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ELECTRONIC DESIGN

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ELECTRONIC DESIGN

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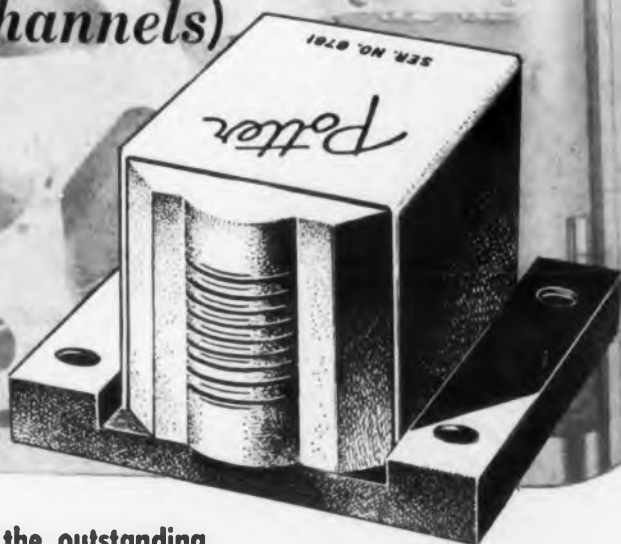


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Gap alignment: Within .0001"

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Nominal 1 mhy for transistor record amplifiers
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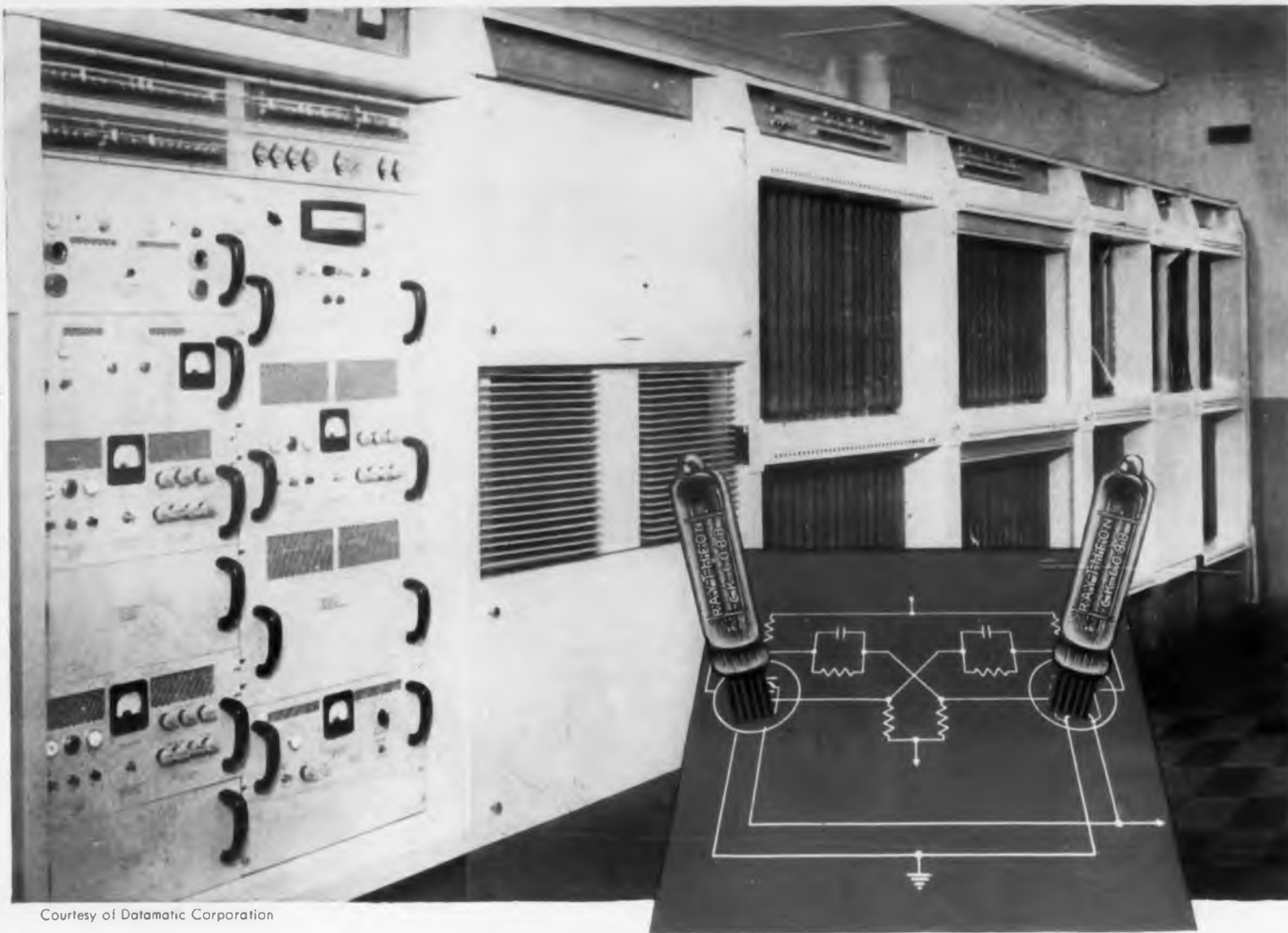


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Courtesy of Datamatic Corporation

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Here are the figures on CK6418 and CK6088 power input as compared with a popular heater-cathode tube such as CK5814

	plate supply	power per 1000 flip-flop circuits
CK6418	30 volts	29.5 watts (2000 tubes)
CK6088	45 volts	63.5 watts (2000 tubes)
CK5814	150 volts	2500. watts (1000 tubes)

Raytheon Filamentary Subminiature Tubes are distinguished by low power requirements, high efficiency, instant heating, no interface resistance, small size, exceptional ruggedness and long life. They are insensitive to ambient temperature change.

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120 tubes after 11,000 hours, with daily on-off cycles: no failures, all tubes still operating

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Editorial

Make It Smaller!

The cry being heard almost everywhere in engineering departments these days is: "Make it smaller." This request, along with demands for greater reliability, higher and lower temperature operation, high impact and vibration resistance, and tolerance to other environments as well, challenge the design engineer as never before. Few formal courses of study offer any help. Engineers are mostly on their own.

This issue of *ELECTRONIC DESIGN* is dedicated to the concept of *thinking small*. The designer must condition himself to think initially in terms of millionths of an inch instead of thousandths, hundredths, and tenths. It is wasteful to redesign a standard-size package of electronic gear to miniaturize it when it can be foreseen in advance of initial design that it will be needed in the smaller form.

We initially called our readers' attention in our Dec. 15, 1956 Editorial to the need to study watchmaking techniques in design of electronic components and systems. In this issue we present two articles by watchmakers themselves which might be considered the first step in conveying the thinking of this industry "under a microscope" to electronic engineers. We hope to present more specific design suggestions from them and others working in the field from time to time.

Look to this issue for a beginning in your study of the micro-miniaturization trend. Then follow *ELECTRONIC DESIGN* in the months ahead for a well-rounded program of articles and announcements of new products necessary for designers in their quest for ways to *make it smaller*. E.T.E.



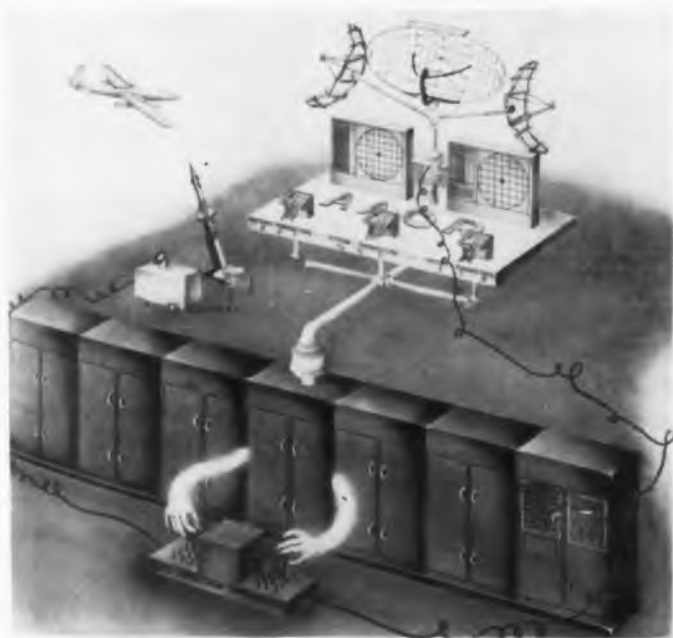
Looks good, Bill . . . But remember, our Packaging Engineers have to squeeze it into a vest pocket!

Courtesy, Stromberg-Carlson Div., General Dynamics Corp.

ELECTRONIC DESIGN • July 1, 1957

Engineering Review

For more information on developments described in "Engineering Review," write directly to the address given in the individual item.



MATABE, a computer system to be used by anti-aircraft control centers, makes possible the quick decision of tactical problems that might arise during a defense situation. The computer acts upon information derived from routine observations, possible tactical compromises, as well as from the immediate data of a given defense situation.

Tactical Computer for Air Defense

A control system capable of performing 136,000 mathematical steps in less than a second has been developed to assist anti-aircraft operation centers in organizing defense against enemy aircraft. The equipment, officially called the Multi-weapon-Automatic Target and Battery Evaluator (MATABE), was conceived by the Army Signal Engineering Labs., Ft. Monmouth, N.J., and was developed by the Burroughs Corp. in Paoli, Pa.

The system is a result of the need to aid anti-aircraft officers to calculate quickly the information

needed to make the most favorable use of their weapons in the destruction of aircraft.

The problem which must be solved in organizing a defense pattern is a complex one. The common sense solution, namely that of evenly spacing weapons around the area to be defended and assigning a given sector of defense to each weapon, is not necessarily the best solution. Too many variables are involved, such as anti-aircraft batteries that may be placed partially out of action, and the relative importance of each of the attacking planes. For instance, it might well be disastrous if the plane carrying the bomb became the total responsibility of one anti-aircraft battery, simply because the plane happened to be entirely within that particular battery's sector. Defense at such a moment would be greatly strengthened if another battery, which might be temporarily unoccupied in its own sector, were called in for assistance.

MATABE will give such information as the time it takes a missile to get from the battery to its bursting point; how much time a battery needs to carry out its assignment; the point of intercept; whether a target is within effective range; the kill probability of a battery-target assignment; percentage of total bomb damage attacking planes are capable of inflicting; and military value of a target according to strategic goals or the target priority of a group of attacking planes. Computations are based on data fed into the system derived from routine observations and strategic compromises.

The system is capable of analyzing both air attacks and defense plans. Its evaluations can lead to major tactical changes in specific attack or defense plans, and minor alterations in the position or type of batteries in a defense system. The system is 29 feet long, over seven feet high and consists of seven cabinets housing the electronic equipment. It can be controlled from two panels and is cooled by a nine-ton air conditioning unit.



Solar Bats in Army's Helmet: Clusters of solar cells placed on either side of helmet supply the necessary power for keeping the Signal Engineering Laboratory's helmet-radio alive. Use of the solar cells in combination with rechargeable nickel-cadmium batteries is expected to provide power for many months, possibly a year or more. With the dry cells formerly used in the helmet-radio, battery life was less than a day if used continuously, which placed considerable limitation on the helmet-radio as a practical piece of equipment.

Problems were encountered in raising the 4.5 v output of the solar-battery combination to the 50 v needed for the transmitter-receiver. However, careful design produced a transistorized converter small enough to fit, with the nickel-cadmium cells, in the aluminum housing already designed for the dry batteries previously used in the helmet-radio. Even with the solar cells, power converter and nickel-cadmium batteries, the sun-powered version of the radio is as light as the dry battery set, which weighs slightly less than a pound.

Frequency Standards

The Standard of Accuracy

announces **.01%** DIRECT READING
C BAND X BAND
FREQUENCY METERS



- 0.01% accuracy
- 1 MC calibration spacing
- Invar steel construction
- Loaded Q of 7000
- Wide temperature range

Five models of Frequency Standards Inc. direct-reading frequency meters are available for C and X band. Model 5459-1DRX covers from 5400 to 5900 MC and includes a crystal in mount. Model 5865-1DRX also includes a crystal, covers from 5850 to 6500 MC. Model 5865-1DR, without crystal, covers the same range. Model 9095-1DR operates in the 9000 to 9500 range; Model 1011-1DR from 10650 to 11750 MC.

These cavity wavemeters incorporate a plunger coupled to a precision ground spindle. The differential between the spindle thread and cylinder external thread is translated to the lateral movement of the indicator, providing a reliable and easily readable frequency index. Calibrations are engraved directly upon the cylinder and provide 1 MC marks not less than .075" apart, with the actual frequency engraved each ten MC. The accuracy of 0.01% is maintained over the range of from zero to 50 degrees Centigrade for the X band cavities; from 10 to 40 degrees Centigrade for the C band units.

ADDITIONAL SPECIFICATIONS

MODEL	5459-1 DRX	5865-1 DR	5865-1 DRX	9095-1 DR	1011-1 DR
FREQ. RANGE (KMC)	5.4-5.9	5.85-6.5	5.85-6.5	9.0-9.5	10.65-11.75
ACCURACY	0.01%	0.01%	0.01%	0.01%	0.01%
WAVEGUIDE	RG-49/U	RG-50/U	RG-50/U	RG-52/U	RG-52/U
FLANGES	UG-149/U	UG-344/U	UG-344/U	UG-39/U	UG-39/U
DIA. CAVITY	3 3/4"	3 1/2"	3 1/2"	2 3/8"	2 1/8"
DIA. DRUM	4"	3 3/8"	3 3/8"	3 1/2"	3 1/2"
TOTAL LENGTH	8 1/2"	8 1/2"	8 1/2"	6 3/8"	6 1/8"
FLANGE-to-FLANGE	5"	5"	5"	5"	4 1/2"
WEIGHT (LBS)	8	6	6	5	4 3/4

Frequency Standards

P.O. Box 504 Asbury Park, N. J.
PRospect 4-0500

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Engineering Review

Inertial Guidance

The inertial guidance system was demonstrated recently at Cambridge, Mass., where much of the fundamental research had been accomplished by an M.I.T. group. It was revealed for the first time at that conference that on Feb. 8, 1953, the device had guided a U.S. Air Force B-29 from Bedford, Mass., to Los Angeles, Calif., with an error of only 10 miles at the final destination. Since the system does not depend in any way on information received from an outside source, it has the obvious advantage of not being able to be jammed or otherwise affected by enemy or other interference.

Engineers describe it in the simplest terms as the system that knows where it is because it knew where it was and where it's going. The system keeps track of its position in space by counting to itself units of acceleration in horizontal North-South and East-West directions. This counting process is continually integrated. The system, therefore, can tell itself at any time how far, how fast and in what direction it has come from its starting place.

The Aeronautical Division of Minneapolis-Honeywell Regulator Co. is in production on several of the components such as inertial hermetic integrating gyroscope that can detect infinitesimal rates of movements and a pendulous gyro accelerometer. Other components of the system include analog computers and gyro stabilized platform for the accelerometers.



This model of the inertial guidance system was shown at an MIT conference, during which it was revealed that a comparable system had guided a B-29, in 1953, from Bedford, Mass., to Los Angeles, Calif., with an error of only 10 miles.

Food Preservation with Radar

Radar is being used to preserve fresh and cooked foods so they can be stored on a kitchen or grocer's shelf at room temperature indefinitely without refrigeration. Still in the experimental stage at the Raytheon Mfg. Co. Food Lab., Waltham, Mass., the new process is expected to make available normally perishable meats, fish, fruits and vegetables in unfrozen form the year round without loss of flavor, texture or nutrient value. Beef, shrimp, strawberries and other foods have been successfully preserved by this technique.

In recent flavor evaluations at MIT, panel members found no significant difference between the experimentally processed food and the cooked fresh product used as a control.

The preserved food weighs only a fraction of the fresh product. From 70 to 95 per cent of the fresh food's weight is water, removed in processing by applying microwave energy while the food is held under vacuum at below freezing temperatures. About 70 to 75 per cent of steak is water; shrimp is 80 per cent; and strawberries, about 90 per cent.

When food is needed, it is restored to its original fresh condition in minutes simply by immersing in water. The food soaks up the water and may then be cooked in any ordinary way.

Changing Usage of High Frequency Power

A different utilization of high frequency electric power was predicted in a paper at the Summer General Meeting of the AIEE. Vernon C. Geckler, of General Motors Corp., Bristol, Conn., stated that with some exceptions, automation and integration lines will dictate the use of smaller size generating units located and sized specifically for a particular production line. Generating units used for these integrated lines would not be direct connected units but V-belt driven units on which the belts may be changed to vary the generator speed to gain a different frequency. This means a greater number of units to maintain but the end results of integration would warrant the application of these small units.

In the not too distant future it was thought possible that there would be developed an electronic unit which would be sufficiently small in size as to be installed on a machine tool, and have the ability to vary its frequency within the range requirements of the machine. High frequency, is expected to have continued application for internal grinding, portable tools for high production lines, woodworking machines and commercial and industrial lighting. The last two would include auditoriums, gymnasiums, large store areas and large manufacturing floor.

The use of high frequency is not new, but has been used satisfactorily to a limited degree for 50 years, although at that time little was known about its application. General Electric developed the first large industrial application for high frequency power in 1904 by utilizing 150 cps at Bristol, Conn.

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with wide continuously adjustable
24 TO 32 VOLT RANGE

by **PERKIN!**

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- Missile Check-Out and Launching
- Aircraft Engine "Soft" Starting and Testing.
- Battery Charging & Standby Service
- ... and other heavy duty 28 volt DC Power applications.

immediate delivery!

OUTSTANDING FEATURES:

Automatic Magnetic Amplifier Regulation to $\pm 1/2\%$... No Tubes, Moving Parts or Vibrating Contacts... Remote Voltage Sensing to Provide Regulation at Remote Loads... Wide 24 to 32 Volt Output Range to Compensate for Voltage Drop in Output Cable... Fast Response (0.1 to 0.2 seconds) With No Hunting or Drift... AC Line Voltage Stabilization... No Disturbing Radio Interference... Higher Efficiency, Maintenance-Free and No Warm-Up Time as Compared to M-G Sets... MIL-Type Workmanship & Conservative Design.

There are over 15,000 Perkin units in operation in industry today.

ADDITIONAL SPECIFICATIONS:

Regulation: $\pm 1/2\%$ for any combination of line and load changes.
AC Input: 208, 230 or 460V, $\pm 10\%$, 3 phase, 60 cps. **Ripple:** 1% RMS.
All units available with dollies for mobility.

AVAILABLE MODELS:

MR2432-200A, 200 amps • MR2432-300A, 300 amps • MR2432-400A, 400 amps
MR2432-500A, 500 amps

When you require a power supply, SPECIFY PERKIN,
for a wider range of standard models and immediate delivery from stock.

Wire factory collect for prices. For a prompt reply on your
application, write factory on your letterhead.

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New York area office: Sales and Warehousing: 1060 Broad St., Newark 2, N.J., Market 3-1454

Chicago area: Loren F. Green & Associates, 5218 W. Diversey Ave., Chicago 39, Ill., Palisade 5-6824

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OTHER
PERKIN
STANDARD
DC POWER SUPPLIES

28 Volt Models

Model	Volts	Amps	Reg.	AC Input (60 cps)	Ripple rms
28-5VFM	0-32 V	5	15-20% (24-32V range)	115 V 1 phase	2%
28-10WX	24-32 V	10	$\pm 1/2\%$	100-125 V 1 phase	1%
MR532-15A	2-36V	15	$\pm 1/2\%$	105-125V 1 phase	1%
28-15VFM	0-32 V	15	15-20% (24-32V range)	115 V 1 phase	5%
M60V	0-32V	25	$\pm 1\%$	115V 1 phase	1%
MR1040-30A	5-40V	30	$\pm 1\%$	100-130V 1 phase	1%
28-30WXM	24-32V	30	$\pm 1/2\%$	100-125V 1 phase	1%
28-50WX	24-32 V $\pm 10\%$	50	$\pm 1/2\%$	230 V* 3 phase	1%
MR2432-100XA	24-32V	100	$\pm 1/2\%$	208/230V* 3 phase	1%
MR2432-200	24-32 V	200	$\pm 1/2\%$	208/230V* 3 phase	1%
MR2432-300	24-32 V	300	$\pm 1/2\%$	208/230V* 3 phase	1%
MR2432-500	24-32 V	500	$\pm 1/2\%$	208/230V* 3 phase	1%

* $\pm 10\%$. Also available in 460 V $\pm 10\%$ AC input. Will be supplied with 230 V input unless otherwise specified.

6, 12, 115 Volt Models

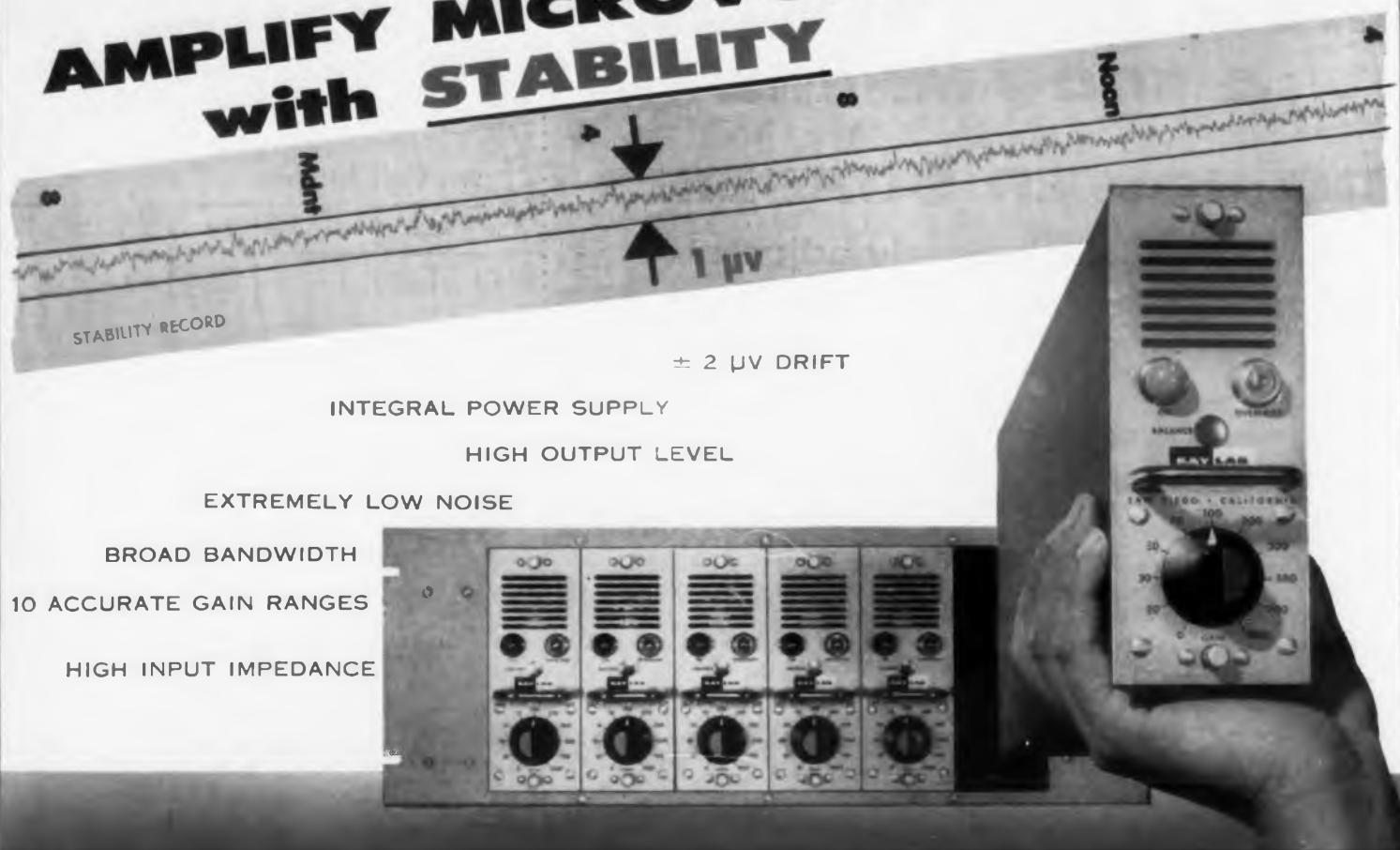
Model	Volts	Amps	Reg.	AC Input (60 cps)	Ripple rms
6-5WX	6 $\pm 10\%$	5	$\pm 1\%$	95-130 V 1 phase	1%
6-15WX	6 $\pm 10\%$	15	$\pm 1\%$	95-130 V 1 phase	1%
6-40WX	6 $\pm 10\%$	40	$\pm 1\%$	95-130 V 1 phase	1%
12-15WX	12 $\pm 10\%$	15	$\pm 1\%$	95-130 V 1 phase	1%
115-5WX	115 $\pm 10\%$	5	$\pm 1/2\%$	95-130 V 1 phase	1%
MR15125-5	15-125	5	$\pm 1\%$ †	95-130 V 1 phase	1%††
G125-25**	115-125	25	$\pm 1 1/2-4\%$	230/460 V 3 phase	5%

**Germanium Rectifier Unit ††Increases to 4% @ 15V.
†Increases to 2% @ 15V.



KINTEL

[KAY LAB]

FOR DRIFT-FREE DC INSTRUMENTATION**AMPLIFY MICROVOLTS
with STABILITY**

The KIN TEL Model 111 amplifier provides maximum stability and the lowest drift of any commercially available broadband d-c amplifier. It is the end result of years of research in the field of chopper stabilized broadband d-c amplifiers. Thousands of KIN TEL amplifiers are in daily use. The Model 111 incorporates KIN TEL's proven chopper amplifier circuitry and provides ten extremely precise, feedback controlled gain ranges. Several feedback loops assure high accuracy, stability and uniform frequency response. The completely new and unique circuit provides rapid recovery from severe overloading and unsurpassed dynamic performance—unaffected by load or gain changes.

The Model 111 is available in a single-unit cabinet or in a six-unit rack-mountable module. The amplifiers are extremely compact; the six-unit module occupies only a 19-inch rack width.

APPLICATIONS: The Model 111 is ideal for permanent low level d-c instrumentation, telemetering, or as a strain gage amplifier, transducer amplifier, scope preamplifier, recorder driver amplifier, or general purpose laboratory amplifier.

SPECIFICATIONS

Gain	0, 20, 30, 50, 70, 100, 200, 300, 500, 700, 1000
Gain Accuracy	± 1% DC to 2 KC
Input Impedance	100,000 Ω
Output Capability at DC	0 to ± 35 V where RL > 1000 Ω 0 to ± 40 MA where RL is 10 to 400 Ω
Output Impedance	Less than 1 Ω in series with 25 μh
Equivalent Input Drift	± 2 μv with regulated line
Equivalent Input Noise	0 to 3 cps, less than 5 μv peak to peak 0 to 750 cps, less than 5 μv RMS 0 to 50 kc, less than 12 μv RMS
Chopper Intermodulation	Less than 0.1%
Linearity	Better than 0.1% to 2 KC
Frequency Response	± 3% (0.3 db) DC to 10 KC, less than 3 db down at 40 KC

Power Requirements:	
Amplifier	117 V—60 cycles—70 VA
Cabinet	117 V—60 cycles—15 VA
6 Unit Rack Adaptor	117 V—60 cycles—45 VA
Dimensions: Amplifier Unit	2 1/4" wide, 7 1/2" high, 14 1/2" deep
Rack Adaptor for 6 Units	19" wide, 8 1/4" high, 18 1/4" deep
Net Weight—Amplifier	11 pounds
PRICE: Amplifier Unit	\$550.00
19-inch Rack Adaptor for 6 amplifier (with fans and connectors)	200.00
Cabinet for single amplifier (with fan and connector) is available.	

...the Standard in chopper-stabilized instruments

KINTEL

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WITH CHOPPER AMPLIFIERS

Engineering Review**Ferromagnetic Garnets**

A group of ferromagnetic materials called garnets promise to extend the increased efficiency which ferrites give to radar and similar transmissions into lower transmission bands, by increasing the lower limit down to 100 mc. This implies considerable advantages in systems where power is limited, for example in airplanes and missiles. Presently under study by Professor C. Lester Hogan of Harvard University's Div. of Engineering and Applied Physics, these man-made ferromagnetic garnets have the same crystal structure as the gem stone but have been chemically modified so that they are ferromagnetic. Previous ferrites which Hogan and others have developed have doubled the efficiency in the range above 1000 mc.

Ordinary broadcast antennas are wasteful of signal power because they tend to reflect part of the outgoing signal back in the direction of the oscillator. To combat this reflection, which can throw the oscillator out of phase, large resistances must be introduced between the antenna and the signal source. Garnets and other ferrites have the unique property of passing microwaves in one direction only, blocking them if they attempt to return. When introduced into a communications system between the oscillator and the antenna, garnets and other ferrites eliminate the need for large resistances, and make increases of about 100 per cent of the signal power possible without increasing power input at the oscillator.

The one-way property of garnets and other ferrites, is explained in terms of the spin of the electron. Since the electron possesses charge, it produces a magnetic field when it spins. This act of spinning also gives the electron the properties of a tiny gyroscope. When disturbed, electrons precess. The axis of precession for the top and for the electron is determined by the axis of the magnetic force-field acting upon them. When microwave radiation enters the garnet or ferrite in one direction, its direction agrees with the direction of the electron's precession. But if the wave is reflected in the other direction, its direction disagrees with the electron's precession and the wave is blocked. The characteristic of garnets which permits their use at lower frequencies is their long relaxation time, the time it takes for the precession of its electrons to become damped and disappear. Some garnets have relaxation times as long as 1 μsec, whereas other ferrites have relaxation times in the vicinity of 0.01 μsec.

Garnets and other ferrites are produced by powder metallurgy techniques. A powdered mixture of the ingredients is compressed under high pressure and fused in a high temperature furnace. They are

dark, heavy materials with a high dielectric strength (nearly perfect insulators) but are strongly magnetic. Manufacture of garnets for experimental purposes is carried on in the ferrite preparation laboratory at Harvard's McKay Laboratory.

Recently, Dr. Harry Suhl of Bell Telephone Labs. has proposed a new type of microwave amplifier which would use single crystals of these garnets. This amplifier promises to be the lowest noise amplifier yet which will operate at room temperature.

Picture Tube for Battery TV

A new cathode-ray tube that will enable television receiver designs to operate from batteries when using a combination kit of transistors and tubes has been developed by Multi-Tron Lab., Inc., 4624 W. Washington Blvd., Chicago, Ill. This tube is a further application of the patented pure-signal cathode-ray tube design which permits direct operation from diode or transistor output, thus eliminating the video amplifier in home receivers. It is not expected, however, that the industry will complete circuit and component development for production of the battery TV receiver prior to the first quarter of 1958.



3001 Ft. Per Sec: A spin pit, constructed by the Aluminum Co. of America, whirls parts at nearly three times the speed of sound in order to test their strength. The company reports that parts have been spun at peripheral velocities of 3000 ft. per sec without rupture. The weights of parts to be investigated range up to nearly a ton, and speeds exceed 100,000 rpm. Aluminum parts, bolted to an air-driven turbine, are spun in a vacuum so that air resistance will not impede them. According to one witness, as the speed increases, the turbine emits a sound like a police siren which soon dies away only to be reinforced at successive intervals by other harmonics.

Burnell SUBMINIATURE FILTERS

AS SMALL AS 3/4" X 3/4" X 13/8"
AS LIGHT AS 1 1/4 OUNCES



"TOM THUMB" TELEMETERING FILTERS

Designed and tested to specification #MIL-T 26985

Supplied in two principal case sizes:

1. For RDB channels 1 through 6, case size is 3/4 x 1 1/2 x 2 1/4 inches high; weight: 4 ounces.
 2. For channels 7 and up, case size is 3/4 inches square and 1 3/8 inches high; weight: 1 1/4 ounces.
- These cases are generally equipped with a 4-pin plug to match the small Winchester socket.

ATTENUATION CHARACTERISTICS

Impedance: 100 K ohms in and out.

Insertion loss: less than 6 db.

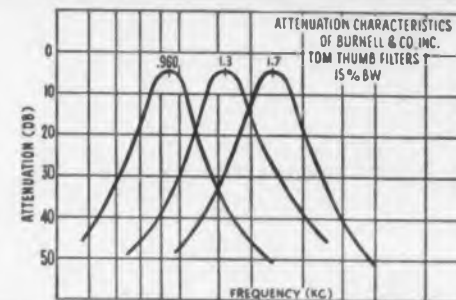
At $\pm 7.5\%$ band width is less than 3 db.

At $\pm 25\%$ band width is greater than 15 db.

At 1.75 f attenuation is 40 db or more.

At .57 f attenuation is 40 db or more.

CHAN. #	FREQ.	IMP. 100K P/N	B. W.	SIZE	WT.
1	400 cps.	S-60001	$\pm 7\frac{1}{2}\%$	3/4 x 1 1/2 x 2 1/4 H	4 oz.
2	560 cps.	S-60002	$\pm 7\frac{1}{2}\%$	3/4 x 1 1/2 x 2 1/4 H	4 oz.
3	730 cps.	S-60003	$\pm 7\frac{1}{2}\%$	3/4 x 1 1/2 x 2 1/4 H	4 oz.
4	960 cps.	S-60004	$\pm 7\frac{1}{2}\%$	3/4 x 1 1/2 x 2 1/4 H	4 oz.
5	1300 cps.	S-60005	$\pm 7\frac{1}{2}\%$	3/4 x 1 1/2 x 2 1/4 H	4 oz.
6	1700 cps.	S-60006	$\pm 7\frac{1}{2}\%$	3/4 x 1 1/2 x 2 1/4 H	4 oz.
7	2300 cps.	S-60007	$\pm 7\frac{1}{2}\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
8	3 KC	S-60008	$\pm 7\frac{1}{2}\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
9	3.9 KC	S-60009	$\pm 7\frac{1}{2}\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
10	5.4 KC	S-60010	$\pm 7\frac{1}{2}\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
11	7.35 KC	S-60011	$\pm 7\frac{1}{2}\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
12	10.5 KC	S-60012	$\pm 7\frac{1}{2}\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
13	14.5 KC	S-60013	$\pm 7\frac{1}{2}\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
14	22 KC	S-60014	$\pm 7\frac{1}{2}\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
15	30 KC	S-60015	$\pm 7\frac{1}{2}\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
16	40 KC	S-60016	$\pm 7\frac{1}{2}\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
17	52.5 KC	S-60017	$\pm 7\frac{1}{2}\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
18	70 KC	S-60018	$\pm 7\frac{1}{2}\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
A	22 KC	S-60019	$\pm 15\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
B	30 KC	S-60020	$\pm 15\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
C	40 KC	S-60021	$\pm 15\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
D	52.5 KC	S-60022	$\pm 15\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.
E	70 KC	S-60023	$\pm 15\%$	3/4 x 3/4 x 1 3/8 H	1 1/4 oz.



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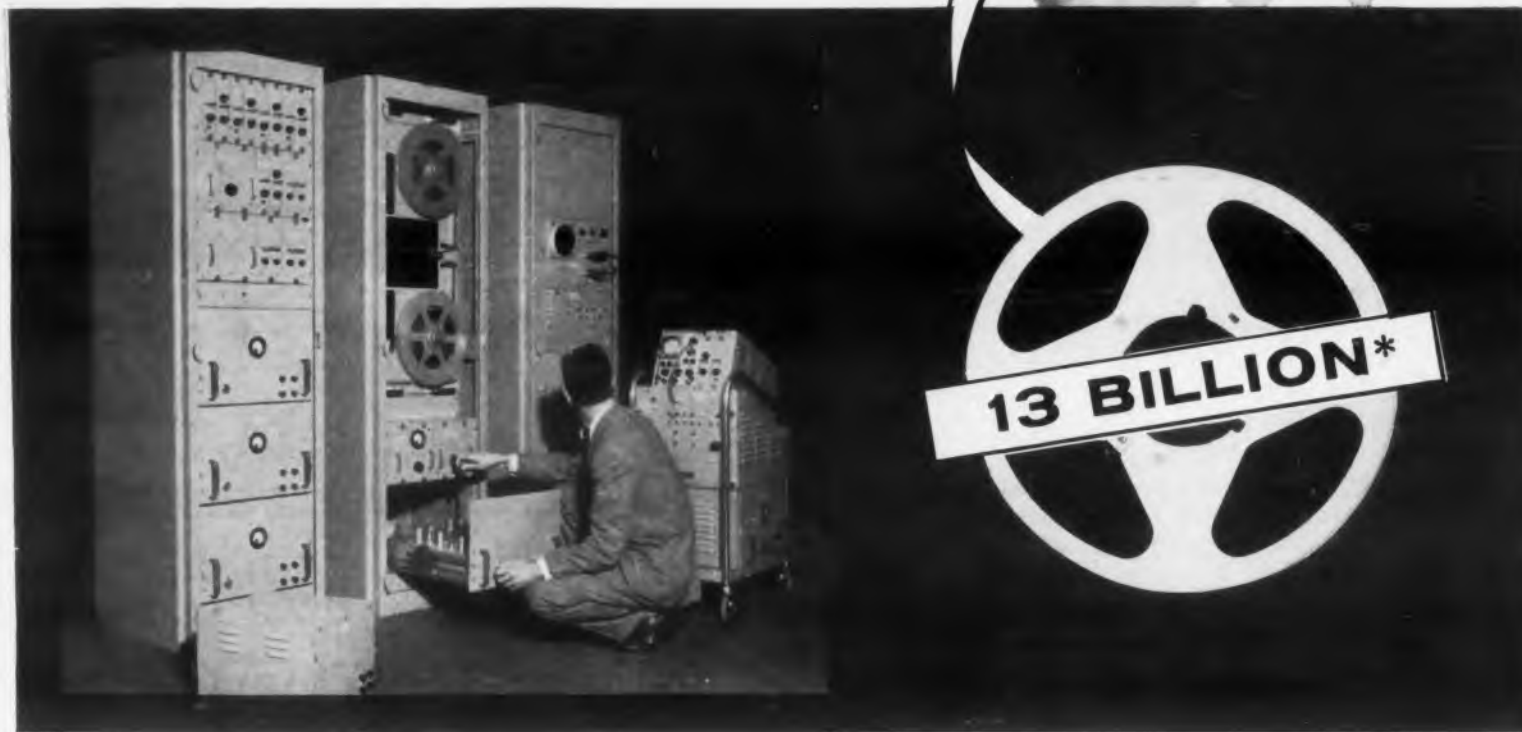


Mincom's laboratories have developed multi-channel (as many as 7 channels on half-inch tape) magnetic systems, in which each channel is capable of directly recording the full frequency response of radar video, t-v video, high speed data signals, or other similar types of data information.

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Mincom's direct frequency recording is utilized for response from 200 cycles to 2.5 megacycles, and in addition, FM techniques can be used on each channel for extension of frequency response down to DC. Many special techniques have been developed to provide practically an error-free recording system, i.e., wow and flutter compensation, drop-out reduction devices, high accuracy speed control, etc. Equipment has been developed for both airborne and ground-base use which meets military requirements for ruggedness. A number of systems are in use and have proved to excel in performance and reliability.

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Engineering Review

Operation Moonwatch

Keeping track of the earth satellite is expected to pose somewhat of a problem. Since the satellite's batteries will run down within a few weeks, scientists will depend on visual observation to locate the man-made moon. This has created a demand for observation posts across the country; a demand which is already in the process of being fulfilled.

The first post to be financed by private enterprise is located on the rooftop of the Valley National Bank in Phoenix, Ariz. The equipment on top of the 12-story building includes a 24-ft T mast, 12 sighting benches, an equal number of wide-angle telescopes, shortwave radio, tape recorder, and even coffee-making facilities for use on cool mornings. Scientists expect the sphere to cross over Southwestern skies during the first dawn following its release into space. Actually, the satellite will make 15 globe-girdling trips during every 24-hour period but it will only be visible at twilight. At other times, the satellite will be lost in the night sky or in the daylight brilliance.

The hope that other private enterprises would follow suit in the support of Operation Moonwatch has been partly fulfilled. Business firms in over a score of American cities have agreed to finance comparable stations. At the present over half of the 200 posts originally proposed are in the process of being constructed, and a majority of the remainder are in the planning stage.

Surplus Searchlight Provides Solar Furnace

Tungsten arc or carbon resistor furnaces have commonly been employed in the past for high temperature studies, but with the disadvantage that the crucibles, electrodes, or resistors contaminate the reaction and give false indications.

As a solution to this problem, the National Bureau of Standards has acquired a new research facility in the form of a furnace. Producing temperatures up to 3500 C, the furnace will melt refractory materials in a controlled environment free of contaminating agents.

The furnace was converted from a surplus Army searchlight with a 5-ft diameter parabolic mirror. It collects the sun's rays and focuses them into an intensely hot spot about 1/4 in. in diameter. Heating occurs only at this small spot, and the experiment is carried out here. This area can be isolated by closed glass tubing, which can be evacuated or filled with gas of the experimenter's choice. The glass enclosure is not affected by the sun's rays since the image of the sun is unfocused where the light passes through the enclosure and no local heating of the glass results.

The curved mirror faces a flat mirror, about 8 ft sq., which is directed at the sun and reflects the light



into the furnace. This is attached to a searchlight mount, which is controlled by an assembly of photo-cells and other appropriate electronic equipment to follow the sun's apparent motion.

Besides study of the properties of refractory materials, the solar furnace can be used in the zone refining of oxides of zirconium, thorium, or uranium to produce extremely pure samples of those compounds. Another possible use of the furnace would be to aid in growing single crystals of these and similar materials for laboratory studies.

Magnetic Laminators Installed

Four film processing laboratories have been equipped to laminate magnetic sound tracks to 8 and 16 mm motion picture film. Most recent applications for the laminated sound tracks have been in television news coverage where the film can now be stripped prior to exposure and used in the new sound-on-film cameras which record magnetically. Primary advantage of the magnetic track over conventional optical tracks is in greatly improved fidelity of sound while maintaining top picture quality. Installation of the magnetic laminators was announced by the Minnesota Mining and Manufacturing Co., St. Paul, Minn.

Sodium-Cooled Reactor Fired

On April 25, self-sustaining nuclear fission was achieved in the Sodium Reactor Experiment, a small-scale experimental civilian atomic power project being developed near Los Angeles, Calif., by Atomics International, a division of North American Aviation, Inc. This is the first sodium-cooled reactor to produce a sustained nuclear chain reaction. It uses neutrons moderated with graphite to sustain the fission process, and liquid sodium is circulated through the reactor core to remove heat produced by the atomic fission. During the initial start-up test, the reactor operated at a power level of about 1 kw of heat. No electricity was generated. The design capacity of the reactor is 20,000 kw of heat.

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3. Complete elimination of gas, not from the surface only but from the entire mass. Alloys so produced are therefore more desirable in the manufacture of electron tubes.
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cal and analytical control show improvement in one or more of the above ways. If you are seeking further improvements in the D-H Alloys you use, inquire now for information on how Driver-Harris Vacuum Melting Service can help you. Address your inquiry to Dept. VMS.



Polished and etched sample of Air Melted NICHROME V in annealed condition.*



Vacuum melted NICHROME V, annealed. Note that reduced inclusions result in much larger grain size for the same annealing treatment.



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Meetings

Aug. 1: Deadline for papers proposed for the Oct. 31-Nov. 1 conference of the Professional Group on Electronic Devices, IRE, in Washington, D.C. Abstracts should be submitted to the program chairman, W. M. Webster, RCA Semiconductor Div., Somerville, N.J. Subject matter should concern developmental techniques and devices, such as electron tubes and transistors, rather than basic research or circuit applications.

Aug. 20-23: Wescon (Western Electronic Show and Convention)

Cow Palace, San Francisco, Calif. Sponsored by the San Francisco and Los Angeles Sections representing the Seventh Region IRE and West Coast Electronic Manufacturers Association. For more information write to Don Larson, Business Manager, 342 N. LaBrea Ave., Los Angeles 36, Calif.

Sept. 4-6: Special Technical Conference on Magnetic Amplifiers

Penn Sheraton Hotel, Pittsburgh, Pa. Sponsored by the AIEE and the IRE. The program's four sessions will deal with New Circuits and Techniques, Analysis and Design, and Applications. For more information, write to D. Feldman, Bell Telephone Labs.

Sept. 9-13: Twelfth Annual Instrument-Automation Conference and Exhibit

Cleveland Auditorium, Cleveland, Ohio. Sponsored by the ISA. Organized under the unifying theme, "Instrumentation for Systems Control," the conference will open with formal sessions devoted to data handling and instrument terminology. Following these there will be individual workshop sessions in limited discussion groups covering such topics as aircraft and missiles (excluding propulsion), wind tunnels, flight propulsion systems, process industries, power generation and distribution, meteorological, nuclear, medical, geophysical exploration and general industrial laboratories. Some 100 papers will be presented at the technical sessions. There will be about 500 exhibits. For details of the technical program write to Herbert S. Kindler, Director of Technical Programs, ISA, 313 Sixth Ave., Pittsburgh, Pa.

Sept. 17-18: RETMA Symposium on Numerical Control Systems for Machine Tools

Ambassador Hotel, Los Angeles, Calif. For details write to RETMA, Room 650, 11 W. 42nd St., New York 36, N.Y.

Oct. 16-18: 1957 IRE Canadian Convention and Exposition

Automotive Building, Exhibition Park, Toronto, Canada. Sponsored by the Canadian Sections of the IRE. For information write to Grant Smedmor, IRE Canadian Convention, 745 Mt. Pleasant Rd., Toronto 7, Canada.

Oct. 31-Nov. 1: Third Annual Technical Conference of the Professional Group on Electron Devices, IRE.

Shoreham Hotel, Washington, D.C. Those interested in submitting papers should check the paper deadlines at the end of this section. For more information, write W. M. Webster, RCA Semiconductor Div., Somerville, N.J.

Nov. 11-13: Third Annual Instrumentation Conference

Biltmore Hotel, Atlanta, Ga. The theme of this conference will be "Instrumentation for Data Handling" with special symposiums on electronic instrumentation as applied to medicine and the sales and purchasing aspects of electronic instrumentation. Papers should be submitted to Lamar Whittle, Federal Telecommunications Lab., 1389 Peachtree St., N.E., Atlanta, Ga. For more information write B. J. Dasher, School of Electrical Engineering, Georgia Institute of Technology, Atlanta, Ga.

Nov. 13-14: Mid-America Electronics Convention

Municipal Auditorium and Hotel Muehlebach, Kansas City, Mo. Sponsored by the Kansas City Section of the IRE. There will be exhibits and twelve technical sessions. Approximately thirty papers will deal with medical electronics, airborne electronics, instrumentation, engineering management, electronics in nucleonics and a diversity of other subjects. Persons who want to submit papers should contact the Technical Papers Chairman, MAECON, 5109 Cherry St., Kansas City 10, Mo. The deadline for submissions is Aug. 15. For more information write Richard L. Clarke, 425 Volker Blvd., Kansas City 10, Mo.

Nov. 13-15: Eighth National Conference on Standards

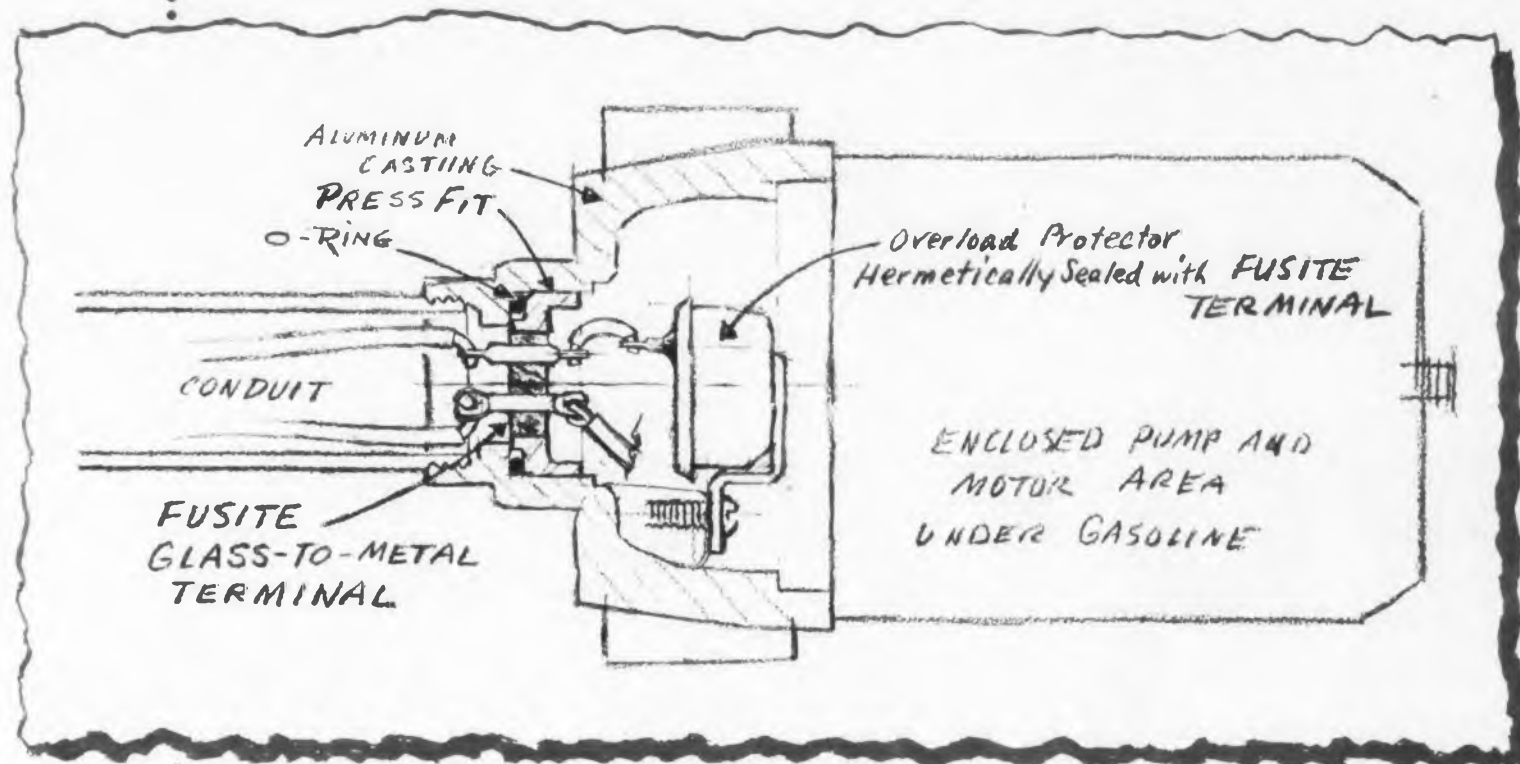
St. Francis Hotel, San Francisco, Calif. Sponsored by the American Standards Association. Emphasis will be on standards as a key to progress and profits. Sessions will cover radiation exposure, electronics, industrial preparedness, motion pictures and television, purchasing, company standards, technical communications, government standards and safety. For more information, write to D. E. Denton, ASA, 70 E. 45th St., New York 17, N.Y.



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Washington Report

Herbert H. Rosen

Pay-See TV Legal Says FCC

Under pressure from Congress and part of the electronic industries, the Federal Communications Commission has finally decided that it "has statutory authority to authorize the use of television broadcast frequencies for subscription television operations." The decision was reached after receiving some 25,000 comments from industry and the public. The Commission also received proposals for three different systems for encoding and decoding the TV signals: "Phonovision," sponsored by Zenith and TECO, Inc.; "Subscriber-Vision," by Skiatron Electronics and Television Corp. and Skiatron TV; and "Telemeter," by International Telemeter Corp.

But the FCC is not yet willing to give the green light to Pay-See TV. In spite of the many comments and detailed proposals, there is still some question as to whether the system would "be in the public interest." Consequently, the FCC is now in receipt of more comments on the "manner in which subscription television would operate in actual practice." Obviously, a proportion of the first 25,000 comments was opposed to the idea. Their main argument is that the airways are free and that subscription TV would "seriously impair the capacity of the present system to continue to provide advertiser-financed programming. . . ."

By now, the FCC will have its staff finding out if a trial demonstration is feasible. In fact, the Commissioners feel that the trial is indispensable in determining "acceptability to the public." They will have been given views on which cities should be used in the test. Whether single stations or networks of stations should be employed. The time needed in planning and preparing for a series of tests. The number of hours thought necessary for a true test. And the hours of the day that they should be run. What operating and performing restrictions should be imposed. And a guess of what the impact on the public will be.

If the analysis of the current crop of comments proves that inadequate information has been supplied, the FCC will conduct oral hearings on specific issues. Ultimately, standards will be developed that will call for one or more encoding and decoding systems.

First Grants for Over-Horizon TV Transmission Made

AT & T and Florida Micro Communications, Inc. are the first companies authorized by the FCC to

ELECTRONIC DESIGN • July 1, 1957

relay TV programs by the tropospheric scatter technique. A 180-mile link will be established between Florida and Cuba in the uhf portion of the radio spectrum. AT & T will operate on 840 and 880 mc and will use the link to supplement its submarine telephone cables across the Florida Strait.

Florida Micro Communications, operating on 500 mc, initially, will use the link as a one-way relay for monochrome or color TV signals from Miami to Cuba. Later, the system will be made two-way.

Airways Plan Faces Rocky Road

A Federal Airways Modernization plan now before Congress looks like it may have some trouble before passage and implementation. First of all, there are some Congressmen who feel it too ambitious a program and too radical in approach. The plan, proposed by E. P. Curtis, Special Assistant to the President, calls for the establishment of a temporary Airways Modernization Board to lay down policy and be responsible for bringing the nation's airways and airports up to date. The AMB would be replaced in three years by the Federal Airways Agency, a permanent, independent organ that would attempt to keep the airways system abreast of aviation developments—jets, helicopters, turbos, atomic energy, etc.

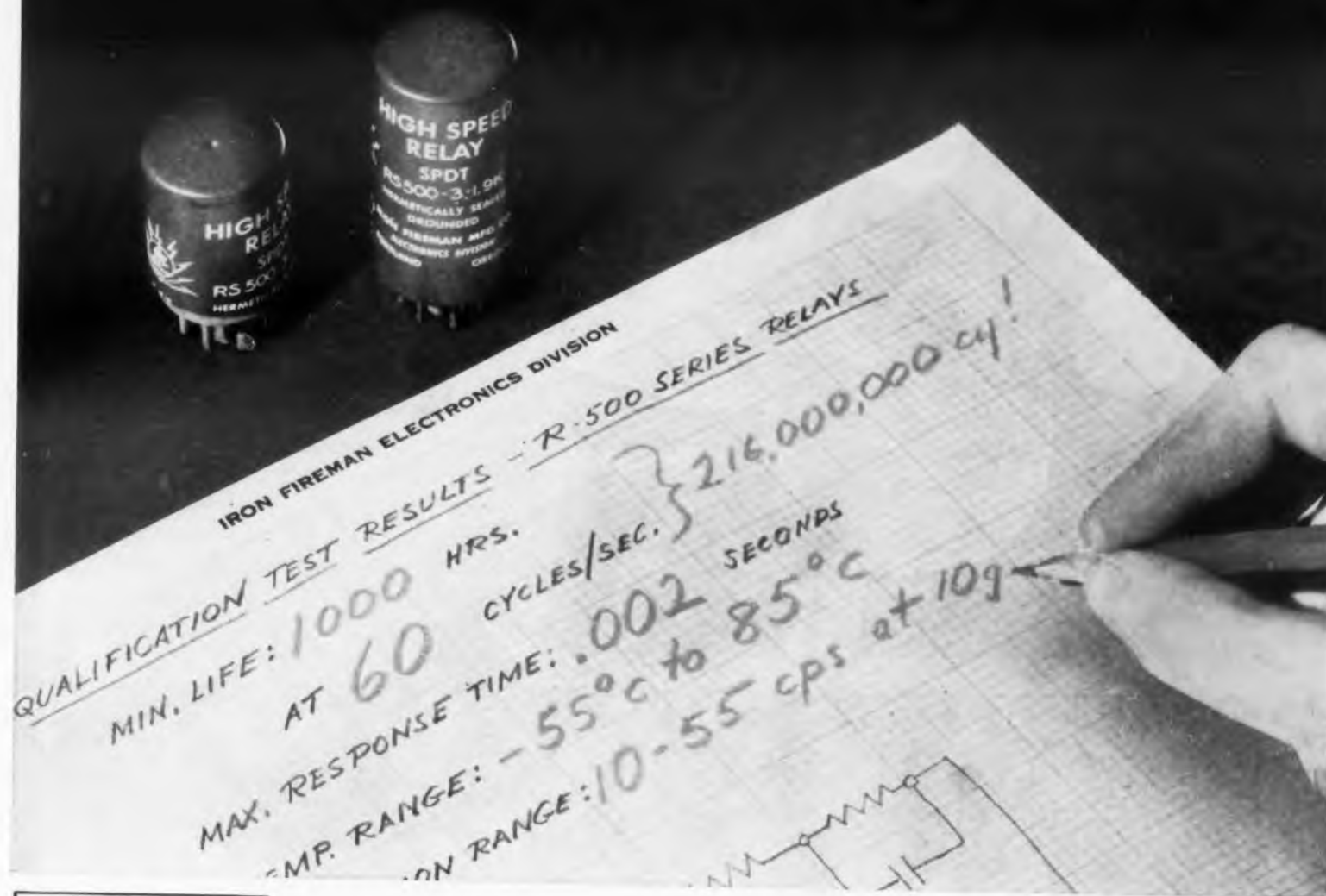
But the major obstacle to success of the plan is the absence of the electronic equipment to do the job called for. By 1975 the total air traffic will be approximately two times what it is today. This requires a tenfold increase in capacity of the air traffic control systems to serve the users. It also means greater use of automatic radar systems, better flight control and detecting instruments, more automatic and reliable communications, and a tremendously expanded application of computers and storage devices.

Mr. Curtis foresees the airplane pilot sitting up in the cockpit of his plane using his inbred judgment, but doing little else about flying it. Take-off and landing will be largely electronic-automatic. In-flight control will be dictated by controllers—human and electronic—that know immediate position and tell what the next position should be. Even portions of SAGE and VOLSCAN have deficiencies that would prohibit their use in 1975.

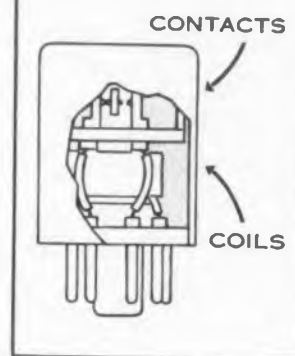
There seems to be every indication that Congress will authorize the establishment of at least the Air Modernization Board. When that happens, the functions of the old ANDB will be absorbed and more authority will be issued. This means that studies will be started on what equipment will have to be developed to bring the antiquated airways system up to at least 1960 levels. The AMB will also have the authority to start some development programs in this area. But the ultimate success of the program will be heavily dependent on what the electronic industries can come up with to speed the handling and control of military and civil aircraft.

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Micro-Miniaturization

Introduction

ELECTRONIC DESIGN would define "micro-miniature" in its pure sense as *technology under a microscope*. In this sense it is new to our thinking because it requires tools of fabrication generally unknown to the electronic industry. To design for it requires thinking smaller than ever before. We cannot be satisfied, either, with redesigns of standard-sized equipment by "experts" in micro-miniaturization such as watchmakers. Electronic designers must think "micro-miniature" at the outset of a design that must eventually be produced "under a microscope." Any other approach is wasteful of precious design effort; and warmed-over designs are rarely as good either economically or functionally as fresh, straightforward designs based on end use.

Miniaturization, sub-miniaturization, and micro-miniaturization are all terms now in our electronic language book. Yet, we would be in error to assume any sharp line of demarcation between the three concepts. We suggest, for instance, that "micro-miniaturization," from a practical standpoint, is just smaller subminiature or extremely small miniature. The trend will continue. What is micro-miniature today may only be subminiature tomorrow. The ultimate may be complete electronic systems fabricated in the solid state without need for interconnecting leads and with virtually 100 per cent efficient use of

space. Printed wiring may become as obsolete as the rotary spark gap.

The concept of this special "status report" on micro-miniaturization was born following the excellent orientation symposium on this subject at the recent IRE National Convention in New York. The articles by Messrs. Henry A. Stone, Dr. Clelio Brunetti et al, W. W. Hamilton, and John R. Moore, are based on papers they read at this symposium.

In order to get the concept of "thinking small" before electronic designers at the earliest possible moment, time did not permit an exhaustive survey of every electronic firm that might have information to contribute to the subject. Illustrations shown and information presented should only be considered examples of the trend—not in any sense a complete summary of what is available either in micro-miniature components or equipment. Better examples could undoubtedly have been given, but only at the expense of delaying presentation of vital material of timely importance.

Electronic Design solicits further articles and new examples of micro-miniaturization from any and all sources. Further reports on this subject will be forthcoming.

E.T.E.

Component Development for Micro-miniaturization

Henry A. Stone, Jr.

Bell Telephone Laboratories
Murray Hill, N. J.

A Definition

Micro-miniaturization is defined by Henry A. Stone, Jr. of Bell Telephone Laboratories, Murray Hill, N. J. as "miniaturization of electronic equipment carried to the ultimate degree." According to Mr. Stone, available subminiature components have volumes as small as 0.01 cu in., but this is still not small enough for increasingly complex air and missile borne systems nor for equipment which will be worn or carried by personnel.

"Micro-miniaturization challenges the component engineer to realize the utmost performance from the materials at his disposal, and the highest degree of control in the processes of manufacture. To a greater degree than ever before the chemistry and physics of materials, and their behaviour in components, must be understood on the basic level. Automation and automatic process testing are essential to insure the quality and uniformity demanded by increasingly stringent goals in reliability."

MICRO-MINIATURIZATION has been described as "the ultimate in miniaturization" so small that further size reduction is of no practical interest. Since some day someone is certain to want a two-way color television set built into a wrist-watch, it can be assumed that micro-miniaturization will allow plenty of scope for engineering ingenuity and imagination.

The objective of this article is to review the history of miniaturization as it has applied to various passive components and to assess present trends and some of the approaches to micro-miniaturization for designers.

Inductors and Transformers

The most obvious aid to miniaturization is provided by materials with improved electrical characteristics, which can be directly substituted for older materials. Ferrites, as used in inductors and transformers, represent a recent and glamorous example of miniaturization by direct substitution. At A Fig. 1 is shown a high-Q filter inductor using a Molybdenum permalloy core; at B is a subminiature ferrite core coil for similar applications in transistor circuits. By direct substitution it is not implied, of course, that the sizes and shapes of the cores in

these coils are the same, but it does mean that both designs were derived from the same kind of mathematics. In both cases the parameters were permeability, loss factor, modulation, etc. and mechanical handling qualities. No new technological concepts were involved.

Chronological development of core materials since about 1917 is illustrated in Fig. 2. The "Q" represents a quality factor of importance in inductors. Each increase in Q has been accompanied by size reduction in coils. It is a rather obvious extrapolation that new magnetic materials having higher Q's will permit still further size reduction. Recent developments in the ferrite field indicate that not only will Q's be improved, but better ferrites suitable for higher frequencies will make it possible to substitute magnetic core coils where much larger air core coils must now be used.

But even without waiting for new materials, there is the possibility of micro-miniaturized inductors for some applications. The coil shown in Fig. 1C is a working model that was used recently in a labora-

tory model of a broadband coaxial amplifier.¹

Although not a commercial item, it illustrates the inherent possibilities in currently available ferrites.

Capacitors

Often it is not so much new materials that are needed as it is ingenuity in the use of the old. The development of metallized paper and, later, of stripped lacquer film capacitors, illustrates this point. Some history of size reduction in foil paper capacitors is illustrated in Fig. 3. Almost all of the space saving represented by these successively smaller capacitors was due to direct substitution of new materials, or at least to new developments in material technology. In each case the size reduction followed the development of thinner foils and thinner paper. The smallest capacitor shown uses paper about 0.00025 in. thick and aluminum foils of about the same thickness.

This about represents the end of that particular road. The foils and the paper in these units are self-



Fig. 1. Evolution of inductors. (upper left) Early molybdenum permalloy toroid; (upper right) currently available subminiature ferrite coil; (lower) micro-miniature ferrite coil now in the laboratory.

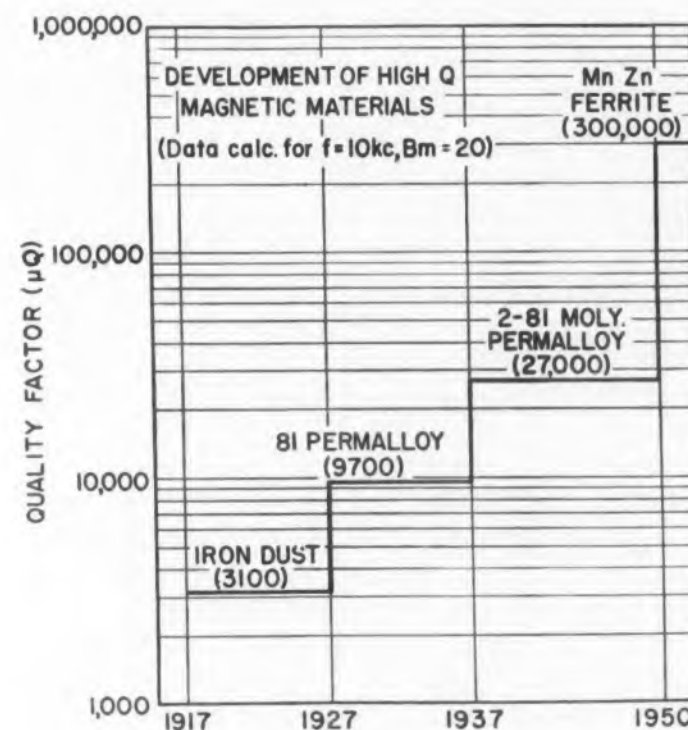


Fig. 2. Improvements in quality (μQ) of magnetic materials over the years. Advance has been especially rapid since 1950.



Micro-Miniaturization

supporting so that they can be handled and wound into capacitors. The further size reduction, illustrated in Fig. 4A, could not have come about through continuing substitution of still thinner foils. It had to depend on new ways of using materials. First there was a new concept; why should the paper and the metal foil both be self-supporting? Why not just coat the paper with a thin film of metal? The now familiar metallized paper capacitor resulted from this kind of thinking. By now it is an old story that metallizing not only got rid of most of the bulk occupied by discrete metal foils, but because of its self-healing properties it was even possible to eliminate some of the paper.

Even though the paper or plastic film used for metallized capacitors was only a fraction of a thousandth of an inch thick, this was thicker than necessary to withstand the low voltages employed with transistors; and it therefore represented waste volume. But the films could not be made any thinner or they would break during the metallizing process. Another new concept was needed, and it came in the form of the thought that a supporting backing could be provided during metallizing and removed before the capacitor was wound. In Fig. 4B is shown the result of this inspiration.² It is a metallized unit in which the dielectric is about 0.0001 in. thick, and it occupies only 1/5 the volume of a metallized paper capacitor having an equivalent capacitance.

What about capacitors for the future? So far as general purpose capacitors are concerned, there are two developments that will bear watching. The first is improvements in the solid type electrolytics. Tantalum electrolytics using tantalum wire instead of the more conventional sintered material have been made with orders of stability and Q that already compete with paper or plastic film types. For comparison, see Fig. 4D. This shows the new volume reduction that can be expected.³

Another potentiality for the future lies in the application of transistor technology to capacitors. It is well known that there is energy storage in semiconductor junctions, and perhaps less well known that in a reverse biased junction this energy storage is equivalent to high capacitance per unit area with a very high Q. There are problems to be overcome before junction capacitors can compete on a general basis, but already this type of device is being considered for certain specialized applications.

Another current development of interest has to do with application of the lacquer film technique

to precision capacitors. Heretofore, for applications where high quality factor and high temperature stability were important, we have depended for the most part on mica. Recently at Bell Labs, under Signal Corps' sponsorship, a capacitor has been developed whose working dielectric is a skin of polystyrene less than 0.2 mil thick. In Fig. 5 is a 25,000 μf unit compared with the mica capacitor that it can replace.

Resistors

Resistors have always held the lead in the field of component miniaturization. Various types of precision resistors are shown in Fig. 6, ranging from the old but still useful wire-wound types to some



Fig. 3. Foil paper capacitors—ancient (1890) vs. modern.

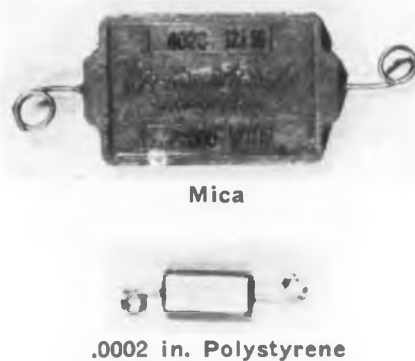


Fig. 5. Evolution of precision capacitors. Both are 0.025 μf .

of the smallest deposited carbon and metal film units. The smallest illustration is of a resistor in which the working body is only 0.008 diam. It consists of a glass fiber metallized with chromium and protected by a glass tube. Actually, until new schemes for terminating and packaging are devised, there is little value in carrying miniaturization to this degree. More will be said later about the problem of packaging.

It is quite possible that in a micro-miniaturized world the resistor as an independent component will be eliminated entirely. Intensive work is being done on improving the characteristics of printed resistors, and thought is being given to metal films which instead of being on individual supports will be deposited directly on the circuit board. These will add no more volume to the equipment than do the letters on a printed page.

New Components

There are two new members of the passive components family, the diode and the switching core, both of which are inherently of an order of size

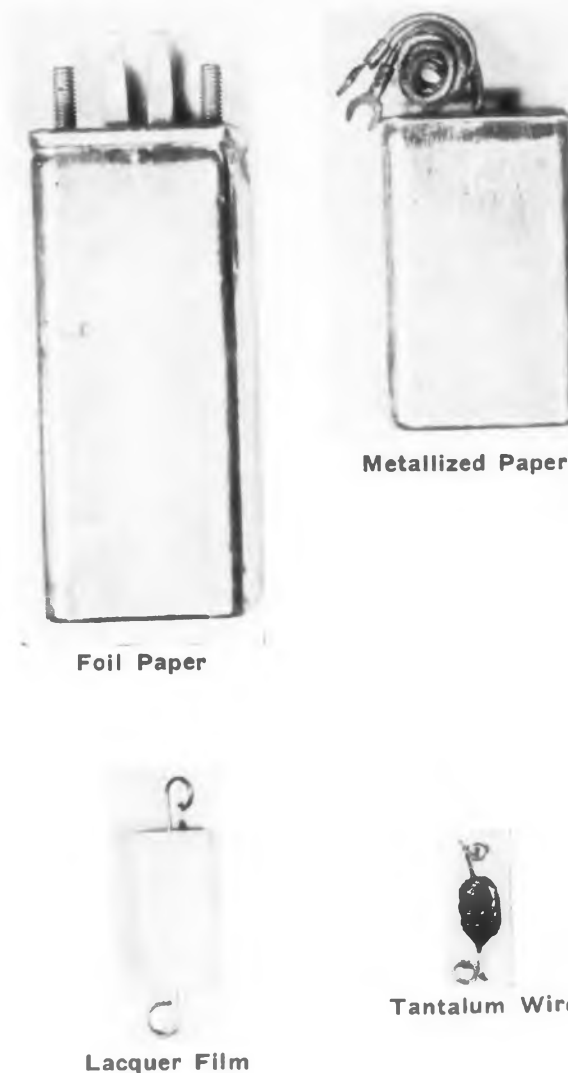


Fig. 4. Size reduction in capacitors—from foil paper to metallized paper, to lacquer film, to tantalum wire.

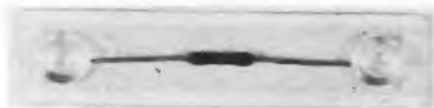
that puts the older components to shame. Fig. 7 is shown the working structure of a typical p-n junction diode and a common size of switching core. Both of these components are illustrative of the volumes one might associate with micro-miniaturization, and both of them present problems that will be met in micro-miniaturization. With the switching core there is the problem of handling and wiring vast numbers of these tiny elements. The assembly not only takes many times more space than the cores actually occupy, but the expense and difficulty of wiring them is a considerable item. Ingenuity has been applied to this problem; and one approach is shown in Fig. 8. Instead of using a hundred or more separate cores, a single sheet of magnetic material is perforated, and printed wiring in the desired form is applied across the sheet and through the holes.^{4,5} Each perforation corresponds to a single core. The importance of this concept is that it illustrates a principle that might be applied to other components. Electronics has always been a matter of making a lot of little individual items and then laboriously putting them all together. This



Wire Wound



Deposited Carbon



Deposited Carbon



Metallic Film

Fig. 6. Evolution (top to bottom) of precision resistors.

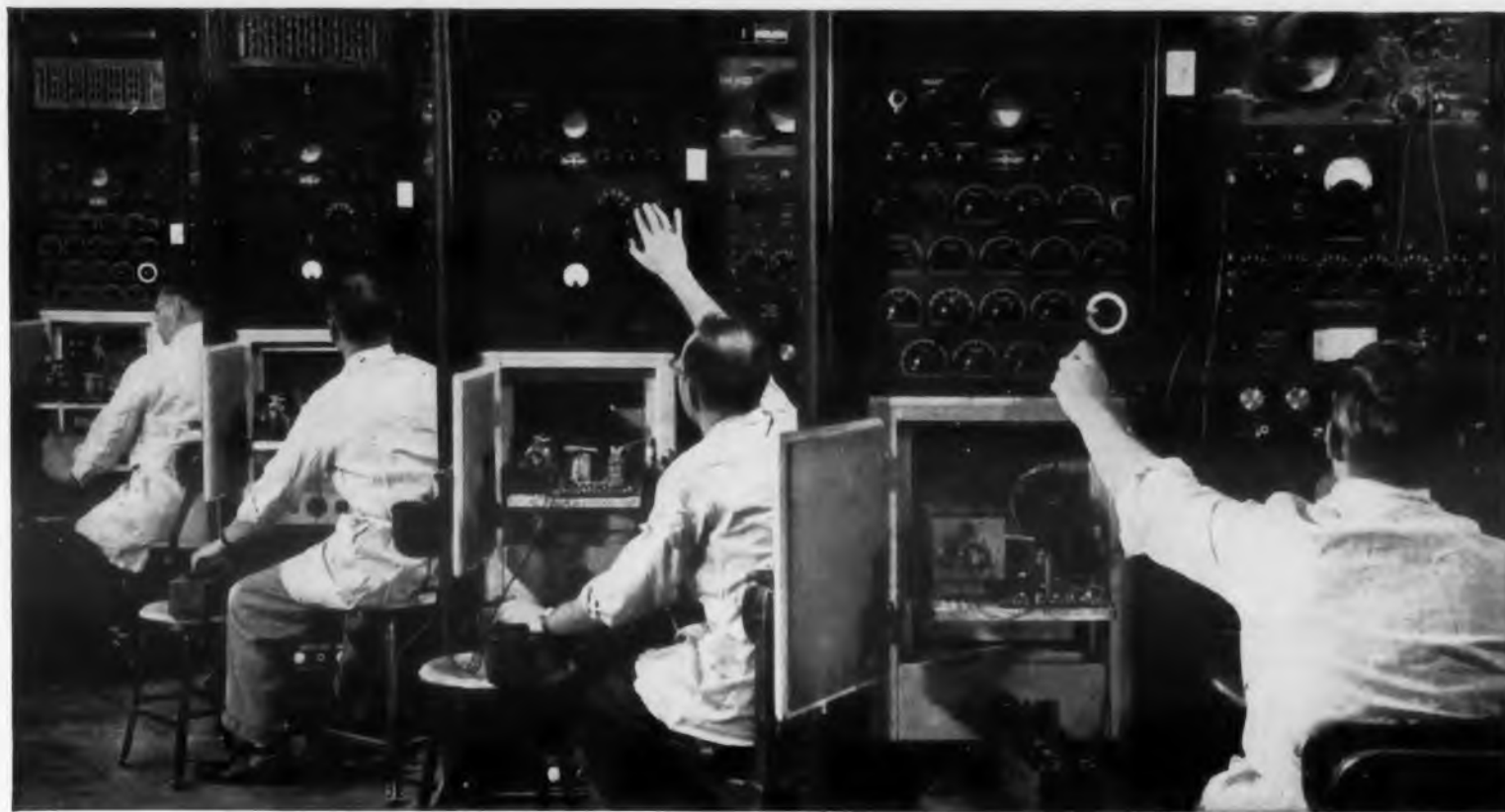


Silicon Junction Diode



Ferrite Switching Core

Fig. 7. These components—diodes and switching cores—are basic to micro-miniaturization.



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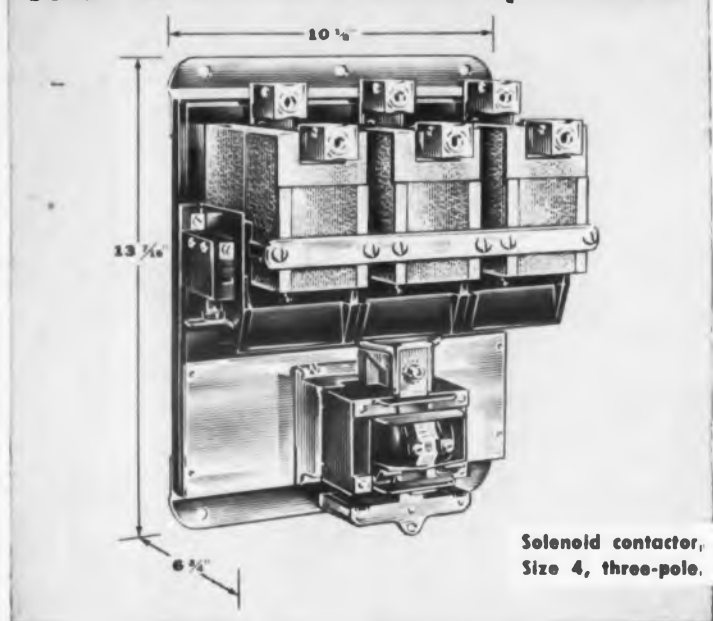
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		Volts	K.W.	Volts	K.W.	
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Component Development



Micro-Miniaturization

is expensive of space as well as money. To any extent that many components can effectively be made out of one physical item, micro-miniaturization is more closely approached. Just how other multiple components will be realized remains a challenge to engineers, but Fig. 9 shows an illustration of one concept. It is an assembly of 100 tantalum wire capacitors complete with individual leads and made with exactly the same number of operations as one capacitor would have required. It can be adapted to a circuit simply by cutting away the connections that are not wanted. A unit in just this form may never find application, and it is shown only to illustrate that there can be possibilities in multiple components.

The diodes and switching cores are not the only new components that will have to be reckoned with in the future. It is certain that there will be a growing demand for many new, and some not yet invented, kinds of passive devices. Voltage sensitive capacitors, isolators, control coils and many other non-linear components are sure to contribute to systems objectives in the near future.

Over-all vs Working Volume

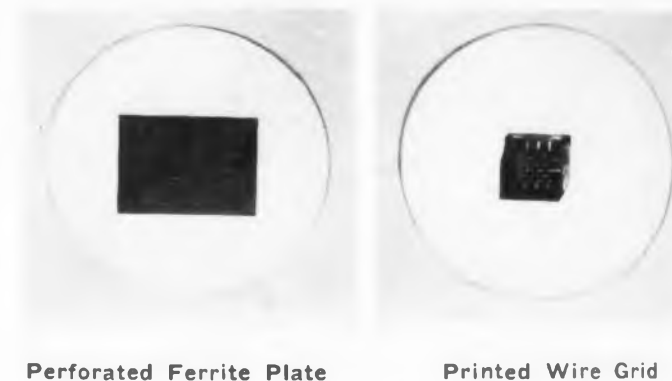
In the last analysis the progress made in micro-miniaturization of the many different types of components will depend on specific solutions to widely differing kinds of problems. Nevertheless, there are some observations to be made that will be applicable by and large, across the board, to the whole component picture.

One lesson that past experience in subminiaturization can teach is that factors which are trivial in large components may become of first importance when large steps in size reduction are attempted. For example, consider the over-all volume of the component and compare it with the necessary volume of the working unit. As an illustration of this point, consider again the foil paper, metallized and lacquer film capacitors. Fig. 10 shows for each of these the relationship between the volume of the actual working unit and the extra space that must be allowed for margins, terminations and housing. In the standard foil-paper capacitor, 80 per cent of the volume is actually occupied by the electrode and the dielectric. Only 20 per cent is devoted to insulators, terminations, margins, etc. In the metallized capacitor the working volume is only 33 per cent of the total; and in the lacquer film capacitor, the unit itself is down to 26 per cent of the total volume. In other words, three times as much space

is devoted to incidentals as to the carefully engineered basic element. In approaching micro-miniaturization increasing attention must be devoted to the problems of terminating, protecting and housing without using up all the space that has been saved by refinements in the units themselves.

Packaging

This same line of reasoning extends to component assemblies or packages. A printed wiring assembly is shown in Fig. 11. This particular assembly does not represent the most concentrated package that has ever been achieved, but it is typical



Perforated Ferrite Plate

Printed Wire Grid

Fig. 8. New approaches to memory grids; perforated ferrite film (left), perforated film with printed wiring (right).

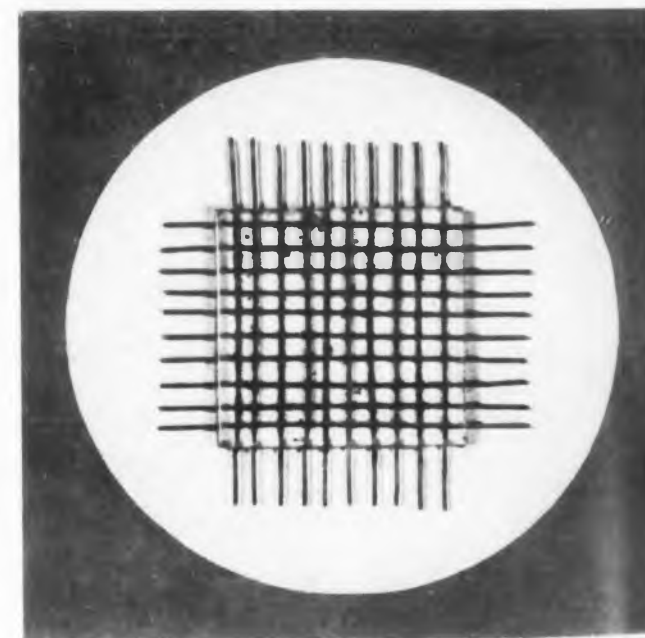


Fig. 9. Multiple tantalum-wire capacitor. A tantalum capacitor is embodied in each intersection of the wires.

of current art. It occupies a volume 7-1/4 x 7-1/4 x 3 in., or 39 cu in., in the equipment in which it is used; and it contains 117 components. This is an average of just about 1/3 cu. in. per component which in comparison with chassis mounted assemblies is most impressive. However, a rough analysis shows that the total volume occupied by the component bodies is only 1.25 cu in. This circuit has a packaging efficiency (ratio of component volume to over-all volume) of only 3.2 per cent.

It is easy to see that one reason for so much unproductive space is that the components vary widely in size and shape. Another reason is that this kind of an assembly requires an amount of headroom determined by the highest component. Obviously there is waste space when 3/4 in. headroom is allowed for a diode which may only project 1/8 in. from the board.

There are two conclusions that can be drawn here and it is easy to predict who will draw them. The equipment man will see at once that the answer is better standardization of components; and the component man will argue that if one is going to package components, the packaging scheme should be adaptable to variations in their sizes and shapes. Both will be right. There is still plenty of room for standardization in the geometry of components, but this can only be carried to a certain point. Beyond this point the essential differences in types and values of components will mean variations in dimensions, and the packaging must take such factors into account.

Materials

Just as progress in electronic systems is bounded by limitations in components available to the systems engineer, so are advances in the components themselves limited by the materials with which the component engineer has to work. Without reviewing all the interesting new developments in component materials there are a few general observations that can be made.

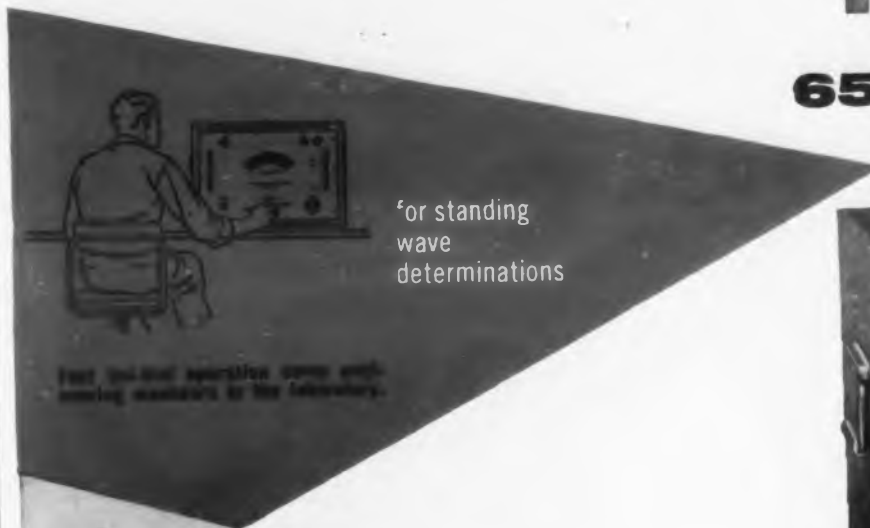
One is a growing recognition of the need for improved uniformity and control which has already resulted in a strong trend toward substitution of synthetic materials for natural ones. In accepting natural products we generally have to take variations in quality that we can't do anything about. For an example, the ultimate quality of capacitor paper depends not only on the kind of tree that furnishes the pulp, but even on the climatic conditions that obtain during the tree's growth. Natural materials are rapidly being supplemented by substitutes synthesized from simple compounds that are well understood and subject to control. Nylon for silk, glass for mica, synthesized oils, Mylar for paper are a few items from a rapidly growing list.

The importance of purity in materials reaches its highest level in the field of semiconductors. Germanium and silicon, for applications in transistors,

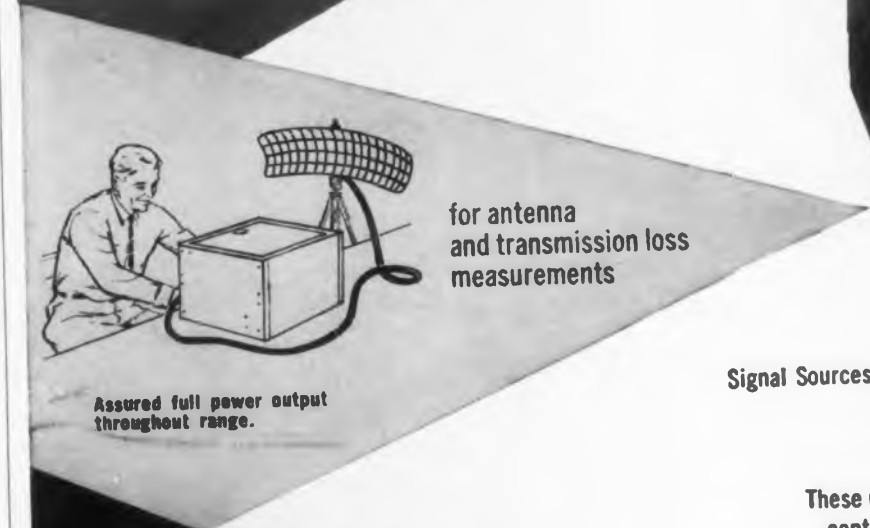
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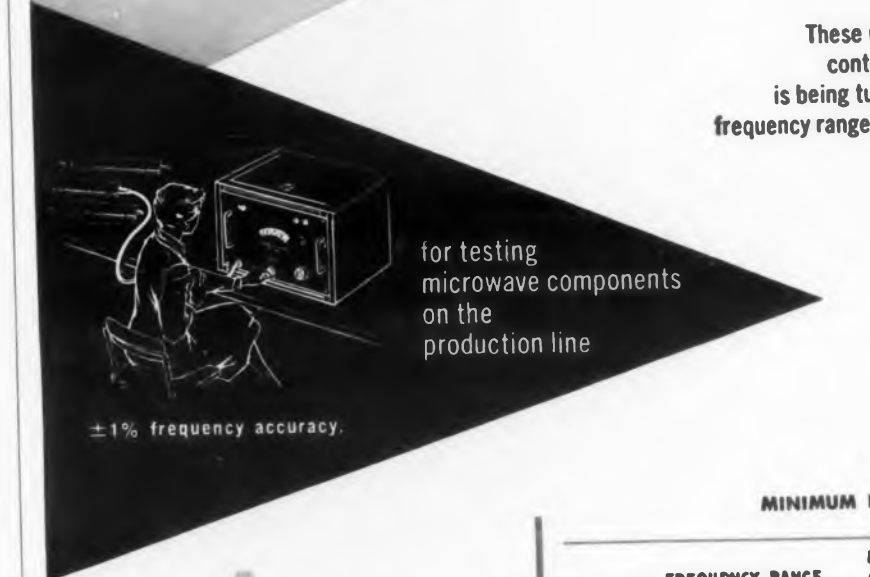
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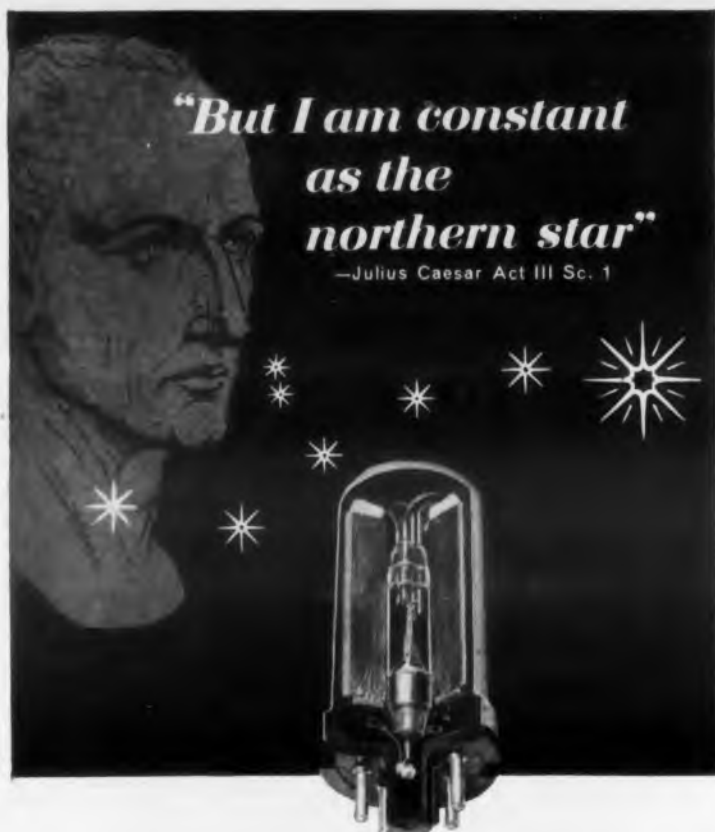
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Component Development

Micro-Miniaturization

are refined by ingenious new methods to the point where the impurity concentration may be less than one part in hundreds of millions. But semiconductor devices are not the only components in which a high degree of purity can be important to performance. Take, for instance, the aluminum used in electrolytic capacitors. Past practice has been to use aluminum of about 99.7 per cent purity for the foils. This is already somewhat purer than Ivory soap, but recent studies indicate that important improvements result from the use of even further purified aluminum. Some work has been done on aluminum of 99.99 per cent purity and indications are that its use in electrolytic capacitors will lead to improved shelf life, lower leakage, and fewer open circuits due to corrosion.

Similarly in experience with tantalum there is ample evidence to show that extreme purity in the material results directly in improved capacitor performance.

Another and highly important trend which can be observed today is the growing emphasis on fundamental understanding of materials and their behaviour. The rapid development of transistor art has resulted from basic research into the electronic nature of semiconductors. And while this important body of knowledge has been created primarily for transistors, there can be no doubt that it has an important contribution to offer for passive components of the future. To be sure, there are semiconductor passive components now, the carbon film resistor and the tantalum solid capacitor being two examples. But there will be more direct applications of transistor technology such as, for example, the junction capacitor referred to previously.

But even in the more traditional lines of component development the empirical approach has reached the point of diminishing returns. More stress than ever before is being laid on understanding of the basic physical and chemical mechanisms of conductivity, breakdown, magnetism and so forth, and this kind of knowledge cannot help but lead to better and more reliable components.

Reliability

It would be a mistake to look on micro-miniaturization only as size reduction of existing components. In addition to being smaller, the new components for future systems must meet new requirements on performance and environment. And foremost among

these is the requirement of fantastic orders of reliability. Failure rates in today's passive components run from 1 in 10,000 to 1 in 100,000 per year, depending on the component and its use. These failure rates, which are already low, will still have to be decreased by orders of magnitude. This is true

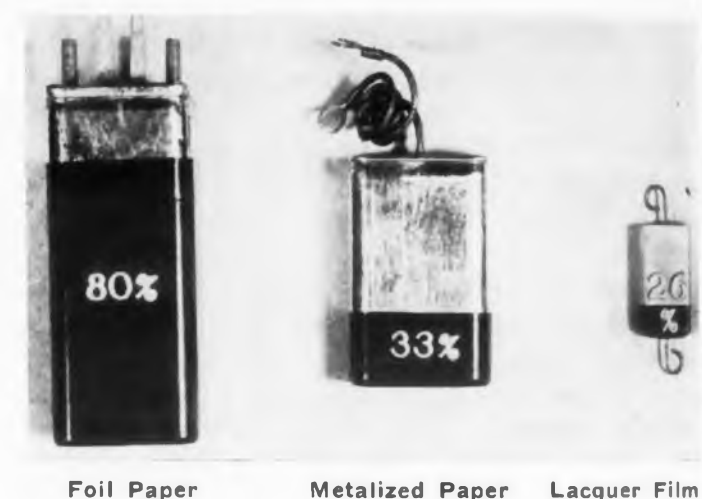


Fig. 10. How working volumetric efficiency has decreased as capacitors became smaller. Here is an area for design consideration.

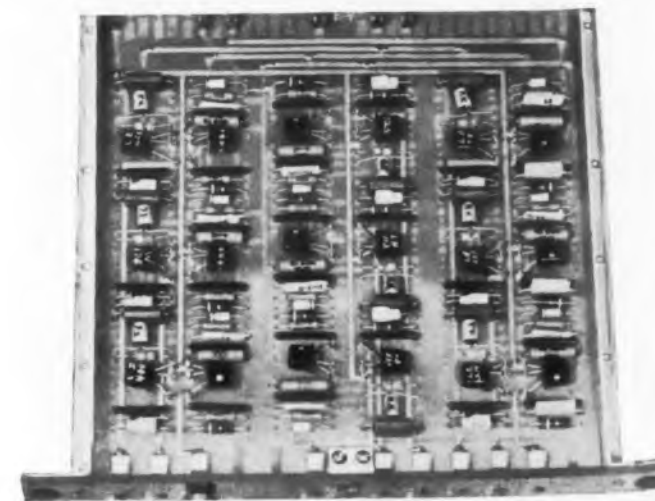


Fig. 11. Typical printed wiring assembly. Volumetric efficiency is only 3.2%.

not only for military equipment in which the urgency of dependability is obvious, but it is also true for non-military systems. This is because in everything from television to telephones the numbers of components being used, and on which satisfactory performance depends, are beginning to reach staggering proportions.

Unfortunately we are getting way beyond the point where we can evaluate component reliability by statistical methods in reasonable lengths of time. As an example of this, the components for the recently installed transatlantic cable must have an effective average annual failure rate of less than one in a million to meet the objectives for system reliability. If for every component made for the system a duplicate had been made for life testing, some 600 samples would need to be on test for 400 years before one could have demonstrated a one-in-a-million failure rate.

In the face of these facts the only possible philosophy was to build the most reliable components that could be made under the most careful control possible, so that whether or not they met the objective, they would be known to be the best that could be made.

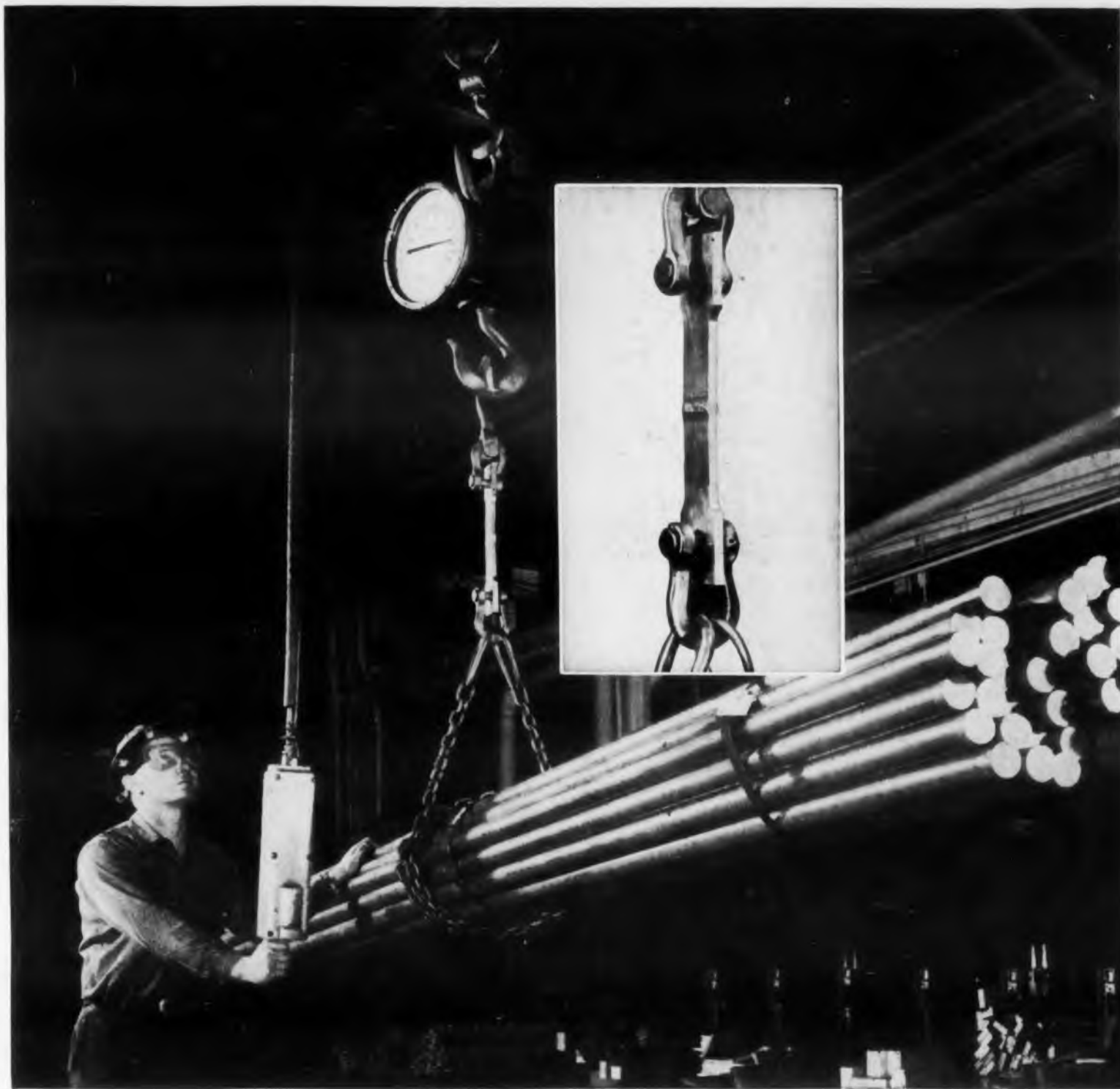
Characterization of reliability is important, but even more important is producing reliability, and for this a higher order of control in manufacture is an unavoidable necessity. This includes control of uniformity in materials, control of cleanliness in manufacture, and control of processes by automation. It also implies a high incidence of process testing. The day has long since gone by when endpoint requirements were sufficient to guarantee a component. It will be necessary that future specifications for high quality components concern themselves with requirements covering every stage of manufacture.

Components of the future will not only have to meet more stringent reliability objectives but they will have to meet them under more severe environmental conditions. No crystal ball is needed to predict that military components will be subjected to higher orders of shock and vibration than ever before, or that resistance to radiation and to extremely high temperature, and to other environmental factors, will become prime considerations.

Microminiaturization is certainly coming, but its realization will depend on a new order of discipline in materials preparation and component design. It will require all the help that the basic sciences can give it, and it will call for a philosophy of perfection in every detail of design and manufacture.

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Micro-Miniaturization Requires New Thinking

Dr. Cleo Brunetti, Dr. Otmar Stuetzer,
John W. Buffington and L. K. Lee

General Mills, Inc.

THE DEMANDS to make electronic equipment smaller, lighter, more efficient, and more reliable are getting louder, and the effort spent in these directions is greatly increased. We have a long way to go before achieving the ultimate in miniaturization. Yet, as technology opens new approaches, we see means for eventually achieving our desired goals. In guided missiles fired by interceptors, guidance systems employing well over one hundred tubes are condensed into a space less than one-half a cubic foot. The small 200 lb automatic pilots used in aircraft during World War II are now obsolete. New Models weigh much less than half this amount and perform many times the number of functions

Definition

We may define micro-miniaturization as the design of electronic equipment using solid state and other nonthermionic devices to obtain a higher order of magnitude reduction in size and weight than possible heretofore.

Why Micro-Miniaturization?

Why micro-miniaturization? It would appear that we still have to exploit all the advantages and solve all the problems attendant to subminiature size equipment. This is quite true. But we see a serious need for smaller equipment. As the use and complexity of electronic equipment becomes greater, it becomes essential that the size of the equipment be reduced. Otherwise we will be building enormous plants not just to fabricate the equipment, but also to house it. And the increasing plant size would not be a straight-line growth. The graph, Fig. 1, illustrates the increasing complexity of military electronic weapon systems measured by tubes in use. In 1937, a destroyer used 60 tubes; a 1955 destroyer uses well over 5,000 tubes. Similarly, the number of tubes in bomber aircraft has been multiplied by over 150 times since 1937. Mechanically micro-miniaturization is important, too. Switches, dials,

relays, motors, gear trains and other mechanical components must also be made smaller if we are to realize to the fullest the possible impact of micro-miniaturization.

The basic need for micro-miniaturization is due primarily to increasing applications of electronic equipment, increasing complexity of electronic equipment and an increasing need for more rugged and reliable equipment.

Ruggedness is, of course, necessarily a by-word of modern equipment. We must investigate the design of equipment to operate under conditions of high shock and vibration. Here micro-miniaturization will have its impact. Let us take the specific example of a supporting member or column. For

a given material, axial strength is proportional to area of d^2 . For a given acceleration stress is proportional to weight ($F = ma$) or volume d^3 . Thus the strength to stress ratio is $\frac{kd^2}{d^3}$ or $\frac{k}{d}$. As the size decreases, the strength to stress ratio becomes larger, and resistance to shock and vibration increases.

Micro-miniaturization is also necessary as another step towards absolute reliability. As we make things smaller and simpler by the elimination or reduction in number of connectors, for example, we remove many sources of unreliability. By the development of new design and of new techniques to produce micro-miniaturized equipment, we may be able to

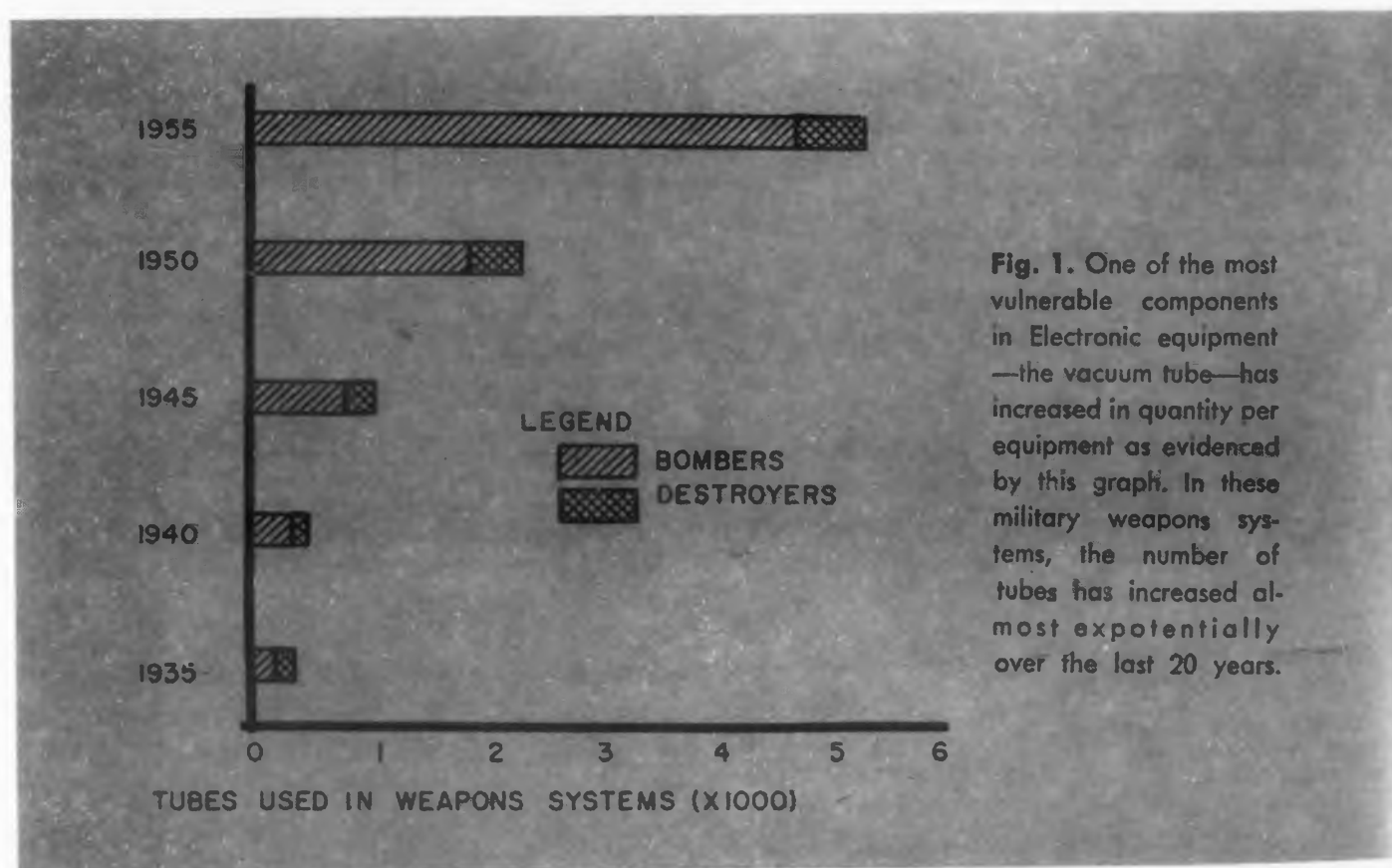


Fig. 1. One of the most vulnerable components in Electronic equipment—the vacuum tube—has increased in quantity per equipment as evidenced by this graph. In these military weapons systems, the number of tubes has increased almost exponentially over the last 20 years.

gain additional reliability which is sorely needed in all electronics equipment.

As in most technical fields, the development and acceptance of micro-miniaturization will no doubt be an evolutionary process. We see the beginnings now in equipments that use solid state devices and tubes, and in many cases still contain conventional passive components. Even in these pioneering stages, a hint is available of the advantages that micro-miniaturization will bring. New components are being developed compatible with the lessened requirements of transistor circuitry. Reliability, simplicity and ruggedness are being improved, and power requirements significantly reduced. The situation calls for focusing our sights way down the road rather than just before us.

Designer Holds The Key

How can we assure that adequate effort is applied to the development of micro-miniaturization? First, we must make our needs known to materials processors such as the chemists and physicists who must explore and pioneer the development of the materials and discover phenomena which may become applicable. At today's stage in this picture, the achievements of micro-miniaturization will be dependent even more on the chemist and physicist than on the electronics engineer.

Next comes the problem of telling or educating the consumer, the military agencies, industry and the public who will eventually use, manufacture and develop the micro-miniaturized equipment, of the advantages to be gained, the work necessary and the financial support required.

One very good method of finding ideas for micro-miniaturization is a brainstorming session on the subject: "How can it be micro-miniaturized?" Part from the conventional, or even reality, and dream up as many ideas as possible. Then judiciously examine these ideas—not during the brainstorming session, but afterwards. We did this at General Mills several months ago and were amazed at the number of promising ideas which were proposed.

Achieving the Advantages

In trying to achieve the advantages that micro-miniaturization promises, there are four steps by which we can make major gains: 1. We must do a striptease act on our present equipment and components; 2. We must investigate new materials and their application to electronic components; 3. We must develop new fabrication techniques; and 4. We must discover and then apply new physical phenomena.

Eliminating the Unessentials. To reduce our present equipment to its bare essentials, we must study each component and piece of hardware used and ask if each is really needed or if it is there simply because we've always used it and never taken the time to consider how to do without it. Tailor all

equipment designs for specific jobs. Eliminate unnecessary components. Use components in dual capacities or functions whenever possible.

Examine the components themselves. For example, take a resistor. It is a mixture of carbon and binder that restricts the flow of current in a circuit. How is it made? First a phenolic jacket. This has no part in the resistor action, so let's strip that part off. Second, the end tabs are only a means of getting at the resistor and do not control the flow of current, so off they go, and so on.

Today, the active material of a normal electronic component or circuit accounts for only a small portion of the total volume it takes up. The rest is insulating material and empty space. Even in a tiny transistor the ratio of the volume of the element to the volume of the case is extremely small. The volumetric efficiency of a transistor is less than a thousandth of one per cent. Can we create circuits out of only the active materials first and then pot the entire circuit in a single block of insulating material?

Consider New Materials. As an example of the development and application of new materials, one company has announced an information storage unit which can reduce the size of a memory unit capable of storing a million bits of information to approximately half a cubic foot in volume. It is simpler to produce, simpler to operate and to maintain. This device consists of thin printed plates of a special ferromagnetic material which is molded into small perforated squares 0.83 in. in size. Each square is perforated by 256 apertures, each of which stores a bit, a binary digit.

Future electronic equipment will become more intricate and compact as the functional requirements become more complex and more precise. Components may be quite different in size configuration and use of materials. The resistive, capacitive and inductive components as we recognize them today, may be completely changed, any may possibly be even more different than the printed rectangular resistive element is from the conventional resistor. New circuit concepts and analysis techniques will most probably be used to take advantage of the development of new active devices in a network. Shielding and intermodulation problems will be quite different, and less bulky materials and techniques must be developed for their solution. Most important of all is the growing requirement for developing more and completely new transducers. Unless this work is accelerated, these end organs or input and output devices can rapidly become the bottleneck for complete micro-miniaturization of a system. This includes microphones, photocells, relays, transformers and others.

But many of our most significant developments today were considered possible but highly impractical twenty years ago. Through research, principally in the physics and chemistry laboratories, has

come the development of materials which make the ideas and applications of twenty-five years ago more than practical today. The best example we have is the Cinderella rags-to-riches experience which semi-conductors have made in their transition from the galena crystal with its cat's whisker of 35 years ago to become the high quality transistors of today.

The transistor is a significant achievement in micro-miniaturization. This device with an average life of almost 800,000 hours is indicative of the performance of solid state devices. Its ruggedness is attested by the fact that transistors have survived exposures to shock of over 1000 g's. Compare this with the thermionic tube in which the average life is about 5,000 hours and lucky to withstand a few hundred g's. And the transistor is basically a simpler and much smaller structure than a thermionic tube.

Now we have the cryotron, a sliver of wire with another wire coiled around it. This cryotron duplicates many of the functions of both transistors and vacuum tubes. It is small enough that fifty will fit into one of the lenses of eyeglasses. It requires a cooling system which might occupy considerable space, but we can still see substantial space savings. It is conceivable by the use of this type component and others to be developed that our computers which now occupy dozens of cubic feet can one day be put into one or two cubic feet of space or, might we hope, into a brief case.

We should not laugh at such seemingly fantastic ideas as this. Remember the three-dimensional printed circuits we were experimenting with ten years ago. Today we are approaching a state of the art and knowledge of materials where these circuits should be possible and highly efficient in the not-too-distant future.

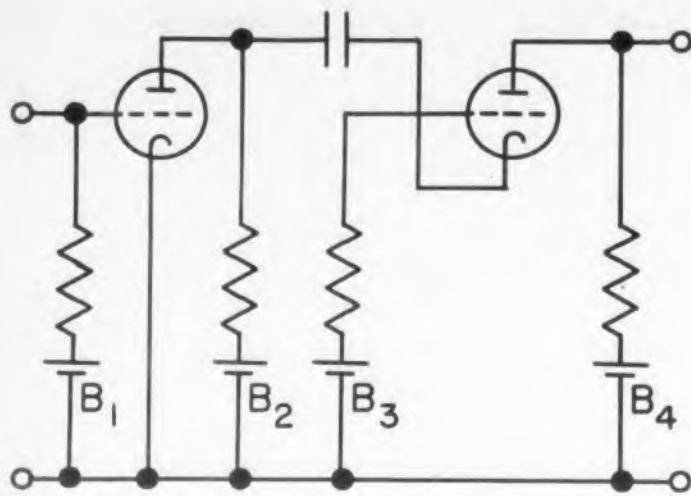
In solid-state physics we are only beginning to become acquainted with the possibilities for micro-miniaturization. We can begin to look forward to what we might call "Solid State Circuits." Solid State Circuits would be three-dimensional combinations of metallic, inter-metallic and insulating materials which transmit and control currents in the same manner as combinations of ordinary electronic components.

The present need to introduce terminals, connections and connectors between individual electronic components in a circuit adds parts that make no contribution to the electrical performance of the circuit, and in addition introduce a source of unreliability which the military and industry have long sought to overcome.

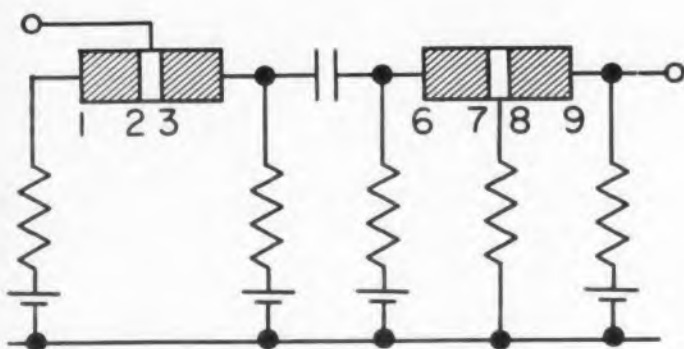
New Fabrication Techniques

By laying down combinations of materials in three dimensional patterns, it is possible to achieve circuits of at best only fair efficiency today. Through continued research in the improvement of the types of materials used and the techniques for depositing

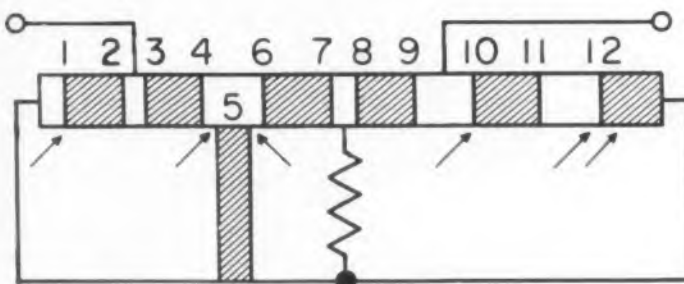
Micro-Miniaturization



a. Preamplifier and cathode-coupled amplifier stage.



b. Transistorized circuit. The P-type semiconductor is shown shaded; N-type, unshaded.



c. Proposed solid-state circuit to replace b. Shaded area is P-type semiconductor; unshaded area is N-type.

Fig. 2. Evolution of electronic amplifier circuit—from the conventional tube amplifier at a to its transistorized version b and proposed solid-state replacement at c. Functions of the elements in the solid-state circuit are: 1. Illuminated, low penetration, low impedance, replacing R_1 and B_1 ; 2. emitter; 3. collector; 4. ohmic; 5. illuminated, deep penetration, high impedance, replacing R_2 and B_2 ; 6. illuminated, low penetration, low impedance, replacing R_3 and B_3 ; 7. emitter; 8. collector; 9. ohmic; 10 and 12. illuminated, deep penetration, high impedance, replacing R_4 and B_4 ; 11. ohmic.

them, we should be able to effect at least an order of magnitude size reduction and a corresponding increase in reliability.

It must be borne in mind, however, that no matter how ideal an equipment is in design, it must be producible under practical production conditions. As the devices become smaller, human engineering problems will become pressing. Human hands will become too cumbersome for fabrication tasks, and automatic techniques will have to be developed. Micro-miniature equipment will be produced by completely automatic manufacturing methods. The key to micro-miniature design is perhaps the production technique.

Printed electronic circuits in the form of couplates or Bulplates or Erie Packs suggest what we can do at present using capacitors, resistors, and conductors. But what about all the other component types used in electronics today? If we are to achieve solid state circuits, we must develop substitutes for inductors, transducers and many others.

A solid state circuit containing active devices might look like that shown in "c" of Fig. 2. This is the solid state equivalent of the conventional combination of a preamplifier and cathode coupled amplifier stage shown in "a," first converted to the transistor circuitry as shown in "b." The solid state circuit consists entirely of P N junctions, such as can be rather easily produced by rate of growing techniques. Junctions 1, 5, 6, 10 and 12 are used as power supply batteries by shining a suitable amount of light on them. By using this system of power supply, the number of connections is minimized and blocking condensers are eliminated, and minimum dimensions are prescribed by the diffusion lengths of the carriers in the respective junctions.

The absence of standard types of connectors and terminals is an obvious advantage of this type of construction. There are many methods by which conducting and insulating materials can be selectively removed or added through such processes as electro-deposition, spraying, evaporation, elective etching and many other techniques or produce Solid State Circuits of size limited principally by the types of electrodes or depositing tools employed in laying down or removing the material.

Carrying one's imagination a step further, we can visualize combinations of germanium, silicon, ferroelectric, ferromagnetic and other types of organic and inorganic materials deposited automatically in

volumes of a thousandth the space now occupied by electronics produced by ordinary methods.

To achieve satisfactory circuits by these means, we will have to engage in a great deal of research and development work delving into the physics and chemistry of conducting, semi-conducting, insulating, dielectric, magnetic, ferroelectric and many other types of materials. Studies will have to be conducted to either eliminate or compensate for properties of such layer built materials which can limit their performance. This includes variation in capacity with frequency and temperature, aging of the materials, high power losses and other undesirable characteristics.

Ferromagnetic ferrites for example have made it possible to reduce microwave components very materially in size. In order to extend these benefits to the lower frequencies, considerable studies will have to be made in the regions below X Band in order to improve the efficiency of phase shifters, amplitude modulators, isolators, duplexers, and switches. The ability of ferromagnetic materials to act as switches by rotating the plane of polarization of microwaves transmitted through them should be harnessed for other uses simulating the performance of resistors, capacitors, attenuators, and so forth.

New Physical Phenomena

While we can look for substantial reduction in size and weight of present types of electronic components through the use of better and more efficient materials and improved packaging techniques, our real breakthrough in micro-miniaturization will probably come from some totally new approach and the continued exploitation of the newer concepts of electronic materials.

Let us rethink our circuits through in terms of what each component or group of components is supposed to do to the current or voltage. See if we can't find a simpler way. Can we go from the input to the desired output directly? R, L, and C are mathematical concepts and may disappear as we go to the ultimate. We can treat a circuit as a short transmission line with distributed constants. Can we also use interrelated force fields (electro-static, magnetic, and others) to control the flow of current?

Walter Hausz has another interesting idea. "Fundamental to the many ways of making electronic equipment smaller is the realization that many of the things we want to do are at the information handling rather than the power handling level.

Power levels of components can be in micro-micro watts before they approach inherent noise levels that jeopardize their operation." Indeed, some sensory devices, such as the eye, already approach the ultimate and require very few quanta of input to produce a detectable signal output.

Expanding applications in all phases of industry are requiring more electronic instrumentation for greater speed, precision, control; to supply more information or to perform more difficult functions. Take, for example, the electronic computer. Although it can perform many types of operations at great speeds, the intelligence or judgment of a computer is equal to only about one-hundredth that of a moron. Rooms full of equipment are required to perform the limited computer operations. Thousands of tubes may be used, each acting as an excellent heat source. Just to cool the large computer systems requires several kilowatts of power for blowers. Although it is possible to store a wealth of information in an electronic computer, there is no simple and quick way of getting to this information. The access problem is one major bottleneck.

When we compare electronic computers with the human brain, we see how much work is needed just to catch up with Mother Nature. Some of her designs are not vastly different from our own, but the difference in size is astounding. Compare the micro-miniaturized human eye and nerve system to its electronic counterpart. Nature has contained in just several cubic inches the optical transducer and generating, modulating and control system to convert a visual picture into a parallel series of constant amplitude modulated signals to the brain. The details of this are not essential, but such a system, using sub-miniature techniques, would require something of the order of 120 cu. ft of space, and would be approximately 60,000 times larger than the human optical system.

Would we not be wise to look more closely at the performance of organic materials in our efforts to micro-miniaturize? First, we would bring together the electron scientists and the organic or physiological scientists in an effort to bring them on common ground with common objectives. Then perhaps an effort should be made to create workable organic components and systems as well as to understand those produced in nature. Both organic components and systems should be analyzed. Nature has a marvelous system of connectors. Perhaps these should be studied even more than the organic components.

In the human brain, not only can a wealth of information be stored in a very small space, but we have access to much of this information at a moment's notice. The random access problem has been solved and all the storage mechanisms needed are contained in a volume of several cubic inches, and during our most concentrated thinking, we are dissipating less than a tenth of a watt of power. Compare this to a room full of gadgets generating enough heat to require a 50 ton air-conditioning system just to keep the components cool enough so that they will work. What we need to develop is a system of low calorie circuits—circuits composed of components with low power dissipating. Thus we could minimize their acting as a source of internal heat. Unless we do materially reduce our power requirements, we will discover that as we build our circuits smaller and smaller the heat generated per unit volume will increase, and more heat per volume will have to be dissipated. Should we not examine the basic functions of components and try to eliminate all effects which are there in piggy-back style? For example, the heat generated in a resistor is an undesirable hitch-hiker. Could we use the idea described earlier of a P-N junction of a transistor to afford a voltage drop?

Great gains can also be accomplished if we can find better ways of transferring heat away from components. Again, the resistor. Instead of protecting a resistor by embedding it in plastic material, could we surround it first by a thin coat of insulating material such as beryllium oxide, and then a peltier junction? Recalling the peltier effect, what other new ideas can we come up with in solid state thermal converters to dissipate heat by converting it into another form of energy?

Our goal is to be able to build electronic equipment of a size belonging more to the insect world than to our own, and of 100 per cent reliability under all conditions of pressure, temperature, shock and vibration.

Mother Nature did a marvelously expert job of creating the human brain. Its capacity is astounding, and its size a true achievement of micro-miniaturization. But the human brain exists in delicate balance with its environment, and it is temperamental. Temperature and atmospheric changes can snuff out its life, and its efficiency is greatly affected by the lack of rest and food. Through electronic micro-miniaturization we hope to be able to build a brain—a computer—which will be able to do much the same as the human brain but which will be impervious to damage from temperature, shock, vibration or any other antagonistic condition and which will still achieve the optimum in space efficiency. Reliability must not be compromised. The achievement of this goal is a long and difficult task. We have taken some first steps, but many new and novel concepts will have to be created.



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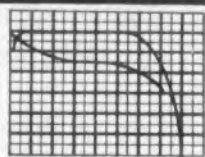
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Micro-miniaturization—A

WE THINK of the term miniaturization as somewhat of a paradox—and we feel that if you don't see the paradox you really miss the most important point of miniaturization.

Of course, miniaturization, as it is commonly used, does mean smaller hearing aids, less bulky electronic computers, lighter aircraft. But these reductions in size and weight really are valid only to the extent that they provide more function, more service, more convenience to the user.

For this reason we equate miniaturization with more from less. It's a workable concept that broadens the definition and hence the field for miniaturization.

For now we can truly miniaturize a product without necessarily reducing its size or weight. We can keep the same size—and pack 50 per cent more power, twice the versatility, three times the usefulness into the same space and weight. Or, for that matter, we can build products that are twice as big, yet give four times the output of their predecessors. All are examples of miniaturization . . . or more and more from less and less.

Miniaturization has many guises other than mere reduction in size. It might better be defined as a planned increase in service or function per unit volume or per unit weight of product.

Geometry of Miniaturization

Let's consider the "Vanishing Cube" as a clue to a basic approach to miniaturization.

It's really a simple matter of solid geometry. The volume of a cube equals, and hence varies as the product of, its three dimensions. This simple geometrical gambit is probably known, if not always appreciated by all. Trouble is that most of us think in terms of addition and subtraction, while most physical phenomena increase or decrease at the more rapid rate of multiplication or division.

Cut a line or a length of pipe in three equal parts as in the diagram—and each segment is one-third the original size. Now divide a square or a sheet of metal into a tic-tac-toe pattern—three squares to a

side—and each small square will contain one-ninth the area of the whole.

But slice a cube or a block of metal—each of whose sides has been divided in three—and you find that the resulting tiny cube contains exactly one-twenty-seventh of the weight and volume of the large cube.

In general this principle of the Vanishing Cube applies to solids of all shapes. It applies to the weight as well as to the size of these solids.

Thanks to the Vanishing Cube, seemingly minor reductions in all the dimensions of a product can produce dramatic savings in weight and volume. A cut in dimensions of only 10 per cent reduces volume by 27 per cent; a dimensional reduction of just 25 per cent can shrink weight and size by 58 per cent. You can work out other reductions as we did by using the chart at right.

There's a challenge here for the metallurgist and the product designer to make less and less of material do more and more—and thus capitalize on the potential savings of 27 to 1, or even more.

Miniaturization is Contagious

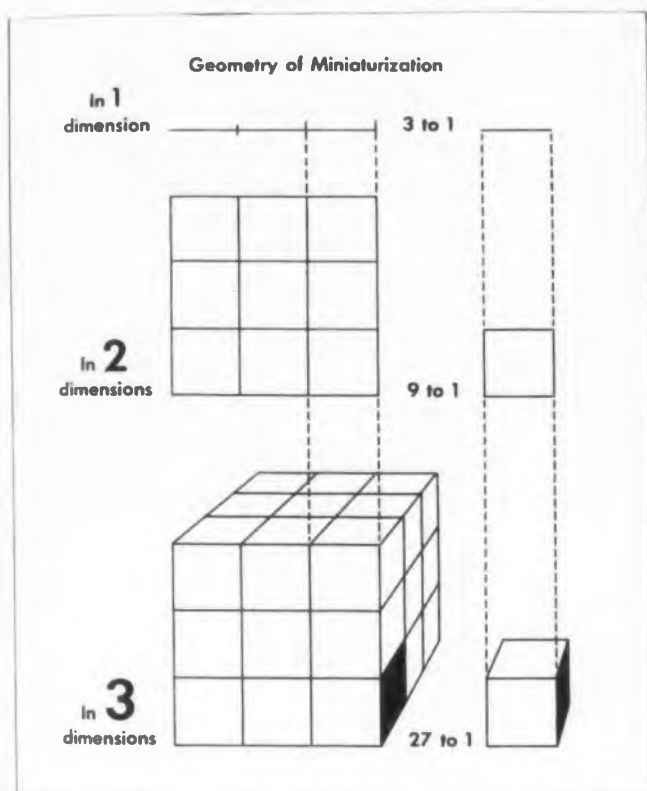
A product is only as small or as light as the sum of all its parts—and all the parts don't shrink in size or weight overnight. In practice, first one, then another of the component parts is miniaturized before the smaller end-product, once only a gleam in a designer's eye, becomes a reality.

As a result, there's steady pressure on most suppliers to keep in step. For when his best customer has reduced all other components in a product by a 27 to 1 ratio, pity the poor supplier who can't provide a part similarly scaled down.

The advent of a transistor, 100 times smaller than a vacuum tube, does not signal the immediate reduction of all electronic gear from 100 to 1. First there is need for the shrinking of a hundred and one auxiliary components to connect, contain, complement and power the tiny wonder elements. Only then can the full fruits of miniaturization be achieved.

This article expresses the views of Standard Pressed Steel Co. of Jenkintown, Pa., on "making it smaller." The thought is expressed that by miniaturization techniques, more functions and more reliability can be provided in a given-sized package.

A Paradox?



The pressure of miniaturization daily brings forth such products as mighty midget motors that can fit in a hand's palm; tiny ball bearings for shafts as thin as 0.025 in.; delicate, high speed blowers little more than an inch in diameter; lighter, more powerful fasteners, etc.

The contagion affects the makers of raw materials—those who produce the basic substances that will do more with less. New synthetics have and will be developed. New metals, like titanium, are being hurried into manhood. Old standbys, like steel and aluminum, are being more cleverly wrought and fabricated. Both are part of the continuing effort to produce stronger, lighter fasteners and other structural products.

There's no fixed goal, no smallest possible weight or size. It is a steady, continuing effort that calls upon the ingenuity of the materials engineer, the



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A Paradox?



Micro-

metallurgist, the product designer and many others, to build ever more service into less and less space and weight.

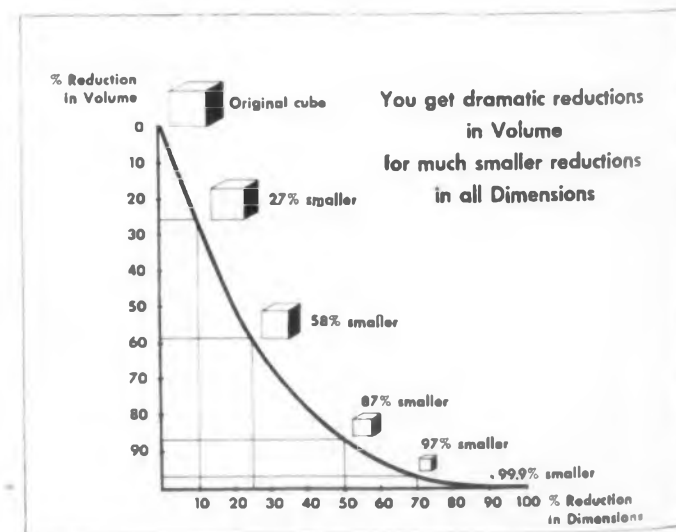
Designing for Miniaturization

Miniaturization need not wait on the discovery of wonder components, on the development of superstrength alloys. There is so much room for size and weight reduction in most products today that miniaturization really is more a designer's frame of mind than it is a manipulation of new devices and wonder metals.

Many major product reductions can be made through a study of basic function, a review and re-design of allowable stresses and necessary clearances and the use of available parts and components that already have been miniaturized.

There are many such miniaturized components available to help the designer. Some are just begging for ingenious application. One manufacturer reports that he can draw precision tubing as fine as 0.0014 in. in diam. It's so fine that no one has found use for it yet . . . but chances are it will be put to work soon.

In the realm of precision fasteners, too, there are many components that either in basic design or inherent strength are man-made tools for miniaturization. Knowledge of loads and of the ability of



Miniaturization

structural parts to sustain these loads will play an increasing role in future miniaturization.

Current lack of knowledge of this kind forces designers to rely on excessively high factors of safety to insure product durability. As a result, many structures are built too large and too heavy—much larger than an intimate knowledge of loads and materials would warrant.

Materials for Miniaturization

The basic materials, old and new, are playing a critical role in the miniaturization of a wide range of products.

New synthetics, with unusually high electric and thermal insulating properties, make it possible to pack more electric motor, more transformer and more electronic equipment into smaller spaces. Weight is being saved without loss of function by the use of nylon as a gear material, by the substitution of lightweight plastics for steel and aluminum in noncritical applications.

The metals, however, are still our most important structural materials. The future course of miniaturization depends heavily on the development of stronger, lighter metals—and on the fabrication of ever stronger parts from existing alloys.

Steel, titanium and aluminum offer the most promise for continued space and weight reduction. For this role, they are being assessed against several criteria.

One criterion is the inherent strength of the metal. The stronger it is, the less of it you have to use.

A more subtle standard—yet one of even greater significance to the aviation industry—is the strength-to-weight ratio of a metal. This is a measure of the load carrying ability per pound of metal. Though aluminum is nowhere near as strong as steel, it weighs only about one-third as much. In many applications, its strength-to-weight ratio, therefore, is greater than that of steel—and as a result you can use less aluminum than steel to do the job.

The main advantage of miniaturization lies not always in a smaller, lighter end product, but often in the ability to put more product, more service into a given space.

TELEMETERING BY ASCOP

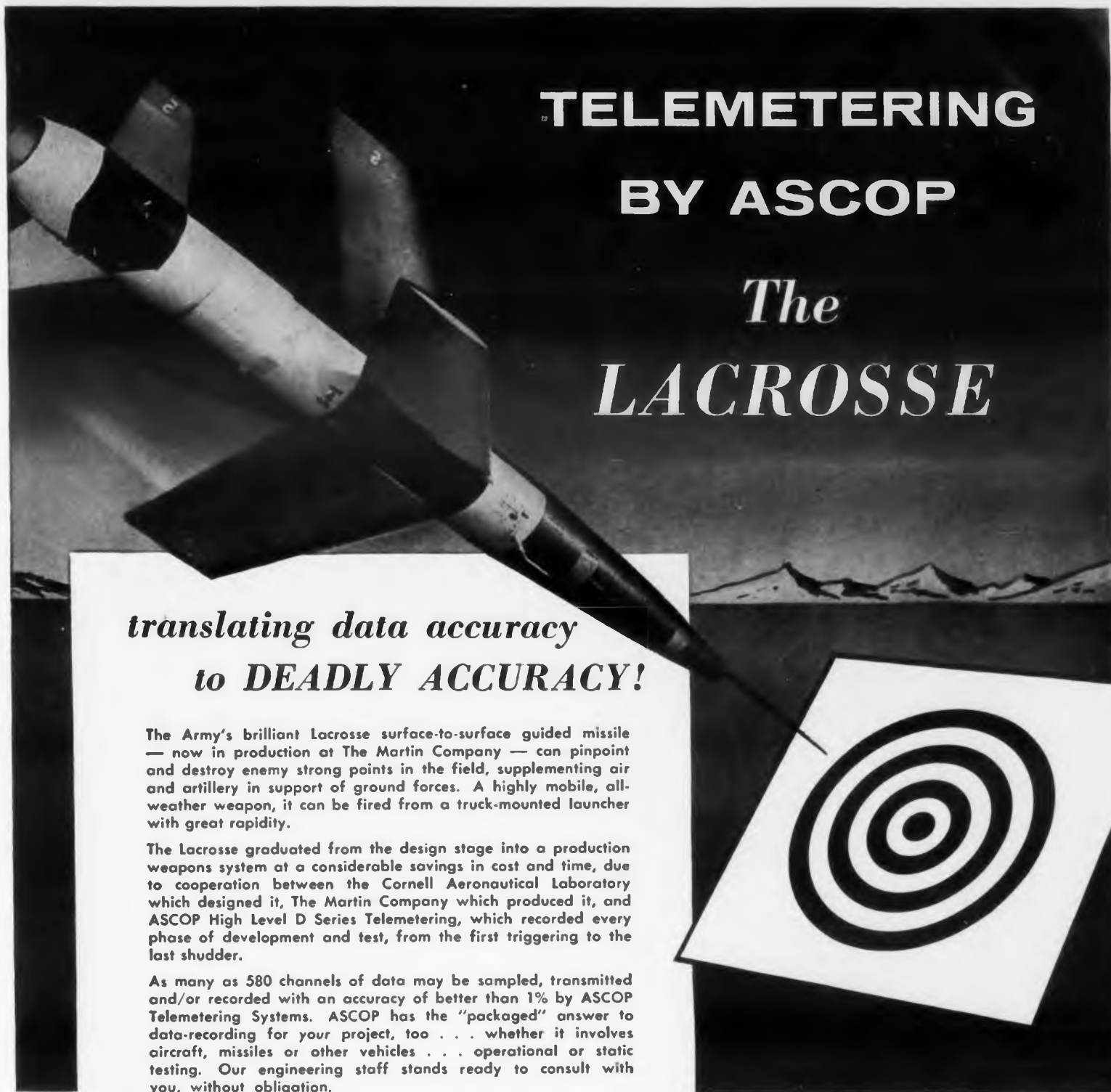
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The Lacrosse graduated from the design stage into a production weapons system at a considerable savings in cost and time, due to cooperation between the Cornell Aeronautical Laboratory which designed it, The Martin Company which produced it, and ASCOP High Level D Series Telemetering, which recorded every phase of development and test, from the first triggering to the last shudder.

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Micro-

FOR YEARS the watch industry has dealt with things miniature, a factor which has set a pattern for making, gaging, inspecting and handling micro-miniature, sometimes microscopically small parts and assemblies with considerable skill. Basically then, we are on firm ground from the point of heritage alone when speaking about miniaturization, especially as concerns its application to day-to-day mass production.

An example of the type of problem the average manufacturer can have with miniaturization was brought to our attention not more than a month after we entered the commercial miniaturization field at Elgin just a year ago.

We were called upon by an established manufacturer of special control devices for help in producing a miniaturized version of a sensor. It is important to note that they had already designed a smaller version of the device, but realized they had no machinery or know-how to produce it. One of their chief problems was dimension tolerance. They had no idea what strength or stresses each pinion, pivot fly-ball arrangement or plate should have, nor what materials to use to achieve these factors. Elgin was permitted to re-design any part or major assembly in the device. We successfully delivered prototype models, which are currently under test for use in jet aircraft.

Watchmaker's Technique

First of all, our design engineers worked with the customer to obtain necessary data to permit intelligent redesign of the unit. It had already been established that manufacture would be directed by the size of Elgin's machines which were capable of producing a micro-miniature version of the sensor. We actually reduced the volume by a ratio of 300 to 1. We applied what is called the parts density theory to the job. It works this way:

Miniature Techniques

W. W. Hamilton

Elgin National Watch Company
Micronics Division

One of the smallest precision mechanisms made at our plant is the movement for a ladies' wrist watch which consists of nearly 125 parts in an area the size of three dimes stacked together. On a cubic inch basis this works out to about 104 parts per 3/4 cu in. of space and determines a size base to which our machines and personnel are normally geared, and which would not necessitate new overall tooling. We determine the number of parts needed in the sensor and projected the reduction of these parts in size on a per cubic inch basis to learn whether or not the redesigned item would be in the particular size range for this project.

This method also permits a close look at the device when it is broken down into its component parts and often permits simplification of several sections of the device as well as the employment of different principles than in its larger counterpart.

Elgin engineers designed the fly-ball arrangement in the sensor by using a new spring made of watch alloys; and it was this fly-ball that was the size determinant for our miniaturization project.

Problem is Basically Mechanical

The hue and cry from the electronic industries today is not, "can we make it?" It's "how do we make it?"

Recently a design engineer for a leading aircraft company, whose job is procurement of electronic components for planes, described electronic miniaturization as a mechanical problem. As this aircraft design engineer said, the problem is one of mechanical abilities . . . the ability to design and build special machines, tools, gages, jigs and fixtures, that will produce the almost microscopically small parts that are needed for lightweight, tiny electronic components. The problem is increased by the lack of personnel equipped to handle these small parts, much less make the necessary machines.

$I = \frac{E}{\sqrt{R^2 + (WL - \frac{1}{WC})^2}}$

FORMULA for LONG LIFE

THE KEY COMPONENT

$Z = \sqrt{R^2 + (WL - \frac{1}{WC})^2}$

$f = \frac{1}{2\pi\sqrt{LC}}$

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you put Synthane laminated plastics to work



Synthane (arrow) serves as bearing in landing gear shock struts.

Synthane laminated plastics lead a busy life aloft.

In communications equipment, Synthane is found in hundreds of insulating parts. In aircraft instruments, precision ball bearing retainers and innumerable other parts Synthane is at work. The airframe itself finds Synthane at work in a number of critical applications such as landing gear struts.

The value of Synthane to the aircraft industry lies in its unique combination of properties in one material. It is light in weight (half the weight of aluminum), mechanically strong, dimensionally stable, easily machined and is a good

electrical insulator.

Synthane is valued in electrical applications chiefly for its high dielectric strength, low moisture absorption and low dissipation factor. Synthane is available in over 30 standard grades in sheet, rods, tubes or you can avail yourself of our complete fabricating services.

For more information about the many properties of Synthane laminated plastics and how you can benefit by using Synthane materials and fabricating services, write for our latest product catalog. Synthane Corporation, 42 River Road, Oaks, Pennsylvania.



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LIGHT WEIGHT



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EASILY MACHINED

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Techniques



Micro-Miniaturization

This is one of the chief areas where the watch industry can help because it has long experience in skills that are not learned in a hurry.

Special Skills Needed

The men who make our tool and dies have at least 10 years experience. Those assigned to build a shaped punch with a diameter of 0.004 in. (something they cannot see with the naked eye) usually have more than 14 years experience.

Many dies in the watch industry are of the compound, sub-press category (invented at Elgin) and are capable of stamping precision-located pivot holes in a plate not bigger than a grain of wheat. A miniature relay plate, armature assembly, or potentiometer plate requires the same machining know-how. This work is accomplished on special machines, many of them made at Elgin, and which are inherent to the watch industry. It is only recently that they have been turned loose on commercial devices foreign to the horological field.

Today's requirements in the electronic industries make it necessary for electronic designers to familiarize themselves with the capabilities of these type machines to enable them to design within their size ranges.

A Typical Design

One Elgin product is the Neomite relay, a tiny switching unit no bigger than a pencil eraser, which has an interesting history. It is important to note that it was actually designed by an electronic engineer outside the watch industry. His design was good, based on the best relay theory then known: but the item proved to small for his firm's machinery or personnel to produce. His first prototype models were assembled by, and from parts made by a local watchmaker working at his repair bench.

Elgin Watch purchased this firm nearly two years ago and was fascinated by the Neomite which then had been placed on the shelf as unproducible. It was turned over to watch engineers who began a year's study to work out, according to watch techniques, methods that would allow it to be produced by mass production techniques.

More than 10 basic designs were laid out including a new type of armature assembly and the use of tiny threaded screws for precision adjustments of the contacts in the relay. These screws are so small it takes more than 8,000 of them to fill a thimble. Because they were made of silver it was decided to use the screw itself as the contact in one application.

The armature was designed to function similarly to the pallet or balance control arm in a wristwatch, which permitted accurate and continuous operation without having the armature jumping out of action.

A tiny coil for the relay was made on a special coil winding machine designed and built at Elgin nearly five years before, during development work on an electronic wrist watch. The Neomite coil is no bigger than the head of a paper match.

Mass production of the relay was accomplished by a team of operators with an average of 5-1/2 years of experience working with tiny watch parts and assemblies, and capable of using vacuum screwdrivers, watch tapping machines and other special tools.

Machining tricks that made mass production possible included knowledge of special alloys used for contact springs, precision die-stamping for the coil frame, and watch gaging methods to govern quality control on parts so tiny that each must be assembled into the final unit with the aid of magnifying lenses.

Frame-of-Mind Important

Part of the miniaturization approach must be considered as a frame of mind—actually the ability to think small—both from the standpoint of the design engineer, the tool maker, and the production engineer. It is this frame of mind that has become a part of the watch craftsman's true micro-miniaturization skill—his ability to approach a miniaturization problem with confidence because he considers it to be in "his neighborhood".

Design Flexibility Required

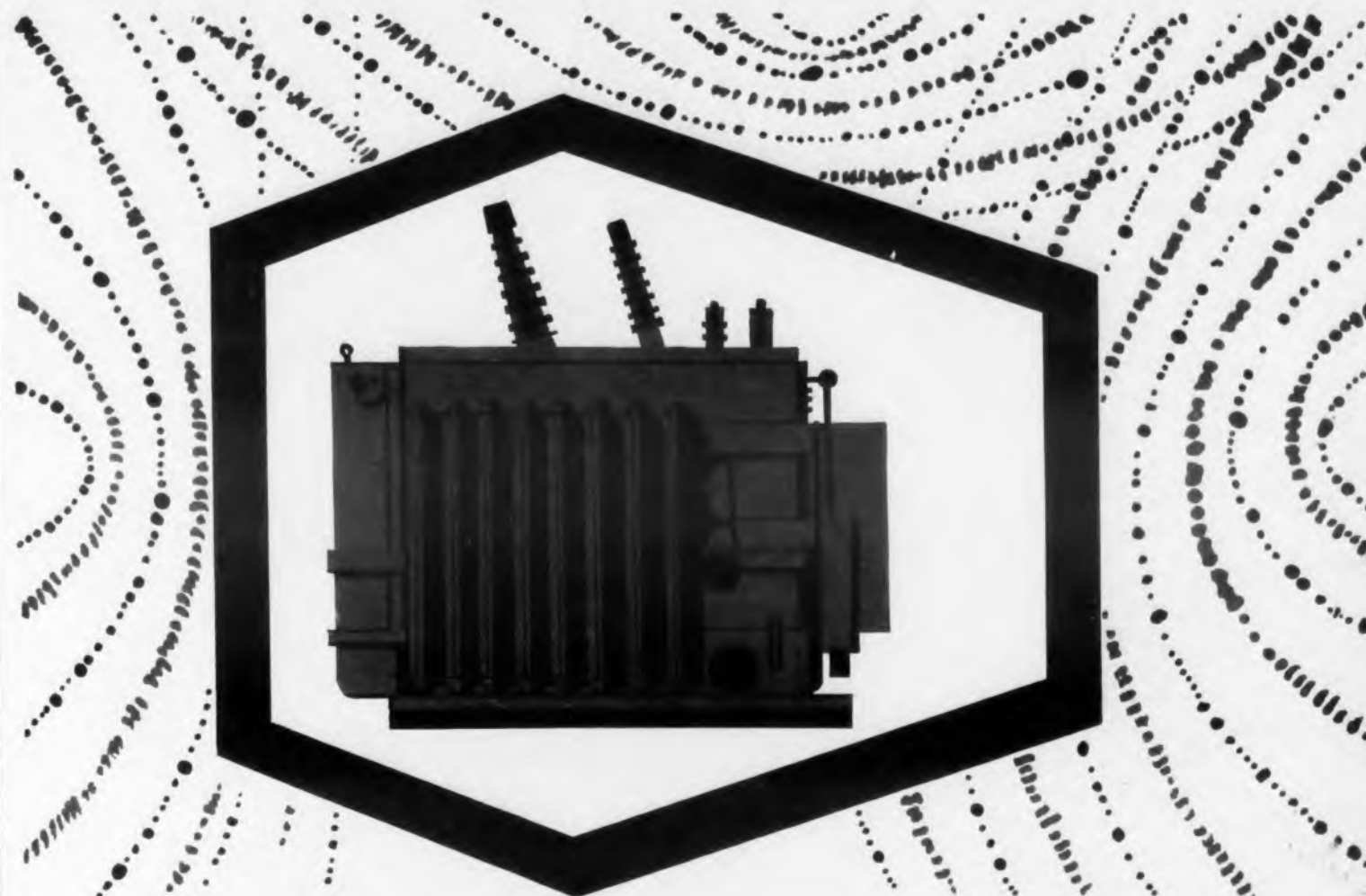
When entering the field of micro-miniaturization design engineers should have a free rein to toy with new designs of old established devices. They must enter the "dream world" of smallness. Successful miniaturization usually entails some untried method or principle, and always requires redesign.

New emphasis must be put on tool and die facilities and personnel. You can expect to make more in-plant machines since there are few outside the field who will even attempt to make what you need. The use of new materials will necessitate broader knowledge, longer learning time, and new equipment expense, especially as concerns plastics, metals, ceramics, and resins.

Smaller parts mean finer gaging, increased inspection and quality control, as well as the use of special optical projection equipment scaled up as high as 100 to 1 just to see what you are doing.

Miniaturization demands on-your-toes research and development to keep pace with what's available to help you, often in fields far removed from that in which one is familiar.

And finally, it demands that new frame of mind—that ability to think small. You will know you have achieved it when the impossible of today becomes the commonplace of tomorrow.



how Westinghouse stretches transformer life through R-F studies in ACE enclosure

R-F interference which often occurs in power transformers comes under strict regulation by both the FCC and military authorities. Standardized tests have been set up to check this interference against allowable limits. But at Westinghouse Electric Company's new Transformer Test Center at Sharon, Pa., engineers go on to use these measurements of radio frequency to actually improve the life of transformers.

When r-f generation occurs in a transformer, it releases ionized gasses which have a deleterious effect on the transformer windings. Reducing, or eliminating the cause of gas ionization, indicated by the generation of r-f interference, greatly increases transformer life.

To make the accurate radio frequency measurements required, both the transformers and the delicate test instruments must be isolated from all sorts of outside radiations. A large Ace shielded enclosure—measuring 28 feet long, 32

feet wide, and 25 feet high—fulfills this requirement by providing a guaranteed attenuation of over 100 db for all frequencies from 14 kc to 1000 mc.

This Ace enclosure is constructed of prefabricated galvanized steel panels and frames (RFI-Design)* which assures permanent warp-free protection. A unique feature of the enclosure is its 16- by 20-foot electrically operated vertical lift door. Air-operated contact fingers around the periphery completely seal the door against r-f leakage.

This example of Ace enclosures for r-f shielding is just one of the many "rooms" Ace has designed and supplied to meet the requirements of industry, military, and medical work. If you have a shielding problem in your plant, an Ace Engineer would be glad to discuss it with you and outline an effective, yet economical solution. Or write for a free catalog on Ace standard enclosures.

*Lindsay Structure



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CIRCLE 27 ON READER-SERVICE CARD FOR MORE INFORMATION

Watch battery with year long life. Developed by National Carbon Co. for Hamilton Watch Co.'s electric wrist watch, this is believed to be the smallest mass-produced battery of its type. Made exclusively of non-magnetic materials, it occupies only 0.31 cu mc, has a nominal rating of 1.5 v, and provides 60 ma-hr until 1.3 v cutoff.



THINGS ARE GETTING SMALLER . . .

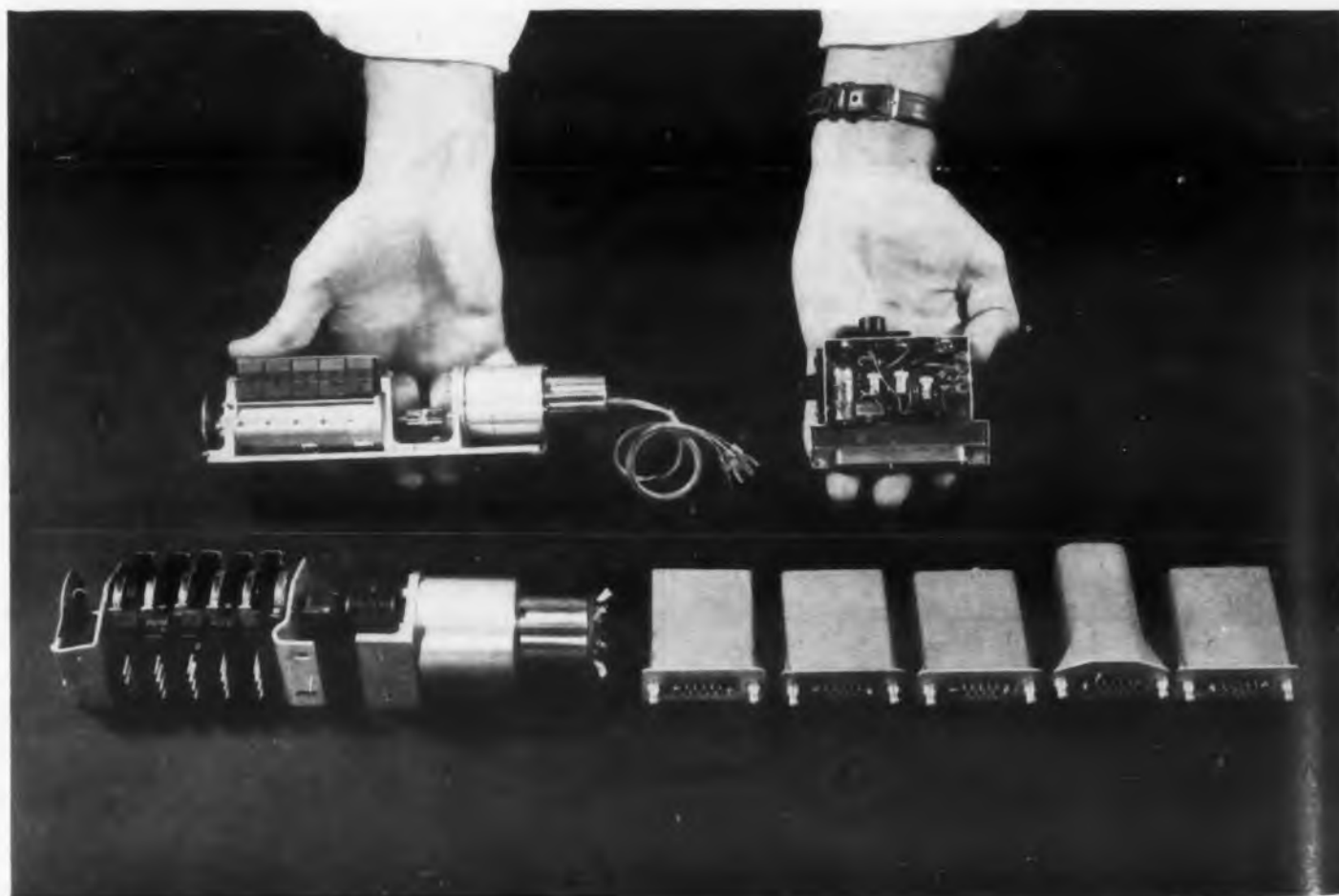


Eveready low current battery, 95 v per in, no leakage, almost unlimited shelf life.



Centralab's "ultra-kap" and a conventional disc capacitor of the same rating.

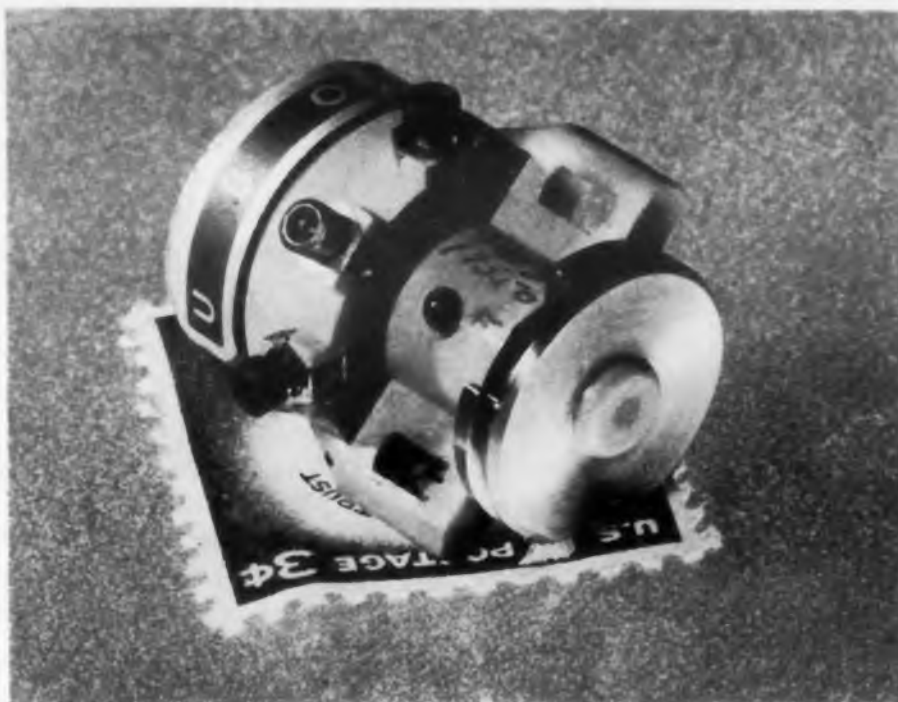
Miniaturization program at Westinghouse Air Arm Division in Baltimore has resulted in one transistorized servo amplifier (being held at right) replacing the five molded units using vacuum tubes (below). Total weight was reduced about 10 fold and power consumption 40 fold.



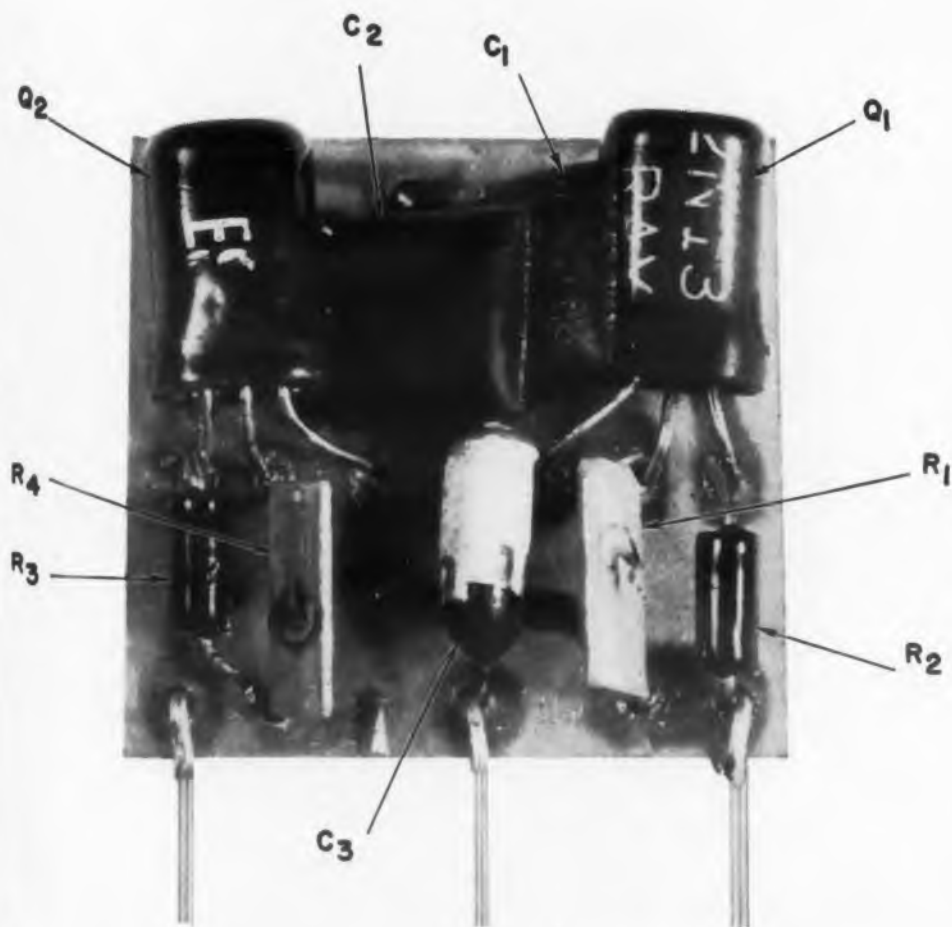


Aerovox's new "Cerafil" ceramic capacitors. Shown here are 1000 μmf , 100 v dc units, claimed to be smallest ever made.

Thumb-sized potentiometer (below) for Falcon missile. It is less than 1/2 in. in diam. Developed by Fairchild Camera and Instrument Corp., the control is employed as sensors and attitude instruments in missile guidance systems.



Mechanical differential (above), developed by the Pitometer Log Corp., is believed to be the smallest in existence. Overall diam. is 1/8 in. Weight is approximately 10 grams including typical end gears. Breakaway torque: 0.01 oz-in. (08. gm-cm). Unit employs sub-miniature ball bearings.



Size, weight, and power requirements were reduced when the magnetic amplifier auto pilot (above) replaced an electronic vacuum tube system in the USAF TM-61 Martin Matador. The new unit also increases the reliability. (Courtesy, The Martin Co.)

This 400 cycle multivibrator is one of a line of miniaturized circuit assemblies which will fit in less than one fifth of a cubic. M F Electronics Co., N. Y. features stability and reliability over a temperature range from -25 to $+50$ C. The circuits are encapsulated in epoxy resin in a drawn nickel-silver can. In the photo, **Q1** and **Q2** are Raytheon PNP transistors; **R1**, **R4**, **C1**, and **C2** are Glenco products, **R2** and **R3** are Allen-Bradley resistors and **C3** is made by Ohmite.



Micro-Miniaturization in Missiles

John R. Moore
 General Manager,
 Autonetics Division,
 North American Aviation, Inc.

THE GUIDED MISSILE industry has been principally responsible for the trend toward miniaturization, then sub-miniaturization, and now to micro-miniaturization. Because a missile requires robot pilots, navigators, and bombardiers, more electronic and electromechanical equipment must be employed in the guidance and control systems than would be needed with a human crew at the controls. This equipment, together with the missile's destructive payload and required operating characteristics, now normally constitutes the basis for airframe design and power plant selection. As a result, the guided missile has reversed a former trend of airframe design which saw the power plant as the starting point followed by the requirements of the aerodynamicist, with electronic and control equipment often added almost as an afterthought and certainly without optimum system integration.

Micro-miniaturization, properly integrated into the missile system, increases the weapon effectiveness of all types of missiles. This increased effectiveness takes a number of forms and springs not only from the reduction in size and weight, but also from increased reliability, flexibility, maintainability and transportability.

Improved Missile Reliability

Micro-miniaturization guidance and control equipment makes it possible to combine relatively large numbers of circuit elements on single etched or printed cards. Experience indicates that today's printed circuits with their modern soldering methods are considerably more reliable than connectors. The micro-miniaturization which makes feasible large printed circuits also eliminates the use of many pin connectors and, consequently, increases the reliability of electronic equipment. This reverses a trend which is now prevalent in some applications and which was almost universally accepted in the aircraft industry two years ago that the best designs

from the standpoint of reliability and field maintenance should employ multiple plug-in amplifiers. In addition, micro-miniaturization minimizes the need for wiring harnesses, intermodular cabling, and junction boxes, any one of which can be the weak link in a missile's overall reliability.

Also, because micro-miniaturization permits the design of equipment with minimum power requirements it is possible to maximize the reliability of prime movers, special power supplies, and cooling equipment, either by the use of unusually rugged construction or redundancy.

What To Micro-miniaturize

A missile's guidance and control system normally uses electronics as a means of getting from a meas-

ured input to a desired output. These may be the positions and velocities of a target as detected by tracking equipment, angular velocities and accelerations of the missile's airframe, and components of its velocity over the ground. Primarily, outputs may take the form of control signals to the missile's propulsion system or to its aerodynamic surfaces and signals to the missile's warhead. It is important to micro-miniaturization such input equipment as trackers, gyros, accelerometers, and air data detectors, as well as electric, hydraulic or pneumatic actuators and their position, velocity, acceleration and pressure transducers. Whereas the printed circuit and the semi-conductor have made the most dramatic breakthrough in micro-miniaturization, less spectacular but equally important work

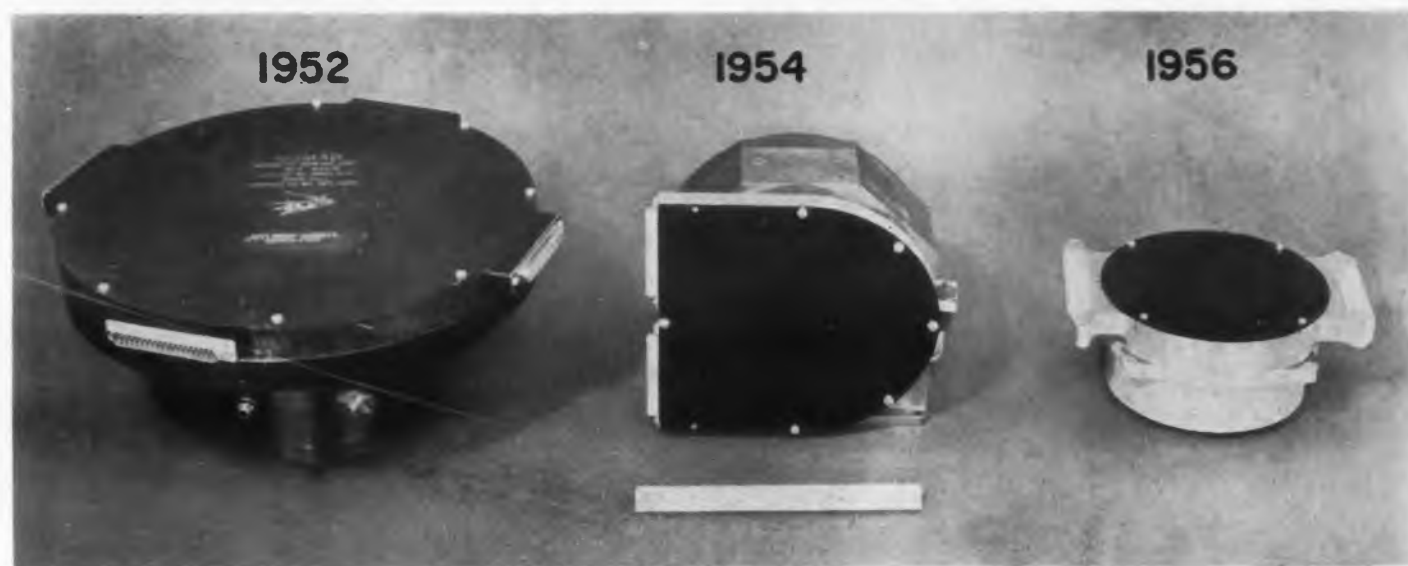


Fig. 1. Twenty thousand bits of storage information for an Autonetics' autonavigator digital computer are provided by each of these autolubricated, air-bearing magnetic-disc memory units. This graphically illustrates reduction in size and weight without loss of capacity.

as been going on in improving detectors and transducers. In Fig. 1 is an example of the evaluation of magnetic memory units which have been getting progressively smaller.

Integrated Design Important

Major size, weight, and power reductions should be achieved by an integrated system design. Very definite progress is being made in this direction in both aircraft and guided missiles but the principal credit for starting this trend probably belongs to the missile. Consider, for example, a systems engineering approach to an air-to-air guided rocket. The autopilot and guidance equipment for such a missile requires the establishment of angles and angular rates relative to inertial space. There would be a normal tendency for the guidance equipment engineers to supply their angular reference and angular rate gyros, whereas the automatic pilot engineers would prescribe a separate set of equipment for the missile flight control system. Savings in size, weight, and cost both in the missile and in its auxiliary equipment can be achieved if a suitably designed three-axis angular reference system is provided for use throughout the missile. It must be emphasized, however, that unconsidered attempts to force the guidance and autopilot engineers into the use of the same equipment may actually lead to more difficulty than improvement. This is particularly true if the common angular reference is a source of unreliability and if it requires more auxiliary computing equipment to use its output throughout the missile than the additional gyro equipment it replaces.

Another example of the advantages of the integrated system design is found in the concept of the central computer. Such a computer combines all of

the computing functions aboard the missile into a single center. Normally, these computing functions are handled separately in the autopilot, the guidance equipment, the programming elements, and the communication system. Only with the development of practical, high-performance, micro-miniaturized digital computers can such a computing center be considered feasible. However, such computers must be properly designed to withstand the environmental vibration, acceleration, temperature, and pressure characteristics of a missile. Furthermore, their reliability must be substantially greater than that of their analog counterparts. When these conditions are met such micro-miniaturized missile computing centers can result in minimized size, weight, and power along with decreasing cost and increasing flexibility.

Dangers in Electronic Micro-miniaturization

In micro-miniaturization as in every other new science, care must be exercised to avoid going overboard and generating a fiasco. An example, where present manufacturing and service facilities make micro-miniaturization impractical, is shown in Fig. 2. There are many instances on record where whole programs were based upon elements which worked satisfactorily when built in model shop quantities and tested in the laboratory, but which were complete failures in the field. The transistor itself has a history of production difficulties when used in guided missile environments which had not been predicted on the basis of engineering models or small sample pilot runs. Thus, the first requirement of micro-miniaturization is a realistic appraisal of the micro-miniaturized components in production quantities under

field conditions. Other difficulties arise in a failure to take actual operating conditions into account in the initial design.

Other problems have been encountered because electronic engineers in designing their circuits neglected the effects of humidity on parallel impedances or the effects of electromagnetic pickup. There are undoubtedly many instances where it was felt that a very high impedance circuit could be used in a humid environment because the circuit was potted and its container was hermetically sealed. One example was that of a major change in system philosophy that had to be effected in a missile guidance system because signals detecting initial settings of flight path parameters obtained from the launch point countdown equipment had to go through an umbilical connector. In this particular case, despite the fact that the guidance equipment was hermetically sealed and the high impedance circuits potted, it was found that under humid conditions leakage resistance between two pins in the umbilical connector would render the missile performance totally unacceptable.

In micro-miniaturization, the engineer must be careful to properly include all of the auxiliary mechanical factors which often are more important for a successful operation of electronic equipment than the electronic design. Such mechanical factors vary from proper mounting of components to withstand vibration, through shock mounting and temperature controls of complete packages, to the effects of switching from prelaunch power supplies to missile power supplies.

Other factors which are basic to a successful micro-miniaturized design are the proper location of cold spots so that condensate does not wet electrical components and connections; the location of batteries containing acid so that the effects of an acid leak are minimized, or the placement of circuits of secondary importance (such as temperature controls) so that a short in such a circuit will not damage adjacent primary equipment. Of equal importance is to design the equipment so that test points are accessible and to package it in modules which can be removed for maintenance. Other dangers which may be encountered in the attempt to reduce size and weight are in designs which are so cramped or require so much skill in assembly that they are totally incapable of being produced in quantity.

Common areas of difficulty in estimating actual weight of newly conceived guidance and control equipment include such items which appear inconsequential in schematic diagrams—cables, junction boxes, shock mounts, brackets, heat exchangers, cooling systems, switching equipment, and primary power supplies.

Material presented in the above article was selected from Mr. Moore's remarks at the IRE National Convention, Mar. 19, 1957.

Overminiaturization?

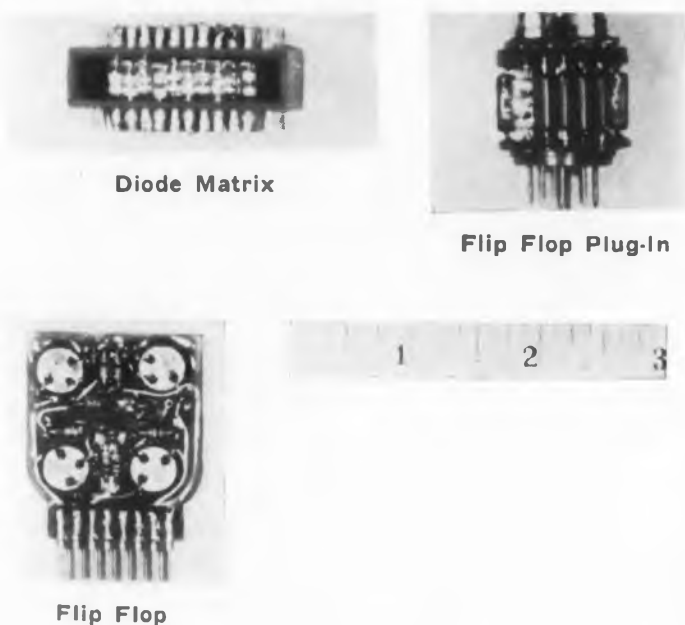


Fig. 2. Indicative of possible overminiaturization, these laboratory-built units are nevertheless workable, usable devices. Each has a drastic drawback, including excessive assembly skill, difficult package utilization, and poor thermal characteristics. The diode matrix has 100 diodes together with logical interconnections in 1-1/4 x 1-1/4 x 3/4 in. The flip-flop plug-in is a complete four-transistor unit in less than one cu in. with proven, high quality components. The flip-flop is also a complete four-transistor unit less than 0.8 cu in. in size, but minimum-size components have been used together with completely etched circuitry.



Watchmaking Techniques— Key To Micro-Miniaturization

W. A. Sterling, Operations Manager

Hamilton Watch Company
Allied Products Div.

MINIATURE is a term about which considerable confusion exists. It is often applied to a part or assembly which is just small. Even though small, it is not miniature if standard-size components are used and space utilization is not better than average. Actually, items of relatively large size can be genuine miniatures.

The concepts of miniaturization—the reduction to scale of size, weight, and cubic volume, while performance is held at the same or a higher level—is one with which the watch manufacturer has long lived. Within a generation, the size of watches made on a mass-production basis has been reduced with a scale factor of about fifty. The key term here, of course, is “mass-production.” The miniaturized part or assembly must, if it is to be of use to industry, be susceptible of fast, highly accurate reproduction by the hundreds of thousands.

Generally speaking, miniaturizations are of three types. There is miniaturization to a set, limited degree, which is governed by functional factors. There is pure miniaturization or micro-miniaturization in which assembly is reduced to the smallest possible size and bulk consonant with practical operation. Finally, there is the partial micro-miniaturization, in which some dimensions of an assembly are reduced without necessarily making the whole unit smaller.

Three examples, one of each type, which have actually been produced by the Hamilton Watch Company's Allied Products Division, will serve to illustrate.

Design engineers should find, in the base plate system described, many valuable ideas on machining techniques, tooling arrangements, and inspection methods, helpful in solving their own micro-miniaturization and mass-production problems.

Selective Micro-Miniaturization

Excellent as an example of the principle of limited or selective micro-miniaturization is the Raydist Position Indicator, whose computer element was micro-miniaturized.

The old computer was 12 in. wide, 8 in. high, and 6 in. deep, with two dials with a 2-3/4 in. track diameter. It was actuated by a collection of gears which required a fair amount of power. Specifications required a computer-indicator with two input shafts operating two dials which would continuously give distances from the two known-position transmitting stations. Only one input shaft indicates the exact distance to shore station. The other shaft indicates the *difference* in the distance of the receiver from two shore stations. Hence, a differential was required to add algebraically the revolutions of the two input shafts so that the second counter would register the actual distance to its respective shore station.

A further requirement was for an improved method of resetting the dials. The values on the dials change rapidly when the Raydist Position Indicator is in use, and with the old indicator a motor-

driven and time-consuming winding-through process was necessary in resetting the dials.

The new indicator, as designed by Hamilton, uses simple counters whose digital drums can be reset individually. This type of counter also offers the best torque characteristics.

Human Factors Limit Size. The actual size of the computer-indicator, and the degree of miniaturization, were limited by the dials. Since these had to be readily readable, the smallest dial size consistent with normal aircraft instrumentation policies—with a track diameter of 1-5/8 in.—was selected and the instrument built around them.

The final instrument cased measures 6-1/2 in. wide, 3-1/4 in. high, and 2 in. deep. Fig. 1 shows the old and new computers. Fig. 2 shows the high-precision gear train arrangement (backlash is less than one degree) in the new computer.

The combined computer, and the electronic com-



Fig. 1. Reduction in size of the Raydist Position Indicator is made possible primarily by use of watch-making techniques. Old Indicator is shown for comparison. Detailed requirements of micro-miniaturized computer-indicator are given in the text.

ponents in the redesigned micro-miniaturized Raydist Position Indicator have been reduced in weight by more than one-half, and there has been a 75 per cent reduction in space requirements. In addition, lower torque requirements have diminished the size and weight of the power source by 90 per cent. These considerable reductions have been accompanied by greater range, less lag, and a three-times improvement in accuracy over the old unit.

When there are no limiting factors—such as the dial size in the Raydist Position Indicator—such micro-miniaturization can be carried down to microscopic dimensions. The mass-production of extremely minute, high-precision gear train assemblies at Hamilton is essentially routine. Such assemblies, consisting of wheels and pinions mounted on base plates, are universally used in watch construction and in recent years their remarkable adaptability to other tiny mechanisms has been recognized, particularly for special control instrumentation in the electronic, electrical and electromechanical fields.

The manufacture of miniaturized gear trains by this system is a two-part, interrelated process—base plates on one hand and wheels-and-pinions on the other.

Base Plate—Key Element. Base plates are the accurately-made structural elements which mount the precise moving parts in a miniature gear train. In the base plate system, all rotating or moving parts are mounted on a single, precisely-made master plate and smaller sub-plates, themselves secured to the master plate, keep moving parts in accurate alignment.

Production begins with the die-stamping of a base plate blanked out of sheet stock, which is then ma-

chined to produce accurately parallel faces. After this, the blank is successively punched with carbide "shaving" dies which first trim the blank to the precise profile required and subsequently enlarge holes in the plate to exact diameters.

All carbide dies are of standard form, using carbide inserts pressed into a steel ring (Fig. 3). The use of carbide dies prevents dimensional distortion occurring when steel dies are heat-treated for hardening. Also, die-shaving permits the simultaneous production of many holes, all accurate in size and precisely located. Holes as small as 0.019 in. are produced by this die-shaving process. A striking proof of the precision in hole-size accuracy achieved by this die shaving technique is the fact that Hamilton can push-fit jewel bearings directly into the mounting plates. No hand-fitting of the bearing is necessary, and no special mountings are needed to secure the jewel bearing in the plate.

Two other highlights of the production process, largely responsible for the high precision of the base plates produced, are the method used for dimensioning and locating, and the inspection procedure used for quality control.

The conventions of coordinate dimensioning are simple and flexible. They consist of rules and forms adapting classical Cartesian coordinates to practical requirements of engineering drawings. On drawings the coordinate field is restricted to the first quadrant (Fig. 4) to eliminate negative values. However, by adapting this principle, all dimensions are given from a single reference point in terms of distances along two (x and y) rectangular coordinated axes to locate holes on a small part. This eliminates the pile-up of machining errors due to an accumulation of tolerances.

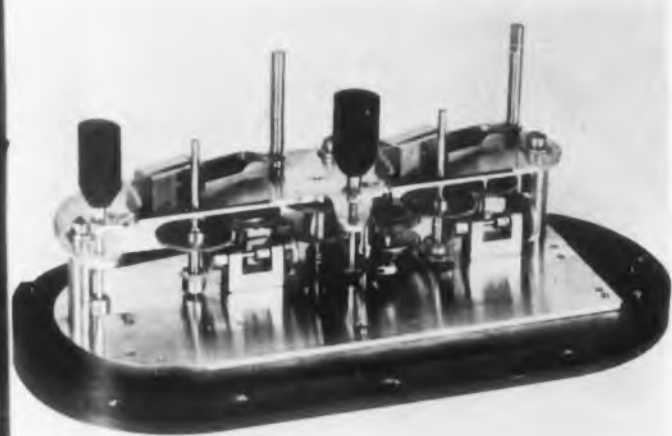
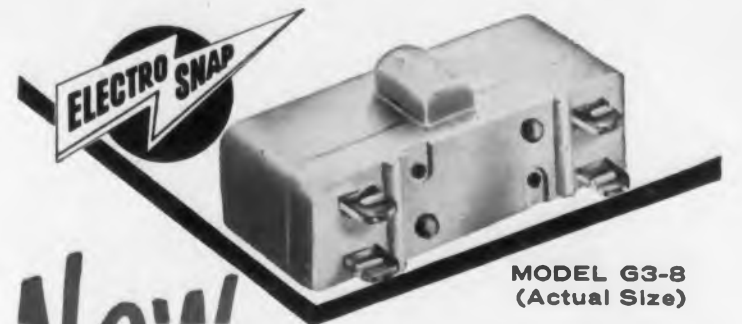


Fig. 2. Precision gear train arrangement in new computer. Gears are produced to watch-making precision. Backlash in this arrangement is held to less than one degree.



Fig. 3. Dies use carbide inserts pressed into a steel ring as shown. High accuracy results.



New 40 AMP. BASIC SWITCH is tiny; has high capacity

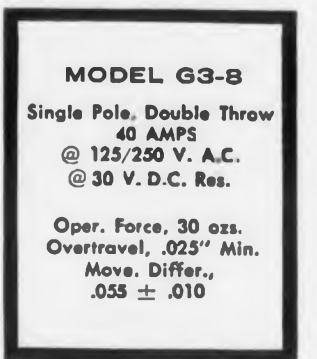
Measuring only $1\frac{3}{4}$ " x $\frac{43}{64}$ " x $\frac{43}{64}$ ", the new Electro-Snap G3-8 Basic Switch handles current ratings up to 40 amps. A new method of combining Electro-Snap's double-break action with a heavy-duty switching element assures electrical and mechanical life of 100,000 cycles at large capacities; also provides constant stability of tolerances and accurate repeatability.

New plastic compound case gives the switch an ambient temperature rating of -65° to $+300^{\circ}$ F. with extreme shock resistance. Small size makes it ideal for motor controls and compact automation setups. A wide range of actuators is available.

Write for details in Data Sheet GS-7.

ELECTRO-SNAP SWITCH & MFG. CO.

4216 W. LAKE ST., CHICAGO 24, ILLINOIS



Subminiature sealed switch

is environment-free; mounts

interchangeably with MS25085



MODEL EF-3

Single Pole, Double Throw
Move. Differential, .004 Max.
Overtravel, .003 Min.
Oper. Force, 5 to 17 oz.
Release Force, 60 gram
Elec. Life Ratings:
150,000 ops. @ 125/250 V. A.C.,
2.5 AMP.
100,000 ops. @ 125/250 V. A.C.,
5.0 AMP.
50,000 ops. @ 30 V. D.C.,
(2.5 AMP. IND.; 4.0 AMP. RES.)
Amb. Temp., -65° to $+180^{\circ}$ F.

Sealed in a corrosion-resistant, treated aluminum enclosure, this tiny switch is environment-free; highly vibration and shock resistant. It carries 5 amps. at 125/250 V.A.C. with an electrical life rating of 100,000 operations. Low operating force and small movement differential make it ideal for bi-metal temperature, diaphragm operated and other "feather-touch" devices, while small size permits mounting singly or ganged in restricted space. Rugged and dependable, it has positive snap action.

WRITE FOR DETAILS IN DATA SHEET ES-7



ELECTRO-SNAP
SWITCH & MFG. CO.
4216 W. LAKE ST., CHICAGO 24, ILLINOIS

CIRCLE 28 ON READER-SERVICE CARD FOR MORE INFORMATION



Micro-Miniaturization

Another important factor in eliminating errors in machining is the practice of making the base plate blank with attached tabs, also called lugs or ears. Accurate holes in these tabs permit precision positioning of the work in machining operations. Machining completed, the tabs are removed. A unique feature of the tabs is that they are outside the base plate itself. Hence, if any inaccuracy is present in the locating tabs, the error produced inside the plate is smaller. This principle helps substantially in holding machining operations to extremely close tolerances.

Microscopic Inspections. Practically every machining operation is immediately followed by an inspection operation to insure that tolerance limits are being kept. Many inspections are done either by optical projection to check profiles and locations of slots, recesses and holes, or by the use of a coordinate locator consisting of a high-powered microscope through which the work can be viewed while it is moved along either of two coordinated axes by high-precision calibrated screws, Fig. 5.

The bulk of the inspections, however, are performed by checking holes with specially designed "go and no-go" plug gages. These gages, made of

long-wearing but hard-to-machine carbide, are designed with the correct gage diameter over their entire length instead of tapering at the open end as conventional plug gages do. The untapered end permits accurate gaging of holes in thin plates, for which tapered-end gages are unreliable, Fig. 6.

Final Operations. The final operations are the removal of bumps and ridges with an automatic facing machine, shaving a layer of metal 0.003 in. thick from the faces of the plate; the insertion of jewel bearings in the proper holes in the plate; and rhodium plating to prevent a corrosion. The jewel bearings are inserted before plating, because the plating process causes tiny overhangs at the edges of the holes which would break the jewels if the plating were done first.

Wheels and Pinions. Correlative to plate manufacture in the base plate system is the wheels-and-pinions operation. The mass-production manufacture of wheels and pinions—the moving parts supported by the base plate—has been refined to the point where a great deal of it, in spite of the minuscule parts and of tolerances expressed in ten-thousandths of an inch, is automatic, on machines designed and built at Hamilton.

Standard parts in wheels-and-pinions manufacture may vary enormously in size. The center pinion of a marine chronometer, for instance is 1-3/4 in. in length by 0.250 in. in diameter. Parts of comparable size are used in the Raydist Position Indicator. A center pinion for a lady's 21-0 wristwatch is 3/16 in. by 0.050 in.

Actual fabrication in either case is essentially the same and equally precise. In the first step, a section of high-carbon drill rod is set in an automatic turning lathe, with Hamilton-designed cams and tooling, and turned down to size and shape, with tolerances of ± 0.0003 in. for length and ± 0.0002 in. for diameter. The part is then cleaned, inspected, and put on a pinion tooth milling machine. When the teeth are cut, the part is again cleaned and inspected by optical projection, at an enlargement of 100:1, for tooth conformation. It is then hardened, tumbled, tempered, cleaned, and polished on a leaf polishing machine. It is cleaned again, inspected, gaged, deburred, cleaned and the pivots burnished. It is cleaned again and the pivots gaged. This is followed by a final tumbling.

While pinions are made of hard burnished steel, because of the torque demands on them, wheels are made for the most part of brass. The bearing of brass wheels upon the steel pinions burnishes the bearing surfaces of the wheels and supplies the best wear characteristics with the least friction.

A wheel to fit the center pinion of the 21-0 watch is first blanked from brass strip stock, 0.0075 in. thick by 0.310 in. wide. It is pierced, cleaned, gaged and stacked in an arbor for feeding into a milling or hobbing machine which forms teeth. Teeth and outside diameter are then inspected, the part is cleaned and tooth shape is checked by optical projection. The center hole is bored to fit the pinion and establish concentricity, and the part is

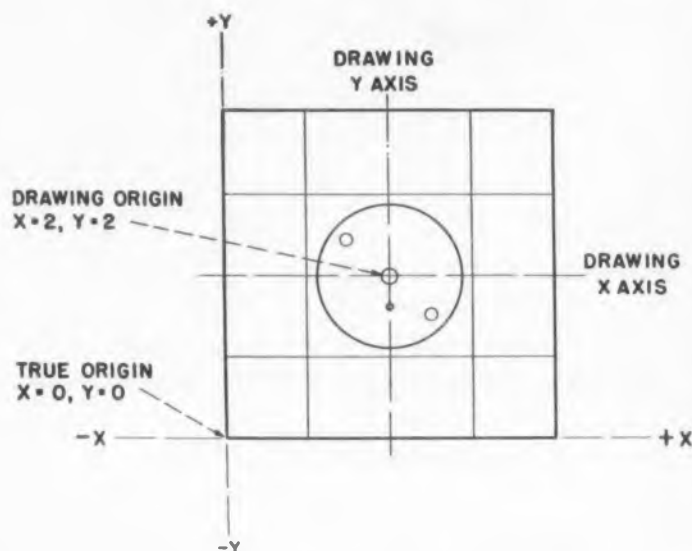


Fig. 4. On drawings, by restricting the cartesian-coordinate field to the first quadrant, all dimensions are based on a single reference point. This prevents compounding machining errors.



Fig. 5. This machine has its own built-in microscopic inspection device for close, accurate tolerances.



Fig. 6. Special "go-no-go" plug gage developed by Hamilton to assure close tolerances in holes.



Fig. 7. Typical of products possible with watchmaking techniques is this motor armature, slightly smaller than the head of a match.

cleaned, tumbled and cleaned. To protect it from oxidization, the wheel is plated with 24 carat gold and given a final inspection.

The next step is the assembly of pinion and wheel. The wheel is pressed on the pinion at a staking stand and then crimp-riveted to the pinion. The assembly is then cleaned and the wheel checked for concentricity and trued on an optical comparator. Final cleaning and inspection follow.

Complete Micro-Miniaturization

Here is an example of micro-miniaturization in its purest form—reducing an assembly to the absolute minimum in weight and bulk while maintaining its ability to perform its rated job without any loss whatsoever in efficiency.

The motor developed at Hamilton was originally designed for an experimental periodic-rewinding watch. It is probably the world's smallest electric motor and is certainly the tiniest practical motor which can be made on a mass-production basis—a factor which brings its unit cost below three dollars. The minuscule size of the motor is indicated by the fact that its rotor assembly is slightly smaller than the head of an ordinary paper match, Fig. 7. The entire motor will fit inside the ferrule of an ordinary lead pencil.

Development specifications on the project called for a miniature, wound-rotor, permanent magnetic field, dc electric motor to be built within the confines of a space 0.250 x 0.250 x 0.200 in. A number of possible designs were considered and many materials, for magnets, coils, bearings, brushes, commutator, etc., were tested. A first, practical unit was built in a rectangular case. Several faults were apparent, notably inability to self-start from all angular positions of the armature—owing to lack of torque—and an unsatisfactory alignment of the armature in the air-gap.

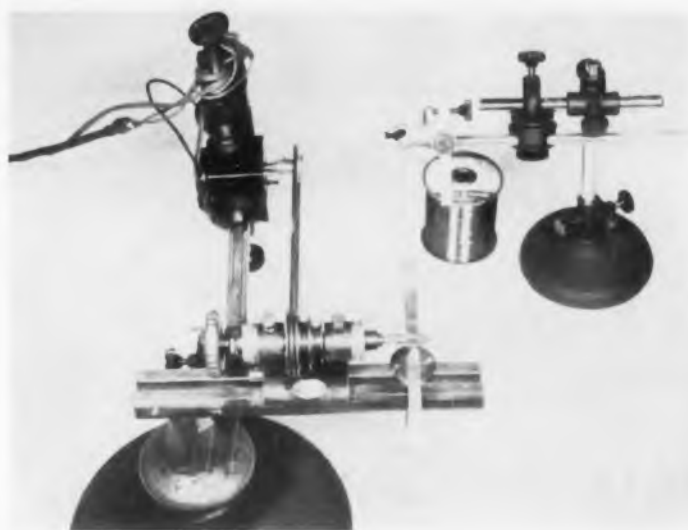


Fig. 8. Machine for winding armature shown in Fig. 7. Adapted watchmaker's lathe is employed. Wire is almost invisible to the naked eye.

These difficulties were analyzed and eliminated by redesign, which included the substitution of a cylindrical form for the previous rectangular one. Several changes in material were made to increase wear-resistance, and a second motor was built.

This second model is practical for mass production and, given the necessary experience and know-how, easy to assemble. It has a rated output of three mph, operating on an eight ma subminiature mercury battery. It has been run for more than two hundred hours. In one instance it was run for eight hours on twice its rated voltage, with no evidence of over-heating.

The rotor assembly consists of the shaft, the commutator—to which the coil leads are soldered—and the armature. The armature is wound with six coils of 0.001 in. copper wire. This winding was done in a routine manner by using a watchmaker's lathe with a low-speed motor, Fig. 8.

Partial Micro-Miniaturization

The Problem: Illustrated here is the miniaturization of certain dimensions only, on a standard assembly—in this case a thermocouple. It resulted from a dilemma encountered by a committee of the American Society for Testing Materials, which was running tests on waxes at elevated temperatures. When specimens of these waxes were placed in a refractometer for index of refraction readings at from 100 to 154 F, there was a variable—on the same specimen and even when the tests were run by the same person.

The heat source and the thermocouple which registered the temperature were both mounted on the outside of the split prism of the refractometer. The committee members reasoned that the variable might be resulting from the fact that the temperature being registered on the outside of the prism was not the same as that at the center where the

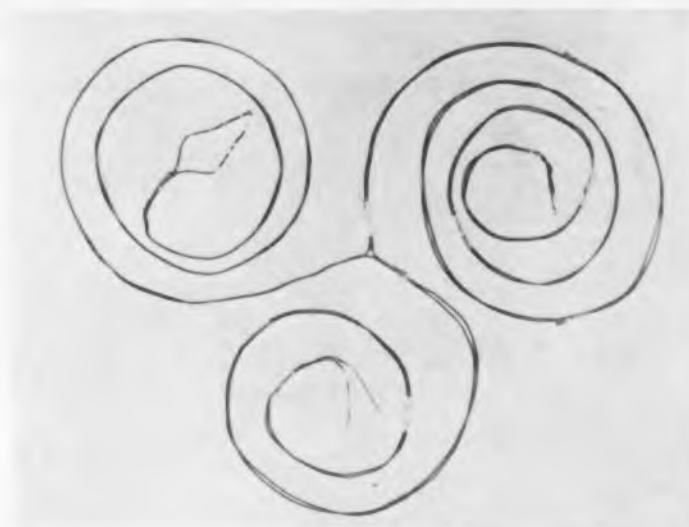


Fig. 9. Thermocouple produced by Hamilton in which the copper and constantan dissimilar elements were rolled into ribbons 0.001 in. thick in a machine designed to make watch springs.

specimens were located. The solution to this, they decided, was to introduce a thermocouple between the halves of the prism in the same plant as the specimens. The question was—how?

The Approach: The thinnest thermocouple wire is 0.020 in. in diameter, and the space between the two halves of the prism was 0.0025 in. To get a thermocouple into this area posed two problems: having the wire precisely rolled to a thinness of less than 0.0025 in. and joining the two dissimilar metals without an increase in the thickness of the assembly at the joint and without burning up the metal. This, then, was the problem.

The solution: Engineers at the Allied Products Div. of Hamilton had the answer to both problems, since the fabrication required is common practice in both watchmaking and micro-miniaturization techniques. The thermocouple produced by Hamilton was standard in all respects except that its wires—copper and constantan—had been rolled into a ribbon 0.001 in. thick on a miniature rolling mill normally used to roll watch hair-springs. The hot junction was made with miniature spot welding equipment without increasing the over-all thickness. The result was an assembly of ordinary dimensions except at the point where miniaturization was required, Fig. 9.

The three examples cited are merely isolated cases used to illustrate different types of micro-miniaturization. The variety of such miniaturizations possible through the application of watchmaking techniques, equipment and experience, is almost limitless. And as critical tolerances become more and more essential in both military and industrial products, and the use of new metals raises problems in fabrication and assembly, the techniques of watchmaking become increasingly important in producing mechanical parts and assemblies whose degree of miniaturization corresponds to that of electronic components.



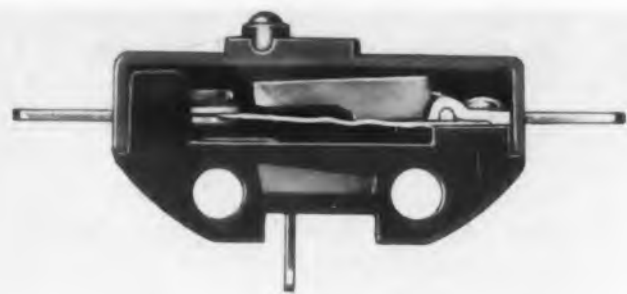
Miniaturization in Precision Switching

Precision Switches

Along with greater demands, especially by the military, for increased ruggedness and reliability of precision switches, is the cry to "make them smaller." We have seen work in this direction by a number of manufacturers. How far they can go in "micro-miniaturizing" them cannot yet be answered. However, the accompanying article is an example of how such a manufacturer is meeting requirements put to it. The switch described was developed by Haydon Switch Inc., to meet a specific military requirement. It undoubtedly is not the ultimate in smallness, and it may not be "micro-miniature," but it further illustrates the trend toward "thinking small."

INCREASING demands for positive switch operation under environmental extremes continually present new design problems. Complicated, electrical and electronic equipment compressed by modern scientific requirements into tighter and smaller enclosures continually taxes design and development engineers. The functional requirements of this equipment increase along with the need for making it smaller. How far can this progression to miniaturization with increased product dependability and function go?

Specifications recently proposed required two precision snap switches to be enclosed in a 1 in. diam. can with a waffle finger activator between



Cut-away of Haydon Miniaturized (5304) switch.

the switches. The switches had to be designed so that they could be ganged to fit into a 1 in. tube containing two or up to two hundred units complete with three contacts and necessary space for wiring.

Other specifications were: minimum contact gap 0.015 in.; operating force 20 oz max; resistive 28 v dc, 5 am load; 400 cps, 110 v ac, 5 amp load; life at rated load to be 100,000 activations; ambient temperature range -65 to +300 F.

The case selected for this switch was of glass-alkyd. This gave maximum dimensional stability, least trouble under environmental extremes, and produced the smallest precision snap switch which would meet all the required specifications.

Switch blades are one piece, and of heavy duty, Beryllium copper. Silver contacts are welded in position on the blades to give a true snap make-and-break with 20 per cent higher contact pressures at any point of activation than similar prototype switches.

A number of advantages and uses for this new switch came to light in the process of its development. One distinct advantage of the attempt toward greater miniaturization was the elimination of all non essentials, while at the same time resulting in a more functional product.



Two precision switches in a 1 in. diam case.

Micro-Miniature Inductors



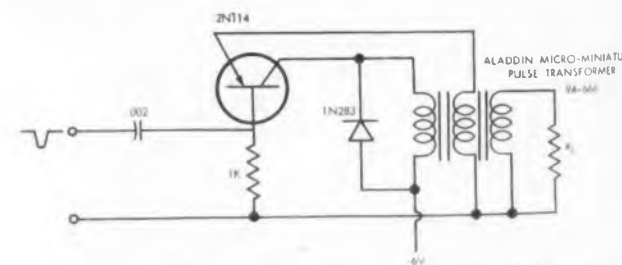
Transformers

In circuits employing transistors, transformer size reduction is often limited by techniques for winding and handling the coils and leads in production. The watch industry has apparently been most successful to date in winding microscopically small wire into micro-miniature coils. However, here is an example of a truly small pulse transformer developed by a non-watchmaker. Other manufacturers may be "geared" to make equally small and precise equipment; but, this demonstrates that practical micro-miniaturization is probably not far off.

A LINE of pulse transformers, little larger than the eraser on a pencil, is manufactured by Aladdin Industries of Nashville, Tenn. They are also in production on micro-miniature ferrite cored inductors.

Although the units were designed to a smaller size with usage in transistorized circuits such as that shown, as a primary objective, it is of interest to note that the reduction in size has benefitted several parameters. Both the leakage inductance and the distributed capacitance have decreased due to the smaller size; this in turn has led to faster rise times in the pulse transformers. Rise times as fast as 0.015 μ sec can be attained and pulse width durations of 50 μ sec are available. In the inductor line it has been possible to obtain as much as 1 H from one of the micro-miniature units.

Many interesting production problems have been encountered in manufacturing these miniature components. With wire sizes running as small as 48 AWG it can be a problem merely to locate the lead wires. Many of the operations have been performed under the magnifying glass, and in several instances special lighting has been used to assist in locating the leads. Closer control of the manufacturing processes has become essential due primarily to the smaller size of the components.



Typical circuit application for micro-miniature pulse transformer—a triggered transistor blocking oscillator. This unit will produce an output pulse of 10 μ sec duration. Other transformers are already available that will produce pulse widths of from 0.5 to 50 μ sec.



Courtesy,
Amphenol

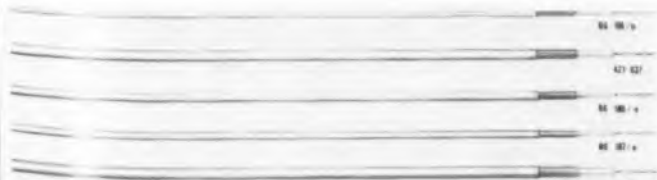
Connectors

AMPHENOL'S concern with the necessary trend toward micro-miniaturization is well expressed in these words by Ray E. King, product manager of their Specialty Connector Division, in a recent issue of *Amphenol Engineering News*. "Miniaturization of electronic equipment has not only taxed the ingenuity of design engineers but has also posed a challenge to electronic component manufacturers. Before the equipment design engineers can achieve miniaturization, smaller components must be built. In the field of connector manufacturing the design engineer is confronted with such problems as maintaining an adequate current rating in the face of a reduction in the cross-sectional area of the contact. He also has the problem of a reduction in voltage rating as he tries to move contacts closer together. The plastic mold engineer also has his problems and is confronted with the necessity of working out new molding techniques caused by the smaller and more intricate plastic insert blanks." He also points out that it is necessary to achieve "miniaturization with reliability."

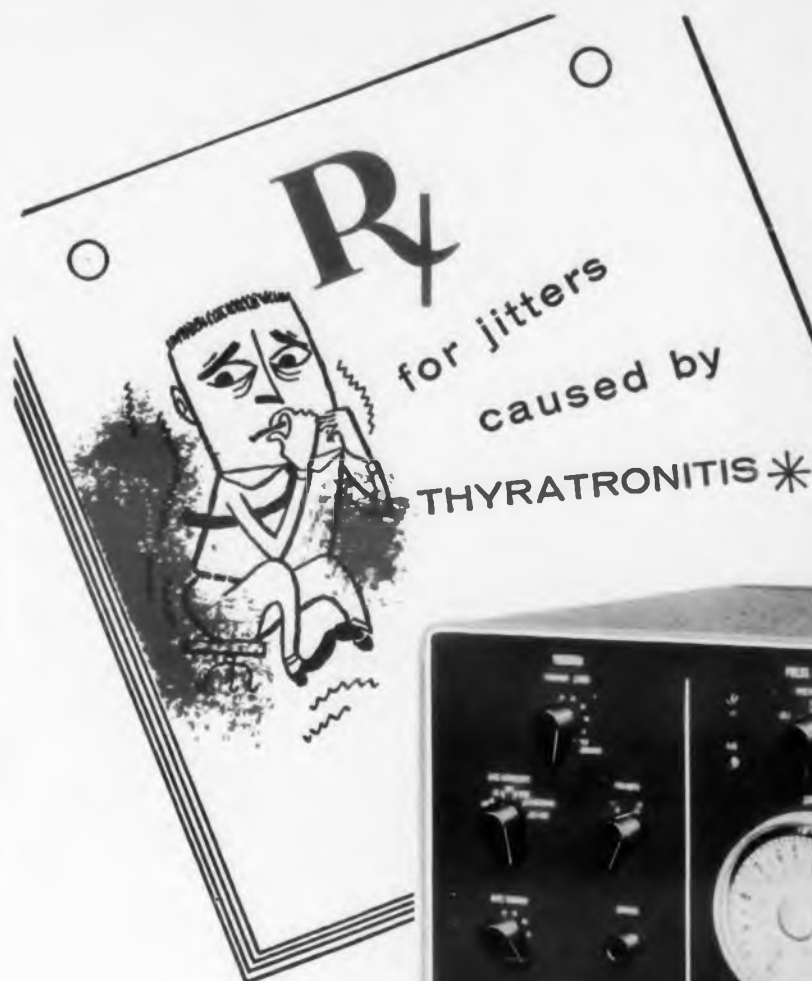
Cadmium bronze is making its debut as a contact material in new miniature connectors. This material provides a greater conductivity than any contact material previously used and will allow a working current up to 5 amp. Gold over silver plating is used for easier soldering and increased shelf life.

Transmission Lines

AS TRANSMISSION lines get smaller and smaller, not only is their uniform manufacture more difficult, but installation problems mount, in spite of demands for improvement. Reliability, is likely to decrease exponentially as size decreases. Reliability also depends upon installation as well as cable fabrication. Cable fasteners must avoid pinching the cable; connectors must be compatible; automatic cable-to-connector assembly techniques will be required to avoid damage on assembly. There will be other problems.



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Repetition Rate: 100,000 PPS to single pulse with either positive or negative polarity



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Trigger Output: 25 volts, 50 ohms, 50 ohm load, 100 μ sec, 100 μ sec, 100 μ sec, 100 μ sec, 100 μ sec, 100 μ sec.

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* **DEFINITION**: A common ailment of an hereditary nature, common to certain species of pulse generators. **Symptoms**: bumps, squiggles, and twitches in pulse. **Cause**: nervous triggering of pulse due to too much hydrogen in thyratron (or something like that).

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Thin Leaf Design Improves

Micro-Miniature Relay Contacts

Relays

Akin to work on coils and transformers is work on small relays. Again, the watchmaking industry has pioneered the way to producing a microscopically small device for micro-miniature equipment applications. The MV relay of the Elgin National Watch Co. is one such device. Described here is one aspect of the design problems encountered in developing this component.

THE physical design and material from which relay contacts are made, in the final analysis, determine just how well they're going to do the job of carrying current and voltage at rated loads under extreme specifications of vibration, shock, temperature, etc., as well as how well they minimize the effects of wear and electrical erosion.

In the new Elgin MV relay, which is the size of a postage stamp and about as thick as a cigarette, engineers have utilized a unique spring leaf design of the contacts to attain high vibration performance in this micro-miniature component.

Silver-Magnesium-Nickel, which has excellent spring properties, as well as high thermal and electrical conductivity, constitutes the entire spring material used. This aids in maintaining a desirable contact pressure and produces a significant wiping or relative motion between the co-acting parts.

With this combination of pressure and wipe a

successful absorption of the impact energy is obtained when contacts are engaged as well as good clamping of any relative motion between contacts, thus eliminating bounce and failure during vibration and shock.

The wiping action also provides self-cleaning necessary in keeping contact resistance low and stable, especially when they are used in dry circuit applications.

The inherent spring qualities of the new material permits the elimination of heavy, bulky contact buttons, thus improving vibration qualities, as well as mechanical wear. At the same time, the thin spring design provides excellent heat dissipation necessary for minimizing electrical erosion.

The *normally closed* contacts are self-loaded and require no actuating means to maintain the contact pressure. The relay armature is entirely removed from intimate contact with the moveable blade in the normally closed position, thus improving vibration resistance.

Contact gap is kept greater than that needed to effectively quench the electrical arc when high currents are carried.

Recent tests show gold contacts improve the relay's performance in dry circuit work, yet do not destroy any of the performance characteristics in standard and military applications.



Precision alignment of the tiny fixed contacts in Elgin's new MV series relays is obtained by using an optional comparator with reticle, an apparatus used by the watch firm in the mounting of hairsprings—the delicate heart of a watch balance system.

Inside the comparator, the reticle—a scale drawing on glass—consists of an elongated square with cross lines bisecting it vertically and horizontally. The operator inserts the relay's header in a special fixture which positions it under the comparator and mounts the fixed contact blades to header posts. By aligning the contacts on each side of the reticle, they are placed in precisely the correct position when soldering.

Soldering is accomplished using resistance welding techniques, which prohibit scoring of the thin spring leaf contact blades made of silver, magnesium, and nickel.



Air Magic: The tiny contact screw with 180 threads to the inch (it takes about 8,000 of them to fill a thimble) is placed in the bushing through use of a watch industry vacuum screwdriver which holds the screw by suction permitting operator to set the screw without damaging threads. A mistake in this operation costs a nearly completed unit.



Resistance Soldering. Tiny wire leads from coil in Elgin's MV series relay are soldered in this special fixture using resistance welding technique. Operator touches foot pedal to activate current which is conducted through carbon soldering iron. Heat is set up at exact point of soldering which prevents damage to coil insulation or fine wire. Fixture revolves so that both leads can be soldered.



Watchmaking precision. Delicate watchmaking dexterity is required in the assembly of the relay armature to the relay body. Tweezers point to threaded adjusting nut (slightly larger than a pinhead) which holds contact blade and shunt to the armature only 3/8 in. long. In immediate foreground is minute spring and adjusting screw which is anchored to the top frame and permanently bonded after proper tension is acquired. The adjusting nut is tightened onto banking pin (term carried over from the watch industry) which runs through the armature and serves as a brake to prevent contact blade from jumping out of action.



Fig. 1. A single stage transistor amplifier no larger than a pencil eraser.

Tiny Transistor-Amplifier

TWENTY-ONE db of voltage gain at 1 kc has been squeezed by Centralab into a transistor amplifier package with a volume of less than .013 cu. in. This ultra-miniature, high-gain audio amplifier stage is about the size of the eraser on the end of a common lead pencil. It is intended for use in hearing aids, pocket-size radios or recorders, pre-amplifiers, and wherever the space factor is an important consideration.

By completely new processes developed by Centralab, 900 E. Keefe Ave., Milwaukee, Wisconsin, transistors are combined with resistors, capacitors and wiring in a single package. The amplifier illustrated here draws only 0.5 ma from a 1.3 v mercury cell and has a frequency response from 250 to 20,000 cps. Noise output is held to less than 1/2 mv.

The amplifier, which may be modified at the factory for special applications has a nominal input impedance of 1000 ohms and will drive a load from 500 to 1500 ohms.

In addition to the space saving feature, there is an economy feature. Savings in costly wiring labor, effected by reducing soldering connections from 11 to 4, are accomplished by use of these amplifier stages in place of conventional ones.

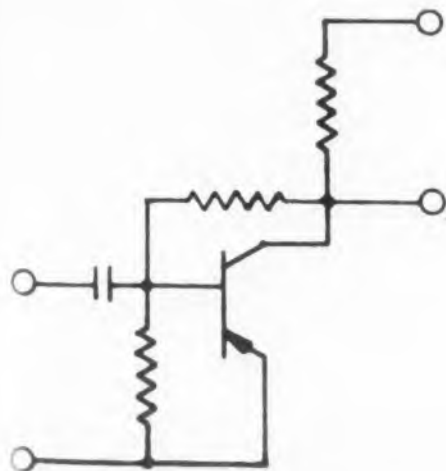


Fig. 2. Circuit of the transistor amplifier.



Airtron inc.

ferrite advances add new chapters to the microwave art

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Airtron, Inc. has been a leading contributor to the extension of the microwave state of the art. It has been Airtron who has written in the **new chapters** on ferrite components and material, double ridge waveguides, and high powered, miniature ferrite and non-ferrite microwave components, to the standard texts that are the only reference source for engineers and users of microwave equipment.

Industry's pressing need for non-reciprocating

microwave components demanded applications for which there was no readily available theory, or reference source. With Airtron, Inc. it has been the application of **practical theory** that has **stamped solved** many of these new microwave **ferrite design problems**. The end results have been quality production items — some of which are in use today in every weather radar system — electronic devices operating with ferrite components — miniature ferrite isolators and duplexers — high powered ferrite components and special designs still under the wraps of security.

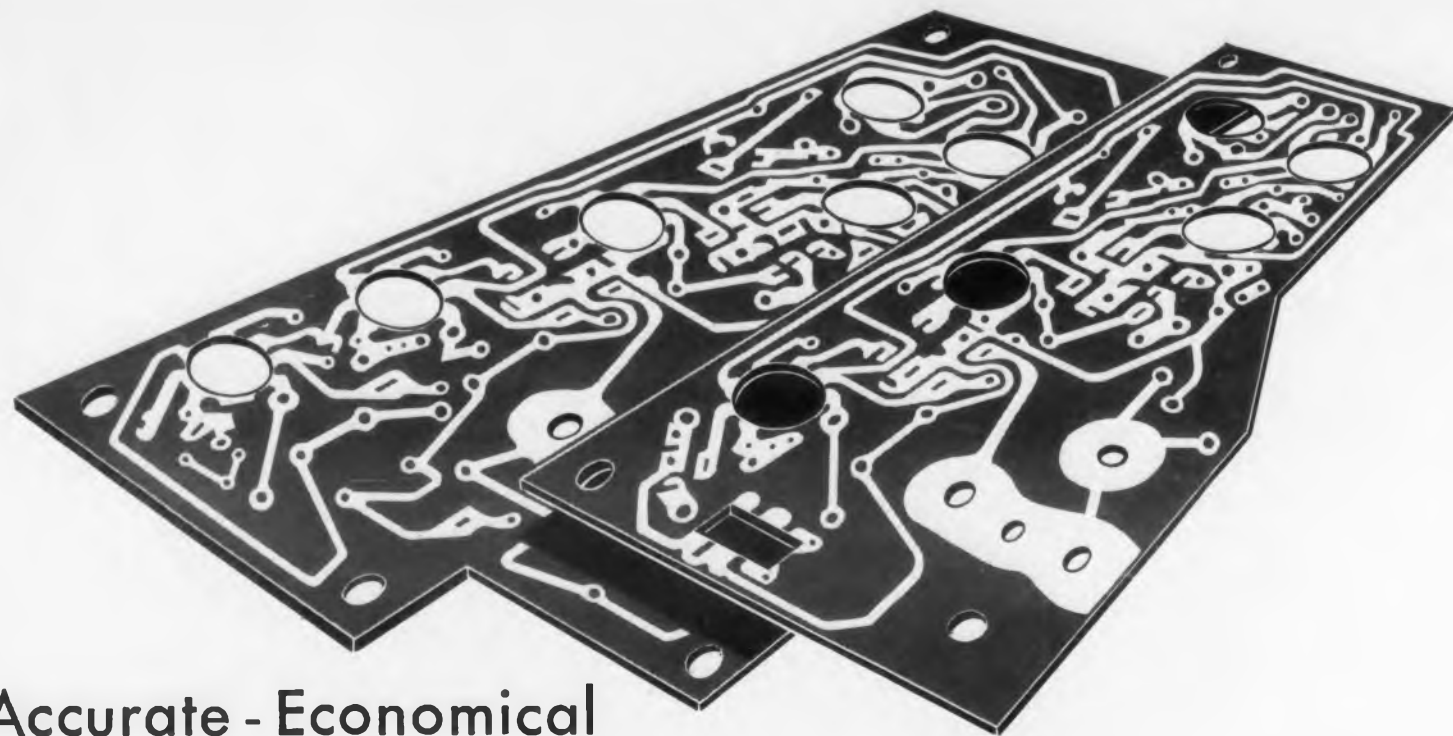
Today — there is only ONE organization which can offer you the complete range of microwave engineering and equipment . . . only one company which can point to the advances of the past decade in the microwave and ferrite art as being almost wholly its own . . . This is Airtron, Inc. creative leaders in the Microwave Art.

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CHARACTERISTIC PROPERTIES

(Values shown are average)

	Cold punch XT-896 After Copper- clad etching	Hot punch T-725 After Copper- clad etching	Hot punch T-812 After Copper- clad etching
Thickness tested	1/16"	1/16"	1/16"
Water absorption	0.46%	0.40%	0.53%
*Power factor	0.027	0.030	0.029
**Power factor D/24/23	0.033	0.031	0.031
*Dielectric constant	3.71	4.2	4.5
**Dielectric constant D/24/23	3.86	4.3	4.6
*Loss factor	0.102	0.126	0.131
**Loss factor D/24/23	0.127	0.134	0.142
Insulation resistance Megohms C/96/40/90†	1,000,000	125,000	290,000
Flexural strength Lengthwise Crosswise	14,000 12,000	19,000 15,000	19,500 15,500
Bond strength lbs/in Copper to laminate	7	8	8
Blister resistance Seconds at 450°F.	15	20	18

*Room conditions 50% RH @ 23°C.

**After immersion in water for 24 hours at 23°C.

†After conditioning for 96 hours at 40°C at 90% relative humidity.



Equipment Design

The Vanishing He

ONE of the major electronic industries, to which credit must go for hastening micro-miniaturization is the hearing aid industry. Urged on by resistance on the part of the user to unsightly gadgets, heavy batteries, tangled "hook-ups," etc., the hearing aid engineers have pushed on toward the development of a "sightless," "weightless," low cost aid to the hard of hearing. Other designers can use the components and techniques they have developed to satisfy the military requirements for gear many times smaller than "standard."

Here is an example of how things got smaller, yet more reliable, for the hard of hearing.

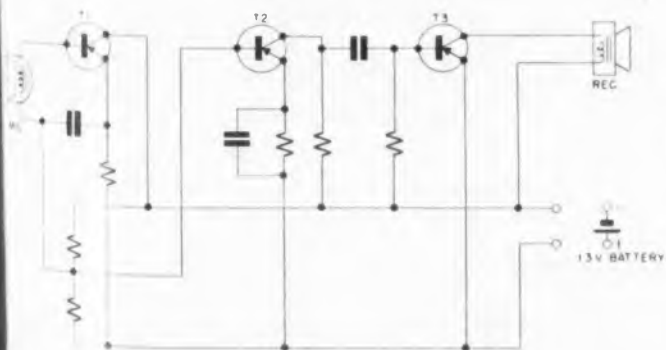


In-the-ear hearing aid. (Top) components mounted on chassis, including three transistors; (Center) for comparison, a nickel; (Lower) chassis without components. Courtesy, Sonotone Corp., Elmsford, N.Y.

ng Hearing Aid



Note the difference between a new Sonotone hearing aid worn entirely in the ear—and a hearing aid of only 12 years ago. The 1945 model (right) weighed 20 oz as worn. The large transmitter was worn on the body, and a thick cord led to a receiver in the ear. External batteries were strapped to the body or legs and connected to the transmitter by another cord. The new aid (left) is 40 times lighter. It weighs only half an ounce with battery.



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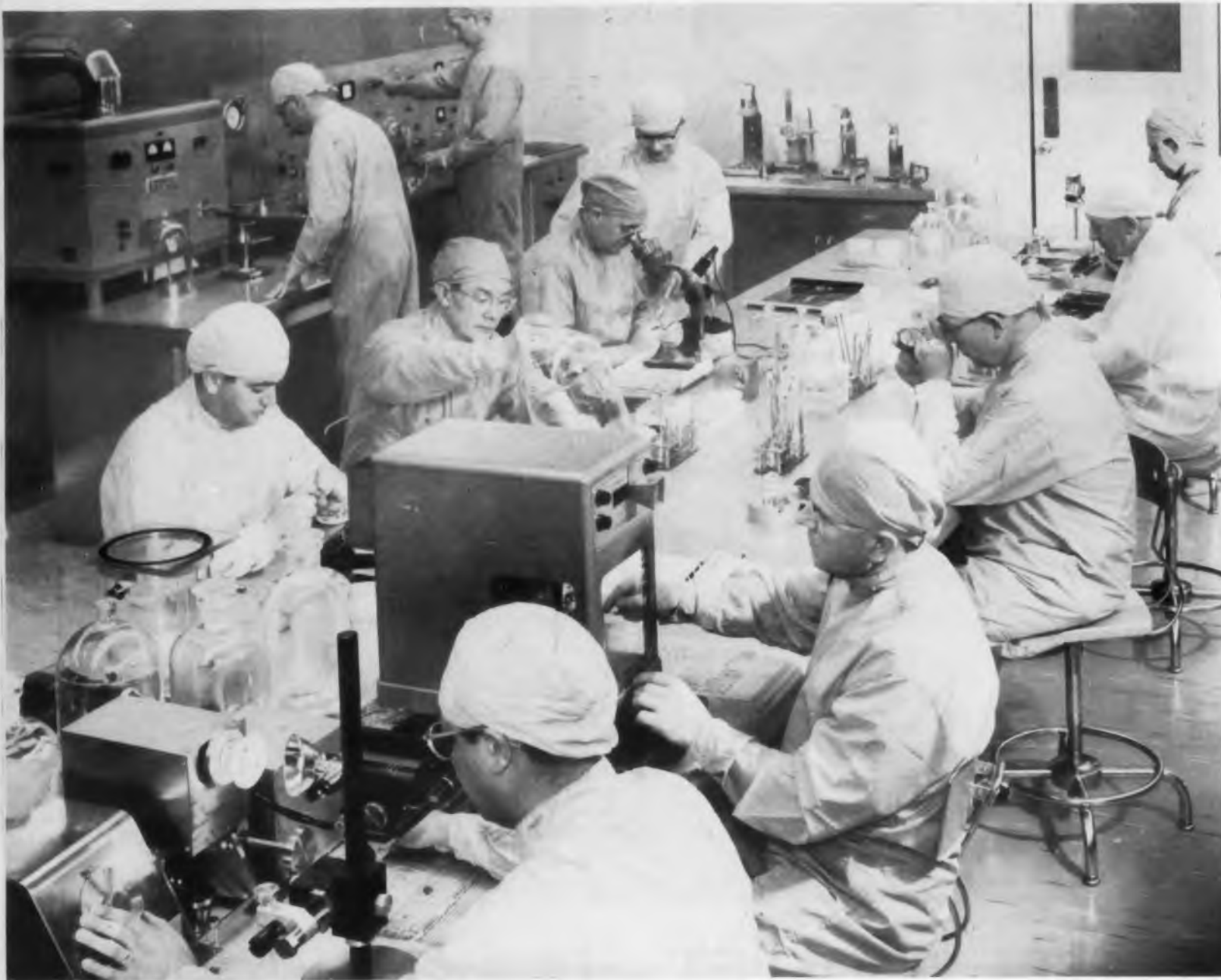
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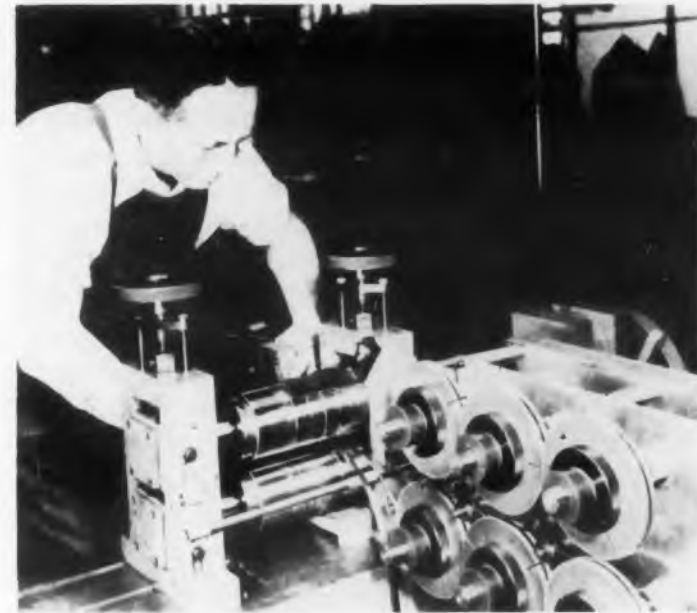
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Thickness of ultra-thin precision-thickness metal strip being measured on dial gage which reads ten-thousandths of an inch.

Editors Note: Use of conductance curves¹ for designing electronic circuits has been the subject of many articles by Mr. Pullen. In this article he points out some interesting conduction ratios which can be used in the design of oscillators. Part I investigates vacuum tube oscillators. Part II which will appear in the July 15th issue, extends the techniques to a variety of transistor oscillators. In an appendix to Part I Mr. Pullen discusses oscillators from a "Necessary for Operation" point of view. For a free reprint of this article, turn to the Reader Service Card and circle 400.

Design of Oscillators—I

Keats A. Pullen, Jr.

Ballistic Research Laboratories
Aberdeen Proving Ground, Maryland

WHEN conductance values are used to analyze an oscillator, the loading effect of resistors, capacitors and inductors in the circuit can be easily determined. Excellent treatments of the basic oscillator circuits are available but there does not appear to be an adequate analysis of the principles in terms of practical problems of design. By using conductance curves, the active device (tube, transistor or similar device) is coordinated with the balance of the circuit. Techniques presented for the design of oscillators are approached from a small-signal point of view with emphasis on sinusoidal oscillators.

Amplifier-Type Oscillators

A major share of the oscillators producing sinusoidal outputs fall into the general category of amplifier-type oscillators. These oscillators have a circuit to feed back some of the output energy into the input of the active device to create the required negative resistance. A study of these oscillators could be based on the equivalent negative immitance characteristic, but practical design has indicated that they can be better analyzed as amplifiers.

The three most important conditions which must exist in an amplifier-type oscillator are *first*, an amplifier capable of providing sufficient loop gain to overcome losses in the coupled circuits, *second*,

a coupled circuit providing a feedback path to the input of the amplifier which will pass only the desired frequency band and at the same time have the required phase characteristics to permit oscillation, and *third*, provision for automatically adjusting overall amplification as a function of amplitude of oscillation to provide a stable output. Normally, the first and the third conditions are provided by the amplifier. The second condition is dependant primarily on the passive or coupled circuit.

An amplifier for use with the oscillator must be designed to perform two functions: amplification, and regulation. The non-linearity inherent in amplifiers fortunately makes them naturally suited for the regulation function. For an oscillator to start oscillating, it is necessary that the initial amplification be more than enough to maintain oscillation. Overall loop gain must be greater than unity for such a condition to exist. If the amplifier can be designed so that loop gain decreases as the amplitude increases, the condition for stable oscillation can, but does not have to, exist in the amplifier.

What is the loop gain of an oscillator? To determine loop gain, it is necessary to open the feedback circuit and determine the ratio of output to input voltage at the division point (Fig. 2). All operating conditions must be exactly the same as with the circuit closed.

Reduction of amplification because of an increase in the amplitude of oscillation is usually accomplished in one of two ways (with transistor oscillators it is frequently a combination of the two). The first way is by shifting the static operating conditions of the amplifier. This method of control is used with most vacuum tube oscillators. Rectification of the input signal is used to change the fixed bias. The second method makes use of the variation of transconductance with bias for a fixed static operating condition. For a reduction of average amplification with amplitude to develop, the effective transconductance for positive signals must rise more slowly than it decreases for negative signals. When the operating frequency is low enough, cathode degeneration can be used to limit maximum amplification and thereby improve amplitude limiting. The average amplification of a circuit is determined from the equation:

$$K_a = (K_p + 2K_s + K_n)/4 \quad (1)$$

If loss in the feedback circuit is constant, Eq. 1 can be used for estimating the average forward amplification and loop gain of the active element. When the loss is not constant, each of the amplifications, K_a , K_p , K_s , and K_n must be replaced with the corresponding product $(KK_f)_a$, etc. to obtain the average loop amplification. (The subscripts a iden-

ifies the average value, p the value at most positive grid bias, s at static bias, and n at the most negative bias.) In either case, the average loop gain $(KK_f)_a$ is unity for the final operating condition. If the oscillator is self pulsing (it squegs), then the average amplification over the squegging cycle is unity. If, however, the output is an unmodulated carrier, then the loop gain is unity when averaged over each individual cycle. Even with multivibrators and blocking oscillators average loop amplification over the full basic operating cycle is unity.

Load Lines

Techniques for determining the load lines have been discussed many times in the electronic literature. A static load line is determined and plotted if required, and a family of dynamic load lines selected. The ratio of transformation from plate to grid is determined to help approximate the effect of grid loading. An estimate of the equivalent loading resistance at the grid is 1000 ohms. This resistance is transformed back to the plate circuit and included in the load impedance for the tube.

The ratio of transformation required in the coupling circuit, between the output and the input circuit, has a minimum value which is directly related to the maximum forward gain available in the active device. The minimum value of K_f may be found from the equation:

$$K_f = g_p/g_m \text{ (for triode tubes)} \quad (2)$$

$$K_f = g_{oe}/g_{fe} \text{ (for transistors)}$$

Where K_f is feed back gain; g_p is plate conductance ($1/Y_p$) and g_m is transconductance. The actual value of K_f will be some what larger than given by Eq. 2, and can be found from the equation:

$$K_a K_f = 1 = K_f g_{ma} R_{LD} \quad (3)$$

Where g_{ma} is the average effective transconductance, and R_{LD} is the load impedance.

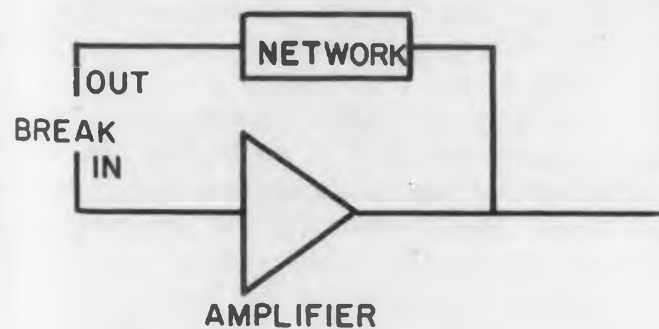


Fig. 1. Loop gain of the oscillator is equal to the ratio of output to input voltage at breakpoint.

The General Oscillator

The general oscillator has been discussed rather thoroughly in the electronics literature, particularly in its linearized form. Its equivalent circuit is shown in Fig. 3. An important fact which appears to have been neglected in these discussions is expressed in the following equations:

$$\begin{array}{l} \text{Triode Tubes} \qquad \qquad \text{Transistors} \\ g_p R_{LD} < 1 \qquad \text{or} \qquad g_{oe} R_{LD} < 1 \text{ and} \\ g_c (n_c/n_p)^2 R_{LD} < 1 \text{ or} \qquad g_{ie} (n_i/n_o)^2 R_{LD} < 1 \end{array} \quad (4a)$$

Where n_c/n_p and n_i/n_o are the impedance ratios from input to output with tube and transistor circuits respectively, and R_{LD} is the output load impedance at operating frequency. Voltage feedback may be written as $K_f = n_c/n_p$, with the result that the equations may be rewritten as:

$$\begin{array}{l} g_p R_{LD} < 1 \qquad \text{or} \qquad g_{oe} R_{LD} < 1 \\ g_c K_f^2 R_{LD} < 1 \text{ or} \qquad g_{ie} K_f^2 R_{LD} < 1 \end{array} \quad (4b)$$

When equations (4a) and (4b) are fulfilled, loading of the active device on the frequency controlling circuit can be neglected and stability will be as good as the circuit itself will permit. The usual equations used with the general oscillator may be generalized to include non-linear properties by replacing the μ with either the ratio g_m/g_p or g_{fe}/g_{oe} as required.

Magnetic Coupled Oscillators

Magnetic coupled oscillators, Fig. 4, can be designed in a very similar manner to that used for the general oscillator. Since at least one additional variable is available with this form of oscillator, namely, the magnetic coupling, greater flexibility is available. As long as coupling between the two coils is kept below the critical value, the ratio of the turns may be traded for coupling factor to obtain an optimum design. Normally, the input coil is adjusted to have a reactance somewhat below the grid input impedance. Coupling is then adjusted to provide oscillation.

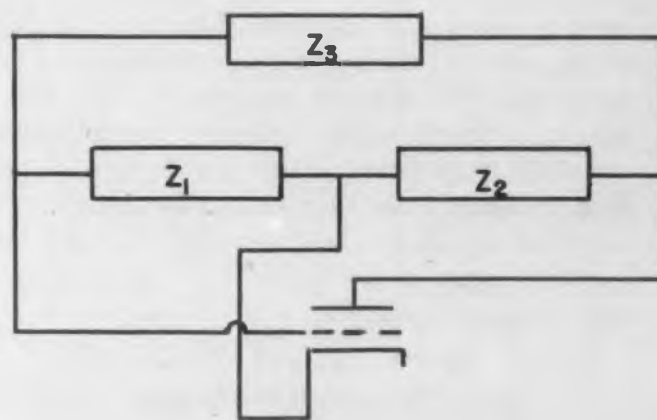


Fig. 2. Equivalent circuit for a general oscillator.

Q—Multiplier or Clapp Oscillator

Both of these oscillators utilize a cathode follower type circuit which introduces amplitude limiting through degeneration. In the Q—multiplier oscillator, Fig. 5a, the reactance from grid to ground consists of the two capacitors in series in one branch, and an inductance in parallel with them in the second branch. In the Clapp oscillator, Fig. 5b, the inductance is replaced by a series L-C circuit. The individual reactances are large compared to the reactance required to resonate the capacitors, but the difference just equals the required reactance.

Since a cathode follower circuit is used for these oscillators, amplification of the active element lies between 0.5 and unity. In order to get the required loop gain, therefore, a voltage step-up is required between the cathode and the grid. The two capacitors C_1 and C_2 form part of a resonant transformer which gives sufficient step-up to make loop gain greater than unity. Using the feedback resistance R_f as shown in Fig. 5, the amplification required of the tube or transistor is:

$$K = g_m R_k / [1 + (g_m + g_p) R_k] \geq (1/2) + R_f/Z \quad (5)$$

Where R_f is the feedback resistance, and Z is the total impedance of the tuned circuit (L/RC). (C is by the equation $C = C_1 C_2 / C_1 + C_2$).

Conditions for Maximum Frequency Stability

Frequency stability is of extreme importance in a majority of the oscillators used to generate sinusoidal waves. The discussion which follows is not all-inclusive, but is intended to point out important factors, with emphasis on points often overlooked.

The Q of a tuned circuit is of very great importance in the stability of an oscillator. Actually the Q which is important is not necessarily that of the tuned circuit by itself, but that of the tuned circuit under its operating conditions. Resistive loading to grid or plate conductance causes just as much damping on the circuit as if it were actually part

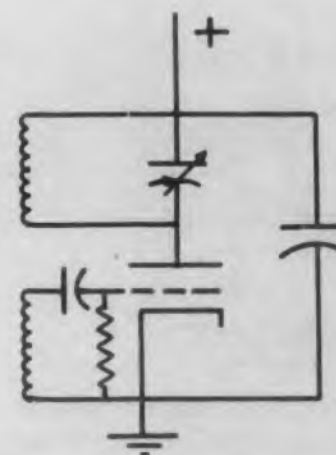


Fig. 3. Magnetic coupled oscillator: If coupling is kept below the critical value, the ratio of turns can be traded for coupling factor to obtain optimum design.

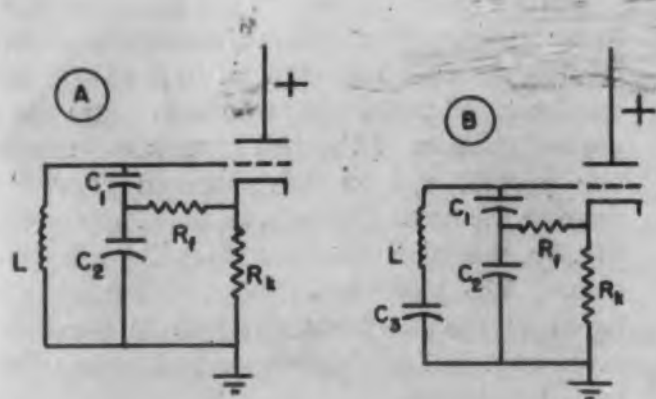


Fig. 4. Q-Multiplier Oscillator (A); CLAPP Oscillator (B).

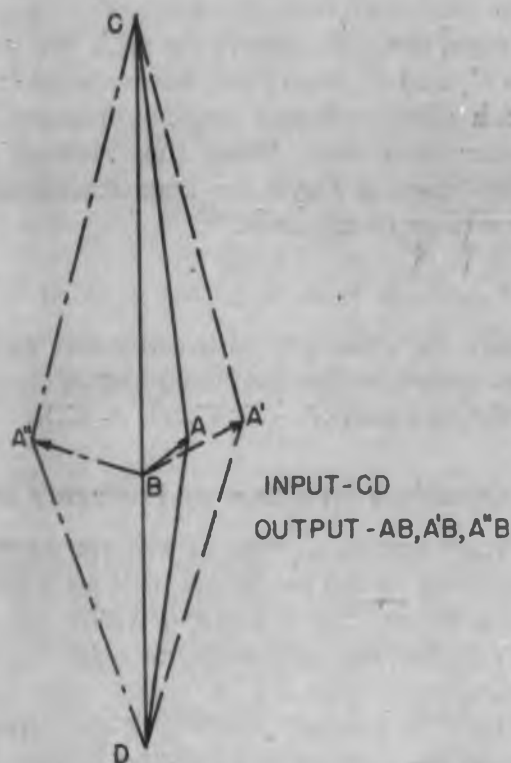


Fig. 5. Meacham Phase Diagram: Voltage difference between the points A and B changes much more rapidly in both amplitude and phase than the original component CA.

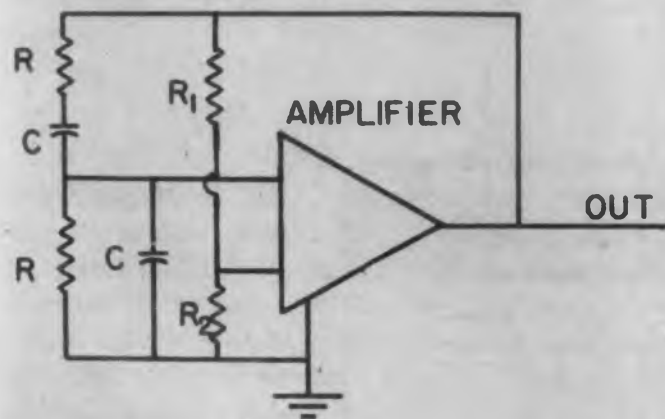


Fig. 6. Wien Bridge Oscillator: A two stage amplifier with zero degrees overall phase change and low output impedance is used to provide the required power to the frequency selection circuit and its association balancing circuit.

of the coil. For this reason the relations (4a) and (4b) should be fulfilled in oscillator design. As has been pointed out, loading of the active device on the frequency controlling circuit can be neglected when equations (4a) and (4b) are satisfied.

Using (4a) and (4b) to keep the impedance sufficiently low to maintain a good Q will also increase the fixed portion of the capacitance of the circuit (recall that $R_{LD} = Z = L/CR$). The result is that variations of the circuit capacitance, and particularly capacitance of the active device, are much less important than would otherwise be the case. The parasitic capacitances in tubes ranges from a fraction to approximately 20 μf . In a transistor the range is from about three to many tens of thousands, depending on the individual device. Since these capacitances vary as a function of operating conditions — especially with transistors — it is important that a minimum of variation in the device actually reach the critical tuned circuit.

Rigid and well-mounted wiring will help keep variations of wire capacitance and inductance to a minimum. It should be noted that as impedance levels are lowered to keep stray capacitance effects under control, the effects of the inductance of the wiring become more important.

Use of stable and well-made parts whose characteristics change in a controlled manner with changes in environment are particularly important. Compensating capacitors used for trimming thermal drifts in tuned circuits are usually made of ceramic material. Since some of the ceramics are voltage sensitive, caution should be used, and the circuit thoroughly tested for both thermal and voltage drifts.

Oscillator circuits in which the oscillator is required to provide the ultimate in stability usually use a bridge-type circuit. A shift of phase with bridge balance is utilized to increase sensitivity of the frequency control circuit. This action is demonstrated in Fig. 6. The difference in output between the fixed arm of the bridge, identified by the letters CBD, and the variable arm CAD is required to keep the oscillator functioning. As can be seen, the voltage difference between the points A and B changes much more rapidly in amplitude and phase than does the original component CA. For this reason, a much higher order of stability can be obtained from an oscillator which uses a bridge type of control circuit rather than the more conventional feedback arrangement. The Meacham oscillator is one of the better known types using the bridge phase technique.

Phase Shift Oscillators

Phase shift oscillators depend on a time delay or advance through phase shift circuits. These oscillators usually use a combination or resistive and reactive components in the frequency control net,

rather than two types of reactive components. Since the reactive component is usually a capacitor, they are often called RC oscillators.

Two types of RC oscillators are in fairly common use. The first of these — the Wien bridge type — uses an arrangement which is somewhat similar to a dual network. One member, usually the series one, consists of a capacitor and resistor in series, and the other member, which is connected in shunt, is either the load for the series combination or its source of signal. Since both resistors normally have equal resistance, and the capacitors equal capacitance, the phase angle between voltage and current through the network, for the output voltage to be in phase with the input voltage, is 45 deg. A two stage amplifier having zero deg. overall phase change and a low output impedance is used to provide the required power to the frequency selection circuit and its associated balancing circuit, Fig. 7.

At operating frequency the voltage gain in the frequency selective circuit has a maximum value of one-third. In order for oscillation to start it is necessary that the stabilizing circuit return a signal to the feedback point which is just less than one-third. The stabilizing circuit is made self-adjusting by using some type of thermistor as part of one of the two resistors. Feedback voltage then rises as the amplitude of the signal voltage rises, causing a reduction of the net amplification KK_f and limiting the output amplitude.

The second type of RC oscillator in common use takes advantage of the phase shift available in successive sections of a ladder network, Fig. 8. When the ladder sections of the network are separated by amplifiers or cathode followers, characteristics of the individual stage determine the overall operation of the oscillator. An example of such a circuit is an oscillator using three ladder sections, each with a phase shift of 60 deg. Two of the sections are coupled by an amplifier. Isolation circuits (cathode followers) are used between the two other sections. The amplifier should have an amplification between eight and twelve. The product of its gain and the gains of the two isolation amplifiers will then give an overall value of between eight and ten.

Usually the ladder sections are used without isolation amplifiers. Each section then causes an additional loss on the sections ahead of it in the chain. The equation for the operating frequency and for the loss in the network can be obtained from the numerator of the function F which is a continued fraction:

$$F = [Z_1 Y_2 + \frac{1}{1 + \frac{1}{Z_1 Y_2 + \frac{1}{1 + \frac{1}{Z_1 Y_2 + \text{etc.}}}}}]$$

The first few numerators for this expansion are:

Two ladders: $Z_1^2 Y_2^2 + 3 Z_1 Y_2 + 1$

Three ladders: $Z_1^3 Y_2^3 + 5 Z_1^2 Y_2^2 + 6 Z_1 Y_2 + 1$

Four ladders: $Z_1^4 Y_2^4 + 7 Z_1^3 Y_2^3 + 25 Z_1^2 Y_2^2 + 10 Z_1 Y_2 + 1$

Five ladders: $Z_1^5 Y_2^5 + 9 Z_1^4 Y_2^4 + 28 Z_1^3 Y_2^3 + 35 Z_1^2 Y_2^2 + 15 Z_1 Y_2 + 1$

Similar expressions can be developed for circuits having more sections. Frequency is determined from the odd order terms. The forward amplification required is obtained by substituting the frequency value into the even order terms. For example: for a three ladder net, solving the first and third power terms together gives

$$Z_1 Y_2 = \sqrt{-6}$$

Substituting this in the even power terms gives a required amplification for the amplifier of 29.

As can be seen from these equations, only combinations of three and four sections give a single real frequency. Use of two sections does not give sufficient phase shift and four or more sections result in quadratics in $Z_1^2 Y_2^2$, with two possible operating frequencies. Five sections give an operating frequency determined by the equation $Z_1 Y_2 = \sqrt{-10/7}$, and a required forward amplification of approximately 13. The reduction in amplification results from a smaller phase shift per section and therefore a smaller loss.

When a ladder network is used with an amplifier in the described manner, its input impedance should be high compared to the output impedance of the amplifier supplying it, or its loading effect may prevent the circuit from oscillating. A reasonable gain margin—possibly twenty percent—should be provided for safe tolerances. A potentiometer can be used to readjust the gain, particularly when it is accomplished by a variation in degeneration, since principal tolerances are those of the static network.

The second part of this article will extend the techniques to a variety of transistor circuits.

Working equations for transistor oscillators will be presented. Emphasis will be on conductance values.

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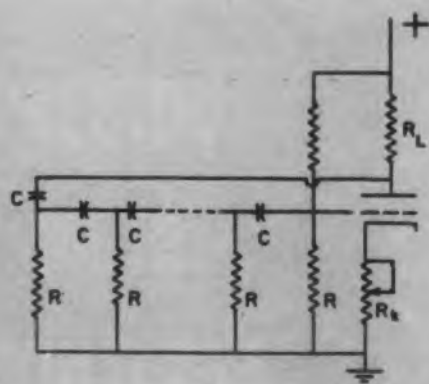


Fig. 7. Phase Shift Oscillator: Input impedance of the ladder should be high compared to the output impedance of the amplifier supplying it, or its loading effect may prevent the circuit oscillating.

Appendix

Necessary Conditions for Oscillation

Oscillators are energy transducers; they withdraw energy from a source capable of providing a steady flow of current (for example, a battery) and convert it into a pulsating form. Some oscillators generate sinusoidal waveforms, and others generate irregular waveforms such as square, triangular and sawtooth waves. All of these oscillators require the presence of an active element in the circuit. This active element may be a transistor, a vacuum tube or other similar device.

Sinusoidal oscillations can be generated by active elements used as negative resistance devices or they may be generated by active elements used as amplifiers in feedback circuits. Either phase shift or tuned circuits may be used for frequency selection.

Strictly, negative resistance devices should be called negative immittance devices, since immittance by definition includes both admittance and impedance. Both types of negative immittance (admittance and impedance) can be obtained with tubes or transistors. The most practical device, however, is the negative conductance type. It can be identified by the fact that its contour¹, when plotted in terms of output voltage and output current, is single valued with respect to voltage, but multiple valued with respect to current, see Fig. 8A. In a similar manner, a negative resistance device is single valued with respect to current, but multiple valued with respect to voltage, Fig. 8B. Oscillation occurs in a negative conductance element when, for the proper supply voltage, the impedance of the coupled circuit is high enough to cause the load line to intersect

the negative region A-A in more than one, usually three, places. Likewise, with a negative resistance device, an impedance less than a specified value is required to provide oscillation. The negative conductance device is used with an antiresonant or shunt tuned circuit, and the negative resistance with a resonant or series tuned circuit.

Tuned circuits consist of elements capable of storing potential energy (capacitors) in conjunction with other elements (inductors) capable of storing kinetic energy. The former store energy by building up a pressure or voltage, the latter by building up a flow of current. With one of the elements, a change of voltage occurs in conjunction with a flow of current, with the other, a change of current develops a voltage. The two types of elements are said to be duals of one-another. Except for the interchange of voltage and current, the behavior of both elements is similar. Any network which can be obtained from another network by the substitution of L for C and vice versa is the dual of the other.

A tuned circuit cannot be built without such dual elements since both energy storage and immittance—either proportional or inversely proportional to frequency—are required. If the reactance of one element is proportional to frequency, the susceptance of the other is also proportional to frequency; if one varies inversely with frequency, so does the other. Only under these conditions is it possible to find a frequency at which cancellation of either the reactance or the susceptance can be obtained to provide the required resonant or anti-resonant condition.

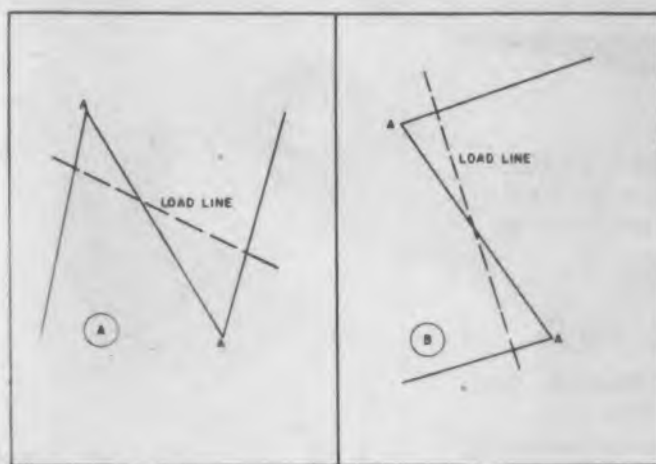
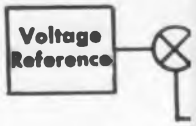


Fig. 8. A plot of output voltage vs output current shows that a negative conductance device (A) is single valued with respect to voltage and multiple valued with respect to current. A negative resistance device (B) is single valued with respect to current and multiple valued with respect to voltage.

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SELECT from the many combinations shown below. Any choice is available in a wide selection of standard resistance values ... for military or commercial applications.

these TERMINALS:



WIRE LEADS

SOLDER LUGS

PRINTED
CIRCUIT PINS

in these TYPES:

(select one or any combination)

HIGH OR
MEDIUM
TEMPERATURE

HUMIDITY
PROOF

HIGH
RESISTANCE

DUAL
OUTPUT

VARIABLE
RESISTOR

with these RESISTANCE ELEMENTS:

WIREWOUND



CARBON



ALL UNITS FEATURE sub-miniature size ... space-saving configuration ... self-locking shaft with 25-turn screwdriver adjustment ... excellent acceleration, vibration and shock characteristics ... mounting individually or in stacked assemblies, with standard 2-56 screws.

Over 50,000 units in stock. Send for complete catalog on the TRIMPOT and related potentiometers.

PLUS THE NEW TRIMPOT JR.



Micro-miniature size $\frac{3}{16} \times \frac{5}{16} \times 1$ "
2.0-watt power rating. Humidity proof.
175°C. max. operating temperature.

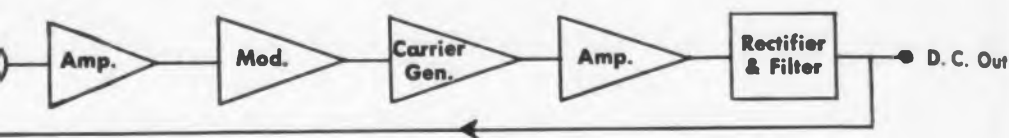


BOURNS LABORATORIES, INC.

General Offices: 6135 Magnolia Ave., Riverside, Calif.
Plants: Riverside, California—Ames, Iowa

TRIMPOT • LINEAR MOTION POTENTIOMETERS • PRESSURE TRANSDUCERS AND ACCELEROMETERS

CIRCLE 36 ON READER-SERVICE CARD FOR MORE INFORMATION



Simplified block diagram of the regulated low voltage dc power supply using a modulated ultrasonic carrier system.

Ultrasonically Regulated Power Supply

UTILIZING an ultrasonic carrier system to achieve optimum performance, this low voltage dc power supply can deliver 0 to 7.0 v at up to 1.5 amps. In many applications, this compact unit is far superior to batteries. It may be used for strain gages, dc filaments, transistors, bias and precision electroplating. Even under load it may be used as a precision laboratory reference.

The manufacturer, Optimized Devices, Inc., Box 38, Gedney Station, White Plains, N.Y., has incorporated feedback loops and corrective networks to keep the output voltage virtually independent of line and load fluctuations. Regulation is complete even down to zero volts.

Negative voltage feedback contributes to the low drift, low noise and low output impedance, while adjustable current feedback reduces the output impedance to 0.005 ohm. This adjustment can provide negative resistance characteristics to compensate for lead length.

The output is continuously variable without switching. Two 3-1/2 in. plastic-cased meters monitor the output voltage and current with 1 per cent accuracy. High resolution is obtained using coarse and fine controls.

Regulation is excellent. The output voltage change from no load to full load does not exceed 10 mv and the output change is less than 1 mv per volt of ac line change. Drift is kept to less than 10 mv per hour.

A response time of less than 20 msec and a noise output of less than 1 mv are other features of this power supply. A floating output enables one to ground either positive or negative terminal.

Power is taken from a 60 cps line providing 105

to 12
only
ing c
8-1/4
Fo
turn

This
sonic
and

ELEC

ed Power Supply

to 125 v. At full output, the power supply draws only 70 w. It is light, compact and portable, weighing only 23 lbs. Its measurements are 10 in. h. x 8-1/4 in. w. x 13-1/2 in. l.

For further information on this power supply turn to the Reader's Service card and circle 37.



This unusual low voltage power supply uses ultrasonics and feedback to maintain excellent regulation and extremely low output impedance.

PRECIOUS METAL CONTACTS PROVIDE LONG OPERATING LIFE AND UNVARYING PERFORMANCE



Progressive research development policies, coupled with vast experience in related fields, enable BAKER to apply its know-how in precious metals to meet the diverse problems accompanying the selection of precious metal contacts to suit individual requirements. The following BAKER precious metal materials serve to illustrate what BAKER's research departments make available in SILVER, PLATINUM, PALLADIUM and GOLD, in pure or alloy form, for supply as wire, rod, sheet, and as fabricated forms, such as rivets, discs, solderbacks, welding types, overlay, edgelay, inlay and irregular shapes.

SILVER AND SILVER ALLOYS

One of the most widely used materials for electrical contacts, SILVER provides high resistance to atmospheric corrosion. Silver Alloys—which contain base metals to achieve specific properties—provide other modified characteristics, such as increased resistance to arc erosion, sticking and metal transfer.

PLATINUM AND PLATINUM ALLOYS

Offering a higher resistance to tarnish and corrosion than any other contact material, the contact resistance of platinum can be maintained at a low value throughout its operating life. Platinum alloys provide higher melting points and hardness, greater resistance to deformation, longer life and increased resistance to sticking and metal transfer.

Write for complete catalog material and details.



NITRONEAL® GAS GENERATOR economically and safely provides fully automatic furnace brazing and bright annealing of stainless steel.

FINE WIRE of ductile and non-ductile material meets the expanding requirements of industry with highest quality.

RHODIUM PLATING provides a hard, brilliant white, non-tarnishable surface extremely resistant to corrosive conditions.

BAKER PRECIOUS METALS

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ENGELHARD INDUSTRIES

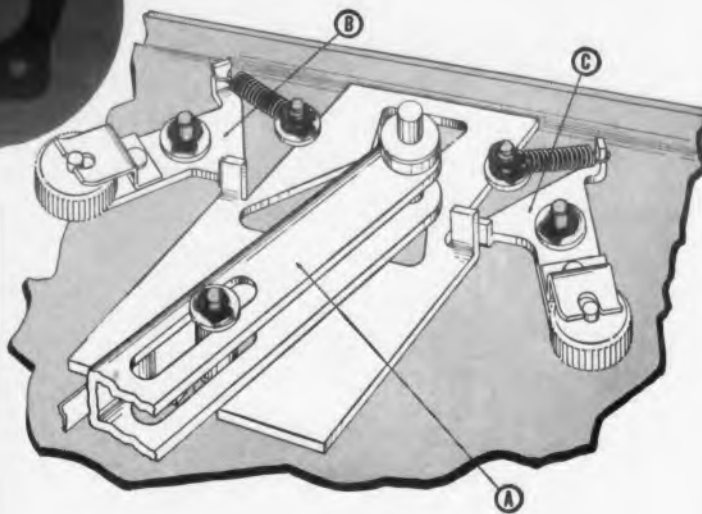
RESEARCH MAINTAINS BAKER'S LEADERSHIP IN PRECIOUS METALS
CIRCLE 38 ON READER-SERVICE CARD FOR MORE INFORMATION

Waldes Truarc grip rings used on die-cast studs eliminate threading, tapping, other costly machining



Mark Simpson Manufacturing Co., Long Island City, N. Y., uses Waldes Truarc series 5555 Grip Rings to secure parts to studs of the zinc die-cast base of its "Masco 500" portable tape recorder.

The rings—which need no grooves—replace nuts, screws, cotter pins and other types of fastening devices which require threading, tapping, drilling and other expensive machining operations. Because a single cracked or broken stud would render the entire cast base useless—and with it, all assembly completed to that point—the rings also eliminate extremely costly rejects.



Pivot Assembly of shift lever (A) is secured by a single Waldes Truarc Grip Ring and washer. Because the washer must be installed over the shift level in a sliding fit, critical tolerances would have to be maintained if a screw or cotter pin were used. The Truarc Grip Ring eliminates that problem: it requires no groove and may be seated over the washer at any point on the stud, automatically compensating for accumulated tolerances in the parts. BRAKE ASSEMBLIES (B and C) use Grip Rings to secure the brake wheel and spring sub-assemblies. Here again problems of critical tolerances are avoided and expensive rejects eliminated.

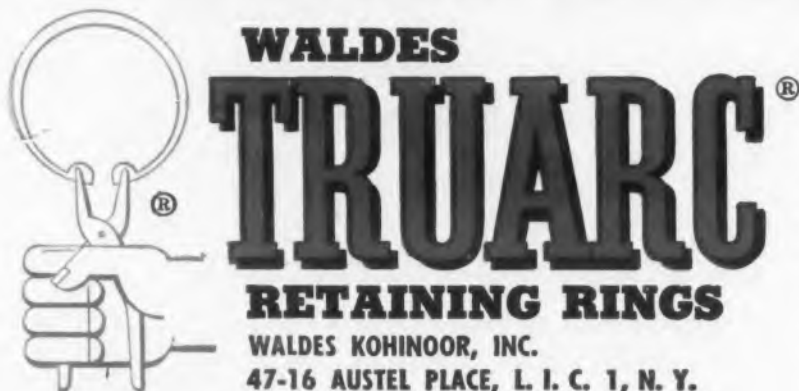
Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product...to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types...as many as 97

different sizes within a type...5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

For precision internal grooving and undercutting...Waldes Truarc Grooving Tool!



Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

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Title.....
Company.....
Business Address.....
City..... Zone..... State.....

ED079

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

CIRCLE 39 ON READER-SERVICE CARD FOR MORE INFORMATION

High Power Silicon Rectifier

DESIGNED to carry 140 average amp, 170 de amp, or 1,500 one cycle surge peak amp per cell at a 40 C ambient, this silicon cell assembly is available in voltage levels from 50 to 300 piv. The ability of the rectifier to operate at high ambients—up to 200 C junction temperature—makes it useful in supplying filament power for industrial and transmitting tubes, power supplies for computers and radars, and airborne transformer rectifiers.

Believed by the General Electric Company, West Lynn, Massachusetts to have an infinitely long theoretical life, the cell is expected to be reliable. The cost of silicon makes it competitive with other rectifier materials, when it can be used up to its full rating. Silicon cells are generally smaller and more efficient than selenium or germanium for a given power rating. While the G. E. cell must be current-derated at elevated junction temperatures—down to 0 at 200 C—it will supply about 75 amp at 125 C; a triad of cells operating in a three phase circuit could supply 215 amp.

All cells are furnished in matched sets so that parallel operation is practical. Load equalizing reactors are in this way dispensed with. The cells can

Fig. 2. Hermetically sealed ceramic-and-stainless-steel cell package. Cutaway view shows Ferr steel cup and flange, ceramic wa and lower copper contact-bottom. Steel is brazed to the ceramic and all seams are welded



Fig. 1. This silicon rectifier cell is capable of carrying 140 average amp in a 40 C ambient, with 1,000 linear ft per min cooling air and mounted on a 6 x 6 x 1/4 in. copper plate. Standard stud mounting insures tight fit to cooling plate, using conventional nut. Power take-off is heavy braid for low resistance path.

be connected in series by using shunting resistors across each.

The cell mounting device, shown in Fig. 1, is a standard stud rather than a tapered stud. This means that the rectifier can be bolted to a plate with a conventional nut and pulled up tight. A tight fit between the cooling plate and the body of the rectifier is needed for good heat transfer; this is difficult of accomplishment with tapered pipe thread. The G.E. design provides a hex-head so that the cell assembly can be held with an open-end wrench. Any strain in mounting is on the stud, not the cell. A heavy braided power take-off lead insures a reasonably low resistance path and at the same time contributes substantially to the cooling of the cell.

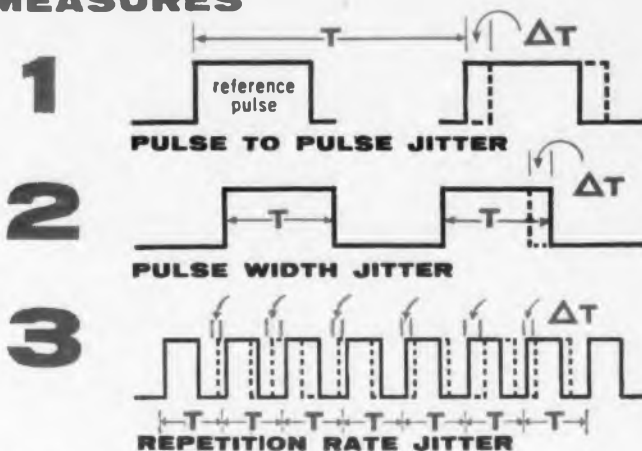
Enclosed is a hermetically sealed package of ceramic and stainless steel, the construction of which is shown in Fig. 2. The silicon wafer is adequately protected for field environments. This construction has been used very successfully over a long period of time with germanium rectifiers.

For further information on this silicon rectifier, turn to the Reader's Service Card and circle 40.



PULSE JITTER TESTER

MEASURES



DISPLAYS

- JITTER MAGNITUDE
- JITTER WAVEFORM

A new Polarad instrument to show the magnitude and waveform of jitter modulation in rate generators, pulse width modulators encoding devices, precision time generators.

Here is how it measures:

1. **pulse to pulse jitter**. Two 5 mc oscillators are pulsed—one with the leading edge of each pulse. The outputs of the oscillators are compared in the phase detector and displayed on the CRT.
2. **pulse width jitter**. The leading and trailing edges of a pulse gate the 5 mc oscillators and are compared.
3. **repetition rate jitter**. The leading edge of the pulse gates a 5 mc oscillator which is compared with a stable 5 mc crystal controlled oscillator in a phase detector. The output of the phase detector is divided by a calibrated attenuator in factors of ten and two and displayed on a CRT.
4. **waveform of jitter**. Obtained by rectifying the output of the phase detector.



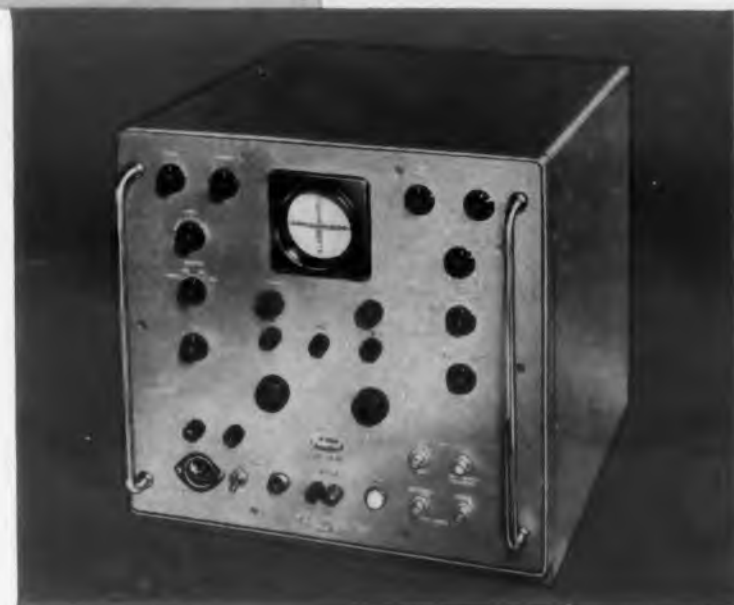
ELECTRONICS CORPORATION
43-20 34th Street • Long Island City 1, N. Y.

REPRESENTATIVES: Albuquerque, Atlanta, Baltimore, Boston, Buffalo, Chicago, Cleveland, Dayton, Denver, Fort Worth, Kansas City, Los Angeles, New York, Philadelphia, Portland, St. Louis, San Francisco, Schenectady, Syracuse, Washington, D. C., Winston-Salem, Canada; Arnprior, Ontario. Resident Representatives in Principal Foreign Cities

CIRCLE 41 ON READER-SERVICE CARD FOR MORE INFORMATION

FEATURES

- Self-contained cathode ray tube with continuously adjustable horizontal sweep from 40 to 2,000 cps. Can be synchronized with signal.
- Printed circuit construction
- Self-contained calibration in three ranges: 100 milli u sec., 10 milli u sec., 5 milli u sec.
- Power frequency range from 50 to 420 cps.
- Provision for measurement of jitter frequency by Lissajous figures.



MODEL PJ-1

SPECIFICATIONS

Input Requirements:

Pulse Width	0.2 to 10.0 microseconds.
Repetition Rate	50 to 6,000 pps.
Amplitude	5 to 50 volts, peak-to-peak.
Polarity	Positive or negative.
Input Impedance	82,000 ohms shunted by 25 micromicrofarads.
Measuring Level	50% point of input pulse, nominal.

Jitter Measurements:

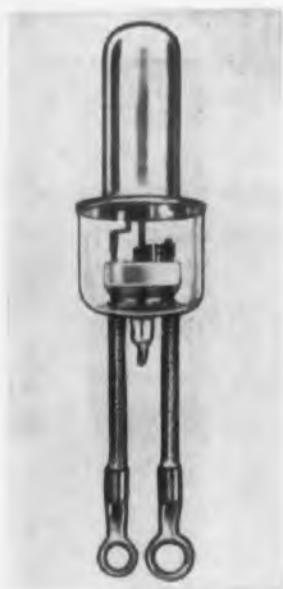
Repetition Rate Jitter	5, 10, 100 millimicroseconds and 1, 10, 100 microseconds full scale.
Width or Relative Jitter	5, 10, 100 millimicroseconds full scale.
Residual Jitter	Less than 0.5 millimicroseconds on 5, 10, and 100 millimicrosecond ranges.
Useable Horizontal Frequency Range	15 cycles to 25 kc.
Power Input	115 v \pm 10%, 50 to 420 cps, 400 watts.
Dimensions	19 wide by 17½ high by 12 inches deep.
Weight	60 lbs.
Outputs Provided For	(1) External oscilloscope; (2) Recorder (\pm 5 ma. into 1,000 ohms) for disturbance frequency.

AVAILABLE ON EQUIPMENT LEASE PLAN

Maintenance Available by
Field Service Specialists



New Products



**External Anode Tube
Power Diode**

This thermionic power diode is designed for air or liquid immersed operation. As a rectifier, the 545 provides an average plate current of 50 ma dc and is rated for EPX 5 kv. Weighing less than 0.7 oz, the tube is 2 in. long, 7/8 in. wide and has a shock rating of 300 g. Maximum bulb temperature is 265 C.

United Electronics Co., Dept. ED, 42 Spring St., Newark, N.J.

CIRCLE 42 ON READER-SERVICE CARD FOR MORE INFORMATION



**Instant Reset Delay
No Wait to Recycle**

Type BR time delay relay resets instantly when its energizing circuit is interrupted, either during the timing cycle or after its completion. The unit contains thermal and magnetic elements mounted in a single case. The total delay interval comprises a brief heating period followed by a longer cooling period, and the output contacts operate when this total cycle has run to completion. The thermal elements at this point are cool and ready for another timing cycle. Short energizing pulses may be repeated indefinitely without causing contact operation.

Type BR units are available for standard delay intervals of 2, 5, 15, 20, 30, 60, 120, 180 and 300 sec. Energizing voltage is 28 v dc. Time delay tolerance is ± 10 per cent. Output contacts are either normally open or normally closed spst. Contacts are rated at 2 amp up to 230 v ac and 1 amp up to 32 v dc. Energizing power averages 6 w during the timing cycle. Ambient temperature range is -65 to $+125$ C and the device will withstand shock of 30 and 10 g vibration over the 5 to 500 cps range.

G-V Controls Inc., Dept. ED, Hollywood Plaza, East Orange, N.J.

CIRCLE 43 ON READER-SERVICE CARD FOR MORE INFORMATION

**Diffused Junction Transistor
Dissipates 15 W at 100 C**



This gaseous diffused-junction silicon transistor has a rated power dissipation of 37.5 w at 25 C and 15 w at 100 C, making possible high power transistorized servo and audio output systems for use in high temperatures. With a 2 amp collector current, the 2N389 features a maximum saturation resistance of 6 ohms. When used in aircraft applications, a 60 v collector-to-emitter rating allows power to be taken directly from the 28 v power supply.

This is the first commercially available transistor produced by a diffusion process similar in basic principles to the process announced by Bell Telephone Labs., Inc. in January, 1956. Operating temperature range is from -65 to $+150$ C. The transistor is projection welded in a metal case designed to meet the requirements of MIL-T-19500. All diffused-junction 2N389 high power units are stored at an ambient temperature of 185 C for 16 hrs and then temperature cycled before being electrically tested.

Texas Instruments, Inc., Dept. ED, 6000 Lemmon Ave., Dallas 9, Tex.

CIRCLE 44 ON READER-SERVICE CARD FOR MORE INFORMATION



**Current Transformer
Weighs 13 Oz**

Used for metering and relaying on airborne systems, the unit has a 250:2 amp current ratio and operates on 115 v, 3 phase, 4 wire, 400 cps systems. The transformer is molded from a new lightweight high-temperature insulating resin, and has a smooth, metallic finish and rounded edges. It will operate in ambient temperatures from -55 to $+170$ C. It will withstand vibration, shock, and extreme humidity normally encountered in aircraft systems and conforms to requirements of specification MIL-T-7210 for Type D-2 current transformers. The unit has a maximum height and width of 3.25 in., a hole diameter of 1.12 in. min, and weighs less than 13 oz.

Westinghouse Electric Corp., Dept. ED, P.O. Box 2099, Pittsburgh 30, Pa.

CIRCLE 45 ON READER-SERVICE CARD FOR MORE INFORMATION



**Coaxial Attenuators
1000 to 10,000 Mc**

These Broadband coaxial attenuators have type C connectors and cover the frequency range of 1000 to 10,000 mc. Units in these series are available in 1 db steps from 1 to 10 db. Model 520, 521, and 522 have various combinations of male and female connections.

Typical Properties of 3 db Unit, Model 520-3 are: 5 w Average, 10 kw peak power input; accuracy at 4 kmc of 3 ± 0.1 db, and maximum frequency sensitivity, from 1000 to 10,000 mc, of 0.4 db.

Weinschel Engineering, Dept. ED, 10503 Metropolitan Ave., Kensington, Md.

CIRCLE 46 ON READER-SERVICE CARD FOR MORE INFORMATION



Switch Actuator
Requires 40 Grams

The ATM-1 actuator requires 40 g maximum to operate the snap action of a USM switch. When used with this basic switch, pre-travel is 1/8" and over-travel is 1/32" approximately. The actuator mechanism, furnished separately from the switch, may be used with all USM Series switches. These switches are manufactured for use up to 275 F and will satisfy MIL-S-6743.

Division of The Maxson Corp., Dept. ED, Ives Road, Wallingford, Conn.

CIRCLE 47 ON READER-SERVICE CARD FOR MORE INFORMATION



Scintillation Well Counter
Radioactive Measurement

Model DS5-5 contains features not previously available in radiation detectors of this type. These include: a scaler-spectrometer circuit which permits use of the detector with any scaler, ratemeter, or gamma-ray spectrometer system; more than 2 in. of lead shielding surrounding the sodium iodide well crystal to reduce cosmic ray and other background to a minimum; a position lock at the side of the lead shield to enable the operator to move the detector to any height; and a detector which can be removed from the lead shielding to permit substitution of alpha, beta, or solid gamma sensitive crystals for the well crystal.

The instrument permits accurate measurement of gamma sources with activities as low as 10^{-5} microcuries. Overall sensitivity is approximately 50 per cent. Background counting rate when used with a scaler or ratemeter is approximately 300 counts-per-minute and is reduced to 20-30 counts-per-minute when used with a gamma-ray spectrometer system. Count rate is independent of sample volume up to 5 milliliters.

Nuclear-Chicago Corp., Dept. ED, 229 West Erie St., Chicago 10, Ill.

CIRCLE 48 ON READER-SERVICE CARD FOR MORE INFORMATION

*first in
Performance
Reliability
and Quality*



kepco

*introduces
the first in
a series of*
**NEW
MAGNETIC
TUBELESS
VOLTAGE
REGULATED
POWER SUPPLIES**



**MODEL
KM 236-15**

**2-36 VOLTS
15 AMPS.**

featuring

- ▶ **Output voltage within 0.5% during recovery time for line transients 105-125 volts.**
- ▶ **Short circuit will not damage supply.**
- ▶ **Full current may be drawn at any voltage from 2-36 volts.**

OUTPUT VOLTAGE DC: 2-36 volts continuously variable.

OUTPUT CURRENT DC: 0-15 amperes continuous duty.

REGULATION: In the range 2-36 volts the output voltage variation is less than 0.5% for line fluctuation from 105-125 volts, and less than 0.5% or 25 millivolts, whichever is greater, for load variations from minimum to maximum current.

RIPPLE VOLTAGE: Less than 0.5% or 25 millivolts RMS, whichever is greater.

FUSE PROTECTION: Input fuses on front panel.

OVERLOAD PROTECTION: An automatic current limiting device allows direct shorting of the output terminals without damage to the supply.

Visit Booth #808-809 •
WESCON Show • August 20-23

POWER REQUIREMENTS: 105-125 volts, 57-63 cycles.

OUTPUT TERMINATIONS: DC terminals are clearly marked on the front panel. Either positive or negative terminal of the supply may be grounded. DC terminals are isolated from the chassis. A binding post is available for connecting to the chassis. All terminals are also brought out at the rear of the chassis. Two terminals are mounted at the rear of the chassis to provide for picking up the error signal directly at the load. This connection compensates for the voltage drop in the wires connecting the power supply to the load.

METERS: Ammeter: 0-15 amperes, 4" rectangular
Voltmeter: 0-15 volts, 4" rectangular

CONTROLS: Power on-off switch, DC on-off switch, remote error signal on-off switch, coarse and fine voltage controls.

PHYSICAL SPECIFICATIONS: Rack panel construction. Panel height 12 1/4", width 19", depth 17". Color Kepco standard gray hammertone. This unit is designed for relay rack mounting or bench use. Carry handles are provided.

OPERATIONAL CHARACTERISTICS: This regulated unit consists of a ferro-resonant line regulator followed by a magnetic amplifier regulator. The ferro-resonant line regulator furnishes well regulated transient free AC power. The high gain magnetic amplifier is used to regulate the DC output voltage to compensate for voltage changes in the power unit for varying load currents. The response time for pulse loads is less than 0.2 seconds.

**WRITE FOR SPECIFICATIONS ON 30
AND 50 AMP. MAGNETIC SUPPLIES.**



KEPCO LABORATORIES, INC.

131-38 SANFORD AVENUE • FLUSHING 55, N. Y. • INDEPENDENCE 1-7000

CIRCLE 49 ON READER-SERVICE CARD FOR MORE INFORMATION

T/I
progress report on
SILICON
single junction
RECTIFIERS

**TYPES 1N1130 AND 1N1131
GROWN SINGLE JUNCTION SILICON RECTIFIERS**

Texas Instruments Types 1N1130 and 1N1131 grown single junction silicon rectifiers are designed for stable operation at high ambient temperatures (to 150° C) for high breakdown voltage (1500 V minimum). Ideal for purposes, they are stud mounted for maximum heat dissipation and withstand extreme conditions of shock, vibration, and humidity. The 1N1130 and 1N1131 units differ only in polarity. High voltage insulation between units can be eliminated by the proper choice of either the 1N1130 or 1N1131.

To assure maximum reliability, stability, and long life, all units are of welded construction and are heat cycled from -55° C to +150° C for four cycles. All units are thoroughly tested for rigid adherence to design characteristics.

The units are hermetically sealed with glass-to-metal hermetic seal between case and lead. Approximate weight is .015 g.

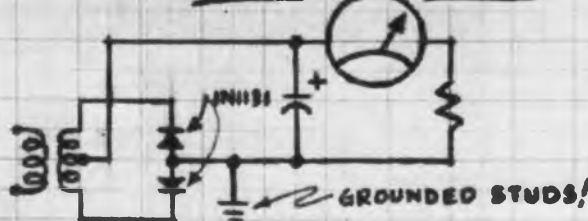


absolute maximum ratings*

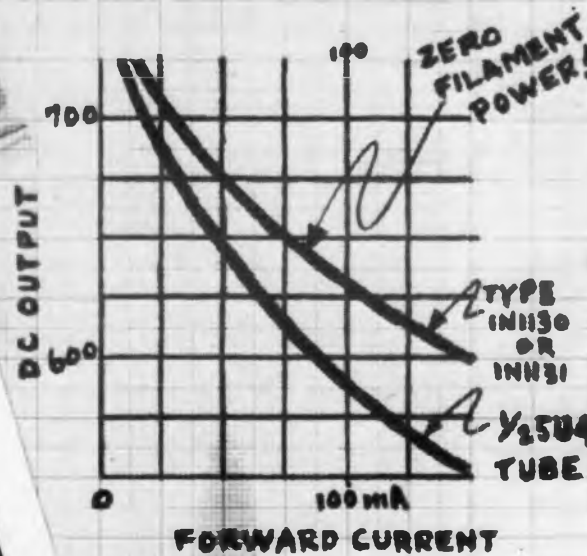
- Recurrent Peak Inverse Voltage
 - 65° C
 - +25° C
 - +100° C
 - +150° C
- Average Rectified Forward Current at Maximum PIV†
 - 65° C
 - +25° C
 - +100° C
 - +150° C
- Recurrent Peak Current (-65° C to +150° C)
 - Stud Temperature
 - Altitude at Maximum Ratings
 - Surge Current, 1 Second, D.C.

Specifications at 25° C. Leakage at -1500 v D.C. Drop at 150 mA.

PIV=1500V I₀=600mA



TYPICAL POWER SUPPLY CIRCUIT



1500 V
1500 V
1250 V
1000 V
300 mA
300 mA
230 mA
150 mA
900 mA
165° C
70,000 ft
2 A



new design freedom for your miniature high voltage power supplies with...

NEW TI 1500 V, 300 mA RECTIFIERS

You can replace 5R4 and 5U4 rectifiers with TI's new single junction rectifiers in many applications. In a fraction of the space, you will get instant operation at high temperatures with *zero filament power*. Here are some significant ratings of these new Texas Instruments Types 1N1130 and 1N1131 (differing only in polarity):

VALUE	AMBIENT TEMPERATURE	
	25° C	150° C
PIV	1500 V	1000 V
I _r (at max. PIV with heat sink)	300 mA	150 mA

Designed to meet stringent military requirements, these TI rectifiers give you the ultimate in hermetic seal protection. The standard RETMA stud is of copper for optimum performance and the hex base assures high-torque chassis mounting. High volt-

age insulation between stud and chassis can be eliminated by proper choice of either 1N1130 or 1N1131.



**400 V, 750 mA TI TYPE 1N540
ECONOMICAL diffused RECTIFIER
lower FORWARD VOLTAGE DROP**

Reliability of your power supplies is assured by this rectifier... giving you cooler operation. Typically, at 150° C, they give you 0.64 V voltage drop at 250 mA and 0.20 mA reverse current at 250 V.

 **TEXAS INSTRUMENTS**
INCORPORATED
6000 LEMMON AVENUE DALLAS 9, TEXAS

New Products

**Voltage Check Panel
Null Type Calibrator**

A specialized voltage check panel, Model 7102 is for use as a null type calibrator with strain gage power supplies. Specifications are as follows: Power, self contained battery guaranteed one year in normal usage; voltage adjustment, 10 turn potentiometers; reference voltage, Model 4 type 3 standard cell; ±0.01 per cent null meter, 1.5 μamp for 5 deg deflection at null, 300 μamp continuous without damage. When used with Model 7P01 strain gage power supplies, the output voltage may be adjusted to 10 v dc, ±0.02 per cent with this instrument. This unit is rack mounted on 7 x 24 in. panel.

Western Gear Corp., Dept. ED, P.O. Box 182, Lynwood, Calif.

CIRCLE 64 ON READER-SERVICE CARD

**Power Amplifier
For L and S Bands**

The Series 411 power amplifier is a cavity amplifier specifically designed to utilize the 2C39B Lighthouse Triode of ceramic construction, covering the range from 1,250 mc to 2,400 mc. The cavity features a gain of 10 db to 15 db with a minimum rf output of more than 20 w. It has a resonant anode cavity with four tuning slugs, for a maximum tuning range of 100 mc. The cathode section is coaxial line, and can be adjusted by knob or screwdriver for a tuning range equal to that of the anode section. Input and output connections are 50 ohm loop couplings, with Teflon insulation on input line to minimize rf losses. External grid biasing is provided to allow accommodation for metering grid drive. All electrical surfaces are silver and rhodium plated. External surfaces are nickel-rhodium or anodized. Aluminum alloys are used wherever possible, for lightweight construction.

Amerac, Inc., Dept. ED, 116 Topfield Rd., Wenham, Mass.

CIRCLE 65 ON READER-SERVICE CARD

◀ CIRCLE 63 ON READER-SERVICE CARD

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T/I
progress report on
SILICON
single junction
RECTIFIERS

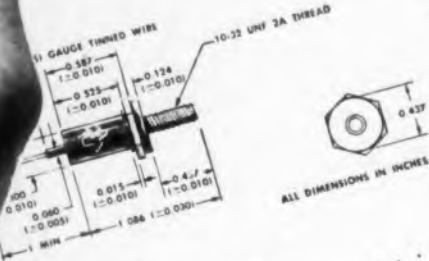
**TYPES 1N1130 AND 1N1131
GROWN SINGLE JUNCTION SILICON RECTIFIERS**

As Instruments Types 1N1130 and 1N1131 grown single junction silicon rectifiers for stable operation at high ambient temperatures (to 150°C) and high breakdown voltage (1500 V minimum). Ideal for purposes, they are stud mounted for maximum heat dissipation and withstand extreme conditions of shock, vibration, and humidity. The 1N1130 and 1N1131 units differ only in polarity. High voltage insulation between stud and chassis may be eliminated by the proper choice of either the 1N1130 or 1N1131.

To assure maximum reliability, stability, and long life, all units are of welded construction and are heat cycled from -55°C to +150°C for four cycles. All units are thoroughly tested for rigid adherence to design characteristics.

with glass-to-metal hermetic seal between case and lead. Approximate weight is

with glass-to-metal hermetic seal between case and lead. Approximate weight is



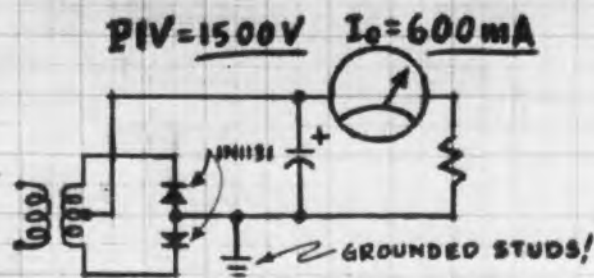
absolute maximum ratings*

Recurrent Peak Inverse Voltage
-65°C
+25°C
+100°C
+150°C

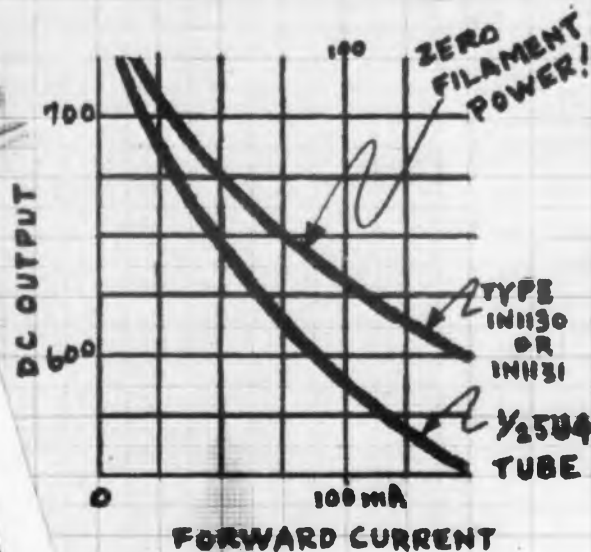
Average Rectified Forward Current at Maximum PIV
-65°C
+25°C
+100°C
+150°C

Recurrent Peak Current (-65°C to +150°C)
Stud Temperature
Altitude at Maximum Ratings
Surge Current, 1 Second, D.C.

Specifications
+25°C Leakage at -1500 v D.C.
Drop at 150 mA



TYPICAL POWER SUPPLY CIRCUIT



1500 V ✓
1500 V ✓
1250 V ✓
1000 V ✓
300 mA ✓
300 mA ✓
230 mA ✓
150 mA ✓
900 mA ✓
165 °C ✓
70,000 ft ✓
2 A ✓

**new design freedom for your miniature
high voltage power supplies with...**

NEW TI 1500 V, 300 mA RECTIFIERS

You can replace 5R4 and 5U4 rectifiers with TI's new single junction rectifiers in many applications. In a fraction of the space, you will get instant operation at high temperatures with *zero filament power*. Here are some significant ratings of these new Texas Instruments Types 1N1130 and 1N1131 (differing only in polarity):

VALUE	AMBIENT TEMPERATURE	
	25°C	150°C
PIV	1500 V	1000 V
I _f (at max. PIV with heat sink)	300 mA	150 mA

Designed to meet stringent military requirements, these TI rectifiers give you the ultimate in hermetic seal protection. The standard RETMA stud is of copper for optimum performance and the hex base assures high-torque chassis mounting. High volt-

age insulation between stud and chassis can be *eliminated* by proper choice of either 1N1130 or 1N1131.

**400 V, 750 mA TI TYPE 1N540
ECONOMICAL *diffused* RECTIFIER
lower FORWARD VOLTAGE DROP**

Reliability of your power supplies is assured by this rectifier... giving you cooler operation. Typically, at 150°C, they give you 0.64 V voltage drop at 250 mA and 0.20 mA reverse current at 250 V.



TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE DALLAS 9, TEXAS

New Products

Voltage Check Panel Null Type Calibrator

A specialized voltage check panel, Model 7102 is for use as a null type calibrator with strain gage power supplies. Specifications are as follows: Power, self contained battery guaranteed one year in normal usage; voltage adjustment, 10 turn potentiometers; reference voltage, Model 4 type 3 standard cell; ±0.01 per cent null meter, 1.5 μamp for 5 deg deflection at null, 300 μamp continuous without damage. When used with Model 7P01 strain gage power supplies, the output voltage may be adjusted to 10 v dc, ±0.02 per cent with this instrument. This unit is rack mounted on 7 x 24 in. panel.

Western Gear Corp., Dept. ED, P.O. Box 182, Lynwood, Calif.

CIRCLE 64 ON READER-SERVICE CARD

Power Amplifier For L and S Bands

The Series 411 power amplifier is a cavity amplifier specifically designed to utilize the 2C39B Lighthouse Triode of ceramic construction, covering the range from 1,250 mc to 2,400 mc. The cavity features a gain of 10 db to 15 db with a minimum rf output of more than 20 w. It has a resonant anode cavity with four tuning slugs, for a maximum tuning range of 100 mc. The cathode section is coaxial line, and can be adjusted by knob or screwdriver for a tuning range equal to that of the anode section. Input and output connections are 50 ohm loop couplings, with Teflon insulation on input line to minimize rf losses. External grid biasing is provided to allow accommodation for metering grid drive. All electrical surfaces are silver and rhodium plated. External surfaces are nickel-rhodium or anodized. Aluminum alloys are used wherever possible, for lightweight construction.

Amerac, Inc., Dept. ED, 116 Topfield Rd., Wenham, Mass.

CIRCLE 65 ON READER-SERVICE CARD

◀ CIRCLE 63 ON READER-SERVICE CARD

January 1st through June 15, 1957

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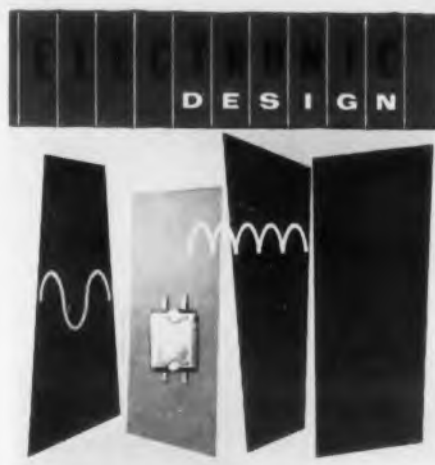
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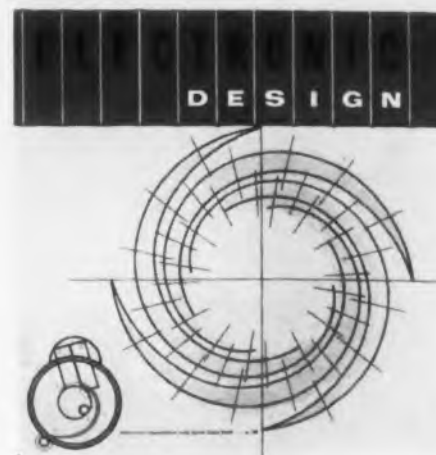
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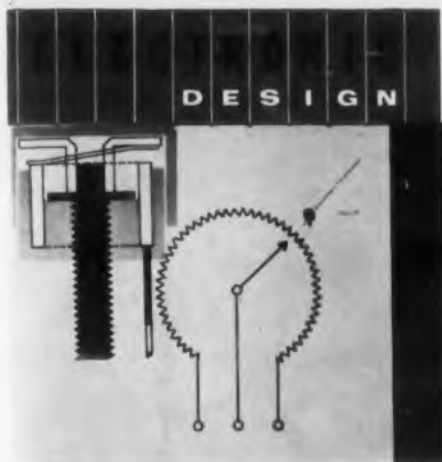
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Epoxy Foams, by L. Bolstad and A. Stenerson (p 28) Properties and status of epoxy foam insulating materials is reported.

Mag-Amp Motor Control (p 32) A passive device to regulate the speed of a series-wound universal motor within ± 5 per cent over the full torque range from 0 to 100 per cent. (CGS Labs, Inc.)

Miniature Strip Transmission Line and Components—I, by E. N. Torgow and J. W. E. Griemsmann (p 34) Deals with the versatility and important characteristics of strip line and strip line components.

Tunable Stalos (p 38) Description of stable local oscillators which are tunable over a range of 10 per cent of center frequency. (Pitometer Log Corp.)

Molded Printed Circuits (p 40) Clever but simple molded printed circuit design for use in an inexpensive automatic component assembly machine. (Die-Form Circuits, Inc.)

UV-IR Photometer (p 44) The use of transistors resulted in a precision portable photometer design and manufacture. (Servo Corp of America)

A New Family of Transistor Switching Circuits (p 46) A number of outstanding advantages are gained by a new circuit using direct-coupled pnp and npn transistors, dual-range circuits. (AIEE Winter General Meeting Report)

Transistor NOR Circuit Design (p 48) Design of a transistor NOR circuit producing a single logic element. (AIEE Winter General Meeting Report)

Ideas for Design (p 72) Making Printed Circuits in the Laboratory; Transistorized Transmitter; Push-Pull Flexible Control; Visual Commutator Inspection.

Cathode Follower Nomogram (p 88) A working nomogram for computing the output impedance and bandwidth of a cathode follower. (Russian Abstract)

What the Russians Are Writing (p 90) Devoted to papers dealing with radio engineering and electronic phases of the design of high-energy proton accelerations. (Russian Translation)

Measuring Techniques for Nonlinear Networks (p 92) Method is presented for determining the even-harmonic content of a distorted signal. (German Abstract)

April 15

Design Procedures for Semiconductor Regulated Power Supplies, by S. Sherr, P. Levy and T. Kwap (p 22) The article describes design procedures and shows several practical circuits, with calculated and measured performance data.

A Review of Modulators and Their Requirements, by M. H. Zinn (p 26) Operational factors and circuit requirements and their relationship to the modulator device are reviewed; advantages and limitations of various modulator types are discussed.

Versatile Current Stabilizer (p 30) The Current Governor can be used as a constant current source, an ammeter calibrating reference and for various voltage and component tests. (North Hills Electric Co.)

Purchase Specifications for Pulse-Forming Networks, by J. W. Trinkaus (p 32) A guide listing the salient items to be included in a purchase spec.

Miniature Strip Transmission Line and Components—II, by Eugene N. Torgow and John Griemsmann (p 36) The design of various strip line components for miniaturization.

Simplified Coincident Motion Picture Sound Using a Tape Recorder (p 40) The design of an inexpensive, technically straightforward sound track for all film sizes and speeds.

Elapsed Time Indicator (p 44) The Chronistor is an electro-chemical device that measures total number of hours of operation, fits into a 3AG fuse clip. (Bergen Laboratories)



April 1

High-Efficiency Crystal Detector Mounts (p 46) Used for frequencies between 500 and 4500 mc, provide a video gain improvement of 2 to 6.5 db. (American Electronics Laboratories)

Ideas for Design (p 120) Improved Radar Target; Spring Washer Cartridge; Edge Trim for Sheet Metal; Preferred AFC Circuit; Beryllium Spring Solves Fatigue Problem.

The Regeneration Method in the Design of Transistor Amplifier Stages, by J. George Adashko (p 134) Defines the regeneration coefficient as applied to a transistor-amplifier stage and tabulates the coefficients for different circuit types. (Russian Translation)

Electronic Test Image Generator (p 138) Adjustable video signal, easily duplicated. (German Abstract)

Transistor TV Deflection System (p 140) Transistors are used in a TV deflection system; circuit diagram is given. (Abstract)

Radio Communication in Tunnels (p 140) The problem of economical communication in tunnels is solved by using a continuous transmission line for a radiating antenna. (Abstract)

Backward-Wave Oscillators (p 144) Two bwo's for use as voltage-tunable local oscillators. (Abstract)

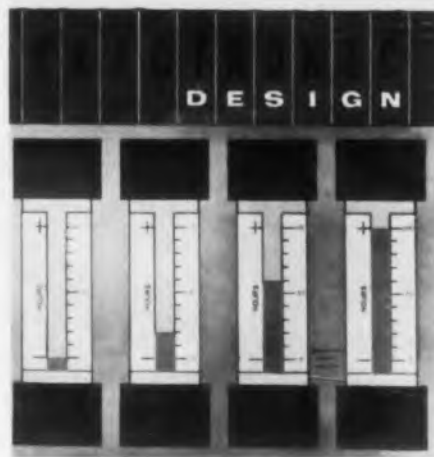
The Clamp-Type AC Microammeter (p 146) Capable of measuring microamperes over a side band of audio frequencies, this experimental, 7-transistor circuit is shown. (Abstract)

May 1

Reliability in Electrical Connections, by R. George Roesch (p 20) A survey of problems involved in making electrical connections, soldering, fluxing, et al.

Adjustable Precision Resistor (p 26) Socket head screw adjustments are used to vary the resistance from 1 K to 200 M. Coarse and fine adjustments featured. (Clark Electronic Laboratories)

Jamming Figure of Merit for Radar Designers, by A. Mandell and W. G. Madison (p 28) A hand calculator for determining the cross-over point (the distance at which a radar target can be detected through jamming noise) of any radar.



April 15

Brushless Alternator (p 30) This dc-excited salient pole synchronous alternator has no brushes or slip rings; only rotating part is a smooth cylinder. (Bekey Electric Co.)

Broadband Microwave Amplifier (p 32) The Platinotron is a crossed-field vacuum tube used to generate microwave energy. (Raytheon Mfg. Co.)

500 C Insulator (p 34) Supramica 560, a moldable ceramoplastic insulating material, with stands 500 C ambient. (Mycalex Corp. of America)

Designing With Modular Enclosures (p 36) Involving no packaging development cost, modular cabinets also save time when used for prototypes to prove out a design.

Sweeping Power Supply (p 40) For general-purpose laboratory use with traveling-wave tubes, this supply delivers an exponentially increasing output with linearly increasing input. (Alfred Electronics)

Design for Service (p 42) Meeting report of the *Instrumentation and Control In the Process Industries* conference.

Transformer Design Nomograph—1, by M. Berger (p 44) An Iron Core Inductance nomograph is shown. It is intended to aid in designing small audio transformers and filter coils.

Ideas for Design (p 78) Hybrid Hi-Fi Amplifier; Convenient AC Outlets; Quick Hole Seal; Appearance Design.

What the Russians Are Writing (p 92) A review of developments published in recent Russian periodicals. (Avtomatika i Telemekhanika)

Stabilization With Temperature Compensated Thermistors (p 96) Above 10 cps a thermistor acts as a constant resistance, while below this frequency it has a zero or negative differential resistance. This sluggishness makes it suitable for stabilization purposes. (German Abstract)

Analog Correlation System (p 98) Designed to measure the degree of correspondence between two wave train wave pairs. Schematic, block diagram, and theory is given. (Abstract)

May 15

Cooling Packaged Electronic Equipment—I, by A. Hay (p 22) Basic design principles of cooling and methods of natural air convection and metallic conduction are described and presented.

Relay-Operated Voltage Divider (p 26) High accuracy and reference standard stability is provided by this unit. (Julic Research Labs)

The Cryotron—A New Computer Device—By S. Parker (p 28) This computer element is small, light, and dissipates little power. A large-scale digital computer could be packed in 1 cu ft, dissipate one-half watt.

Direct Printed Circuits (p 32) Silver inks can be printed on virtually any material; circuits produced may have excellent flexibility and conductance characteristics. (J. Frank Motson Co.)

Oscillator Design Techniques Using Conductance Curves—by K. Pullen (p 34) Some notes on oscillator theory are given and design procedures for developing regenerative detectors and oscillators, Q-multiplier oscillators, RC oscillators, and 3 phase RC oscillators. An outline of the requirements for oscillator stability is presented.

Transformer Design Nomograph—II, by M. Berger (p 38) Used for computing the reactance of known components and the capacitance needed to tune a given inductance. Frequency limits between 60 and 400 cps.

Extra High Resistivity Potentiometer Wire (p 40) Resistances up to 1100 ohms per mil foot are possible using palladium-gold iron alloys (Baker and Co. Inc.)

Modular Instruments (p 42) Rack, stack and carry instruments are designed to be mounted or stacked without sacrifice of space, efficiency or performance. (Teletronics Lab, Inc.)

Miniature One-Shot Power Supply (p 44) An output of 28 v at 700 w is produced for 2 min by this miniature silver-zinc battery. (Frank R. Cook Co.)

Broadband Ceramic Klystron (p 44)—This reflex Klystron has ceramic insulation, a continuously variable output frequency from 1500 to 6000 mc. (Polarad Electronics Corp.)

Performance and Packaging of Modulators, by M. Zina (p 46) A review of the performance and packaging factors imposing limits on the design of radar modulators.

Rigidized Flexible Waveguide (p 50) Flexible waveguide can be rigidized by application of a paste-like compound which hardens into a strong, lightweight jacket. (Technicraft Labs, Inc.)

Determining Transistor Reliability, by B. Reich and H. Wood (p 52) This article compares the results of operating and non-operating life tests in an effort to reduce the problem of component over-specification.

Ideas for Design (p 112) Transistorized Sawtooth Amplifier; Surge Limiting Device; Simplified Potting; Three Bolts Do the Work of Four.

What the Russians Are Writing (p 130) Devoted to semiconductors and their applications in engineering; annotated table of contents of Radiotekhnika i Elektronika, August 1956. (Russian Translation)

A New Photocell for Infra-Red (p 134) This photocell uses a lead sulfide semiconductor whose resistance is proportional to infra red radiation. Characteristics given. (German Abstract)

Ionization Chamber Time Delay Relay (p 136) Use of an appropriately designed ionization chamber permits time delays up to several hours with a rather small capacitance. (German Abstract)

Transistors in a Reactor Field (p 138) Transistorized electronic equipment for use in a Nuclear field should take into account transient, semipermanent and permanent designing effects. (Abstract)

Transistorized Phase Discriminator (p 139) High sensitivity and temperature stability between +125 and -55C obtained with this device. Schematic given. (Abstract)

Portable Frequency Standard (p 140) Circuit schematics and general description of a compact frequency standard requiring only periodic connection to a commercial power line is presented. (Abstract)

Interference Control Through Design (p 142) Greater reliability, improved performance, longer life and less maintenance for any equipment will result from observing the design principles outlined. (Abstract)

Microwave Noise Generation (p 144) A good quality noise source useful for radar jamming and producing signal strengths of the order of 1 μ w per mc over a broad band is described.

June 1

Ferrites—1957 (p 20) The composition and material properties of ferrites are dealt with, along with an exposition of the various fields of application. Emphasis on rf-device cores, rectangular hysteresis loop toroids and broadband microwave devices.

Heater Voltage-Current Relationships, by A. Szilasi (p 24) Tube heaters act as nonlinear resistances; law governing this empirical fact is examined and discussed.

A Q-Probe for RF Monitoring, by R. Baer (p 26) A means of inspecting a transmitter modulator carrier by sampling the rf signal and displaying it on a scope is presented.

Blocking Oscillator Transformers (p 30) Miniature plug-in pulse transformers for use in NBS—"preferred" circuits have been developed. (Airpax Products Co.)

Modular Preferred Circuits (p 30) Twenty-three single tube modular circuits are provided in a kit, together with the NBS "Preferred Circuits Handbook." (Dale Boison Co.)



May 15

Design of Mixers Using Conductance Curves, by K. Pullen, Jr., (p 32) Diode, triode and multigrad mixer design using transconductance characteristics is exposed. Examples given.

Transformer Design Nomograph—III, by M. Berger (p 36) Intended for use in designing small audio transformers and filter inductances. Given two parameters of dc magnetizing force, number of turns or type core, the third may be found.

A High Input Impedance Transistor Circuit, by P. Anzalone (p 38) Presents a design method for increasing the obtainable input impedance orders of magnitude beyond that observed for conventional transistor circuits.

Developments in Printed Antenna Design, by J. McDonough, R. Malech, J. Kowalsky (p 42) End-fire and broadside arrays practical for microwave frequencies, using etching techniques.

Continuously Variable Coaxial Attenuator (p 46) An insertion loss of 1 db instead of 15 to 20 db for previous piston type models is obtained. (Douglas Microwave Co.)

Cooling Packaged Electronic Equipment—II, by A. Hay (p 48) Methods of cooling are presented, together with design data to aid in selecting the right method for a given application.

Ideas for Design (p 102) Modular Design with Printed Circuit Connectors; Dielectric Fluid; Electrostrictive Relay; Polyethylene Stabilized by Electron Bombardment; Fidelity in Miniature; Tube Fitting for Flexible Tubing; Filled Nylon Thrust Washers for Vertical Shaft Motors; Adjustable Parts Bin.

What the Russians Are Writing (p 118) Contents of Radiotekhnika i Elektronika No. 9, 1956; brief abstracts.

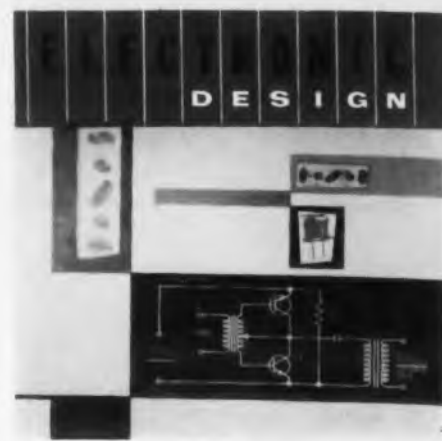
Amplifier Design with Simple HF Compensation (p 120) Pentode amplifier design, without making possibly erroneous assumptions concerning parameters. (Russian Abstract)

Classification of Crystal Oscillators (p 122) Crystal controlled oscillators as series or parallel resonant. (German Abstract)

Wobulator with Large Frequency Deviation (p 124) For the visual examination of amplitude characteristics of two terminal pairs. Large-frequency-swing wobulator development is described. (German Abstract)



June 1



June 15

June 15

Selecting Plastic Laminates, by Norman A. Skow (p 22) Aids to initial selection of plastic laminates with cost related to dissipation factor, dielectric strength, and water absorption.

Direct Coupled Transistor Logic Complementing Flip-Flop Circuits—I, by E. G. Clark (p 24) An investigation into building-block circuits utilizing direct-coupled transistor logic.

Vacuum Coaxial Relay (p 28) A high power coaxial transmission line switching relay which permits switching under full power up to 1100 mc. (Jennings Radio Mfg. Corp.)

Electronically Modulated Transistorized DC Amplifier (p 30) Modulated entirely by electronic means, this all-transistor dc amplifier uses no mechanical chopper. (Texas Instruments, Inc.)

Resistor Performance Levels, by Ralph Osche (p 32) Performance characteristics of general purpose composition resistors, deposited carbon film resistors, and the new pyrolitic film resistors.

3-D Printed Circuit Laminate (p 36) The first commercially available three dimensional molded and laminated printed circuit board. (Rogers Corp)

Basic Standards for Science and Industry—I, by R. Huntoon (p 38) A fundamental approach to basic standards.

High Power Silicon Transistor (p 42) A diffused-junction silicon transistor applicable to transistorized servo and audio output systems. (Texas Instruments, Inc.)

Transformer Design Nomograph—IV, by M. Berger (p 44) A nomograph useful for calculations of wire size and mean turn lengths.

Ideas for Design (p 106) Transistorized Amplifier Design; Low Speed Indicator; 10-Minute Etching and Anodizing Process; Felt Lubrication Seals.

What the Russians Are Writing (p 126) Annotated tables of contents of Radiotekhnika, Sept. 1956, and the October 1956 issues of Radiotekhnika i Elektronika, Avtomatika i Telemekhanika, and Elektrosviaz'. (Russian Translation)

Status of Special Purpose Tubes (p 134) A brief review of the major trends in special purpose tubes. (Abstract)

Temperature Limited Diode

RMS Detector

Type 1236C diode is designed for service as a rms detector for differential voltmeters; as a rms detector for ac voltage and current stabilizers, or as a detector for dc voltage and current stabilizers. It has a T9 bulb with a Bakelite base of the 8 pin locking-in type D8-1. Its average operating characteristics are a cathode voltage of 1.9 v ac or dc, 440 ma and a plate voltage of 600 dc, 0.7 ma dc.

The Superior Electric Co., Dept. ED, 83 Laurel St., Bristol, Conn.

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Pressure Lubricant

Bonds to Metal

Molykote, Type GX, is a molybdenum disulfide lubricant with a strong affinity for bonding to metal without building excessive accumulation on the surface. In Type GX the maximum effectiveness of MoS_2 as an extreme pressure lubricant in a grease is achieved by increasing the total surface area of the molybdenum disulfide through a reduction of particle size. This permits a sharp reduction of the MoS_2 content.

The decrease in particle size brings more molybdenum disulfide in contact with the metal while the reduction in solid content minimizes excessive surface accumulation.

The Alpha Molykote Corp., Dept. ED, 65 Harvard Ave., Stamford, Conn.

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Magnetic Tape

No Print Through

Layer-to-layer magnetic print-through has been reduced in order to cause no harmful effects during long storage. The reduction in print-through, amounting to 8 db as compared with present standard thickness tape, has been achieved without any change in the other characteristics, such as frequency range, signal-to-noise ratio, etc. Thus the tape is completely interchangeable on recording machines with standard tape.

Audio Devices, Inc., Dept. ED, 444 Madison Ave., New York, N.Y.

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CIRCLE 69 ON READER-SERVICE CARD ➤

F-I-a-s-h!...from Transistor Center, U.S.A.

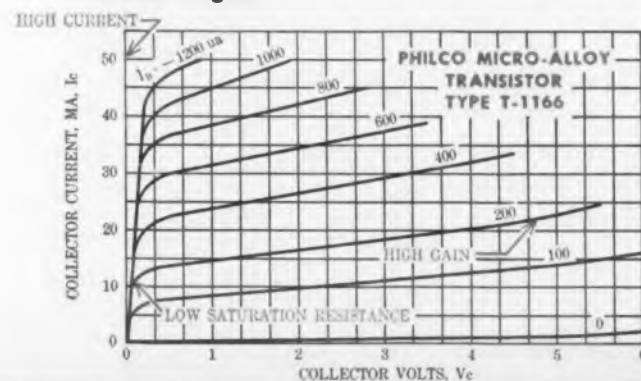


Announcing a new transistor class... The PHILCO Micro-Alloy Transistor (MAT)*



CHECK THESE UNEQUALLED FEATURES

- Excellent High Speed Switching characteristics.
- Low Saturation Voltage (low impedance)
- Excellent high frequency amplification.
- Excellent low-level amplifier over entire frequency range from D.C. to Megacycles.
- Exceptionally Long Life (hermetically sealed)
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...world's first production transistor with exceptionally high frequency and high gain... plus low saturation resistance!

This newest development from Philco Transistor Center features the characteristic high frequency response obtainable with extremely precise base width control. Designed for low voltage operation, the new MAT transistor is especially well suited for high speed applications where low saturation resistance (reduced power consumption) is necessary.

To combine high gain at high currents with high frequency response, the new MAT transistor employs a gallium doped alloy junction for the emitter electrode.

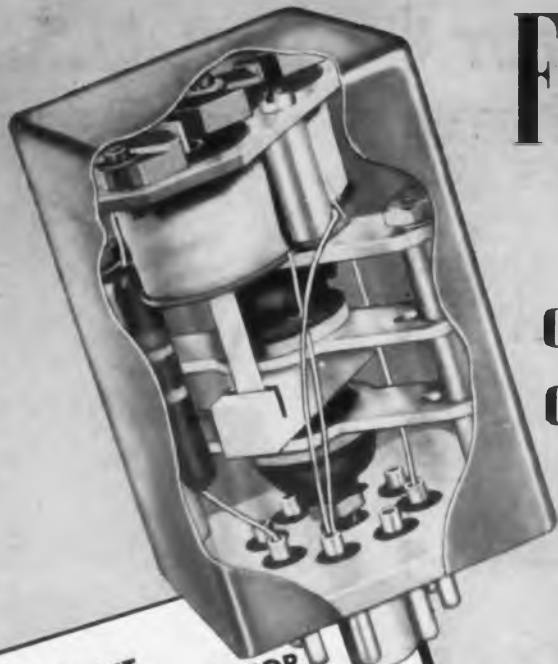
A special short-alloying cycle, combined with precise electro-chemical production techniques (pioneered and developed at Philco Transistor Center for production of SBT), results in the micro-alloy contact for exceptionally high injection efficiency. This new process assures higher gain, and permits operation at higher current. Beta linearity is excellent over the entire range of operating currents... up to 50 milliamperes.

● Write for complete information and specifications. Make Philco your prime source of information for high frequency transistor applications.

*Patent Applied For

Visit The Unique Philco Transistor Display at WESCON Show, San Francisco Cow Palace, August 20-23, Booth #2217-2218.

PHILCO CORPORATION
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LANSDALE, PENNSYLVANIA



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OSCILLATOR CONTROLS

FEATURES

- High accuracy
- Stability of frequency control
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- Infinite service life
- Integral, sealed, magnetically shielded
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CIRCUIT COMPONENTS FOR
ELECTRIC OSCILLATORS
MAINTAIN OSCILLATOR
OUTPUT FREQUENCY
WITHIN CLOSE LIMITS
ALSO USED AS
ELECTRO-MECHANICAL
BANDPASS FILTERS

APPLICATIONS

- Electrical and Acoustical Measurements
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- Remote Operation and Supervisory Control of Machinery and Apparatus
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Frahm Oscillator Controls, Type ROC, make possible the design and construction of inexpensive, precision tone generators that are small and light weight. These generators will have accurate output frequency and output voltage with very nearly sinusoidal wave shape.

They can be made with any one nominal control frequency between 20 and 1100 cps. They will control the output frequency of circuits, under specified conditions, constant within $\pm 0.15\%$ of the nominal control frequency.

We particularly encourage your inquiries and correspondence on special applications and problems. If you haven't explored these Frahm Oscillator Controls we'll be glad to send you complete specifications, characteristics, etc. Write for Bulletin 34-ED.

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New Products



**Temperature
Transducer**
Glued to Surface

A surface-temperature transducer accurate between at least -320 and $+950$ F consists of a woven grid of fine platinum wire. It can be attached easily to any surface with a special dielectric cement, with the grid interstices providing good mechanical interlock. Purchasers can specify a 100 ohm change or more over an assigned temperature span of 100 to several hundred degrees. The device has a high thermal mass because of the grid design, and thus can follow rapid temperature transients closely. To go with the transducer, a lead tape composed of strands of fine silver woven into porous glass has been developed. It can be attached to surfaces with the same cement used for the transducer itself. The tape is available with either two or three conductors.

Charles Engelhard, Inc., Dept. ED, 850 Passaic Ave., East Newark, N.J.

CIRCLE 56 ON READER-SERVICE CARD FOR MORE INFORMATION



**Variable
Transformer**
Isolated Secondary

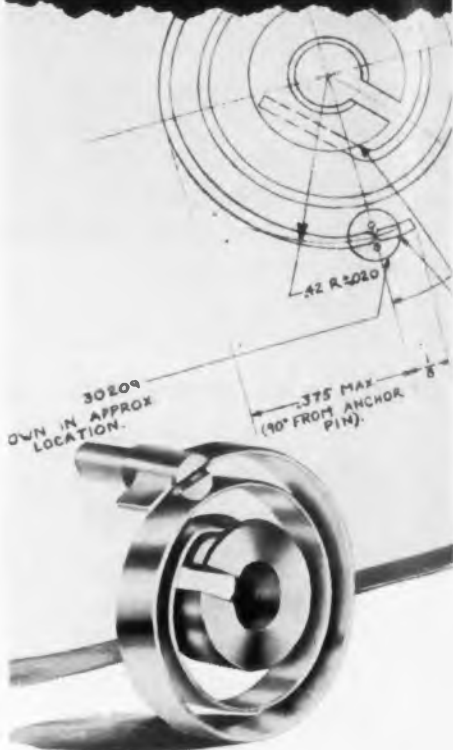
Variable transformer type LW136 is a double wound assembly with an isolated secondary on a single core. The absence of an electrical linkage between the windings permits connections for its use as a source of adjustable low voltage output, a limited range line corrector or a limited range buck-boost variable transformer. The primary consists of two windings arranged for either parallel or series connection.

Any single phase unit can be connected for either 120 or 240 v, 50 to 60 cps input and can be used as a source of 0 to 30 v isolated output, as either a 120 or 240 v line corrector, or as a 120 or 240 v limited range buck-boost variable transformer.

The Superior Electric Co., Dept. ED, 83 Laurel St., Bristol, Conn.

CIRCLE 57 ON READER-SERVICE CARD FOR MORE INFORMATION

RIGID SPRING SPECS?



We're used to them here at John Chatillon & Sons. Specifications calling for incredibly close tolerances and little-known alloys are capably met by experienced hands and brains.

When the machinery you design calls for precision springs seemingly not available, consult with the Spring Engineers at John Chatillon & Sons. You'll save time, and get springs designed for your most exacting needs.

Over 120 years of experience and training await your call. Get into the habit of contacting Chatillon... Write Department D-3.



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Manufacturers of Precision Springs and
Force Measuring Instruments Since 1835.

CIRCLE 58 ON READER-SERVICE CARD

Coaxial Line Filters VSWR of 1.06

These filters offer the following features: They have a vswr averaging less than 1.06 over the band, with maximum insertion loss on reject band (over 40 db) and minimum insertion loss in the band pass frequencies. To preserve contact integrity and longevity of corrosion resistance, precious metal plating is employed.

General Bronze Corp., Dept. ED,
Stewart Avenue, Garden City, N.Y.

CIRCLE 59 ON READER-SERVICE CARD

Diode Mount High Voltage

Type CS-84 diode mount, is designed for reliable operation at high voltages and altitudes. It is available in four internal thread sizes ranging from 6-32 to 1/4-28 to accommodate various makes of stud-type silicon diodes, rectifiers, and power transistors. Other thread sizes are available on order.

The mount consists of a copper-alloy body, terminal lug, and insulating sleeve brazed into one piece. The entire chassis serves as the heat sink, resulting in an overall thermal drop of approximately 1 C per w. Voltage rating is 1500 v at sea level.

Raytheon Manufacturing Co., Dept. ED, Ceramic Sales, Waltham 54, Mass.

CIRCLE 60 ON READER-SERVICE CARD

Finish Remover For Epoxy Resin

Epoxystrip is an all-purpose finish-stripper. Tests prove it will remove paint, lacquer, enamel, and many other finishes from various metal surfaces, and is especially formulated to work on epoxy-resin finishes. After 20 sec following application, the treated epoxy-resin swells and pops off. It can be then flushed away with water. The metal surface is left clean and, after drying, is ready for refinishing. It does not remove or damage the bonderizing or phosphate coating.

Beck Equipment Co., Dept. ED,
3350 West 137th St., Cleveland 11,
Ohio.

CIRCLE 61 ON READER-SERVICE CARD

CIRCLE 62 ON READER-SERVICE CARD

The Design Engineer's

STRONG RIGHT ARM!

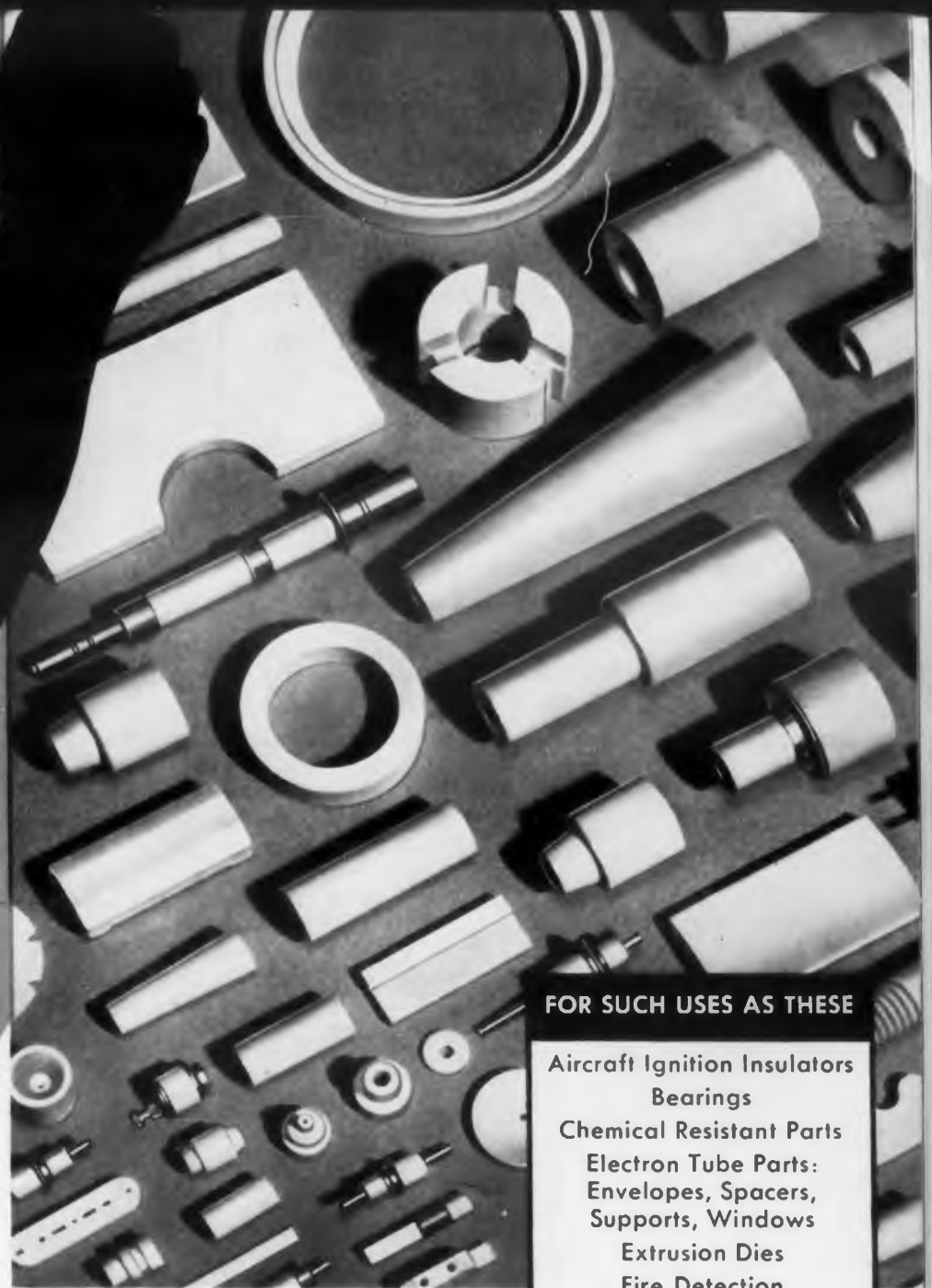
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No. 576 and No. 614

Industry endorsed. For demanding mechanical and electrical applications: AlSiMag 576 is strong, versatile, economical; AlSiMag 614 offers even greater strength plus valuable low loss factors. Many more special purpose AlSiMag Aluminas available.

Important physical advantages: Sapphire hard (9 on Mohs' scale). Permanently rigid. Abrasion resistant. Chemically inert. Vacuum tight. High compressive, flexural, tensile strengths. Uniform. Resists chipping and spalling. Held to precision tolerances.

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Parts shown approximately 1/2 size.

Metal-ceramic combinations: Large-scale metalizing facilities . . . high or low temperature. Custom and standard designs in any volume. Advanced techniques. Permanent bonding.

Prototype Service available: Test your designs under actual operating conditions . . . without investing in production tooling!

Prompt shipment in any quantity! For complete information on AlSiMag parts in the Alumina material best suited for your application, send blueprint or sketch with details of operation.

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for Jet Engines,
Rockets, etc.
Mounting Plates
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Pump Plungers
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and Supports
Thermocouple Tubes
Wear Plates and Guides
Work Holding Devices

A Subsidiary of
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56TH YEAR OF CERAMIC LEADERSHIP

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New Products

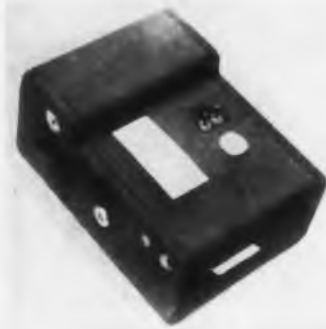


Voltage Adjuster
Both Up and Down

The Model LVB-10 has a 250 w, 100 to 130 v 50 60 cps rating. It has a 4 position switch with 10 v boost; 10 v drop; straight through; and off positions. Finish is oven baked. The unit has a size of 3 x 3 x 3 in. in a weight of 2 lb.

Microtran Company, Inc., Dept. ED, 145 E. Mineola Ave., Valley Stream, N.Y.

CIRCLE 50 ON READER-SERVICE CARD FOR MORE INFORMATION



Gyro Drift Recorder
Drift and Random Only

The Model 2249 recorder is capable of detecting and recording with accuracy the minute increments of drift characteristic of high-precision gyros. The machine ignores Scorsby motion, dither, and other cyclic motions, while remaining highly sensitive to drift and random disturbances. The recorder provides a permanent record of the mean shaft position of any mechanical device that is subject to a gross symmetrical motion, such as Scorsby oscillation, dither, or sustained vibration. The pen motion is deliberately limited to a rate of 2 deg per min, resulting in an accurate plot of mean position, including low velocity relative motion, while ignoring cyclic motional velocities of unlimited amplitude, occurring at rates as low as 1 cy per min.

A 10 deg sector of shaft rotation is plotted across 2 in. of chart width. The chart is pulled past the pen at 12 in. per hr. The standard model is fitted with a synchro ct input device, compatible with any standard 26/11.8 volt 400 cycle synchro shaft pickoff device. The recorder can easily be adapted to work with other than synchro data pickoffs. About 2 va at 16 to 28 v, 400 cps nominal, is required for the reference input.

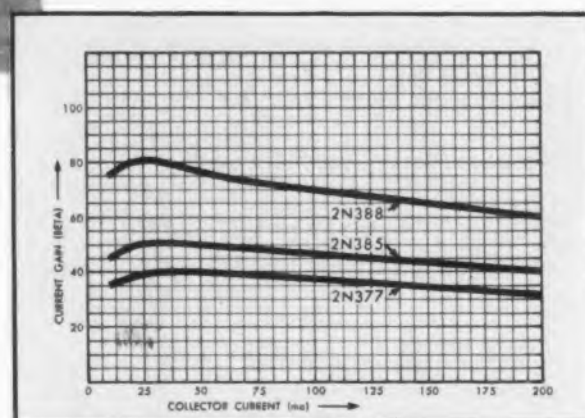
Lear Inc., LearCal Div., Dept. ED, 3171 South Bundy, Santa Monica, Calif.

CIRCLE 51 ON READER-SERVICE CARD FOR MORE INFORMATION

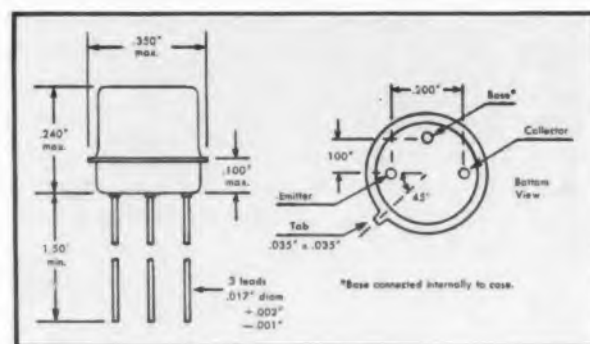
New Computer

Types 2N 377....2N 385

*Stability during life
sets new standard for reliable use*



Typical current gain vs. collector current



Triangular basing arrangement of the new computer transistors lends itself to printed circuit board insertion and dip soldering techniques.

New Sylvania NPN germanium alloy junction transistors, types 2N385, 2N377 and 2N388, are specifically designed for computer use. Higher, more constant beta over a wide range of operating conditions and fast switching time make the new Sylvania units ideal for computer and switching applications. They meet environmental tests typical of those required in military applications. In addition, the new Sylvania computer transistors meet RETMA size group 30 dimensions.

The outstanding characteristics of the new Sylvania transistors have been achieved in two ways—by new non-symmetrical design and by additional production steps. The optimum size relationship between emitter and collector has been determined for superior collector efficiency. This inherently better design is stabilized in production by carefully controlled surface treatment.

New Sylvania techniques are not only responsible for higher beta in the 2N385, 2N377 and 2N388 but for more constant beta at changing current levels. In addition, the design of the three types significantly improves leakage stability. Total dissipation is conservatively rated at 150 mw with ambient temperature at 25° C.

Thus, new and greater stability and reliability for computer and switching operations are built into these latest transistor developments from Sylvania. Call your Sylvania representative for further information.

“Sylvania—synonymous with  Semiconductors”

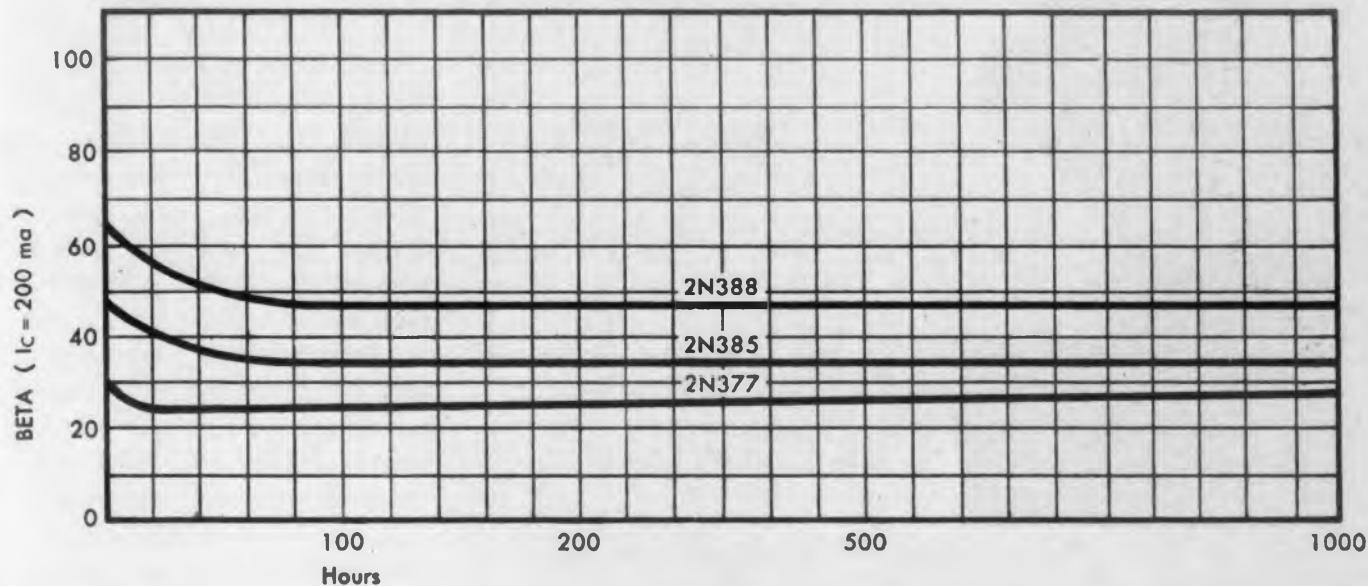
CIRCLE 52 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistors

.... 2N 388



1,000-hour evaluation of the new Sylvania transistors at 100° C shows a new high in beta stability throughout the test after a small initial change.



Typical Characteristics (25°C)

	2N385	2N377	2N388
Collector Cut-off Current, I_{CO} $V_{CB} = 25.0$ emitter open	5 μ a	6 μ a	6 μ a
Emitter Cut-off Current, I_{EO} $V_{EB} = 15.0$, collector open	5 μ a	6 μ a	6 μ a
Current gain, B $V_{CE} = 0.75$, $I_C = 30$ ma	60	40	80
Current gain, B $V_{CE} = 0.75$, $I_C = 200$ ma	45	30	60
Frequency Alpha Cut-off, $F_{\alpha CO}$ $V_{CE} = 5.0$, $I_C = 10$ ma	6.0 Mc	4.0 Mc	8.0 Mc
Collector Current $I_C (-5, 10K)$ $V_{CE} = 20$ V, $R_{BE} = 10K$, $V_{BB} = -5V$	10 μ a	10 μ a	10 μ a
Storage or junction temperature	100° C.	100° C.	100° C.



SYLVANIA

SYLVANIA ELECTRIC PRODUCTS INC.
1740 Broadway, New York 19, N. Y.
In Canada: Sylvania Electric (Canada) Ltd.
Shell Tower Bldg., Montreal

LIGHTING • RADIO • TELEVISION • ELECTRONICS • ATOMIC ENERGY

CIRCLE 52 ON READER-SERVICE CARD FOR MORE INFORMATION

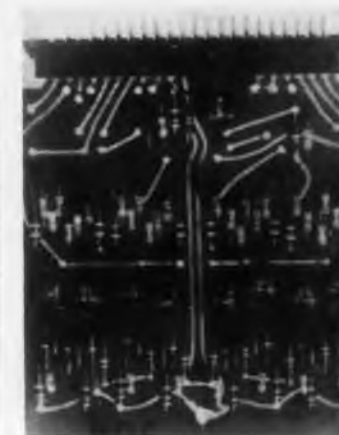


Speed Reducers Interchangeable Parts

This in-line series of speed reducers, designated StraitLine, is available in double and triple reduction. Double reduction units are offered in 15 standard ratios from 3.39:1 to 57.3:1 with ratings up to 100 hp. Triple reduction units are available in nine ratios from 82.1:1 to 190.7:1 with ratings up to 50 hp. The reducers feature complete interchangeability of individual parts throughout frame sizes as well as packaged sub-assemblies.

Western Gear Corp., Dept ED, P. O. Box 182, Lynwood, Calif.

CIRCLE 53 ON READER-SERVICE CARD FOR MORE INFORMATION



Binary Decimal Counter

Maximum Speed 500 Kc

Model BDC-1 is a high speed transistorized counter. It utilizes a gated binary circuit reset to zero on the count of 10. The unit is packaged as a printed circuit card with input, output and reset available. Accessory cards are available for readout and preset. The counter cards may be used in multiple, each driving a succeeding stage from its output. Each printed circuit card together with its components measures 4-1/2 x 5 in. mounted on 5/8 in. centers. A 22-pin printed circuit connector is provided.

Power requirements are 12 v at 14 ma, 6 v at 1.4 ma and -12 v at 1.8 ma. Total power consumption per card is 0.2 w. Maximum speed is 500 kc. A 5 to 8 v negative pulse with a one-half μ sec rise time produces a 5 v square wave at the output. The counter may be reset to zero by opening the reset lead. It may be preset electronically or manually to any number.

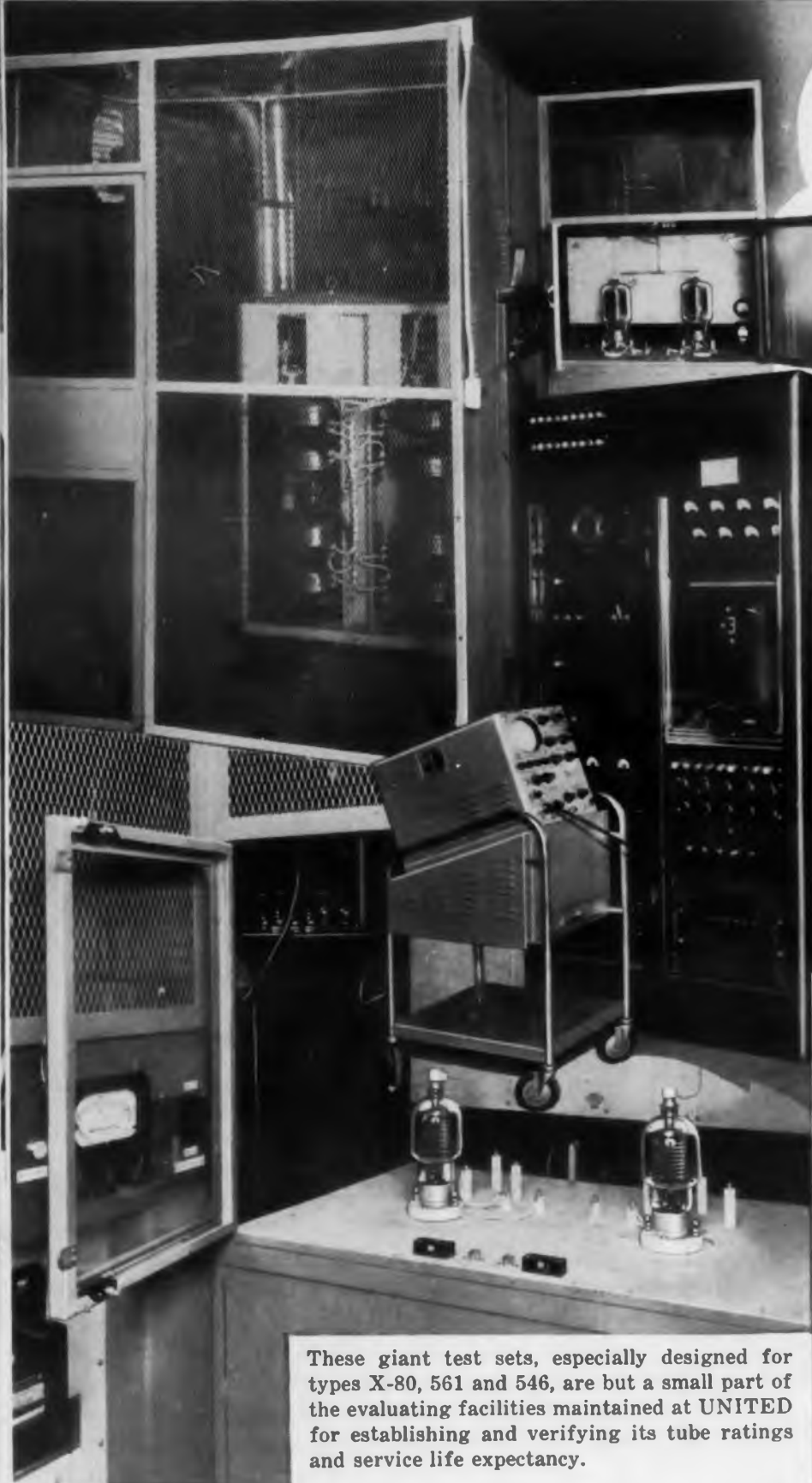
Ransom Research, Dept. ED, P.O. Box 382, San Pedro, Calif.

CIRCLE 54 ON READER-SERVICE CARD FOR MORE INFORMATION



UNITED ELECTRONICS

TUBES FOR RADAR MEGAWATTS



These giant test sets, especially designed for types X-80, 561 and 546, are but a small part of the evaluating facilities maintained at UNITED for establishing and verifying its tube ratings and service life expectancy.

Type	Code	Filament		epx kv	Anode ib	Ib A	Maximum	
		Vac	Aac				Length"	Diam."
X-80	A	11.5	15.25	40	2.5	.700dc	9 1/4"	3 3/8"
	B	12.2	15.5	33	50	1.25ac		
546	A	11.5	63.0	35	8.1	2.6dc	12 3/4"	6 1/4"
	B	12.2	65.0	35	150	5.2ac		
561	A	11.5	15.25	33	2.7	.860dc	9 3/4"	3 3/8"
	B	11.5	15.25	33	50	1.25ac		

CODE: (A) RECTIFIER (B) CLIPPER DIODE

The enormous power these high vacuum diodes deliver is explained in part by the superior combination of graphite anode and bonded thoria emitter techniques. Only UNITED ELECTRONICS, because of its singular mastery of these related processes, has accomplished in high vacuum thermionic tubes the high peak energy in small unit sizes such as represented by these paragons of our Major Series.

WRITE FOR DETAILED DATA BULLETIN CDB-2.

UNITED  ELECTRONICS, 42 Spring Street, Newark 4, N. J.

Infrared Detector

Sensitive to 7 Microns

An infrared detector is available which is sensitive to seven microns and has a time constant of less than one μ sec. Operating without the need for cooling or bias voltage, the detector has a noise equivalent power of about 0.001 μ w.

Radiation Electronics Corp., Dept. ED, 8241 N. Kimball Ave., Skokie, Ill.

CIRCLE 72 ON READER-SERVICE CARD

Microwave Absorbing Materials

99 Per Cent Absorption

One of the two classes of these materials is wide band, while the other utilizes the interference principle. Both feature low reflectivity and high absorption at centrimetric wavelength. The absorbing materials, developed for S and X band frequencies, are fabricated of loaded rubber sheets bonded to brass gauze. AF 10 and AF 11 broadband dielectric materials are for use over the frequency range of 2500 to 50,000 mc with 99 per cent power absorption. M materials are backed with perfect reflectors and have a power absorption of 99.5 per cent.

Gulton Industries, Inc., Dept. ED, 212 Durham Ave., Metuchen, N.J.

CIRCLE 73 ON READER-SERVICE CARD

Cleaning Solvent

No Damage to Surface

SS-25 solvent has no flash at the boiling point and is a safe replacement for many inflammable petroleum solvents. It is corrosion free, leaves no residue, safe for all surfaces, and has never been found to contribute to dermatitis.

It is recommended for cleaning and degreasing electric motors, parts and components. SS-25 will not harm rubber or enamel insulation, and may be applied to any surface or part by a sprayer, either hand or air, by a brush, or by wiping with a soft saturated cloth.

National Disinfectant Co., Dept. ED, 2417 Commerce St., Dallas, Tex.

CIRCLE 74 ON READER-SERVICE CARD

← CIRCLE 71 ON READER-SERVICE CARD

F

R

E

E

SAMPLES

of **silicone rubber parts**
mass produced at low cost

Here's an easy way for you to inspect and test the outstanding properties of silicone rubber. Here's a quick and simple method of checking the close-tolerance production of a growing silicone fabricator—to help you judge quality and skill. Samples of silicone rubber O-rings, miniature and sub-miniature parts will be forwarded to you without cost or obligation.

Free quotation quickly made from your sample or blueprint

To help you overcome design problems, our engineering staff and experience are at your disposal. To assist you in meeting production deadlines and quality standards, we offer the finest facilities for fast mass production with highest uniformity. Compound selection and molding to meet your exact specifications are also available. Why not write today for your free samples or quotation, no obligation, of course.

MINNESOTA SILICONE RUBBER CO.

5724 W. 36th St., Minneapolis 16, Minn. Dept. 313

Affiliated with Minn. Rubber & Gasket Co.

Offices in principal cities.

CIRCLE 75 ON READER-SERVICE CARD



DC to AC Power Supplies
One and Three Phase

These transistorized units produce up to 250 va from 28 v dc input, and custom units are available for up to 2 kva output. Units can be made to meet MIL specs, and can be as compact as 2/3 cu in. per va and as light as 1/2 oz per va. Typical of the series is model UAC 100 va/115-1000 which delivers 100 va (100 v ac, 1000 cps at 1 amp), weighs 3-1/2 lb and comes in a 3-29/32 x 3-11/32 x 5-7/32 in. package. Dc to 3-phase ac units are available for special applications.

Universal Transistor Products Corp., Dept. ED, 143 East 49th St., New York 17, N.Y.

CIRCLE 76 ON READER-SERVICE CARD FOR MORE INFORMATION



30 Oz AC Voltmeters

3 to 5 Per Cent Accuracy

These transistorized instruments measure 3-1/4 in. wide x 5-1/4 in. high and weigh 30 oz. Known as the D-21 series, the three voltmeters provide coverage, respectively, of the frequency ranges 10 cps to 1 mc, 5 cps to 500 kc, and 10 cps to 500 kc. Accuracy is better than ± 3 per cent throughout most of range, and within ± 5 per cent full range. Readings from 1 mv to 300 v are available full scale; readings may also be made with accuracy down to 50 uv. Battery power plus high internal impedance insures low stray pickup and freedom from noise. The D-21 series voltmeters employ high alpha cut-off transistors. They may also serve as null indicators, broadband amplifiers, or sensitive ammeters when used with appropriate shunt resistors. For multiple-instrument installation, they are available in relay rack mounts containing from two to five voltmeters mounted side-by-side.

Alto Scientific Co., Dept. ED, 855 Commercial St., Palo Alto, Calif.

CIRCLE 77 ON READER-SERVICE CARD FOR MORE INFORMATION

WINCHESTER ELECTRONICS, INC.

Pioneering Specialists in

CONNECTORS

CONTROLLED
HIGH QUALITY
SINCE 1941

QUALITY Control in the manufacture of electrical and electronic Connectors is an original concept rigidly adhered to by Winchester Electronics since this company received the first of many patents honoring its "original" art. This Quality Control, from design inception to final assembly of all its critical parts, assures you of the unqualified reliability of every Winchester Electronics Connector delivered to you.

Specializing *exclusively* in Connectors, Winchester Electronics' many patents . . . and numerous other original designs . . . are the product of continuous research, development of sound ideas . . . and broad experience!



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WINCHESTER ELECTRONICS, Inc.
PRODUCTS AND DESIGNS ARE AVAILABLE
ONLY FROM . . .

WINCHESTER ELECTRONICS
INCORPORATED
NORWALK, CONNECTICUT

West Coast Branch: 1218 Fifth Street, Santa Monica, Calif.

CIRCLE 78 ON READER-SERVICE CARD FOR MORE INFORMATION



George L. Larse (right), Group Engineer, Instrumentation and Development, discusses development of high performance FM sub-carrier oscillators for application in advanced telemetry systems with Electronic Research Engineers Hans Becker (left) and Jay Cox.

ELECTRONIC SYSTEMS FOR GUIDED MISSILES

Continuing advances in guided missiles require electronic systems possessing ever faster, more accurate perceptions and reactions. Problems faced by missiles engineers and scientists grow constantly in magnitude and complexity.

At Lockheed Missile Systems Division, Electronic Systems and Components Engineers receive the broadest possible responsibility in fulfilling their assignments. New activities have created positions in a wide range of areas, including:

- Command guidance involving development and application of radio frequency communication, pulse circuitry and control devices.
- Data transmission and telemetry involving development and application of antennas, transducers, VHF transmitters and receivers.

- Automatic data processing equipment requiring analog-to-digital conversion, and electronic and magnetic storage devices.

Positions are open on Lockheed's Palo Alto, Sunnyvale and Van Nuys Staffs. Those possessing a high order of ability in both systems and component development are invited to write. Please address the Research and Development Staff, Palo Alto 22, California.

Lockheed

MISSILE SYSTEMS DIVISION
 LOCKHEED AIRCRAFT CORPORATION
 PALO ALTO • SUNNYVALE • VAN NUYS
 CALIFORNIA

New Products

Record-Reproduce Heads

Wide Range Available

Originally developed for use with the company's magnetic recording systems, ET200 Magnetic Recording Heads are offered in a broad range of electrical and mechanical characteristics. Typical of the ET200 line is the Type 2A Head, with an inductance of approximately 500 mh and a resistance of 200 ohms. Gap width is 0.00025 in.; the head has a track width of 0.05 in. Type 2A Heads measure 0.656 x 0.77 x 0.125 in. The heads are available either singly or in multiple-head blocks. They can be permanently imbedded or made individually replaceable. All heads are vacuum impregnated and potted in epoxy resin. Shielding is of Mumetal.

Electrodynamic Instrument Corp., Dept. ED, 2508 Tangley Road, Houston 5, Tex.

CIRCLE 80 ON READER-SERVICE CARD

Mounted Paper

For Durable Drawings

For drawings that are subject to frequent handling or alteration over a period of years, Stabilene opaque drawing film combines a high-grade paper with a muslin backing. Tear strength, durability, flexibility, and flatness, are some of its qualities. In addition, the film is fully resistant to moisture, where paper can be made only partly water repellent at best. The film will not smudge and can be wiped clean with a moist cloth. It has a dimensional stability of 0.000006 in. per in. averaged in both directions for temperatures from 80 to 220 F. and in the range from 0 to 98 per cent relative humidity. It takes pencil and ink well without feathering, penetration, or ghosting, even after erasures have been made. Very hard degree pencils may be used.

Keuffel & Esser Co., Dept. ED, Hoboken, N.J.

CIRCLE 81 ON READER-SERVICE CARD

◀ CIRCLE 570 ON READER-SERVICE CARD



Relays 1 Mw per Contact Sensitivity

Sensitivity in this series, Types 101, 102, 103 and 104, can be adjusted to as low as 1 mw per contact and is available in combinations from spst to tpdt. The dust cover is made of impact extruded aluminum and is available either with the removable bayonet cover, pressure fit or crimped covers. Screwdriver adjustment can be made to change contact pressures, pickup and drop-out characteristics, or power requirements.

The relays are designed with a thorough wipe action on the contacts for self cleaning for good contact connections. Pickup and drop-out ratios can be made as high as 85 per cent or as low as 10 per cent. Coil resistance is standard up to 30,000 ohms, and special winding to 100,000 ohms. Contact capacity ranges from 3 to 5 amp resistive, depending on sensitivity. The relays are made for either dc or ac operation; ac relays are made with built-in rectifiers or diodes. Mounting is available in standard plug-in headers or with solder lug terminals. Tests have indicated the life of these relays to be well over 25 million operations with no evidence of fatigue or deterioration on the contacts.

General Automatic Corp., Dept. ED, 12 Carlton Ave., Mountain View, N.J.

CIRCLE 83 ON READER-SERVICE CARD



Load Isolator 8.2 to 12.4 Kmc

Model X-121, a broadband load isolator, operates within a frequency range of 8.2 to 12.4 kmc. Forward attenuation is 1.4 db max. Reverse attenuation at band edges is 20 db max. Vswr is 1.25 max. Power handling capability is 200 w average, 200 kw peak. The unit is 9-1/2 in. long over-all and weighs 5 lb. Input and output flanges are UG-39/U.

Cascade Research Corp., Dept. ED, 53 Victory Lane, Los Gatos, Calif.

CIRCLE 84 ON READER-SERVICE CARD

How to be a magnetic tape recording expert

Introducing a useful new brochure on tape in instrumentation

Tape is the stuff of which memories are made — the versatile data memories for a jet propelled age of electronic miracles. If you are one who keeps up with times and techniques, it is a field well worth knowing. This new brochure gives a wide-angle view of the whole subject.



Typical pages

What kinds of applications do you think of when magnetic tape recording is mentioned? Sound recording, of course, and telemetering, if you are in that business. But what about simulating a rough road to test truck axles, controlling a milling machine to cut an aircraft wing section out of a solid billet, monitoring for a sudden occurrence that may happen only once in a year or two, recording data that can be reduced to graphs and tabulations without ever being touched by

human hands? These and many more are described.

How significant is the fact that magnetic tape recording reproduces data in the same electrical form in which it was recorded? Enormously important, when you realize all the things the reproduced data can do that couldn't be done with the original signals or with the common forms of visual recording. For example the data can be slowed down to look at fast transients. It can be speeded up for wave analysis. It can be read out in any form. A tabular comparison between original signals and taped signals gives the full story. And a step-by-step pictorial demonstration of magnetic tape recording and reproduction puts the electrical-data idea into tangible, easily visualized form.

What does the data on magnetic tape look like? You can't see it, but the brochure will give you an idea of what it would be like if you could. And incidentally this may help to clarify the differences between various magnetic-tape-recording techniques.

Do you talk in tape's language? When is a tape recorder not a recorder? What is the difference between a channel and a track? What is a servo speed control? A much needed glossary gives the consensus of our views on terms.

For whom did we write this booklet... the expert, or the man for whom the whole subject is new? Both. It is written and illustrated so that any engineer or technically trained person can readily grasp the concepts and gain a broad understanding of the subject. If you are one of those who has already worked extensively with tape, you will find some new twists in the way the subject is explained, and perhaps ideas on new areas you hadn't explored. And incidentally, a copy of this brochure in some handy file will give you a good start in indoctrinating that new man in the department.



For your copy, write us today on your company's letterhead. Address your request to Department ZZ-5.

INSTRUMENTATION
DIVISION

AMPEX
CORPORATION

FIRST IN MAGNETIC TAPE INSTRUMENTATION

934 CHARTER STREET · REDWOOD CITY, CALIFORNIA

District offices serving all areas of the United States and Canada; Foreign Representatives in countries around the world.

CIRCLE 85 ON READER-SERVICE CARD FOR MORE INFORMATION

MAGNETIC
TAPE
APPLICATION
BY AMPEX

5

NO. 5



New Products

DC Power Supply

28 V DC Input



The REL-202 Power Supply transforms the standard 28 v dc aircraft power supply to high voltage dc. Transistors serve as switches to obtain a square wave ac which is stepped up through a toroidal wound transformer and then rectified to provide the dc output voltage. Output voltage and current from the connector, as determined by jumper position is +350 v dc at 110 ma, +300 v dc at 130 ma, and +260 v dc at 160 ma. Output power is 40 w, and ripple is less than 1.5 per cent. Regulations for load variations is 3.0 per cent, from 10 per cent to full load. Operating temperature range (no derating) is -35 F to +165 F.

Rheem Manufacturing Co., Dept. ED, 9236 East Hall Rd., Downey, Calif.

CIRCLE 87 ON READER-SERVICE CARD

Battery Connectors

Moisture Sealed

A moisture sealed, single pole battery connector has been designed for service up to 28 v dc at 300 amp. CA21986 receptacle is panel mounted and incorporates O rings for moisture seals on both sides of the panel and about the contact of the mating plug. The receptacle contains a bail latch that allows the plug to rotate 360 deg when mated and latched.

CA21985 plug incorporates a terminal lug for a no. 1/0 cable that is 90 deg to the contact. The socket terminal ends are designed for a no. 1/0 terminal lug.

Cannon Electric Co., Dept. ED, 3208 Humboldt St., Los Angeles 31, Calif.

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CIRCLE 89 ON READER-SERVICE CARD ►

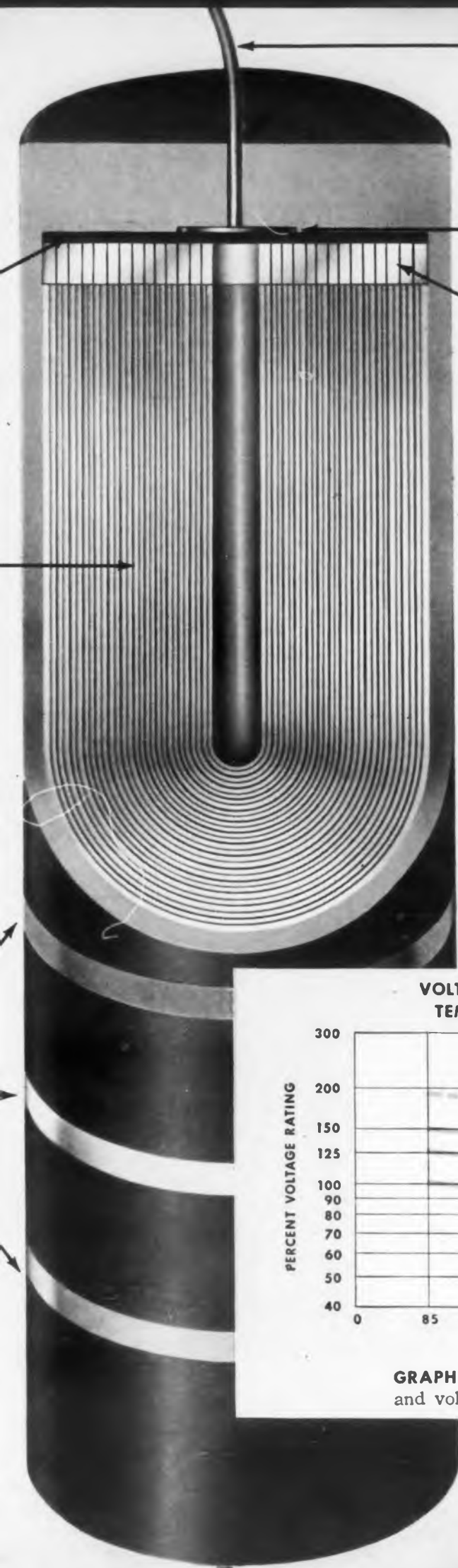


CAPACITORS

SOLDER

PAPER AND FOIL
WITH SOLID
IMPREGNANT

COLOR CODE



SOLDER-COATED
LEAD

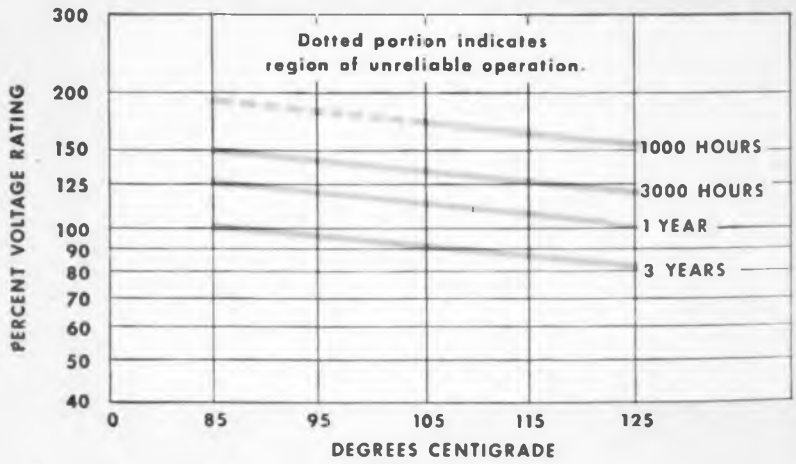
LEAD CONNECTOR

EXPOSED FOIL

COMPRESSION-MOLDED
PHENOLIC CASE

**CUTAWAY VIEW OF
PVZ CAPACITOR
ENLARGED 13 TIMES**

**VOLTAGE RATING VS LIFE AT ELEVATED
TEMPERATURE FOR 95% RELIABILITY**



GRAPH ABOVE shows outstanding temperature and voltage characteristics for 95% reliability.

Solve critical space and temperature problems with subminiature PVZ* capacitors

Low-cost molded units operate from -55 C to $+125\text{ C}$

Now immediately available for exacting applications in commercial and military electronic equipment, these molded paper capacitors meet performance requirements of Characteristic "E" for MIL-C-91A. General Electric's PVZ capacitors are priced substantially lower than comparable metal-clad tubulars. They are designed to operate for a minimum of one year at $+125\text{ C}$ with no voltage derating.

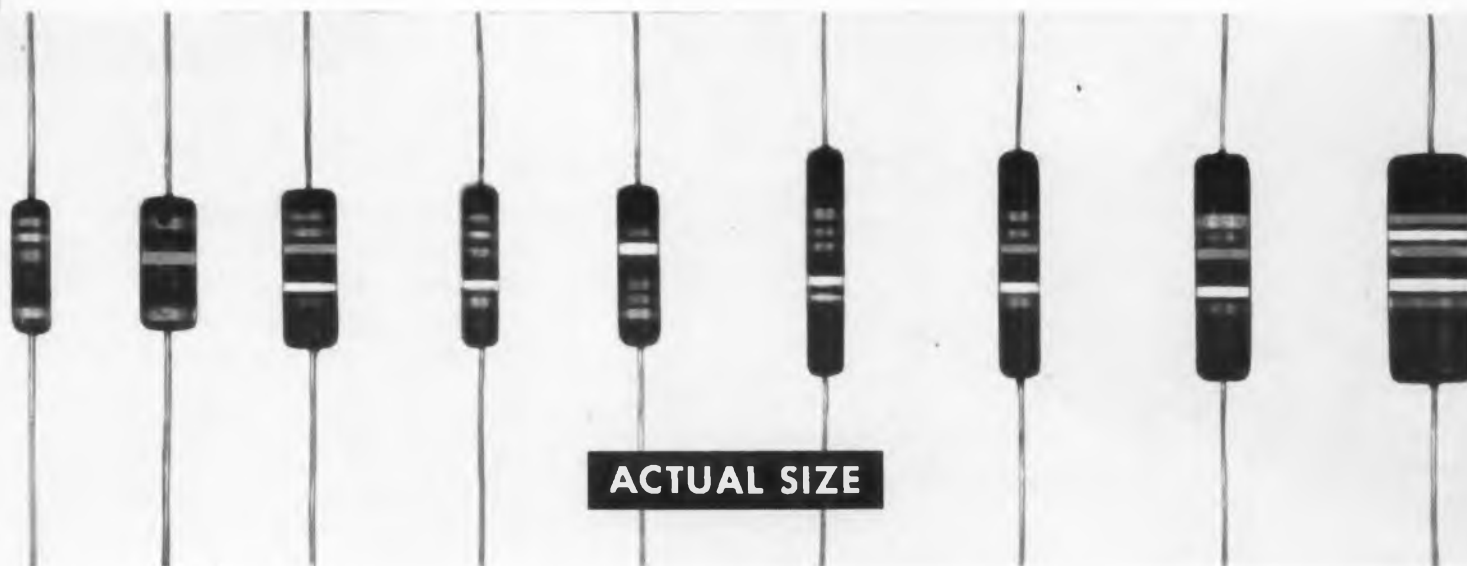
Completely solid after molding, PVZ capacitors feature the following advantages:

- small size
- excellent humidity resistance
- high lead-strength

- insulated body—solid impregnant
- high shock and vibration resistance
- color code for easy identification

General Electric PVZ capacitors are available at 100, 200, 300, and 400 volts. Microfarad ratings range from .00047 to .15.

If you need a capacitor with the characteristics described above, ask your General Electric Apparatus Sales Engineer about PVZ tubulars. He can give you expert application information. He can also arrange for immediate delivery of PVZ capacitors from factory stock in most ratings. For descriptive data write for bulletin GEC-1452 to General Electric, Section 447-2, Schenectady 5, N. Y. *Trademark of the General Electric Co.



PVZ CAPACITORS range in size from .175" diameter by .625" length to .375" diameter by 1.0625" length. Capacitance ratings are available with $\pm 20\%$, $\pm 10\%$, and $\pm 5\%$ tolerances. The color code indicates microfarads, volts, and capacitance tolerance.

Progress Is Our Most Important Product

GENERAL  ELECTRIC

Temperature Probe

0 to 1200 C



A miniaturized (.004 in.) high temperature resistance thermometer probe is capable of operation over a range of 0 to 1200 C. Probe allows measurement of high temperatures, by the resistance thermometer technique, in a small area. Utilizing a grid of extremely fine platinum wire welded to platinum lead wires, the probe is a flat grid temperature element wound on the end of a 1 mm tube. All temperature sensitive wires lie in one plane, giving grid resistance value of from 12 to 16 ohms at room temperature.

Arthur C. Ruge Assoc. Inc., Dept. ED, Cambridge, Mass.

CIRCLE 90 ON READER-SERVICE CARD

Fabric Reinforced Seals

Fluoro-Silicone Rubber

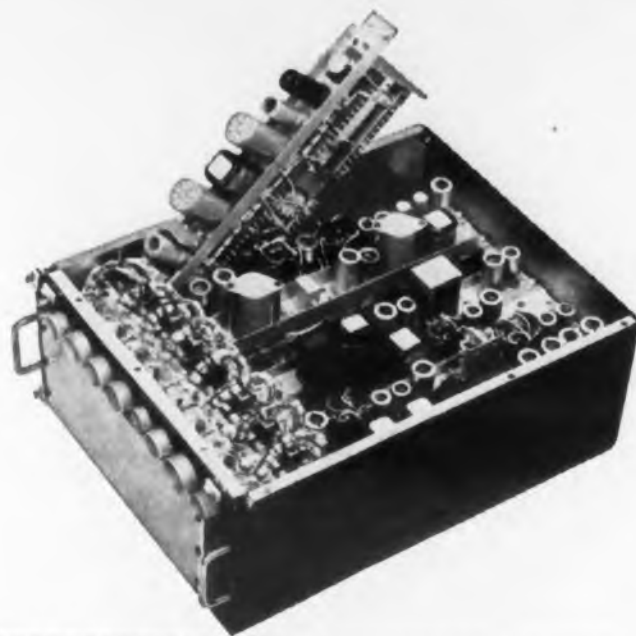
Fuel resistant, fabric covered and fabric reinforced seals for -65 to $+400$ deg F applications are being produced using LS-53, Dow Corning's fluoro-silicone rubber. The fabric covered seals provide high tear and abrasion resistance. The LS-53 fluoro-silicone rubber remains resilient, resists swelling and destruction by aviation fuel and synthetic oils at extreme temperatures. Although fluoro-silicone rubber costs considerable more than ordinary silicone rubber, fabric covered or fabric reinforced seal constructions provide the most practical and economical use of the rubber.

The Connecticut Hard Rubber Co., Dept. ED, 407 East St., New Haven 9, Conn.

CIRCLE 91 ON READER-SERVICE CARD

◀ CIRCLE 89 ON READER-SERVICE CARD

Problem:



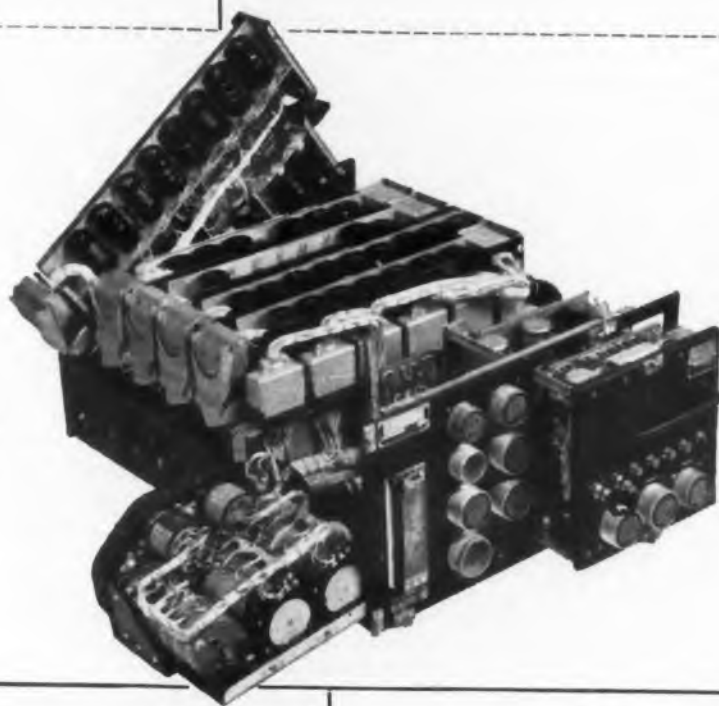
Redesign of an airborne analog computer to perform additional functions called for 20 per cent more parts—with no over-all increase in size, or change in form. At the same time, a high degree of reliability had to be maintained.

APPROACH TO RELIABILITY

Advanced radar fire control systems for military aircraft demand the highest degree of reliability under severe restrictions. These include quantity manufacturability, minimum size and weight, protection from shock and heat, serviceability, and exacting performance.

At Hughes, one objective of equipment design engineers is to maintain consistent essential performance of the systems while steadily improving reliability. Following is an example of accomplishment by Hughes engineers in this specialized area:

Solution:



By use of improved components, unique packaging techniques, and thorough environmental testing, Hughes design engineers were able to meet specifications and improve reliability as well. Result was that the new computer operated at mean internal temperatures in excess of 120°C and withstood shocks of 50 g's— as against 85°C and 30 g's for the original unit.

ENGINEERS experienced in the fields of product design, electronics packaging, miniaturization and component reliability will find outlets for their abilities in new advanced packaging and reliability problems.

VACATIONING IN SOUTHERN CALIFORNIA?
YOU ARE INVITED TO VISIT HUGHES

CIRCLE 571 ON READER-SERVICE CARD FOR MORE INFORMATION

HUGHES

RESEARCH AND DEVELOPMENT LABORATORIES
SCIENTIFIC STAFF RELATIONS
Hughes Aircraft Company, Culver City, California

New Products



Torque Motor
Unharmful by Stall
Current

Designed for tape recorder take-up reel drive and capable of withstanding stall currents continuously, the SR-89 has a nearly linear speed-torque curve to stall. No-load speed is 2150 rpm. Double shielded, factory lubricated ball bearings are used. It weighs 5-1/4 lb.

Dalmotor Co., Dept. ED, 1375 Clay Street, Santa Clara, Calif.

CIRCLE 95 ON READER-SERVICE CARD FOR MORE INFORMATION

Pulsed Power Source
Combined L- and S-Band



Model PC-52 pulsed power source utilizes a Federal X-6825 traveling-wave tube and an Eimac X-551E klystron. Either L-band or S-band power is obtained by switching a common high voltage pulser to one tube or the other. The Federal tube produces up to 200 w of pulse power over the band from 2.7 to 2.9 kmc. The Eimac tube produces 1.5 to 3 kw pulse power over the band from 1.25 to 1.365 kmc. Pulse lengths are variable from 2 to 10 μ sec at repetition rates from 200 to 450 cps.

System includes a built-in trigger generator capable of internal or external sync, a Maxson M1141 uhf power oscillator as the source of low level signal power, a Tektronix 315D oscilloscope for monitoring, a Hewlett-Packard 430C power bridge for power measurements, and both L-band and S-band directional couplers. Equipment requires about 4 kva of power from a 115-v, single-phase, 60-cps source.

Levinthal Electronic Products, Inc., Dept. ED, 758 Stanford Industrial Park, Palo Alto, Calif.

CIRCLE 96 ON READER-SERVICE CARD FOR MORE INFORMATION



Miniature DC Motors Durable Design

Designated Series 500, these precision-built motors are designed to resist shock, heat and cold. Nylon-molded commutator hubs, lead insulators, motor brush supports and governor mounting base resist vibratory fatigue and are self-lubricating. Six series, 100 to 600, of small dc motors have torque ranges from 0.3 to 3-1/2 in. oz and speeds varying from 1800 to 18,000 rpm, for 3 to 24 v usage. The 500 and 600 series motors are available with governors for constant speed applications.

Allied Chemical & Dye Corp., Barrett Division, Dept. ED, 40 Rector St., New York 6, N.Y.

CIRCLE 97 ON READER-SERVICE CARD FOR MORE INFORMATION



One Ton Strain Gage Total Excursion; 0.00035 In.

Measuring forces up to 2000 lb with a total excursion of 0.00035 in., these strain-gage force pickups are useful in measuring sudden forces applied to rigid physical structures such as rocket launching platforms and airframes. Either compression or tension forces may be measured, depending on how the instrument is mounted. The force pickups may also be used to test force-producing components such as solenoids. These pickups can measure initial solenoid output force as distinct from armature momentum. The pickups consist of a force probe, an unbonded strain-gage, and an electrical strain-gage connector built into a small cylinder. In operation, a pickup is mounted so that the force probe is in direct physical contact with the object under study. Linearity is within 0.5 per cent of full scale. Hysteresis is 0.25 per cent, maximum, full scale. Acceleration effects are limited to 0.005 psi per g. Temperature range is -65 to +350 F. Mounting threads are 1/2 in., no. 20. Units are constructed of stainless steel and weigh 2 oz.

Dynamic Instrument Co., Inc., Dept. ED, 28 Carleton St., Cambridge, Mass.

CIRCLE 98 ON READER-SERVICE CARD FOR MORE INFORMATION



HUGHES SEMICONDUCTORS

First of all, for reliability



RELIABILITY

WHAT IT IS. At Hughes, reliability is the probability that a device will give satisfactory performance during a specific period of time when used in the manner intended. And at Hughes, the probability is high, approaching certainty.

HOW HUGHES ACHIEVES IT. With meticulous consideration to every detail, Hughes has accumulated extensive knowledge of the semiconductor art, extensive knowledge of all the subtle and delicate, yet critical, factors involved. To *really* know is essential. Then, and only then, reliability becomes an automatic result—built into every unit.

HOW HUGHES MAINTAINS IT. Hughes Quality Control is the “watchdog,” checking and rechecking every phase of production on a carefully regulated statistical basis. This extensive effort ensures prompt discovery of any variation which might affect the ultimate quality—and the *reliability*.

HOW YOU OBTAIN IT. Specify Hughes, for the greatest possible assurance. For additional information, please write:

SEMICONDUCTOR DIVISION
HUGHES PRODUCTS

International Airport Station, Los Angeles 45, California

*Creating a
new world
with
ELECTRONICS*

HUGHES PRODUCTS

HUGHES



SEMICONDUCTORS

New Hipermag* cores...

now up magnetic amplifier yields 35%

All core sizes in stock, delivery immediate

A large eastern manufacturer reports Westinghouse Roberts-tested Hipermag cores have increased Magamp* yields from 70% to 95%. Here are just three of the many reasons why.

- All the quality in Hipermag cores is proved out with the exclusive Westinghouse Roberts dynamic tester. This test provides four values actually measuring magnetic properties of cores under simulated amplifier conditions. Test values are equivalent to final core performance in your finished reactor.
- Westinghouse Hipermag toroidal cores are wound with Hipernik® V. Hipernik V is a highly oriented iron nickel alloy of exceptional temperature stability, high remanence and low coercive force, making these cores ideally suited to high-quality saturable reactors.
- For especially high shock resistance, cores can be hermetically-sealed, and their rugged nylon or aluminum cases filled with a Westinghouse-developed silicone oil. Prevents core damage. Minimizes magnetic change due to strains, pressure, shock or vibration. Provides foolproof protection when reactors are vacuum impregnated, encapsulated or resin treated.

A Westinghouse Hipermag specification will give you perfectly matched, quality cores in abundance—all sizes are in stock for delivery today! Also available in a full range are Hipersil® and Hiperthin* cores. Call Westinghouse Electric Corporation, or write Specialty Transformer Department, P. O. Box 231, Greenville, Pa.

*Trade-Mark
J-70797

YOU CAN BE SURE...IF IT'S

Westinghouse



CIRCLE 100 ON READER-SERVICE CARD FOR MORE INFORMATION



New Products

Variable Delay Line

50 μ Sec Range



Model 103-10R provides for 50 μ sec delay with 10 fully adjustable outputs. The closest pickup separation is 0.75 μ sec, and the minimum pulse transmitted is 0.05 μ sec. With a 1 μ sec input pulse, attenuation is 45 db. The unit measures 1-3/4 x 19 x 4-1/4 in. back of panel.

Delttime, Inc., Dept. ED, 608 Fayette Ave., Mamaroneck, N.Y.

CIRCLE 101 ON READER-SERVICE CARD FOR MORE INFORMATION



Motor Generator Miniature 400 Cps Supply

The Dalmotor MG-146 is 7-3/4 in. long over-all, 4-1/4 in. high, 4-5/8 in. wide and weighs 7 lb 5 oz. It is a two-bearing machine consisting of a dc motor and an alternator utilizing a common shaft. The unit delivers 100 va, 400 cps, at 115 v continuously. Output termination is a three phase Y with one leg grounded. Maximum harmonic distortion is less than 3 per cent. The MG-146 draws 7 amp at full rated load with input voltage at 28 v. Output voltage is maintained within ± 7.5 v and remains within ± 8 cps of 400 cps, with input varying between 25 and 29 v. The unit will deliver up to 200 va, twice its rating, for periods of up to 5 sec without causing output voltage to drop below 90 v even if input voltage is as low as 25 v. Both input and output circuits are equipped with rf filters. The alternator employs a permanent magnet rotor, obviating the need for slip rings. The governor-regulated, compound-wound dc motor runs at a rated speed of 8000 rpm. For special applications this unit can be provided with other input or output voltages and other output frequencies within the limits of the frame.

Dalmotor Co., Dept. ED, 1375 Clay St., Santa Clara, Calif.

CIRCLE 102 ON READER-SERVICE CARD FOR MORE INFORMATION



DC Power Supply Three Outputs

This dc power supply has three simultaneous outputs rated at +300 v dc at 300 ma.; +150 v dc at 200 ma.; and -150 v dc at 200 ma. The unit operates on 208 v, 400 cps current and provides regulation against input and load better than 0.01 per cent. Long time stability is also rated at better than 0.01 per cent (24 hr).

The supply is designed to meet MIL-E-5400 specifications for operation from -50 C to +50 C at altitudes up to 50,000 ft. The unit weighs 68 lb and measures 10-1/2 in. high 17 in. wide and 17-1/2 in. deep.

Davenport Manufacturing Co., Dept ED, 1713 N. Ashland Ave., Chicago 22, Ill.

CIRCLE 103 ON READER-SERVICE CARD FOR MORE INFORMATION

Low-Level AC VTVM Fits Into Standard Consoles

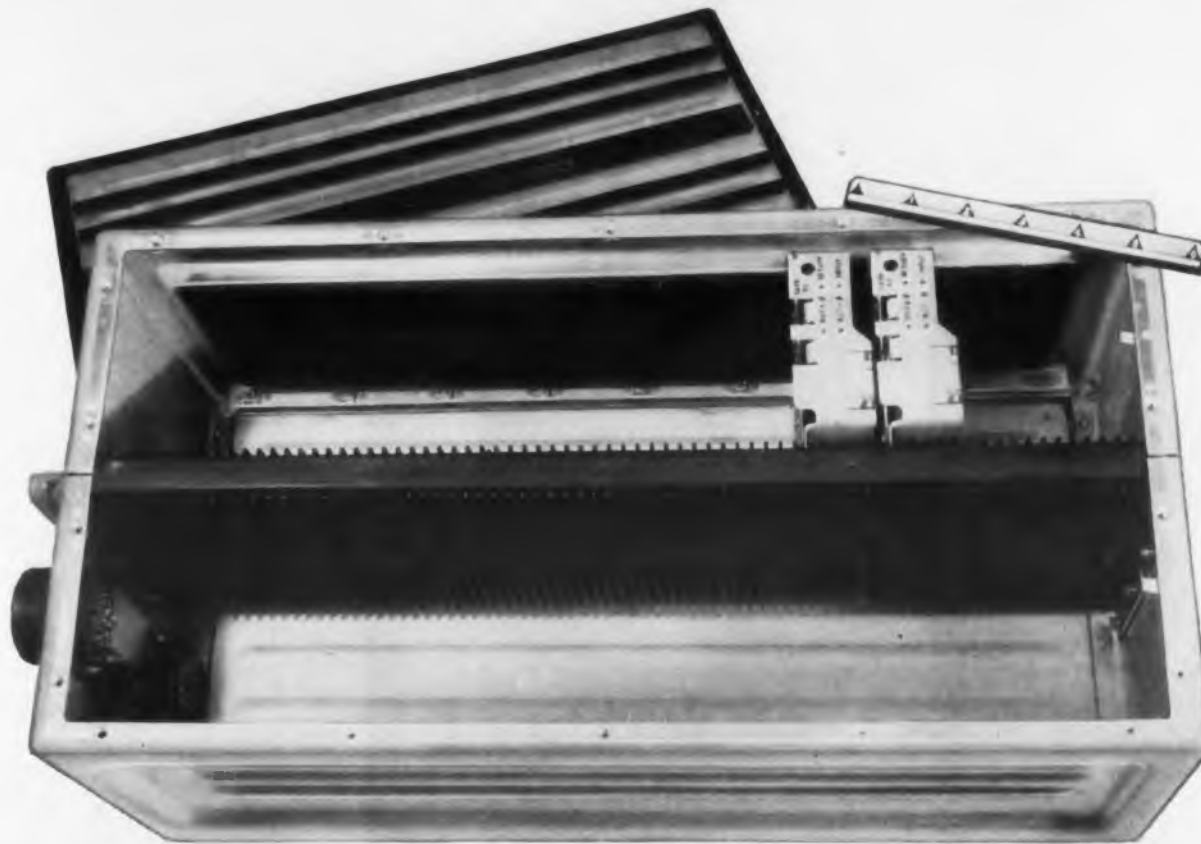


Designed specifically for panel-mounting, the Model 109-1 ac vtvm is suited for integration into test equipment or modular-type consoles. Its signal leads are so isolated that voltages may be measured between any two independent test points. The instrument is capable of reading as low as 50 μ v. Twelve ranges from 1 mv to 300 v ac are provided with an over-all accuracy of 2 per cent of full scale. Input impedance is 10 meg and frequency response is 20 to 80,000 cps.

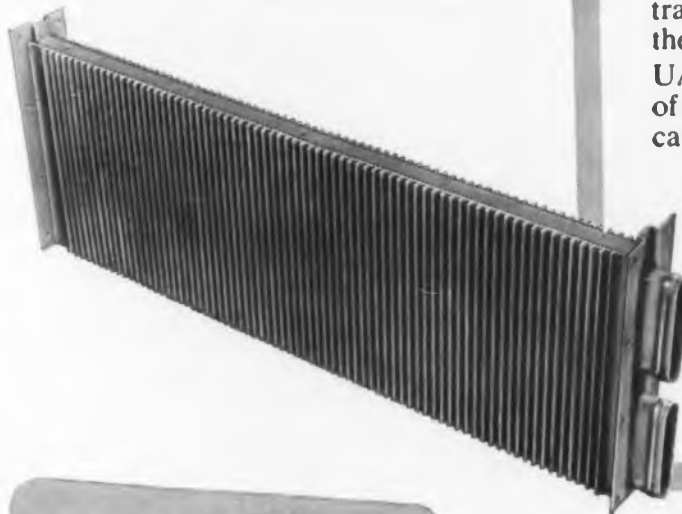
Having printed circuit construction, the 109-1 is simple to maintain. Two adjustments perform complete voltage and frequency calibration. Line voltage variations of 70 to 140 v do not appreciably affect readings or accuracy. Vacuum tubes may be interchanged or replaced without matching or pre-selection. The unit operates from a 115 v, 50 to 500 cps source. Its 5-1/4 x 9-1/2 in. panel, with standard RETMA notches and spacings, fits standard modular-type consoles.

Tri-Labs., Inc., Dept. ED, 4025 Merrick Rd., Seaford, N.Y.

CIRCLE 104 ON READER-SERVICE CARD FOR MORE INFORMATION



Precision control of groove depth and spacing assures ease of servicing and interchangeability of circuit shells.



Printed Circuit Heat Control

Here is how one airframe manufacturer integrated printed circuit design with "black box" design.

A UAP cold-plate heat exchanger forms the central member of the assembly. Grooves machined into the heavy face plates of the cold-plate, match grooves in the two compounded plates which line the longer inner walls of the box. Printed circuit shells are inserted into the grooves in two banks, either at random spacing or closely packed with an assured minimum clearance between shells. Electrical contact is made with the circuits by pressure only. Heat from the printed circuits is transmitted to the aluminum UAP cold plate and conducted to the ultimate heat sink.

UAP develops and manufactures cold-plates and other types of heat exchangers and systems for electronic equipment application on either a proprietary or contract basis.

**For complete information call the nearest
UAP Contractual Engineering Office**

CALIFORNIA.....1101 Chestnut St., Burbank, Calif., VI 9-4236
NEW YORK.....50 E. 42nd St., New York 17, N.Y., MU 7-1283
OHIO.....1116 Bolander Ave., Dayton, Ohio, MI 3841
CANADA.....United Aircraft Products, Ltd., 5257 Queen Mary Road,
Montreal, Canada, ELwood 4131

a famous family of aircraft essentials since 1929

UNITED AIRCRAFT PRODUCTS, INC.
1116 BOLANDER AVENUE, DAYTON, OHIO

CIRCLE 105 ON READER-SERVICE CARD FOR MORE INFORMATION

International Rectifiers

For all DC needs from microwatts to megawatts!

SELENIUM



SUB-MINIATURE SELENIUM DIODES

Developed for use in limited space at ambient temperatures ranging from -50°C to $+100^{\circ}\text{C}$. Encapsulated to resist adverse environmental conditions. Output voltages from 20 to 160 volts; output currents of 100 microamperes to 11 MA. Bulletin SD-1B



HIGH VOLTAGE CARTRIDGE RECTIFIERS

Designed for long life and reliability in Half-Wave, Voltage Doubler, Bridge, Center-Tap Circuits, and 3-Phase Circuit Types. Phenolic Cartridge and Hermetically Sealed types available. Operating temperature range: -65°C to $+100^{\circ}\text{C}$. Specify Bulletin H-2



TV AND RADIO RECTIFIERS

The widest range in the industry! Designed for Radio, Television, TV booster, UHF converter and experimental applications. Input ratings from 25 to 156 volts AC and up. DC output current 50 to 1,200 MA. Write for application information. Bulletin ER-178-A



INDUSTRIAL POWER RECTIFIERS

For all DC power needs from microwatts to kilowatts. Features: long life; compact, light weight and low initial cost. Ratings: to 250 KW, 50 ma to 2,300 amperes and up. 6 volts to 30,000 volts and up. Efficiency to 87%. Power factor to 95%. Bulletin C-349

GERMANIUM



GERMANIUM DIODES

This series of general purpose, high quality point contact diodes provide excellent rectification efficiency for very high frequency applications. Special "RED DOT" series available for ambient temperatures from -55°C to $+100^{\circ}\text{C}$. Bulletin SR-140.



GERMANIUM RECTIFIER STACKS

Extremely low reverse leakage values make this series ideal for magnetic amplifier applications. These units utilize 10 amp junctions—26 to 66 AC input volts rms—are available in a wide range of circuit types and DC current ratings. Bulletin SR-148.



AIR-COOLED GERMANIUM JUNCTIONS

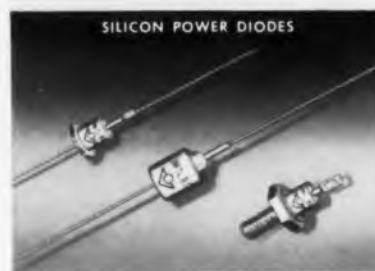
Engineered for heavy power applications, these highly efficient forced air cooled units feature moisture and corrosion resistant housings. A complete series in each of 3 current ratings: 150, 330 and 500 Amperes @ 26 to 66 volts rms. Request Bulletin GPR-2.



LIQUID COOLED GERMANIUM JUNCTIONS

Liquid cooled for maximum power in minimum space. Junction rating: 670 amps at 26 to 66 volts rms. Housed in high-conductivity copper cast around special steel coils. Water, oil or other accepted coolants may be used. For complete data. Bulletin GPR-2.

SILICON



SILICON POWER DIODES

Hundreds of types in three basic styles, for operating temperatures from -55°C to $+150^{\circ}\text{C}$. Up to 800ma DC output current per junction over a voltage range of 50 to 1,000 PIV. Hermetically sealed. For complete information on all types. Bulletin SR-A.



SILICON CARTRIDGE RECTIFIERS

The answer to tough miniaturization problems! Ratings for high temperature applications: from 1000 volts PIV at 100ma half-wave DC output to 16,000 volts PIV at 45ma. Hermetically sealed, metallized ceramic housing. Request Bulletin SR-139B



SILICON MEDIUM POWER RECTIFIERS

Specifically engineered for industrial applications—the most conservatively rated silicon rectifiers in the industry! Rugged all-welded construction and hermetic sealing mean greater reliability—longer life. Types available in 3 series. Request Bulletin SR-143B.



SILICON RECTIFIER STACKS

These units consist of hermetically sealed junction diodes mounted on copper cooling fins, stacked to include the interconnections required for specific circuits. Junction ratings: 1.25 amps. DC output; 70 to 350 AC input volts rms. Request Bulletin SR-137A.

New Products



Rotary Grounding Switch

Three Positions

In such circuit applications as sensitivity controls, this switch permits easy adjustment of signal strength for local, intermediate and fringe reception. Simplified construction permits quick, low-cost assembly due to twist-tab mounting of switch to chassis or wiring board.

P. R. Mallory & Co., Inc., Dept ED, Indianapolis, Ind.

CIRCLE 107 ON READER-SERVICE CARD FOR MORE INFORMATION



Selector Switches For Pyrometry Circuits

The switches provide versatile means of connecting sensing elements to indicators, recorders or other instruments. Two-position key switches, 4pdt, permit the optional connection of a number of sensing elements to either of two instruments. Selection or transfer is made by flicking a switch. Locking or non-locking construction.

Two-position key switches, dpst, permit rapid checking of temperatures from many points or averaging temperatures from a number of sensing elements. Non-locking construction is available for spot checking and locking construction for maintained contact.

Three-position key switches can be used to connect thermocouples or resistance bulbs to an indicator or recorder or to transfer them from one instrument to another. Moisture-proof and dust-tight cases are suitable for flush-panel or wall mounting. Case capacities range from 12 to 144 points for both thermocouples and resistance bulbs.

Thermo Electric Co., Inc., Dept. ED, Saddle Brook, N.J.

CIRCLE 108 ON READER-SERVICE CARD FOR MORE INFORMATION

ELECTRONIC DESIGN • July 1, 1957

International Rectifier

C O R P O R A T I O N

EXECUTIVE OFFICES: EL SEGUNDO, CALIFORNIA • PHONE OREGON 8-6281

NEW YORK: 132 E. 70TH ST., TRAFALGAR 9-3330 • CHICAGO: 205 W. WACKER DR., FRANKLIN 2-3888

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THE WORLD'S LARGEST SUPPLIER OF INDUSTRIAL METALLIC RECTIFIERS

CIRCLE 106 ON READER-SERVICE CARD FOR MORE INFORMATION





Switch and Actuators High Rating

Five actuators including leaf, frame leaf, roller leaf, plunger and toggle models, are available for use with a developed switch about 3/4 in. in length. The switch is rated 10 amp 125-250 v ac; 1/4 hp 125 v ac; and 10 amp 28 v dc. It is of double throw, double circuit design. The switch mechanism is enclosed in a durable plastic case.

Robertshaw-Fulton Controls Co., Acro Division, Dept. ED, Columbus 16, Ohio.

CIRCLE 109 ON READER-SERVICE CARD FOR MORE INFORMATION

Precision Delay Generator

1 to 10,000 μ Sec.



The delay generator type 6010, consists of three modular constructed units with both power and signals internally interconnected by cabling to make a self-contained piece of test equipment. The three units comprising the complete generator and their functions are as follows:

Trigger Generator Type 101—provides a standard negative pulse output from an input signal composed of slow rising sine waves or fast rise time pulses or either polarity up to 100 kc. The unit can also function as a self-contained pulse generator, producing its own repetition frequency at any one of ten preset frequencies ranging from 50 cps to 100 kc.

Delay Generator Type 131—triggered by the standard negative pulse output from the Type 101 Trigger Generator, the unit produces five outputs; both positive and negative delayed pulses, positive and negative gating pulses, and a linear negative going ramp function.

Power Supply Type 9804—the supply maintains less than one mv rms of ripple on the output voltage. The unit provides three positive voltages and one negative voltage with regulation better than 0.5 per cent.

Burroughs Corp., Electronic Instruments Div., Dept. ED, 1209 Vine St., Philadelphia 7, Pa.

CIRCLE 110 ON READER-SERVICE CARD FOR MORE INFORMATION



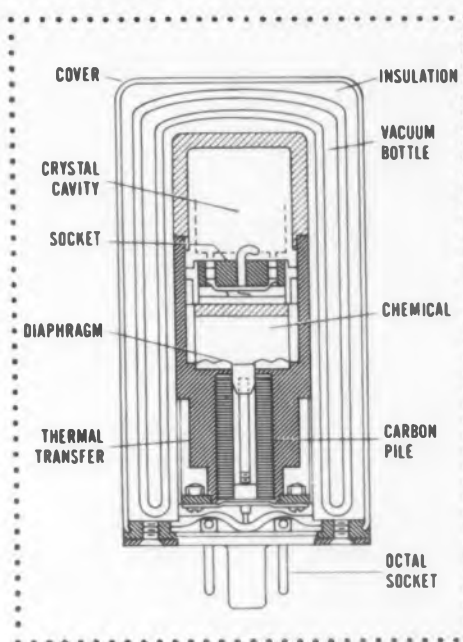
PRECISE FREQUENCY CONTROL Robertshaw-Fulton Crystal Oven

This new compact precision Crystal Oven uses fusion temperatures of crystalline materials to provide extremely constant crystal cavity temperatures.

Completely self-contained, the unit features a continuous proportional control system which eliminates contact noise, power surges, random variations of oven temperatures, and cavity temperature drift.

SPECIFICATIONS

- CAVITY TEMPERATURE:**
70.6°C at 24°C ambient.
- TEMPERATURE CONTROL:**
Within $\pm 0.5^\circ\text{C}$ from -20°C to $+50^\circ\text{C}$ ambient.
Approx. $\pm 0.005^\circ\text{C}$ at fixed ambient.
- HEATER VOLTAGE:**
5 v. a.c. or v. d.c. regulated $\pm 2\%$.
- HEAT POWER:**
On warm up: approx. 5 watts
Under control: 1.6 w at TA 24°C
3.5 w at TA -20°C
- DIMENSIONS:**
2" O.D. x 4" Length.
- WEIGHT:**
Approximately 12 ounces.
- CRYSTAL HOLDER:**
Accommodates 1 HC-6/U holder.



APPLICATIONS

Temperature control of a crystal or crystal oscillator for secondary frequency standards.

Temperature control of sensitive components, such as resistance-capacitance networks in oscillators or computer circuits.

Temperature control of zener diodes for voltage reference units in d.c. power supplies.

Constant temperature for thermocouple reference junctions.

Reference temperature for calibrating thermistors by using ovens with different cavity temperatures.

For more information on this compact, extremely reliable Crystal Oven, send for Bulletin No. 1181-1.



PRODUCTS FOR PROGRESS
BY THE MEN OF
AERONAUTICAL DIVISION

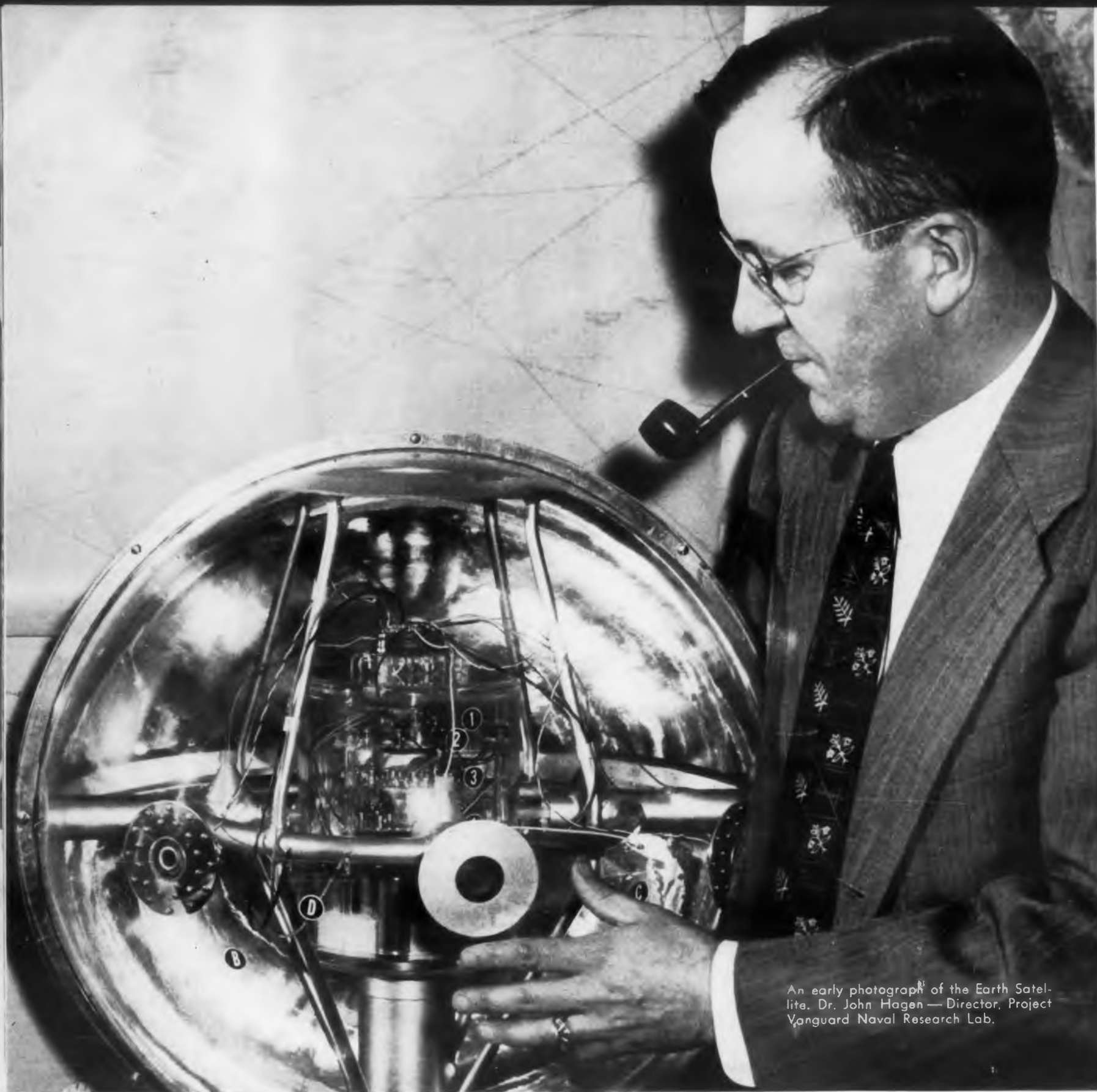


Robertshaw-Fulton
CONTROLS COMPANY

Santa Ana Freeway at Euclid Avenue • Anaheim, California

OUTSTANDING FACILITIES FOR THE RESEARCH AND DEVELOPMENT OF SPECIALIZED CONTROL DEVICES

CIRCLE 111 ON READER-SERVICE CARD FOR MORE INFORMATION



An early photograph of the Earth Satellite. Dr. John Hagen — Director, Project Vanguard Naval Research Lab.

NOW IS THE TIME TO SELL THE FUTURE

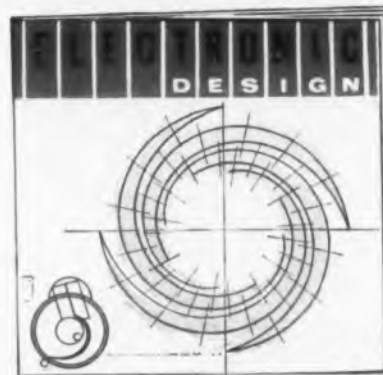
In the electronic industries, tomorrow's sales are being formed in the minds of today's design engineers. If you want to sell this market of the future, now is the time to tell your story to the men who will specify your products. Your electronics advertising will be read in **ELECTRONIC DESIGN**.

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New Products

Hysteresis Motors 8000 and 12,000 Rpm



This synchronous motor is available in a size 10 frame (1 in. OD), and comes in 8000 and 12,000 rpm models, single-phase and 3-phase, 26-v and 115-v. The motors are constructed with homogeneous rotors and stators featuring constant torque independent of rotor position. They have an inherently high starting torque, and are designed to meet the environmental requirements of MIL-5400.

Luther Manufacturing Co., Dept. ED, 7312 Varna Ave., North Hollywood, Calif.

CIRCLE 113 ON READER-SERVICE CARD

Monitor Amplifier Low Level Input



For thermocouples and strain gage pickups, Type P/P-C has an input impedance in excess of 200 k and works with spans as low as 5 mv dc. Both low and high level adjustable 5 amp. alarm contacts are provided. Input floats relative to ground. Circuit utilizes chopper and single quality vacuum tube. The input impedance permits use with loggers and servo instruments with insignificant loading error.

Indikon Co., Dept. ED, 76 Coolidge Hill Rd., Watertown, Mass.

CIRCLE 112 ON READER-SERVICE CARD

Micro-Microammeter

10⁻³ to 10⁻¹¹ Amp



The Model 411 micro-microammeter provides high resolution for a range of measurements from 10⁻³ to 10⁻¹¹ amp. It has no switching transients and covers eight decades with 17 ranges. Zero drift is less than 2 per cent of full scale per week from source voltages above 10 v. Response time is less than one second on the 10⁻¹⁰ range and drops to 40 usec on the 10⁻³ range with 5000 μ f across the input. Input drop is less than five mv. Added features include a 216 v tap for polarizing ion chambers, and a 10 v output to drive either 50 mv or 5 ma recorders.

Keithley Instruments, Inc., Dept. ED, 12415 Euclid Avenue, Cleveland 6, Ohio.

CIRCLE 115 ON READER-SERVICE CARD FOR MORE INFORMATION



Galvanometer and Amplifier Chopper Stabilized

The Model 204A is a combination dc null detector, linear deflection indicator, microvoltmeter, micromicroammeter, and low level dc amplifier. It is functionally equivalent to suspension galvanometers. The instrument is insensitive to vibration, shock, microphonics, earth's magnetic field and stray pickup. It may be mounted in any position, can withstand overloading with no offset on return to zero and has rapid response. Seven decades ranges cover dc voltages from 10 μ v to 10 v full scale or currents from 0.001 μ a to 1 ma full scale. The sensitivity control functions as an attenuator and is calibrated in attenuation. Input resistance is a constant 10,000 ohms and there are no restrictions on source resistance. A high degree of isolation is provided between ac line, chassis, and the amplifier circuit. The unit has a floating input. As a current galvanometer, it has 2 x 10⁻¹¹ amps-per-division sensitivity. As a voltage galvanometer, it has 10⁻¹¹ w full scale power sensitivity.

Kin Tel (Kay Lab), Dept. ED, 5725 Kearny Villa Rd., San Diego, Calif.

CIRCLE 116 ON READER-SERVICE CARD FOR MORE INFORMATION

FOR DYNAMOTORS...



MODEL GY. Includes ratings through 110 watts continuous duty and 300 watts intermittent duty. Outputs to 650 volts.



MODEL G. The all new "Twinvolt" Dynamotor. Operates from 6 to 12 volt input.



TYPE SF. Built to the most exacting specifications. Up to 75 watts continuous duty and 200 watts intermittent duty. Input voltage 6 to 115. Output voltage up to 750 volts.

For further information send for Bulletin 1530.

SANGAMO Electric Company Electronic Components Division

SPRINGFIELD, ILLINOIS

SG57-3

make SANGAMO your major source!

FOR COMMERCIAL AND MILITARY

Sangamo Dynamotors are available in two basic design series: the rugged "G" series for commercial use, and the "S" series for special purpose and military applications. Both types are small, compact, yet capable of unusual output and high efficiency under the most rigorous conditions of service.

DEPENDABLE DELIVERY SCHEDULES

Sangamo utilizes the latest production techniques in the manufacture of power supply units. Push line type of operation contributes substantially to accelerated production—aids in fulfilling all delivery schedules. Specify Sangamo for *dependable* units and *dependable* delivery that meets your production schedules.

EXPANDED PLANT FACILITIES

A new 200,000 square foot "controlled conditions" plant, in Pickens, South Carolina is geared for full capacity production of Dynamotors, Rotary Converters, Generators, Special DC Motors—all built to meet your most exacting specifications for quality and performance.

ENGINEERING HELP AVAILABLE

Sangamo maintains a complete engineering and technical staff to assist any organization with its power supply planning. Ask for an engineering analysis and recommendations for power supply units to meet your special application problems.



CIRCLE 93 ON READER-SERVICE CARD FOR MORE INFORMATION

Looking for a "POT"?



PANEL MOUNT SHOWN,
SERVO MOUNT OPTIONAL

ACTUAL SIZE

SERIES 341 **TEN-TURN PRECISION** **POTENTIOMETER**

Smaller in diameter than a fountain pen — no longer than a shriveled up Gryllidae Gryllus*, this tiny "pot" offers ultimate precision in the smallest package on the market.

Check some of the standard specifications of this precision-built, wire-wound, ten-turn potentiometer:

SIZE: 17/32" x 1-1/64"
WEIGHT: 10 gms. max.
BACKLASH: Essentially zero
PHASE SHIFT: Less than 0.1° at 400 cps
VIBRATION: 20gs to 2000 cps (3 attitudes)
POWER: 2.5 watts at 40°C, 0 watts at 140°C

* also known as a cricket

STANDARD MODELS AVAILABLE IN PRODUCTION QUANTITIES NOW . . . SPECIAL REQUIREMENTS CAN USUALLY BE MET. WRITE TODAY FOR COMPLETE INFORMATION CONCERNING THIS AND OTHER MINIATURE WIRE-WOUND, PRECISION POTENTIOMETERS.

Openings exist for highly qualified engineers

WRITE TODAY FOR DETAILS

ACTUAL SIZE



DAYSTROM PACIFIC CORPORATION

A subsidiary of Daystrom, Inc.

POTENTIOMETER DIVISION

11150 LA GRANGE AVE., WEST LOS ANGELES 25, CALIF.



Series
304

One-turn, Wire-wound,
Precision
Potentiometer.

LOW COST
HIGH PERFORMANCE

CIRCLE 117 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Digit-Set Counter

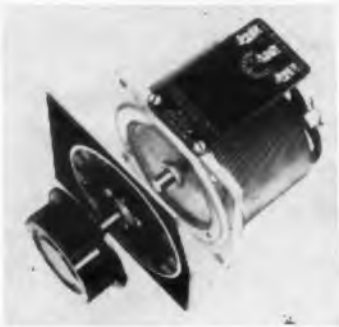
1 Msec to 100 Sec Time Base



Model 1040 counter is for measurement of analog quantities that can be converted into frequencies. Features include the readout and the use of magnetron beam switching tubes. It provides time base selection from 1 msec to 100 sec in 1 msec increments, non-overloading amplifiers from 5 mv to 100 v from 5 cps to 100 kc, and printed readout facility. Reliability is obtained by use of 50,000 hr magnetron beam switching tubes in the counting and dividing circuits. A self-checking feature is also included.

Systron Corp., Dept ED, 2055 Concord Boulevard Concord, Calif.

CIRCLE 118 ON READER-SERVICE CARD FOR MORE INFORMATION



Variable Transformers Increased Ratings

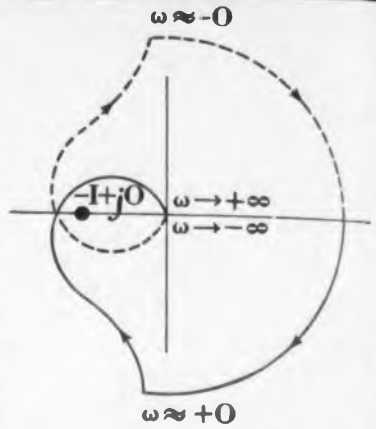
The Type W50 Variac replaces the older Type 50 and is available in a complete series including 115- and 230-v models. Current ratings are increased to 50 and 25 amp for the single 115-v and 230-v models, respectively. Motor drives are available in several speeds for all W50 models.

Model W5L, shown, has been designed for those 115-v, 60-cps applications where the usual over-voltage feature is not needed. By limiting the maximum output voltage to the line voltage and frequency to 60 cps, it is possible to use larger wire and still keep other physical dimensions identical with other Type W5 Variacs. Type W5L can control loads drawing up to 11 amp at line voltage, thus giving an output power rating of over 1-1/4 kva. Up to 8.5 amp can be drawn from the unit at any voltage.

General Radio Co., Dept. ED, 275 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 119 ON READER-SERVICE CARD FOR MORE INFORMATION

An Engineer Speaks Out...



...about a Fast, Reliable Way to Plot Nyquists!

Only one instrument, the Servoscope® Servosystem Analyzer, provides all the necessary data to plot a Nyquist diagram for any servosystem or component. Either sine, square, or modulated carrier wave signal is available as the input to your system. Each of the selected frequencies is fed in turn into the system. By turning the calibrated phase dial for a null pattern, the resulting quantitative changes are read directly. Signal amplitude (voltage gain ratio) is read directly from the associated indicator. The Nyquist diagram is completed by plotting phase and gain for each of the selected frequencies.

Servoscope is the *only* single instrument that:

- Covers the frequency range from 0.001 to 100 cps through choice of 5 standard models.
- Evaluates both AC carrier and DC servosystem.
- Provides all the following signals — sine wave, modulated carrier wave, and square wave phaseable with respect to either electronic linear sweep or sinusoidally modulated reference signal.
- Has a frequency calibration accuracy of $\pm 2\%$; phase measurement accuracy of $\pm 1^\circ$.
- Accepts any carrier frequency from 50 to 2000 cps.
- Requires no calibration.
- Indicates by means of associated oscilloscope, oscillograph, phase meter, or frequency meter.

Thos. Whistons
Chief Control Systems Engineer

Send for the full story on Servoscope Servosystem Analyzer. Just address your request on your company letterhead to Dept. WTF.



SERVO
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OF AMERICA

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CIRCLE 120 ON READER-SERVICE CARD

A personal tool for every engineer



*shrinking 30 engineer
hours...
to 3 minutes!*

ANALOG COMPUTER MODEL 3000

Simplified analog computer solves wide variety of engineering problems. Detachable problem boards and plug-in components facilitate rapid problem set-up.

Can be expanded building block fashion to larger computing system. Function generator, multiplier, chopper stabilizer, and other accessories available. Write for complete data. Model 3000, \$1150, FOB Factory. Problem board \$95

Donner SCIENTIFIC COMPANY

832 Galindo Street
Concord, California

CIRCLE 121 ON READER-SERVICE CARD



Calorimeter Constant Flow Type

This direct reading calorimeter, with frequency range of dc to 4000 mc and power measuring range of 10 to 150 w, is of the constant flow type. It does not use flow meters, or thermometers and does not require any flow adjustment. The only control is the on and off switch for the constant flow system. After the radio frequency power is connected the meter needle climbs to the correct value for approximately one minute. Power is read directly on the meter. Accuracy is 5 per cent. Power supply: 105-120 v, 60 cps 60 w. Other calorimeters covering the range of dc to 12,000 mc, coaxial and waveguide, are available.

Electro Impulse Laboratory, Dept. ED, 208 River St., Red Bank, N.J.

CIRCLE 122 ON READER-SERVICE CARD FOR MORE INFORMATION



Transformer Line Output Proportional To Input

Available in voltages up to 500 vdc, these transistorized transformers have a dc output voltage directly proportional to the input as in conventional ac transformers. Characteristics include load regulation from 6 to 12 per cent, ripple of 0.01 per cent, output range from 15 to 80 w with input of 24 to 30 v dc. Another in the line is a dc voltage regulator consisting of a transistorized oscillator employing a magnetic amplifier as the regulating element. The regulators feature small size, fast response, no maintenance, tantalum capacitors, and very low ripple. Transistorized dc inverters have been designed to provide dependable power for rate gyros where frequency regulation is necessary. Supplied with a normal output of 115 v ac, other characteristics include line wave of 400 cps, harmonic distortion of less than 5 per cent, temperature range of -55 C. to +71 C, frequency stability of ± 0.25 per cent and a voltage change of ± 6 v ac.

Gulton Industries, Inc., Dept. ED, Engineered Magnetics Div., Metuchen, N.J.

CIRCLE 123 ON READER-SERVICE CARD FOR MORE INFORMATION

COULD YOUR PRODUCT'S LABEL BATTLE AN ARCTIC FREEZE?

METAL-CAL STICKS FAST THROUGH "OPERATION DEEP FREEZE"

Your product will probably never undergo the grueling treatment seen here at Operation Deep Freeze (temperature 60 below), but if it is subjected to weathering in any way, you'll be interested in new, patented Metal-Cal.

Metal-Cal's super-strength adhesive makes your product's label permanent in blistering heat or Arctic cold. Best of all, years and years of accumulated weathering leave Metal-Cal clear, sharp, and easy to read... that's because only patented Metal-Cal is made of .003" anodized and dyed, etched aluminum foil. Find out today what Metal-Cal can do for your product.



if it's important, make it permanent

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U. S. Patent 2,769,265

CIRCLE 124 ON READER-SERVICE CARD FOR MORE INFORMATION

precision

Fluorocarbon Parts meet exacting specifications ... cut assembly costs

Profit from precision parts, fabricated from TEFLON*, KEL-F†, and other plastics—by United States Gasket Company.

Quality controlled "from powder to part," they assure uniform electrical, chemical and physical characteristics of the highest quality. Uniform density and dimensional stability permit superior accuracy and dependability in the finished part.

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*duPont Trademark †M. M. & M. Trademark

UNITED STATES GASKET COMPANY
Camden 1, New Jersey



United States Gasket *Plastics Division*

OF THE GARLOCK PACKING COMPANY
CIRCLE 125 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products



Indicator Tube
Monitors Transistor Circuits

The Type 6977 filamentary indicator triode with fluorescent anode is designed specifically for visual monitoring of transistorized computers and other transistor circuits. It is approximately 1-1/8 in. long, has less than 1/4 in. diam, and gives a bright blue-green indication when its control grid is at zero potential. It is designed for 20,000 hrs life. Heater voltage is 30 ma ac or dc. The anode will draw 0.6 ma from a 50 v supply during the zero-bias on condition. A 3.5 v dc voltage is sufficient to cut off plate current and light. High input impedance and small consumption prevent it from loading transistor circuits. Since it permits the use of a series grid resistor, it does not short out the transistor circuit if it should develop a defect in operation.

Amperex Electronic Corp., Dept. ED, Computer Products Div., 230 Duffy Ave., Hicksville, N.Y.

CIRCLE 126 ON READER-SERVICE CARD FOR MORE INFORMATION



Flutter and Wow Meter
Regulated

Designated as Model F1-3D, this flutter and wow meter is designed to the requirements for measuring flutter content in recording and reproducing systems as established by the IRE, ASA and SMPTE. Full scale sensitivities of 2.0 per cent and 0.5 per cent are available with accuracies better than 10 per cent. An output terminal is included to provide a dc to 250 cps signal for graphic recording purposes. A regulated power supply insures stable operation of internal 3000 cps carrier oscillator over wide excursions of the input line voltage. The FL-3D measures 7 in. x 12 in. x 6 in. and weighs 10-1/2 lb.

D & R, Ltd., Dept ED, 402 East Gutierrez St., Santa Barbara, Calif.

CIRCLE 127 ON READER-SERVICE CARD FOR MORE INFORMATION

Motor driven variable transformers for **REMOTE CONTROL**



Adjust-A-Volt
M 3012

(One of 22 basic models)

Where you need accurate and positive remote control of variable voltage, you'll get the results you want from one of the twenty-two basic motor driven models available in the Adjust-A-Volt series.

Single units or up to 6-gang assemblies, with load ratings from .35 to 28 KVA—115V or 230V input—will help you solve many application problems where "long distance" push-button or switch operation is required.

Typical in the series is the M3012 shown above. This is a compact, rugged transformer with high performance value. Maximum load rating is 6.0 KVA; output 0-135V or 0-115V; maximum current output, 30.A.

All models equipped with standard 115V, 60 cycle motors, or lower voltage motors if specified. Travel speeds of 6, 13, 26 or 45 seconds are available. Clockwise and counterclockwise limit switches are standard features. Units are enclosed in a well ventilated case, protected with a grey wrinkle finish. Militarized 60 cycle or 400 cycle units available.

Send for the catalog describing the complete Adjust-A-Volt line.

STANDARD
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2240 E. THIRD ST., DAYTON, OHIO

CIRCLE 128 ON READER-SERVICE CARD

Longest Delay

of any Continuously
Variable Video
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ever made!
(up to 20.0 μ sec.)

Series 500

FEATURES:

- *Resolution: better than 1/1000 of maximum delay*
- *External termination*
- *Can be operated above ground potential*

- *Operation: continuously variable shaft rotation of 10 turns from zero to maximum delay*
- *High impedance tap (variable)*
- *Outside dimensions: 7-1/4" x 1" x 1-5/8"*

Write ESC for an informative catalog and complete information.



ESC

CORPORATION

552 BERGEN BOULEVARD, PALISADES PARK, N. J.

CIRCLE 129 ON READER-SERVICE CARD



Pressure Transducers Fused Silica

Single or multiple convolution bellows and twisted bourdon tubes are the two basic types of pressure cells offered made from fused silica. The bourdon tube shown is 8 mm diam by 45 mm long. Its scale factor is 0.2 deg rotation per atmosphere with a safe working pressure of 5 atmospheres. Other tubes 15 mm in diam with a 0.8 deg rotation per atmosphere have been produced. The three convolution bellows is 15 mm in diameter and has a sensitivity of 0.0001 in motion per psi, 5 atmospheres working pressure.

Emil Boblett Co., Dept ED, Box 666, Manhattan Beach, Calif.

CIRCLE 130 ON READER-SERVICE CARD FOR MORE INFORMATION



Variable Power Supply Nonshorting, 500 μ v Ripple

A continuously variable dual transistorized power supply produces 2 to 30 v at 0 to 1.0 amp. The Model 800-A power supply features a ripple voltage of less than 500 μ v, less than 0.01 output voltage variation from no load to 1.0 amp, with automatic short circuit and overload protection. When the load exceeds the rated current by 50 per cent, a protection circuit opens the regulator loop and prevents the output current from flowing. At approximately 4-sec intervals the supply endeavors to reestablish the output voltage, and it will succeed when the overload or short circuit has been removed. The response to a sudden no-load to full-load change in current does not break the regulator loop. For example, a no-load to 1.0 amp current change produces an output voltage transient of less than 50 mv.

Harrison Labs., Inc., Dept. ED, Berkeley Heights, N.J.

CIRCLE 131 ON READER-SERVICE CARD FOR MORE INFORMATION



THERMAL CONDITIONING OF ROCKETS AND GUIDED MISSILES



HEATING OPTICAL, ELECTRONIC, OR HYDRAULIC AIRBORNE EQUIPMENT

WHERE CAN YOU USE G-E SPECIALTY HEATING EQUIPMENT?

Whenever your equipment requires thermal conditioning, General Electric specialty heating equipment can help.

G.E. has had extensive design and manufacturing experience in providing controlled heating for a wide variety of applications. These applications range from giant guided missile blankets to tiny one-inch-long accelerometer heaters. Problems of intricate shape, large or small size, unusual environmental conditions, and amount of heat required have all been solved.

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Position

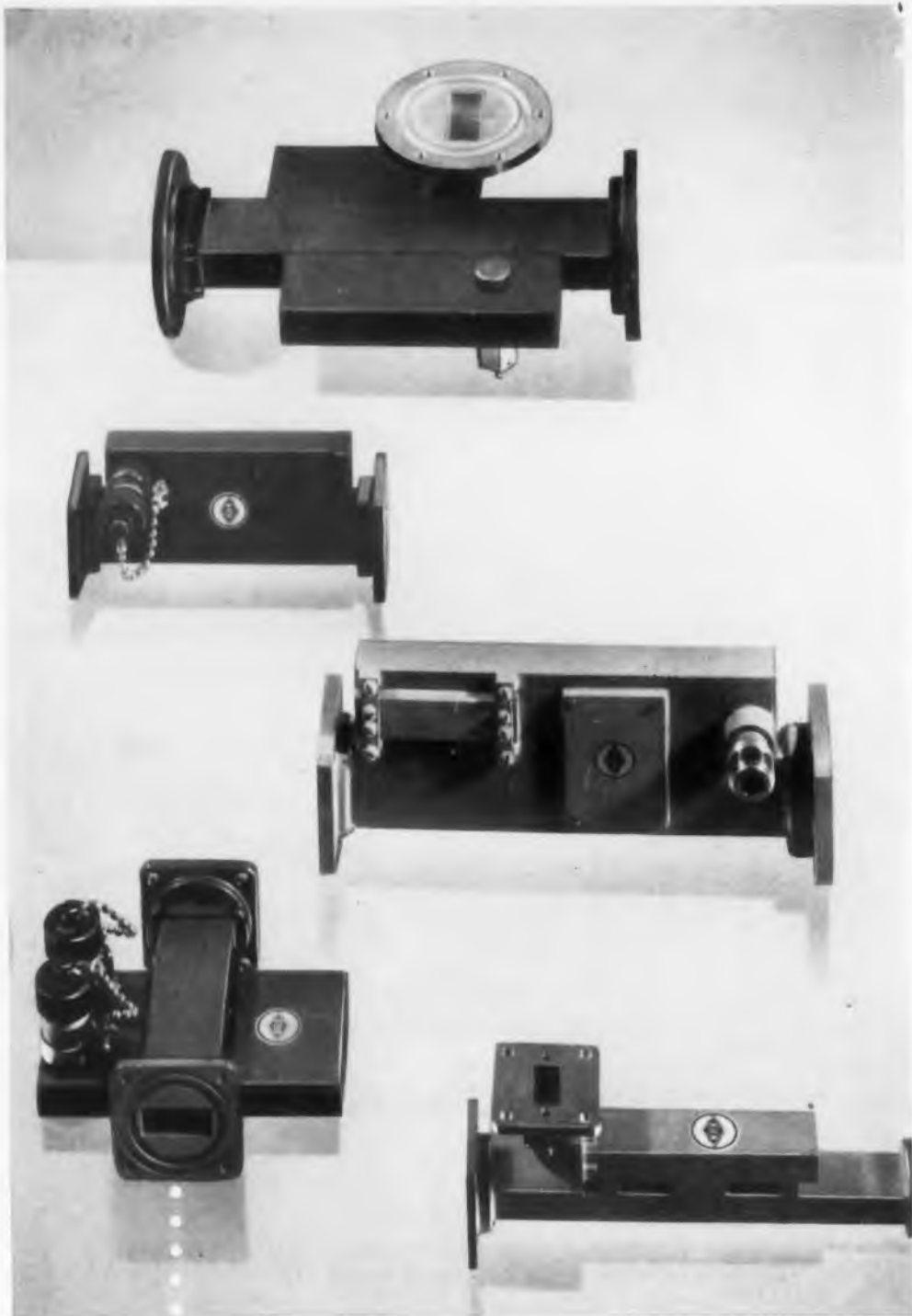
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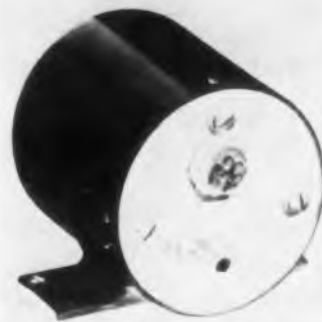
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Microwave Assemblies, Radar Components and Precision Instruments... manufactured and designed to your specifications.

CIRCLE 133 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products



Pressure Transducers

1 Per Cent, -54 to +100 C

Models have been designed to measure pressures in extreme environments. One is linear, the other provides high resistance pick offs and non-linear functions, and both have temperature range of from -54 to +100 C. The units feature good performance in respect to resolution, repeatability, hysteresis, linearity and acceleration error. In model 22002 maximum change in output is 1 per cent except at resonance, in model 22008 maximum change in output is 1 per cent.

Physical Measurements Corp., Dept ED, 1650-19th St, Santa Monica, Calif.

CIRCLE 134 ON READER-SERVICE CARD FOR MORE INFORMATION

Function Programmer

32 Switching Functions



The function programmer is an electro-mechanical timing control device consisting of two basic parts; a supporting frame and cover equipped with a dc driving motor and operating controls, and basic linear switching elements. There are eight switching elements which can be sequenced in multiples to handle up to 32 switching functions, timed in accordance with customer requirements. Units can be provided with linear or non-linear potentiometer elements to be used in lieu of or in combination with switching elements. Six of the eight switching elements can be of the modified plug-in type providing timing changes, to be incorporated into the flight control program, before firing. The additional function of an identifying pulse at every 1/2 sec interval, can also be had without any major design change in the timer.

Hubbard Scientific Labs., Inc. Dept. ED, 1292 E. Third St., Pomona, Calif.

CIRCLE 135 ON READER-SERVICE CARD FOR MORE INFORMATION

Using Thermistors

Edited by
FENWAL ELECTRONICS

Here's more news on thermistors — the tiny, highly temperature-sensitive, semi-conductors that are being used in more and more applications in all types of industry.

Let's look at just three ways thermistors are now being used... Time Delay, Remote Control and Switching.

A thermistor placed with a variable resistor in series with a battery and a relay (Fig. 1) makes an excellent time delay relay. The high resistance of the thermistor limits the current flow when the switch is closed. The delay time may be increased or decreased by increasing or decreasing the series resistance.

By selecting a thermistor with the same constant as the tube filament it will be in series with, you can keep the current constant during the initial warm-up and prevent an initial current surge.

Bead thermistors are available with attached heaters and mounted in a vacuum bulb. (Fig. 2) The thermistors' resistance is reduced when power is applied to the heater. When placed in the input of a vacuum tube amplifier these thermistors make smooth, noiseless remote gain controls, because there are no moving parts or controls in the grid circuit.

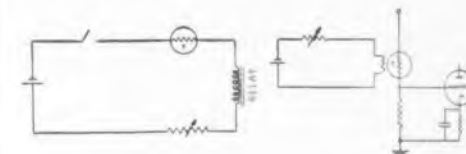


FIG. 1

FIG. 2

When several low voltage light bulbs are connected in series with a suitable thermistor connected in parallel with each unit, (Fig. 3) very little current will pass through the thermistors. Thermistors are not appreciably heated by the small voltage drop across the bulb. If one bulb burns out, the other bulbs remain lighted — the thermistor continues to carry the load of the extinguished bulb. When the bulb is replaced it takes the current from the thermistor. The thermistor then cools off and returns to its idle condition of high resistance and low current.

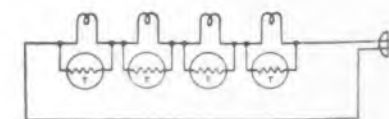


FIG. 3

Engineers: these and other thermistor applications are discussed in 12-page catalog EMC-1. Write for your copy to FENWAL ELECTRONICS, INC., 36 Mellen St., Framingham, Massachusetts.



Makers of Precision Thermistors

CIRCLE 136 ON READER-SERVICE CARD

AMAZING NEW SILICONE COATING

*Insulates and
Protects
Resistors*



Serviceable to 275°C.

● A special formulation of SICON now protects Corning Glass Works LP resistors against damage from moisture and handling, and acts as an effective insulating coating. It thus guards against dielectric breakdown and subsequent shorting to other parts of TV and radio equipment. SICON does not change the characteristics of the Corning low-power line, and is serviceable to 275°C.

Sicon®

The Original Silicone Base
Heat Resistant Finish

● The versatility of SICON as a high temperature protective coating is shown by its remarkably varied use on products of all kinds—resistors, jet engine parts, manifolds, heating elements—and its amazing adherence and color retention when used as a decorative finish for heaters, grills, incinerators, etc. Easy to apply, SICON protects up to 1000°F. in black or aluminum, and up to 500°F. in smart colors.

WRITE FOR BULLETIN NO. CG 100 TODAY
Dept. G-23

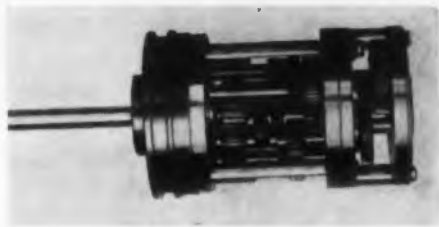
MIDLAND
Industrial Finishes Co.

Waukegan, Illinois

CIRCLE 137 ON READER-SERVICE CARD

Gearhead Variations

For Size 11 Motor



Four precision motor gearhead adaptations in 1.062-in. diameters have been designed for use with Size 11 motors. Gearheads 1384-GH, X-295, X-507 and X-414 are essentially variations of the standard 1062-GH gearhead in order to suit custom needs for extended ratios, special sizes, off center shaft positions and other mechanical requirements. Tandem design in the X-507, shown, provides ratios up to 3 million to 1 and higher, while maintaining the low backlash of smaller units. 1384-GH is for installations requiring short length at standard ratios, but which must withstand relatively heavy duty applications. X-295 features an off center shaft and ratios up to 1000 to 1. The unit mounts to MK-14 motors by using an adapter plate. X-414 contains internal stops to limit rotation, and has a slip clutch to prevent damage to the motor gearhead. All four custom variations include general 1062-GH specifications such as an operating load torque of 25-in.-oz, and starting torque of 0.005 in.-oz.

Bowmar Instrument Corp., Dept. ED, 2419 Pennsylvania St., Fort Wayne, Ind.

CIRCLE 138 ON READER-SERVICE CARD FOR MORE INFORMATION

Traveling Wave Tube

L-Band



The HA-14 operates from 1.0 to 2.0 kmc without the necessity of any electrical or mechanical operating adjustments. The tube is a high gain, low noise broadband device suitable as the first stage of a receiver in microwave applications. Noise figure reduction is accomplished by multi-anode techniques in gun construction, with all electrode potentials less than 200 v. Noise figure of 10 db max; small signal gain of 30 db min; saturation gain of 25 db; magnetic field of 1000 gauss; capsule length of 15-1/2 in.; capsule diam of 1.0 in.; and net weight of 1 lb.

Huggins Labs. Inc., Dept. ED, 711 Hamilton Ave., Menlo Pk, Calif.

CIRCLE 139 ON READER-SERVICE CARD FOR MORE INFORMATION

ANOTHER MANSON MILESTONE

1-mc HARMONIC REFERENCE OSCILLATOR

A frequency standard with a stability of parts in 10^9 per day.

A high-quality, high level millimicrosecond pulse source for harmonic measurements.

Precision engineering and versatility, with a new design concept that reduces costs to a small fraction of any comparable instrument.



The instrument, ready to use, is priced at \$750

These Features are included:

- ★ Output Frequency independent of all circuit parameters except the Crystal, which is shock-mounted to provide a high degree of insensitivity to vibration and is maintained $\pm 0.01^\circ \text{C}$ in an oven.
- ★ Unique Circuit for adjusting fundamental frequency ± 25 cps without degrading stability.
- ★ Ultra-linear Dial, accurate to 0.01 cps, with direct-reading frequency counter giving substantially zero-error readability.
- ★ Sine-Wave Output, 3 Volts rms across 50 Ohms.
- ★ Millimicrosecond jitter-free balanced Pulse Output; 40-Volt peak across 250 Ohms; harmonics usable to 1000 mc.
- ★ Built-in balanced Mixer, to determine unknown external frequencies up to the kilomegacycle region.
- ★ Self-contained Power Supply.

MATCHING ACCESSORY: 100-KC PHASE-STABLE DIVIDER

A companion instrument to give an additional fundamental frequency (100 kc) with jitter-free *pulse* and *sine-wave* outputs. Incorporates its own mixer and beat-frequency amplifier; also usable as an independent 100-kc Oscillator.

Manson offers to Engineers and Technicians a rewarding present and attractive future in suburban Connecticut.

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Designers and Builders of Specialized Electronic Equipment.

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ENGINEERED FACILITIES



FOR HIGH RELIABILITY

RESISTOR PRODUCTION ONLY!

(Environmental production testing optional, but recommended)

- Hermetically Sealed Deposited Carbon Resistors
- Sealed Resistor Networks
- Encapsulated Precision Wire Wound Resistors

MEPCO INC., MORRISTOWN, NEW JERSEY
CIRCLE 238 ON READER-SERVICE CARD FOR MORE INFORMATION

VITRAMON capacitors
are as small as this

Life Size Photograph

Two materials — a monolithic block of porcelain enamel and fine-silver electrodes — fused into one strong, stable, efficient and effectively homogeneous **RELIABLE** unit.

Vitramon[®] CAPACITORS

will help you build **MINIATURE**
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Sheer bigness . . . great in Texas . . . has no place in an electronic circuit. VITRAMON capacitors save you space and deliver critical electrical performance at the same time.

MINIATURE? YES! PLUS . . .

RUGGED LOW LOSS STABLE
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LOW NOISE VAPORPROOF

The biggest names in electronics use VITRAMON capacitors in guided missiles, jet ignition, proximity fuses and in radar, servo, guidance, fire control, telemetering and carrier telephone systems.

If substitutes are not good enough . . . if you need the best . . . write today!

Vitramon[®]
Incorporated

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CIRCLE 141 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products



Capacitor Motor Reversible

Designed primarily for small business machine applications, Type FL 19-frame 2-pole permanent-split motor is rated at either 1/40 or 1/20 hp. It will operate on 115 or 230 v, single phase, 50 or 60 cps, and has a speed of 3200 rpm. It will run either clockwise or counterclockwise and can be made reversible. The motor measures 3 in. diam (2-3/8 in. across the flats), while length of the 1/40- and 1/20-hp ratings is 4-18 and 5 in. respectively. The open, self-ventilated motor can be mounted rigidly, or provided with rubber rings for resilient mounting. A pinion that is integral with the shaft can be supplied on request. Bearings are of the self-aligning, oil-impregnated porous-bronze type. Rotors and end brackets are die-cast.

Westinghouse Electric Corp., Dept. ED, P.O. Box 2099, Pittsburgh 30, Pa.

CIRCLE 142 ON READER-SERVICE CARD FOR MORE INFORMATION

Low Pass Filter Cutoff of 20, 30 or 40 cps



A line of data-filters combines galvanometer damping resistors with a low pass filter housed in standard damping resistor plug-ins. They attenuate unwanted high frequency components or noise at a rate approaching 12 db per octave above standard cut-off frequencies of 20, 30, or 40 cps. Units are designed to operate in conjunction with the 7-315 and 7-318 types of galvanometers. A typical application of these units is the removal of high frequency vibration when making oscillographic recordings of motion accelerations.

United Telemetering Co., Dept. ED, 1632 Pico Blvd., Santa Monica, Calif.

CIRCLE 143 ON READER-SERVICE CARD FOR MORE INFORMATION

THE ACTON 550-A Direct-Writing Direct-Reading OSCILLOGRAPHIC RECORDER



- 5 times the resolution*
- 15 times the recording capacity*
- 1/25 the operating cost*

* Based on the nearest ALL competitor approaching the 550-A characteristics.

- Direct writing—no development required—view recording immediately.
- Eight channels plus marker.
- $\pm 10\%$ from DC to 800 cps without changing galvanometers.

For more details, send for our complete brochure and a sample recording.



ACTON
LABORATORIES, INC.
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DO YOU NEED

a really
RUGGED*
COMPACT
SENSITIVE
LIGHT-BEAM

GALVANOMETER



*Will take
25 G's!

this is it...

Here is a new series of light-beam galvanometers that were developed to withstand the extremely severe conditions of shock and vibration encountered in field servicing and testing of jet aircraft.

Through unique folding of the light beam, great compactness is achieved while retaining sensitivity to the highest degree... equal to that of laboratory instruments!

These Howell Galvanometers feature excellent readability. They are readily adaptable to existing instruments. They are competitively priced.

SPECIFICATIONS:

Sensitivity to .105 microamperes per millimeter
Resistances: 20, 100, 500 and 1000 ohms. Short
period; high speed response. SIZE: ONLY 2.6"
x 3.62" x 3.615" Sealed construction.

For full information
please write or wire



HOWELL INSTRUMENT Company

3101 Trinity St. • Fort Worth 7, Texas

CIRCLE 145 ON READER-SERVICE CARD

**Microwave Noise Source
To Check Receiver Performance**



The Type TE10 noise tube provides a stable noise source of small size and weight which can be built into X band systems to provide a regular check on receiver performance. The waveguide mount is fitted with a three screw matching section which is normally set for operation at 9375 mc with a vswr of 1.01. Under these conditions the vswr with the tube in operation is less than 1.25 over the range 8900 to 9800 mc, with a noise output of 15.5 db and a nonoperating insertion loss of less than 0.2 db. The matching section can be tuned to a center frequency anywhere in the band 8500 to 10,500 mc. A simple resonant circuit provides for striking and operating the tube from a 150 v 35 ma dc supply.

Ferranti Electric, Inc., Dept. ED, 30 Rockefeller Plaza, New York 20, N.Y.

CIRCLE 146 ON READER-SERVICE CARD FOR MORE INFORMATION

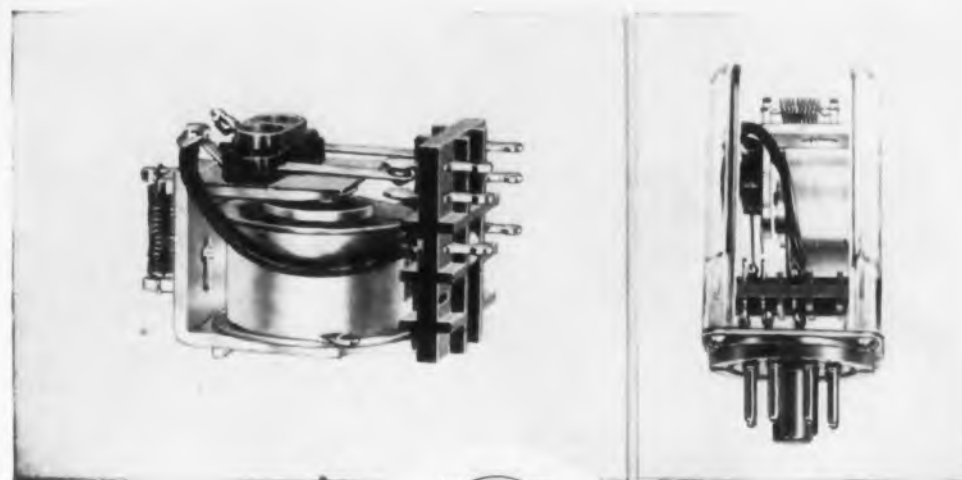
**Position Indicator
3 Per Cent Accuracy**



A transmitter-receiver system for remote angular position indication. One transmitter can serve any number of receivers with no loss of linearity or accuracy over the 320 deg range. The transmitter has standard bushing type mounting, with positive mechanical stops. Two separate adjustments are provided for zeroing-in at either end of scale. A linear type dial is calibrated from 0 to 100. Requires only two wires from the transmitter. Additional receivers may be connected in parallel. Over-all accuracy is 3 per cent, with no loading error. Weight of the transmitter is 29 oz, and of the receiver is 20 oz. Adjustable signal or limit switch contacts can be provided at either or both ends of the receiver.

Certi-Fact Engineering, Inc., Dept. ED, P.O. Box 774, Sherman Oaks, Calif.

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ELGIN
announces the



NEW ADVANCE

GH
SERIES

Low Cost

Midget Relays

... open or plastic enclosed

Elgin's new GH series combines the high efficiency required of general purpose relays with low cost. Their midget size suits them for installations where space is a problem (see specifications below). Open relays in 5 and 10 ampere ratings and clear plastic dust-tight enclosed 5 ampere relays are immediately available from stock. Specify dependable ELGIN performance... specify GH from your electronic parts distributor!

SPECIFICATIONS

GHA SERIES, 5 amp. open relay

Contact rating, 5 amps. resistive, 2 amps. inductive at 115 volts AC or 26.5 volts DC. Contact material is fine silver, 1C, 2C, 3C arrangements only. Relay is 1.1" high, 1.732" long and .937" wide. Contact terminals can be used as solder lugs or for printed circuitry.

(Also available: GHB series, 10 amp. open relay.)

GHP SERIES, 5 amp. clear plastic enclosed relay.

Dust-tight plug-in. Contact rating, 5 amps. resistive, 2 amps. inductive at 115 volts AC or 26.5 volts DC. Contact material is fine silver, available in 1C or 2C arrangements only. Enclosure is 2 1/16" x 1 1/32" overall. 2 1/8" overall length above chassis.

NOMINAL POWER REQ.—DC relays, 1 to 2 watts; AC relays, 2 to 3 volt amperes.
NOMINAL VOLTAGE—DC relays, 6 to 120 volts; AC relays, 6 to 220 volts. (On specification, DC voltage coil up to 220 volts or AC voltage coil up to 440 volts can be supplied.)

RESISTANCE—DC relays, 25 to 8,000 ohms; AC relays, 4 to 5,000 ohms.

PULL-IN CURRENT VALUES—7.2 Milliamps max. at 2,500 ohms; 5.0 milliamps max. at 5,000 ohms.

DUTY CYCLE—continuous.

TEMPERATURE RANGE— -55° to +85°C when specified.

INSULATION RESISTANCE—100 meg-ohms min.

DIELECTRIC STRENGTH—standard: 500 volts RMS. (When specified, 1,000 volts RMS can be met.)

MAXIMUM WEIGHT—2 ounces.



ELECTRONICS DIVISION

ELGIN NATIONAL WATCH COMPANY

2435 N. Naomi Street, Burbank, California

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E-Z CODE self adhering wire markers provide...

POSITIVE IDENTIFICATION FOR WIRE OF ANY SIZE!

ELIMINATE WIRING GUESSWORK with easy to read E-Z CODE Wire Markers. Patent features let you apply markers without affecting adhesive quality. Thousands of stock items in standard lengths of 3/4" and 1 1/2", prices start low as 1/8¢ per wire lead! E-Z CODE Vari-temp cloth markers (temperature range 300F.) meet MIL-D-10369B for fungus resistance; stock markers also available in aluminum foil.

Available nationally from over 200 distributors, write for free working samples and catalog.

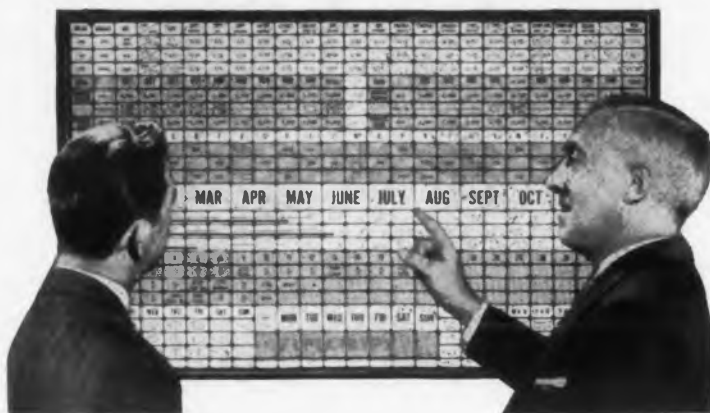


WESTLINE PRODUCTS

Division of
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604 East Second St.
Los Angeles 54, Calif.

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How To Get Things Done



BOARDMASTER VISUAL CONTROL

Gives you a Graphic Picture of your operations, spotlighted in color. You See what is happening at a glance. Facts at eye level—saves you time, prevents errors.

Simple, flexible—easily adapted to your needs. Easy to operate. Type or write on interchangeable cards, snap in grooves. Ideal for production, scheduling, sales, traffic, inventory, etc. Made of metal. Compact, attractive.

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New Products

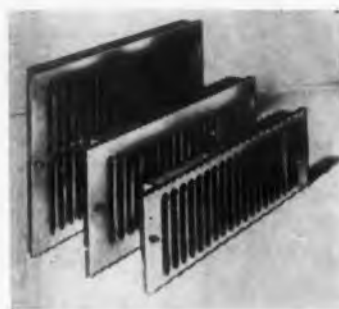


Subsonic Analyzer Resolution of 0.5 Cps

Features resolution of 0.5 cps over the full frequency range from 0.5 to 2250 cps and 0.1 cps resolution up to 225 cps. Six different sweepwidths which may be centered at almost any point. A heterodyne type analyzer, the LF-2 automatically presents a permanent paper recording of the frequency and amplitude of waveform components. It is used for vibrations and sound analysis of large structures or devices in which members rotate or oscillate at approximately the same or multiples of the same rate. The instrument has a scan range selector providing sweepwidths of 2 to 500 cps and a variable center frequency control. Resolution is adjustable in steps from 0.1 to 20 cps. Selectable amplitude scales (20 db linear and 40 db log) permit a broad range of comparative analyses.

Panoramic Radio Products, Inc., 10 S. Second Ave., Mount Vernon, N.Y.

CIRCLE 151 ON READER-SERVICE CARD FOR MORE INFORMATION



Filtered Grille Assemblies for 19 In. Racks

Available for relay racks without louvres to be used as an outlet for air if the rack is pressurized and as an inlet for air if an exhaust fan is used. When used with a metallic permanent filter it is useful as an rf shield as well as a filter. Disposable filter is available.

The assembly is fabricated in standard modular heights of 5-1/4, 7 and 10-1/2 in. for 19 in. standard racks. The grille is of polished stainless steel to harmonize with all racks to match the inlet grilles on the company's packaged blower and fan assemblies for relay racks. The filter may be removed without removing the assembly.

McLean Eng. Labs., Dept. ED, 70 Washington Rd., Princeton, N.J.

CIRCLE 152 ON READER-SERVICE CARD FOR MORE INFORMATION

5 Helpful Heart Facts



1 Some forms of heart disease can be prevented... a few can be cured.

2 All heart cases can be cared for best if diagnosed early.



3 Almost every heart condition can be helped by proper treatment.

4 Most heart patients can keep on working—very often at the same job.



5 Your "symptoms" may or may not mean heart disease. Don't guess—don't worry. See your doctor and be sure.

FIGHT FEAR WITH FACTS

Help
Your
Heart
Fund



Help
Your
Heart



Differential DC Amplifier

Temperature Compensated

Draft is minimized to less than 3 μ v over the temperature range of -50 to $+120$ F in the Model 73-R Amplifier. The amplifier has been packaged to permit rack mounting. The integral power supply is designated for direct operation from a 115 v unregulated power source at any frequency between 50 cps and 400 cps.

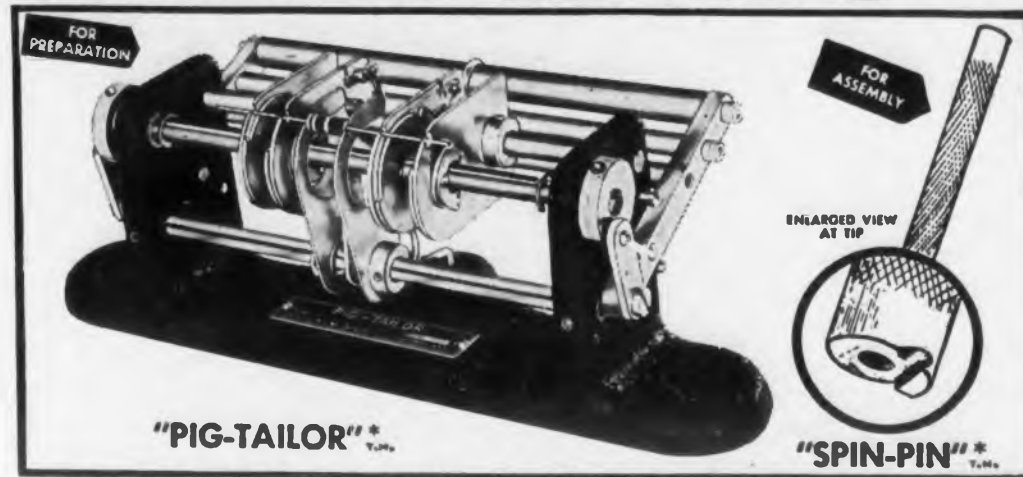
Bandwidth extends from dc to 50 kc. Gain is adjustable in five steps from 20 to 500 and the output is ± 5 volts, either differential or single-ended. This compact amplifier features low noise and high transient response with gaussian fall-off and high common mode rejection.

Video Instruments Co., Dept. ED, 2430 Sawtelle Blvd., Los Angeles 64, Calif.

CIRCLE 155 ON READER-SERVICE CARD FOR MORE INFORMATION

"PIG-TAILORING"

... a revolutionary new mechanical process for higher production at lower costs. Fastest PREPARATION and ASSEMBLY of Resistors, Capacitors, Diodes and all other axial lead components for TERMINAL BOARDS, PRINTED CIRCUITS and MINIATURIZED ASSEMBLIES.



The "PIG-TAILOR" plus "SPIN-PIN" — Accurately Measures, Cuts, Bends, Ejects and Assembles both leads simultaneously to individual lengths and shapes — 3 minute set-up — No accessories — Foot operated — 1 hour training time.

PIG-TAILORING provides:

1. Uniform component position.
2. Uniform marking exposure.
3. Miniaturization spacing control.
4. "S" leads for terminals.
5. "U" leads for printed circuits.
6. Individual cut and bend lengths.
7. Better time/rate analysis.
8. Closer cost control.
9. Invaluable labor saving.
10. Immediate cost recovery.

PIG-TAILORING eliminates:

1. Diagonal cutters.
2. Long-nose pliers.
3. Operator judgment.
4. 90% operator training time.
5. Broken components.
6. Broken leads.
7. Short circuits from clippings.
8. 65% chassis handling.
9. Excessive lead tautness.
10. Haphazard assembly methods.

* PATENT PENDING

Write for illustrated, descriptive text on "PIG-TAILORING" to Dept. ED-7P

BRUNO-NEW YORK INDUSTRIES CORPORATION

DESIGNERS AND MANUFACTURERS OF ELECTRONIC EQUIPMENT
460 WEST 34TH STREET • NEW YORK 1, N. Y.



CIRCLE 157 ON READER-SERVICE CARD FOR MORE INFORMATION



VSWR Measuring System

8400 to 12,000 Mc Sweep

The Model 160 sweep-frequency vswr measuring system is a direct-reading, X-Band instrument. Employing a backward-wave oscillator, the unit can sweep all or any portion of its range at rates of 0.02, 0.1, 1.0, and 3.0 cps. It contains a 5 in. oscilloscope with its graticule scaled directly in vswr in two ranges: 1.02 to 1.20 and 1.1 to 2.1. Presentation is duplicated on a 4 in. meter, and for permanent records, a recorder with charts ruled in vswr is available as an accessory.

The system uses a bi-directional coupler having 16 db of coupling and over 45 db of directivity in each arm. Also included are a wavemeter to provide a frequency marker pip accurate to 0.08 per cent and an adjustable 19 in. front panels if rack mounting is desired. Total height is 33-1/4 in. The waveguide assembly is 32 in. long including the wavemeter.

California Technical Ind., Dept. ED, 1440 Old County Rd., Belmont, Calif.

CIRCLE 156 ON READER-SERVICE CARD FOR MORE INFORMATION

HERMASEAL . . . Specialists in Glass-to-Metal Seals!

Hermaseal

CALL US ON STANDARD AND SPECIAL TERMINALS.

Hermaseal OCTAL Plug. ▶



Hermaseal

... A successful pioneer since 1943 in glass-to-metal seals, compression (cold rolled steel) and matched (Kovar), to meet your needs. ▶

Hermaseal NOVAL Header and Bracket Assembly.



Hermaseal

... with its expert engineering staff and the latest in production equipment is ready to serve you. ▶

Hermaseal 10 kilovolt TERMINAL. ▶



For further information, phone 2-3773 or write.



THE HERMASEAL COMPANY, INC
1010 N. Main, Elkhart, Indiana

CIRCLE 240 ON READER-SERVICE CARD FOR MORE INFORMATION

3A threads: what they are; how to gage them—new SPS booklet tells all



Threads made to Class 3A fit are the most precise in general use in industry. But you do not always get the 3A precision you specify. Because of many different gaging techniques that yield varying results, screws with threads well outside the Class 3A tolerance limits often pass inspection.

SPS has prepared a new booklet on this subject. It explains clearly what Class 3A threads are and the pros and cons involved in the widely varying gaging techniques in use today. It reviews the gaging of high and low limits of 3A threads, sampling techniques, and even the methods of gaging gages. Write for your copy today.

All standard UNBRAKO socket screw products fall within specified tolerance limits *no matter what method is used to gage them*. Leading industrial distributors carry complete stocks. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 12, Pa.

STANDARD PRESSED STEEL CO.



SOCKET SCREW DIVISION



JENKINTOWN PENNSYLVANIA

CIRCLE 158 ON READER-SERVICE CARD FOR MORE INFORMATION

SIGMA SENSITIVE RELAY SLIDECHART



For the sake of brevity, the separate bulletin sheets in the Sigma Relay Catalog give only the operating power levels for each adjustment (and not the operating currents for each coil resistance in each adjustment). There were complaints. In this case, brevity was the sole of nitwits. Customers were suffering from Ohm's Law Exhaustion just to buy one relay; so the problem was to devise a device devised to provide a fast, correct answer. And there you have it pictured above, at slightly less than half actual size.

That took care of the front. On the reverse side miscellaneous information and scales were placed, which are not usually found together. This—we divined—would make the SC attractive to you who never lost a second's sleep over what the operating current of a Sigma relay is; would get our name on your desk—and let us charge off a fair chunk of the cost to advertising.

For a limited time only, you can get a Slidechart free if you will ask for it on your company letterhead. We reserve the right to sell them at some later date.



You don't need a company letterhead (or even a job) to get a reprint of our current directory advertisement which seems to be a handy guide for those who wonder what we make in terms of what they need. Just ask for EBG* reprint.

* Electronics' Bar & Grill

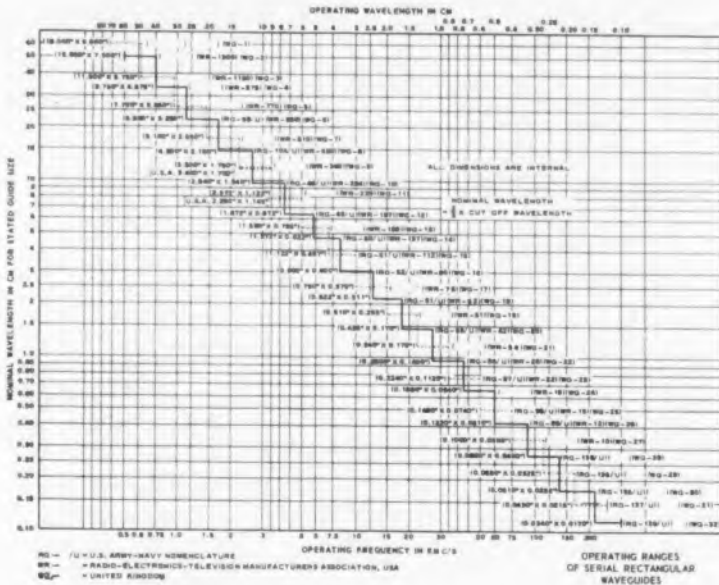
SIGMA INSTRUMENTS, INC.
91 Pearl Street, So. Braintree 85, Mass.

CIRCLE 159 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Waveguide Standards 161
 "Your Guide to Waveguide Standards" is a new brochure which can be adapted to a wall chart. It outlines the story behind the company's services in microwave produc-

tion and presents seven useful charts of specifications: RMA Standards for rigid rectangular waveguides, Guide to selection of standard waveguide flanges, Waveguide assemblies, Waveguide flanges, Guide to



You can measure accurately

0.000,000,000,000,000,1 amp = 10^{-16} amp



with the
**CURTISS-WRIGHT
 Dynamic
 Capacitor
 Electrometer**

Electronic Component &
 Instrument Sales Department

FEATURES

A micro-microammeter and millivoltmeter in one instrument • Measures currents from 10^{-16} to 10^{-8} amperes • 10, 100, and 1,000 mv ranges plus recorder output • Exclusive, diaphragm-type dynamic capacitor provides longer life, greater stability and reliability • High stability, both short and long term • Extremely high input impedance— 10^{15} ohms • Better than 2% accuracy • \$1,075.00 F.O.B. Carlstadt, N. J.

TYPICAL APPLICATIONS

- Electronics:** Measurement of semi-conductor parameters, low-level voltages, static charges, floating grid potentials, grid currents, residual noise in summing amplifiers, and insulation resistance
- Physics and Chemistry:** Mass spectrometry, pH measurements
- Nuclear:** Reactor control and radiation monitoring systems
- Industrial:** Beta and gamma gauge control systems
- Biophysics and Medicine:** Measurement of stomach acidity, skin and cell potentials.



CIRCLE 160 ON READER-SERVICE CARD FOR MORE INFORMATION

selection of standard rigid rectangular waveguides (physical dimensions), Rigid rectangular waveguides, and Operating ranges of serial rectangular waveguides, the last of which is here reprinted. Budd-Stanley Co., Inc., 43-01 22nd St., L.I.C., N.Y.

Tubular Capacitors 162

Detailed information on six up-right mounting paper or Mylar dielectric tubular capacitor types are described in brochure just released.

The illustrated models in the brochure are described in full and in each case, the applications, characteristics are included. Good All Electric Mfg. Co., 120 First St., Ogallala, Neb.

Adhesives and Sealants 163

In an 8-page brochure, a complete line of epoxide adhesives, cements and sealants is covered. The advantages, uses and properties of each type are described along with instructions for applying it. Prices of the above and other products are listed. The bulletin also contains a revised list of standard available products. Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.

Induction Heating Review 164

This review, No. 1—Feb. 1957, will be printed periodically for those who are interested in simplifying any of the operations where heat is required.

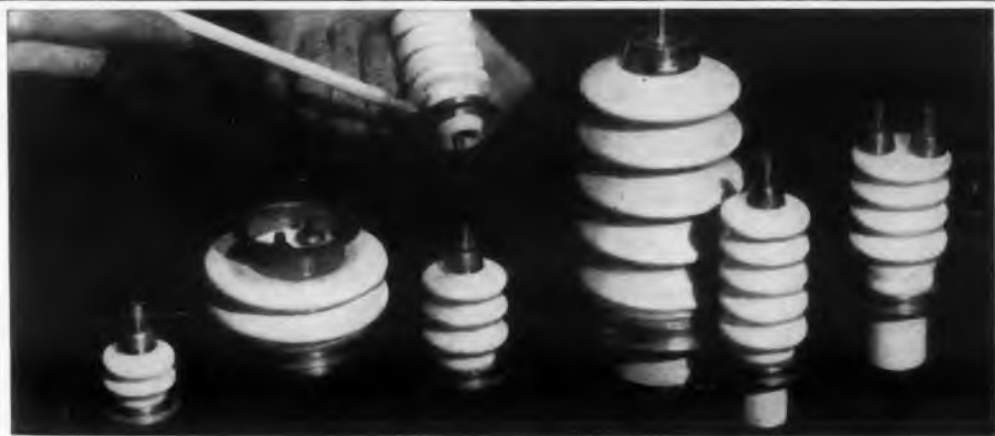
The illustrated pamphlet shows many typical applications, schematics and tables. Lepel High Frequency Labs. Inc., 55th St., and 37th Ave., Woodside 77, N.Y.

Rack Mounting Oscillographs 165

Multi-channel rack mounting oscillographs are described in an eight-page folder just released. The instruments permit simultaneous recording of up to eight phenomena in clearly legible chart form.

Accurate and permanent records are thus immediately available for analysis. These oscillographs feature an electrically-controlled transmission which allows instantaneous switch selection of 16 different chart speeds ranging from 10 in. per sec to 10 in. per day. When used with amplifiers, recordings may be made over a frequency range extending from dc to 100 cps.

The illustrated folder gives details on many of the instruments features and covers engineering and operating information. Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio.



For exacting, high-temperature applications...

CERAMASEAL LEAK-TIGHT TERMINALS

Assuring you savings in installation and operation, these Ceramaseal high-temperature terminals are 100% leak-tested and guaranteed leak-tight when shipped.

High-alumina ceramic and metal parts of Ceramaseal terminals are joined by an exclusive process to form a high-strength, long-life molecular seal.

Brazing, welding or soldering techniques can be used for installation, without resulting damage to the seal, thus eliminating costly rework or replacement.

For brochure and spec sheets, or complete information on special high-temperature terminals, write: Ceramaseal, Inc., Box 25, New Lebanon Center, New York.

Supplying High-temperature, Quality Terminals for Five Years

CERAMASEAL, Inc.

CIRCLE 166 ON READER-SERVICE CARD FOR MORE INFORMATION

GENERATES ENTHUSIASM



High Stability
Wide Range
Crystal Calibration
Marconi Precision



MODEL 995A/2

MARCONI SIGNAL GENERATOR FM-AM, 1.5-220 MC

Engineers will appreciate the calibrated incremental frequency control and oscillator temperature compensation which are the latest improvements in Marconi 995 Signal Generators. Built-in crystal calibrator, variable metered deviation from 0 to 600 kc, AM without FM and precise output calibration are retained in Model 995A/2 AND—the price is right.

BRIEF SPECIFICATION:—

Frequency 1.5 to 220 Mc in 5 bands.	FM 0-25 kc, 0-75 kc and up to 600 kc.
Output $.1\mu\text{V}$ to 200 mV.	AM 0-50%.
Accuracy ± 1 db to 100 Mc, ± 2 db to 220 Mc.	Mod. Accuracy AM or FM — 5%.
Leakage Unmeasurable with $.1\mu\text{V}$ receiver.	Tubes 6AK5, 6AK6, 6AU6, 12AT7, 0A2, 5Z4G.

Price \$940

Delivery Immediate

Try it first, at OUR cost. Full specification available, of course.



MARCONI instruments

44 NEW STREET • NEW YORK 4, NEW YORK

CIRCLE 167 ON READER-SERVICE CARD FOR MORE INFORMATION

Unparalleled savings for parallel resistor-capacitor applications

Centralab TUBE-R-Cap*

Saves Space! —

Combines a high-quality ceramic capacitor and a built-in fixed resistor in the space of a tubular capacitor alone.

Saves Initial Cost!

Costs you less than an equivalent combination of individual resistor and capacitor.

Saves Handling Costs! —

Only one piece to insert, instead of two; only one piece to carry on inventory.

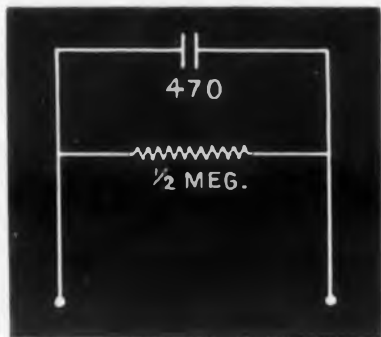
Provides any normal capacitor specification through 4700 mmf. and any resistance value from 100 ohms through 3 megohms (with $\pm 20\%$ tolerance up through 1 megohm . . . $\pm 30\%$ or wider above 1 megohm).

6,000,000 Tube-R-Caps are now in use, in antenna-line and many other applications. Lead spacings provided for any printed-circuit board. (See illustration below.)

Write us for further information. Or have the nearby Centralab representative tell you more. If you don't know who he is, ask us for his name.



ACTUAL SIZE



TYPICAL EXAMPLES

DA620

Max. length, .530" — max. diam., .260"
470 mmf., $\pm 20\%$, 500V
470 K ohms, $\pm 20\%$

DA625

Max. length, .810" — max. diam., .260"
1000 mmf., $\pm 20\%$, 500V
330 K ohms, $\pm 20\%$

DA632

Max. length, .900" — max. diam., .280"
470 mmf., GMV, 1500 VAC (UL rated)
.3 to 1 megohm



Available with crimped leads,
for printed wiring board insertion

Centralab

A DIVISION OF
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Milwaukee 1, Wis.

In Canada:
804 Mt. Pleasant Road
Toronto, Ontario

*Trademark

D-2558

CIRCLE 171 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Electromagnetic Controls 173

Six electromagnetic control catalogs are available either individually or bound as a composite. Catalog 57-S1, 56 pages, provides complete information on mechanically and magnetically held automatic transfer switches. Described are switches for all classes of load. Catalog 57-S2, 34 pages, covers a line of remote control switches which are mechanically held and available for all classes of load. Catalog 57-S3, 27 pages, describes magnetically held contactors available for all normally open and normally closed classes of load. Catalog 57-S4, 41 pages, describes magnetically and mechanically held relays obtainable in unlimited pole combinations. In addition, this catalog covers special purpose relays. Catalog 57-S5, 12 pages, lists a variety of ac and dc solenoids. Catalog 57-S6, 12 pages, describes electric plant controls, including complete systems, paralleling, changeover and alternating panels, load demand controls, battery chargers and adapter units.

Catalog 57-S, the complete Electromagnetic Control Catalog, combines all six

catalogs, with an inclusive index. In each of the booklets, a comprehensive text is amply illustrated with photographs and diagrams.

Requests for these catalogs must be on letterhead stationery. Automatic Switch Co., 50-56 Hanover Rd., Florham Park, N.J.

Battery Guide 174

A 1957 comparative guide to portable radio batteries has been issued in wall chart form. To details on the battery components of more than 600 portable radio models is added a section on "transistor batteries". Ray-O-Vac Co., 212 E. Washington Ave., Madison, Wis.

Shop Problems 175

Simple shop setups to eliminate special tooling and cut production time and costs are discussed in a booklet of 6 pages entitled "Solving Shop Problems". The article describes and illustrates some typical problems and how they were handled. Servo Corp. of America, New Hyde Park, N.Y.



Teflon connectors, hermetically sealed,

FOR TEMPERATURES FROM **-100 TO +500 F**

No other material, natural or synthetic, compares with DuPont Teflon for toughness, chemical inertness, high dielectric strength. It will not char or carbonize from arcing; stands thumping shocks and vibration; will not warp or loosen at jet engine heats or sub-zero climates. Made by a revolutionary new molding process. Every manufacturer of high frequency radio, radar and other electronic equipment should write for details.

The **Joclin** manufacturing company 20 Lufbery Avenue
Wallingford, Connecticut

CIRCLE 172 ON READER-SERVICE CARD FOR MORE INFORMATION

ELECTRONIC DESIGN • July 1, 1957

Dynamotors

176

Engineering design and performance data on a line of dynamotors are available in a 1-page information sheet. The units described cover a wide range of input and output voltages and power outputs and have a brush life of 1000 hours. The literature is illustrated with a graph and dimensional diagrams. Induction Motors Corp., 570 Main St., Westbury, N. Y.

Modular Digital Instruments

177

A four-page, illustrated catalog gives brief specifications for a series of modular digital instruments. The booklet describes available units and shows how they can be combined into single-purpose instruments such as digital voltmeters, digital ohmmeters, digital ratiometers or complete check out systems. Electro Instruments, Inc., 3794 Rosecrans, San Diego, Calif.

University Training Reactor

178

The University Training Reactor, designed to meet the needs of nuclear engineering curricula in college and university,

is the topic of a 16-page brochure. The booklet lists specifications and shows a cut-away view of the reactor and a typical layout for the arrangement of facilities. American-Standard Corp., Atomic Energy Div., Redwood City, Calif.

Timing Devices

179

In concise form, Catalog Sheet BX-219 provides basic engineering data on a series of timing devices. Shown on an illustrated chart are a variety of switching arrangements and features. The 2-page sheet also contains mounting illustrations and dimensional drawings. M. H. Rhodes, Inc., 29 Bartholomew Ave., Hartford, Conn.

Silicone Applications

180

An 8-page catalog, CDS-97, describes 115 applications for silicones, including resins for electrical insulation. Qualitative dielectric characteristics, service life, power/weight ratio, and moisture and corrosion resistance information is given. Resins providing class H insulation are denoted. General Electric Co., Silicone Prods. Dept., Waterford, N.Y.

Engineers:

Stimulating work... Stimulating play
just minutes apart



This is Honeywell in Minneapolis... an ideal atmosphere for the engineering mind. At work; outstanding technical facilities plus the opportunity to work on today's most advanced electronic projects, a chance to work in a small group, guide your own project, get the recognition you deserve.

And in Minneapolis, just minutes from your work, 22 lakes and 151 natural parks. Swimming, fishing, boating... year-round outdoor play for you and your family, good schools, theatres and shopping, too!

At Honeywell you move ahead quickly. This fast growing company, already world leader in automatic controls, has more than doubled sales in the last five years, increased its engineering force over 100%. In such a company, promotions open quickly. At Honeywell, they come from within. You start at a first-rate salary and it's just the start.

Honeywell
First in Controls



Career opportunities for:

*Design and Development,
Production and Analysis
Engineers in:*

Ordnance Division:

WARHEADS • INFRARED SYSTEMS • TEST AND TRAINING DEVICES • THERMAL BATTERIES FUZING • CONVERTERS • RECTIFIERS • INVERTERS • SONAR SYSTEMS • FIRE CONTROL SYSTEMS

Residential, Industrial and Commercial Controls Divisions:

TEMPERATURE, PRESSURE AND HUMIDITY CONTROLS • AMPLIFIERS • COMBUSTION SAFEGUARDS • DAMPER MOTORS CONTROL PANELS AND SYSTEMS

Add this
VERSATILE
Electric
COUNTING UNIT
to your **PRODUCT,**
MACHINE, or METHOD

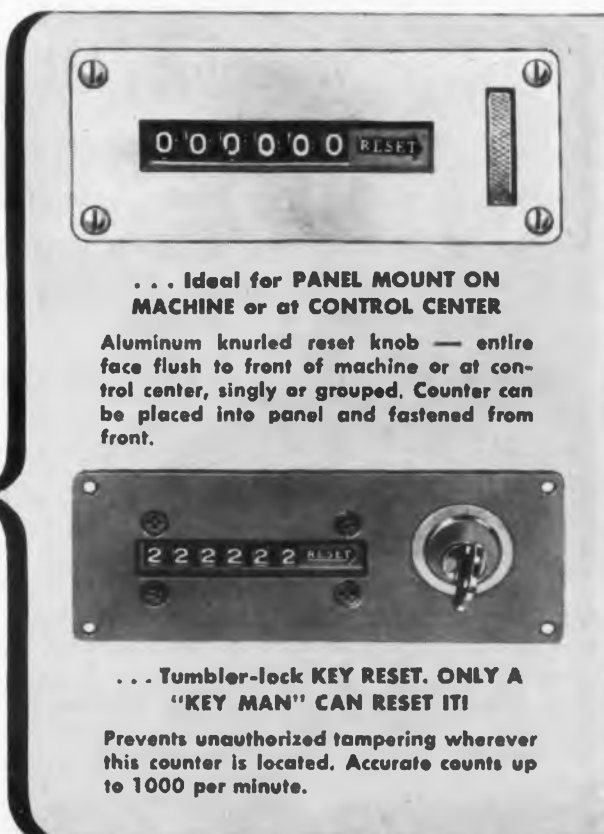


Model 6-Y-1-MF
with Knob Reset

Small, compact — with mechanism entirely enclosed as protection against dust and moisture. Maximum visibility. Records accurate count at high, low and intermediate speeds.

Send for Bulletin No. 55

DURANT MFG. CO.
1993 N. Buffum St., Milwaukee 1, Wis.
193 S. Water St., Providence 3, R.I.
Representatives in Principal Cities



... Ideal for **PANEL MOUNT ON MACHINE** or at **CONTROL CENTER**

Aluminum knurled reset knob — entire face flush to front of machine or at control center, singly or grouped. Counter can be placed into panel and fastened from front.

... Tumbler-lock **KEY RESET. ONLY A "KEY MAN" CAN RESET IT!**

Prevents unauthorized tampering wherever this counter is located. Accurate counts up to 1000 per minute.

PRODUCTIMETERS
SINCE 1879 *Count Everything*

CIRCLE 181 ON READER-SERVICE CARD FOR MORE INFORMATION

MAIL THIS COUPON NOW

Mr. W. D. Conley, Dept. TM20D
Minneapolis-Honeywell Regulator Company
2753 4th Avenue, South, Minneapolis 8, Minnesota

- Résumé attached
 Send more information about opportunities at Honeywell

NAME _____ DEGREE _____

STREET AND NO. _____

CITY _____ ZONE _____ STATE _____

CIRCLE 569 ON READER-SERVICE CARD FOR MORE INFORMATION

ONE OF THESE **4** PACIFIC
Accelerometers

CAN PROVIDE RELIABLE ACCELERATION MEASUREMENT FOR YOUR OWN NEEDS!

Four basic Pacific Accelerometer types — already designed and developed — can be used to meet practically any acceleration measurement requirement! Send for complete data sheets!

HIGH ACCURACY POT

Single or dual potentiometer pick-off and/or switches . . . automatic caging mechanism. A unique torsion-bar suspension and restraining system provides very low hysteresis with exceptionally rugged, long life. Available in a wide variety of G ranges.

SERIES 4202



LIGHTWEIGHT, MINIATURE

accelerometer combines a wide flexibility of design and performance characteristics with a proven, high production instrument. Potentiometer pick-off . . . wide selection of G ranges with an operating range of 0 — ± 1 G to 0 — ± 50 G.

SERIES 4201

HIGH ACCURACY AC OUTPUT

linear accelerometer designed for high response systems requiring AC signal. This unit provides an accurate, large output AC signal while maintaining a high natural frequency and low cross talk. Temperature compensated fluid damping provides exceptional dynamic characteristics without heater.

SERIES 4204



NO CROSS TALK

due to uni-directional design this instrument measures acceleration in one direction only, and cannot produce any output signal from cross accelerations. Pot pick-off . . . available in a choice of many G ranges.

SERIES 4203



PACIFIC SCIENTIFIC CO.

P.O. BOX 22019 LOS ANGELES • LUDLOW 3-1121
 LOS ANGELES • SAN FRANCISCO • SAN
 DIEGO • SEATTLE • ARLINGTON, TEXAS

REPRESENTATIVES:

Eastern U.S.
 AERO ENGINEERING CO
 Canada
 GARRETT MFG. CORP.

CIRCLE 183 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Aluminum Dip Brazing

185

Bulletin 23 describes Alumibraze, an alloy in a form that offers an improved method for joining aluminum parts. Well illustrated, the four-page bulletin gives step-by-step details on dip brazing with this powdered aluminum-silicon alloy which is applied to the joint in the form of a paste. It also describes design techniques, fixturing arrangements and salt-bath requirements to produce strong, dependable joints in various aluminum alloys. Handy & Harman, 82 Fulton St., New York 38, N.Y.

Plastic Rods and Tubing

186

In Bulletin 105, dimensional tables cover tubing and rod made of nylon, cellulose-acetate-butyrate, methacrylate (lucite or plexiglas), polyethylene, polystyrene and vinyl. The eight-page illustrated booklet lists rods in coils, reels and straight lengths. It also points out the characteristics of the aforementioned plastics. Tables show ID and OD dimensions, wall thickness and weight per 100 ft for each material. Jessall Plastics, Inc., Kensington, Conn.

Coil Bobbin Data

187

Covered on a single-page data sheet is a line of one-piece molded nylon coil bobbins. In addition to tabulating complete dimensions of all available round standard bobbins, the sheet shows a number of standard variations which the user may specify without incurring tool costs. Also available are standard drawings of square, rectangular and oval coil bobbins. Gries Reproducer Corp., 400 Beechwood Ave., New Rochelle, N.Y.

K and RK Connectors

188

Catalog K6 provides 64 pages of information on K and RK electrical connectors designed for use in aircraft, radio, and many types of instruments and general electrical equipment. Listed are seven basic shell types with eight insert sizes, or more than 220 arrangements. Television connectors and hermetic-sealed types are included in this edition. Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.

Machlett ML-6908

A New High Power Rectifier Tube For Radar Installations



supplies where insensitivity to low ambient temperatures as well as high current at high power are necessities. The ML-6908 incorporates a thoriated-tungsten filament of catenary design which permits both high peak inverse voltage and low internal voltage drop. A heavy wall copper anode protects the tube against overload.

General Specifications: Filament: 12v, 23a; Max. Voltage Drop 2400v at 10 amps. peak; Peak Inverse Anode Voltage, 150,000v; Peak Anode Current, 10a; Anode Dissipation, 2000w.

Average D-C Load Current: 3-phase double-Y parallel, filtered, choke input: 9.0 amps. 3-phase, full-wave, choke input; 4.5 amps.

Machlett Laboratories, Inc., 1063 Hope Street, Springdale, Connecticut

CIRCLE 184 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistor List

As a service in the electronic component field a new subscription plan beginning with the second edition of the Transistor list of April 1957 has been announced. Issued in complete form every six months, the subscription plan will provide continuity of the latest information available on all American and a substantial number of foreign transistors. More than 350 transistors will appear in the April issue, reflecting at least 175 additions, revisions, or deletions since the first edition in July 1956. The second edition and future lists will also include many suggestions of present users; such as derating of maximum collector dissipation; material used—germanium or silicon; as well as distinct symbols indicating new transistors, revised data, and foreign types. Transistor List subscriptions, beginning with the second edition in April are available at \$12.00 per year. Derivation and Tabulation Assoc., Inc., 67 Lawrence Ave., West Orange, N.J.

Optical Tooling

190

An illustrated catalog listing complete line of optical tooling equipment has just

been released. It lists such standard items as jig transits, alignment telescopes, and paragon tilting levels, together with a large number of accessories, instrument stands, fixtures collimators, scales, targets, and optical attachments, including the optical square. Keuffel & Esser Co., Hoboken, N.J.

Plastic Capacitor Chart

191

Quickly available capacitor data comes on a 7-5/8 x 4-1/8-in. plastic card. The handy reference chart shows dielectric qualities and temperature coefficients of tubular and disc Ceramicons and maximum available nominal capacities in micromicrofarads. The reverse side of the card gives dimensions of Ceramicons and PAC's. Erie Resistor Corp., Electronics Div., Erie, Pa.

Metal Film Precision Resistors

192

In 4 pages, Bulletin B-3 presents comprehensive data on the construction, applications and characteristics of several types of metal film precision resistors. Detailed performance charts are presented along with dimensional diagrams and graphs. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

A PROVEN INSTRUMENT FOR
SENSITIVITY MEASUREMENTS ON TRANSISTORS TO 50 mc

KAY *Microlter*

Wide-Band, High-Frequency, Low-Level Vacuum Tube Voltmeter Employing a High Impedance Probe. A Unique Design Utilizes Extremely Wide-Band Amplifiers for Measurement at Higher Frequencies.

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The unit permits measurement of low level RF signals. A 7 position switch provides *full scale* steps of 1, .3, .1, .03, .01, .003 and .001 volts, the lowest reading being 250 microvolts. These ratios permit an easily read meter scale.



SPECIFICATIONS

Frequency Range: Model 50: 100 cycles to 50 megacycles. Direct Reading in voltage or decibels.

Accuracy: $\pm 10\%$ of full scale reading.

Frequency Response: Model 50: ± 1 db.

Voltage Range: 1 millivolt to 1 volt full scale in 7 ranges.

Sensitivity: Will measure down to 250 microvolts.

Input Impedance: Capacitance 5 mmf, resistance loading dependent on frequency (1 megohm at 1 megacycle to 30,000 ohms at 50 megacycles)

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The Model 50 may be used as a wide-band video amplifier, maximum output approximately .25 volts at 75 ohms. Gains of up to 44 db.

Prices: Model 50 \$495.00
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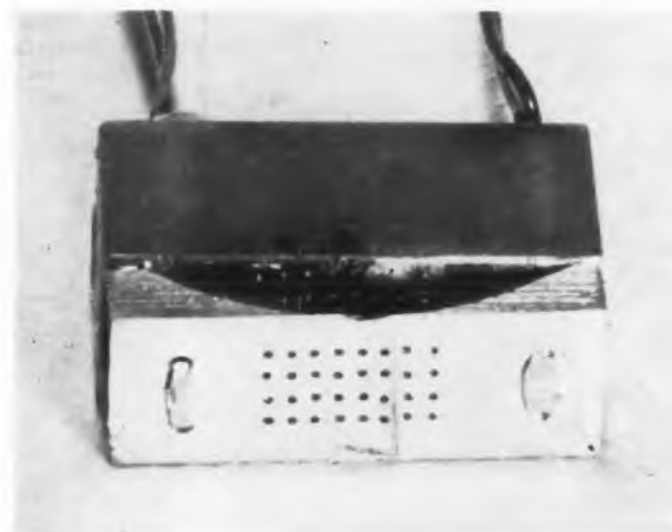
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Ideas for Design

Fast Response



Air temperature sensing device
as mounted on an aircraft.



Convair-developed fast-
response thermocouple.

BASED on a growing need during extended flight instrumentation programs for a very-fast, temperature indicating device that will measure rapidly changing air temperatures, Convair's electronics test laboratory has developed a thermocouple which provides the fast response needed to register the changing air temperatures encountered by modern supersonic aircraft. These varying temperatures might be caused by maneuvers, explosions, or rockets passing through the air. Thus, the hot air region encountered would be narrow and its temperature quite high in comparison to the ambient air temperature.

Suppose there is a region of air at 560 F which is 100 ft. wide. An aircraft flies through it at Mach 1. The ambient air might be at -60 F. Then the change in temperature would be 500 F. The total time that the airplane would be in this hot region would be 0.091 sec. Therefore, in order for aircraft systems to have time to adjust to this large air temperature change, the sensing element should be able to give a total response in 0.01 to 0.02 sec.

To reduce the thermal mass to an absolute minimum, evaporated metal film junctions were tried. The use of evaporated metal films permitted junctions to be prepared with small amounts of metal, and, yet still conduct electricity. These junctions, however, are too thin to support themselves and must be put on a suitable base.

This base material must meet very stiff requirements. Only glass and wood meet these requirements. Some plastics such as the Epoxy resins can be made to have expansion characteristics similar to metal but when this is done the heat conductivity is too high to be useful. Glass is fragile when made into a shape that would give good heat transfer to the thermocouple and its heat conductivity coefficient is rather high compared to wood. Wood appears to be the best choice.

Tests were made with hard and soft woods. The soft woods have lower rates of heat transfer but they do not produce good conducting vacuum metallized films. The wood which was finally selected was somewhat by chance. Bamboo was selected when it was noticed that it could be made

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Thermocouple

very thin and still be quite strong as in saxophone reeds. It was also found to have the very dense structure needed to produce a very smooth surface for good conducting metallized films. Its only disadvantage is its fairly high specific heat, but this is partially compensated by making the base thin.

Probe Design

The present design is shown. It consists of a bridge shaped bamboo section which is made very thin under the junction area, a plastic base on which the bridge is mounted, copper and nickel wire leads and the copper-nickel vacuum metallized junction. The bamboo section is perforated with a number of small holes to allow the air to circulate through it and thus produce a much thinner boundary layer. The area and thickness of the metallized junction can be varied, and at present the metal films are about 5,000 A thick. Special techniques have been devised for thermocouple fabrication.

Since thermocouples characteristically have an exponential response, it is customary to refer to a time constant. This time constant being the time required for the thermocouple output to reach 63 per cent of its final value with step input conditions. It is relatively easy to obtain time constants of 0.08 sec while time constants of 0.05 sec have been reached. The conventional temperature probes tested do not approach this response—being about 0.2 sec.

Applications

This probe could find use in electronically controlled air conditioning systems where the air temperatures must be held within very close limits such as in some laboratory applications. It could be used as the sensing element in crystal oven control circuits where the crystal temperature has to be very constant in order to maintain the crystal frequency accurately. It could be used to evaluate heat transfer through air boundary layers since it measures the temperature at the probe's surface. The junction area and the heat capacity of the probe would have to be known for heat transfer studies.—R. J. Reid, development engineer; W. M. Gross, chemist; Conair, San Diego, Calif., Div. of General Dynamics Corp.

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Ideas for Design

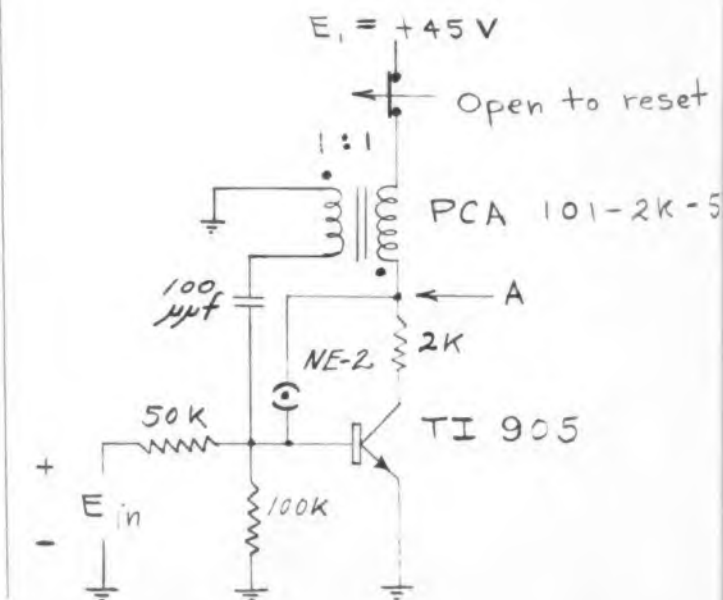
Transistor "Thyratron" Circuit

The circuit shown in the figure provides a thyratron-like latching action using a neon bulb and transistor, with the advantage of insignificant standby power consumption. The action of the circuit is as follows.

The supply voltage E_1 is chosen to lie about halfway between the circuit extinction and firing voltages, so that when power is initially applied to the circuit (with the input voltage zero) no current will flow in the load. The circuit extinction voltage and the neon extinction voltage should be the same. The circuit firing voltage, however, will be lower than the firing voltage of the neon alone, since the neon will furnish some "dark" current to the transistor base and cause the circuit to fire and latch at a voltage lower than that required to fire the neon itself. Because of the variation between neons, it may be convenient in some applications to furnish voltage E_1 from a variable regulated source. Such a source may be easily constructed using a low current potentiometer bleeder and emitter-follower regulator combination.

As the input voltage and transistor base current increase, a critical point is reached. The usual blocking oscillator action occurs at the critical input and produces a negative pulse at point A. The positive overshoot of the negative pulse produced at point A, superimposed on the supply voltage E_1 , is sufficient to fire the neon. Because the supply voltage E_1 is greater than the neon extinction voltage, the neon remains fired after the blocking oscillator pulse is over. The neon furnishes base current to the transistor and latches the circuit in the "on" condition. To reset the circuit, it is necessary to reduce the input below the critical value and temporarily interrupt the supply voltage E_1 . Typical circuit values are shown. At input of +4 v, this circuit will fire and latch, providing 15 ma to the 2000 ohm load.

W. F. Nielsen, Sandia Corp., Albuquerque, N.M.



ELECTRONIC DESIGN • July 1, 1957

IDEAS FOR DESIGN — *ENTRY BLANK*

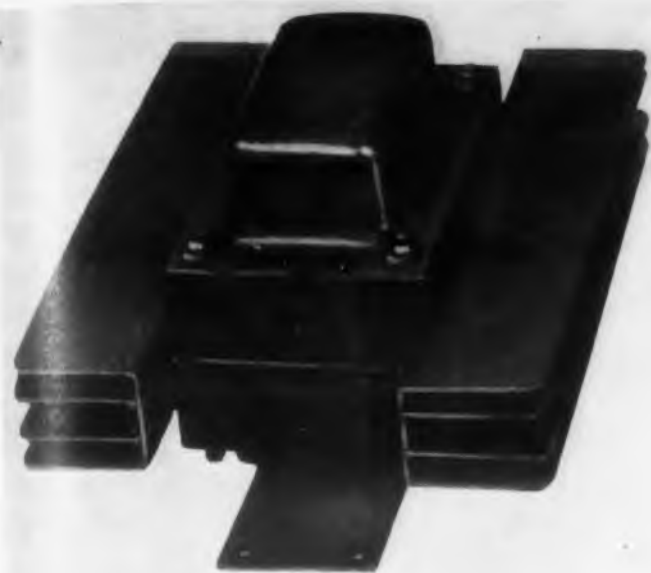
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STATEMENT OF THE PROBLEM—

MY SOLUTION, AND WHY — (Please be explicit. Include sketches or photos that will help get the idea across)



Fin-cooled power transformer.

Fin-Cooled Power Transformer

This fin-cooled power transformer for television receivers developed by Zenith Radio Corp. solves its own heat dispelling problem and effects savings of about 10 per cent in cost. By using a multiple-fin construction in the transformer, the surface area has been increased by 185 per cent. This steps up the rate of heat dispersal by 50 per cent, permits a substantial reduction in the amount of iron and copper used, and markedly reduces the weight of the transformer itself.

Zenith mounts this transformer on the TV chassis in such a way that it acts as a pump, pulling cool air in from a vent located on the under side of the chassis. The air rises through the vertical chimney-like fins, cools the transformer and escapes at the top of the cabinet back.

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Patents

Dynamic Amplifier

Patent No. 2,779,921. R. C. Hawes. (Assigned to Beckman Instruments, Inc.)

The amplifier serves to measure a small input current signal. The input signal circuit has a vacuum tube with a control grid and an anode. A switch connects the positive terminal of a plate voltage supply to the anode. A signal input capacitor is provided in series between the grid and the anode. The output circuit includes an output capacitor and a current measuring device in series. The anode is connected to the output circuit so as to control the current in the latter. One of the terminals of the output capacitor is connected to a point between the switch and the anode.

Self-Latching Oscillator

Patent No. 2,778,939. J. A. Haddad. (Assigned to International Business Machines Corp.)

The patent is directed to an electrical oscillating circuit having an electron discharge tube and the circuit oscillates when the tube is conducting. A control circuit provides a negative bias for the tube to maintain the tube in a non-conductive condition. The application of a pulse drives the tube into a conducting condition. A gaseous discharge tube is energized by the output of the oscillating circuit and controls electrical means which overcomes the bias of the control circuit to maintain the oscillating circuit in an operating condition.

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ELECTRONIC DESIGN • July 1, 1957

Magnetic Memory System

Patent No. 2,776,419. J. A. Rajchman and M. Rosenberg. (Assigned to Radio Corporation of America)

The invention is directed to a magnetic memory system having a plurality of saturable magnetic cores. To a selected core only, a magnetomotive force of core saturating strength is applied through suitable coil means. The saturating magnetomotive force is applied to the core successively in one sense and then in the opposite sense to complete a cycle. A winding is coupled to all of the cores, and an integrating circuit is coupled to receive the output of this winding and to integrate it over the complete cycle.

Oscillating Control Apparatus

Patent No. 2,778,574. W. Moore, Jr., and R. J. Ehert. (Assigned to Minneapolis-Honeywell Regulator Co.)

A circuit for the control of an oscillator is described. The circuit includes one or more tubes, and a pair of tank circuits. One tank circuit is connected to the output of the tube or tubes and the other tank circuit is

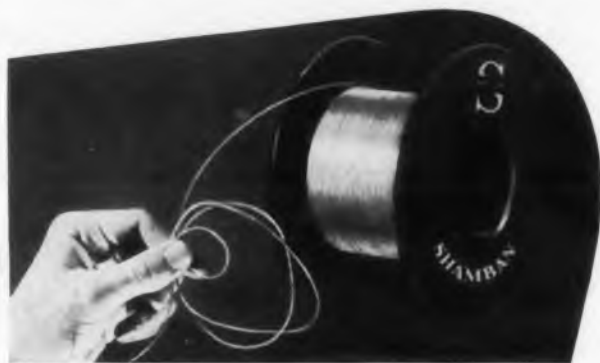
connected to the input. A single inductive element is common to both circuits. A vane is provided which varies the effect of the inductive element on the oscillating circuit and causes the latter to go into and out of oscillation in accordance with its relative position with respect to said inductive element. An additional variable coupling is inserted between the inductive element and the input which varies the coupling in the oscillating circuit.

Automatic Beam-Centering Circuit for Cathode-Ray Devices

Patent No. 2,779,894. C. A. Gallagher. (Assigned to Servo Corporation of America.)

The cathode-ray deflection means of the patent has a centering control for the beam which includes a four-element bridge. One pair of diagonal corners is connected to a source of direct current supply. A third corner of the bridge is connected to an input terminal of each of the usual deflection systems and a capacitor is provided between the third and fourth corners. A potentiometer, across the dc source, is connected to the other terminal of each of the usual deflection systems.

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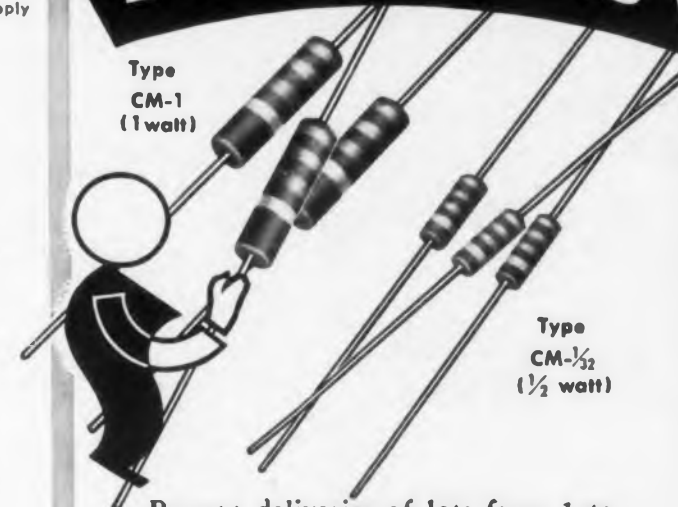
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MODEL 531



MODEL 541A



MODEL 459

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Model 459 (TS-330/TSM) covers 1-15 mc frequency range for crystals having resonance resistances from 0 to 9900 ohms. Price \$695.

Model 1207 (AN/TSM-15) covers frequency range of 75-200 mcs for 10-125 ohm crystals. Crystal voltage at series resonance is measured and power calculated. Built-in ohmmeter.

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CIRCLE 206 ON READER-SERVICE CARD FOR MORE INFORMATION

Patents

Cascode Circuits

Patent No. 2,775,659. E. K. Nelson. (Assigned to Standard Coil Products Co. Inc.)

The patent describes a television receiver circuit which will receive an upper and a lower frequency band and also a new wide band high frequency amplifier circuit having general application as well as being advantageous in the receiver circuit. The amplifier circuit includes a first triode having a grounded cathode and a second triode having a grounded grid. A network automatically tunes the amplifier to the frequency spectrum in the upper and lower frequency bands and includes an inductance between the plate of the first triode and the cathode of the second triode. The value of the inductance is selected so that it provides parallel resonance with the plate interelectrode capacitance of the first triode at the high frequency portion of the upper frequency band and series resonance with the cathode interelectrode capacitance of the second triode at the low frequency

portion of the band. In the amplifier the second triode is connected as a cathode-input grounded-grid stage with its cathode having a predetermined capacitance to ground. The first triode is connected as a grid-input grounded-cathode driving stage.

Television Scanning Unit

Patent No. 2,777,089. K. E. Farr. (Assigned to Westinghouse Electric Corp.)

An improved beam deflection system for a cathode ray tube is illustrated and described which uses a transformer having a primary winding and a pair of secondary windings. One of the secondary windings provides current through a deflection coil of the CR tube. The other secondary winding supplies current through a rectifier to an anode of the CR tube. One end of the primary winding is coupled to one end of the



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ELECTRONIC DESIGN • July 1, 1957

first secondary winding by a condenser and the other end of this secondary winding is connected to the negative pole of a direct current source. The positive pole of the source provides current to the primary winding through a rectifier to induce substantially saw-tooth current waves in the deflection coil. A variable inductor in series with a second condenser connects this same end of the primary winding with the negative pole of the current source.

Coherent Radar System

Patent No. 2,776,425. F. J. Altman. (Assigned to International Telephone and Telegraph Corp.)

A radar system includes a transmitter for radiating oscillatory energy toward a mobile reflecting object and a receiver for receiving waves reflected by said object. In the system of the patent the difference in phase between the transmitted energy and the reflected energy is detected and fed to means which obtains the difference in fre-

quency between the transmitted wave and the reflected wave. A control voltage is then derived which is responsive to the detected difference in frequency. Means responsive to this control voltage locks a variable oscillator to the detected frequency difference.

Cascade Multivibrator

Patent No. 2,778,935. R. L. Ropiequet. (Assigned to Tektronix, Inc.)

The trigger-actuated multivibrator uses a plurality of tubes arranged in a normally conducting side and a normally non-conducting side. One side of the multivibrator consists of a pair of tubes with the cathode of the first tube connected to the plate of the second tube. The other side includes a pair of tubes with the plate of the first tube and the grid of the second tube connected through suitable means to the other side of the multivibrator. The other electrodes of each tube are connected to a source of operating potential. The triggering signal is applied to the connection between the cathode and plate of the first pair of tubes.

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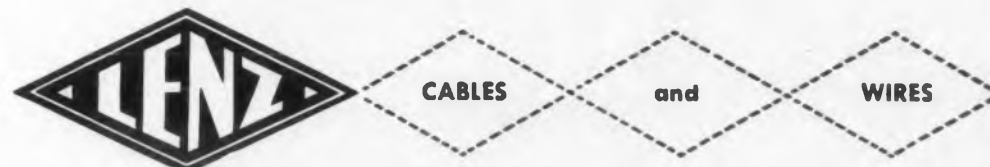
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Books

Television Receiving Equipment

W. T. Cocking, *Philosophical Library, Inc.*,
15 East 40 St., New York 16, N.Y. 454 pages,
\$15.00.

In preparing this fourth edition of "Television Receiving Equipment" Cocking has rewritten approximately three-fourths of his original text, in order to keep up with rapid developments in television.

Band III reception is thoroughly treated as well as the increasing problems of attaining freedom from interference combined with high definition. Magnetic deflection has been expanded to five chapters

and synchronizing methods are fully discussed, including flywheel sync. Automatic gain control systems are explained in detail.

The book assumes that the reader will have a fair knowledge of ordinary sound-radio technique, which is a necessary preliminary to an understanding of television. The treatment is largely non-mathematical, but formulae useful to the designer have been collected in the appendices. Two chapters on faults and servicing which appeared in previous editions have been omitted.



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Proceedings of the 1957 National Nuclear Instrumentation Conference.

Instrument Society of America, 313 Sixth Avenue, Pittsburgh 22, Pa., \$5.00.

A complete source of nuclear instrumentation information is contained in the published proceedings of the Instrument Society of America's National Nuclear Instrumentation Conference held in Atlanta April 10, 11 and 12. The papers included cover seven major session headings including two separate meetings on Reactor Instrumentation, and additional sessions on Industrial Nuclear Instrumentation, Basic Problems in Nuclear Instrumentation Health Physics Radiation Instrumentation, University Nuclear Instrumentation Program, and Nuclear Instrumentation in the Medical Field.

VHF Television Tuners

D. H. Fisher. *Philosophical Library, 15 East 40 St., New York 16, N.Y., 136 pages, \$6.00.*

The treatment of television tuners by D. H. Fisher is divided into three sections: Tuner Design; Tuner Construction; Tests, Measurements, and Servicing. Theoretical

factors are considered first. Section I gives a complete introduction to the problems to be solved and an understanding of the reasons underlying the choice of a particular unit. In Section II the practical considerations of tuner construction are discussed. The intention is to show what is being done and why. Laboratory, production and service problems are studied in Section III.

The Heating Ventilating & Air Conditioning Guide

1957, 35th edition published by American Society of Heating and Air Conditioning Engineers, 1250 pages, \$12.00.

Electronic engineers concerned with the control of industrial environment should find Chapter 44 of this text interesting. A new method is described for establishing standards to indicate heat stress. A chart, which is presented, permits combining the effects of various factors into a single heat stress index. Methods discussed for controlling heat exposure include: control at source; exhaust ventilation; radiation shielding; and local relief. Methods also are given for controlling air contaminant concentrations.

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What the Russians are Writing

J. George Adashko

RADIO ENGINEERING

(Contents of Radiotekhnika No. 10, 1956)

Pulse Detector

Pulse Detector with LCR Filter, E. L. Gerenrot, (8 pp, 4 figs).

The transients in an ideal detector with an LCR filter are investigated with proper allowances for the internal impedance of the current source (of the current-generator equivalent of the signal voltage). The effect of the inductance on the "overshoot" that accompanies the detection of a rectangular pulse is discussed. Simple computation methods and analytic expressions are derived for the detection of other waveforms.

Transistor Circuits

Graphical Design of Temperature Compensated Resistance-Coupled Transistor Amplifiers, G. V. Voishvillo, V. S. Davydov, (7 pp, 6 figs).

Essentially based on the analytical derivations contained in Shea, "Principles of Transistor Circuits," Keonjian, "Temperature-Compensated DC Transistor Amplifier" (*Proc. IRE*, April 1954), and Oakes, "DC Stability of Transistor Circuits," (*Wireless World*, April 1955). The family of transistor static characteristic is used to determine the shift in the operating point caused by temperature fluctuations. The inverse problem, that of using the static characteristics to establish the circuit elements for which the temperature drift will lie within a specified range or vanish entirely, is also treated.

Equivalent Circuit of Semiconductor at High Frequencies, I. I. Litvinov, (5 pp, 7 figs, 1 table).

Another attack on this popular problem, based this time on using the approximate operator equation

$$h(p) = A \frac{1}{p^2 + 2ap + c^2}$$

for the transfer function of the transistor equivalent circuit. The constants A, a and c^2 are evaluated for several Russian transistors.

Oscillator

Self-Oscillating Systems with Two Degrees of Freedom, and with Common-Multiple Natural Frequencies, G. M. Utkin, (11 pp, 1 fig).

The simple circuit shown in Fig. 1 can oscillate at two simultaneous frequencies that are common multiples of each other, provided the circuit parameters are properly chosen. An extensive analysis of such circuits is given, and their performance in frequency multiplication and division circuits and in frequency modulation is discussed.

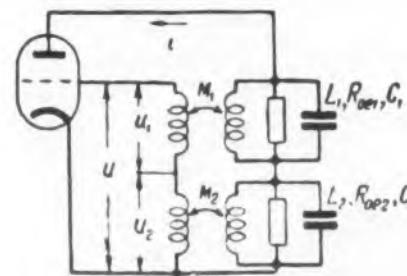


Fig. 1. Simple multiple-frequency oscillator

Audio Power Amplification

Pulse Methods in Audio Frequency Power Amplification, V. V. Malanov, (9 pp, 8 figs).

A theoretical analysis, giving no circuit data, of a scheme whereby the audio signal is pulse-width modulated, amplified, and demodulated in a selector-modulator circuit, which separates the modulating frequency from the higher harmonics in the amplifier output. These harmonics can be rectified and supply part of the amplifier power. The idea was first proposed by Prof. D. V. Ageev (presumably of the Gor'ki Polytechnic Institute, where the work abstracted in the article was done as a Candidate's thesis project) in 1951 and was independently suggested in France by R. Charbonnier (neither date nor reference cited). It is shown that this method becomes attractive only at high powers (above 20 watts) and apparently for voice frequencies only.

Panoramic Receiver

Choice of Intermediate Frequency in Panoramic Receivers, N. I. Svetlov, (19 pp, 3 figs, 5 tables).

The design of a panoramic receiver involves the simultaneous determination of several parameters, including the choice of first and second IF's, choice and design of the f-m heterodyne circuit, the compensation of the frequency characteristics of the wide-band channel, and the choice of the pass band and of the type of filter used in the second IF amplifier and sweep-frequency generator. The article deals only with the choice of intermediate frequencies and with the prevention of cross-modulation effects.

RADIO ENGINEERING

(Contents of Radiotekhnika No. 11, 1956)

Filters

Bandpass Filters with Constant Shape of Frequency Characteristic, I. M. Simontov, (3 pp, 3 figs).

Essentially intended for long-wave receivers.

Charts for Design of Filters for Specified Characteristic Parameters, M. M. Shenberg, (6 pp, 2 figs).

A single chart makes it possible to determine the parameters of matched filter elements for a specified attenuation and effective bandwidth. A nomogram is also given to obtain the frequency characteristic of the insertion loss of the filter in the attenuation band.

Quality Control

Choice of Parameter Tolerances for Radio Circuits, N. F. Vollerner, (10 pp, 6 figs, 1 table).

A quality-control discussion, showing the effects of maximum deviations of various parameters of radio circuits on the overall performance of the apparatus.

Radio Interference

Radio Interference Produced by Gas-Filled Rectifiers in the Transmitter, G. S. Shul'man, (2 pp).

This interference can be filtered out, like all other static, with a grounded-center capacitor network.

Phase Detector

Practical Elimination of "Inverted Operation" of an Amplitude-Phase Detector in the Presence of Pulsed Noise, Iu. S. Lezin, (8 pp, 4 figs).

An analysis of the same circuit, but in the presence of fluctuating noise, was given by the author in *Radiotekhnika i Elektronika* for March 1956 and abstracted in the December 15, 1956 issue of *ELECTRONIC DESIGN*. "Inverted operation," whereby noise causes the signals to reverse polarity, can be eliminated considerably by making the bandwidth of the detector grid circuit much narrower than the bandwidth of the receiver.

Circuit Design

Design of Certain Circuits Based on Their Response to a Unit Step Voltage, V. V. Zgirskis, (8 pp, 4 figs).

Straightforward procedure for synthesis of a resonant or aperiodic L-pad for a specified response to a unit step function. The transfer function is obtained by determining graphically from the response curve the frequency and attenuation factor which, together with the initial and final values of the output voltage, are used to determine the transfer function in operator form.

Miscellaneous

The Averaging Method and Its Application to Certain Non-Linear Problems in Electronics, Iu. N. Bakaev and P. I. Kuznetsov, (10 pp, 3 figs).

The "averaging method" is one developed by N. N. Bogoliubov to obtain approximate integrals for differential equations with slowly-varying nearly-sinusoidal and quasi-linear parameters. These equations are used in electronics for the analysis of various non-linear circuits, such as the exponential detector and similar devices.

Comparison of Statistical and Non-Statistical Prediction, R. A. Kazarian, (5 pp, 1 fig).

The criterion of comparison is the least-squared error. The article proves that no linear physically-realizable prediction network can yield a smaller least-square error than is obtainable by statistical prediction. Refers to Westcott, "Criteria of Prediction and Discrimination," (*Transactions IRE*, Prof. Group on Inform. Theory, 1, 1953) and to Bode and Shannon, "A Simplified Derivation of Linear Least Square Smoothing and Prediction Theory," (*Proc. IRE*, Vol. 38, No. 4, 1950).

Noise Rejection of a Radio Receiver at High Fluctuation-Noise Level, A. G. Ziuko, (2 pp, 2 figs).

Given here is a brief statistical discussion in which a comparison is made of several types of modulation. The effects of highly fluctuating noise levels on the noise rejection capabilities of a radio receiver are discussed.

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Russian Translations

Radio Engineering #11 Cont.

TV Synchronization

Determination of the Stability Region of an AFC System of Television Synchronization, Iu. N. Bakaev, P. I. Kuznetsov, (8 pp, 5 figs).

The differential equations of the system are solved to a higher order of approximation than employed by Preston and Fellier ("The Lock-In performance of an AFC Circuit," *Proc. IRE*, No. 2, 1953) or Gruen ("Theory of AFC Synchronization," *Proc. IRE*, No. 8, 1953). The use of the small-parameter method is proposed for the investigation of the aperiodic state of the system.

Transistor Circuits

Practical Video-Amplifier Transistor Circuits, T. M. Agakhanian, Iu. A. Volkov, (7 pp, 11 figs).

Continuing the work described in an earlier article (Reduction of Pulse-Front Distortion in Junction-Transistor Video Amplifiers, *Radiotekhnika*, Sept. 1956, (*ED*, June 15, 1956) the authors show how the common-emitter amplifier incorporating with a network to redistribute the current carriers near the base, can be used as a practical video amplifier. Fig. 2 shows three types of single-stage amplifiers, and Fig. 3 shows a four-stage amplifier, with an amplification factor of 750 and a 550 kc bandwidth. Russian type PIE transistors are used.

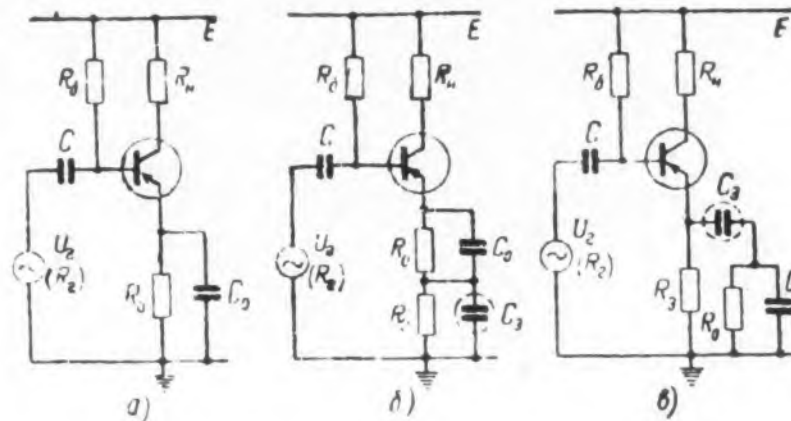


Fig. 2. Three types of single-stage transistor video amplifiers. Circuit a is simpler, but has the disadvantage that the base-circuit resistor R_b must be selected by trial, for even transistors of the same type show enough variation in their parameters to necessitate different resistor values. Circuits b and c are free of this shortcoming and are somewhat more stable.

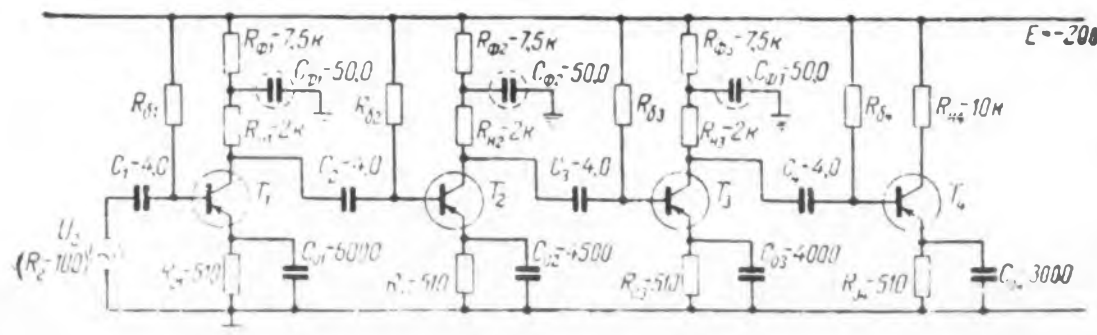


Fig. 3. Four-stage amplifier using Russian type PIE transistors (Note — capacitor values are in micromicrofarads, except for electrolytics, identified by dotted circles, which are in microfarads).

Frequency Converters

Pentode Frequency Converters for Meter Waves, I. I. Levenstern, (7 pp, 7 figs).

Discusses several versions of pentode converters, their operating features at meter waves, and experimental results on the converter shown in Fig. 4.

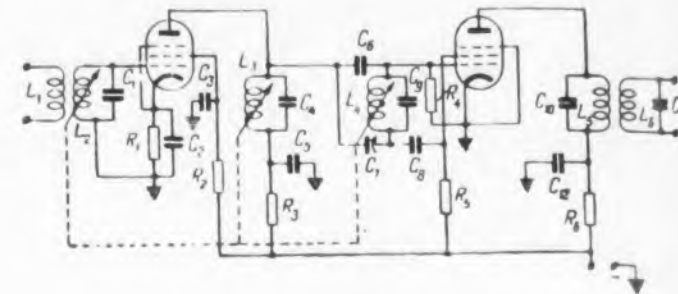


Fig. 4. Pentode converter preceded by hf stage. The tube characteristics are: $E_p = 250$, $E_{g2} = 150$, $E_r = 6.3$, $S = 5$ ma/v, $R_1 = 0.5$ Meg, $C_{in} = 6.5$ μ mf, $C_{out} = 1.5$ μ mf, $C_{pg} = 0.025$ μ mf, $r = 1500$ ohm ($f = 70$ mc). The computed amplification and conversion coefficients for 70 cycles were 12.9 and 12.7 respectively, while the measured values in the 66-73 mc band were 11 to 14 and 10 to 11 respectively.

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Miscellaneous

Reflection of Normally-Polarized Plane Wave from Wire Grid, V. G. Lampolski, (5 pp, 3 figs).

It is known that wire grids are strong reflectors of electromagnetic waves polarized parallel to the wires but when the polarization is perpendicular to the axes of the wires, the field is barely reflected from the grid. Parallel polarization was thoroughly treated in the literature many years ago. This article is devoted to normal polarization for wire diameters much smaller than the wavelength.

Concerning the Geometric Proof of the Shannon Theorem, E. L. Blokh, A. A. Kharkevich, (12 pp, 7 figs).

Previous attempts to formulate a geometric proof of Shannon's theorem on the bandwidth of a channel have led to disagreement with Shannon's results. Further investigation has shown that these discrepancies were due to an incorrectly assumed geometric model.

AUTOMATION AND TELEMECHANICS

(Contents of Avtomatika i Telemekhanika
No. 11, 1956)

Servomechanisms

Use of Non-Linear Correcting Devices in Second-Order Automatic Regulation Systems, G. M. Ostrovski, (6 pp, 5 figs).

Discusses conditions under which the response of second-order linear servomechanisms can be improved by introducing special non-linear elements. Refers to Neiswander & MacNeal, "Optimization of Nonlinear Control Systems by Means of Nonlinear Feedback" (*Trans. AIEE*, vol 72, 1953) and West, Douce, and Naylor, "The Effect of the Addition of Some Nonlinear Elements on the Transient Performance of Simple RPC System Possessing Torque Limitations." (*Proc. IEE*, No. 80, 1954).

Stability Criteria for Two-Phase Induction Servomotor, E. I. Slepushkin, (9 pp, 4 figs).

The servomotor is considered here as an element in an open-loop automatic-control system, and the response of the system to changes in line voltage and in phase angle is analyzed in terms of generalized parameters of the equivalent circuit of the motor. The author indicates the range of voltage and phase-angle variations for which no special closed-loop regulation system is needed for stable motor operation. Reference is made to Koopman, "Operating Characteristics of Two-Phase Servomotors," (*Trans. AIEE*, vol 68, 1949), and to two Russian articles by Kasprzhak from Avtomatikai Telemekhanika No. 7 and No. 9, 1956, abstracted in *ED* in the January 1, 1956 and May 1, 1956 issues.

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Russian Translations

Cybernetics

On Certain Regularities in the Work of a Human Operator, S. S. Medvedev, (15 pp, 12 figs).

Right elegant and sophisticated cybernetic study of a man matching the pointer of a meter against a moving index. Results obtained testing four operators are given, together with a mathematical analysis of the experimental results (using both statistical theory and analysis in the frequency domain), leading to an equation describing the average reactions of the operator. Refers to Tustin, "The Nature of the Operator's Response in Manual Control," *Il. IEE*, vol. 94, part IIA, No. 2, 1947.

Relaxation Oscillator

Controllable Relaxation Oscillator Using Glow-Discharge Tube, S. V. Svechnikov, (6 pp, 6 figs).

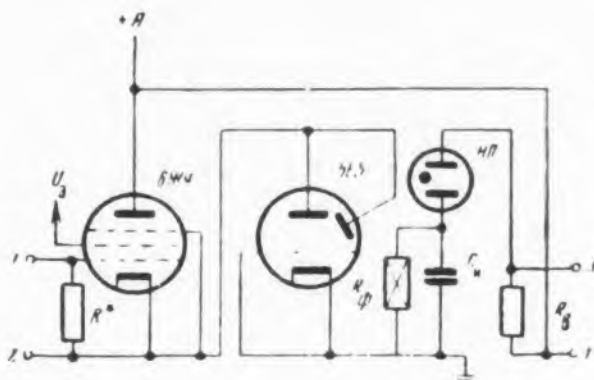


Fig. 5. Relaxation oscillations are produced in this interesting circuit by a neon tube (a cold-cathode thyratron or a voltage-regulator tube will do just as well) in conjunction with cadmium-sulfide photoresistor acting as a contactless potentiometer, the resistance of which is varied by changing the brightness of a tuning-eye tube (6E5) operating as a diode with a variable load, namely the pentode. Terminals 1 and 2 are the input, 3 and 4 are the output (picked off load resistor R_B).

Relay Systems

On Periodic Operating States of Relay Systems with Internal Feedback, N. A. Korolev (10 pp, 6 figs).

Another theoretical paper, which considers the periodic operating states (either self-oscillations or forced oscillations) in relay systems with internal feedback. It is shown that relay systems using delay feedback (also called relaxation, inertia, or time-lag feedback) can become oscillating in response to an abrupt change in the derivative of the input signal from the relay element.

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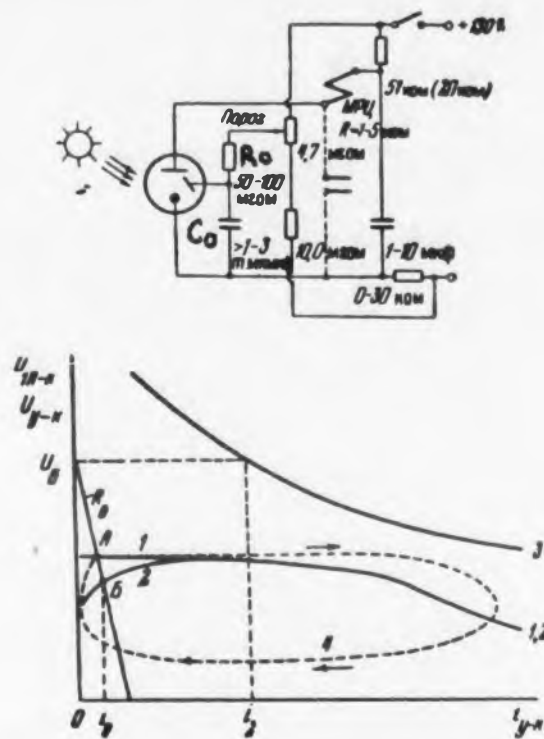
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Ionic Photorelay, L. N. Korabev, (2 pp, 3 figs).



Figs. 6 and 7. The feature of the circuit shown is that a single three-electrode cold-cathode tube serves simultaneously as a photocell as well as an ionic relay. The voltage applied to the anode of the tube is less than the firing voltage, but higher than the glow voltage. If the tube is not illuminated, the current-voltage characteristic of the discharge between the anode and cathode is represented by curve 1 of Fig. 7. If the tube is illuminated, the corresponding characteristic is curve 2. These curves intersect the load line R_0 at points A and B, respectively, but the slopes of the characteristics are such that point B (dark) is stable, point A (illuminated) is not. If C_0 is large enough, and the tube is illuminated, the capacitor is charged to a value A, which, being an unstable point on the cell characteristic, will cause the tube to ignite and the relay to operate.

Miscellaneous

"Certain Problems in the Development of Automation in the Czechoslovak Republic," Iu. Benesh (5 pp). "On the Stability of Automatic Regulation Systems Containing a Single Regulating Element," B. S. Razmukhin, (11 pp). (Highly theoretical treatment, using Liapunov's theory.) "Frequency-Analysis Method of Determining the Derivatives of the Transfer Function," V. M. Kagan, (3 pp.) "Wattmeter with Rectifier Elements for Power Telemetering," Sh. Iu. Ismailov, A. V. Fremke (2 pp, 2 figs). "Experimental Determination of Stiffness of Rubberized-Cloth Membranes," V. P. Temnyi, (4 pp, 4 figs). "Use of Computing Devices in Automatic Systems," A. A. Fel'dbaum, (11 pp, 13 figs). (Survey of the state of the art, citing many American references.) "Theory of a Control Element of the 'Nozzle-Gate Valve' Type Operating in Oil," A. G. Shashkov (20 pp, 15 figs).

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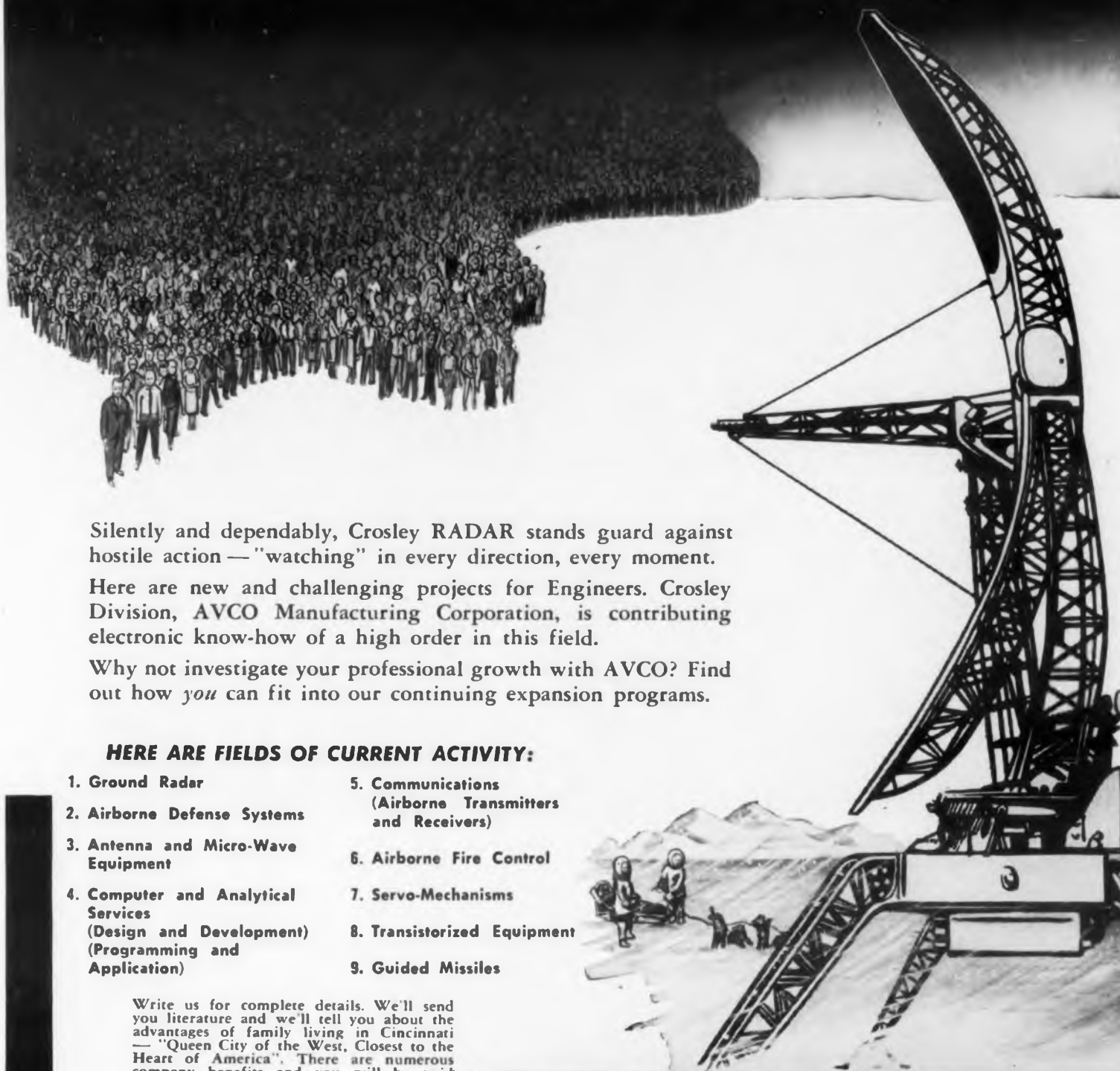
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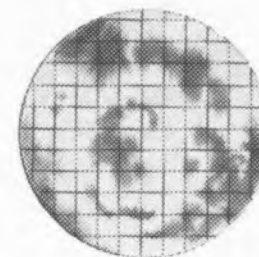
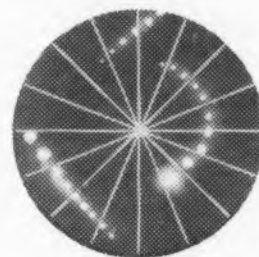
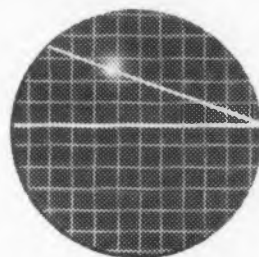
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Mr. Robert B. Wright, Technical Personnel Director

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Research and Development

Design electronic and mechanical control circuits for use in underwater acoustic homing devices and systems such as torpedoes, targets and decoys.

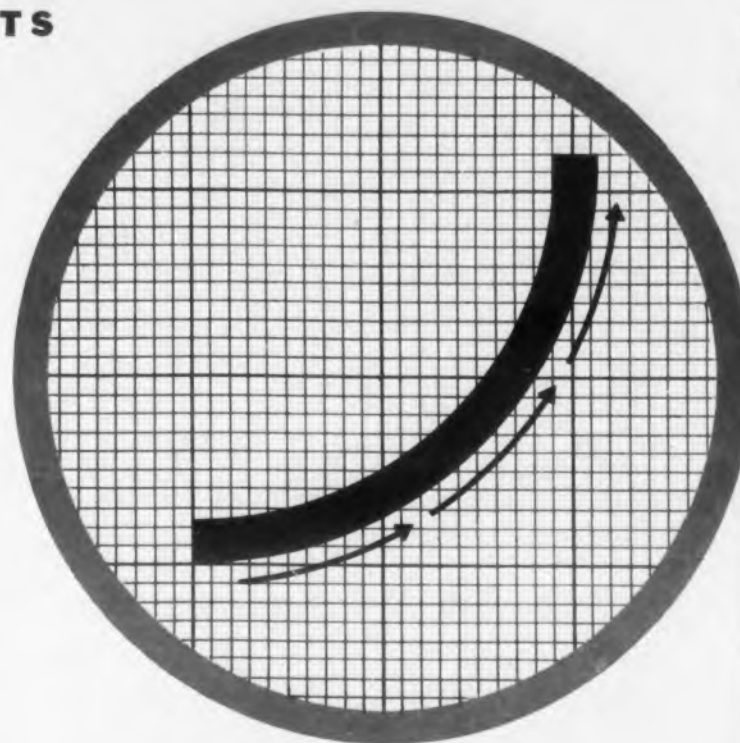
We have openings for engineers with either advanced or limited experience. There are openings in both Cleveland, Ohio and Key West, Florida.

Clevite Research Center develops new principles and new products for other units of Clevite Corporation. The Research Center provides the ideal environment for the engineer because it has been supplied with the facilities, equipment and library to provide new knowledge and new products for Clevite Corporation, a company whose entire product line is in the growth fields of electronics, semiconductors and automotive and aircraft power plants.

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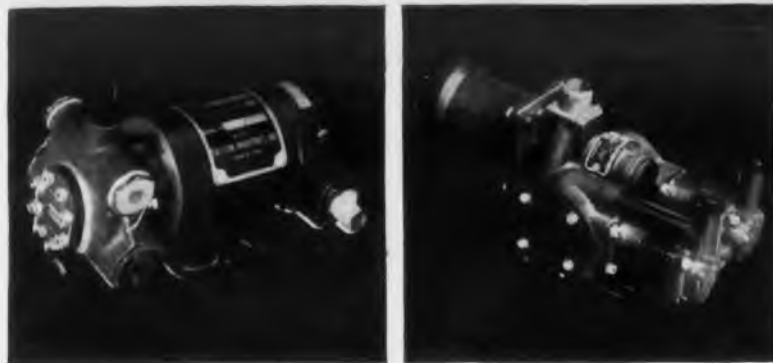
ELECTRONIC SYSTEMS DIVISION

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★ **AIRCRAFT PUMPS**

Precision-built to rigid government specifications, a broad selection among Eastern pumps offers flexibility to your choice. Modifications can be made, or custom-made units designed to suit your project. Trim in size, light in weight, Eastern Aircraft Pumps give reliable long-term service.



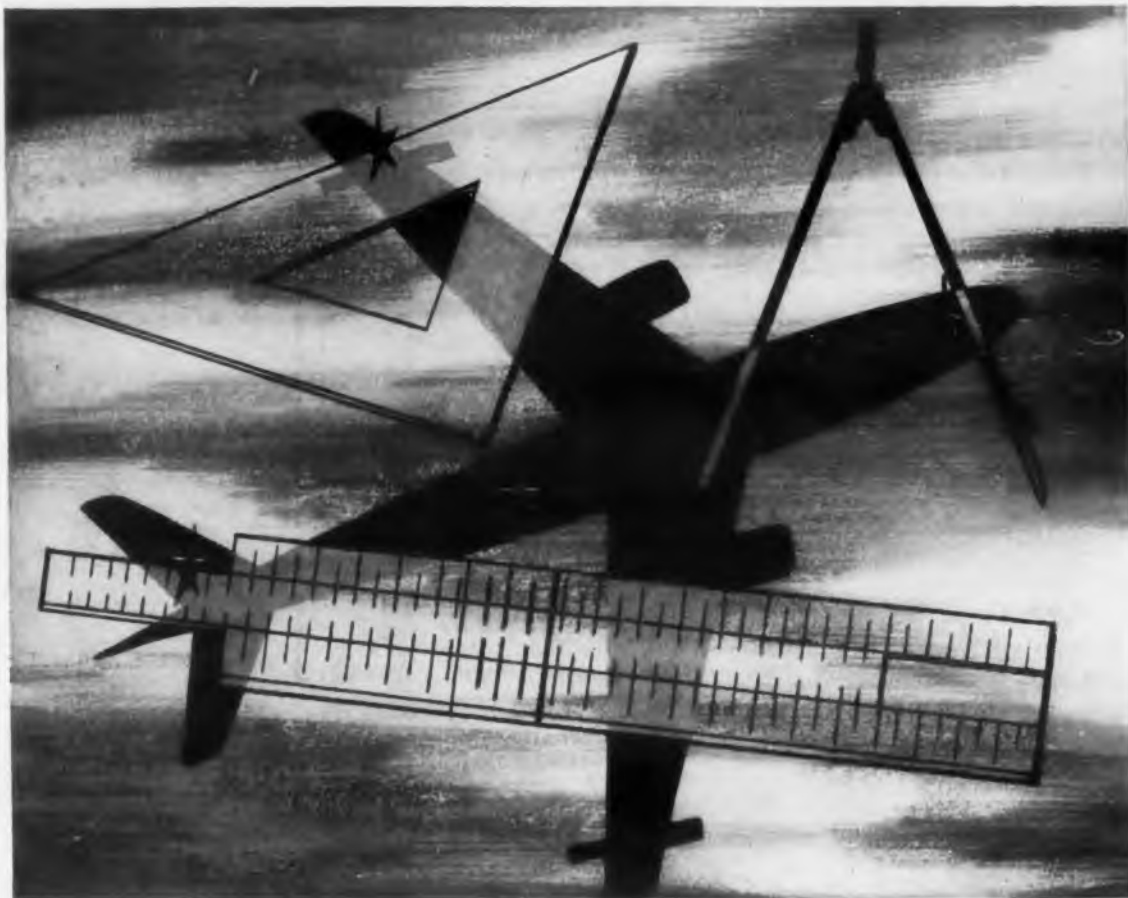
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Write for Aviation Products Catalog, Bulletin 330.

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23 223 233 243 253 263 273 283 293	503	513 523 533 543 553 563 573 583 593	
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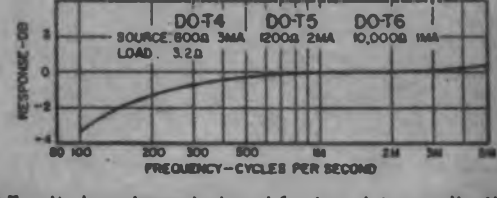
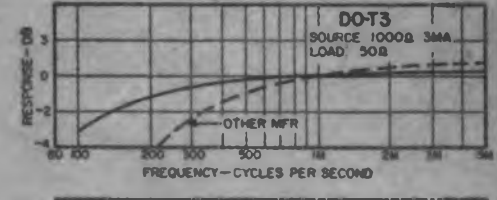
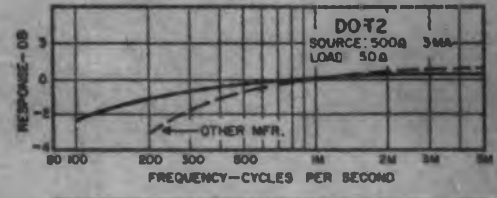
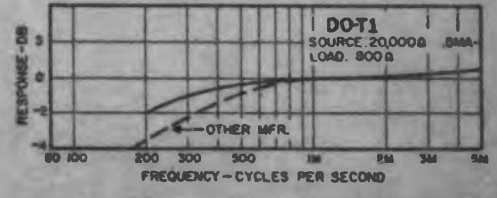
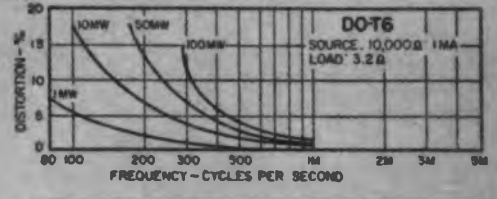
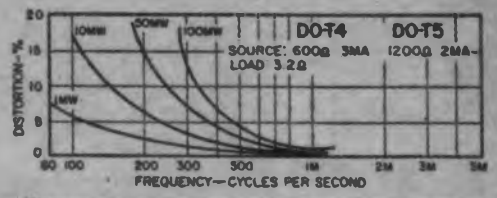
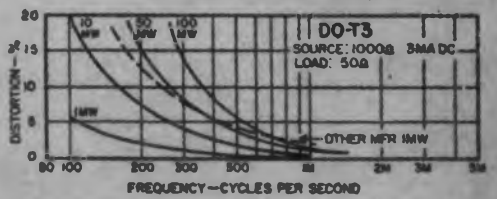
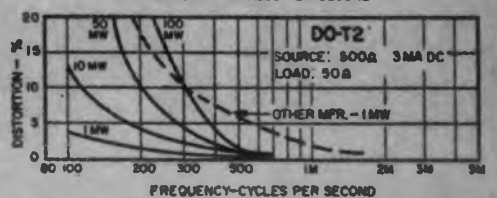
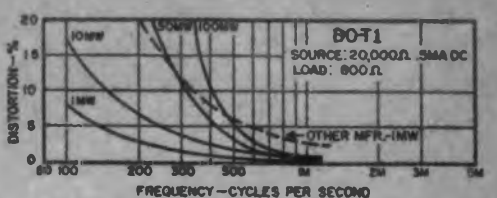
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Reader's Service Dept.



TYPICAL DO-T PERFORMANCE CURVES

Power curves based on setting output power at 1 KC, then maintaining same input level over frequency range.



CIRCLE 29 ON READER-SERVICE CARD

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O-T-S

T

S

Conventional miniaturized transistor transformers have inherently poor electrical characteristics, perform with insufficient reliability and are woefully inadequate for many applications. The radical design of the new UTC DO-T transistor transformers** provides unprecedented power handling capacity and reliability, coupled with extremely small size. Twenty-five stock types cover virtually every transistor application*. Special types can be made to order.

- High Power Rating . . . up to 100 times greater.
- Excellent Response . . . twice as good at low end.
- Low Distortion . . . reduced 80%.
- High Efficiency . . . up to 30% better.
- Moisture Proof . . . hermetically sealed to MIL-T-27A.
- Rugged . . . completely cased.
- Anchored Leads . . . will withstand 10 pound pull test.
- Printed Circuit Use . . . (solder melting) plastic insulated leads.



Type No.	MIL Type	Application	Pri. Imp.	D.C. Ma.‡ in Pri.	Sec. Imp.	Pri. Res.	Level Mw.
DO-T1	TF4RX13YY	Interstage	20,000 30,000	.5 .5	800 1200	850	50
DO-T2	TF4RX17YY	Output	500 600	3 3	50 60	60	100
DO-T3	TF4RX13YY	Output	1000 1200	3 3	50 60	115	100
DO-T4	TF4RX17YY	Output	600	3	3.2	60	100
DO-T5	TF4RX13YY	Output	1200	2	3.2	115	100
DO-T6	TF4RX13YY	Output	10,000	1	3.2	1000	100
DO-T7	TF4RX16YY	Input	200,000	0	1000	8500	25
DO-T8	TF4RX20YY	Reactor 3.5 Hys. @ 2 Ma. DC				630	
DO-T9	TF4RX13YY	Output or driver	10,000 12,500	1 1	500 CT 600 CT	800	100
DO-T10	TF4RX13YY	Driver	10,000 12,500	1 1	1200 CT 1500 CT	800	100
DO-T11	TF4RX13YY	Driver	10,000 12,000	1 1	2000 CT 2500 CT	800	100
DO-T12	TF4RX17YY	Single or PP output	150 CT 200 CT	10 10	12 16	11	500
DO-T13	TF4RX17YY	Single or PP output	300 CT 400 CT	7 7	12 16	20	500
DO-T14	TF4RX17YY	Single or PP output	600 CT 800 CT	5 5	12 16	43	500
DO-T15	TF4RX17YY	Single or PP output	800 CT 1070 CT	4 4	12 16	51	500
DO-T16	TF4RX13YY	Single or PP output	1000 CT 1330 CT	3.5 3.5	12 16	71	500
DO-T17	TF4RX13YY	Single or PP output	1500 CT 2000 CT	3 3	12 16	108	500
DO-T18	TF4RX13YY	Single or PP output	7500 CT 10,000 CT	1 1	12 16	505	200
DO-T19	TF4RX17YY	Output to line	300 CT	7	600	19	500
DO-T20	TF4RX17YY	Output or matching to line	500 CT	5.5	600	31	500
DO-T21	TF4RX17YY	Output to line	900 CT	4	600	53	500
DO-T22	TF4RX13YY	Output to line	1500 CT	3	600	86	500
DO-T23	TF4RX13YY	Interstage	20,000 CT 30,000 CT	.5 .5	800 CT 1200 CT	850	100
DO-T24	TF4RX16YY	Input (usable for chopper service)	200,000 CT	0	1000 CT	8500	25
DO-T25	TF4RX13YY	Interstage	10,000 CT 12,000 CT	1 1	1500 CT 1800 CT	800	100

‡DCMA shown is for single ended usage (under 5% distortion—100MW—1KC) . . . for push pull, DCMA can be any balanced value taken by .5W transistors (under 5% distortion—500MW—1KC)



RCA "PREMIUM" TUBES AND COMPUTER TUBES

Operating Reliability

...extended to new levels of performance

To pace the demands for higher quality tubes in critical applications, RCA "Premium" Tubes and Computer Tubes have opened new possibilities for sustained reliability that exceeds previous levels of tube performance. Here are two important ways in which RCA insures that it *builds* QUALITY into these tubes:

- 1 RCA has developed a precision-type quality-control system that provides never-ending vigilance over the quality of "Premium" Tubes and Computer Tubes—throughout every phase of tube manufacture.
- 2 RCA backs up this quality-control system with 100% microscopic monitoring of 24 different categories of tube workmanship. By this method, each manufacturing point is constantly under surveillance, and prompt corrective action can be taken if needed.

Precision Quality-Control—coupled closely with microscopic monitoring—is another big step ahead in the manufacture of RCA "Premium" Tubes and Computer Tubes to assure excellent uniformity of characteristics and long-term reliability.

Your RCA Field Representative will welcome an opportunity to discuss the unusual advantages of RCA "Premium" Tubes and Computer Tubes for your specific applications. Contact him at the RCA Field Office nearest you:

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