don't care about anything else but life. It is in between those extremes where we are all working. I just wanted to make the point that Established Reliability relays are not inherently reliable devices but only capable of reliable performance if you properly apply them.

COMMENT: AUDIENCE

I would like to further add that it is a proven fact – it is my experience that there is a method whereby you can weed out the weak sisters, and ER specifications calls out this in their application, where you test for so many cycles per 10,000, so many failures per 10,000 cycles, and if you wrote a screening process 100 percent at a certain level, it is a known fact that the ones who survived this test are very, very satisfactory in most applications.

ANSWER: MR. SYKES

I don't mean to disparage that point of view at all. If you have a defined set of circuit conditions and you are testing relays under those circuit conditions, there will be some relays that work better than others; and if you screen those out and use them, certainly.

QUESTION: MR. JONES

Mr. Jones, what do you see as the lowest power solid state relay requirement? Voltage, how low? Fifty millivolts?

ANSWER:

Our present specification defines power controllers for 400 cycle, 115 volt AC, 400 cycle, 26 volt; and 28 volt DC to provide compatibly with the present aircraft distribution system voltages. In future aircraft we may be using a different distribution voltage. It may be 130 volt DC, or 230 volt DC. I don't know yet, but in most cases the solid state power controller will operate more efficiently at a high voltage than it will at a low voltage; so you probably would not want to make application of these in 6 volt circuits.

COMMENT: AUDIENCE

I am interested in how low a voltage you ultimately might want to go in switching for signal sensing circuitry; things of this nature.

ANSWER: MR. JONES

As previously stated we have addressed the problem of control power to this time. We do not at the present time have a switch suitable for use in a synchro line, for instance, where you are primarily interested in accuracy around the nul point.

The reason we are not using solid state switches in those circuits – at the present time we don't have one. Certainly in the synchro applications you would be interested in voltages in the very small millivolt range. If you have a large deadband there as you would have if you tried to use SCR's, this would not be a practical application at all.

ANSWER: MR. DICKEY

Let me add one thing. We certainly are interested in getting devices that can be operated in these ranges, and this is part of the program in the future – to develop devices that can be added to the system to handle the switching requirements that are not presently capable within the power spectrum that we are working; so this is further refinement of the total system; and we are interested in it because we want to tie the multiplexing system into single switching as well as high power switching.

QUESTION: MR. DICKEY OR MR. JONES

One of your slides showed many power factor curves. Where did this information come from? Was it from AC 400 hertz or DC? I might have missed the point.

ANSWER: MR. JONES

That was one of my curves that came out of MIL-STD-704, and it is for AC.

QUESTION: MR. RODE

Have your findings shown the major factor of failures to be teflon?

ANSWER:

I guess the answer to the question is yes. We haven't found anything else recently. Since we instituted a high rel. assembly program four or five years ago, we have had isolated failures, and they have been due to – if I remember correctly – teflon, a black deposit on the contacts, which appeared to be and which was analyzed to be a teflon derivative as possibly a result of arcing. Those are the major onces.

QUESTION: MR. JONES

Do you need isolated ground between driver circuit and load circuit or can you accept common ground?

ANSWER:

We would prefer to have isolated systems between the control circuit and the power circuits. We are getting hardware at the present time with a common ground. We will be evaluating this at the end of this year and further establishing our requirements there. I think the answer is that we would prefer to have isolation.

QUESTION: MR. STEINER

What minimum technical information is typically absent, in your opinion, from available relay catalog sheets? There is a practical size limit on the number of items which can be listed.

ANSWER:

Yes, you are correct, sir. I had the pleasure of discussing it during the intermission. Of course, we realize there is no limit. You can never please everybody, and even if a 10-page manual were furnished as it may happen now, it may be considered incomplete yet. For example, the torque for mounting screws should be recorded, or the inductance of the coil and other things.

I repeat my willingness to cooperate with every party who wishes to receive inputs of this kind as they occur in my daily relay life.

COMMENT: AUDIENCE

I would like to amplify a little bit on one of Mr. Dickey's statements. I agree with him that it will be at least two years to get the solid state systems to a production-acceptable state, but we do expect to have individual controllers in production before the end of this year. That will have been qualified, but from that point on there will be the LTV study program of systems; and I am sure there will be a large study program – maybe even flight test programs by the government before you could really talk about a proven system.

QUESTION: BY MR. STEINER

Mr. Sykes, I wonder whether it would be possible to become a little more specific about the pros and cons of bifurcated contacts.

ANSWER: MR. SYKES

More specific in general without defining specific? Are you trying to get me to say that I am for bifurcated contacts or against bifurcated contacts?

QUESTION: BY MR. STEINER

Well, let's try for that.

ANSWER: MR. SYKES

All right. I have tried to be very fair in this thing. I recognize that there are cases where bifurcated contacts are used correctly, and they improve the reliability under those cases.

On the other hand I have attempted to show that the number of circuit combinations under which they result in less reliability is greater than the number under which they result in improved reliability; so if you don't know what the circuit operating conditions are going to be or can't define it – you don't have the source and load all within your little box, then I guess I have to say that the evidence shows you shouldn't gamble by using it.

QUESTION: BY MR. STEINER

I see. Well, I was hoping for a statement like: if it is a plain bifurcated contact – and I wish to be corrected if necessary – that if it is possible to make and break at the same time, the first to make will be the last to break and take all the beating.

ANSWER: MR. SYKES

Yes, that is what I said this morning.

QUESTION: BY MR. STEINER

We would have to bifurcate the contact so that one arm is shorter than the other. We would accomplish at least one additional purpose, namely, to maybe make it more vibration resistant because the natural period of one will not respond to the natural period of the other; so there is at least one advantage. But having it just bifurcated and not possible to make contact with both halves at the same time, I see no advantage at all.

So this is the kind of decisions I was wishing for.

ANSWER: MR. SYKES

With the dust example – contacts operated in the air and the dusty environment, you can argue that a piece of dust will get under one or the other, but not under both simultaneously. That could happen and in the best of all possible situations would result in a 20-percent improvement in reliability over a single contact.

QUESTION: BY MR. STEINER

Assuming that each half is capable of carrying the whole current?

ANSWER: MR. SYKES

Yes. And assuming they are equally exposed to the dust and properly compensated so they have the increased force equal to the individual contact.

QUESTION: BY MR. STEINER

I should stop here. Thank you for this interpretation. Otherwise we will run into midnight.

QUESTION: MR. JONES

Mr. Jones, is there a basic requirement for conventional "feel" control devices? For example, toggle-type actuated solid state switches, or trip-free mechanical feel for circuit breakers?

ANSWER:

I am really not sure on this. The solid state power controller does provide tripout when you have an abnormal operating condition on the line. At the time the device trips out, it provides a trip indication signal which may be used to drive a lamp or other indicating-type device which would be analogous to the white stripe on the thermal circuit breaker when it trips.

As far as a reset is concerned, this signal is a 5-volt, 10 milli-amp signal supplied to the controller to cause it to reset; and this may be provided by any type of solid state signal sources. Or as far as that goes, a make and break type contact with a bounce eliminator on it, if you want to.

Does that answer your question?

ANSWER: MR. DICKEY

In toggle-type actuated switches, your feel is in the mechanical part of the toggle. In toggle and push-button type signal sources, the mechanical portions which provide "feel" are unchanged, only the electrical switching portions are converted to solid state.

ANSWER: MR. JONES

I might add a little bit to that. On toggle-actuating devices, you have some sort of a mechanism inside to hold the baton in the proper position so that when you look at the switch you can tell whether or not it is in the one state or zero state from a physical standpoint; so externally the devices look just like a baton-actuated or toggle-actuated switch. Internally it would have some sort of a cam device for holding it in that position until you desire to return it to the other position.

So there you would have the tactal feel built into it.

QUESTION: MR. RODE

What was the particulate detection scheme in the vibration test, in units without windows?

What was the method used for "miss" detection? Level of contact resistance considered as an open? Length of time for an open to classify as an open, et cetera?

ANSWER:

We used an oscilloscope as a miss detector. In answer to the first question: What was the detection scheme used in the vibration test and in units without windows. We did the same profile as for units with windows with an oscilloscope as a miss detector. That answers part of question two.

The level of contact resistance considered as an open was anything over 10,000 ohms. The length of time for an open was not measured but we had a 10 microsecond miss-detector attached to the circuit so if there was anything longer than 10 microseconds, it was a miss.

COMMENT: AUDIENCE

Sir, was this miss detection done at room temperature only?

ANSWER: MR. RODE

Room temperature only.

COMMENT: AUDIENCE

It has been my experience that a high-low temperature miss test is the most valid miss test that I have ever heard of. In other words, if you heat a relay up to a maximum temperature and cycle it for "X" amount of cycles –

ANSWER: MR. RODE

We did not perform a temperature test; only a vibration test.

COMMENT: AUDIENCE

I misunderstood you, sir.

QUESTION: MR. DICKEY

Are you anticipating a transition of failure modes when you make the transition from electromechanical relays to solid state relays? That is, are you trading one kind of a failure mode for another? What are the risks in applying solid state relays?

ANSWER:

There is a possibility of trading your failure modes. We do not see right now what the problems are going to be, of course, with the solid state devices. Experience we have had with them – they have been free enough from failure modes. It is going to take time to discover any additional failure modes and what our problems have been.

I am sure you get into production – about production use of them. There will be some discovered and you will have figured out how to overcome them.

QUESTION: MR. RODE

Concerning you level of contamination during your test, did you use one eyelash, one solder splash? Was there any level established for this?

ANSWER: MR. RODE

No, it was random. It is recognized that we did introduce a lot more contamination than you would find in manufacturing processes, but it was done randomly; it wasn't following any set pattern.

COMMENT: AUDIENCE

Just proving a theory?

ANSWER: MR. RODE

That's correct.

QUESTION: MR. RODE

With all the particles you put in those relays, it's no wonder some found their way into the contacts.

Do you believe that "PVT" testing a clean production relay with only one or two particles of contamination would necessarily disclose the existence of those particles?

ANSWER:

Yes, I do. Alongside of the experimental sample we ran a control sample of theoretically or presumably clean relays. One of those samples failed at the same level of vibration as the experimental samples, so we do believe that.

QUESTION: MR. STEINER

When you have a relay application, what manufacturer do you think of first for MIL relays, two amps or less; MIL relays, high current switching; commercial relays, all kinds?

ANSWER:

This is again one of those fortunate questions that contains already some answers. If my application is two amps or less, naturally I select that; and for higher current switching, I very likely take the higher current relay.

The commercial relays are sometimes the only way out.

Now, what I have to check according to Howard's interpretation here is the emphasis of this question on the manufacturer; the make of the relays or the rating of relays. Would the writer be able to help me here.

COMMENT: AUDIENCE

On manufacturer of relays. Who manufactures the relays?

ANSWER: MR. STEINER

You mean –

ANSWER: MR. RODE

Like Leach.

ANSWER: MR. STEINER

A or B or C in regard to each of the three?

COMMENT: AUDIENCE

Electronic Specialties, Leach, or someone.

ANSWER: MR. STEINER

Does this explanation now refer to question one, two, and three each?

COMMENT: AUDIENCE

Right. In other words, for the military relay, who would you think of first if you had an application for two amps – two-amp switching? Who would you look at first in the catalog? Leach? Electronic Specialties?

ANSWER: MR. STEINER

Well, it is probably the most complex question that I have heard today. Not only ending up in my spot here, but anyone here at the table. My selections are based on qualification reports, whether they are our own or those which we retrieve through the IDEP system or others.

Very frequently I go on the phone if neither of these sources can help me and ask for references.

So what comparable system have you used, item one or two or three? If there is no usage shown in the answer, I probably turn to manufacturer "B" and then to manufacturer "C." That is the best answer I can give you. I personally have no preference except quality.

COMMENT: AUDIENCE

As the only representative of distribution here, I would be more than happy to answer that question for you later on as far as specifications.

QUESTION: MR. RODE

What is the minimum level of contamination that you expect to screen?

ANSWER: MR. RODE

That is a good question. That is a hard one to answer. A single particle, something on the order of .005 diameter or .010 diameter. That is enough to cause a miss.

QUESTION: MR. RODE

Was the PVT system compared with the particle impact noise detection system with respect to relative effectiveness? What is the difference in instrumentation complexity between the two systems?

ANSWER:

Well, comparison was made, but I don't remember all the details of the findings. I would be happy to mail you a copy of our reports, whoever asked that question. We can get together after the meeting and set up a communications channel. We find that the noise particle impingement method is not as good as the one we have developed. The reasons are explained in the report.

QUESTION: MR. JONES

If we should reduce the requirements of MIL-STD-704A for applications where no contacts are used and all controls are solid state, how could we withstand the occasional high transient voltage resulting from a broken wire or an intermittent connection?

ANSWER:

I assume here that you mean a power wire being broken and thus providing a step change in the loading on the generator. If this is the case, the over-voltage transient is probably going to be somewhat less than we now experience in the conventional generators. The 180 volt transient that is specified by MIL-STD-704 is a result of switching approximately two-thirds the capacity of the generator off and allowing the generator voltage then to overshoot because of the regulator response characteristics of the regulator.

So if we are talking about just an individual wire breaking, the load on that wire would represent a much smaller proportion of the total generator capacity and we would have a very small overshoot. If a bus feeder line were to break you have lots more trouble than just over voltage.

COMMENT: AUDIENCE

That was my question. What I was concerned about was the transient voltage conductive load portion of the circuit. It is the same as if you had opened a switch or a contact in that circuit. You get an inductive voltage spike.

ANSWER: MR. JONES

What you are saying now is that those voltages produced by switching inductive loads are in the neighborhood of 600 volts as presently specified by MIL-STD-704. Now, one way of dealing with those, of course, is to put larger Zener arrangements on the DC bus to take care of spikes that are presently generated.

To begin with, these spikes generally occur on the DC line – 28-volt DC line, and by use of the solid state DC controller, the inductive spike is minimized for normal switching. Now, if you break the line and have an opening similar to the mechanical contact that we now have, you would have the high voltage spike generated, and this would be coupled to adjacent wires and carried back towards the bus. Depending upon the polarity of this spike, it might be carried to ground by a Zener in the power controller which would be used for protection of the switching transistors; or it may be carried to the bus and then to ground on the bus Zener. So I think it would be accommodated either way. The spike would be reduced and prevented from being coupled onto or coupled into other equipment by the characteristics of the power switch itself. We might discuss this further after the meeting.

QUESTION: MR. RODE

Were parts vibrated with small particles, .001 to .005 of an inch? If so what were the results? Were there one or two particles per relay or more?

For magnetic particles in a magnetic latch relay, is the same test effective? What problems?

ANSWER:

Well, the answer to the first part was answered quite some time ago when I pointed out that we introduced particles at random in large quantities. There were some particles in the size area specified here, .001 to .005. The results of the test cannot be conclusively directed toward the size of the particle.

In answer to the second question on magnetic latching relay, we didn't test any of that type.

QUESTION: MR. RODE

Do you 100 percent test all relays for contamination? If not, what sampling do you use?

ANSWER:

Vibration testing is 100 percent.

QUESTION: MR. STEINER

You stated that the U.L. standard which you quoted has specific requirements for 51 volts and over, but none for 50 volts and under. In other U.L. standards, these values are 31 and 30 volts, respectively.

Do you have, or know of, any technical basis to justify these break points? In other words, what justification is there for not having requirements for one voltage when they are established for only one volt higher?

This may appear to be trivial, but in light of recent court decisions regarding liability of manufacturers, this could become extremely important and apparently the origin of these values has been lost in antiquity.

ANSWER:

I will be ready to answer that in some detail if I understood one phrase here which I would like to have repeated.

Am I to understand that you are referring to other value 31 volts and 30 volts values in other U.L. standards? Is this the meaning of this question?

COMMENT: AUDIENCE

That was.

ANSWER: MR. STEINER

I don't doubt that this exists. I just happened to pick one that started at 51. I just want to make sure I interpreted it right.

COMMENT: AUDIENCE

It is immaterial.

ANSWER: MR. STEINER

Did you pick that 31?

COMMENT: AUDIENCE

It is immaterial which value you deal with. The fact is merely that these court decisions could hinge on the fact that in one case you have a voltage of one value; you go one volt higher. How are you going to justify that you have a standard in one case and not in another? I know this is one that has arisen a number of times and recently; and I know – so far as I know, no one knows exactly where either the value of 30 volts or the value of 50 volts has originally come from.

ANSWER: MR. STEINER

Well, assuming I understood both your question and your interpretation correctly, I report the following from experience agreeing with you about the history. The values are antiquated. They came about through random choices made by people like Thomas Edison and his relatives and those who worked later on in his laboratory.

The situation is much less humorous than I chose to present it. There is no real background. I went personally to the Underwriters' Laboratories not only to determine what I was reporting to you. You are correct; they are arbitrary. The time has come to propose a change based upon logic rather than on grandfather experiences.

As far as language used in some of these standards, it is sometimes atrocious. For example, there shouldn't be any limits like if this is what you mean from 51 to 100; 100 to 200, because it leaves one volt uncovered. It should say from 50 to 100 and then in excess of 100 to 200 and excess of 200 to 300; but that is for Philadelphia lawyers perhaps to tackle first.

All I can say is that your question deserves great merit and has great merit and deserves great attention, and I would suggest that you write to the authorities who are in charge of it like Underwriters' Laboratories; and I will be happy to assist.

COMMENT: AUDIENCE

We have already made such contact, but we have come up with about the same answers that you have. I thought possibly with your Austrian background you might have some additional information somewhere that we didn't have here in the United States; but everything that we have come across has apparently led back to some of the original workers such as Edison and others of his era, and apparently everyone who was involved in the establishment of these values has long since died so that now you say it is a real problem, especially with the lawyers getting into the thing.

It wasn't so much the gap of one volt, but over and above that was - here you have an arbitrary breakoff point whether it be 30 volts or 50 volts is immaterial, but you have an arbitrary breakoff at some point. How do you justify at one voltage? You must have these requirements and just by that voltage, it isn't necessary.

ANSWER: MR. STEINER

Right. No, this is true; and apparently worldwide, so my place of birth has little to do with it, I am afraid.

One of the worse statements - if I may steal one more minute of your time–is the statement "something should be tested at least twice the rated voltage plus 1,000 volts." It is entirely without history and entirely without logic. I think I was the only one who did look into this, however, without success.

Thank you.

QUESTION: MR. RODE

You have been screening relays now with your vibration test and we were wondering what percentage do you get of good lots. We almost thought you said you never got a good lot. Could you give us the details.

ANSWER: MR. RODE

I never said that. The failure rate has been very low. I don't have any statistical data on that, but roughly it is about one out of 5,000.

COMMENT: AUDIENCE

This is incoming parts?

ANSWER: MR. RODE

Yes.

COMMENT: AUDIENCE

So you are getting one in 5,000 out in incoming parts in your screening? How much do you think you are improving your reliability by doing this?

ANSWER: MR. RODE

That I can't answer. I am not a reliability expert; I don't know how the number works.

COMMENT: AUDIENCE

Is it worth anywhere near the cost?

ANSWER: MR. RODE

The cost is worth the additional testing.

COMMENT: AUDIENCE

To get that one in 5,000 in your program?

ANSWER: MR. RODE

That's correct. In our program, cost is not spared in order to save a life.

COMMENT: AUDIENCE

Could I ask what program it is.

ANSWER: MR. RODE

Apollo.

Anymore questions?

Thank you, gentlemen.

A MESSAGE FROM SAE:

The Society of Automotive Engineers (SAE) and the National Association of Relay Manufacturers (NARM) have been watching the Ohmite THINK-IN series with considerable interest and satisfaction. Not by plan, but by Ohmite invitation to speakers of their selection, at least two A-2R committee members have spoken at each of the three THINK-INS.

The 3 Ohmite Sponsored THINK-INS have confirmed our thoughts that more relay education is needed and would be welcomed by design engineers and users.

Under the guidance of the SAE Aerospace, Electric and Electronic Equipment Subcommittee for relays, A-2R, plans are being developed for an educational program to be conducted in the 70's.

We wish to thank Ohmite for the service they are doing for industry, and for affording us the opportunity to advise you that SAE plans special relay education. As the subjects, topics, faculty and plans develop, we will keep you advised via various news media. Again, our thanks to Ohmite.

E. U. Thomas, Chairman SAE, A-2R Relay Committee.

Carl E. Nelson, SAE Manager, Continuing Engineering Education, Society of Automotive Engineers, Inc. 2 Pennsylvania Plaza, New York, N.Y. 10001.




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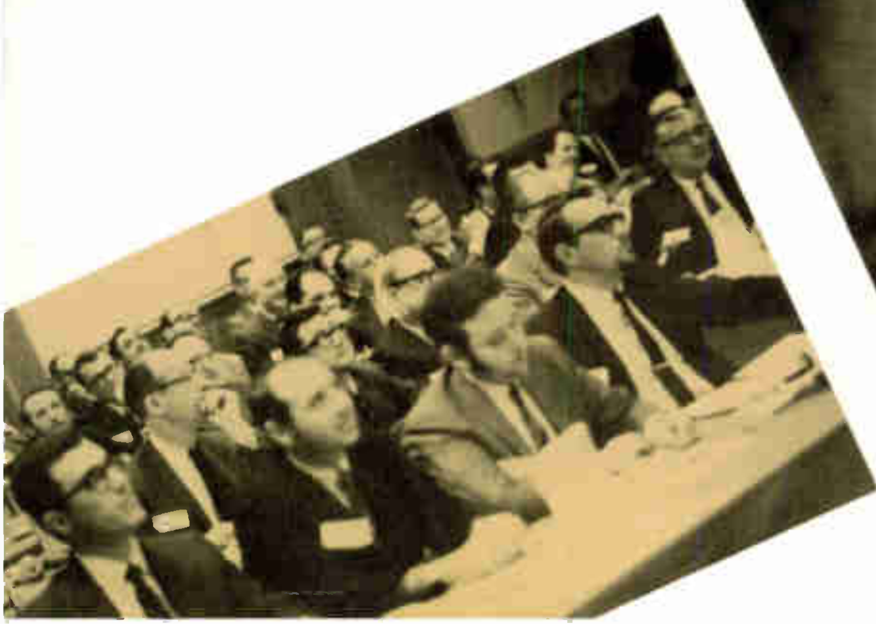

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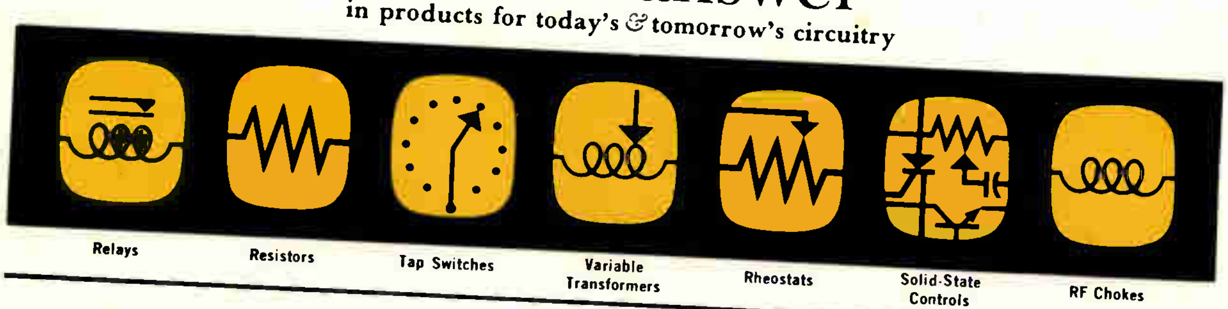

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an exchange of ideas about
Relays and Related Devices

OHMITE

think-in report

Seminar I

HYATT HOUSE HOTEL
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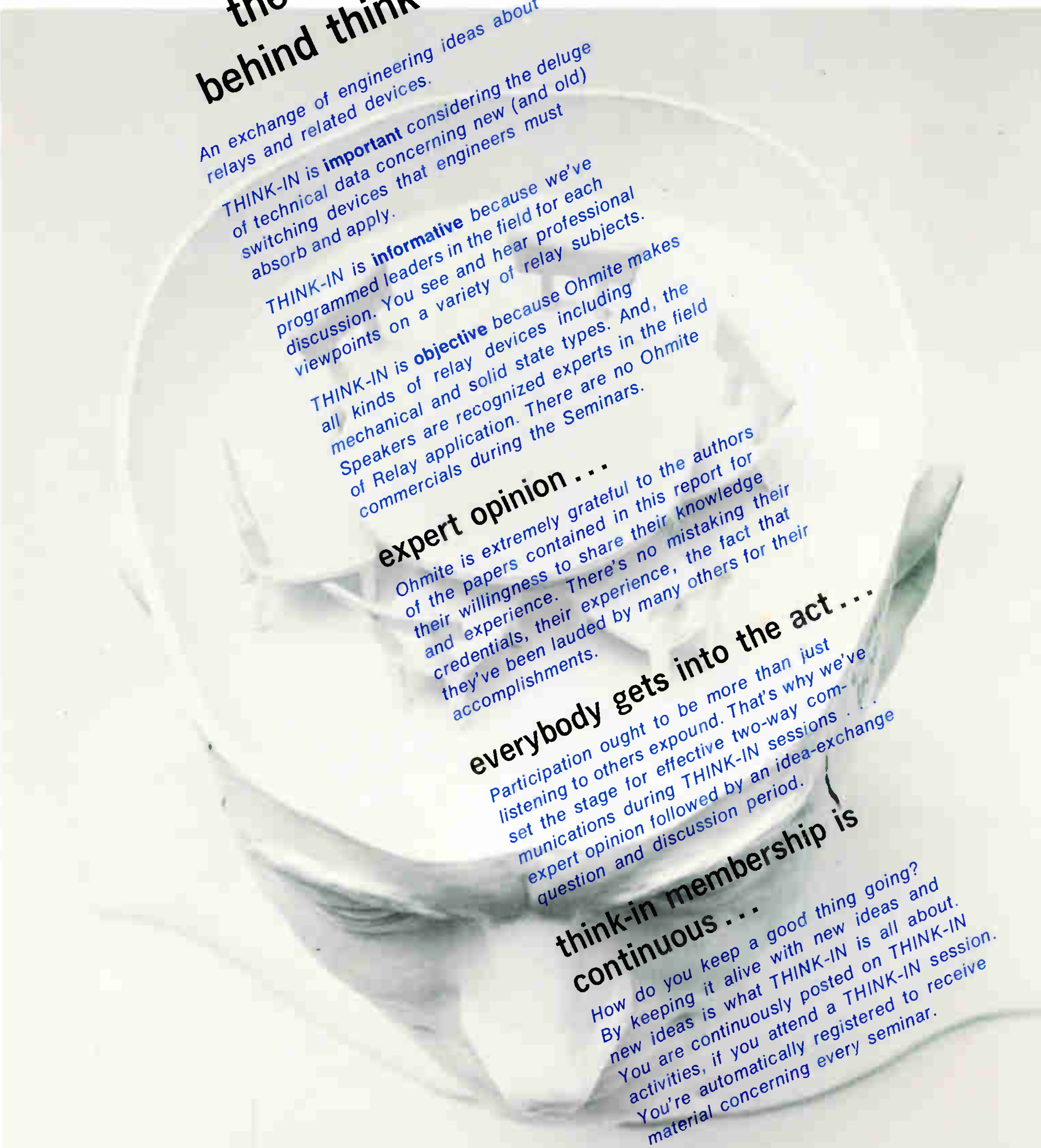
FEBRUARY 26, 1969



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OHMITE THINK-IN SEMINAR I

Hyatt House Hotel, Lincolnwood, Ill. **February 26, 1969**

Contents

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"SOLID STATE - FRIEND OR FOE"

By **William A. Paulson**, Principal Engineer, Industrial Instruments Div., Barber-Colman Company

I should admit, at the outset, that when the idea of sharing some of my experience with relays was broached, my first reaction was rather negative. After all, everyone knows relays are terribly old-fashioned and besides, after all the effort expended over the years in various stamp-out relay movements, it might be a little frightening to look back and see that they're gaining on us. A little reflection, however, brought to light two areas that might be of general interest. One has to do with the effect of solid state - integrated circuit technology on the circuit imposed specifications of relays, and the other has to do with the apparent logical conflict between strenuous efforts to do away with relays in some applications, and their routine inclusion in others.

Before elaborating on these items, it is appropriate to give some indication of the kind of experience on which these remarks are based. I hope this will clarify some of the illustrations, but most importantly it should help avoid the temptation to extend conclusions drawn from limited experience too far afield.

The Industrial Instruments Division of Barber-Colman manufactures a variety of instruments intended to control industrial processes, with the major emphasis being on the control of temperatures, using thermocouples as sensors. This market, while highly competitive in itself, places somewhat greater emphasis on performance than on cost - greater, generally, than the "consumer" or "entertainment" markets, but certainly less than the aerospace hardware market.

The chief role of relays in such instruments is to switch load power - directly or through intermediate relays or contactors - in response to signals derived from the primary transducer, and interpreted by the instrument's electronics.

For insight into the direction modern semiconductors have headed us, a backward glance may be in order. In the good old days, when the world was simpler, and active devices relatively expensive and bulky, the route to reliable, economic designs was to use as few such devices as possible to achieve the desired effect. The result was frequently something like the circuit shown in Figure 1.

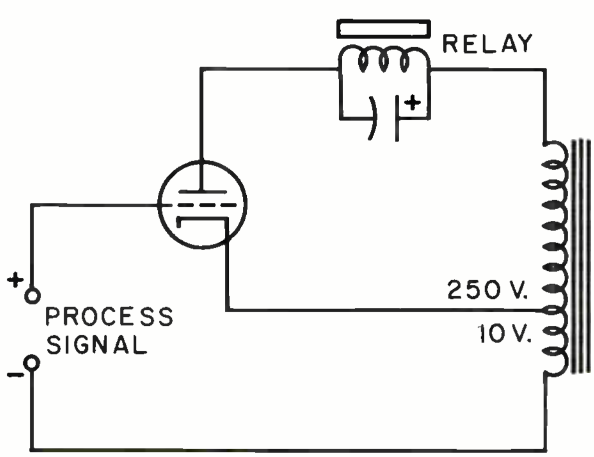

FIGURE 1

The idea of such a circuit was to close the relay when the process input signal became sufficiently large (as, for example, when the controlled temperature rose) and to cause the relay to drop out when the process signal fell. Although very simple in form, this circuit interacted with relay design in a number of ways.

1. Because the active devices handled voltage easily but handled low currents, relay coils had to be wound with an inordinate number of turns of very fragile wire, tending to increase cost and reduce reliability.

2. Large margins had to be provided for tube wearout, (a 50% decrease in Gm in 8000 hours was a routine expectation) which tended to increase initial dissipation undesirably.

3. The heat produced by the tubes tended to aggravate the temperature rise caused by (2).

4. The pressures that led to a preference for relatively simple circuits often placed additional burdens on relay design and adjustment.

Figure 2 illustrates the general relationship between coil current and relay state. Although familiar, it is reproduced here mainly to permit later comparison of this characteristic with the switching characteristics of a rather common present-day circuit.

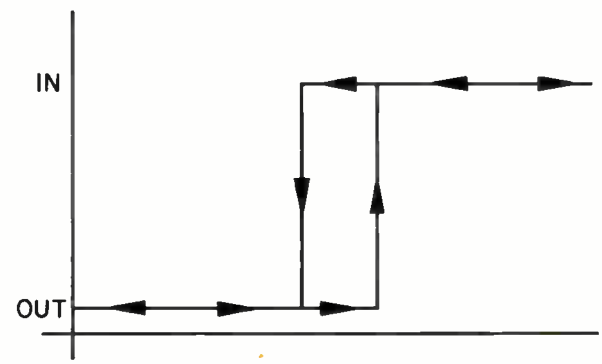

FIGURE 2

The well known hysteresis depicted in Figure 2 not only is an inherent trait of all common relay designs, but also is a very significant operating characteristic of the control circuit as a whole. Some applications called for very narrow control deadbands, some wide, and all too many demanded rather narrow tolerances on whatever deadband was required. Obviously, much liaison between user and supplier, and (often reluctant) compromise on both sides was required to get and maintain such circuits in volume production.

The first impact of the move from vacuum tubes to transistors as relay drivers was somewhat a mixed blessing. Even early semiconductors exhibited little degradation over tens of thousands of hours, and so relieved the dissipation problem caused by large allowances for such degradation in the initial designs. However, they were all too often so limited in power-handling capacity that a great deal of pressure was exerted by users to reduce relay operating power below what many relay designers considered good practice.

Today, the near avalanche of low-cost, high-performance silicon devices pouring out of the semiconductor industry has all but eliminated this last limitation, and has given the circuit designer unprecedented freedom in choosing relay drivers. Active devices are cheap enough to encourage the use of more complex circuitry, such as Schmidt triggers, to take over the jobs of insuring unambiguous switching and controlling hysteresis. A variety of switching devices, notably the "four layer" families (SCR's and SCS's) possessing rectifying and high voltage capabilities reminiscent of tubes, and inherent bistable operation and high current capabilities as well, are now available and widely used for driving relays. Although not without problems of their own, such devices have drastically reduced the pressures leading to undesirable compromises, whether from the point of view of the circuit designer or the relay manufacturer.

A further simplification of the relay's task seems inevitable as a consequence of the recent drastic expansion of capability and even more violent price reductions in integrated circuits. Although a number of examples might be cited, one outstanding trend should be sufficient to illustrate the point. Not long ago a "709 type" operational amplifier was in the \$25 - \$50 class, restricting interest to designers of exotic, "hang the cost" systems. Today, they are under \$2 in modest quantities, with talk of reaching the fifty cent level in large quantities within the next one to two years. The uses for this versatile circuit are so numerous that most builders of electronic products will have several applications active, and thus tend to use them as routinely as any other component. One use, particularly appropriate to the present topic is shown in Figure 3.

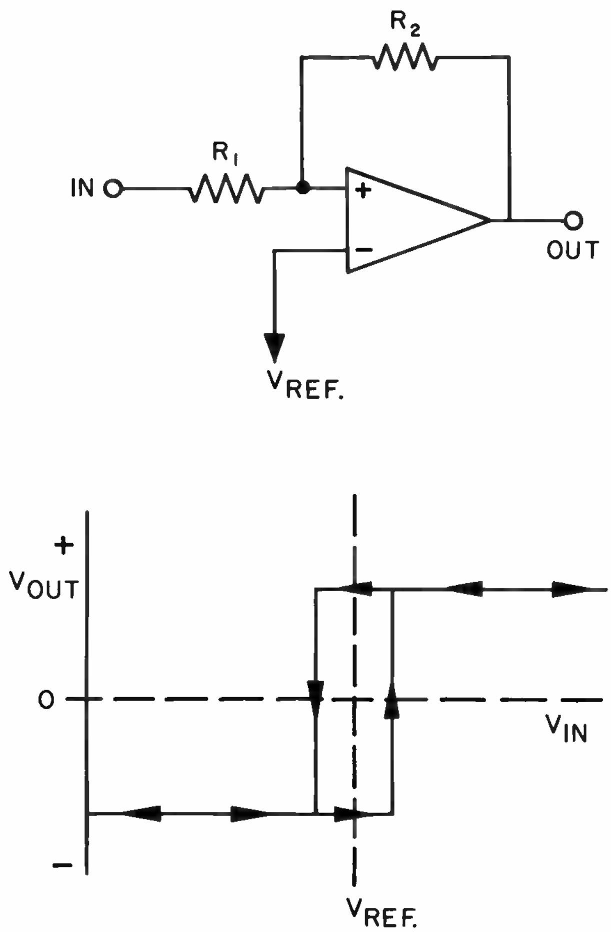

FIGURE 3

The similarity between the transfer characteristic of this circuit and Figure 2 is obvious. What is particularly significant is that the hysteresis, so limited in range and difficult to adjust in relays, is now a simple and easily manipulated function. Expressed as a percent of the switch on, or reference value, it is given approximately by:

$$\% \text{ Hysteresis} = \frac{200 R_1 V_{out}}{(R_1 + R_2) V_{re}}$$

In most cases, the output of the top amp will not drive a relay directly, but will drive a power transistor of SCR to make ample power available to eliminate the need for marginal relay designs. Thus the relay is freed of circuit limitations to do the uncomplicated switching job it can do best.

So far, the advent of solid state technology has been decidedly to the advantage of the relay maker, as well as the user. However, the combination of the relay like characteristic of Figure 3 and semiconductors of really significant switching capability has other, but equally obvious implications.

Although it is hard to classify many individual cases, it appears that the functions performed by relays may be divided into two broad categories: logic and power switching. The reason it is difficult to classify some uses is simply that, especially in simpler systems, the two functions are frequently performed simultaneously by the same elements, and so not easily seen as separate functions. The logic capability of relays arises, of course, from the shape of the characteristic of Figure 2.

Because this discussion of relays is oriented towards the power switching function, the logic function, though important, will not be treated in detail. The pace of integrated logic development strongly suggests that the future role of relays as logic elements will be chiefly in systems of rather limited complexity for economic reasons alone, if not for others. It should not be inferred, however, that this means that relays will not continue to be used in large numbers to perform logic functions. The majority of machine tool control panels, for example, are rather simple from the viewpoint of integrated logic systems, and relays will continue to be widely used. In small systems one of the chief attractions of relays is the ease with which the power switching and logic functions are combined at a considerable economic advantage, as in simple interlocks.

One of the outstanding attributes of relays, so commonplace it is often overlooked in discussions of relay vs. "solid state" switching, is the ease with which additional, isolated contacts may be added to supplement the primary function, or to perform a function, such as 3-phase motor reversal, where this property is inherently necessary. Especially in the field of power switching, this relay characteristic is essential, yet rather difficult and expensive to achieve in solid state switches.

It is in the field of power switching that the challenge of "solid state" is most dramatic. Perhaps this is only because relays have been the only significant factor in this area for so long that any potential replacement would seem exciting. In any event, relays have performed so long and so well in this function that it may be worthwhile to examine the forces behind what many observers feel will be a major revolution in power switching technology.

First, it must be admitted, that in spite of the excellent results obtained in the past with relays, nagging questions of reliability remain, particularly for extended service, or service in hostile environments. It is no doubt naive to expect that solid state switches will solve all these problems, but there are a number of circumstances where failure mechanisms can be eliminated by solid state switches without (apparently) introducing new ones. In the long run, shock, vibration and corrosive atmospheres will probably be dealt with more effectively with nonmechanical switching.

Secondly, there are many applications where continuous control of power has such inherent advantages that relays were only used for lack of alternatives. Such applications are already dominated by solid state devices, and this preponderance is certain to increase to the virtual exclusion of relays. Even here, however, the competition between mechanical and semiconductor switching is not as direct as it might seem. A large portion (most likely the majority) of such applications simply never were candidates for relay application (residential light dimmers are a good example), and so should be considered as new territory opened up by and largely open only to, semiconductor power switching devices.

A third major reason for preferring the solid state approach in spite of higher initial cost, is the hoped for lack of maintenance costs with properly designed semiconductor switches. A good example of this motive is found in industrial process temperature controls.

Control instruments of the type previously described, that switch power "on" when the process temperature falls and "off" when it rises, inevitably cause some cyclic fluctuation of the controlled temperature. Such cycling of the process is usually considered objectionable and is often unacceptable. To overcome this problem, it is common practice to modify such "on-off" action by causing the power to be switched periodically at a rate much faster than the process time constant, with control of average power affected by the switching duty cycle. This method, known as time proportioning, is very effective, but places severe life requirements on the switching device. A typical time proportioning controller may cycle at a 10 second rate, resulting in over three million operations per year on a continuous process. "Telephone type" relays are often capable of tens of millions of operations; few power relays are even with severe de-rating. Thus the compromise between good control response (fast cycling rate) and relay life (slow cycle rate) is often an unhappy one.

The advantage of solid state switching in such cases is so clear that only initial cost and development time has so far prevented wholesale replacement of relays by semiconductor devices. The situation today is very fluid, with every reason to expect a large upsurge in solid state switching in the next two years.

For these reasons alone, it is clear that solid state switch families will expand rapidly in the next few years, and will very substantially increase their penetration into areas now served by electro-mechanical relays. However, it does not follow that the latter will be replaced en mass, or even decline. The factors favoring solid state switches are rather selective, and, though important, are by no means universal.

If the time is ever to come when a single technology will be dominant in a field as varied as this one, my crystal ball is too cloudy to predict it. If anything, the ability of solid state relays to do well some jobs electro-mechanical relays have done poorly, will in the long run improve the reputation of the latter by confining them to applications in which they perform reliably.

If there really is a contest between solid state and electro-mechanical relays, the real winner will be the product designer, who will be in a better position than ever to make rational choices for his many switching functions.

Biographical Sketch: WILLIAM A. PAULSON

William A. Paulson is Principal Engineer for the Industrial Instruments Division of the Barber-Colman Company, Rockford, Illinois.

The Industrial Instruments Division of Barber-Colman manufactures industrial process controls and, therefore, is a prime user of relays and related devices. Mr. Paulson received his BSEE degree from the University of Illinois. He holds six patents in the control area including industrial, process and radio transmitting controls.

APPLICATION OF ELECTRO-MECHANICAL, HYBRID, AND SOLID STATE RELAYS

By James E. Davies, Manager of Engineering, Specialty Products Division, Cutler-Hammer, Inc.

If you think I'm going to solve all your relay problems, forget it! I'm only 92 miles from home and that doesn't quite qualify me as an expert; however, we have some thoughts that we think might be of interest to this group. We're going to talk about relay hang-ups. Problems that you can get into - maybe have gotten into - in the application of electromechanical and hybrid or solid state relays.

Now, I think in order to start we ought to define the types of relays we are talking about. The most common relays in commercial or military applications as we see it today are (and incidentally I am going to leave covering of specifications in these areas up to Mr. Neyhouse who is going to follow me and who I am sure will make a very thorough and capable presentation in this area) are the crystal can, DC armature type, AC armature type, rotary, power, mercury wetted and dry reed.

In addition to these basic types there are what I would like to refer to as miscellaneous types for specific applications. Some of these are offshoots of basic types. You might argue, in fact, that some of them are basic types. If you do, I am not going to argue with you. These miscellaneous types are thermal, bimetallic, time delay, stepping, sensitive, latched, polarized, vacuum, meter, crossbar, coaxial and hybrid and solid state.

Now, I would like to break the hybrid out as a separate subcategory. First of all, I would like to give you my definition of a hybrid relay. My definition, for better or for worse, is a combination of electromechanical and electronic components usually tailored for a specific purpose. Okay, what types of hybrid relays do we have. Time delay, sensing, sensing under and over voltage, under and over current, under and over frequency, phase, phase shift, phase sequence, etc. The rectified relay which permits operating a DC coil or solenoid directly from an AC line is an old stand-by which also comes under the hybrid category. An amplifier relay combination such that a conventional relay can be operated from low level logic or other low level electronic sources is a hybrid relay also as far as I am concerned. Bounce free or suppressed relays fall in this category, i.e., the RFI filtered relay.

At this point I would like to take a minute to define or explore what a relay is generally used for. We're here to talk about the problems we can get into in applying relays. We have now defined what relays we are talking about, we ought now to take a look at what relays are generally used for. In the language I would like to use, I would say they are basically used for two general categories of application. Commutation and logic in the broadest sense. Commutation of what? Commutation of motors, lamps, heaters, other relays, load transfer, power supply transfer, and commutation or turning on and off electronic circuits. I didn't define commutation. I assume I won't get any static in the audience if I say it means "turning on and off."

Logic in the broadest sense I would define by examples such as time delay, over and under voltage, over and under frequency, phase and phase sequence relays, zero sequence relays, current sensitive relays - now that could be a current sensitive relay in the signal sense or overload which, in effect, makes the relay a circuit breaker. Other logic examples are reverse current relays, reverse current sensing, temperature sensitive relays and last, true logic where the relay is used in an "or," "and," "not," "exclusive or" or other logic circuit. These are all, of course, prime applications of hybrid relays in this latter area whereas you will primarily find conventional electromechanical relays in the former or commutation area.

Now, we're here to talk hang-ups and from my experience, limited as it is, one of the big hang-ups - I would say the biggest hang-up, is application. The communication between the manufacturer and the user, with either the Military or in some cases an independent testing or specifying laboratory such as U.L., an intermediary represents the communication area where some of our biggest hang-ups occur.

What does the user need to know to apply a relay? First of all, I'd say of primary importance is contact voltage and current. Not just the current but the maximum, minimum and nominal. The type of load. Is it inductive, resistive or capacitance or motor? If it is a motor, is there an inrush, or if it is lamp and there is an inrush, what is the amount of the inrush and time duration of the inrush. If it's a motor, will the relay ever have to interrupt locked rotor current? This is frequently overlooked, but in many motor applications it is possible for the motor, due to perfectly natural causes, to be stalled, and the relay has to either make or break or both at the stalled condition. This could be trouble, if the relay isn't designed right. What is the inductance or power factor, if AC? Is there over voltage at the moment of interruption? If the relay is going to handle a motor, will the motor ever be reversed or "plugged"? What's the duty cycle? This is frequently overlooked. It can be quite significant. I've seen several applications where everything else was very carefully thought out but an electromechanical relay was rated for a limited number of electrical cycles and in the particular application this number of cycles could be run during a very rapid period of time with resultant trouble. What's the available space? Is there heat sinking available? And believe me, for hybrid and solid state this is very important. What terminations are required? Will the relay be used on single phase or three phase on AC? What is the power supply and what is its capability?

Okay, we've now established some of the basic electrical data which is necessary in order to properly specify a relay. What are some of the environmental hang-ups we can run into? First of all, let's look at commercial and industrial applications. What kind of data do we need to know there to properly specify a relay? We need to know the ambient temperature; normally this is not a problem. In most industrial plants it will be somewhere within a few degrees of plus or minus 70 - 75 degrees. However, relays, particularly in the industrial area, are called on to operate close to furnaces, in deep freezes and other non-normal environmental areas. Will there be exposure to dust environment or fluid? Will there be exposure to mechanical damage? Will there be exposure to tampering? Will the relay be repaired? (This may surprise some of you in the audience who are used to working with small hermetically sealed relays both as designers and/or users, but in the industrial area power relays and contactors are not only repaired, but they are designed to be repaired. Contacts are replaced at frequent intervals, coils can be replaced. This is standard practice in industrial and motor starting contactors.) Will there be exposure to explosive atmospheres? Again, in the military area, many, in fact, most devices are designed to be resistant to explosive vapors and in the commercial sense there is an entirely different category of explosion proof device which involves either extremely low voltage, low wattage control circuitry and/or power being controlled by devices in cast iron or cast metal cases with huge flanges which will dissipate the energy of any arc which might attempt to escape from within the enclosure.

So much for commercial and industrial environment, what about military. And here I would guess that most of you are quite familiar with the environmental specifications of altitude, the necessity for hermetic sealing versus environmental sealing versus dust tight enclosures, vibration requirements, shock requirements, maximum and minimum temperature, thermal shock, aircraft fluid, hydraulic fluid can be, of course, extremely injurious to many materials, radiation environment, voltage spikes, vacuum. Today, of course, we find relays operating in hard vacuum. The designers really didn't know how devices were going to perform out in hard vacuum until the last few years. We find to our great satisfaction that they perform pretty well if properly designed.

We've covered what we need to know for general categories of relays but how about the hybrid and solid state. What additional information do we need to know to apply hybrid and solid state devices. Well, we need **exact** voltage limits. This can be quite critical. We need to know DVDT in addition to just what the voltage is. We want to know what the maximum rate of change of voltage can be and this can be very critical to certain semiconductors. We need to know the absolute maximum temperature. On conventional relays we are used to the abuse of occasionally permitting temperature to exceed recommended limits. Most relays will take this for limited periods of time. Solid state devices will not. We must know the exact maximum temperature that the device will ever see. We need to know detailed information on transients which the solid state or hybrid relay may be exposed to. We need to know what the requirements are at minimum temperature. Again, semiconductor devices can fall off quite rapidly at low temperatures below zero. Beta or gain can drop off with resultant loss of amplification which may or may not put the device outside spec limits. How much heat must be dissipated, and how much heat sink can be provided needs to be known. This is perhaps the most critical area in specifying a solid state or hybrid relay.

Now, we've covered the big hang-up, environment. Where are some of the other application areas that we can get in trouble? I'd like to break these down into hang-ups on the electromechanical relays and then separately discuss hang-ups on the hybrid or solid state relays, with electromechanical first.

Perhaps one of the most frequent mis-applications of electromechanical relays is using a relay that is rated for single phase AC in a three-phase AC circuit. Now, my good friend Ed Thomas of Grumman Aircraft Engineering on Long Island has given considerable publicity to this cause over the last three or four years. I think he has gotten his story pretty well sold with engineers who are applying relays throughout the company. Incidentally, Mr. Thomas and Mr. Leonard W. Wendling, Naval Air Systems Command, are going to give a paper at the Oklahoma Relay Conference in April jointly sponsored by the National Association of Relay Manufacturers. Their paper will be on relay reliability. I may be covering some of the points that they are going to cover in this paper. I hope I am not stealing their thunder, however.

Next mis-application of an electromechanical relay is using a 115V AC only relay on 28V or higher DC voltages. You know, with AC either 400 hertz or 60 hertz, on every half cycle the voltage and current go through zero. Now they may not go through at identical times if there is a power factor involved, but, nevertheless, they do go through zero. And you have an opportunity to put an arc out at this point and interrupt the current. If a relay is designed with small arc gaps and single break contacts, it may handle 115V AC loads of substantial amounts quite adequately and yet be incapable of interrupting even very small loads at 28V DC and virtually nothing at 120V DC. Don't get sold down the river on this. Another hang-up is using a 400 hertz rated relay on 60 hertz voltage at the same rating as at 400. This has been a subject of considerable discussion in the industry. You will hear people say that 400 hertz is more severe than 60 hertz. If you are talking normal relay ratings - **don't you believe it**. It's a simple matter. At 400 hertz your half cycle time is one seventh that of 60 hertz, or one seventh of 8 milliseconds. So you are going to go through zero in a matter of one to one and a half milliseconds maximum and the current will go out. On 60 hertz, if you have a power load of any kind, the arc can hang on for up to 8 or 9 milliseconds. The additional wear and tear on the contact is, as the patent lawyer's say "obvious" to anyone skilled in the art. Now there is **some** justification for the argument that 400 hertz is more severe than 60 hertz and this situation occurs when you have very heavy power loads approaching short circuits. I'm talking currents at 115V AC in the vicinity of 1500 amps and on up. Under these circumstances, on 400 hertz AC your current goes through zero so rapidly that the arc has insufficient time to deionize before the current reverses in the opposite direction and the arc hangs on or as it is commonly called, re-strike occurs. Under these circumstances, 400 hertz is more severe than 60 hertz. At normal rated load of conventional relays of 10 amps or even up to 50 or 100 or 200 amps, your contacts will last a lot longer at 400 hertz than they will at 60 hertz for a given load.

Next hang-up is poor regulation of power supply. This occurs much more frequently than we would like to believe. It can be a particular problem on power relays moreso than smaller relays in the 1, 2, 5 or even 10 amp area. One way it can get you is, if you are drawing a power load, the relay contacts close and the voltage dips as a result of poor regulation. The relay may suddenly find itself with a voltage that drops so low that there is insufficient coil power to pull the contacts completely home, in which case they sit there and fry or may even blow open. When they blow open, the voltage pops right back up to normal and then the coil starts back in again and you end up with a motor boating situation similar to what our P.A. system did earlier today. This will keep on until the relay contacts melt down and permanently interrupt the current.

The other problem with regulation of power supply is involved with overshoot on break and again this is primarily a problem either on high voltage applications or a combination of medium voltage and high current; where, at the moment of interruption, (the generator providing the voltage source has been fighting for regulation control) the voltage shoots up way over normal. This presents a very severe arcing load on the contacts, which lasts until the voltage gets back down to normal or goes through zero. This can be quite severe and is a hang-up that again is not always understood, but occurs more than you would believe.

The next hang-up on a mechanical relay is using a single break contact such as you will find on a crystal can or a 2A, 5A or 10A relay on motor loads for reversing or motor starting applications where the motor load capability of the device is considerably below the resistive load capability. Although the drawing for this device may say it is a 10A or 5A device if you look in fine print you will find on the specification that the motor load rating is 6A on a 10A relay or possibly 2 or 3A on a 5A relay. An amazing number of times engineers will apply this supposed 10A relay on a 10A motor. It just can't handle the load. Again, they get sold down the primrose path, because many of the power relays with which they are familiar have double break contacts which are capable of handling the same motor load rating as their resistive load rating or even their inductive or lamp load. If an engineer had grown up with power devices, he doesn't realize when he gets into the crystal can or the TO5 can relays that this rule of thumb no longer applies.

Another hang-up with mechanical relays, of course, is using them in very rapidly cycling applications. And, of course, here is where the solid state or the hybrid combination solid state relay shines - on the rapid cycling, long life applications. Another problem area is the use of power relays in low level applications or vice versa. Most of your power relays have a composition contact and generally these are rated not to be used below 10% of their maximum rating. In other words, if it's 100A or a 200A relay, it should not be used below 10A or 20A. Frequently, users of relays find they have great success with these power relays and they are very reliable. They are one of the most reliable tools the aircraft designer has. However, he thinks because it works fine at 100A that it ought to work equally well at 1A or 1-1/2A and this just ain't so . . . Beware if you go much below 10% of the maximum rating on a power relay. When you get to the 10A relays and lower, they have silver contacts and in some cases gold plated silver contacts and if used as rated by the manufacturer they can be used on the quite low levels. The auxiliary contacts on the power relays can, but not the power contacts.

Another area where we get into trouble is reversing and power supply transfer applications or load transfer applications. In the old days, designers were used to using a 3PDT relay with center off or a SPDT relay on DC with center off so that you have, in essence, two different relays with two separate coils wired to transfer between these two power supplies. So, you have got, in effect, infinite arc gap. The one cannot close until the other one is fully open. In many instances nowadays to save weight, the designers are using, in essence, form C type or I guess it's form Z with a double break contact. We have a normally open and normally closed and they transfer from the normally closed to the normally open. Well, the arc gap here between the normally open and normally closed contacts may only be 25 or 30 thousandths of an inch and it is possible to have an arc hanging on when the supply is transferred. In a reversing application, the arc may be hanging on, which in effect shorts out the line. These are areas that must be guarded against.

Now we've talked about the most common hang-ups for the electromechanical relays, let's have a look at some of the hang-ups on the hybrid relay. I think one of the first ones we have to be concerned about is using a hybrid or solid state relay on any voltage other than rated. Now, electromechanical relays may actually work quite satisfactorily on voltage lower than rated; however, if it's a hybrid relay with a contact output and logic input, the logic may not work at all or certainly not within specifications. Poor power supply regulation again is another major problem here which could permit operation but not within specification limits. Perhaps one of the most frequent problems with hybrid or solid state relays is exceeding the transient or steady state voltage current or temperature. Again, we are used to abusing the electromechanical relay. We've been doing it for many, many years. But with solid state you cannot. When you exceed the maximum current your semiconductors are done, that's it. At the other temperature extreme you can get in trouble as I indicated earlier. At low temperature your transistors and semiconductor devices lose their gain or beta and the device will not work per specification, if at all.

Another area of mis-application is using hybrid or solid state relays for complete output isolation where freedom from crosstalk is needed. It is true that we now have metal oxide field effect transistors (MOSFETS) which have very high input impedances. The fact remains that high input impedance or not you can still get crosstalk with a solid state amplifier type device, either in a hybrid or an all solid state relay.

Another rather unexpected area of problems with the solid state or hybrid device is inherent current limiting which may limit inrush to a motor and prevent starting of the motor, or cause burnout as the case may be. This is one of the problems that perhaps Mr. Neyhouse will touch on later. But if you design an all solid state relay to have inherent current limiting, you had better be sure that a motor which you use this relay to control can obtain sufficient starting torque to get moving or you sit there in stalled rotor condition and the motor will overheat and either the semiconductor or the motor will burn out.

I'd like to close by listing the areas where I think electromechanical relays are best and those where hybrid and solid state relays are best. Incidentally, I went to a symposium several years ago which the Signal Corps put on on solid state relays. They had a contract at the time with a manufacturer who did some very excellent work for them. One of the speakers at this symposium, and this must have been six years ago or possibly seven, predicted that the mechanical relay was a dodo bird and that it was going to be out of existence in 2-3 years. Well, gentlemen, this is now 6-7 years later and the electromechanical relay is still going strong. They are finding applications in combination with electronic semiconductor devices that they couldn't perform before but are still going strong.

Okay, where is the electromechanical relay best? Well, again, where you need complete isolation. Where you may have possible over-temperature, over-current, or voltage transients. Where you have high power applications without any capability to sink heat. Where you may have locked rotor type loads. (A motor load where the mechanical load on the motor is such that it may be locked under certain circumstances.) The semiconductors are good on inrush, don't misunderstand me, but if they have to carry that locked rotor current for very long periods, unless they are very heavily rated and very heavily heat sunk they are in trouble. On multiple applications your mechanical relay is better. It's cheaper, you can get more poles per dollar, and more poles for a given weight. The conventional relay at present is better in deep space or radiation or reactor type environments. If you need low millivolt drop and low total heat generation, the relay obviously has it all over the solid state or hybrid relay. Again, a mechanical relay can be latched so that there is zero coil drain (in the energized position) for missile applications. You don't have to match impedances with conventional relays and again the relay costs less per pole. Now I would like to point out however, that with logic there are many applications where a single pole solid state relay may replace a multipole conventional relay. Of course this can be true of a hybrid relay also.

Finally, where are the hybrid or solid state relays best? What is their best area of application? Extremely long life. Extremely fast operation where you need complicated logic. Your conventional relay can do logic function with 4 P NO NC contacts. You can do logic with relays, but more economically and in a smaller space with solid state logic. I think more and more sensing type applications are going to be taken over by either hybrid or solid state relays. Very high shock and vibration applications will necessitate the use of solid state circuit. No audible noise is a solid state advantage. Semi-conductors are very good on inrush type loads if the loads are of short enough duration.

I think I have conveyed my feelings that both of these devices, or all three of them, are going to be with us for a considerable period of time. If we are going to be able to effectively use them, we have to learn how to apply them properly. Given the proper application information between the relay manufacturer or the solid state relay manufacturer and the user in cooperation with the specifying agency, the electromechanical relay in the areas where it is best and the hybrid or solid state relay in the areas where they perform best should be among your most reliable devices in any commercial application or military vehicle. It isn't always so, but it can and should be so.

Biographical Sketch: JAMES E. DAVIES

James E. Davies is Manager of Engineering, for the Specialty Products Division, of Cutler-Hammer, Inc. Milwaukee, Wisconsin. He possesses a wealth of first hand experience in applying relays of all kinds. He has been active in the National Association of Relay Manufacturers and has recently been elected second vice-president of that organization.

Mr. Davies is also a member of IEEE and the GAES Group on Aerospace Systems. He has co-authored the paper "Specification and Design of Established Reliability of Power Relays" in addition to presentation of several talks covering the requirements of electrical aerospace systems. He serves with the Military Specification Coordinating Committee and the NARM Reliability Committee.

Mr. Davies is presently co-holder of five patents on electro-magnetic contactors.

"RELAY SPECIFICATION PRACTICES"

By George A. Neyhouse, Electronic Engineer, Relays, Defense Electronics Supply Center

Mr. Roeser, panelists, and guests. Mr. Davies is a difficult person for any speaker to follow. To compensate for that, you should find me to be a speaker that any person finds difficult to follow.

The fundamental differences among electro-magnetic, relays, solid state relays and hybrid relays have been well covered.*1

Relay specifications are a necessity to competent control circuit designers. A schematic diagram without definitive references for the components is analogous to a mechanical assembly drawing without proper identification of the parts - useful only to illustrate the principles involved. Specifications of the relays of various types provide information about the pertinent characteristics.

In order to compare relays covered by specifications, it will be helpful to reiterate the criteria by which the specifications are developed. Scope of a general specification is that of a generic type of relay. It describes the parameters by which the relays are classified and outlines the conditions under which the relays are applied. A testing regime is defined to stimulate the environments and treatments of relays from the time of their manufacture to the time of their installation in the intended application, and the operating characteristics after they have been installed. The procedures are designed to provide assurance that the relays remain intact while undergoing the rigors to which they may be subjected during shipment or storage under the adverse conditions possible or for prolonged periods of time. Furthermore, after installation, relays must operate satisfactorily initially, and continue to function properly during the various conditions which they could be expected to encounter during their service life. Certain test procedures, optionally required either in whole or in part, are needed for particular types of relays. These procedures are those that stress relays in areas known to be critical for the particular type of relay.

A procedure may include testing of the relays under combinations of thermal conditions, hostile environments, mechanical stresses, and electrical loading and switching operations. Typically, thermal tests include thermal shock, resistance to soldering heat, storage and operation at high and low temperature ambients, and thermal E.M.F. measurements; environmental tests include seal test, moisture resistance, salt spray, and exposures to explosive atmospheres or those containing acid, alkali, detergent, hydrocarbon, sand and dust; and mechanically-oriented tests include shock, vibration, acoustical noise, terminal strength, solderability, and visual, mechanical, and dimensional checks a part of the routine. Relays also undergo tests to determine insulation resistance, dielectric withstanding voltage, capacitance, electro-magnetic noise and cross-talk.

Meeting the foregoing tests, coupled with passing the electrical testing, constitute the requirements for determination of acceptable items. Electrical tests are made with the coil both energized and de-energized. Readings are made of coil current, resistance, and inductance, and of the contact resistance or voltage drop under stable conditions; measurements of pickup and dropout voltages, operate and release times, and contact bounce are made during the switching transfer operations of the relays. Inclusion of a requirement in a relay specification is by deliberate consideration.

Transient voltages, including overloads, are imposed on the coil and contact test circuit networks. The relays are then cycled with a variety of contact loads with various environmental and electrical conditions. (The terms "coil" and "contacts" are used throughout regardless of the actual relay type involved; the intended connotations are those of "operating input" and "load output," respectively.)

No imagination is required to agree that relays used in military systems are in critical operations, which encompass the entire range of conditions mentioned.

Therefore, the specifications for relays for the military are more rigorous and extensive than those for similar items intended for commercial and industrial applications. Relay functions in military equipments are identical to those used in commercial and industrial electrical and electronic gear. The operational requirements differ in terms of reliability under adverse conditions. Military specifications for relays reflect this by requiring additional test procedures beyond those routinely prescribed.

The particular requirements concerning thermal shock and high and low temperature operation, acoustic noise, vibration test, mechanical shock resistance, EMI and EMC, gravitational effects, acceleration, minimum current, altitude (reduced barometric tests), RI, abnormal voltage, salt spray, moisture resistance and internal moisture, fungus resistance dissimilar metals, are paraphrased for simplicity and clarity as follows:

> See enclosure 1 (Applicable paragraphs from MIL-R-5757E covering the procedures).

Individual specification sheets include the dimension, identification, ratings of coils and contacts, electrical and mechanical arrangements, mounting means and terminal styles. Specification sheets include statements as to the applicability of these requirements which are listed as optional in the general specifications. Pertinent classifications, such as enclosure design, vibration characteristic, temperature range, shock type, and pressure range likewise appear. Individual specification sheets also delineate and emphasize additional special information such as deviations from the requirements of the general specification and extraordinary requirements or procedures.

The information offered concerning relay specifications has been condensed to generalize on the fundamental issues and no effort has been directed toward any particular type; however, with regard to specifications of solid-state and electro-mechanical relays, since each family has certain inherent characteristics, adequate specifications for each would reflect those parameters. Due to these and other differences, neither type, as presently conceived and manufactured, will completely dominate the relay market.

This testing procedure is used to demonstrate suitability of a relay type. The points mentioned are more elaborately detailed in actual specifications. MIL-R-5757E exemplifies a general specification for electro-mechanical relays; MIL-R-27777A covers solid-state telegraph relays. MIL-STD-202 contains test methods applicable to all electronic parts. It is used extensively in the testing of relays used by the military services, thereby imposing similar test conditions to assure compatibility of a variety of parts used in conjunction with relays in control systems.

In recognition of the critical functions performed by relays, general specification MIL-R-39016 covering relays of established reliability is recommended for consideration.

*1 - Presentation by Mr. James Davies of Cutler-Hammer preceding this paper. Mr. Neyhouse's comments and opinions are solely his own and should not be construed as to be official U.S. Government Information.

Although it is recognized that performance specs are technically preferable to material (or design type) specs, universal performance type specs are impractical. For example, were "educated sawdust" available to perform a relay function satisfactorily to replace a classically accepted relay, specifications of the new type relay would differ from those it could replace. As an illustration, knowledge of the response under predetermined conditions would obviate testing of a solid-state relay in geometric planes, whereas such testing in various attitudes is needed for mercury-wetted reed types. Similarly, acceleration tests might correctly be omitted for solid-state relays, but be required for electromagnetic relays. Adequate specification coverage of hybrid relays entails the complete repertoire of parameter listing and testing. Hybrid relays, having the operational advantage of combining the speed and sensitivity of a solid-state nervous system with the isolation and low-contact resistance of an electromagnetic muscle system, also have the disadvantage of requiring complete test procedures including consideration of all tests normally to be expected with either type alone.

Specifications for relays for military use not only describe the requirements for the relays and the complementary testing required to assure the adequacy of the relays, but also include these types of tests:

a. Qualification testing, in which the complete testing of the relay is required. Design and construction, materials, environmental, mechanical and electrical testing are called for. Life test is a part of this routine. Relays undergo a complete examination for approval. Due to the rigor of the testing, the equipment required, and the attendant expense, such qualification is not undertaken frivolously. Passing this testing assures that the design of the relay is adequate.

b. Group A tests, imposed on all lots; these are routine tests of a type normally expected to be performed by a reputable manufacturer for his own quality control, but definitely required by military specifications. Testing may be required on each relay in the lot, or on a random sampling plan, or a combination, in which all relays are subjected to certain of the tests, are applied to random samples. These tests eliminate infant mortality of the relays as well as indicating the need for tighter production and inspection by the manufacturer.

c. Periodic inspection of predetermined numbers of samples; these tests are more thorough, and are intended to assure the maintenance of the quality of the relays.

Each general specification covers a generic type of relays and is used as a matrix to specify particular models within its scope. Specification sheets are developed to define the parameters of particular standard relays used in control systems. Advancement in the state-of-the-art is reflected by the revisions to existing specifications and by the issuing of new specifications, some generated by the requirements of new systems.

The elapsed time during which a particular relay will remain active in the military system is indefinitely long; therefore, traceability is a logistics factor required in military specifications; standard marking methods are incorporated for this purpose.

Due to the multiplicity of standard relay types and models available, a project to tabulate their characteristics and features has been initiated to assist circuit design engineers in the selection of relays adapted to particular applications.

To conserve time, not all facets have been completely covered; however, questions regarding relay specifications will be entertained at the close.

The choice of suitable relays remains the responsibility of the circuit designer.

Biographical Sketch: GEORGE A. NEYHOUSE

George A. Neyhouse is an Electronics Engineer for the Defense Electronic Supply Center – EMD, Dayton, Ohio 45401.

Mr. Neyhouse is in charge of establishing standards for electronic systems and components. He obtained his BSEE degree from Rose Polytechnic Institute and is presently working on his MA degree in math at the University of Dayton.

Mr. Neyhouse has presented papers at the AIEG conference, and is a part-time instructor in Electric Machines, control circuits and math at the University of Dayton.

Mr. Neyhouse holds eleven patents with 4 more pending.

A TRANSCRIPT OF A THREE-HOUR QUESTION AND DISCUSSION PERIOD

QUESTION: MR. PAULSON
What might be considered a major impediment in the way of near universal application of solid state relays?

ANSWER:
There are enough impediments. It's pretty hard to say which is major. I alluded in the talk to design and development time, which in the fields where there are clear advantages, it is probably the significant one. Another one has to do with the maintenance problem and with the fact that especially in the smaller sized devices it is almost impossible to protect the semi-conductors against short circuited loads, which are fairly common, if you have uncontrolled circuit wiring. Very often the first time the thing is hooked up there will be a short in the load. If it's an electro-mechanical relay, you may burn the contact, some; you may even weld them together. The average mechanic can come out and look at it and see what's wrong; pry them apart; file them; and put the system back into operation. If it's a silent failure hidden in the thing, the only recourse you have is to diagnose that and locate the special part. In some applications this will always be a very significant thing.

QUESTION: MR. DAVIES
Solid State relays can be equipped with suitable circuitry to minimize any chance of false actuation. However, assuming that a transient pulse is of sufficient duration and size to actuate a solid state relay, this may not necessarily cause the problem. For example, if the load is a heating element. What parts of loads do you consider most likely to cause a problem in solid state relays?

ANSWER:
One would be where they are working into other logic or where the solid state relay is controlling other electronic components as a part of a logic system. If you are in a counting sequence, any false actuation of the relay would give you an unwanted output condition. This could be a broad category of applications.

Another application that could cause problems using solid state relays is machine tools. This could certainly be an application where electro-mechanical would be safer, because a transient under no circumstances operates electro-mechanical relays. If the circuit isn't properly protected, operating a solid state relay could cause a problem.

QUESTION: MR. NEYHOUSE
Do you think that the present MIL-R-5757E Quality Assurance, group B, is an adequate program?

ANSWER:
No. However, there is an amendment on the way to rectify the situation.

QUESTION: MR. NEYHOUSE
Is there a time table on this amendment?

ANSWER:
Yes there is and it should be circulated in about a month and a half.

QUESTION: MR. DAVIES
What are the typical operate and release times for a typical general purpose relay and can you give a comparison for the DC versus an AC relay?

ANSWER:
Of course it depends on the size, but if you were to take the 10 ampere size of general purpose relay, your operate time would be in the 10 to 15 milli-second range, release time might be in the 5 milli-second range. Getting to the power relays you may have operate times going up to as much as 25 to 30 milli-seconds, release time again being in the vicinity of 10 to 15 milli-seconds. You get into the reeds, then I believe you're down to the 1 to 2 milli-second range.

To answer the second part of the question, an AC relay will generally operate faster than a DC relay. You've got the heavy in-rush of current in the coil and as soon as the magnetic circuit is closed the current drops off. I'd say perhaps twice the speed of a DC in half the time for a given frame size. (This applies to "True" AC relays, not rectified relays with DC coils.)

QUESTION: MR. DAVIES
How can an industrial user intelligently apply relays when guide line data is not available from the manufacturers?

ANSWER:
First of all I would say that manufacturers in their literature do restrict the total amount of information available and they do it for two reasons. One, we want to know what the application is. We think our application engineers at the factory and/or our sales engineers in the field can specifically tailor a device to an application if they get into that application. If our trade literature gives all of the parameters of these devices and if we try to be all things to all people and include everything we know about it, my personal feeling is that we would get into more application trouble than we do when we put the basic operating characteristics of the device, the current it will handle, the load, operating time, and so forth, and then rely on the applier to come to us for additional help when he needs it.

QUESTION: MR. NEYHOUSE
Why is there no specifications for "concurrency" for multipole military relays?

ANSWER:
If "concurrency" means "simultaneity," there is a test that can be called out when specified in MIL-R-5757E Class III relays. It is not a usual requirement.

QUESTION: MR. NEYHOUSE
Why shouldn't the simultaneity of relays be called out as a rule?

ANSWER:
In multiple-pole telephone relay applications, where phone companies refer to it as "stagger," we call contact differential operating time; it is indeed one of the factors that could be called out. It is an expensive test and therefore not required on all general purpose relays. It becomes more important when you get into larger power relays because you'll be single phasing for two or 3 milli-seconds. These contacts play a piano as they come in and I think most of the manufacturers are aware of this and set internal specifications, usually of 1 to 2 milli-seconds differential operation of the contact.

QUESTION: MR. DAVIES
Mr. Davies, you indicated that solid state relays are sometimes used as sensing devices. Could you elaborate on that?

ANSWER:
I think the gentleman from Barber-Coleman, Mr. Paulson, indicated one area and that is in the temperature sensing area. Perhaps I should have said that in the hybrid area solid state sensing is used in conjunction with relays, either electro-mechanical or solid state. You can sense temperature with a thermistor, you can sense overcurrent with a thermistor by the heat generated. You can sense things with either passive or active solid state devices and then drive either a conventional relay or a solid state relay with them. If I said the solid state relay itself could be used as a sensor, I mis-spoke. The relay is used with some kind of a transducer that sends the signal to it, or perhaps an amplifier in between, solid state, generally. Other sensors could be overvoltage sensing, current sensing and so forth. For example, in the military, in a generator control panel, they may want to sense any over-voltage condition. Or you may want to sense wrong phase sequence to check motors running the wrong way and crank the landing gear up into the body of the plane. You may want to sense that the power coming into a military vehicle is correct. This is done electronically in many instances. Other examples are, where you want to be sure that the phase sequence, phase voltage, frequency, etc. all are within the parameters that will permit the devices in that vehicle to operate properly.

QUESTION: MR. NEYHOUSE
Is there any activity in mil specs specifically regarding solid state relays? I know you mentioned the telegraph type relay which is used in teletype equipment. This question is more directly concerned with the power type solid state relay.

ANSWER:
I don't know whether we call it power type essentially but, we have a project active, listed as 5945-0164 to promulgate a specification for both control and power solid state relays, excluding telegraph relays.

QUESTION: Does MIL-R-27777, the telegraph spec, specify the requirements for solid state relays and include recommended terminology?

ANSWER:
The terminology is, if I may be allowed the term, a hybrid between the telegraphy vernacular and the vocabulary of the solid state people and that of the NARM Convention.

QUESTION: MR. DAVIES
Does Cutler-Hammer have solid state relays available of a general purpose nature and if so what are the switching capabilities?

ANSWER:
I would say no to that. I think somebody made the point earlier that an off-the-shelf general purpose solid state relay may be a long time coming - that doesn't mean that you can't make solid state relays - people are making them today and are selling them. I think you have to specify the application so finely on a solid state relay that it's going to be difficult to sell such an item as an off-the-shelf item unless you very very carefully control the applications of it and the usages of it. Time may prove me to be wrong on this - improvement of semi-conductor devices beyond today's state of the art, may permit you sometime in the future to make a GP solid state relay but just at the moment I don't really see it. Does the rest of the panel agree with me on this?

COMMENT: MR. PAULSON
Yes, I would say that in our own experience in house we view the relay as an integral part of the controller and its specifications are tailored this way. With this kind of control and this kind of knowledge of where it is to be used you can make something approaching a general purpose but you might say general purpose for specific fields. We intend to have available shortly, for example, a line of what we are going to call solid state contactors for use with our controlling instrument to handle power in the sense that it will be normally switched in a small and delicate instrument. It will be made in sizes fairly comparable to industrial contactors. In fact, they will be called size one and size two contactors, etc. Now, in one sense they're general purpose in that we aren't specifying exactly where they are going, but in another sense they're quite definite in purpose because basically the market, the usage area where the instruments are sold, is itself a fairly definite and very restricted area.

QUESTION: MR. DAVIES
You mentioned that electro-mechanical relays are the ones to be used for complete isolation. What resistance and voltage breakdown combination would one estimate is adequate to call complete isolation, if one was to consider going to solid state for reliability requirements?

ANSWER:
It would, of course, depend upon the application. Your electromechanical relay is generally going to have 100 meg ohms or better insulation resistance. We are getting MOS devices today which are up to one meg ohm or a couple of meg ohms - so they are beginning to get to the point where you have an input impedance to an electronic circuit which begins to approach that of an electro mechanical relay. The addition of another order of magnitude would, perhaps, make the two types of relays comparable. At the present time though you are talking two orders of magnitude difference, generally, between the solid state device and the electro mechanical relay. It depends on your circuit though and what voltage you may have generated. In a three volt circuit - perhaps you don't need 100 meg ohms of resistance if you're not going to have transients over 20 or 30 volts. The 100 meg ohms of the relay may be academic and unnecessary.

COMMENT: OHMITE REPRESENTATIVE
We would like to comment on this subject of whether there is a solid state relay with isolation and if there is a solid state relay for general purpose use. Ohmite is sponsoring this THINK-IN, wishes to refrain from entering into any of the discussion, to insure an unbiased exchange of ideas. If we were to remain silent on this point, however, we feel we would be doing a disservice to this audience. Therefore, we wish to advise you that there is a solid state relay on the market that has true isolation between coil and contacts, in the order of 500 Kilo meg ohms, and that the relay is designed for direct replacement of electro-mechanical general purpose relays. This being a professional THINK-IN rather than any Ohmite selling pitch, all we wish to do at this time is to refer those who are interested, to Ohmite Catalog 750, describing the Model SSA all solid state true relay. It describes both isolation between "coil" and "contacts" and also isolation between the terminals and between the case and the terminals.

QUESTION: MR. PAULSON
From your vantage point what do you see the impact of Reed switches on the relay market?

ANSWER:
I'm not that familiar with the relay market as such. I can just illustrate a couple of places where we used these switches. The Reed switch is, of course, a logic type device, just by the nature of its' current carrying capacity. It is usually not capable of handling useful amounts of power, though that varies in what you call useful. One of our product groups has had some success using some of the larger Reed relays to switch directly the shading windings of shaded-pole motors. But this is unusual. Mostly they are in the logic area where they compete directly with digital integrated circuits. With the price and capabilities and speed of the latter increasing their use, therefore, is almost limited to interfaces.

About a year ago we made a solid state programmer for use with some furnace temperature controls for which we developed program ramps, not by electro-mechanical means but by means of summing pulses from a clock, in a digital integrated register. Then we utilized a bank of Reed switches, driven from this register, to control a resistance ladder network to generate a voltage very precisely proportional to the count. This sort of application has a good many applications for Reed relays, because the reeds do combine, as a rule, very good insulation between the coil and contact in sense of insulation resistance. They are almost always grossly defficient in terms of electrical clearance for those applications where you're getting into or approaching line voltage. In fact, the electric clearance area is a real sore point with small devices in general. Reed switches are excellent from the isolation stand point but as are all small devices, they are limited. I don't see Reed switches as having a fundamental impact on the relay market because they represent an extension into an area of usage that relays haven't performed well in. It is comparable to the impact of solid state switching in the light dimmer market. They'll open up new areas - more than they will take old areas away.

COMMENT: AUDIENCE
Just recently some Reeds have been introduced that can handle sizeable currents and we're beginning to use them on machine tool controls located in extremely dirty and corrosive areas, such as foundries. I'm referring to the Cutler-Hammer Power Reed Relay.

COMMENT: MR. DAVIES
I think hermetic sealing is an answer to handling these extremely severe environments. It has been in the military areas where relays have been hermetically sealed and, of course, the Reed switch either the small ones or the power ones are hermetically sealed.

QUESTION: DIRECTED TO ALL THREE PANELISTS
What new techniques and/or devices are available for protection of contacts from arcing effects due to breaking conductive loads and, No. 2, prevention or suppression of spikes or noise generated when de-energizing coils.

ANSWER: MR. NEYHOUSE
I think there are filter networks available and the use of a Zener diode properly applied would tend to suppress a great many of the spikes.

ANSWER: MR. PAULSON
Breaking inductive loads is a thing that we run into very frequently in our solid state devices, even, in fact, some devices we wouldn't call switching devices. We have some outputs which we call current output, where we are delivering a regular DC current source but because the demand signal might cause turnoff rapidly or disconnect or something, we have to treat it as a switch, they often feed inductive loads. The most effective protection for that however, when it is possible, is to have free wheeling diodes across the load which is possible of course in DC circuits only. I think techniques similar to this could be done on AC circuits where a pair of switchable devices like SCR's might be made to act like free wheeling diodes by appropriate logic. It isn't universal because there are many cases where you simply do not have access to the load although we generally could have protection inside the controller at the instrument's terminals.

ANSWER: MR. DAVIES
It is just a question of getting the load off the line. Putting multiple breaks in series could be an answer to this problem. However, that may actually intensify the spiking situation because you may interrupt more quickly. But this will insure that you do get off the line. It splits the arc across several contacts thereby minimizing the effect of it.

ANSWER: MR. NEYHOUSE
I would like to comment on the use of the free wheeling diode. I think that it is one of the very good practices, however, it too has its limitations and we should realize that probably the time constant is going to change if you apply one. It's one of the reasons why I think many relays have a longer release time. They essentially have free wheeling diodes. It's wonderful, except the release time has been changed from that of immediately dropping to one of a sustained lingering in the energized position.

ANSWER: MR. OAVIES
That's a good point Mr. Neyhouse - there is another connotation to this also, particularly in the power area. If you put a protective circuit across the coil which slows down the release you may also lose hammer blow on break which is inherently built into the device. You will be unable to break welds the relay would normally be capable of breaking. Do this with great caution and check with the manufacturer before you use a protective circuit on his device. I would strongly recommend that.

QUESTION: MR. OAVIES
What do you mean by the double-break contact you mentioned?

ANSWER:
Again, breaking both sides of the line is one way of putting it, or having a bridging type contact is a better way of saying it, where you break the circuit at two points simultaneously. With two breaks in series (on DC), you can break approximately four times as much current as you can break with one break and handle a larger load and higher voltages.

QUESTION: MR. NEYHOUSE
Has DESC purchased any pure solid state relays?

ANSWER:
I really wouldn't know since I don't get in on those things. I'm probably the last to know. There have been solid state telegraph relays purchased - but none of what might be classed as a general purpose type.

QUESTION: MR. OAVIES
You indicated that the contact switching capability was better at 400 hertz than at 60 hertz except for heavy current ratings. At what current does this apply?

ANSWER:
It's really hard to exactly specify the breaking point. I would say certainly up to relays rated 400 amp at their normal rated loads, you generally will get longer life on 400 hertz, than on 60 hertz. We also know that if you get up to 2000 amperes short circuit current, it switches over and 400 becomes more significant and more difficult. Where between 400 and 2000 that occurs, I'm not prepared to tell you, I don't have the data, but it is somewhere between there that it switches over.

QUESTION: MR. OAVIES
Could you give us a brief description of the TO5 relay and do you feel that there is an increase in demand for the miniature packaged relays of this type for direct mounting to printed circuit boards?

ANSWER:
The TO5 relay, as the name implies, is a miniature relay put in a TO5 transistor can which measures about .250 inches in diameter or something like that with wire leads coming out through miniature glass hermetically sealed terminals. When they first came out I couldn't believe that they would find real wide application. I've been wrong before and I'll be wrong again. Apparently they are finding rather broad application in printed circuit application, whether it is growing or not, I don't know.

COMMENT: FROM FLOOR
We would like to see an 8 pole machine tool control relay in that can.

ANSWER: MR. OAVIES
Give the industry enough money and enough time and they'll have it.

QUESTION: MR. PAULSON
Would you please explain the meaning of a free wheeling diode?

ANSWER:
In a DC circuit, this is simply a diode placed across the load. For example, when driving a relay, you place the diode across the load coil so that the normal or applied voltage would see the diode in a reversed direction. Then when the current to the circuit is interrupted, the current that is then in the inductance, which must continue, can then flow through the diode around a loop consisting of simply the diode and the relay and it will flow there until the dissipation in the circuit damps it off. It causes no losses when the circuit is normally operating, however, as soon as the circuit is de-energized the relay current circulates within the loop of the free wheeling diode relay. This is why Mr. Neyhouse pointed out that there is a considerable change in the release time of the relay because you are now waiting for a current die-out by internal resistance damping rather than forcing it suddenly to zero. You can put resistance in series with the diode and affect the dropout time because you'll change the RC time current. You can put enough resistance in so that you have very little effect on the dropout time I'd say of the medium sized power relay, I'm not sure about some others, and still have a very pronounced limiting effect on the transient current. You don't get as much limiting though. If you have very abrupt cutoff of the power, you can get 10 or 100 times the normal circuit voltage as an inductive kick. With a free wheeling diode, even if that diode is in series with a resistance equal to that of the relay coil, you'll only get at most the normal circuit voltage or if your resistance gets quite high, only a few times the normal circuit voltage as an inductive kick.

ANSWER: MR. OAVIES
There is another technique that has been tried here and it isn't universally used and I'm not sure that it's going to be and that the use of a bi-filar wound coil. A dual wound coil with the windings dispersed on the relay bobbin and one of the two windings is short circuited and serves the same function–to dissipate the energy at the moment of opening. But this has some disadvantages in that you're in essence carying waste copper when you're doing this, and you're taking away from your reliability because you've got two extra connections in your relay. Whether this will find universal acceptance or not is somewhat questionable.

ANSWER: MR. NEYHOUSE
With respect to bi-filar windings the same time delay in release will be encountered as with the free wheeling diode.

ANSWER: MR. PAULSON
This winding will also influence both pick-up and dropout. By contrast the free wheeling diode will affect dropout but not pick-up.

ANSWER: MR. OAVIES (cont.)
NASA is interested in this for some of their applications and I believe tried it somewhat successfully.

QUESTION: MR. OAVIES
What is the future of photo or life activated relays and would you like to comment as to any new developments in that area?

ANSWER:
There is certainly one advantage here in that we get isolation between input and output which you don't normally get with a solid state device. This is more comparable to the isolation you get with an electro-mechanical relay. In applications where this is critical you may see some growth of these devices. I don't know how much it will be, I can't predict.

QUESTION: MR. OAVIES
From the users point of view there are two problems involved in relay testing. One is when you get the relay, how do you tell whether you have a good one? The other one happens when the industrial user has a relay not completely protected against mishandling. By the time this relay is mounted to the control chassis, you may have a defective relay simply due to mishandling. It is often a problem for the user to tell when there is a maintenance problem or whether the relay needs an adjustment.

ANSWER:
We've encountered situations like this. I think it's a problem of communication and education. One example is rectified relays. Occasionally they get high potted improperly in in-coming inspection. You've got to see that the in-coming inspection people know that they are not to high pot across the two coil terminals and blow that rectifier. I think this problem is going to be even more severe, though, with solid state relays, particularly if we ever do get to that wonderful point where there is such a thing as a general purpose solid state relay. They will even have to be more tightly specified as to how they are inspected on in-coming inspection. Another problem area occurs when in-coming inspection may decide to test gold flashed contracts designed for 10 milli amps duty, with a light. The gold is gone and it's no longer a dry circuit relay.

QUESTION: PANEL ANO AUOIENCE
With the various kinds of solid state relays or so called solid state

relays that are on the market right now there is quite a bit of confusion between solid state switching devices and true solid state relays. Could you give us a quick definition of a relay?

ANSWER: AUDIENCE
In our organization we say a solid state relay should have the same general characteristics of an electro-mechanical relay. We want the input isolated from the output devices, so that you could not get in trouble. It should have the capability of handling the same kind of currents with fairly high ratios of in rush to average currents. So far as I'm aware, there are no solid state relays on the market. You know there are solid state switching devices on the market but there are no solid state relays for sale that I could take an electro-mechanical relay out of a circuit and put a solid state in place of it and it would operate in the same way.
(Ed. Note. See Ohmite Catalog 750 on Solid State Relays that replace electro-mechanical relays rated to 10 amperes.)

ANSWER: MR. PAULSON
I'm inclined to agree that isolation is one of the most important distinctions. We have found it necessary to have isolation in all of our output control packages. Another point of distinction besides isolation is the manner in which it controls output power. For several years we have made packages using SCR's based on isolated input circuitry which deliver output power proportional to an input control current. They are, of course, doing a switching job. They are phase controlled in that the conduction angle is a function of the input signal. If you took such a package and hit it with a fully "on" to fully "off" input signal you would have, in essence, a solid state relay although it would be an expensive one. We also have a line which we call solid state contactors. These, too, are fully isolated. They are not general purpose relays because we do have to know something of the loads that they are to deliver. One of the problems in solid state relays is when we have an inductive load, such as loads coupled with transformers. The transients due to this condition can drive such loads into saturation. The resultant excessive current would be damaging both to the equipment and to the solid state switch. It's things like this that would tend to make solid state relays special purpose. To be truly a general purpose solid state relay, it has to be able to handle all conditions without regard to special situations.

ANSWER: MR. NEYHOUSE
May I comment on special purpose relays. You are entirely right that normally you do not get the isolation. However, on solid state telegraph relays, a requirement is that the input have a 50 meg ohm isolation from the output, which isn't easily achieved.

QUESTION: PANEL
Would you define the term hybrid relay, semi-solid state relay and solid state relay? Does this mean that a hybrid relay could have a solid state input with an electro-mechanical output or vice versa, an electro-mechanical input and a solid state output?

ANSWER: MR. DAVIES
I attempted to define a hybrid relay earlier as a combination of electro-mechanical and electronic components usually tailored for a specific purpose. I don't see why you couldn't have an electro-mechanical input and a solid state output or vice versa.

ANSWER: MR. NEYHOUSE
The term solid state relay has been taken to mean a relay with all passive semi-conducting or other parts, none of which move during the operation of the relay. The term hybrid has two separate and distinct meanings. As we have been applying it, the hybrid is a combination of a solid state input or output with an electro-mechanical relay and in order to term it a relay it must all be within the same package. Otherwise it is discrete components. There's another definition of hybrid used frequently by the people who deal in solid state items only which is a combination of discrete components with perhaps an IC circuit.

ANSWER: MR. DAVIES
Would a saturable reactor be a solid state relay? It has no moving parts. With DC you can control the AC output, turning it on and off.

ANSWER: MR. NEYHOUSE
This and devices such as transistors, SCR's, triacs and the like, although they do perform a switching function and in many respects could be construed as a relay since they are a device which switches in response to an electric signal, have not been termed a relay by common consent.

QUESTION: PANEL
What is the difference between the solid state switch and a solid state relay?

ANSWER: MR. NEYHOUSE
Frequently it becomes a matter of cataloging and nomenclature. Those who are in the telephone industry and deal with stepping switches may call an item which is of the same general package a stepping switch. A pin ball manufacturer may term it a stepping relay. There is a very grey area, and depending on how close you care to define it, there is going to be an overlap. But frequently it's merely a matter of semantics, whether it be called a switching device or a relay.

ANSWER: MR. PAULSON
The distinction very often is formed on whether there is electrical isolation between the signal or the command circuit and the main power circuit. It is by no means a universal definition. No standardization groups have yet met and agreed on a standard definition but I have noticed this distinction being accepted in practice today. A solid state device without isolation would be called a switch if it is bilateral such as a triac or package consisting of two SCR's back-to-back. GE is marketing a thing they call an AC switch which is a couple of large chips and water pipes. This is a switching device but it does not contain isolation from the command signal. There is an SCS, a silicon controlled switch but again, it fits in the switch category. In electronic switching you do not consider isolation. Where you add the word "relay," it would, I believe, clarify the terminology if isolation were always a part of the device.

COMMENT: MR. VIRGIL JAMES, MEMBER OF NARM
We struggled with this problem of what is a relay and what is a switch when we wrote the NARM Relay Handbook a few years ago. I am sure our definitions are opposite from what you are thinking of right now. We decided that as far as electro-magnetic switches are concerned, at least, a "relay" was something that was either up or down or it was to the right or the left or had a neutral position. In other words, it was either two position or three position or bi-stable or something of the sort. If it could assume more than three positions, it then became a "switch" and this was strictly in the category of telephone switching. In other words, a stepping switch which had a multiple number of positions and was not restructed to either "on" or "off" or to the right or left or neutral was defined as a switch. I think, based on that definition, it is pretty much opposed to what you have been talking about in respect to solid state, if I've followed the discussion.

NARM has had a committee for a couple of years that has been struggling with this problem of solid state devices and relays and hybrids. This committee's report is now final and it will be incorporated in the next edition of the **Engineers' Relay Handbook**. I see already a deficiency in their words because they have not defined what these devices are. There is no section given over to definitions. So if somebody can come up with some definitions that are meaningful, I think we would be very grateful to have them.

QUESTION: MR. DAVIES
Would the panel discuss the difference between input and output isolation in solid state relays and the isolation (open circuit resistance) between the output terminals?

ANSWER:
I made quite a strong point in my talk about the difference in isolation between the electro-mechanical relay and the solid state relay. I think I failed to define that we are really talking two different things in isolation. This question brings that out quite well. Talking about the input versus output isolation is one thing. In the relay you have a coil that may have a million meg ohms resistance between it and the contacts. On the other hand, you also in a multi-pole relay have output contacts which have to meet a minimum of 1000 meg ohms between themselves. In your solid state devices, as somebody earlier suggested, you might have a light activated input which would give very good isolation between input and output but if there were a multi-pole output on that relay sharing a common power supply, the isolation between the output poles probably would be considerably less than the isolation between input and output.

QUESTION: MR. DAVIES
Do you have any characteristic figures on the isolation between the output terminals in an open position?

ANSWER:
I think that's a function of a semi-conductor. Basically, most semi-conductor manufacturers rate the device for reverse leakage. A typical backward conduction might be about 15 microamperes. So, for example, at 15 volts, it would be about 1 meg ohm.

ANSWER: MR. PAULSON
That 15 microampere does not directly lead to ohm figure because that is only the resistance at the point where it is beginning to

go over to breakover. Below that point the breakage current becomes many times lower, often times a couple of orders of magnitude lower. Thus at even 10% less than normal breakover voltage will receive 10 or 100 times less current. Therefore, the ratio of resistance to a usual load will be much higher than would be implied by the device rating. As a rule it's high enough that with respect to power circuits you can consider it the same as an electro-mechanical relay, i.e. when it is open, it's really open. Exceptions to that usually arise from circuit modifications. It is extremely common to apply a damping network across the semiconductor switch typically consisting of a capacitor in series with some resistance. This provides some beneficial functions so far as the switch is concerned, but also provides a finite impedance in the "off" state.

COMMENT: AUDIENCE
We don't consider the back resistance of any one of these semiconductors as sufficient isolation between a 460 volts system and an operator. As far as maintenance people are concerned and operators are concerned we must provide them with something better than this.

ANSWER: MR. DAVIES
400 volts is probably the most lethal voltage you have because you grasp it and can not let go. If you get higher voltages, say 600 or 800 volts, you'll be kicked away. But 400 volts can drive enough current through you to do the job.

COMMENT: AUDIENCE
I'd like to indicate what really constitutes a safe system. You indicate that you don't have a great variety of test subjects in order to try this system. What would you in your opinion consider something being safe? What kind of current flow would be acceptable?

ANSWER: MR. DAVIES
There is a lot of work that needs to be done in this area. I understand they've been having quite a problem with swimming pool lighting - low voltage, 6 volt lights. You just wouldn't believe that somebody could be electrocuted at 6 volts, but there have been reports that people lying out flat in a swimming pool between two lights - where the current crosses the chest through the heart - have been knocked out and drowned. It apparently has caused enough concern that they are now specifying ground fault indicators in swimming pool lighting circuits.

COMMENT: AUDIENCE
Underwriters has indicated that there are safe levels of current that the body can tolerate without shock hazard, about 5 or 10 milli-amps - I guess. Semi-conductors presently are below that level of leakage current.

ANSWER: MR. DAVIES
Now wait a minute. The SCR's are higher. It all depends on whether you're standing in salt water or whether the current crosses the chest. If it goes in one finger and out the thumb, you can take 5 amperes through there and you may get a bad burn but you won't be electrocuted.

COMMENT: AUDIENCE – M. JOYCE
It does sound that in order to be absolutely sure and where hard contacts have to be used in an open state, it would seem since it's near infinite that your application would always preclude the use of semi-conductor devices unless they were absolutely equivalent to hard contacts in an open state, meaning infinite resistance.

ANSWER: MR. DAVIES
It's going to be an inhibiting factor, you're absolutely right.

COMMENT: AUDIENCE
To my understanding, the hospitals who are very concerned with their equipment, do allow a current, they ignore voltage completely, but they allow two mills as being safe. Tektronix recently published some figures and ignored voltage, too. It's the current that kills you. If it's over, say in area of 2 and 5 mills, it can kill you. Beyond these levels, you have chance of survival because the shock probably will knock you out temporarily. A low current, 2 to 5 milli amperes or so, causes your heart to go into fibrillation and there is nothing they can do for you except to give you another shock. Below this value, nothing happens, above it, you get thrown clear. So generally speaking, current limitation is important, not higher or lower than 440 volts or 200 for something.

ANSWER: MR. DAVIES
It's the voltage that drives that current through you.

ANSWER: MR. PAULSON
I think it's the safety factor that you have that probably is behind us more than anything else. Take an electro-mechanical relay, especially the double-break contactors and the like that are rated for service up to 600 volts and so forth. When they are turned off, if you were simply to try to increase the voltage across the contacts and failed to arc through you'd go many many times the circuit rating. Whereas the typical 480 volt SCR package which is capable of controlling power all right and switching at 480, you would not have to increase the voltage to as much as twice before the device would turn itself on. Then of course line transients do exist, although they may be very momentary. It may be, of course, that ultimately you'll get such large safety margins with semi-conductor devices that you'll treat them just as you do other switches. But until safety factors for breakdown and breakover reach at least 5 and preferably 10 times the rated voltage, there will always be considered a certain amount of risk involved. This should not inhibit their use in a great many applications where the turn on of a switch is not in itself an immediate hazard. Certainly you wouldn't use them at present for disconnect switches on equipment that people have to maintain. They'd still have to have a disconnect that is more positive. In controlling the speed of motors and the like, the amount of damage that can be done by an occasional cycle of random firing is nil and doesn't constitute a hazard. This is something that at present state the user has to decide. He has to ask himself, under any circumstances will a single half cycle or a single cycle turned on anytime randomly create an unsafe condition. If it will, then you have a need for other backup. If it won't, then the only question becomes one of personnel safety and this is handled by a fairly conventional method.

COMMENT: AUDIENCE
I wanted to speak at this point about what a safe number is. The low milliamperes mentioned is generally a figure of merit, given the assumption that the skin is at normal moisture and the electrical contact does not pierce the surface of the skin. If the patient has a weak heart, figures of merit are in the low microampere range. There is a rash of literature that has been generated in the last two months in the trade magazines related to medical electronic equipment, and why people are killed at the rate approaching 2,000 because of faults in medical instrumentation.

COMMENT: AUDIENCE

I might add to that, as this gentleman just indicated, if you do pierce the skin and if you are going through the blood path especially if it's crossing the heart path, that as little as 5 microamperes or almost any low voltage will do you in. This has been determined from medical electronics that even the small potentials that are used, even on the order of 2 volts is lethal.

QUESTION: MR. NEYHOUSE
Has the military published preferred lists of QPL items and if so, are there multiple sources?

ANSWER:
There are such documents for relays. For Control Relays under 10 amperes it is QPL-5757. For thermal time delay relays it is QPL-19648. For heavy duty and aircraft relays it is QPL-6106. Established reliability products are listed in QPL-39016. These are preferred parts list.

I think you must all understand that the Military is in the same position as any manufacturer in trying to maintain equipment. It is considered poor practice to put all your eggs in one container. If you have only a single preferred item then everyone else goes out of business and if the remaining supplier is on strike or for various reasons cannot supply, then you're in a bind. The maintenance of more than one supplier is considered good business practice both in industry and in the military. Please do not get the impression that we're talking preferred manufacturers list, this is not true. Most of them are multiple source items and the listing is one of preferred parts.

QUESTION: MR. DAVIES
For a relay that must switch power, 10 to 15 amperes, and also switch dry circuits, what type of contacts should be used and what is the minimum current that can be dependably switched in low power contacts?

ANSWER:
I have to be a little careful in answering this in order not to give out proprietary information. I think it's generally accepted that gold is one of the good contact materials for low level applications if it is properly specified and properly applied. As far as the question of going from 15 ampere power down to low level, I think I'll beg off on that one. Generally, I think it's not a good practice although it's possible to do so.

QUESTION: MR. DAVIES
Would you recommend different materials for the two applications just discussed?

ANSWER
Generally, I'd say yes, although it is technically possible to have a material that will handle 15 amperes and also milli-volt levels but it ties in with the design of the relay, whether there is wipe in the contacts, whether it's hermetically sealed, what environment you put in the hermetic sealed container of the relay. These are all involved and I think most of us who are manufacturers would be a little bit hesitant to reveal our trade secrets in this area.

QUESTION: MR. DAVIES
When you mentioned gold contacts for dry circuits, were you referring to gold flash, or were you referring to solid gold or some gold plating?

ANSWER:
Not necessarily solid gold but sufficient gold not to wear away during the mechanical life of the relay.

QUESTION: MR. NEYHOUSE
Is there such a thing as shelf life for solid state relays? If so what parameters of the relay are affected assuming that the relay is under ideal storage conditions?

ANSWER:
It seems semi-conductors are supposedly rated for some half-life like 5 billion years or the age of the earth. I imagine that they fall far short of that. But in any case to throw out a little philosophy, you've got to remember that if you get an infinite shelf life it's going to be awful hard to get the recording equipment to indicate that as well as the observers that will really bear you out on it. You'd have the same thing if you had a relay that would stand any temperature from zero up to infinite. The equipment to bring it up to the temperature might be a little hard to come by. However, we've had experience with certain relays that have lasted 5 years in an operating system and these are not, shall I say experimental types, these are production type relays. At this time there is some thought about should they be replaced or not. Perhaps the question should be more on whether the technician should become acquainted with what these items are so that when a relay does fail, they know in what corner of the equipment it is located.

QUESTION: MR. NEYHOUSE
Would you have any comments about the relative life of those solid state telegraph relays that are covered by the mil spec? At one time they were electro-mechanical and they had a limited life. Now that you're using solid state, does the life of the solid state come up to your expectations or go beyond it?

ANSWER:
The five years that I was telling you about was the solid state telegraph relay. They are unlikely to fail on the shelf. They are unlikely to fail in service. But, they are subject to all the ills of any semi-conductor if you hit them with a spike, you then look for a replacement. If you run them at either too high or too low a temperature, the relay function either fails or the relay runs away. Other than that they seem to be, I think it's termed, indefinitely long-lived. It seems they'll last forever and even longer if properly applied. In other words all we can really say is that we have no way of knowing when it will fail. Actually, you can be certain that it will fail, eventually.

COMMENT: MR. PAULSON
Regarding this business of life expectancy, rating it "indefinitely" is probably the best scheme. Everybody admits the fact that there is a strong motive behind the push toward solid state. There is a feeling that since there is no known wear-out mechanism the thing has no life that can be expressed as X number of cycles, or so many years of normal service. Everything made by man by hand contains some imperfections to a degree somewhere - sometimes it's a matter of enough time for impurities to diffuse. At high temperature, it might be a matter of minutes, weeks, days, it might be a matter of 10,000 years at room temperature. The fact is we have no way of knowing what defects are possibly buried there. But this is not so much in the way of shelf life or wear-out as it's the fact that you are saying nothing is 100% reliable, that you cannot guarantee with perfect confidence there is no fault lying lurking. However, there are some fairly sophisticated screening methods which can look for faults in solid state devices if you are willing to pay the price. If you are self-screening, I can see no reason at all why a relay containing nothing but the type of devices that have been so reliable should have any short life rating of any kind. A good many packages might well contain, besides the relays, things such as electrolytic capacitors, which on the average, go quite a long time. But I've known failure rates and drying out times.

You have to be extremely careful that the so called solid state expression applies in depth throughout the whole package.

COMMENT: MR. DAVIES
There are many connections in these packages too and they are certainly potential spots where corrosion will occur slowly over a long period of time. I think many of us are familiar with the purple plague problem they had with the highest quality transistors a few years ago. I think this is solved now but it was a tremendous problem some period of time ago, and had nothing to do with the chips themselves but with inter-connections with the outside world.

QUESTION: MR. DAVIES
This question refers back to your discussion of an electro mechanical relay rated for 28 volts DC, whether it would be perfectly satisfactory on 120 volts AC. Is there a fixed and known ratio between AC and DC resistive load contact ratings and one with a 75% - 80% power factor? This might apply to Reed switches.

ANSWER:
It's hard to answer that because it's a function of the arc gap and the number of breaks. We have found in the power relay area that if you have two breaks and a certain minimum arc gap, which shall remain unspecified for the moment, you can handle the same amount of power at 28 volts and 400 hertz - 115 volts AC. But this would not necessarily be true of a TO5 can relay with a single break and perhaps a .005 or .010 inch arc gap. So, I can't really give a ratio for that. The TO5 can with a .005 arc gap would probably interrupt a 1/4 of an amp or 1/2 an amp at 400 hertz and it might only handle micro amps or milli-amps at 28 volts DC. It's a function of the design, in other words.

Any more questions?

Please Note: Mr. Neyhouse's comments and opinions are solely his own and should not be construed as official U.S. Government information.

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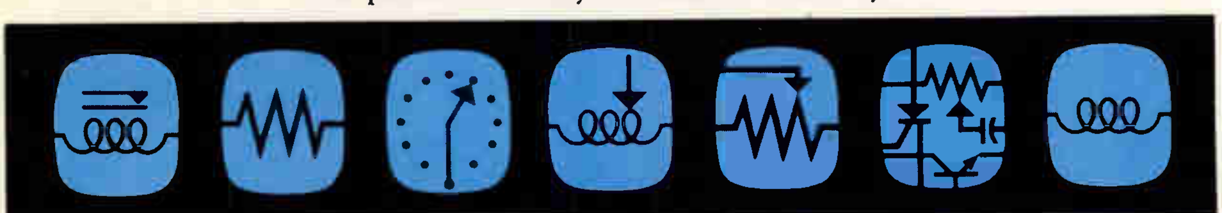

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Ohmite Manufacturing Company a North American Philips Company
3601 Howard Street, Skokie, Illinois 60076/Phone (312) 675-2600/TWX: 910-223-0805/TELEX 72-4433

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