Complete in this issue

Mechanical Design of Electronic Equipment

a 64-page Special Report
OUR MILLIONTH FILTER SHIPPED THIS YEAR...

FILTERS
FOR EVERY APPLICATION

TELEMETERING FILTERS
UTC manufactures a wide variety of band-pass filters for multi-channel telemetering. Illustrated are a group of filters supplied for 400 cycle to 40 KC service. Miniaturized units have been made for many applications. For example, a group of 4 cubic inch units which provide 50 channels between 4 KC and 100 KC.

FILTERS FOR EVERY APPLICATION

CARRIER FILTERS
A wide variety of carrier filters are available for specific applications. This type of tone channel filter can be supplied in a varied range of band widths and attenuations. The curves shown are typical units.

DISCRIMINATORS
These high Q discriminators provide exceptional amplification and linearity. Typical characteristics available are illustrated by the low and higher frequency curves shown.

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UNITED TRANSFORMER CO
150 Varick Street, New York 13, N. Y. EXPORT DIVISION: 13 E. 40th St., New York 16, N. Y. CABLES: "ARLAI"
Figures of the Month

Industry Report

Automatic Circuit Tester Speeds Production ........................................... by Robert J. Stahl and George R. West 136
TV Receiver Operates on Four System Standards ........................................... by W. Werner 140
Component Design Trends—Precision Potentiometers Use New Materials .......... by Frank Rockett 144
The Microwave Market Picture ................................................................. by John M. Carroll 152
Germanium Modulator for Infrared Communication ..................................... by Alan F. Gibson 155
Radio Receiver Counts Lightning Strokes .................................................... by A. W. Sullivan, J. D. Wells and H. E. Dinger 158
Fifty-Watt Amplifier for High-Quality Audio .............................................. by Alexander B. Bereskin 160
Regulated D-C Supply has High Efficiency ................................................... by D. C. Bakeman and J. E. Richardson 165
Direct-Reading Grenz-Ray Dosimeter ....................................................... by H. B. Weisbecker and R. Steinitz 168
Fast-Response Magnetic Servo Amplifier .................................................... by Frank Hill and Joseph A. Fingerrett 170
High-Speed Counting with One-Tube Decades ............................................ by R. E. Nather 174
Magnetic Recorder Arrests Transients ....................................................... by Max Hoberman 178
Automatically Plotting Electrostatic Field Lines ........................................ by David H. Andrews 182
Operation of CRT Storage Devices ............................................................ by Stanley Winkler and Seymour Nozick 184
Servocoupler Matches Aircraft Antennas .................................................... by E. W. Schwittek 188

MECHANICAL DESIGN OF ELECTRONIC EQUIPMENT ........................................ M-1 to M-64

Circular Waveguide Chart (Reference Sheet) .............................................. by A. C. Hudson 194

Crosstalk .................................. 135 Electrons at Work .......................... 196 Production Techniques ............ 252 New Products .................. 310
Plants and People ......................... 376 New Books .................................. 438 Backtalk ................................. 454 Index to Advertisers ............... 495


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OCTOBER, 1954

ELECTRONICS

Vol. 22, No. 10

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In the short time the Model 1001 Regulator has been on the market, more than 300 of the instruments have been sold, mainly for meter calibration applications and for use in standards laboratories.

As a result, it can now be said — and proved — that the Model 1001 gives hairsplitting precision with the rugged dependability of operation associated with voltage regulators of "ordinary" regulating accuracy!

**Sorensen Model 1001**

*electronic AC Voltage Regulator*

**specifications**

<table>
<thead>
<tr>
<th>Input</th>
<th>95-130 VAC, 18, 50-60 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>110-120 VAC, adjustable</td>
</tr>
<tr>
<td>Load range</td>
<td>0-1000 VA</td>
</tr>
<tr>
<td>Regulation accuracy</td>
<td>±0.01% against line and ±0.01% against load guaranteed at room temperature, for a resistive load, on input variation of ±10% and over a 2-to-1 load change. For all other conditions within the specifications the 1001 has a proportionate amount of accommodation.</td>
</tr>
<tr>
<td>Distortion</td>
<td>3% RMS maximum</td>
</tr>
<tr>
<td>P. F. range</td>
<td>0.95 leading to 0.7 lagging</td>
</tr>
<tr>
<td>Time constant</td>
<td>0.1 second</td>
</tr>
<tr>
<td>Tube complement</td>
<td>6SL7GT (1), 6L6GA (1), 5Y3GT (1), 2AS15 (1)</td>
</tr>
</tbody>
</table>

Even greater capacity with similar accuracy will be available this fall when the Sorensen Model 2501 Regulator — ±0.01% accuracy, 2500 VA capacity — goes into production.

**general catalog available**

**AC VOLTAGE REGULATORS** — 150VA to 15000VA capacities, 115 volt and 230 volt output, 400-cycle regulators, 3-phase regulators

**FREQUENCY CHANGERS** — 60 cycle and 400 cycle, accuracy to ±0.01%

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**B-NOBATRONS** — Regulated high-voltage, low-current B power supplies

**NOBATRON-RANGERS** — Wide-range variable DC sources

**TUBELESS DC SUPPLIES** — Magnetic amplifier supplies with various outputs and capacities

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MUIRHEAD & CO. LIMITED • BECKENHAM • KENT • ENGLAND

ELECTRONICS — October, 1954

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**FIGURES OF THE YEAR**

**TELEVISION SET PRODUCTION**

<table>
<thead>
<tr>
<th>Year</th>
<th>Previous Year</th>
<th>Latest Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>1953</td>
<td>7,214,787</td>
<td>7,841,900</td>
</tr>
</tbody>
</table>

**RADIO SET PRODUCTION**

<table>
<thead>
<tr>
<th>Year</th>
<th>Previous Year</th>
<th>Latest Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>1953</td>
<td>13,368,556</td>
<td>13,387,512</td>
</tr>
</tbody>
</table>

**CATHODE-RAY TUBE SALES**

<table>
<thead>
<tr>
<th>Year</th>
<th>Previous Year</th>
<th>Latest Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>1953</td>
<td>7,064,485</td>
<td>7,043,432</td>
</tr>
</tbody>
</table>

**COMMUNICATION AUTHORIZATIONS**

<table>
<thead>
<tr>
<th>Source</th>
<th>July '53</th>
<th>June '54</th>
<th>July '54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeronautical</td>
<td>274,655</td>
<td>274,154</td>
<td>273,000</td>
</tr>
<tr>
<td>Marine</td>
<td>41,473</td>
<td>42,369</td>
<td>46,200</td>
</tr>
<tr>
<td>Police, fire, etc.</td>
<td>13,869</td>
<td>15,697</td>
<td>15,926</td>
</tr>
<tr>
<td>Industrial</td>
<td>17,951</td>
<td>21,598</td>
<td>21,867</td>
</tr>
</tbody>
</table>

**EMPLOYMENT AND PAYROLLS**

<table>
<thead>
<tr>
<th>Source</th>
<th>June '53</th>
<th>May '54</th>
<th>June '54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prod. workers, comm. equip.</td>
<td>417,800</td>
<td>342,600</td>
<td>339,300</td>
</tr>
<tr>
<td>Av. w/k, earnings, radio</td>
<td>564,64</td>
<td>566,98</td>
<td>567,94</td>
</tr>
</tbody>
</table>

**STOCK PRICE AVERAGES**

<table>
<thead>
<tr>
<th>Source</th>
<th>Aug. '53</th>
<th>July '54</th>
<th>Aug. '54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio-TV &amp; electronics</td>
<td>260.0</td>
<td>351.2</td>
<td>350.9</td>
</tr>
<tr>
<td>Radio broadcasters</td>
<td>274.8</td>
<td>377.3</td>
<td>381.3</td>
</tr>
</tbody>
</table>

**TOTALS FOR FIRST SEVEN MONTHS**

<table>
<thead>
<tr>
<th>Year</th>
<th>1953</th>
<th>1954</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,150,525</td>
<td>3,152,127</td>
<td>1952</td>
<td>-34.0</td>
</tr>
<tr>
<td>7,941,000</td>
<td>5,324,620</td>
<td>1952</td>
<td>-32.9</td>
</tr>
<tr>
<td>3,116,306</td>
<td>3,174,394</td>
<td>1952</td>
<td>+1.9</td>
</tr>
</tbody>
</table>

October, 1954 — ELECTRONICS
Automatic Production Speeds TV Receiver Output

Machine-assembled eight-tube circuits appear in 21-inch television sets

Complex machines 30 feet long, into which resistors and wire jumpers are automatically fed, deliver assembled printed circuit boards at Admiral Corp.

> How—The electronically controlled machines, designed and built by the firm’s engineers, utilize printed circuit boards that are photo-etched and stamped at one of the company’s plants. As the boards automatically move from machine to machine down the 30-foot line, fifty resistors and wire jumpers are machine-inserted in each board, some singly, some two and three at a time, depending on spacing. Before the resistors are inserted, the machines trim and bend the wire leads to size. After insertion, dies crimp the leads precisely against the copper circuit pattern to insure getting good contacts by dip soldering.

Whenever any part fails to feed from its chute, a red light goes on at that machine and the entire line is automatically halted until adjustments are made.

> Future—Two other machines, one approximately 100 feet long, are under construction and will be in use in early 1955. It is expected that eventually the robots will be able to insert items such as tube sockets and tubes. This means that some components will be redesigned for automatic feeding.

According to the company, production has been increased so much with the new machines that, rather than displacing personnel, it has been necessary to hire more women employees to complete final assembly of the printed circuit boards. Two new vertical-chassis 21-inch tv table models now on the market use the automatically produced eight-tube circuits. Tubes are mounted horizontally for removal from the rear.

Electronic Industry Booms In California

Growth mirrored in record WESCON attendance is backed by new L. A. survey

Growing importance of the electronics industry on the west coast was pointed up at the recent Western Electronic Show and Convention and by a new survey of Los Angeles electronic manufacturers.

> WESCON—More than 23,000 engineers, technicians and members of allied industries registered for the 1954 show in Los Angeles, exceeding last year’s registration by...
10,000. More than 2,800 attended the technical sessions at which 115 papers were delivered. Equipment ranging from silicon transistors to computers was exhibited by over 600 manufacturers in 522 booths, about 150 more than were used in 1953.

► Survey—Backing up the growth of the WESCON were the survey facts recently published by the Los Angeles Chamber of Commerce. They show that billings of electronic firms in the Los Angeles metropolitan area have grown from $95 million in 1946 to $750 million last year. Capital investment of firms in the area has also grown rapidly.

Last year the electronic industry in Los Angeles county invested $26.5 million, $17.3 million in seven new plants and $9.1 million in 34 expansions of existing facilities. This compares to total expenditures of $4.6 million in 1952 and $4.3 million in 1951. In the first seven months of 1954, the electronic industry ranked second in the area in the number of new expanded plants, with 32 projects representing a capital investment of $12.9 million.

► Companies—According to the survey, there are 374 firms occupying 424 plants in metropolitan Los Angeles that manufacture electronic equipment. They have a combined total of 7.7 million sq ft of plant facilities and manufacture 172 different electronic products. The total number of workers employed by these firms is 60,900, representing 75 percent of electronic employees in the west and an annual payroll of $231 million.

Breakdown of some of the 374 firms in the Los Angeles area shows that 161 are research and development firms, 19 are engineering and design companies and 22 are service and testing firms.

Radio Control System Guides Tractor-Trains

Pushbutton unit on belt cuts order-filling costs in large warehouses

OLD-TIME MILKMEN did very little driving. Only an occasional whistle was necessary to keep horse and wagon moving down the street in step with the milkman as he cut across lawns and back yards. With modern in-plant material-handling tractor-trains, however, the driver-loader must often spend half his time running back to the controls.

A new electronic control system has solved this difficulty. A warehouseman loading groceries and supplies onto a tractor-train need touch the tractor controls only occasionally. To move from dry cereals to soap powders, for example, he merely pushes one of three buttons. Three different tone signals whistle the tractor to start, turn right or turn left. When his finger is removed, the tractor brakes to a smooth halt.

► Who Can Use It?—So far, only about two dozen radio-controlled tractors have been put into service, eight of them in one warehouse. Time studies now in progress indicate that there may be as much as 20 percent savings in an order-filler’s time.

Cost of the radio system and

Larger Color Picture Tube Bows

NEW RCA 21-inch color tv tube with 250 square inches of picture area is compared with its 15-inch predecessor. It will be used in a new color tv receiver that employs 28 tubes including the picture tube. Cost of the tube is $175 and sets using the new tube will retail between $800 and $900. Sampling of the picture tube to other manufacturers is scheduled to begin Nov. 1.

Initial sets using the tube will employ modified 19-inch chassis containing 39 tubes. A few thousand of these sets will be made and are expected to be on the market before the end of the year.
HIGHLY SENSITIVE...COMPACT IN SIZE!

SYLVANIA PHOTODIODE

IN77A

The Sylvania 1N77A is a highly sensitive compact junction photodiode.
Its useful sensitivity covers the visible spectrum and extends into the infrared region where it peaks at approximately 15,000 Angstrom Units.

Consider these advantages:
1 Hermetically sealed in glass.
2 Extreme stability in operation.
3 Uniformly high sensitivity (8.5 volts min. to 17.0 volts max. across a 100 k-ohm load).
4 Low dark current (200 µA @ -50 volts).

The high sensitivity and compact packaging of the 1N77A should provide the answer to many light-sensing application problems. Still more reasons why it pays to specify Sylvania.

SYLVANIA

Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.
In Canada: Sylvania Electric (Canada) Ltd., University Tower Bldg.,
St. Catherine Street, Montreal, P. Q.

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www.americanradiohistory.com
electric tractor together is $4,000 but the radio gear itself sells for about $1,400. The manufacturers believe such control equipment can be applied satisfactorily to fork trucks, bridge cranes and other devices subject to remote operation.

► Radio System—Although design details have not yet been revealed, it is known that the radio control operates under FCC low-power rules without necessity for a license. The mobile receiver uses the rubber-tired tractor and trailers as antenna.

Color Set Makers Size Up Color Broadcasting

Networks and network routes are set for color programs but local stations lag

It has been almost axiomatic in new black-and-white TV markets that when programs were poor or sparse so were TV set sales. Good shows sold sets. Manufacturers who will have color receivers on the market this fall are therefore taking a hard look at the color program plans of networks and stations for this year.

► Programs—NBC has the most ambitious lineup of color programs among the networks. It has scheduled 491 hours of color programming for the fall season. By the first of the year it will have facilities for color origination available for 60 hours of color programs a month.

CBS has 77 separate color shows now scheduled through April 6 of next year for about 40 hours of color programs.

Du Mont's WABD goes on the air in September with one color program a week. This will be stepped up later to three weekly programs. This firm's Pittsburgh and Washington, D.C. stations expect to be equipped for color this year. All of its initial programs will be taken from color film.

► Network—AT&T will have its routes ready for network color programs. Already 31,000 of the 59,000 channel miles of TV facilities now in service have been reengineered and re-equipped to carry color programs. Color TV can now be transmitted to 65 cities across the nation.

At present 145 stations in these cities are receiving network TV service and about 95 of them are getting color in addition to black-and-white. AT&T estimates that by November most of its principal routes will be equipped with color and that by the end of the year it will be able to transmit color programs to about 95 of the 202 cities now linked for black-and-white TV.

► Local—Although there may be a total of 100 hours of network color programs available this year to help sell color sets, sizeable gaps in a prospective color set owner's viewing schedule remain. As with black-and-white TV, these gaps will be taken up by color programs of local stations.

So far, outside of the networks, only about 10 stations have equipment for originating live color programs. Only about 10 color film scanners have been delivered for color film use. The four scanner manufacturers, DuMont, GE, Philco and RCA, are stepping up their production schedules, however. It is expected that as color sets trickle into local markets, more local stations will order color cameras and film equipment or convert present equipment.

Intercom TV Makes Its Debut

TELEVISION-TELEPHONE intercom system became a commercial reality when Kay Lab recently demonstrated its new unit. It is designed around a 17-inch TV receiver, a vidicon industrial TV camera, a telephone handset and the necessary switching equipment. Approximate cost of a two-station installation is $5,000, with additional stations costing proportionately less per unit.

► Operation—When the telephone is lifted from its hook, the caller's image appears on one-half of both his and the called party's screen. The answering party's image appears on the remaining half of each screen. Either user can make the entire screen available if desired, for uses such as viewing signatures, blueprints and documents. When the telephone is not

October, 1954 — ELECTRONICS
As a new line of reliable components for digital computers, Sprague has introduced and is in production on pulse transformers of a new type. This transformer line is principally directed to high speed, low power computer circuits, with some designs also finding application in blocking oscillator circuits, memory ring driving circuits, etc.

Two major types are offered: a miniature transformer, Type 10Z, for 0.05 to 0.5 microsecond pulse circuits, and a larger transformer, Type 20Z, for handling pulses up to 20 microseconds in length. Intermediate sizes and plug-in units are also available for special customer requirements.

Basic data on the high reliability miniature transformer is tabulated at right. Complete details are in Engineering Bulletin M 502. A copy will be sent you on letterhead request to the Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

Sprague, on request, will provide you with complete application engineering service for optimum results in the use of pulse transformers for computers.

BASIC CHARACTERISTICS OF TYPE 10Z PULSE TRANSFORMERS

| Pulse Duration | .05 to 0.5 microseconds. |
| Applications   | flipflop circuits • buffer circuits pulse amplifier circuits • gating circuits • other circuits with pulse lengths up to about 0.5 microseconds. |
| Physical Description | Hermetically sealed. Housed in corrosion-resistant can with glass-to-metal solder-seal terminals at each end. Can length is 3/4" and diameter is 1/2". Transformers can be mounted and supported by lead wires in most applications. |
| Ratios Offered | Ratio 1:1 — Cat. No. 10Z3 Ratio 2:1 — Cat. No. 10Z5 Ratio 3:1 — Cat. No. 10Z4 Ratio 4:1 — Cat. No. 10Z2 Ratio 5:1 — Cat. No. 10Z1 Special Ratios Available |
| Maximum Repetition Rate | For a pulse length of 0.1 microsecond, pulse repetition rates up to 2 megacycles per second can be employed. |
| Pulse Amplitude | Normally used in circuits whose pulse amplitude varies up to 60 volts. |
| D-C Rating | Maximum working voltage, 300VDC. Flash tested between windings at 600VDC. May be life tested at 450 VDC between windings, 85°C, for 250 hours. |
| Temperature | May be operated between -55°C and +85°C. Higher temperature units available on request. |
| Insulation Resistance | 20,000 megohms minimum between windings, measured at 25°C and 180 Volts DC. |
in use, the monitor can be used for regular closed-circuit tv, subscription tv or as a standard tv set.

Use—The tv intercom is designed primarily for applications in industry, for interplant conferences and other uses where savings in time and expense can be made. The system is seen as being especially applicable as a surveillance aid. A unit installed at electrically controlled gate stations could eliminate the expense of full-time guards. The cost of maintaining a single guard position at large installations is estimated at $20,000 annually.

Electronic firms are among the top five manufacturing groups in fringe payments

Electronic pay envelopes reflect only part of labor costs for manufacturers in the field because of increasing payments made in the form of fringe benefits. Today these benefits, measured against total payrolls in the industry, represent 18 percent of wage costs, 35 cents per payroll hour or about $700 extra per year for each employee.

Trend—There has been a steady rise in fringe benefits in the electrical machinery industry classification, which includes electronic firms, since 1947, as is shown in the chart. In 1947, according to a survey by the U.S. Chamber of Commerce, fringe payments in the field represented about 13 percent of total payroll, 18 cents per payroll hour and $390 per year per employee. In 1951 benefits had jumped to 16.4 percent measured against total industry payroll, 28 cents per payroll hour and $616 per year per employee.

Main increase in benefits between 1951 and 1953 was in the employers' share for pensions and other agreed-upon payments such as accident and medical care insurance premiums, hospitalization, death benefits, life insurance premiums, separation pay allowances and tuition refunds. Other increases were in paid rest periods, lunch periods and payments for time not worked. Bonuses and profit-sharing payments showed a slight drop for the industry in the period.

Where—Amounts paid in fringe benefits vary with a manufacturer's location in the U.S. Producers in the North East, from Pennsylvania to Maine, paid 18.4 percent of payroll in fringe benefits for the highest percentage in the country. Manufacturers in East North Central States paid 16 percent of payroll and those in the West spent 15.2 percent in fringe benefits.

Size of the company affected benefit payments randomly. According to the survey, those companies in the field with between 500 and 999 employees paid 18.1 percent of total payroll in fringes. Companies with under 500 workers and others with between 1,000 and 2,449 workers paid 17 percent. Firms with 2,500 to 4,999 employees paid 16.2 percent and those with 5,000 and over paid 16.9 percent of payroll in fringe benefits.

Comparison—Total fringe payments made by other manufacturing industries show wide variation. Electronic and electrical manufacturers ranked sixth among 12 industries in benefits paid. Petroleum companies led all industries surveyed with fringe payments equal to 28 percent of total payroll. Transportation equipment manufacturers were lowest with 14.8 percent. The fact that there is variation in the amounts paid by each industry group may not mean, however, that one industry is ahead or behind another because, in many cases, the employer and the workers may prefer to have income reflected entirely or chiefly in the pay envelope.

U.S. Navy Encourages Automatic Production

Bureau of Aeronautics adopts new policy giving preference to mechanized electronics

Divisions of Navy's Bureau of Aeronautics concerned with the design and procurement of electronic equipment have been directed to encourage electronic contractors, through development and production contracts, to utilize mechanized production techniques. According to the new policy, BUAER intends, whenever practicable, to select new designs for electronic equipment that have the increased mobilization potential of mechanized production. The automatic production of equipments...
Magnets for rotors or stators
...any design or size you may require

The use of Alnico permanent magnets in rotor and stator assemblies of motors, generators, magnetores and tachometers has revolutionized the designs of these devices. Whatever your need may be—from a tiny rotor for a timing device to a large slab for power generators—Arnold can take care of your requirements, either for experimental samples or production quantities.

Let us work with you. You will have the advantage of working with a leading producer of rotor magnets, whose manufacturing and testing facilities—the most modern in the business—give you the best assurance of high quality standards and uniform performance.
with high mobilization requirements will be particularly encouraged where it will substantially reduce the lead time required for mobilization production schedules.

**Aim**—Purpose behind BUAEr’s new policy is to develop sufficient capacity in the electronics industry to produce the large volume of military-quality equipments that will be required in the event of a global war. The Bureau feels that progress in the field of mechanized production has now advanced sufficiently to warrant its use in field equipment for the fleet.

**Status**—So far the only product in current production for BUAEr that uses mechanized techniques is the sonobuoy under a contract with Willys Motors. This contract, however, is drawing to a close and it is reported that the company is contemplating moving out of this field. The machines in its pilot plant are owned by BUAEr and no decision on their disposition has yet been made.

**Advances**—National Bureau of Standards is continuing to develop components for use in Tinkertoy production. A self-adhesive tape capacitor, manufactured in much the same manner as the NBS tape resistor, has been developed. It can be applied to one side of a wafer.

Industry Proposal Spurs UHF-TV

**RETMA committee would add low-power stations to aid tv coverage**

Controversy on how to help uhf television may taper off fast if industry plans for modifying Commission rules get the green light in Washington. A special committee of Radio-Electronics and Television Manufacturers Association suggests two new classes of television stations. Such stations are expected to improve television coverage for both vhf and uhf.

**Definitions**—One type of station, defined by the committee as a satellite, would operate unattended on the same television channel as the primary or controlling station upon which it depends for all its program and identification material. Such a station has been commonly called a booster—a term now deleted by the committee.

The other type, a Special Serv-

(Continued on page 14)

Defense Needs Spur Lighting Panel Sales

**Plastic Lighting panels** that permit military pilots to read their instruments without losing their dark adaptation or night vision sustain about a $10 million industry filling largely Defense needs.

**Market**—A new B-52 bomber requires 175 panels—covering for the most part electronic equipment. Another 30 to 40 panels are installed on government-furnished equipment mounted in the plane. Plastic lighting panels are expensive since they must be made to exacting tolerances. Twenty-nine firms are reportedly in the business, although a half-dozen of these claim to do the lion’s share of the business. The industry is concentrated near New York, Chicago and Los Angeles.

**What Is It**—Basically a plastic lighting panel is a 3/8-in. sheet of clear methacrylate plastic in which is embedded a tiny light bulb equipped with a red filter. The panel is then painted an opaque black with the lettering and indicators done in translucent white. The panel is thus black and white by day and red by night. Such a panel is transilluminated.

Red light is chosen to illuminate the panels since a pilot may look at a dim red light and preserve his night vision. Military specifications require that the light source may be dimmed over a 7 to 1 ratio.

Receiving antenna made up of eight zigzag rods receives weak television signal 37 miles from the WJTV transmitter in Jackson, Miss. Signal is amplified and rebroadcast from low-power RCA transmitter attached to similar high-gain antenna to fill holes in coverage area of this uhf television station.
Here's how to get production quantities of precision components for TRANSISTORS • DIODES • RADIO TUBES • HERMETIC SEALS • LAMPS

Now it is possible for progressive manufacturers to produce their own precision electronic components. For example, the Automatic Lead Wire Welding Machine, shown below, was recently designed and built by Kahle to produce 12,000 3-piece leads per hour for miniature receiving tubes. Although this machine, Model 2148, is designed to make standard welds, it is but one step from a machine to produce leads for electronics' latest wonder...the transistor. In addition, Kahle has produced a fully automatic Filament Making and Tabbing Machine, Model 2036, that produces from 1,200 to 3,000 filaments per hour depending upon wire diameter.

These machines reflect Kahle's ability to design and build special-purpose machinery to meet any given specifications. Regardless of your current production problems, learn...without obligation...how Kahle's more than 40 years of practical experience can benefit you.

For specific information, write Kahle...now.
Airline Orders Boost Radar Sales

Storm warning gear for big transports looms as multi-million-dollar business

SALE of airborne storm-detecting radar to commercial airlines may become a major part of the non-military radar business. Both domestic and overwater carriers are interested in the equipment, which warns pilots of impending storms while providing a map of terrain features below. Big advantages are increased safety and added payload since extra gas need not be carried for flying long, circuitous paths around storm centers. The pilot can see the storm’s center and select the shortest route around it.

▶ Overseas—Panagra, which flies to Latin American points, has had a Bendix 9,000-ku set installed aboard one of their new DC-6B’s since April. The line plans to buy five more sets for installation aboard its new DC-7’s. Delivery is planned for 1955. Cost is $35,000 per plane, installed.

Other overwater carriers are looking into storm-detection radar. These include Air France, BOAC (British), KLM (Dutch) and Sabena (Belgian). In addition, many private firms with their own executive fleets are enthused.

▶ Other Lines—The board of United Air Lines has earmarked $4 million for storm-detection radar on their new DC-7’s. This action follows four months during which an RCA 5,400-ku set was flight-tested aboard a United Air Lines plane. According to RCA, four other carriers—Braniff Airways, National Airlines, Pan-American World Airways and Trans-World Airlines—have also requested equipment for flight evaluation. Delivery is promised for this year.

The RCA unit operates in the C-band, which some experts claim is best for weather-monitoring purposes. The unit weighs 150 lb and has a 75-kw transmitter.

▶ Military—Meanwhile, the Sperry Gyroscope Co. has announced the APN-59, a lightweight radar for installation on Air Force cargo and troop-carrying planes. The Sperry radar, it is claimed, combines terrain clearance data, collision warnings and search and surveillance functions with its navigational and storm warning duties.

Rebuilt Picture Tube Sales Increase

Growing portion of total picture tube sales is being made up of reworked glass envelopes

More rebuilt picture tubes are being used in U. S. tv sets. Last year over 1.2 million reworked tubes were sold. The trend so far this year indicates that 1954 sales will go considerably higher.

▶ Companies—It is estimated that nearly 40 firms of all types are engaged in rebuilding tv picture tubes. Bulk of the business, however, is being done by about 5 companies in the field.

Many of the major new tube manufacturers have been in the rebuilding business at one time or another. Some major tube makers have glass allowance programs in effect whereby they pay service organizations for burned-out tubes. The fact that major glass envelope manufacturers no longer produce
Barry Engineers Report on Design Methods

Technical articles written by Barry engineers over the past several years on the protection of electronic apparatus against damage by vibration and shock, are now available. The information presented covers both the theoretical and the practical aspects of shock and vibration protection—for aircraft, naval, mobile, and industrial equipment.

Engineers who wish copies of these reports may obtain them by asking for them by number; requests should be addressed to Mr. A. S. Chivers, Barry Corporation, Watertown, Mass.

Designing for Shock Resistance

Shock Testing of Airborne Equipment

How to Evaluate Shock Tests

Toned-Down Noise Tunes Up Operation

Mounting Keeps Vibration in its Place

Shock or Vibration Isolators?

Mock-ups for Vibration and Shock Testing

Vibration Isolators speed up plant changes

The Role of Shock Testing Machines in Design

Electronics—October, 1954

SHOCK, VIBRATION and NOISE

DO YOU WANT Complete DATA?

CATALOG 523-A. Air-damped Barrymounts for shock and vibration protection of military airborne equipment.

BULLETIN 532. Vibration isolator Type 915, for isolating vibration and noise caused by high-speed motors or motor-driven equipment.

BULLETIN 533. Medium-impact shock machine Type 150-400VD, for qualification and acceptance shock tests up to 77g.

BULLETIN 534. Series M64 ALL-METL vibration isolators and Series TOMA mounting bases, for military airborne equipment under extreme operating conditions.

BULLETIN 535. Component shock machine Type 20 VI, for qualification and acceptance shock tests up to 210g.

“LOOK — NO LAGGING!” Increasing profits through the use of the new Leveling Barrymount for industrial machinery.

BULLETIN 536. Series M64 ALL-METL vibration isolators and Series AOMA and NOMA mounting bases, for military airborne equipment under extreme operating conditions.

BULLETIN 537. Series 262/633 vibration isolators, for isolating vibration and noise caused by medium-speed motors or motor-driven machinery.

BULLETIN 538. Series 670/297 shock and vibration isolators, for isolating shock caused by impact-type machines, and vibration and noise caused by heavy rotating machinery.

Here are complete engineering data, application information, and pointers to profits in every field of shock and vibration isolation. Write TODAY for your free copies of the ones you need.

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Philadelphia Phoenix Rochester St. Louis San Francisco Seattle Toronto Washington

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some of the smaller-sized envelopes indicates that a few manufacturers may be reusing glass envelopes for such replacement sales.

Cost—Main reasons for the success of the reworked tube business are price and the growing replacement and second-set markets. Prices of reworked tubes vary from 60 to 90 percent of the cost of a similar new tube. This price differential has become important especially to the small-screen replacement market where the consumer is unwilling to pay the full price for a small screen. This is especially true, according to tube companies, where the tube is to be used in a second set in the home.

Rebuilt tubes also find a market in some new tv sets that are on the market. According to one re-builder, at least four major tv set producers use reworked picture tubes in their current lines.

How—There are many degrees of quality in rebuilt tv picture tubes. In some only the envelope itself is reused. The old tubes are taken in, washed out, refaced with phosphor and the guns are replaced. In other rebuilding operations only the gun or a defective part in the tube is replaced or repaired before the tube is put back on the market.

Currently the dominant sellers in rebuilt tube lines are in the 16 to 19-inch size bracket. But rebuilders expect that soon the 21-inch rebuilt will be the volume seller, as it is now for new picture tubes.

Uncle Sam’s Radio Voice Increases in Volume

Equipment buying and rental mean business for broadcasters and manufacturers

Voice of America is probably the world’s biggest broadcasting network—if not in number of outlets, certainly in total kilowatts of signal on the air. The voice broadcasts 75 separate programs daily, amounting to 31 program hours in 38 different languages to a worldwide audience estimated at 400,000,000.

Nerve Center—New $700,000 studios in Washington’s Health, Education and Welfare building will feed 77 transmitters. Thirty of these are located in continental United States and are used as short-wave relays. Transmitting facilities within the U. S. are rented by the Voice and private firms in the international broadcasting business collect $1.9 million annually.

Outlets—The Voice operates one-million-watt transmitters in Munich, the Philippines and Okinawa. Cost of these monster transmitters is estimated at a dollar a watt. Other high-power facilities are located in Salonika, Tangier, Ceylon, Honolulu and aboard the U. S. Coast Guard Cutter Courier anchored off the island of Rhodes in the Eastern Mediterranean. The Voice has spent $15 million on capital equipment in the last five years.

In addition to this equipment the Voice rents facilities from the BBC regularly and from local broadcasters overseas whenever additional coverage is required or when Russian jamming temporarily dislocates normal operations.

(Continued on page 18)
Introduced by General Radio Company in 1949, the VARIAC® Motor Speed Control won immediate acceptance as a new and unique system for varying speed of d-c motors operating on a-c lines.

Separate selenium rectifiers for field and armature, with a VARIAC continuously-adjustable autotransformer ahead of the armature rectifier, provide a unique combination of characteristics. This is a true adjustable armature-voltage speed control in extremely simple and compact form.

VARIAC Motor Speed Controls feature:

**Very Wide Speed Range** — continuously-adjustable from rated speed to zero. Full rated torque can be delivered even at zero speed continuously without overheating.

**No Electron Tubes** — selenium rectifiers require no warm-up — motor starts immediately when the power is turned on.

**Excellent Controlled-Starting Characteristics** — delicate equipment can be started without jerk. Heavy machines can be started very quickly.

**Very Fast Start-Stop-Reverse** — ample capacities permit heavy loads to be started, stopped and reversed repeatedly, without damage.

**Extra-Smooth Torque** — satisfies the most critical requirements for low torque pulsation — excellent for such applications as precision grinding.

**Effectively Eliminates Need for Gears, Step Pulleys, and other types of mechanical speed changers.** Any speed desired can be obtained.

**Low Initial Cost** — Simple Installation

**Long Life** with minimum maintenance — no tubes to replace.

**Available in 9 Models** for d-c motors from 1/15th hp and less up to 13/2 hp.

Prices shown do not include motor. Standard motors for each control are sold separately and are obtainable from General Radio. Prices and specifications on request.

We sell direct. Prices shown are NET, f.o.b. Cambridge or W. Concord, Mass.

---

**Type 1701-AM . . . $75**
For high-speed shunt motor performance from universal motors. Speed range 0 to rated. All controls on panel.

**Type 1700-B . . . $170**
For d-c shunt or compound-wound motors. Dynamic braking for extra fast stopping. Speed range 0 to rated. All controls on panel.

---

**Type 1702-A . . . $245**
For d-c shunt or compound-wound motors. Dynamic braking. Speed range 0 to rated. All controls on panel.

**Type 1702-M . . . $350**
Identical with Type 1702-A (above) except for push button operation at remote control station.

---

**Type 1703-A . . . $97.50**
For d-c shunt or compound-wound motors. Dynamic braking for extra fast stopping. Speed range 0 to rated. All controls on panel.

**Type 1703-M . . . $200**
Identical in size and appearance with Type 1704-A (above). For d-c shunt and compound motors. For push button operation at remote station. Speed range 0 to rated.

---

To meet the requests of many manufacturers and users who want to incorporate these versatile units into their own equipment or machines, four models are now supplied in stripped-down form.

They consist of the basic components mounted on a panel and wired to a terminal strip, all necessary leads are brought out.

All of the standard functions of the mounted models, including fusing, dynamic braking and start-stop-reverse can be incorporated easily in the external circuits in the user's equipment.

Illustrated is the Type 1700-BW for 1/4-1/3 hp motors. Unit Price: $135.00. Other models available are for 1/6, 3/4 and 1 hp.

Quantity prices on the stripped-down units are available upon request.

**Write for the VARIAC MOTOR SPEED BULLETIN**
Transistor Developed For UHF

New pnp design presents potential threat to TV tube manufacturers

PRESENT-DAY TRANSISTORS cannot be used in many television receiver circuits because of frequency limitations inherent in their design. A new transistor developed by Bell Labs oscillates at 440 mc and is expected to eventually oscillate at 3,000 mc, which in effect will remove the frequency limitation from the transistor business.

► Construction—The main difference between this and conventional junction transistors is incorporation of a layer of chemically pure germanium termed an intrinsic barrier. This layer is located between the usual pnp layers to form a pnp configuration. Besides decreasing capacitances between the transistor input and output areas, the intrinsic layer permits the transistor to be operated at much higher voltages.

Traffic Control Saves $3 Million

Newly available frequency permits replacing cables with coded radio signals

CHICAGO is going all-out for an electronic solution of traffic problems that many other big cities have encountered. The direct solution is synchronization of all important intersections to speed incoming morning traffic and outgoing evening flow of vehicles. Sufficient cables to do the job would cost $7,500 an intersection. So Chicago will use coded radio signals.

► Basic Problem—During most of the day, inbound and outbound cars will receive equal consideration, with cross-traffic given its chance, too. Control signals to program this operation will be sent out from a central station.

Once the special morning and evening signals have been sent, they will generally require no further attention—except in bad weather. Roadside neon signs will show the optimum speed for which the system is set so the motorist can proceed without stops. Need for exact timing control becomes evident when it is understood that the distances between traffic signals are not identical. A steady traffic pace can be kept only if each individual light receives the code that ties it in with the rest.

► Pilot Run—For a start, the city will equip eleven heavy-traffic intersections with antennas, receivers, decoders and traffic-light controllers. Two other intersections, 8 miles from the transmitter, will be similarly equipped.

At present, Chicago has 1,200 signalized intersections. Plans call for an eventual total of 3,000. Of these, some 450 will need the special steady-pace signals. Connected by cables the control system would cost $3,375,000. Using radio, costs drop to about $480,000.

► How It Works—Top pace for rush-hour traffic is expected to be 30 mph. When fog, sleet or snow occur, the optimum speed must be reduced, but smooth flow will be possible only with exact, individual timing of lights. Information to set this timing will be sent out as a series of coded pulses. Each receiver will pick out only the pulses assigned to it. The radio signals will emanate from the tower of the Board of Trade in the Loop. Transmissions will radiate on a newly available frequency of 27,255 mc. On-the-air time will normally amount to 0.2 second out of each hour.

Because other cities at great distances, and medical and industrial radio equipments can use frequencies in the same band, the Chicago signals must be highly coded to avoid traffic snarls from other transmitters.

Receiving Tube Makers Push Volume Sales

Manufacturers concentrate bulk production and sales on four entertainment tube types

FACTORY sales of receiving tubes, averaging about 40 million units a month so far this year, are made up largely of entertainment tube types for the home market. In June, for example, of the 31 million tubes sold, approximately 80 percent were accounted for by sales of major entertainment receiving tube types. Of these, about 20 percent were represented by four tube types, the 6CB6, 6SN7GT & GTA, 6AU6 and 12AU7, with total sales of 5.6 million units, as shown in the chart.

► Market—The initial equipment market is the main one for the top tube sellers shown. Renewal sales are also substantial, although only
these are the

STANDOUTS

for exacting military and commercial applications

RARrTHEON

RELIABLE MINIATURE TUBES

These tubes have earned the right to your confidence — and specification — by their demonstrated ability to stand up under the toughest service conditions. They are stable, rugged, reliable. They are subject to rigid quality control. Many of them meet 1000 hour life tests at elevated temperatures.

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Reliable Subminiature and Miniature Tubes - Semiconductor Diodes and Transistors - Analogic Tubes - Microwave Tubes - Receiving and Picture Tubes

ELECTRONICS — October, 1954

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the 6SN7, a relative oldtimer, has shown replacement sales exceeding 50 percent of initial equipment volume. Sales to other markets, which include government and export sales, represent only 30,000 units monthly for each of the four types.

**Use—**The 6CB6 and 6AU6 are sharp-cutoff pentodes of miniature type, used in tv sets as an i-f amplifier and as an r-f amplifier in vhf tv tuners.

The 6SN7-GT, a medium-mu twin triode, is largely used as a horizontal oscillator in tv receivers.

The 12AU7, a medium-mu twin triode, is a miniature type used in tv sets, as a phase inverter or amplifier in a-c/d-c radio equipment and in many diversified applications such as multivibrators or oscillators in industrial control devices.

**Future—**There are signs that new tube types may take over as sales leaders. Several manufacturers have introduced receiving types designed for application in tv sets that use series-connected heaters. If series-string tv goes over, the 6CB6 may be replaced by the 3CB6, the 6SN7 GTA by the 6SN7 GTB, the 6AU6 by the 5AU6 and the 12AU7 by the 6AU7.

**Amateur Radio Sales Make Gains**

**Volume of transmitters and receivers sold increases as more hobbyists enter field**

Companies in the amateur radio equipment manufacturing field have experienced substantial increases in sales in the past few years. This is pointed up by the fact that in the last year alone, the number of transmitters authorized to operate in the amateur radio service increased by 12,000 for one of the largest gains on record.

Since 1951 the number of amateur transmitters authorized has increased from some 30,000 in 1951 to 123,000 in June of this year. Receiver sales have shown a similar rising trend. Manufacturers estimate that receiver sales have far exceeded transmitter sales because of larger export volume and sales in the hi-fi field.

**Why—**Some of the main reasons for growing sales of transmitters and receivers for amateur use in the last 4 years are the changes made in amateur rules by the FCC. License requirements were relaxed with the establishment of the novice class, which is the most elementary type of amateur operator license available, and the technician class which lowered code requirements. Since July 1951, when the novice class was established, over 22,000 such licenses have been issued. In the technician class more than 7,000 licenses were issued in the period;

the number of extra-class licenses at the close of 1953 was 1,300, an increase of 400 over the previous year.

**Equipment—**There are approximately 30 manufacturers of amateur transmitters and about the same number in the amateur receiver field. Transmitter and receiver kits account for the majority of sales in the field. However, some manufacturers note that there is a tendency now for more amateurs to buy factory-made equipment because of television interference caused by some home-made sets.

New development in the factory-made amateur equipment is the use of printed circuits in receivers. The short-wave set shown uses a tinned copper-on-XXXX-phenolic in the r-f section. Sectionalized mechanical construction similar to plug-in unit construction found in some military equipment is also being used.

**Renegotiation Changes Help Manufacturers**

**Fewer government contracts are subject to review as Congress passes revised bill**

Electronic manufacturers who have had government contracts subject to renegotiation may gain some relief under the revised Renegotiation Act recently passed by Congress. Under the new bill a manufacturer with an annual income from government contracts of $500,000 or under is not subject to renegotiation. Previously, the minimum was $250,000. The new minimum applies to fiscal years ending on or after June 30, 1953.

**Changes—**The revised Act also eases other provisions of the 1951 bill. It exempts from renegotiation, under certain conditions, contracts for standard commercial articles as defined in the bill. This applies when cost figures supplied by contractors show that competitive conditions prevent excessive profit. It also applies if the Renegotiation Board does not find ex-
An Announcement

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Doing Research and Design
Work in the Entire Audio Frequency Range.

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is proud to announce the development
of an entirely new product—

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a Variable Toroidal Inductor

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- is a continuously variable, stepless toroidal inductor which can provide a 3:1 range of maximum to minimum inductance in 180° rotation of a shaft.
- employs no mechanical resistance contacts and is therefore free of noise and wear.
- requires no DC saturating currents and thereby eliminates the need for circuitry.
- is applicable over the entire audio range (from approximately 300 cps). ROTOROID is not limited to any stock value of nominal inductance. It is available in any value of inductance now available in regular toroids.
- is hermetically sealed and is virtually vibration and shock-proof, can be chassis or panel mounted.

Write Department C for further information.

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An outstanding feature of ROTOROID is that, at maximum inductance, it provides the full Q of the toroid it contains. Thus, the user is at once able to take advantage of the high Q characteristics of toroids while at the same time having available a variable inductor not previously available in a toroid.

Applications: Virtually unlimited. Just a few of the many possible uses of ROTOROID are:
- Tunable Audio Oscillators
- Variable Z Devices
- Servo Systems
- Telemetering
- Adjustable Selective Networks
- Variable Phase Shift Networks
- Variable Filters
- Electro-Mechanical Control Systems

Availability: Immediately available: ROTOROIDS VTI-A and VTI-B which are equivalent in electrical characteristics to Burnell toroids TC-16 and TC-3 in cases 2¼” in diameter, 3-1/16” long. Soon to be available: two miniature types, VTI-C and VTI-D, equivalent to Burnell toroids TCO and TC-6.

FIRST IN TOROIDS AND RELATED NETWORKS

ELECTRONICS — October, 1954

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cessive profits within six months after cost figures have been filed.

**Effect**—The changes in the Renegotiation Act as applied to the electronic industry may be beneficial chiefly to small manufacturers since most of the larger firms in the field have had annual income from defense contracts in excess of $500,000. Sylvania, for example, estimates that about $60 million or 22 percent of its 1953 sales are government sales subject to renegotiation.

Even under the old Act, however, most major electronic manufacturers were not required to make refunds because profits were not excessive. It is estimated that less than five percent of all Navy contracts renegotiated have been subject to substantial refunds. However, many large companies continue to make provision for possible renegotiation refunds in their financial statements.

**More U.S. Watchmakers Make Electronic Items**

NEED for diversification in the face of sliding markets and foreign competition has led major watchmakers in the U.S. to move into new business fields. The electronics industry has been a leading choice for many of them. About eight watch manufacturers are now connected with the industry in some degree. Two of the latest entries are U.S. Time and General Time.

**Products**—Electronic products made by watch firms range from guided missile components to magnetic recorders. U.S. Time recently introduced a magnetic disk recorder and player to retail at $59.95, aimed at the mass home market. Under development for the past year in the firm's electronic division, the recorder utilizes a new magnetic recording head structure and disks composed of iron oxide coating on a plastic base. Recording time is 31 minutes. Tracking is achieved by placing a grooved metal disk over the center portion of the coated plastic record. A stylus on an extension of the pickup arm rides in this groove. The company also plans to enter the tape recording field.

General Time, through its Stromberg division, plans to introduce an electronic time system to supplement its present industrial timing equipment line. Their move into electronics was prompted more by the trend in an established product than as a diversification move.

**Financial Roundup**

INCREASED financial activity among companies in the electronic field was evident in the past month as eight firms made profit reports and eight companies announced security transactions.

Following are the net profit reports of nine electronic manufacturers for the fiscal periods indicated:

<table>
<thead>
<tr>
<th>Company</th>
<th>Net Profit</th>
<th>1953</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acme Electric 12m</td>
<td>$130,975</td>
<td>$230,062</td>
</tr>
<tr>
<td>Admiral 6m</td>
<td>2,855,856</td>
<td>4,156,752</td>
</tr>
<tr>
<td>American Bosch Arma 1m</td>
<td>1,111,905</td>
<td>811,569</td>
</tr>
<tr>
<td>American Electronics 6m</td>
<td>138,225</td>
<td>54,701</td>
</tr>
<tr>
<td>CBS 6m</td>
<td>3,127,149</td>
<td>4,795,270</td>
</tr>
<tr>
<td>Cornell-Dubilier 9m</td>
<td>1,012,000</td>
<td>1,258,000</td>
</tr>
<tr>
<td>Daystrom 8m</td>
<td>105,727</td>
<td>374,219</td>
</tr>
<tr>
<td>Swifty 6m</td>
<td>11,773,813</td>
<td>7,997,470</td>
</tr>
</tbody>
</table>

**Securities** — AT&T registered with SEC covering $250 million of 30-year debentures due Sept. 15, 1984 to be offered for sale at competitive bidding. Proceeds will be used for advances to subsidiaries, purchase of stock by subsidiaries and associates, plant expansion and improvement and for general corporate purposes.

Ketay Instrument registered with SEC covering 300,000 shares of common stock, 10 cents par value, to be offered for sale to the public. Net proceeds of 200,000 shares will be applied to payments in full of outstanding obligations of $1.5 million.

(Continued on page 24)
Five thousand, when compared to the national debt, is a small number. But when one company has manufactured over 5000 different types of special capacitors, this number becomes impressive. Yet, Hammarlund has done just that, in addition to turning out a line of standard variable capacitors. The majority of these special types were designed by us to meet customers' specifications—others were built to customers' designs. Some were quite large and intricate, while others were tiny enough to do a big job in miniature devices. They all have one thing in common: They are all built to Hammarlund's rigid quality standards—built to give optimum results.

If you have a problem calling for a special capacitor, it will pay you to check Hammarlund first. For among these 5,000 special capacitors there probably is one to meet your specification. If this is the case we have the dies; tool costs are nil and delivery is prompt. If, however, none of our existing "specials" can fill the bill, our experienced engineering staff will be happy to work with you to design a capacitor that will.

For detailed information on special and standard capacitors, write to The Hammarlund Manufacturing Co., Inc., 460 West 34th Street, New York 1, N. Y. Ask for Bulletin 105.
Industry Shorts

Sales to the industrial field will take an estimated 18 percent of the national electronic distributor volume for 1954, according to RCA.

Production of large etched circuits for digital computers and other electronic assemblies has been increased to 150 per week by Bendix computer division.

Electronic inspection machines now are being used to check precision-ground exhaust valves for Ford's new overhead valve engine.

Over 315,000 people attended the National Radio Show in England, an increase of 20,000 over last year's attendance and the highest since 1949.

Electronic industry's ratio of research and development expenditures to sales is 5.4 percent compared to the national average of 2 percent.

National average ratio of cost of production equipment to yearly sales is approximately 70 percent compared to 9 percent for the electronic industry.

Fifteen million feet of three-inch wide magnetic recording tape has been ordered by the Air Force under a $220,000 contract with Audio Devices.

Tests made on sample quantities of receiver tubes returned to Magnavox as defective showed that about 40 percent were good.
NOW

a molded boron-carbon resistor

The inherent superiority of a boron-carbon resistor is now available with added advantages of a fully insulated unit. The IRC Type MBC ½ watt, 1% resistor offers significantly better characteristics plus protection against damage during assembly. Send coupon for detailed information.

<table>
<thead>
<tr>
<th>COMPARATIVE ADVANTAGES</th>
<th>MOLDED vs. UNMOLDED BORON-CARBON RESISTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change On 40° Load Life At 500 Hours</td>
<td>50% LESS</td>
</tr>
<tr>
<td>Temperature Characteristics</td>
<td>100% AS EFFICIENT</td>
</tr>
<tr>
<td>Shelf Life At Room Temperature</td>
<td>60% BETTER</td>
</tr>
<tr>
<td>Moisture Test Reaction</td>
<td>75% BETTER</td>
</tr>
</tbody>
</table>

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403 N. Broad Street, Philadelphia 8, Pa.
Please send Technical Bulletin describing Type MBC resistors:

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Title: ...........................................
Company: ...........................................
Address: ...........................................
City: ........................................... State: ...........................................

INTERNATIONAL RESISTANCE COMPANY
Philadelphia 8, Penna.
In Canada: International Resistance Co., Ltd., Toronto License

ELECTRONICS — October, 1954

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The added advantages of molded insulation are now available for 1/2 Watt Deposited Carbon Resistors. New Type MDC is a 1% precision film resistor combining high stability, small size and low cost. The molded plastic housing provides complete mechanical protection, minimizes the effect of moisture and improves load life characteristics.

**COMPARISON SURFACE TEMPERATURE RISE VS. LOAD**

**Molded vs. Unmolded Deposited Carbon Resistor**

<table>
<thead>
<tr>
<th>Load Applied in Watts</th>
<th>Surface Temperature Rise - °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.2</td>
<td>20</td>
</tr>
<tr>
<td>0.4</td>
<td>40</td>
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<tr>
<td>0.6</td>
<td>60</td>
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<tr>
<td>0.8</td>
<td>80</td>
</tr>
<tr>
<td>1.0</td>
<td>100</td>
</tr>
</tbody>
</table>

**Voltsmeter Multipliers • Boron & Deposited Carbon Precitators • Insulated Composition Resistors • Power Resistors • Controls and Potentiometers • Low Wattage Wire Wounds • Germanium Diodes**

**Wherever the Circuit Says IRC**

**Precision Wire Wounds • Ultra HF and Hi-Voltage Resistors • Low Value Capacitors • Selenium Rectifiers • Insulated Chokes • Hermetic Sealing Terminals**

SEND COUPON FOR DATA BULLETIN

INTERNATIONAL RESISTANCE CO.
403 N. Broad Street, Philadelphia 8, Pa.

In Canada: International Resistance Co., Ltd., Toronto, Licensee

Send Technical Bulletin B-9 describing Molded Deposited Carbon Resistors:

Name ________________________________

Title ________________________________

Company ________________________________

Address ________________________________

City __________________________ State ____________________

Want more information? Use post card on last page.
The presence of extreme climatic conditions, unusual ambient temperatures or salt water are offset by a new IRC encapsulating technique. This IRC development uses an epoxy resin compound for both the winding form and the seal. A special molding process avoids air pockets and assures even, complete distribution of the resin. Designed to operate at 125°C, and to meet the military requirements of salt water immersion, these units exceed MIL-R-93A specifications in 1%, 0.5%, 0.25% and 0.1% tolerances.

Also available for MIL Applications . . .
IRC TYPE WWJ Precision Wire Wounds

In 6 MIL-R-93A styles, plus miniature type WW10J, IRC Precision Wire Wound Resistors offer full coverage of requirements for exacting accuracy in critical applications. IRC's superior winding skill and care is the result of over 25 years experience.

ELECTRONICS — October, 1954

Want more information? Use post card on last page.
NOW

3 new wire wound resistors

IRC's new power wire wounds are lower cost per watt than any other power type. At 4, 7 and 10 watts, they offer savings of several cents each in any application requiring compact, low cost, efficient power resistors. Types PW-4, PW-7 and PW-10 resistors assure safe operation in circuits where stability and low wattage dissipation are needed.

4 WATT
Type PW-4 allows safe operation with hot-spot temperatures up to 165°C. Fully insulated housing will not burn or support combustion.

7 WATT
Types PW-7 and PW-10 allow safe operation with hot-spot temperatures up to 275°C.

10 WATT

UNUSUAL DESIGN AND ASSEMBLY TECHNIQUE PROVIDES LOWER COST PER WATT.

SEND COUPON FOR DATA BULLETINS

INTERNATIONAL RESISTANCE CO.
403 N. Broad Street, Philadelphia 8, Pa.
In Canada: International Resistance Co., Ltd., Toronto, Licensee
Please send □ Bulletin P-1 on PW-4 Resistors □ Bulletin P-2 on PW-7 and PW-10 Resistors.

Name ____________________________
Title ____________________________
Company _________________________
Address __________________________
City _____________________________ State, _______________________

October, 1954 — ELECTRONICS
NOW
a new wire wound potentiometer

The mechanical and electrical features of Type 2W Rheostat-Potentiometer are designed for current and future electronic circuits. This modern, 2 watt unit offers maximum application adaptability plus typical IRC superior performance. Electrical operation is improved by one-piece center terminal and collector ring, and direct contact between collector ring and contactor. Advanced mechanical design anchors winding securely to strip, locks element into position, and assures accurate location of terminals.

IMPROVED DESIGN FEATURES

- Better Heat Dissipation
- Greater Dust Protection
- Increased Mechanical Rotation
- Increased Electrical Rotation
- More Resistance Values
- Double and Single Taps Available

Voltmeter Multipliers • Boron & Deposited Carbon Precistors • Insulated Composition Resistors • Power Resistors • Controls and Potentiometers • Low Wattage Wire Wounds • Germanium Diodes

INTERNATIONAL RESISTANCE CO.
403 N. Broad Street, Philadelphia 8, Pa.
In Canada: International Resistance Co., Ltd., Toronto, Licensee

Send Bulletin describing Type 2W Potentiometers:

Name ____________________________
Title ______________________________
Company __________________________
Address __________________________
City __________________________ State
IRC Miniature MICROSTAK Selenium Rectifiers are available in a variety of types for many standard and special applications, in sizes as small as .060" diameter. IRC's processing technique makes possible uniform, high grade, long-life, low capacitance cells with performance characteristics not available elsewhere.

Cell thickness to ± .001. Less than 1% unbalanced voltage on bridge circuits. Hermetically sealed types available.

TYPICAL ADVANCED APPLICATIONS

VOLTAGE REGULATION

\[ R_1 \]

\[ V_{IN} \quad \text{A.C.} \]

\[ V_{OUT} \quad \text{Regulated} \quad \text{A.C.} \]

BALANCED MODULATOR

\[ \text{MODULATION INPUT} \]

\[ \text{SIDE BAND OUTPUT} \]

\[ \text{CARRIER INPUT} \]

LOGARITHMIC CONVERTERS

\[ V_{IN} \quad \text{A.C.} \]

\[ V_{OUT} \quad \text{A.C.} \]

SEND COUPON FOR BULLETIN SHOWING CHARACTERISTICS, SPECIFICATIONS AND TYPICAL APPLICATIONS.

INTERNATIONAL RESISTANCE CO.
403 N. Broad Street, Philadelphia 8, Pa.
In Canada: International Resistance Co., Ltd., Toronto, Licensee


Name: ____________________________________________

Title: ____________________________________________

Company: ________________________________________

Address: _________________________________________

City: _____________________________________________ State: __________

October, 1954 — ELECTRONICS
NEW non-linear resistors

New IRC VARISTORS are voltage sensitive and provide sharp variation of resistance with applied voltage. Designed to meet most needs for non-linear resistors, they are available in 5 convenient cell sizes, and a complete choice of enclosures including hermetic seals.

SEND FOR TECHNICAL DATA BULLETIN

INTERNATIONAL RESISTANCE CO.
403 N. Broad St., Philadelphia 8, Pa.
In Canada: International Resistance Co., Ltd.,
Toronto, licensee
Please send me Technical Bulletin SR-3
Name
Address
City
State

NEW hermetic sealing terminals

New IRC Feed-Thru Terminals are designed for assured hermetic sealing for electrical and electronic components. IRC's exclusive molding technique bonds KEL-F* to metal in a superior, consistent hermetic seal. Molded bodies are chemically inert to solvents, acids, alkalies, etc., and have high resistance to thermal shock (-70°C to +190°C). HS-1 Terminals meet the sealing requirements of MIL-T-27.

SEND FOR TECHNICAL DATA BULLETIN

INTERNATIONAL RESISTANCE CO.
403 N. Broad St., Philadelphia 8, Pa.
In Canada: International Resistance Co., Ltd.,
Toronto, licensee
Please send me Technical Bulletin HS-1.
Name
Address
City
State

NEW low cost insulated chokes

New sizes of IRC Insulated Chokes now provide 4 types — CL1/2, CLA, CL1 and CL2. The wide range of size and characteristic combinations available with these 4 types permit accurate specifications to space and electrical requirements. Insulated housing guards coil from physical damage and prevents shorting.

SEND FOR TECHNICAL DATA BULLETIN

INTERNATIONAL RESISTANCE CO.
403 N. Broad St., Philadelphia 8, Pa.
In Canada: International Resistance Co., Ltd.,
Toronto, licensee
Please send me Technical Bulletin HI-1.
Name
Address
City
State

NEW resistor engineering guide

New IRC 1954-55 RESISTOR ENGINEERING GUIDE gives digested specifications and approximate prices for 138 different resistor types including 56 JAN or MIL equivalents. Data on Insulated Chokes, Selenium Rectifiers, Germanium Diodes and Feed-Thru Terminals also included. Widest coverage of condensed resistor information available.

SEND FOR TECHNICAL DATA BULLETIN

INTERNATIONAL RESISTANCE CO.
403 N. Broad St., Philadelphia 8, Pa.
In Canada: International Resistance Co., Ltd.,
Toronto, licensee
Please send me the IRC Resistor Engineering Guide.
Name
Address
City
State

ELECTRONICS — October, 1954
It will serve on any Panel...

Reported evidence that

Everyone can count on

Veed-Root

Reporter at large... that's what you might call this new Veed-Root Reset Magnetic Counter... adaptable to remote counting from machines or processes to central boards or instrument-clusters, wherever you want to put them. Now... what can your imagination do with these few facts? For the full facts, write:

Veed-Root Incorporated
"The Name That Counts"
Hartford 2, Connecticut
Chicago 6, Ill. • New York 19, N.Y. • Greenville, S.C.
Montreal 2, Canada • Dundee, Scotland
Offices and Agents in Principal Cities

Counts Everything on Earth

Want more information? Use post card on last page. October, 1954 — Electronics
modern new
OHMITE plant

Skokie, Illinois
(Suburb of Chicago)

provides **advanced**
FACILITIES for
DEVELOPMENT and
PRODUCTION
of the FINEST in . . .

Rheostats
Resistors
Tap Switches
Advanced Production Facilities

Several months ago, Ohmite Manufacturing Company moved to its modern new plant in Skokie, Illinois—a north suburb of Chicago. This new plant has provided Ohmite with the greatly increased facilities needed to meet its continuously expanding sales volume.

The new Ohmite factory and offices—covering an area of 128,000 square feet—are completely air conditioned. The plant contains the very latest in equipment and facilities—for efficient production of quality resistance and other electrical control products.

Resistor Firing

Modern, continuous, conveyor-type furnaces rotate resistors being fired. This prevents "pile-up" of the vitreous enamel...assures a uniform coating.

Rheostat Firing

Gradual heating and cooling in this continuous, rotary-type furnace provides a superior coating of vitreous enamel and prevents internal cracking.

Tool and Die Shop

Ohmite designs and builds most of its own tools, dies, gauges, fixtures and special machines in the well-equipped machine shop shown above.
Precision Resistor Testing
Each resistor is given a voltage breakdown test and the resistance value is measured. Ohmite resistors can be made to tolerances as low as 0.1%.

Humidity Chambers
In this equipment, using program-controlled cycles, Ohmite products are tested under a wide range of temperature and humidity conditions.

X-ray Diffractometer and X-ray Fluorescence Spectrometer
These instruments make possible the determination of crystal structure as well as elemental composition of materials and products by means of x-rays.

advanced
RESEARCH AND TESTING LABORATORIES
The new Ohmite research, development, and testing laboratories use the finest scientific instruments and equipment. Here Ohmite products are tested and retested under the most grueling conditions to detect potential sources of trouble. And these same laboratories are used for the development of new materials, new processes, and new designs—to build Ohmite products that set new standards of long life and trouble-free performance.

Testing Resistance Values
Resistors from the production lines are checked for continuity resistance value and tolerance. Standard Ohmite tolerance is ±5% where number of turns and alloy permit.

Microscopic and Perographic Equipment
The Ohmite laboratories contain this equipment for the optical examination of materials and products.

Metallographic Laboratory
Special equipment is available for microscopic analysis of structure using metallograph. Thermal expansion of ceramics and vitreous enamels can be determined with interferometer equipment.

RHEOSTATS
RESISTORS
TAP SWITCHES
Standardization Laboratory
The instruments shown here are used to check and standardize the many pieces of Ohmite electrical test equipment.

Power Panel
This power panel provides AC or DC in a wide range of currents, voltages and frequencies—permits testing Ohmite products under operating conditions.

Vacuum Chambers
Vacuum chambers of this type are used to deposit an extremely thin film or coating of evaporated metal.

Special Purpose Furnaces
High temperature globar furnace; muffle furnace for enamel testing; hydrogen atmosphere sintering furnace.

OHMITE MANUFACTURING COMPANY
3610 N. Howard St., Skokie, Illinois (Suburb of Chicago)

RHEOSTATS RESISTORS TAP SWITCHES
If you want to maintain constant output voltage with zero waveform distortion or constant voltage to large industrial loads, you will find the STABILINE Type EM the answer.

STABILINE automatic voltage regulators Type EM not only stabilize and regulate the voltage output and exactly reproduce the input waveform, but feature:

- outstanding efficiency — comparable to the most conservatively designed fixed-ratio transformers
- fast correction rates for voltage changes
- wide input voltage ranges
- adjustable output voltage settings
- adjustable operating sensitivity

Send coupon below for full details.

THE SUPERIOR ELECTRIC COMPANY
210 Clarke Ave., Bristol, Conn.

Please send Bulletin S351 on STABILINE automatic voltage regulators.

Name: ____________________________
Position: __________________________
Company Name: ____________________
Company Address: __________________
City: _____________________________ State: ____________

ELECTRONICS — October, 1954
Want more information? Use post card on last page.
In 1939, -hp- designed and manufactured the first commercial RC (resistance-capacity) oscillator. Today, this type is recognized as the most versatile, practical, dependable and convenient of all oscillators. Through the years, -hp- RC oscillators have become world-famous for their high stability, accuracy, wide frequency range and compact size.

### 17 OSCILLATORS FOR EVERY NEED

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Primary Uses</th>
<th>Frequency Range</th>
<th>Output</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>-hp- 200AB</td>
<td>Audio tests</td>
<td>20 cps to 40 kc</td>
<td>1 watt/24.5 v</td>
<td>$120.00</td>
</tr>
<tr>
<td>-hp- 200CD</td>
<td>Audio, ultrasonic tests</td>
<td>5 cps to 600 kc</td>
<td>160 mw/20 v</td>
<td>150.00</td>
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<tr>
<td>-hp- 200E</td>
<td>Interpolation and frequency measurements</td>
<td>6 cps to 6 kc</td>
<td>100 mw/10 v</td>
<td>225.00</td>
</tr>
<tr>
<td>-hp- 200T</td>
<td>Telemetry, carrier current tests</td>
<td>250 cps to 100 kc</td>
<td>160 mw/20 v</td>
<td>350.00</td>
</tr>
<tr>
<td>-hp- 201B</td>
<td>High quality audio tests</td>
<td>20 cps to 20 kc</td>
<td>3 w/42.5 v</td>
<td>250.00</td>
</tr>
<tr>
<td>-hp- 202A</td>
<td>Low frequency measurements</td>
<td>0.1 cps to 1 kc</td>
<td>20 mw/10 v</td>
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<tr>
<td>-hp- 202B</td>
<td>Low frequency measurements</td>
<td>1/2 cps to 50 kc</td>
<td>100 mw/10 v</td>
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<td>-hp- 202D</td>
<td>Low frequency measurements</td>
<td>2 cps to 70 kc</td>
<td>100 mw/10 v</td>
<td>275.00</td>
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<tr>
<td>-hp- 204A</td>
<td>Portable, battery operated</td>
<td>2 cps to 20 kc</td>
<td>2.5 mw/5 v</td>
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<tr>
<td>-hp- 205A</td>
<td>High power audio tests</td>
<td>20 cps to 20 kc</td>
<td>5 watts</td>
<td>405.00</td>
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<tr>
<td>-hp- 205AC</td>
<td>High power tests, gain measurements</td>
<td>20 cps to 20 kc</td>
<td>5 watts</td>
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<tr>
<td>-hp- 205AH</td>
<td>High power supersonic tests</td>
<td>1 kc to 100 kc</td>
<td>5 watts</td>
<td>565.00</td>
</tr>
<tr>
<td>-hp- 206A</td>
<td>High quality, high accuracy audio test</td>
<td>20 cps to 40 kc</td>
<td>+1/2 dB</td>
<td>565.00</td>
</tr>
<tr>
<td>-hp- 230A</td>
<td>Carrier test oscillator</td>
<td>35 cps to 35 kc</td>
<td>+14 dBm/400 ohms</td>
<td>275.00</td>
</tr>
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<td>-hp- 231A</td>
<td>Carrier test oscillator</td>
<td>50 cps to 500 kc</td>
<td>3 w/600 ohms</td>
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<tr>
<td>-hp- 234A</td>
<td>Carrier test oscillator</td>
<td>160 cps to 140 kc</td>
<td>+14 dBm/400 ohms</td>
<td>350.00</td>
</tr>
<tr>
<td>-hp- 450A</td>
<td>Wide range video tests</td>
<td>10 cps to 10 mc</td>
<td>15 mw/3 v</td>
<td>490.00</td>
</tr>
</tbody>
</table>

Modern -hp- oscillators give you the broadest usefulness, highest quality and greatest value of any oscillators ever built.

They are the ultimate product of 15 years experience in designing and manufacturing 50,000 quality oscillators. This total of 50,000 is a record unequalled in quality oscillator manufacture.

Seventeen -hp- oscillators, for all types of applications, provide complete coverage of all frequencies 0.01 to 10,000,000 cps. They are uniformly characterized by their flat frequency response, ease of adjustment, low distortion, high stability, accurate calibration and trouble-free operating reliability.

Brief details of these universally-used instruments appear at left. For complete data, ask your -hp- sales engineer, or write factory direct.

*Open circuit, Internal impedance 600 ohms. Data subject to change without notice. Prices f.o.b. factory.

Want more information? Use post card on last page.

October, 1954 — ELECTRONICS
Today, HP RC oscillators are the accepted standard in science and industry. The 50,000th HP oscillator—the golden commemorative instrument pictured here—is an HP 200CD, popular member of the world's largest oscillator family. HP 200CD covers all frequencies 5 to 600,000 cps. Output is 10 volts into 600 ohms. For the entire frequency range response is $\pm$ 1 db, and distortion less than 0.5%. Price, $150.00.
Ketay offers a complete range of sizes and types of rotating components—synchros, servo motors, and resolvers. Specifications for 116 of them are contained in an illustrated brochure, available upon request.

Ketay leadership is the result of sound, imaginative engineering. From the design of a specialized component to the fabrication of complete systems, Ketay engineers create the "standards of tomorrow".

Costs, quality, and stringent delivery schedules, are best controlled when critical manufacturing is done "on the premises"—under close supervision. Ketay plants are fully equipped with modern machines and equipment. This Heald Borematic Department is but one of many such divisions at Ketay.

Components for complete systems including gear trains and amplifiers of conventional and miniaturized types are available to meet the most demanding of design requirements.

Ketay Manufacturing Corporation

Executive Offices:
555 Broadway, N.Y. 12, N.Y.
New York Division
Electronic Instrument Div.
Electronic control devices are among the many instruments Ketay manufactures for aircraft, missiles, marine, ordnance, and civilian application. Special designs to meet the limitations of space and operating conditions.

Electro-mechanical devices some of which are illustrated on these pages. Currently, original Ketay developments are providing instrument performance far above present standards—many of which were set by earlier Ketay developments.

Ketay successfully applies its production facilities and experienced research personnel to specific problems for the leaders in automatic control.

Your interest will be well served by learning fully of the products and services you may obtain from Ketay.

Pacific Division:
12833 Simms Avenue, Hawthorne, Calif.
Research & Development Div.

Write, today, for descriptive specifications of those types of Ketay instruments which may be applied to your designs.

Precision of manufacture is vital in every Ketay unit. To assure continuing reliability for its products, Ketay employs the very latest facilities and techniques. Typical is this “gear room” where modern gear cutting machinery produces gears to the finest of tolerances.

Many specialized units have been designed by Ketay engineers and are in quantity production. Custom engineered units for specific application are also available.

Want more information? Use post card on last page

www.americanradiohistory.com
MANUFACTURED IN
PRODUCTION QUANTITIES
FOR PRECISE ASSEMBLIES

DIVISION OF The CARBORUNDUM Company
Temperature Sensitive Resistors

Used for compensation, measurement and control of temperature, these units decrease in resistance in the order of 3% per degree centigrade rise.

**Volume Resistivity Range:** 10 to 7500 ohms cm

**Manufacturing Tolerances:**
- Resistance—± 5%
- Temperature Characteristic—± 5° from −60° to 30° C.

Available in rods (.010"-.500" dia.); tubes (.020"-.500" OD x ID up to 75% of OD); discs, bars, washers and simple shapes.

Kovar—Hard Glass Seals

The use of hard glass offers superior thermal endurance; high dielectric strength, particularly at high temperatures; and chemical stability. Used in combination with Kovar, Hard Glass produces an exact thermal coefficient match between metal and glass, maximum bond strength, and chemical interfusing between metal and glass for vacuum-tight interface between metal and glass. Thin section, light weight, flexible eyelets can be used. Bulletins 453-A and 145.

Assemblies

Assembly line problems and sub-assembly scrap loss can be minimized or eliminated by using Stupakoff Assemblies. Alumina, low-loss Steatite or other ceramics are combined with silver, copper, brass, stainless steel, monel or Kovar. Ceramics are metallized where required for electrical connection or mechanical assembly. Critical tolerances are precisely held.

Printed Circuits on Ceramic

These compact RC circuits, printed on high-K ceramic plates, protected from abrasion and humidity by a tough plastic coating, provide stable, moisture-proof circuitry ideal for miniaturized, ruggedized electronic applications. Bulletin 1151-A.

**MANUFACTURING COMPANY**

LATROBE, PENNSYLVANIA
1. The Place of Mechanical Design
The function of mechanical design is not new to Bud Radio. For over 25 years we have made electronic components and devices involving the designing of housings, wiring systems and other equipment to improve appearance and add utility not only to our own products but to those of other producers. Economical fabrication, precise design engineering and prompt delivery combine to provide our customers with utmost value, outstanding performance and high quality service. Proper mechanical design assures that components as well as housings will be available at a relatively inexpensive cost and with reasonably short delivery. What better source of supply than BUD Radio Inc. with 1500 stock items in our catalog?

2. Designing the Chassis
Bud regularly makes more than 100 standard sizes and types of chassis for our own account besides constantly supplying special types for other manufacturers of electronic devices. Every facet of chassis construction from selection of metal to careful finishing is checked to insure a superior product. The processes of forming, stamping and welding are performed on the most modern machines by experienced workman before passing through rigid inspection.

3. Making Small Parts
Each day thousands of small parts pass through the Bud plant. Fabricated by machining, stamping and other methods, these products must meet specified standards as do all Bud products. Their mechanical and electrical properties assure proper working qualities when combined with other parts.

4. Shielding and Potting Components
Boxes, shields and containers of various sizes and shapes comprise a large part of the standard Bud line of sheet metal products. Used for a multitude of electronic and electrical applications, these products have found wide acceptance in business and industry. Our long experience and skill in producing this type of component assures true-to-specification results while large volume production guarantees lower prices. Long or short runs of special sizes and designs receive equal attention.

5. Moving Parts
In constructing electronic devices Bud makes and selects only those component parts which will impart smooth motion and control. Coordination between these parts and the balance of the assembly provides proper working qualities. Careful inspection before and after assembly and careful testing are standard procedures at Bud.

6. Power to Impart Motion
While Bud produces no motive power, our primary function is to provide housing for controls for motors, generators, etc. Sturdily built housings give protection to these sensitive controls.

BUD RADIO, INC.
2118 EAST 55TH ST.
DEPT. L
CLEVELAND 3, OHIO

October, 1954 — ELECTRONICS

Want more information? Use post card on last page.
Miniature Wire Insulated with Du Pont TEFLON®
Speeds Soldering Operations, Saves Equipment Space

Abrasion-resistant "Zytel" nylon resin used for five key parts in dictating machine

Five key parts, molded of Du Pont "Zytel" nylon resin, provide improved performance, simplified assembly, and lower production costs in one modern dictating machine.

"Zytel" used as play-back and microphone lock lever gives superior abrasion-resistance to these moving parts. These parts of "Zytel" operate without lubrication and give long service life.

Dielectric Properties

The lightweight but tough recorder coil bobbin of "Zytel" nylon resin has good insulating properties. Because terminal fittings can be riveted directly to this coil, assembly time has been reduced.

The microphone hook lever features "Zytel" molded directly on metal to simplify assembly. The temperature resistance and compression strength of Du Pont "Zytel" are useful properties for the microphone switch lever.

A Material with Many Properties

These five parts are mass-produced to close tolerances by economical injection-molding. They illustrate why versatile "Zytel" nylon resin is used for many specialized parts having different property requirements.

"Zytel" provides excellent thermal stability and dielectric properties

Du Pont "Teflon" tetrafluoroethylene resin has exceptional insulating properties for miniaturized electrical equipment. Where terminals are small and closely fitted, soldering hook-up wires is usually a difficult operation. However, hook-up wires made by the Tensolite Insulated Wire Co., Inc., Tarrytown, N.Y., are coated with Du Pont "Teflon" tetrafluoroethylene resin, providing improved dielectric properties and extra strength, resiliency, and corrosion-resistance.

Because Du Pont "Alathon" has outstanding dielectric properties, the contact points leading to the flashlight switch don't have to be insulated. Short circuits are avoided, which may appreciably shorten battery life. And "Alathon" is warm to the touch even in coldest weather.

"Alathon" combines lightness with resiliency. If the flashlight is accidentally dropped, there's no danger that the threaded connection or case will shatter or dent. Resilient "Alathon" cushions the shock of impact. Do not live dangerously by dropping your flashlight! A flashlight case molded of Du Pont ALATHON®

This Inverter Control Assembly, which regulates output of DC to 400-cycle AC converters, used in aircraft, contains miniature Tensolite wire coated with Du Pont "Teflon". The equipment, which utilizes two Regahm Circuit Controllers, was developed by Electric Regulator Co., Norwalk, Connecticut. It easily withstands ambient temperatures encountered—from -70°C. to 85°C.—and operates efficiently at high altitudes, the manufacturer states.

Flashlight case molded of Du Pont ALATHON®

The simple flashlight case is an interesting new application of Du Pont "Alathon" polyethylene resin. The battery section, end cap, and lens retaining ring are all molded of "Alathon", which gives the flashlight improved dielectric properties, extra strength, resiliency and corrosion-resistance.

Because Du Pont "Alathon" has outstanding dielectric properties, the contact points leading to the flashlight switch don't have to be insulated. Short circuits are avoided, which may appreciably shorten battery life. And "Alathon" is warm to the touch even in coldest weather.

"Alathon" combines lightness with resiliency. If the flashlight is accidentally dropped, there's no danger that the threaded connection or case will shatter or dent. Resilient "Alathon" cushions the shock of impact. Do not live dangerously by dropping your flashlight!

Excellently Dielectric Properties

"Teflon" tetrafluoroethylene resin has excellent dielectric properties. The dielectric strength is high, and losses are very low. Volume resistivity is unaffected by moisture. These dielectric properties are especially important when wires and terminals are in close proximity.

(Continued, column 1 back side)
Miniature Wire (Continued)
Many Electrical Applications for "Teflon"

Du Pont "Teflon" has many applications in the electrical field—coaxial spacings and connectors, high frequency tube sockets, bases for subassemblies and stand-off insulators. For further information on the thermal, electrical, and mechanical properties of this unique Du Pont engineering material, mail the coupon below.

Flashlight Cases (Continued)

blows, minimizing damage to the bulb filament. The manufacturer, Gits Molding Corp., Chicago, Ill., thoroughly tested the case made of "Alathon" and guarantees it "unbreakable", if not wilfully abused.

This engineering material offers other advantages. It resists corrosion. The end cap and barrel of "Alathon" form a virtually waterproof seal.

Investigate DuPont engineering materials in your product development programs

One of the family of these versatile engineering materials is often a key factor in product improvement or new product design.

The wide range of properties available with "Alathon"** polyethylene resin, "Lucite"* acrylic resin, "Teflon"** tetrafluoroethylene resin, and "Zytel"** nylon resin are helping solve industrial design problems.

Construction well along on $3,000,000 Polymethylacrylates laboratory in Wilmington

Du Pont is building a $3,000,000 Sales Service Laboratory in Wilmington, Delaware, to expand the present facilities of its Polymethylacrylates Department. This new laboratory is to provide sales and engineering services to customers in the plastics and other industries.

The laboratory will have the most modern equipment available for developing technical data on the use and processing of Polymethylacrylates Department products. Its facilities for providing technical services, especially in the field of plastic engineering materials such as "Alathon" polyethylene resin, "Teflon" tetrafluoroethylene resin, "Lucite" acrylic resin, and Du Pont "Zytel" nylon resin, will be several times those of the present laboratory in Arlington, New Jersey.

Parts of the new laboratory will be equipped especially for study courses on the utilization of new plastic engineering materials. Space for exhibits of these materials and products made from them is to be provided in a two-story reception area.

Large portions of the laboratory will be equipped for demonstrating new processing methods and for testing. Total floor space: 62,000 square feet.

Preliminary work on the site is now under way and construction is expected to be completed late in 1954.

NEED MORE INFORMATION?

Clip the coupon for additional data on properties and applications of these Du Pont engineering materials.

---

E. L. DU PONT DE NEMOURS & CO. (INC.)
Polychemicals Department,
Room 2210, Du Pont Building, Wilmington 98, Delaware

Please send me more information on the Du Pont engineering materials checked:

□ "Zytel"; □ "Alathon"; □ "Teflon"; □ "Lucite". I am interested in evaluating these materials for:

NAME

COMPANY

STREET

CITY

STATE

TYPE OF BUSINESS

**"Alathon", "Lucite", "Teflon" are registered trade-marks of E. L. du Pont de Nemours & Co. (Inc.)

***"Zytel" is the new trade-mark for Du Pont nylon resin.
"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.
5. "U" leads for printed circuits.
6. Individual cut and bend lengths.
7. Better time/rate analysis.
8. Closer cost control.
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!

Write for illustrated, descriptive text on "PIG-TAILORING" to Dept. MD

BRUNO-NEW YORK INDUSTRIES CORPORATION
DESIGNERS AND MANUFACTURERS OF ELECTRONIC EQUIPMENT
460 WEST 34TH STREET • NEW YORK 1, N. Y.

ELECTRONICS — October, 1954

www.americanradiohistory.com
Same signal recorded at chart speed of 250 mm. per second for optimum resolution.

Typical signal recorded at chart speed of 10 mm. per second.

New Brush Direct Writing Oscillographs

WIDEST RANGE OF RECORDING CHART SPEEDS AVAILABLE

From 10" per day to 10" per second

With the new Brush 4- and 6-channel oscillographs you have a choice of up to 16 chart speeds—from 10 mm. per hour to 250 mm. per second. This permits excellent resolution of a great variety of signals—with economy in chart paper. From the various speeds available, you select the slowest speed that will give desired resolution of recorded signal.

The chart drive is electrically controlled; thus speeds can be changed instantaneously, from either local or remote locations. The high accuracy of the chart drive system provides a linear time base for all recordings at all speeds. With ink writing, the trace is uniform regardless of type of signal or chart speed. Electric writing is also available for unusual operating conditions.

Get all the facts—send the coupon today, or call your nearby Brush representative. Brush Electronics Company, Cleveland 14, Ohio. In Canada: A. C. Wickman, Ltd., Toronto.
Really Reliable

SEMI-COONDUCTOR PRODUCTS
for all your rectifier, diode and transistor needs

- Outstanding performance
- Uniformly dependable
- Long life
- Rigid quality control
- Constantly improved

RADIO RECEPTOR Co. conducts continuing laboratory research to maintain highest standards for existing types of selenium rectifiers, silicon and germanium diodes and transistors—and to develop new units, including those to meet special needs where necessary.

As rapidly as possible we publish bulletins on our products and they are always available upon request. Sometimes, though, we find the printing presses simply cannot keep up with our progress... So, for the best and most up-to-date facts about RADIO RECEPTOR semi-conductor products we suggest you submit your specifications. Our engineers will gladly make recommendations incorporating the very latest information at their command. Just address Section E-3.

Semi-Conductor Division
RADIO RECEPTOR COMPANY, INC.
SALES DEPARTMENT: 251 WEST 19TH STREET, NEW YORK 11, N. Y.
Telephone: WAtkins 4-3633, Factories in Brooklyn, N. Y.
These are our key people ... an integrated team of engineers, production supervisors and field representatives who have made significant contributions to Uncle Sam's growing missile might.

Since 1946 when Bendix-Pacific began its activity in the guided missile equipment field, more than 500 man-years of experience has been accumulated by these people. They will produce many of the hydraulic and electronic systems for tomorrow's Air Force, Army and Navy missiles, with competence born of that experience. Backing up these key people are more than 2,000 skilled workers, experienced in meeting today's exacting missile requirements.

Bendix-Pacific offers a strong, seasoned combination of engineering experience and manufacturing know-how ... a proven source for complete missile electronic and hydraulic systems as well as for components. Inquiries will be treated in complete confidence.
EQUIPMENT EXPERIENCE

Pacific

- Pacific

Hydraulics

Electronics

East Coast Office: 475 5th Ave., N.Y. 17
Export Division: Bendix International 205 E. 42nd St., N.Y. 17
Canadian Distributors: Aviation Electric, Ltd., Montreal 9

Want more information? Use post card on last page.
Kenyon Transformers

Engineered and Built to Meet the Most Rigid Military and Civilian Requirements

Kenyon’s engineering staff and production department have had more than fifteen years’ experience in designing and building units which exactly meet the most rigid and unusual specifications. Your inquiries are invited.

Miniature—Molded—Cased—Hermetically Sealed Oil-Filled—A-Line—T-Line—Toroids—The Kenyon Twins, M-Line to meet all Mil-T-27 Requirements; C-Line for all commercial requirements.

KENYON TRANSFORMER CO., INC.
840 Barry Street, New York 59
Phase Angle at 6.3v, 60 cycles is $21° \pm 5°$, at 30 cycles is nominally $20°$, at 100 cycles $26°$.

Contacts are SPDT, break-before-make, and are rated up to 100 volts maximum, 1 ma maximum.

Dwell Time is approx. 170°. The nominal value of dwell time changes only slightly from 30 cycles to 100 cycles.

Coil demand at 6.3 volts, 60 cycles, is approximately 37 milli-amperes, coil resistance approximately 165 ohms D.C.

Noise with all 3 contacts at one megohm impedance, and with wide band amplifiers, will have an effective value of 50 microvolts or less. The offset of narrow band amplifiers will be very much less. The specification of noise requires careful definition, users should refer to the detail specifications and bulletin 103.

Temperature may be any value from $-65°C$ to $85°C$. The nominal phase angle will vary from about 17 degrees at $-65°C$ to 25 degrees at $85°C$.

Vibration from 10 to 55 cycles will not damage the chopper up to as high as 30 G. At these higher G values there will be some modulation of the phase angle.

Frequency of operation may be any value from 25 to 110 cycles, to maintain full performance, balance, etc.

Humidity may be any value, except of course for external condensation on the header.

Shock values as high as 50G will not damage the chopper.

Altitude may be any value, as the unit is hermetically sealed.
The Type 2003 contains, in addition to the tuning fork, all circuit components which are selected or critical. The tube and remaining components—three resistors and two .01 capacitors—are external and can be laid out and integrated with your equipment.

**TUNING FORK STANDARD**, hermetically sealed.

**SIZE** — 4½ inches long. 1½ inches diameter.

**SIMPLE EXTERNAL CIRCUIT** — 1 tube, 3 resistors, 2 capacitors.

**TUBE** — Choice of 12AT7, 6201, 5751, 6BF7, 6BG7 or 6021.

**POWER REQUIRED** — 75 to 300 V at 1 to 5 m.a. — 6.3 V at 300 or 350 m.a.

**AVAILABLE** — in 400 or 500 cycles

**ACCURACY** guaranteed to .002%, 15° to 35° C.

Write for descriptive literature, specifying Type 2003.

Manufacturer of high precision frequency and timing instruments controlled by tuning fork oscillators.

**American Time Products, Inc.**
580 Fifth Avenue
New York 36, N.Y.

OPERATING UNDER PATENTS OF THE WESTERN ELECTRIC COMPANY

---

Want more information? Use post card on last page.

October, 1954 — ELECTRONICS
General Ceramics

offering 3 complete services...

ENGINEERING-DESIGNING-PRODUCTION

on these 3 basic components...

ELECTRICAL INSULATORS
FERRAMIC® CORES
SOLDERSEAL TERMINALS

1. ELECTRICAL INSULATORS

STEATITE — For low power loss at high frequency. High dielectric strength through wide temperature range. Low thermal expansion.

PORCELAINS — An economical high voltage material of great hardness. Low thermal expansion. Wet or dry process.

ALUMINA — Characterized by great hardness and chip resistance. Will withstand very high temperatures.

ZIRCON — Has low loss properties that vary inversely with frequency. An excellent high frequency material having good thermal shock resistance.

2. FERRAMIC CORES

General Ceramics Ferramic Cores are available in standard toroid, cup core and TV components. Standardization simplifies design problems, speeds delivery and lowers costs. The types illustrated are supplied in many grades of Ferramics for specific applications.

3. SOLDERSEAL TERMINALS

Featuring high mechanical strength, resistance to thermal shock and permanent hermetic sealing. Installation is easy and fast. Terminals are made of glazed Alumina Ceramic with lugs and eyelets hot tinned brass. Metallized areas are silver fired on ceramic, copper electroplated and tin fused for soft soldering.

For complete information on standard components, and recommendations on specific applications, call or write today; there is no obligation.

General Ceramics Corporation

Telephone VALley 6-5100

GENERAL OFFICES and PLANT: KEASBEY, NEW JERSEY
These successful uses of

**PHELPS DODGE BONDEZE**

magnet wire...

*Suggest*

**UNLIMITED NEW**

**COILS**

Random-wound, Layer or Paper-section for potentiometers, telephones, brakes and clutches, clocks and timers, hearing aids, instruments, speakers, relays, television, radio and other applications.

**TRANSFORMERS**

Paper-section, Random-wound, Oil-filled, Air-cooled and High Voltage for distribution, current, X-ray, television, radio and other applications.

**MOTORS**

Windings for shaded pole, series fields, instruments, induction and others.

*First for Lasting Quality—from Mine to Market!*

October, 1954 — ELECTRONICS
Redesigning? \textbf{BONDEZE} may provide one answer to your overall cost reduction program!

\textbf{BONDEZE} is Phelps Dodge magnet wire with a special thermo-plastic film applied over the insulation. It offers a quick, economical means of bonding wires together, turn to turn, through single application of heat or solvents.

\textbf{BONDEZE} offers unusual opportunities for redesign of windings and in many cases influences finished product design with overall savings to the user.

\textit{Any time magnet wire is your problem, consult Phelps Dodge for the quickest, easiest answer.}

*BONDEZE is a Phelps Dodge Trademark

\begin{center}
\textbf{PHELPS DODGE COPPER PRODUCTS CORPORATION}
\end{center}

\begin{center}
\textbf{INCA MANUFACTURING DIVISION}
\textbf{FORT WAYNE, INDIANA}
\end{center}
Starting here it's mostly nickel and chromium...

127 operations later, it's Nichrome*

There are several excellent nickel-chrome combinations on the market. But there is only one Nichrome*. What is it that makes this alloy the universal standard by which engineers judge the properties of heat and corrosion resistance? There is always at least one extra ingredient added to the nickel and chrome. That is... the supreme mastery of the Driver-Harris specialists, gained in their 55 years of melting and drawing experience. This hard-won skill of theirs is reflected in improved heating and quenching techniques... in specially developed deoxidizing anneals... in expert and precise control of every technical process of the entire manufacturing cycle. Sometimes, indeed, there are as many as 127 distinct operations between melting crucible and the finished wire strip, or rod.

In recognition of its unique properties, the United States Patent Office in August, 1908, granted solely and exclusively to us the trademark NICHROME. There is only one Nichrome, and it is produced by Driver-Harris.

Driver-Harris Company
HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Louisville, Los Angeles, San Francisco

In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario.

MAKERS OF THE MOST COMPLETE LINE OF ELECTRIC HEATING, RESISTANCE, AND ELECTRONIC ALLOYS IN THE WORLD

Shallcross Borohm resistors are unusually stable, accurate, and long-lived as a result of Shallcross' basic research on carbon films and manufacturing processes. Complete control of the quality and distribution of the boro-carbon film on specially formulated ceramic rods assures minimum film variation within each unit, as well as from unit to unit.

Automatic machine handling of resistors throughout the carbon deposition process prevents contamination. Rigid automatic control of rod and gas temperatures during deposition eliminates soot formation in the carbon film. Resistance for a given size rod is therefore both predictable and reproducible.

Borohm resistors have negligible voltage coefficient, consistent temperature coefficient, and stability proven by temperature cycling, moisture resistance, and load life tests.

For detailed information as to sizes, styles, ratings, and performance test data results write for the new Shallcross Engineering Bulletin L-33.
HERE’S WHY . . .

Shielding is a vital element in circuit design, and the Magnetics, Inc. "Performance-Guarantee" on your shields is your assurance that they have been designed and manufactured to meet your performance specifications. You then know, whether your shields have been made from Mumetal, A.E.M. 4750, or from any other commercially available magnetic or non-magnetic material selected to meet your needs, they will make money for you on the assembly line by eliminating waste.

You also know that these Performance-Guaranteed Magnetic Shields cost no more—indeed, despite the fact that you have a guarantee of performance, they are sold at prices standard in the industry. Let our Engineering Department design your shields and production engineer to your cost requirements . . . one more important Magnetics, Inc. service to our customers.

How Do You Like Your Shields? . . .

Painted, lacquered . . . or unfinished? Painted . . . to match any equipment shade you select? From any commercially available material to meet your performance and cost needs? That’s exactly how they’re furnished by Magnetics, Inc. . . . to meet your specifications.

WANT THE COMPLETE STORY?
Write us . . . on your company letterhead . . . we’ll be delighted to answer your questions. No obligation, of course . . .

MAGNETICS inc.

DEPT. E-14 BUTLER, PENNSYLVANIA

October, 1954 — ELECTRONICS
HERE'S WHY...

The Magnetics, Inc. "Performance-Guarantee" on molybdenum permalloy Powder Cores is a revolutionary concept in the communications and electronics industries, and opens the way to substantial savings in your production and assembly operations. The guarantee of performance to your specifications is your assurance that these Powder Cores are standardized to meet your circuit requirements.

These Performance-Guaranteed Powder Cores cost no more—indeed, despite the fact that you have a guarantee of performance, they are sold at prices standard in the industry. You can't afford not to investigate Magnetics, Inc. molybdenum permalloy Powder Cores.

Keep in Mind These Advantages of Powder Cores...

1. Low hysteresis and eddy current losses;
2. High electrical resistivity;
3. Constant permeability over widely varying flux densities;

WANT THE COMPLETE STORY...?

Write us...on your company letterhead...we'll be delighted to send you literature, delighted to answer specific questions. No obligation, of course...

*Manufactured under a license agreement with Western Electric Co.

DEPT. E-13 BUTLER, PENNSYLVANIA

ELECTRONICS — October, 1954

Want more information? Use post card on last page.
**KEPCO VOLTAGE REGULATED POWER SUPPLIES**

### MODEL 750

<table>
<thead>
<tr>
<th>MODEL</th>
<th>VOLT</th>
<th>CURRENT</th>
<th>REGULATION</th>
<th>RIPPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>750</td>
<td>0-600</td>
<td>0-750 Ma</td>
<td>0.5%</td>
<td>10 Mv.</td>
</tr>
<tr>
<td>760</td>
<td>0-600</td>
<td>0-1.5 Amp</td>
<td>0.5%</td>
<td>10 Mv.</td>
</tr>
<tr>
<td>770</td>
<td>0-600</td>
<td>0-2.25 Amp</td>
<td>0.5%</td>
<td>10 Mv.</td>
</tr>
<tr>
<td>780</td>
<td>0-600</td>
<td>0-3 Amp.</td>
<td>0.5%</td>
<td>10 Mv.</td>
</tr>
</tbody>
</table>

**DC POWER SUPPLY SPECIFICATIONS**

KEPCO Voltage Regulated Power Supplies are conservatively rated. The specification for each unit is available under all line and load conditions within the range of the instrument.

**REGULATION:** As shown in table for both line fluctuations from 105-125 volts and load variations from minimum to maximum current.

*REGULATION FOR BIAS SUPPLIES:* 10 milli-volts for line 105-125 volts, ½% for load at 150 volts.

†All AC Voltages are unregulated.

---

**WORKMANSHIP**

Workmanship is of a quality with the highest existing production standards and best instrument electronic practices consistent with the intended use of the item as a continuous duty voltage regulated power supply. Oil filled paper condensers and resistor-board construction are included in the design.

**FOR NEW POWER SUPPLY CATALOG — WRITE DEPT. NO. 789**
Hermetic-Seal, Shock-Resistant Tube Sockets of Kel-F® Polymer Cut Heat, Moisture “Fade-Outs” at High Altitudes

KEL-F polymer plastic, molded into a special metal base permitting complete enclosure of an electronic tube, provides this premium socket with a hermetic seal that defies heavy shock loads, extreme thermal cycling and aging. Tube “fade-outs”, due to moisture condensation and collection, are eliminated, tube altitude “ceilings” have been raised significantly.

Positive electrical insulation is maintained under all thermal and moisture service conditions because of the high dielectric strength and low RF loss characteristics of KEL-F polymer.

The high impact and compressive strength of KEL-F polymer helps the socket withstand shock loads up to 100 G’s without cracking or chipping of vital insulation.

The Elco Corporation, Philadelphia, Pa., injection-molds the complex socket from KEL-F polymer Grade 300. A metal tube cover with a silicone rubber gasket completes the assembly.

For further information ask for Application Report E-128

Electronic “Memory” Drum Insulated with Kel-F® to Eliminate Carbonization, Wear Damage ... Extend Service Life

Two obstacles to efficient operation—carbonization shorting and insula-tion “wiping” onto vital contacts—are eliminated through the use of KEL-F plastic as insulation in this special commutator.

High dielectric strength and heat resistance assure positive insulation under all operating temperature and humidity conditions, prevent formation of carbonization tracks between drum contact points. Zero water absorption cuts moisture “shorts”, arcing.

W. S. Shamban & Company of Culver City, Calif., transfer-molded this new commutator of unplasticized KEL-F polymer Grade 300 for use in a special digital-type converter manufactured by Genisco, Inc., Los Angeles, California.

For further information ask for Application Report E-129

® Registered trade-mark for The M. W. Kellogg Company’s fluoroorganic Polymers

www.americanradiohistory.com
Paper-Thin Insulator of KEL-F®
Polymer Solves Space, Precision “Specs” Problem in Microwave Cavity

Found to be the only high-frequency dielectric capable of being machined to close tolerances in this .009” thick insulator, KEL-F plastic effectively prevents pulse leaks between cavity and probe. These units, producing hundreds of watts peak power output, depend largely on the insulator for their 0.0005% per °C temperature coefficient.

The fluorocarbon’s high dielectric strength over a wide temperature range and its dimensional stability assure complete insulation in the limited space provided. Zero water absorption of this fluorocarbon guards the insulator against any changes caused by moisture.

The precision insulator is machined from KEL-F polymer rod and installed in microwave oscillator assemblies by C.G.S. Laboratories, Inc. of Stamford, Conn. C.G.S. obtains its rod stock from the Resistoflex Corporation, Belleville, N. J. who extrude it from unplasticized KEL-F polymer.

For further information ask for Application Report E-127

Molders & Fabricators of the Month

Leading molders, extruders and fabricators specialize in the production of parts made of “KEL-F”... each month this column will spotlight several of these companies with their principal services and products.

Booker & Wallestead, Inc.
Minneapolis, Minn.
Injection molding
Compression & transfer molding (Specialize in short runs)

H & R Industries
Nazareth, Pa.
Extrusion & injection molding
Machining & forming
Rod, tube, tape & strip
Resistor sleeving

Electronic Wave Products, Inc.
New York, N. Y.
Sealing of film
Forming
Container liners, gaskets

Reiss Manufacturing Corporation
(Rway Synthetic Products Div.)
New York, N. Y.
Extrusion, compression & transfer molding
Machining & forming
Rod, tube & sheet
Gaskets & diaphragms
Valve seats

Recent Significant KEL-F Polymer Developments...

Blending equipment is now coated with “baked-on” KEL-F polymer dispersions to eliminate wasteful sticking of special plastics during processing. Chemical inertness and non-stick qualities of coating have cut maintenance and contamination.

Switch seals of the plunger type are now molded of fluorocarbon polymer to provide a hermetic seal that will withstand high altitudes and temperatures.

Valve seats machined from KEL-F polymer rod stock are used in a special valve required in nuclear research. Non-porous, tough plastic effectively keeps active Helium isotope from diffusing through the seat. Low “cold flow” keeps seats smooth and undamaged even after many “high torque” closings.

Covers for high-frequency components are compression molded of fluorocarbon polymer for electrical insulation as well as maximum visibility of contained parts. High impact strength and resistance to aging eliminates need for special protective or reinforcing shields or guards.

OFF THE PRESS...

Revised “BUYERS GUIDE” listing KEL-F polymer products, molders and fabricators.

For complete information regarding any item mentioned in DESIGN AND PRODUCTION NEWS, ask for detailed APPLICATION REPORTS, write

Technical Service
CHEMICAL MANUFACTURING DIVISION
THE M. W. KELLOGG COMPANY
P. O. Box 469, Jersey City 3, N. J.
or offices in Boston, Chicago, Dayton,
Los Angeles and New York

® Registered trademark for The M. W. Kellogg Company's fluorocarbon Polymers
www.americanradiohistory.com
One thing in common...

CROSLEY  COLLINS
Hoffman  Admiral  Magnavox

GREAT NAMES IN COMMUNICATIONS...

RELY ON Midland CRYSTALS

These companies—and many others in leadership position in the field—depend on Midland crystals for completely reliable frequency control in their products.

THAT FACT IN ITSELF is testimonial enough to the kind of performance Midland Quality Control has built into millions of crystals for every communications use.

Whatever your Crystal need, conventional or highly specialized
When it has to be exactly right, contact

Midland MANUFACTURING COMPANY, INC.
3105 Fiberglas Road, Kansas City, Kansas

WORLD'S LARGEST PRODUCER OF QUARTZ CRYSTALS
Miniature TV Tri-color cathode gun solves designer’s dilemma

Sometime this year, a fortunate few thousand TV viewers who can pay the freight will relax at home and watch their favorite stars cavort in color. Back of each screen is a triumph of engineering magic—a tri-color cathode ray gun, actually 3 cathodes—one for each primary color.

To bring color TV within pocketbook range of all of us, the heart of future guns will be a miniaturized version of the present disc cathode. The tubular nickel shank of this new disc cathode has been shortened from .312” to .220” and the outside diameter decreased from .121” to .090”, resulting in a number of improvements adding to the efficiency of the assembly.

Cathode surface area is reduced. Smaller and shorter heaters used. Less power required (300-450 milliamps instead of the 600 required in older guns).

Lower heat radiation, due to less power, offers a constant heat as well as a cooler continual operation.

A smaller shank and cap which will not dish-in offers better transmission of electrons to the TV screen.

Smaller guns permit a more compactly assembled 3-gun unit. By moving guns closer together, the deflection of the electron beams is more closely controlled. Miniaturization of the guns means a smaller neck on the finished TV tube. The 3-barrel color tubes take little more space than black and white types, and vital space is conserved for set manufacturers.

The advantages of the present larger disc cathode for monochrome guns—wide choice of material for cap and shank; close "E" dimension control—are also incorporated in the new design.

If you’re interested in more information on materials used in the new disc cathode, and details on Nickel and Nickel Alloy Tubing, mail coupon today for a blueprint and Data Memo 5 and 19. There's no obligation.


Please send: Blueprint Data Memo 5 and 19 on Superior Nickel and Nickel Alloy Tubing.

Name
Company
Address
City Zone State

Superior Tube
The big name in small tubing
All analyses .010" to ¼" O.D.
Certain analyses in light walls up to 2¼" O.D.

Want more information? Use post card on last page.

October, 1954 — ELECTRONICS
General Electric developed this unique radar system to track, position and control plane traffic with maximum safety.

It provides many advantages over conventional systems. The special shape of the antenna radiates a beam 12,000 ft. vertically and from 30 to 60 miles horizontally, providing control of all planes in proximity to the airport. Within the pattern of this beam all aircraft are easily detected.

The Special Products Division of I-T-E was asked by General Electric to undertake the production, design and fabrication of this antenna to rigid tolerances. Although 10 feet wide and 12 feet high, the finished product deflected only 1/4 inch in actual use when covered with ice and subjected to a 90 knot wind.

This is another of the many ways in which I-T-E technology and specialized fabricating background helps solve production problems for industry. Special Products has an experience in a wide variety of fields. Their engineers might have the solution to your problem.

*Why not send for Publication SP-100 E-10 today,*

*It shows what has been done to help others.*
interested in H-E*? send for 8 page Bulletin

YOU GET Tops IN Transformer PERFORMANCE WHEN BUILT BY NOTHELFER

*HIGH EFFICIENCY

8 page Bulletin gives complete information. Send for it!

NOTHELFER Transformers are superior because they are vacuum-pressure impregnated, and all joints over 10 amperes are silver-soldered. Bus leads of over 100 amperes are silver-plated, conservative copper and steel.

Laminations, oriented and most silicon steels are annealed in accurately controlled nitrogen atmosphere electric furnaces.

We also manufacture air and iron core reactors, and saturable core reactors.

From 10 VA to 300 KVA Dry-Type only. Both open and encased. 1, 2, and 3 Phase. 15 to 400 Cycles.

NOTHELFER

WINDING LABORATORIES
9 ALBEMARLE AVE. TRENTON, NEW JERSEY

Manufacturers of Electrical Transformers—Testing Equipment

October, 1954 — ELECTRONICS
Get a head-start in mechanical assembly

Let Hermetic's Vac-tite* Headers win part of the race for you with mechanical designs to solve your problems.

Here are just a few Hermetic Vac-Tite* seals that eliminate extra production operations and save you money!

1. Unit Header with Studs Attached—Saves space; shaped to fit enclosure or can; eliminates extra welding and soldering operations.
2. Weld Seals—Has the proper projections for leak-tight welds.
3. Lock-Ring "Safety" Seal—Simple, sure method for installing headers that is not dependent on solder alone for mechanical security; removable.
4. Threaded Bushing Seal—Firm mechanical connection has maximum shock and vibration resistance and adaptability for positioning and adjustment.
5. Taper Tab Headers & Terminals—Quick, solderless connections adaptable to many applications.
6. Terminal Strip—Pre-mounted terminals offer advantages of a conductive surface for heat dissipation, arc-resistance of glass, one piece assembly.
7. Attached Bracket Seal—Supports entire assembly on built-in structural member.

Write for engineering assistance, data, prices

HERMETIC SEAL PRODUCTS CO.
31 South Sixth Street, Newark 7, New Jersey

*VAC-TITE is HERMETIC's exclusive vacuum proof compression construction glass-to-metal seal.

FIRST AND FOREMOST IN MINIATURIZATION
Miniature Slip Rings and Brushes

by Iron Fireman

New type slip ring and brush assemblies to meet the precise requirements of modern control systems! Iron Fireman has developed a new production technique which makes possible these improved features:

- Low cost
- Extremely low static and dynamic friction
- High dielectric strength between adjacent circuits
- Multiple circuits in unusually compact assemblies
- Matched color coded leads

TYPICAL APPLICATIONS

- Resolvers
- Torquers
- Telemeters
- Computers
- Potentiometers
- Synchros

Custom made to your requirements

We will design and produce slip rings and brushes to meet the exact requirements of your project.

Other Iron Fireman Electronic and aircraft components

- Vertical Gyros
- Special Motors
- Fire & Heat Detectors
- High Speed Relays
- Sensitive Relays
- Choppers

Iron Fireman Electronics

2800 S. E. 9TH AVENUE, PORTLAND 2, OREGON

Want more information? Use postcard on last page.

October, 1954 — ELECTRGNICS
EVERY ELECTRONICS ENGINEER HAS DESIGNED COILS TO UTILIZE MOLDITE CORE "STANDARDS"

Consistently dependable, Moldite core "Standards" are in demand wherever electronic engineering requires the finest in precision-manufactured cores with absolute uniformity from first to last.

MOLDITE CORE "STANDARDS" OFFER...
ECONOMY  HIGH QUALITY
AVAILABILITY  INTERCHANGEABILITY
UNIFORMITY  FLEXIBILITY

"The right Moldite core for the right coil," is a byword at National Moldite whose precision production facilities have given the industry a superlative core or coil form for every electronic application.

Design with Moldite Core Standards in Mind.

COMPLETE LINE OF MOLDITE ECONOMY-ENGINEERED CORES NOW AVAILABLE
FERRITE CORES
MOLDED COIL FORMS
(iron and phenolic)
MAGNETIC IRON CORES
FILTER CORES
THREADED CORES
SLEEVE CORES
CUP CORES

Send for our new Catalog #120
THE MOST COMPLETE LINE OF CORES IN THE INDUSTRY!

NATIONAL MOLDITE COMPANY
1410 CHESTNUT AVE., HILLSIDE 5, N. J.
COMMON CHARACTERISTICS OF ALL TYPE 2028B MOTOR GENERATOR UNITS

<table>
<thead>
<tr>
<th>Pinion Data</th>
<th>10T. 96P. 20° P.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>O.D. of Case</td>
<td>1.000 inch</td>
</tr>
<tr>
<td>Overall Length</td>
<td>2 37/64 inches</td>
</tr>
<tr>
<td>Weight</td>
<td>5 ounces</td>
</tr>
<tr>
<td>Frequency</td>
<td>400 cycles</td>
</tr>
<tr>
<td>No. of Poles (Motor)</td>
<td>6</td>
</tr>
<tr>
<td>No Load Speed (Min.)</td>
<td>6500 rpm</td>
</tr>
<tr>
<td>Rotor Inertia</td>
<td>1.1 gram-cm²</td>
</tr>
</tbody>
</table>

OUTSTANDING FEATURES OF TYPE 2028B MOTOR GENERATOR

- New methods of manufacture result in high efficiency
- High torque to inertia ratio to give fast response
- Available for 115 volt -115 volt two phase or single ended tube operation
- High impedance winding for direct plate to plate operation available
- High generator output voltage with excellent signal to noise ratio
- Zero degree phase shift in generator
- All metal parts corrosion resistant
- Extremely wide operating temperature range

a new peak of efficiency in small servo motors

Input per phase only 1.8 watts

A new line of units has been added to the Kollsman “Special Purpose Motors” family combining precision machining, advanced electrical design and the latest in new materials. This new line consists of Induction Motors and Induction Generators supplied separately or combined in a single case one-inch in diameter. The new motors have been designed to give the maximum torque per watt ratio with the minimum rotor inertia. The generators have been designed to give the maximum output voltage with the minimum residual voltage and phase shift.

One of the principal features of the Kollsman “Special Purpose Motors” is the interchangeability of parts which permits numerous electrically different combinations of motor and generator windings within the same case.

Another unusual feature of the new line is the integral gear head unit. Contained within a single case is the gear train and motor; or gear train, motor and generator. Gear ratios as high as 300:1 can be supplied.

Other models of one inch O.D. units

<table>
<thead>
<tr>
<th>TYPE NO.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>2103</td>
<td>Induction Motor</td>
</tr>
<tr>
<td>2101</td>
<td>Geared Induction Motor</td>
</tr>
<tr>
<td>2131</td>
<td>Geared Motor Generator</td>
</tr>
</tbody>
</table>

Latest catalog and/or complete specification drawings will be sent upon request.

October, 1954 — ELECTRONICS
Complete coverage of the range 950-10,800 mcs/sec.

Four new Microwave Signal Generators covering the range 950-10,800 mcs/sec. All with famous Polarad single dial operation. Each provides the maximum working range possible in one compact signal generator. And, additional Polarad Signal Generators are available to cover 12.8 to 39.7 kmc.

These features on all MSG units assure fast and simple operation: direct reading, single dial frequency control that tracks reflector voltages automatically . . . direct reading attenuator dial . . . conveniently placed controls, in logical sequence . . . high visibility on the face of each instrument.

Polarad Signal Generators are built to the same high standards required for military equipment. They are practical for the factory assembly line—engineered ventilation assures continuous and stable operation of all instrument functions. Components are readily accessible for easy maintenance. And laboratory accuracy is guaranteed under the most rigorous operating conditions.

Write directly to Polarad or your nearest Polarad representative for details.

**Frequency Range**
- MSG-1: 950-2400 MCS/sec.
- MSG-2: 2150-4600 MCS/sec.
- MSG-3: 4450-8000 MCS/sec.
- MSG-4: 6950-10,800 MCS/sec.

**Frequency Accuracy**
- ±1% (Frequency set by means of a single directly calibrated control)

**Power Output**
- 1 MW
- 2 MW

**Attenuator Range**
- 120 db
- 120 db
- 120 db
- 120 db

**Attenuator Accuracy**
- ±2 db
- ±2 db
- ±2 db
- ±2 db

**Output Impedance**
- 50 ohms
- 50 ohms
- 50 ohms
- 50 ohms

**Input Power**
- 115V±10% 60 cps
- 115V±10% 50-1000 cps
- 115V±10% 50-1000 cps

**Internal Pulse Modulation**
- Pulse Width: 0.5 to 10 microseconds
- Delay: 3 to 300 microseconds
- Rate: 40 to 4000 pulses per second
- Synchronization: Internal or external, sine wave or pulse

**External Pulse Modulation**
- Pulse Width: ±2.5 MCS
- Rate: ±2.5 MCS
- Synchronization: ±6 MCS

**Output Synchronizing Pulses**
- Polarity: Positive or Negative
- Rate: 40 to 4000 pulses per second
- Pulse width: 0.5 to 2500 microseconds
- Pulse separation: (For multiple pulses) 1 to 2500 microseconds
- Voltage: Greater than 25 volts
- Rise time: Less than 1 microsecond

**Approx. weight**
- MSG-1: 50 lbs.
- MSG-2: 120 lbs.
- MSG-3: 200 lbs.
- MSG-4: 300 lbs.

"THE FINEST SIGNAL GENERATORS OF THEIR KIND"

Polarad ELECTRONICS CORPORATION 100 METROPOLITAN AVENUE, BROOKLYN 11, NEW YORK

ELECTRONICS — October, 1954

Want more information? Use post card on last page.
Compare Machlett High Vacuum Rectifier Tubes with any other make

ML-5575/100 compared with competitive high vacuum rectifiers having conventional design features and identical peak ratings.

Conditions: Bridge-type rectifier circuit. Waveform: Square, where

\[ \text{Anode Dissipation} = \text{Forward Volts} \times \text{Amperes} \]

Filament Volts, each tube: 20.

**ML-5575/100** operating at peak rated current uses only 1/3 of anode dissipation rating.

**Competitive Rectifier** operating at 65% of peak anode current uses entire anode dissipation rating.

ML-5575/100 operates at 100% of current rating with 300% safety factor for anode dissipation. Competitive high vacuum rectifier tube operating at 65% of peak anode current is at limit of anode dissipation.

**Machlett High Vacuum Rectifier Tubes** give maximum rectification efficiency and high working load capacity with no increase in anode dissipation requirements, because... unique Machlett catenary type filament, eliminating need for electrostatic shielding, gives...

**Highest Operating Efficiency**

**Coolest Running Anode**

**Highest Working Power Level**

**Highest Overload Capacity**

**Longest Life**

For particle precipitation, chemical recovery, hold-off diode application and general high voltage requirements, a broad range of Machlett High Vacuum Rectifier Tubes are available. Included among the higher power tubes are:

- ML-102A, 75 PKV, 0.75 max anode amps; 750 watts anode dissipation.
- ML-5575/100, 100 PKV, 1.00 max anode amps; 750 watts anode dissipation.
- ML-5576/200, 150 PKV, 2.00 max anode amps; 1000 watts anode dissipation.
- ML-199, 110 PKV, 10.00 max anode amps; 1500 watts anode dissipation.

*Thoriated Tungsten Filament.*

For complete data write to:
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Springdale, Connecticut

Over 55 years of electron tube experience!
Toroids, Subminiature

HS—HERMETIC SEALED
MP—MOLDED PLASTIC
QL—VACUUM IMPREGNATED

QLS  MPF  MPL

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Write for Additional Information

Communication Accessories Company

Hickman Mills, Missouri
Kansas City Phones: S'Outh 5528—5529

www.americanradiohistory.com
For increased reliability in FREQUENCY SHIFT reception specify NORTHERN RADIO.

VARIABLE MASTER OSCILLATOR

- Long-time stability 1 cycle per megacycle
- Variable to ANY frequency from 2 to 4 mc within 1 part per million

In addition to accomplishing these new highs in stability with variability, the Type 173 Model 1 is so easy to operate that it can be handled by completely unskilled personnel: frequency is continuously displayed.

It is excellent as the basic control oscillator for diversity receivers, HF transmitters, and other communication devices, or as a laboratory standard. It also provides both a crystal-controlled BFO and a time base 100 kc crystal oscillator as a secondary standard; stability of the latter is 1 part in 5 million. The power supply for this model is housed in a separate panel.

NEW! FREQUENCY SHIFT DIVERSITY CONVERTER

- for use with either single-receiver frequency diversity systems or two-receiver space diversity systems

The Type 174 Model 1 provides solid copy of signals which are 14 db below white noise level—making it the outstanding unit of today. By means of plug-in units, any reasonable number of channels is available between the frequencies of 425 and 3315 cps for either frequency or space diversity operation. For standard FS operation, the plug-in networks provide shift adjustments from 100 to 1000 cps shift. Normal Input Level: —40 to +10 VU (Zero VU = 1 MW into 600 ohms). Satisfactory operation on fades to — 60 VU.
Kinney Compound Vacuum Pumps produce low absolute pressures of 0.2 micron (McLeod) or better completely unassisted. They are quick starting, high pumping speed units, designed to answer every requirement of the laboratory or pilot plant. All four of these pumps can be effectively gas-ballasted for handling water-vapors.

Write us about your vacuum problems. Competent vacuum engineers in all our district offices are ready to help you. Send coupon for details. Kinney Mfg. Division, Boston 30, Massachusetts.
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No other radio relay system can match the breadth of the experience built into Federal's Pulse-Time Modulation Microwave... culmination of over two decades of research, engineering, manufacturing and installation by associated companies of the world-wide International Telephone and Telegraph Corporation.

Here is the multi-channel system that is outstanding for its advanced design—featuring modern telephone techniques... streamlined circuitry... fewer tubes... simplest, smallest RF equipment... highest RF output... easy, economical maintenance.

Here is the system that is engineered to do a complete communications job for pipelines, railroads, utilities, telephone operating companies and many others... and do the job dependably!

Over 6,000 route-miles of Federal PTM Microwave have already been installed in the U.S.

Whatever your requirements, Federal is ready to help you plan microwave links and networks of any length or channel capacity... to deliver a “turn-key” installation... all from one reliable source of supply. For details, write Dept. H-413.

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Federal Telephone and Radio Company

A Division of INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

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October, 1954 — ELECTRONICS
Behind every piece of tape equipment are these PRESTO "extras"—painstaking craftsmanship, years of experience...quality control...and advanced production facilities that guarantee instruments of absolute precision and lifelong dependability.

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Canadian Division: Instantaneous Recording Service, 42 Lombard Street, Toronto

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☐ R-7 Tape Recorder  ☐ A-920 Tape Amplifier
☐ 900-A Tape Amplifier  ☐ CDR-200 Capstan Drive

NAME

COMPANY

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Response is zero to 5000 cycles on the Ampex 306
100 to 100,000 on the Model 307
and 0 to 70,000 on the Ampex 311.

MORE CHANNELS AT ONCE hundreds, if desired
Up to 14 parallel tracks are standard
—and on magnetic tape each can handle as many as
100 channels of data by modulation techniques.

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Magnetic data is convertible to oscillograph traces,
scope readings, computer feeds, control signals,
punched cards and any electrical form.

ACCURACY UNDER EXTREMES shock, altitude, corrosiveness, etc.
Tape has recorded accurately in rough riding
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of high altitude aircraft and
in corrosive conditions at sea.

REDUCED COST an inexpensive, reusable medium
Usually the magnetic tape consumed
will cost less than film, paper or discs
to record "equivalent" information—and in addition,
tape is reusable and requires no special processing.

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write today to Dept. E-1845

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(Washington D.C. area)

Distributors: Radio Shack, Boston; Bing Crosby
Enterprises, Los Angeles; Southwestern Engineering &
Equipment, Dallas and Houston; Canadian General
Electric Company, Canada.

AMPEX MAGNETIC TAPE RECORDERS
Ampex was first to build tape recorders for data and control—has accumulated broadest experience in their application—and today builds more types than any other manufacturer.

Model 303 — Pulse width data, hundreds of low-frequency channels simultaneously.

Model 306 — 0 to 5000 cycles, high instantaneous accuracy by FM-carrier technique.

Model 307 — 100 to 100,000 cycles, direct recording system.

Model 500 — Most stable tape motion ever achieved, 100 to 100,000 cycles.

Model 700 — Seismic drum type, 26 tracks.

Specialized and combination recorders—Numerous other specialized and combination types have been developed by Ampex under government and private contract. This wide variety of experience is available to help solve your special instrumentation problems.

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October, 1954 — ELECTRONICS
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The New

Pay-As-You-Profit Plans

Two plans for purchasing or leasing modern COIL WINDING MACHINERY

Presented by UNIVERSAL WINDING COMPANY
PROVIDENCE, RHODE ISLAND

Full details on the other side . . .
NOW! Two quick, practical ways to Modernize and Economize!

2 NEW LEESONA Pay-As-You-Profit Plans

Why let lack of adequate coil winding machinery cost you money — in lost production and higher operation and maintenance expenses? Universal’s two new Pay-As-You-Profit Plans provide the benefit of modern coil winding machines — without jeopardizing cash, capital position or borrowing power. Take your choice of two Plans.

I. LEESONA LONG-TERM PURCHASE PLAN
Advantages of Plan I include:

Your Cash Position Safeguarded. Purchases under this plan need not impair your company’s cash position.

Immediate Operating Economies. You get the most up-to-date equipment on the market, thus assuring operating economies at once — without waiting until the complete purchase price has been accumulated out of earnings.

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P. O. BOX 1605, PROVIDENCE 1, RHODE ISLAND

Sales Offices: Providence • Chicago • Los Angeles • Philadelphia
Not a riddle, but a fact... the above statement. We mean simply this. The mechanical design of a waveguide structure... its size, shape and weight, are of equal importance to its electronic properties and performance. Thus accurate design and production planning to suit the finished end product is highly important. We at Budd Stanley exist solely to produce the finished structure you design... exactly as you specify it. And we are uniquely qualified to do so. Our long experience in microwave components and specialized tooling and manufacturing facility is devoted solely to producing microwave components to your design... simple or complex... in light or heavy metals... manufactured and tested to your specification. But check for yourself. A phone call, letter, or wire will put our entire staff at your service. Why not call us in today?

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specialists in microwave application
DEFINITELY DEPENDABLE!

Aerocom's Dual Automatic Radio Beacon

Reliability is built into every part of this dual 1000-watt aerophare unit. Ruggedly constructed and conservatively rated, it provides trouble-free unattended service, and at truly low operating and maintenance cost. It operates in the frequency range 200-415 kcs, using plug-in crystal for desired frequency.

Uses single phase power supply, nominal 220 volts, 50 or 60 cycles. Consists of two 1 kw transmitters with keyer (2 keyers if desired), automatic transfer unit and weatherproof antenna tuner. Each transmitter housed in separate standard rack cabinet, with controls in rack cabinet between the transmitters.

Nominal carrier power is 1000 watts. High level plate modulation of final amplifier is used, giving 30% - 35% tone modulation. P-T switch interrupts tone, permitting voice operation. Operates in ambient temperatures from -35°C to 50°C, humidity up to 95%.

Standby transmitter is placed in operation when main transmitter suffers loss (or low level) of carrier power or modulation, or continuous (30 sec.) tone. Audible indication in monitoring receiver tells when standby transmitter is in operation.

Antenna may be either vertical tower or symmetrical T type.
REED MAGNETIC AMPLIFIERS

Series MAFS

Designed for high-performance control systems

TWO CYCLE RESPONSE TIME — DRIFT-FREE

The Freed MAFS series of Magnetic Amplifiers is characterized by

- **FAST RESPONSE** — 2 cycles of power frequency delay for 100% response to step input signal.
- **PHASE REVERSIBLE A.C. OUTPUT WITH ZERO DRIFT OF NULL POINT**

The MAFS series includes the units described below. Engineering and development facilities are available for the design and development of Magnetic Amplifiers having special performance characteristics.

<table>
<thead>
<tr>
<th>Supply Voltage and Frequency</th>
<th>Full Power Output</th>
<th>Max. Voltage Output</th>
<th>Signal Req. for full output</th>
<th>Max. Power Gain</th>
<th>Mfr. and Type No.</th>
<th>Typical Motor Load</th>
<th>Stall Torque</th>
<th>No Load Speed</th>
<th>FRED Type No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>115V., 60</td>
<td>15 watts</td>
<td>115V. AC phase reversible</td>
<td>IV. AC (10,000 ohms input impedance)</td>
<td>1.5 x 10^6</td>
<td>Diehl FPE 25-11</td>
<td>5.5 in-oz</td>
<td>3500 RPM</td>
<td></td>
<td>MAFS-1</td>
</tr>
<tr>
<td>115V., 400</td>
<td>5</td>
<td>57.5V. AC phase reversible</td>
<td>IV. AC (10,000 ohms input impedance)</td>
<td>5 x 10^6</td>
<td>Kearfott R 110-2</td>
<td>1.5</td>
<td>5300</td>
<td></td>
<td>MAFS-2</td>
</tr>
<tr>
<td>115V., 400</td>
<td>10</td>
<td>57.5V. AC phase reversible</td>
<td>IV. AC (10,000 ohms input impedance)</td>
<td>1 x 10^6</td>
<td>Kearfott R 111-2</td>
<td>2.4</td>
<td>5300</td>
<td></td>
<td>MAFS-3</td>
</tr>
<tr>
<td>115V., 400</td>
<td>50</td>
<td>115V. AC phase reversible</td>
<td>IV. AC (10,000 ohms input impedance)</td>
<td>5 x 10^6</td>
<td>Bendix CK-3000</td>
<td>14</td>
<td>3700</td>
<td></td>
<td>MAFS-4</td>
</tr>
</tbody>
</table>

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FREED RESEARCH, Engineering and Production Facilities Combine to Produce Transformers and Instruments of Top Performance.

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Freed Magnetic Amplifiers, Saturable Transformers and Reactors are designed for efficient operation and long life. They can be used wherever reliable, rugged and maintenance free systems are required.

The types of amplifiers listed are designed to control AC servo-motors.

Development facilities are available for the design of magnetic amplifiers to meet specific requirements.

All standard units are hermetically sealed and meet MIL-T-27 Specifications.

**SATURABLE TRANSFORMERS** — Controlled with triode; plate supply can be either DC or AC; no rectifiers, AC or DC control signals.

**PUSH-PULL MAGNETIC AMPLIFIERS** — AC or DC control signals; high gain, may be used with magnetic or vacuum tube preamplifiers if needed.

**FAST-RESPONSE MAGNETIC AMPLIFIERS** — High gain, half-cycle per stage response time; AC or DC control signals; RC feedback networks for control system stabilization can be used directly, preamplifier not needed.

**HIGH TEMPERATURE MAGNETIC AMPLIFIERS** — Designed to operate in ambient temperatures as high as 200°C; AC or DC control signals.

**DRIFT-FREE MAGNETIC AMPLIFIERS** — For rigid drift-free requirements of control systems; designed to meet specific requirements.

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- High Level Pulse
- High Q Toroids
- Power
- Slug Tapped
- Hermetically Sealed
- Miniature
- Step-down
- Precision Filters

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- Power Supplies
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- Harmonic Distortion Meters
- Wide Band Amplifiers
- Decade Amplifiers
- Decade Inductors
- Decade Capacitors
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- Magnetic Voltage Regulators

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Recent introduction of new 6BQ6-GA and 25BQ6-GA sweep tubes, and this announcement of new G-E rectifier types, are only the first steps in an extensive General Electric program to design and build greatly improved receiving tubes for TV. Manufacturers of sets are asking for better tubes...G.E. is devoting every resource to the task of supplying them!

Keep in touch with G.E. for new-design tubes that will mean new high quality, new value, new reliable performance in the receivers you design and manufacture! Address Tube Department, General Electric Company, Schenectady 5, New York.

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specially designed to

MEET MIL-T-27
TWIST TEST

Now you can get terminals especially designed to meet the new MIL-T-27 Twist Test right from stock, for immediate delivery. Heldor's four types of lock-in terminals lick "twist test" troubles . . . they can't turn, twist or loosen. They can be revised to meet your special requirements. They incorporate the basic advantages of all Heldor Bushings, plus increased electrical insulation due to an increased length of steatite.

Use them with Heldor Cans and Covers. You'll effect further and very substantial economies when you avail yourself of Heldor's complete "package" — cans and covers with these new Lock-In terminals already installed, and the final assembly and hermetic sealing of your components in the cans.

Write today for samples and prices based on your requirements!

HELDOR MANUFACTURING CORPORATION
HELDOR HERMETIC SEAL COMPANY, INC.
238 Lewis Street • Paterson, N. J.
Potter's New Digital Magnetic Tape Handler

- Prime requirements: fast starts, fast stops, fast tape speeds, great accuracy. Using Truarc rings, this new model starts and stops the tape within 5 milliseconds, has tape speeds up to 60 inches per second.

Solenoid Mount and Capstan Assembly

- Miniature Truarc E-Rings on .040 diameter shaft and on continuously running capstans eliminate projecting bolts and screws. Rings permit rapid assembly and disassembly, fast replacement of worn rubber capstans.

Tension Shaft Assembly

- Truarc E-Rings snap quickly into place, act as shoulders for the ball bearings with a minimum of friction. Additional Truarc Rings are used as spacers on shafts, can be located accurately to extremely close tolerances.

Reel Shaft Assembly

- Truarc Standard Rings (Series 51X0) hold the reel shaft assembly firmly in place and permit the use of quick-lock hubs so that the reel tapes can be changed in seconds as they are finished.

Truarc Retaining Rings in their new Model 902 High Speed Digital Magnetic Tape Handler. In addition to solving a variety of fastening problems, Truarc Rings facilitate the rapid acceleration and fast stopping needed in these machines.

Wherever you use machined shoulders, bolts, snap rings, cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better, more economical job. Truarc Rings are precision engineered, quick and easy to assemble and disassemble. They save time and increase operating efficiency.

Find out what Waldes Truarc Retaining Rings can do for you, toward saving costs and improving your product. Send your blueprints to Waldes Truarc Engineers for individual attention without obligation.

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

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Please send me the new Waldes Truarc Retaining Ring catalog.

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Title ......................................................................

Company ................................................................

Business Address ......................................................

City ...................................................... Zone ............ State ...........

E106

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Oscillator Turret

THE HEWLETT-PACKARD COMPANY of Palo Alto, California, as a manufacturer of electronic equipment, has found that PLASKON Alkyds molding compounds can and do meet all of their exacting specifications!

In the VHF Signal Generator pictured above, for instance, a material was needed that could guarantee absolute dimensional stability to a component part, thus assuring the instrument’s unfailing accuracy. It had to be strong enough to hold silver inserts without loosening during a life of 50,000 cycles. It had to have a low coefficient of thermal expansion, be readily molded and offer high resistance to heat and arcing.

According to Hewlett-Packard, glass-reinforced PLASKON Alkyd molding compound is “the only plastic that met all our requirements.” In other instruments, H-P has had equal success with PLASKON Products using both mineral-filled and glass-reinforced alkyds.

We pass this “success story” on to you, with the thought that what PLASKON Products can do for others, they can do for you too.
"PLASKON Alkyd molding compounds' fast cure has cut our costs considerably," says Ralph E. Lee, production engineer at Hewlett-Packard. "We also get appreciable savings by molding parts such as probe body insulators which formerly had to be machined. PLASKON Alkyd molding compounds' outstanding electrical properties result in higher quality for our components too."

1. **PLASKON Alkyd molding compounds** give these transformer terminals high insulation and moisture resistance.

2. Transformer bobbins have high strength, even when walls are molded as thin as .040".

3. Probe body insulator has a resistance of at least 100,000 megohms between terminals, with dimensional stability over long periods at 150°F.

4. Through using PLASKON 422 Alkyd molding compound H-P cuts costs by building only one cavity mold for coil cases instead of many.
Where Can YOU Best Use These Properties?

- Near-perfect Radar Transmission
- Ease of Fabrication
- It's "poured-in-place"
- Great Strength with Light Weight
- Excellent Electrical Properties
  - 6 lb/cu ft Lockfoam tested at 9.375 KMC
  - Dielectric Constant: 1.05
  - Loss Tangent: 0.0005
- Good Thermal Insulation
  - "K" Factors
  - 0.018 at 8 lb/cu ft
  - 0.025 at 11 lb/cu ft
- Wide Range of Densities
  - From 2 to 35 lb/cu ft
- Great Versatility
  - 50 different formulations available

The magnificent range of physical and electrical properties of Nopco Lockfoam—plus its unique pour-in-place versatility and convenience—is rapidly finding many applications in electrical and electronic manufacturing, as well as in aviation.

For Nopco Lockfoam literally "goes where you want it"—fills exactly the configurations of any cavity into which it is poured. It is ideal for fabricating lenses for electronic devices. It is ideal as a space-saving, vibration-free potting material for holding electrical components of circuits in a fixed position. It is sure to find many other practical uses.

You'll surely want the full story. Write today for the Nopco Lockfoam booklet.

Plastics Division
Nopco
Chemical Company
Harrison, New Jersey
Cedartown, Ga. • Richmond, Calif.

New Los Angeles Branch. To aid West Coast manufacturers with complete field service on Nopco Lockfoam, our new office at 4858 Valley Blvd., Los Angeles 32, is now ready to serve you. Drop in and get acquainted, or write.
CUT IRON CORE COSTS

with Stackpole

"PREFERRED TYPES"

"EE" SERIES...

FOR

ENGINEERED ECONOMY

Made to well-known Stackpole quality standards, these new "EE" Cores are available only in commonly needed grades and sizes. They're ready for delivery from stock...at low prices...and without the usual set-up charge for custom-engineered cores.

Mechanical specifications conform to the latest MPA recommendations. Electrical standards fully meet 8 out of 10 requirements of radio, TV, and communications equipment. Write, wire, or 'phone for details.

Electronic Components Division

STACKPOLE CARBON COMPANY

St. Marys, Pa.

STACKPOLE

ELECTRONICS — October, 1954

Want more information? Use post card on last page.

www.americanradiohistory.com
MICRO SWITCH Precision Switches
A PRINCIPLE OF GOOD DESIGN

There are uses unlimited for these small MICRO SWITCH precision switches in electronic devices and instruments

A This subminiature switch is capable of operations in excess of 20 million. It is an improved type of the basic subminiature switch and is available with either solder post or turret type, wrap-around terminals.

B The high temperature basic switch will operate satisfactorily in a temperature range of from -50° to +1000°F. Originally designed for jet aircraft applications, it is equally useful for any application which requires a high-temperature switching component.

C The subminiature rotary selector switch uses from 2 to 8 single-pole, double-throw subminiature switches to control from 2 to 16 electrical circuits. It permits 2 to 8 switching positions with spring or manual return to neutral position.

D This sealed toggle switch is supplied with an external panel seal and an internal bushing seal below the bat handle. It has a bushing for panel mounting and may also be supplied with keying tab.

E The subminiature push button switch assembly is composed of two single-pole, double-throw subminiature switches. The plunger provides an unusually good snap make and break. Available with red or black plastic buttons and either solder post or turret-type, wrap-around terminals.

MICRO SWITCH engineering service, fully experienced in every type of switch use, is available at 16 branch offices to consult with you on your switch application problem. A call to the branch office near you may save time and money. There is no obligation.
Military Equipment Designers:

GET POWER GAIN 10·to·1 AND UP
WITH GL-6283 U-H-F TETRODE!

Wide frequency range a feature!
Tube will operate anywhere between
low audio bands and 900 mc at full input—
above 1,000 mc at reduced input.

GET 150 w of useful CW power—
dependably, with 300 w plate dissipation to
back up performance! Apply this output, as
oscillator or amplifier tube, at any frequency
from kilocycles up to 900 mc! Type GL-6283
meets both these design needs...does so
efficiently, with a 10-to-1 or better power
gain (depending on the circuit) that
spells real economy.

Forced-air-cooled; compact; easy to plug
in or remove—these are GL-6283
installation advantages. The tube is
ideal for voice-communication
transmitters...coded-communication
transmitters which control pilotless
planes and guided missiles...other
military circuits calling for a tube
with low-to-medium power that’s versatile,
efficient, and rugged.

G-E Tube Design Service developed the
GL-6283 with your power needs directly in
mind. Full ratings, performance curves,
and descriptive facts will be rushed on
request. Wire or write Tube Department,
General Electric Co., Schenectady 5, N. Y.

★ Gives a DEPENDABLE 150 w of useful CW output.
★ 300-w plate dissipation means extra margin of operat-
ing safety.
★ Forced-air-cooled for convenience. Only 23 cu. ft. per
  min. required.
★ Installs in seconds. Just grasp tube by handle and lower
  into cavity.

★ Wide areas for spring-finger contacts assure good
electrical connections.
★ Compact—less than 2½" wide, 4½" high. Weighs
  approx. 1 pound.
★ Sturdy, shock-resistant, with strong internal supporting
  members.
★ Long-lived. Durable ceramic construction; high-efficiency
  ceramic-to-metal seals.

Progress Is Our Most Important Product

GENERAL ELECTRIC
Wires **TIGHT** mean **SAFE, SURE LIGHT** thanks to **Everlock**

Specially designed EVERLOCK lock washers help keep R-B-M foot dimmer, headlamp, and horn switches in ever-ready operating order. With their exclusive deep-bite, alternating chisel edges, EVERLOCK lock washers hold the vital screws and connecting wires fast and secure.

Wherever permanent, vibration-proof fastenings are indicated — call on EVERLOCK. With EVERLOCK, you can fasten it and forget it. In sizes and materials to meet any specifications. Write for information or contact your nearest EVERLOCK Representative.

Special EVERLOCK Lock Washers used on Switches Manufactured by R-B-M DIVISION, ESSEX WIRE CORPORATION, Detroit, Michigan

A Full Line of EVERLOCK LOCK NUTS and LOCK WASHERS SEND FOR FREE CATALOG TODAY

"EVERLOCK" IS THE REGISTERED TRADEMARK OF THOMPSON-BREMER & COMPANY

**THOMPSON-BREMER & COMPANY** • 520 N. DEARBORN STREET, CHICAGO 10, ILLINOIS

SUBSIDIARY OF AMERICAN MACHINE AND FOUNDRY COMPANY • NEW YORK, N.Y.

www.americanradiohistory.com
**RATINGS**

RATINGS of G-E drawn-oval capacitors range from 1 to 10 uf, 600 to 1500 volts d-c, and 330 to 660 volts a-c.

---

**G-E drawn-oval capacitors save space and cost less**

If you use fixed paper dielectric capacitors, G-E drawn-ovals offer you an opportunity to save up to 20% on weight, and as much as 10% to 20% on cost. The oval-shaped container, developed by General Electric, offers more capacitance per dollar than similarly rated rectangular capacitors. And, by conforming to the natural shape of the winding, it results in a smaller, lighter unit, too. They’re available in ratings from 1 to 10 uf, 600 to 1500 volts d-c, or 330 to 660 volts a-c, 60 cycles.

G-E drawn-ovals feature: A double-rolled seam, between case and cover that makes a mechanically strong, hermetic seal which stays leak-proof even under severe operating conditions; a choice of eyelet, fork-type, or quick-connect (solderless) terminals; silicone bushings between terminal and cover, that effectively maintain a high insulation resistance despite long operation and wide temperature variation.

General Electric drawn-oval capacitors are being used in room air conditioners, business machines, fluorescent lighting ballasts, and industrial and military control systems. If you would like specific application assistance, contact your local General Electric Apparatus Sales Office. General Electric Company, Schenectady 5, New York.

---

**IN ROOM AIR-CONDITIONERS G-E drawn-oval improves power factor and reduces running current.**

**IN ELECTRIC TYPEWRITERS AND BUSINESS MACHINES, the compact G-E drawn-oval is used with split-phase capacitor-run motors.**

**IN FLUORESCENT LAMP BALLASTS, G-E drawn-ovals (left) improve power factor.**

---

**CAN YOU USE THIS VERSATILE CAPACITOR?**

<table>
<thead>
<tr>
<th>General Electric Co.</th>
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<tbody>
<tr>
<td>Section C442-19</td>
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<tr>
<td>Schenectady 5, New York</td>
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<td>Please send me Bulletin GEA-5777.</td>
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Name _____________________________

Position ____________________________

Company ___________________________

City _____________________________ Zone State ___________________________

---

Progress is Our Most Important Product

**GENERAL ELECTRIC**

Electronics — October, 1954

Want more information? Use post card on last page.
RUGGEDIZED INSTRUMENTS — to military specifications, available in 2½", 3½" and 4½" sizes in D-C, movable iron A-C, rectifier type A-C and thermo instruments. All have sealed, externally operated zero correctors—shock-resisting, flat plastic windows—and connection terminals molded into internal rubber.

ULTRA-SENSITIVE RELAYS — extremely compact and rugged relays which operate on values as low as ½ microampere or ¼ millivolt, direct from thermocouples, resistance bulbs or other generators of minute current. Handle substantial wattage at 110 volts on non-chattering magnetic contacts. Available with single or double contacts, fixed or adjustable, manual or solenoid reset.

"MOTOR LOAD %" METERS — WESTON "per-cent load" ammeters and wattmeters make it easy for operators to secure optimum production from lathes, milling machines, automatics, grinders, etc. Prevent overloading—reduce tool breakage—assure uniform quality with fewer objects. Other scale calibrations available.

RECORDING POTENTIOMETER — ideal for built-in needs because of its extreme compactness plus ruggedness and simplicity. Ranges changed simply by inserting required range standards. Chart speeds changed by simple screwdriver adjustment. Plug-in amplifier removed in a jiffy since no soldered connections are used.

Literature on any of the above instruments sent on request.
WESTON Electrical Instrument Corporation,
614 Frelinghuysen Avenue, Newark 5, New Jersey.

WESTON Instruments
SEALTRON SEALs
quality high, price low.

PLUS COMPLETE SERVICE FACILITIES.

Due to our expanded production facilities and improved manufacturing techniques, we have been able to lower the unit cost of our Hermetic Seals. This in turn is passed on to you in the form of hermetic seals of the highest quality, but at a lower price. Strong believers in modernization, we at Sealtron are well aware of the fact that our progress is your benefit.

Prompt Delivery. No hold up of inquiries and orders at Sealtron. Our flexible engineering and production facilities are geared to give you prompt service and delivery at all times.

Design Service. Design and project engineers look to Sealtron for tailor-made, highly specialized forms of hermetic seals and seal assemblies. Our fully staffed and experienced engineering department will design hermetic seals to fit any product specification.

Seal-Assembly Service. We will solder seals, mount studs, inserts and brackets into complete packages. We will also stamp or form brackets and panels. Eliminate your specialized operations. Cut down overhead and release personnel for other work.

SEALTRON, manufacturers of the world's most complete line of Hermetic Seals . . . over 1600 types.
Standard Equiflex mountings come in two basic types...the Square Plate and the Circular Cup. Both types are available in three different sizes...size 1 for light loads or small equipment, size 2 for medium loads or medium duty equipment, size 3 for heavy loads or heavy duty equipment.

Equiflex mountings withstand 100 hour salt spray tests, take 15G shocks without damage and will keep equipment captive up to 30Gs. Extra-damped mountings are available in which each multiple coil spring is shrouded with polyethylene or Teflon tubing.

Equiflex vibration isolators can be supplied to cover load ranges from \( \frac{1}{4} \) to 35 lbs.

- Greatly prolonged service life.
- Wide temperature range.
- Controlled damping.
- Can be loaded in any direction or position.
- Absence of drift or permanent set.
- Equiflex action or 1:1 ratio of radial and axial spring rates.
- Integral single unit assembly with safety washers included and attached.

---

**Ucinite EQUIFLEX vibration isolators**

---

**The Ucinite Co.**

Newtonville 60, Mass.

Division of United-Carr Fastener Corp.

---

**Specialists in**

ELECTRICAL ASSEMBLIES, RADIO AND AUTOMOTIVE

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Want more information? Use post card on last page.

October, 1954 — ELECTRONICS
How many ways can you use DOT PLASTIC snap in NUTS?

UNITED-CARR FASTENER CORP.
CAMBRIDGE 42, MASSACHUSETTS

UNITED-CARR’s new self-locking, plastic nut is designed for blind application and can be used with all types of metal finishes without scratching or chipping the surface. Its plastic fingers provide rigid anchorage yet will not mar paint, polished metals or even porcelain.

Inexpensive sheet metal screws cut their own threads and expand the nut’s fingers as they are driven, locking both nut and screw tightly in place. Screws can be removed and replaced several times without damage to the nut.

DOT plastic snap-in nuts are electrically non-conductive and provide a high degree of insulation against heat transfer. For all practical purposes, they also provide an effective vapor seal.

Available in several styles and sizes. Write for full information and samples or contact your nearest United-Carr representative.
The producing companies of General Precision Equipment Corporation are engaged in the development, production, and sale of advanced technological products. These products all have a broad common base: 1) they represent precision equipment in some form; 2) they derive from similar fields of technical competence; 3) they save labor, increase productivity, or achieve results which cannot be attained with even limited use of on-the-spot manpower.

A general view of the technical capacities of the GPE Producing Companies is given in the chart. But the chart cannot show the very close interrelation of these capacities nor the highly flexible application of facilities, techniques, and capabilities which exists among these companies. This is achieved through GPE's basic operating policy—Coordinated Precision Technology.

GPE Coordinated Precision Technology operates in all areas—in research, development, and manufacture. The record of the GPE Producing Companies in solving advanced technological problems and meeting the demand for high speed, precision, reliability, light weight and compactness at competitive prices is the result of this coordination, the constant application of the newest and most highly advanced techniques, and unremitting insistence on highest quality.

Perhaps the most conspicuous advantage of GPE Coordinated Precision Technology is that the concept and development of equipment and systems, and of solutions to the underlying technical problems, are not restricted by being confined to the specialized techniques of a particular field. In short, GPE Coordinated Precision Technology permits each company to seek the optimum solution for the customer by the application of all relevant techniques within the total capacities of the entire group. Address inquiries to:

GENERAL PRECISION EQUIPMENT CORPORATION
92 GOLD STREET, NEW YORK 38, NEW YORK

THE PRODUCING COMPANIES

SERVES INDUSTRY THROUGH coordinated

CAPACITIES OF THE GPE PRODUCING COMPANIES

- Precision Mechanics and Ceramics
- Electrical Equipment and Components
- Electronics
- Hydraulics and Liquids Handling
- Professional and Industrial Television Equipment
- Instrumentation
- Servos and Controls
- Automatic Computers and Components
- Ultrasonics
- Radar and Microwave
- Motion Picture and Sound Equipment
- Optical Devices
One of a series telling how the producing companies of General Precision Equipment Corporation are contributing to America's progress.

**precision technology**

<table>
<thead>
<tr>
<th>Company</th>
<th>Manufacturing</th>
<th>Manufacturing and product development</th>
<th>Manufacturing, product development and research</th>
<th>Pilot manufacturing, product development and research</th>
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</thead>
<tbody>
<tr>
<td>AMPRO Corporation, Chicago</td>
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<td>LINK Aviation Inc., Binghamton, N.Y.</td>
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<td>THE STRONG ELECTRIC CORPORATION, Toledo</td>
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<td>ASKANIA Regulator Company, Chicago</td>
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<td>BLUDWORTH MARINE, NEW YORK</td>
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<td>LIBRASCOPE, INCORPORATED, GLENDALE, CALIFORNIA</td>
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</table>
G.E.'s Latest Contribution to Stacked

Custom Built to Provide 143 Power Combinations!

- Smallest unit size yet developed!
- Most reliable performance of any rectifier within this category!
- Hermetically sealed for lifetime use!

The following germanium rectifier stacks, each occupying a volume of only 1.62" x 2.5" x 6.00", are typical of the 143 standard stacks in G. E.'s new rectifier line.

<table>
<thead>
<tr>
<th>CIRCUIT</th>
<th>D.C. OUTPUT (55°C Resistive Load)</th>
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<tbody>
<tr>
<td>Half Wave</td>
<td>2 amps @ 280 volts or 3 amps @ 190 volts</td>
</tr>
<tr>
<td>Full Wave Center Tap</td>
<td>2 amps @ 280 volts or 3 amps @ 190 volts</td>
</tr>
<tr>
<td>Full Wave Bridge</td>
<td>1 amp @ 565 volts or 3 amps @ 210 volts</td>
</tr>
<tr>
<td>Three Phase Half Wave</td>
<td>1.12 amps @ 420 volts or 4.5 amps @ 140 volts</td>
</tr>
<tr>
<td>Three Phase Bridge</td>
<td>1.3 amps @ 575 volts or 2.6 amps @ 280 volts</td>
</tr>
<tr>
<td>Three Phase Star</td>
<td>1.8 amps @ 280 volts or 3.6 amps @ 140 volts</td>
</tr>
</tbody>
</table>

Want more information? Use post card on last page.

October, 1954 — ELECTRONICS
General Electric leads the industry again! Announcement of this revolutionary G-E Stacked Germanium Rectifier opens up new avenues of power progress that were heretofore thought impossible to travel. Now, the amazing total of 143 power combinations has been provided with this one product! Your specifications requiring series or parallel stacks in single or polyphase circuits are custom-completed at G-E's factory.

This unit is smaller, weighs less, is more reliable, lasts longer, has better power ratings than any other dry rectifier made anywhere by any other company. AND, G.E. offers you immediate delivery.

Designed and built to deliver new power performance, the G-E Stacked Rectifier is 75% less by volume and weight than any other comparable dry type rectifier. And, rectifier losses are reduced to one-third or less of those encountered with any other type of rectifier. You can count on extreme reliability... tested for compliance to 10,000-hour standards. Note also that there are no forming or aging effects.

WRITE US TODAY! GET ALL THE FACTS ON THIS IMPORTANT NEW PRODUCT!

General Electric Company, Section X4104, Electronics Park, Syracuse, New York

Want more information? Use post card on last page.
Now...the answer to high-resolution recording of test data

...the Extended Range *ElectroniK* Recorder

**Designed** especially for recording variables which change over a wide range, this new *ElectroniK* instrument records on a chart effectively 55 inches in width. It has five equal measuring spans. Whenever the variable being measured reaches either the upper or lower limit of one of these ranges, the instrument automatically steps to the adjoining range and continues recording.

Two indicating pointers show the range in use and the value within the range. Connected to each pointer is a pen; one draws a purple record showing the range, the other draws a red record of the variable itself. To get the complete reading, you simply add both pen or pointer indications.

The complete range is 10.2 millivolts, in five 2-millivolt steps with an extra 0.2 millivolts on the high end of each span to provide an overlap that facilitates measurements near the change-over point. Pen speed of 4 1/2 seconds full scale affords rapid response to quickly changing variables.

You'll find this new instrument particularly valuable in strain gage measurements and in dozens of other uses where high resolution aids interpretation of data. Your nearby Honeywell sales engineer will be glad to discuss your specific application...and he's as near as your phone.

**MINNEAPOLIS-HONEYWELL REGULATOR CO., Industrial Division, Wayne and Windrim Avenues, Philadelphia 44, Pa.**

**REFERENCE DATA:** Write for Data Sheet No. 10.0.18, "Extended Range Recorder."
**PROVEN: KARP ENCLOSURES ARE YOUR MOST ECONOMICAL BUY**

Karp customers, large and small, from coast to coast, know that Karp's complete "package"—ready for components—means lower costs.

Over 300 different jobs go through our plant every day. This volume allows us to apply mass production techniques to every job—whether simple or complex, long run or short—and we pass the savings on to you.

We have over 3000 stock tools and dies and can usually eliminate your new tooling costs entirely. Our press and brake equipment is fast, modern, adapted for quick set-ups. We employ the latest spot, gas, arc and heliarc welding techniques. Our unmatched finishing and sub-assembly facilities give you a complete "package" ready for your components—eliminating the many hidden costs of extra handling. That's why you, no matter what your needs, can enjoy the luxury of Karp's quality and service.

We will prove to you that your sheet metal requirements in aluminum or steel can be individualized and yet be low in cost. We will prove to you that our complete "package" service will lower your costs. Send us samples, sketch or prints and a prompt quotation will follow.

**KARP METAL PRODUCTS CO.**
Division of H & B American Machine Company
215 63rd STREET, BROOKLYN 20, N. Y.

enclosures reflect the skills within

**FACILITIES FOR ENGINEERED SHEET METAL FABRICATIONS:** in aluminum or steel — long run or short — spot, arc, gas or heliarc welding — any type finish

- Modern plant—3 city blocks long
- Thousands of dies available
- Most modern of sheet metal fabricating equipment
- Air-conditioned spray room... complete baking facilities
- Complete sub-assembly facilities
Do what other electronic and electrical manufacturers have done for years: Turn your fine-wire problems and requirements over to Hudson Wire. You will be served promptly, satisfactorily, economically, by craftsmen backed by over 50 years of fine-wire specialization.

**BARE WIRES**
- Copper
- Brass
- Bronze
- Phosphor-bronze
- Nickel-silver
- Zinc
- Lead
- Tin
- Cadmium
- Oxygen-free copper
- Silver
- Fuse
- Stainless steel
- Brush wires

**SPECIALTY WIRES**
- Silver-plated copper, brasses, bronzes, and alpha-tin copper.
- Stranded and bunched silver-plated.
- Aluminum and silver-plated.
- 'Taps', for voice coils.
- Flat-wire ribbons.

**TEXTILE-COVERED WIRES**
- Nylon
- Cotton
- Celanese
- Rayon
- Silk
- Fiberglass

Available on bare or enameled wire, single- or double-coated.

**INSULATED WIRES**
- Copper, aluminum, iron, magnesium, copper clad steel.
- Tubing, 'Taps', voice coils.
- Multiple and twisted.

**MATERIALS**
- Copper
- Aluminum
- Iron
- Magnesium
- Copper-clad steel

**TYPES**
- Instrument
- Telephony
- Ulls
- Ults
- Multiconductor
- Twisted

**COVERINGS**
- Plastic and heavy enamel.
- Formvar, Ezsol (liquid nylon), Dow Corning, Dow-Corning 1360 silicone.
- Cement-coated enamel.

**FOR BARE & SPECIALTY WIRES**
Hudson Wire Company
Ossining, N.Y.

**FOR INSULATED WIRES**
Winsted Division
Hudson Wire Company
Winsted, Conn.
Cassopolis Division
Hudson Wire Company
Cassopolis, Mich.

Research and development facilities to solve your problems. Exceptionally flexible production to provide "custom" service. Lowest cost with highest quality.

Here's your own WIRE DEPARTMENT!

HUDSON WIRE COMPANY
Constant research and engineering over the past 39 years have resulted in a most complete line of BUSS fuses: dual-element (slow blowing), renewable and one time types . . . in any size from 1/500 amperes up — plus a companion line of fuse clips, blocks and holders.

To make sure that BUSS fuses meet the highest standards of dependability . . . every BUSS fuse normally used by the Electronic Industries is tested in a sensitive electronic device that automatically rejects faulty fuses.

Many manufacturers and service organizations have standardized on BUSS fuses to simplify their buying, stock handling and records — and to safeguard their good-will and reputation. You too, will find it good business to let BUSS meet all your fuse needs.

Let BUSS save you engineering time

If you should have a special problem in electrical protection, BUSS places at your service the world's largest fuse research laboratory and its staff of experienced engineers to help you determine the right fuse for the job and if possible, one available in local wholesalers' stocks.

Makers of a complete line of fuses for home, farm, commercial, electronic and industrial use.

For more information mail this coupon

University at Jefferson, St. Louis 7, Mo.
Please send me bulletin SFB containing facts on BUSS small dimension fuses and fuse holders.

Name......................................................Title.................................
Company...................................................
Address.......................................................
City & Zone........................................State.........................
One big family with a single thought

Whether you need terminals, clips, coils, chokes, capacitors — or any of a number of electronic components — you can be sure they’re right if they’re made by CTC.

One continuing basic idea governs the manufacture of every CTC product. And that idea is: quality control. We could not guarantee our products as we do without a constant check of numerous details that determine reliable performance. Our quality control engineers see to it that these manufacturing standards are consistently maintained — right through to periodic microscopic inspection.

Pictured here are a number of components available at CTC including our three kits. These items come in standard forms and are also custom engineered to meet your particular requirements. We would be glad to give you complete details, including specifications and prices, on any or all CTC units — as well as information on how CTC components can be specially designed to solve your individual electronic components problems.

You will find it well worthwhile to use components that are guaranteed. Write to Cambridge Thermionic Corporation, 437 Concord Avenue, Cambridge 38, Mass. West Coast manufacturers contact: E. V. Roberts, 5068 West Washington Blvd., Los Angeles 16 and 988 Market Street, San Francisco, California.

CTC Components shown include: A. capacitor; B. standard and insulated terminals; C. coil form kit; D. RF choke kit; E. coil forms and coils; F. coil kit; G. RF chokes; H. diode clips; I. panel hardware; J. standard and custom terminal boards; K. ceramic board.

CAMBRIDGE THERMIONIC CORPORATION
makers of guaranteed electronic components, custom or standard
"Easy to Wrap" says Jones & Laughlin.

IRVINGTON heat-resistant

TEMFLEX* 105 Tape

COILS FOR 6600-VOLT STATORS are easily and thoroughly insulated at the coil repair shops of Jones & Laughlin Steel Corporation — by wrapping with strong, flexible Temflex 105 Tape. With its excellent elongation, this tape can be readily hand wrapped over coil bends and other irregular surfaces — and high modulus of elasticity makes it equally adaptable for use in taping heads to produce close, carefully lapped wraps.

USING THE SAME BASIC FORMULATION AS TEMFLEX 105 TUBING — which is approved by Underwriters’ Laboratories for continuous operation at 105° C. in air and 90° C. in oil — Irvington Temflex 105 Tape withstands prolonged baking cycles and continuous high-temperature service.

USE TEMFLEX 105 TAPE for insulating coils, cable, bus bars — and for corrosion protection of piping and other equipment located underground or in corrosive atmospheres.

WRITE FOR TECHNICAL DATA SHEET

IRVINGTON VARNISH & INSULATOR
DIVISION OF MINNESOTA MINING & MANUFACTURING COMPANY

Look to IRVINGTON for Insulation Leadership
INSULATING VARNISH
VARNISHED CAMBRIC
VARNISHED PAPER
VARNISHED GLASS CLOTH
INSULATING TUBING
CLASS "H" INSULATION


Want more information? Use post card on last page.

www.americanradiohistory.com
The assurance that copper is in abundant supply and can be used without restrictions is the "go ahead" for industry. You can now rate performance over availability when choosing materials. By using copper and its alloys, brass and bronze, your product is easier to fabricate, better and more durable.

We can get more copper than we now have. Although industry and government have been consuming more copper than in any previous peacetime period, production has kept pace with this increased demand. And producers are not working at full capacity!

More copper keeps on coming. Eleven major new projects in the U.S. will start producing in the next 3 years. These mines will add 250,000 tons to our annual production—more than ¼ of all the domestic copper mined during 1953. In addition, recent improvements in mining techniques now make it possible to obtain copper from ores considered commercially unworkable in the past.

Copper is virtually indestructible. At least 3 out of every 4 pounds of copper used in today's products, when scrapped, can be re-used in the future. Every day we are adding to our "copper capital". The more copper we use... the more we have!

Copper or its alloys provide these advantages...

- Best conductor of electricity commercially available.
- Does not rust... high corrosion resistance.
- Best heat transfer agent of all commercial metals.
- Easy to machine, form, draw, stamp, polish, plate, etc.
- Welds readily... excellent for soldering and brazing.
Copper has a new ability to serve you. Many of your problems are being solved in the laboratories of the copper and brass industry. Whether it’s a new alloy, a different temper or a special property . . . copper can help you develop new ideas. Copper can bring old methods up to date. Call a supplier of copper and brass and convert your thoughts to action!

COPPER & BRASS
Research Association
Automatic voltage stabilization for sensitive control components

You can eliminate the variable of erratic line voltage on voltage-sensitive elements of automatic control equipment. Do it simply and economically with the Sola Constant Voltage Transformer.

The Sola stabilizer is a static-magnetic regulator which differs from regulators depending solely upon saturation of core materials; or electronic types employing tubes. Their characteristics, listed below, make them ideal for controlling input voltage to voltage-sensitive electronic and electrical control components.

1. Regulation within ±1%, with primary voltage (transient or continuous) variations as great as 30%.
2. Response time less than 1 1/2 cycles.
3. No moving or wearing mechanical parts, nor vacuum tubes; requires no manual adjustments.
5. Self-protecting against short-circuits on output.
7. Isolates the input and output circuits.

Forty-three Sola stock units are available in a wide variety of ratings, voltages and types. In addition, custom-designed units can be manufactured (in production quantities) to meet specific requirements.

The experience of the world’s largest manufacturer of constant voltage transformers is available to you. We invite you to discuss your voltage stabilizing problems with a Sola Sales Engineer.

WRITE FOR LITERATURE. Sola Constant Voltage Transformers are completely described in a 24 page manual. Write for a copy of 7J-CV-200 on your letterhead, please.
A MESSAGE TO AMERICAN INDUSTRY + ONE OF A SERIES

RESULTS OF AN INTELLECTUAL REVOLUTION . . .

"The Western Miracle" Continues . . .
More Automatic Controls for Industry

Within recent weeks three new monthly technical magazines devoted to automatic control systems for industrial processes and machinery have offered the public their first issues. One of these is CONTROL ENGINEERING, a McGraw-Hill publication.

What has caused this surge of interest in the design and application of automatic control systems? What does it portend for the future of American industry? More important, what does it promise for the American standard of living, of which industry is and must be the servant? And what is the role of CONTROL ENGINEERING in this development? It is to those questions that this statement is addressed.

A New Intellectual Revolution

It is frequently asserted that we are now in the throes of a new industrial revolution. The revolution is described as the eliminating of wasteful applications of human labor to repetitive tasks through new technology which makes it possible to transfer those tasks to automatically controlled machinery.

It is perhaps more accurate, however, to say that we are the beneficiaries of a new intellectual revolution in the application of science to industry. This new intellectual revolution points the way toward giant strides in the continuing process of taking dull and laborious work off the backs and minds of men and transferring it to machines operating in large batteries under automatic control.

The practical engineering work required to convert this intellectual revolution into a full-scale industrial revolution, however, in large part still remains to be done. It is to this task that CONTROL ENGINEERING will be devoted. Its role is that of bridging the gap, in engineering and economic terms, between the new conceptions of automatic control of industrial processes and their practical workaday application. These conceptions run the full gamut from systems of control for automatic factories making heavy industrial products to highly personalized systems of automatic control to warn people when they are approaching the broiling point in sunning themselves at the beach or becoming too drowsy to drive their cars safely.

Enter the "Feed-Back" System

Enough work has been done to move these conceptions out of the realm of interesting dreams and into the realm of practical possibilities, and in some cases into the realm of practical realities. Crucial parts of this work were done during World War II when weapons were successfully equipped with "feed-back" systems.
that automatically corrected mistakes made by the weapons in locating their targets.

The principle of the "feed-back" system is as ancient as the personal monitor that tells us not to run into each other as we walk along the street. It feeds back to our locomotion machinery the warning of a collision ahead. But the application of the principle to weapon control and then to more general machinery control required superlatively imaginative and skillful scientific development.

When a "feed-back" system that monitors an automatic process and keeps it lined up precisely is teamed up with a computing machine, capable of making lightning calculations that control both what goes into the process and what is done with the product, the horizons of automatic control become broad indeed. But in large part they still remain horizons. A vast range of practical engineering work remains to be done to realize anything like the full potential of automatic control of industrial processes and machinery.

More and Better Jobs

There are those who view the surge of interest in automatic control with alarm. They conjure up a situation in which automatic processes will at once expand the ranks of the unemployed and reduce many of those still working in industry to the status of robots or automatons.

A look at the record of the American economy—a record of amazing growth, steadily improving job opportunities and a constantly rising standard of living—deminishes the basis for such fears. The introduction of new and more efficient industrial machinery and processes obviously cannot be accomplished without creating some disturbance for some individuals and some companies. But consistently the longer range effect of such local and temporary disturbance has been more jobs and better jobs for Americans.

It is no accident that, while the proportion of industrial wage earners in our population is virtually the same as it was in 1920, the proportion of professional and salaried workers has doubled. The proportion of unskilled workers, furthermore, has dropped by half. This has been an essential part of a continuing process by which drudgery has been transferred to machines while the workers who formerly did the drudgery have been graduated to jobs calling for greater competence and providing better pay.

Higher Living Standard

A British historian, H. J. Hancock, has referred to this general process as "the Western miracle"—that of providing an ever higher and higher standard of living for more and more Americans. The key element in this miracle has been more and more reliance on power-driven machines to get the day's work done.

In the nature of the extremely complicated apparatus involved, full development of systems which have passed through the "think stage" into the status of practical possibilities will be a time-consuming process. It will also be a very exacting process, calling for a tremendous application of engineering skill and ingenuity. However, the engineers who are concentrating on this difficult, workaday phase of the development of apparatus for automatic control will be inspired by the knowledge that they are making a crucial contribution to technical progress which holds great promise of good for the American people.
Gates Radio Company

Litel-McCullough, Inc.
San Bruno, California

Gentlemen:

A few years ago our engineering department was requested to design several entirely new transmitters in the 5/10KW power range for both medium and short wave commercial service. One of the requirements was the establishment of a modern tube complement that would substantially reduce tube cost both initially and in greater life expectancy.

After considerable investigation and exhaustive tests in our own development section, the Eimac 3X2500F3 was decided upon. Performance-wise, the results were excellent but even successful abuse tests could not be a substitute for several years that must pass to obtain records on life expectancy.

These several years have now passed. Gates transmitters employing the 3X2500F3 are all over the world in every kind of service including 24-hour a day international communications, broadcasting and many 5KW mobile units for military service. Checks indicate, as both radio frequency amplifiers and Class B modulators, the life expectancy is not only meeting our original estimates and expectations but in many instances far exceeding them.

We congratulate you on an excellent product that has indeed saved the industry untold thousands in tube expense and again express our appreciation for the excellent cooperation of your engineering department.

Yours very truly,

P. S. Gates
President

Eimac 3X2500F3's featured in Gates models BC-5B and BC-10B the world over.
NEW FEATURES PROVIDE MORE NEARLY PERFECT RELAYS FOR THE MORE EXACTING REQUIREMENTS

One of the more recently developed relay manufacturing techniques is the method of utilizing aluminum time delay blocks in multi-contact time delay relays. These provide time delay features in a multi-contact relay, at the same time keeping the unit weight as light as possible.

COMPLETE FLEXIBILITY OF ALL COMPONENTS

New methods developed at Phillips mean that relays for special or for complex control problems, which formerly have required complete engineering from "scratch," in many cases now can be produced much faster and at little or no increase in price over standard models.

Coils in a wide assortment of winding types and characteristics at Phillips are now almost completely interchangeable during relay assembly. Relay functions calling for varying marginal and timing values are easily fulfilled, as are requirements of operating values, timing sequence and release constants.

WIDE CHOICE OF SPRING AND CONTACT COMBINATIONS

The "custom" addition or omission of springs is accomplished just as easily. And variations of contact forms and of special contacts themselves are standard practice at Phillips.

POWER RELAY SERIES COMPLETE

Requirements of aircraft and mobile equipment for relays to withstand severe shock and vibration have caused important advancements in the design and construction of Phil-trol relays. There are many types of Phil-trol power relays which exemplify the benefit of Phillips' extensive experience in this field.

The type 27QA as illustrated is unexcelled in this field. The type 27QA has been universally accepted by leading aircraft designers as the ideal relay to withstand vibration and shock. It is utilized by almost all leading commercial aircraft in use today.

A comprehensive Phil-trol engineering service is maintained chiefly to consider and recommend, without obligation whatsoever, whether or not there is a "standard" Phil-trol relay which will precisely fulfill rigid specifications with substantial savings in cost.

PROGRESS is synonymous with Phillips. The company, beginning operations in 1946, is the leader in its field, with millions of dollars worth of Phil-trol Relays functioning in hundreds of different applications. More and more Design Engineers rely on Phillips for their relay and actuator needs, because they know that Phillips quality of product is maintained by unparalleled excellence of all Phil-trol components. They have learned, too, that the Phil-trol line provides a broader selection of relay types, and greater flexibility within each type—permitting wider latitude in product design. Phillips management, ever mindful of the company's responsibility as a leading relay supplier, has continued to develop more, improved and strategically located manufacturing facilities.

In July of this year Phillips moved into its new, modern, daylight-type home plant and offices (shown above) in Joliet, Illinois. In August, a new plant at Santa Monica, California, began operating. The modern, fully air-conditioned and air-cleaned plant at Santurce, Puerto Rico, producing high-quality aircraft Relays for more than two years, is being further expanded. Phillips future plans include additional expansions as customer needs indicate.

Phil-trol Type 27QA Relay

This type 27 relay is available in 1, 2, 3, 4, or 5 pole models, with single or double throw. Operating voltage up to 230 D.C., resistance up to 13,400 ohms. Minimum operating current is .001 amps. Available in dust cover, or hermetically sealed (as shown at right).
for Relay Users

Twin Contacts Give Phil-trol Type 8 Relays Exceptional Reliability

Demands for reliable and fast-acting relays for applications where more rapid opening and closing of contact is required, resulted in the design of the Phil-trol Type 8 Relay.

This series of relays features high sensitivity with immediate response, excellent adaptability for marginal operation, with fast, positive and reliable closing and opening. Then, to assure that these characteristics will maintain, the Type 8 Relays are given "Y" springs, providing them with twin contacts which are operative in every circuit function. Long-life bronze bearings assure the maximum precision of operation.

These units physically are compact and light in weight. Their coils may be single or double wound and, if desired, equipped for slow release or for slow operation. They operate up to 230 volts D.C. Come in 3 different forms with maximum pile-up of 10 springs. Their dimensions are 13/4" wide x 2 3/4" long. For heavy-duty service and long life these relays are unexcelled.

'Most All Phil-trol Relays Are Now Available Hermetically Sealed

Advancements in hermetic sealing pioneered at Phillips produce an utterly complete protection of proper relay function. Techniques known only at Phillips are acknowledged to deliver hermetically sealed relays superior to any other similar products in the field.

In general, Phil-trol Relays are mounted on the proper base assemblies, with INFRARED soldering used to affix the glass header. Hydraulic crimping then closes all seams of metal housings to completely enclose the relays, and seams are permanently soldered. Then each enclosure is exhausted to a few microns of pressure, removing all trace of moisture or of gas. It next is thoroughly flushed with chemically dry nitrogen. Again exhausted. Then once more pumped full of dry nitrogen to at least one atmosphere of pressure. The evacuating tube is now pinched off and solder-sealed. A coat of finishing paint over primer still further protects and "dresses" each unit.

Phil-trol Relays protected by Phillips unique hermetic sealing are available for virtually every circuit purpose and requirement. The 20445 Phil-trol Sealed Relay shown here accommodates the type 27QA Relay. It has studs and individual terminals. Terminals are rated at 25 amperes.

PHILLIPS CONTROL CORP., Dept. E., Joliet, Ill.

Gentlemen: Please send me your General Catalog

I am personally interested in Phil-trol Type 27 Relays

Phil-trol Type 8QA Relays

Phil-trol Hermetically Sealed Relays

Name: ____________________________

Company: ________________________

Address: __________________________

City: _____________________________ Zone: ______ State: ______

107
PERHAPS YOUR TIMER WILL BE THE 661st

How do you know we can supply you with the timer that will do your job best? Because we have 19 years of experience in developing new timers to meet our customers widely varied requirements. If one of our standard timers won't do it—or one of the 660 combinations we have thus far developed from our 17 basic units—our engineers will develop the 661st combination, for your specific needs.

We manufacture a complete line of timers in these 4 broad classifications:

TIME DELAY TIMERS • INTERVAL TIMERS
RE-CYCLING TIMERS • RUNNING TIME METERS

And since we maintain large stocks of our 17 basic units, we can assure you of rapid deliveries—and of good deliveries even on special orders. Automation? We're in it up to our ears...just put your problem up to one of our timer specialists. Your inquiries will receive prompt attention.

INDUSTRIAL TIMER CORPORATION
131 OGDEN STREET, NEWARK 4, N. J.
New design possibilities opened by outstanding dielectric strength of Du Pont MYLAR

A new product of Du Pont research—"Mylar" polyester film—offers you a balance of physical, electrical, chemical and thermal properties never before available in a plastic material.

Shown above is the testing of the unusual dielectric strength of this remarkable new film. "Mylar" resists electrical puncture at 4000 volts per mil.

Versatile "Mylar" opens new possibilities in the design of electrical equipment. It is already being used to advantage as slot, phase and wedge insulation in motors; layer insulation in capacitors; conductor insulation in transformers; under-lead insulation for coils; and as a barrier tape for wire and cable. Why not see how "Mylar" can help you improve or develop a product?

SEND FOR FREE BOOKLET:
To help you evaluate the advantages of "Mylar" for your product, this free booklet gives you the property specifications of "Mylar"...shows how this new film can be used to improve electrical products. Write E. I. du Pont de Nemours & Co. (Inc.), Film Department, Room 4-EM, Wilmington 98, Delaware.

DU PONT MYLAR®
Polyester Film

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

ELECTRONICS — October, 1954
MB cycling system runs vibration tests automatically

Versatile electronic "brain" for MB Vibration Exciters saves manpower and manhours — performs a variety of cycled shake-tests unattended!

A vibration test that involves a continuous cycle of changes from 10 to 500 cps along with constant displacement or constant acceleration can now be done with great simplicity, accuracy and minimum supervision. Simply set up the specimen on an MB Shaker — set the controls for the desired actions — and let the cycling system take over.

This electronic unit varies shaker frequency at any sweep speed, and between any two preset frequency limits. It controls the exciter's amplitude or acceleration within ±10% for a dead mass or resonant type of loading and for cycled tests to satisfy MIL-E-5272 and other specifications.

For maximum flexibility of operation, this cycling system also provides for automatic transfer of constant amplitude to constant "g" at any preselected frequency setting.

The system can be operated manually when desired. It's also protected against control failure or conditions of extreme load resonances through use of an automatic structural strain control.

SHAKE TESTING PAYS
Vibration testing tells how well a product will bear up in service, reveals design faults, determines fatigue strength.

Designed for heavy duty service, MB vibration exciters such as the Model C-5, rated at 750 pounds force, and the Model C-25 rated at 3500 pounds force, deliver maximum performance, pure table motion and dependable operation.

Send for detailed specifications on MB cycling systems. Also for Bulletin which gives data on vibration exciters.

THE MB MANUFACTURING COMPANY, INC.
1060 STATE STREET, NEW HAVEN 11, CONN.

PRODUCTS AND EQUIPMENT TO CONTROL VIBRATION • TO MEASURE IT • TO GENERATE IT

MB MODEL T-25 MC CONTROL CABINET
with automatic cycling system developed to control the action of vibration exciters to a specified cycle of events, and with little or no supervision.

A VIBRATION TEST set up on the Model C-5 MB Vibration Exciter—and also one on Model C-25—two of the models which can be automatically controlled by MB's cycling systems.

BULLETIN TELLS MORE
Contains specifications, operating information and helpful hints on usages of the complete line of MB Exciters. Write for Bulletin 1-VE-5.
For Automatic Assembly plus Easy Inventory and Storage

Pallet-Pak, ERIE's exclusive new packaging method for Disc Ceramicons, answers the need for mechanically pre-aligned capacitors that can be fed into automatic assembly machinery. Hand assembly is also improved because of the ease of handling and the physical uniformity of the capacitor.

ERIE is constantly searching for new ways to assist manufacturers in reducing production costs. Pallet-Pak is a development by ERIE Industrial Engineers with this purpose in mind.

The many other advantages of Pallet-Pak are noted at right. Write for our Pallet-Pak Bulletin with complete illustrations and advantages of this new packaging method that is currently available on a portion of ERIE Disc Ceramicon production.

Advantages for Inventory and Storage

- Known number in strip makes inventory control easier.
- Count empty strips—multiply by number for usage control.
- Markings all face one direction for easy identification.
- Drawer type disposable pallet for storage and shipping.

Advantages for Your Production

- Straight lead wires—no tangling—units easily removed by pulling from strip.
- Uniform lead length.
- Carrier insert acts as tote-tray for easy handling.
- Index holes in strip 1 1/2” center to center for use in lead forming and cutting equipment.
- Index holes are above carrier sides—rods can be inserted through holes and entire lot lifted easily in one operation.
- Assurance of uniform quality, resulting from continuous production flow.

ERIE RESISTOR CORPORATION . . . ELECTRONICS DIVISION

Main Offices and Factories: ERIE, PA.
Sales Offices: Clifton, N. J. • Camden, N. J. • Chicago, Ill. • Detroit, Mich.
Cincinnati, Ohio • Fort Wayne, Ind. • Los Angeles, Calif. • Toronto, Ontario
Manufacturing Subsidiaries:
HOLLY SPRINGS, MISSISSIPPI • LONDON, ENGLAND • TRENTON, ONTARIO
THE FLIGHT THAT MADE

10 YEARS AGO, AMERICAN AIRLINES
THE WORLD'S FIRST SCHEDULED

On October 15th, 1944, businessmen found a new way to send their wares to market when an American Airlines DC-3 flew the first flight of the first scheduled airfreight service. Though the event could not compete with the war headlines of the day, it did make news—and good news—to those seeking better methods of distribution.

In the first full year of operation alone, American Airlines delivered more than 2,500,000 pounds of cargo consisting mainly of fish, flowers and pharmaceuticals. Succeeding years saw impressive gains in both volume and variety as well as American's introduction of the first all cargo aircraft to be employed in scheduled freight operations. Today—with ponderous as well as perishable products moving daily by air, the amount of freight carried by American in 1954 is expected to exceed 100,000,000 pounds—again establishing American as the leading carrier of Air Cargo.

With service to leading industrial centers throughout the United States, American Airlines Airfreight is an industry-wide offering whose full potential can only be measured by the imaginations of those who explore and employ its services. American Airlines, Cargo Sales Division, 100 Park Avenue, New York 17, New York.

AMERICAN AIRLINES INC.
America's Leading Airline

Want more information? Use post card on last page.

October, 1954 — ELECTRONICS
October 15th, 1944 — An American DC-3 makes the FIRST scheduled cargo flight.

HISTORY— but not the Front Pages!

INAUGURATED AIRFREIGHT SERVICE

<table>
<thead>
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<tr>
<td>1954</td>
<td>100.0 (estimate)</td>
</tr>
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</table>

Want more information? Use post card on last page.
MECHANICAL CONSTRUCTION COMPONENTS
directed specifically toward trying to simplify the problems of mechanical construction in the following field:

To Mount, Connect, House, Fasten and Monitor Electronic Circuity
Here for the first time is a complete coordinated series of Mechanical Construction Components not only to enhance product utility, but also to facilitate designing so that your production is simplified and your product becomes easier to make.

1. You have to provide for IN-OUT CIRCUITS

Alden Detachable Line Cord to bring the power in

Provide power take-outs with Alden Mini-space AC Outlets

Alden Point-of-Check Back Connectors

Provide front panel Point-of-Check

Blind rat's nest wiring of conventional connectors is avoided.

2. You have to provide INTERNAL CONNECTORS

Here for the first time you have an integrated series of connectors—that can be completely prewired with leads tailored to your specifications—ready to drop abroad your equipment as a low-cost sub-assembly.

INSIDE ALDEN CONNECTORS
Unique Alden Top-Connected Contacts provide: Individual strain relief for each lead.

1. Wire mechanical cramped to Alden contact.
2. Wire connector is solder bonded for perfect electrical connection.
3. Molded clip contact is 100% strain relief all strain on wire to develop of greatest possible electrical strength.

Bare 222 gauge stranded copper wire will break before solder connection gives.

100% molded insulation surrounds each clip and lead.

With Alden top-connected contacts the leads are drawn directly into the solid molded insulation of the clip pockets—eliminating the danger of insulation pull out. There is no distance whatever in the need of insulating leads around wire—and greatly lessens distance over conventional design.

NEW ALDEN TECHNIQUE solves hi-voltage and corona problems

This 20,000 volt 40-ampere cable for TV comprises nylon tube cap. High-voltage Disconnect and 40-ampere, molded by New Alden technique to form integral unit with joints sealed against leakage and corona discharge.

202 FIAC
Available in SV or PCF coding—right angle and straight plug sockets. Write for sample 202 FIAC.

Alden Top-connected Contacts—Unique to Alden!

Request samples of any of these connectors.

COMPLETELY MOLDED CABLES
Combining the unique Alden Top-connected Contacts with a new Alden technique of molding connector insulation right around the wire insulation, complete cables can be made to your specifications comprising any combination of multi-wire connectors and plugs, all molded into completely replaceable cable units. The homogeneous bonding of wire and cable insulation provides the ultimate answer for corona, dust and moisture seals to give new freedom from maintenance in the field of cabling. This is a natural whenever a high quality cabling job is wanted or where tricky environmental conditions must be overcome. Outline your problem and let us work with you.

ALDEN PRODUCTS CO. 1127 N. Main St., Brockton 64, Mass.
3. To Provide for CIRCUITRY MOUNTING

Here is a Terminal Card Mounting System that lets you mount your circuitry in space-saving vertical planes and reduces circuitry problems to speedy sub-assembly jobs. Terminal mounting cards you can cut off any length, or order cut to your specs in volume . . . ratchet terminals that require no pliering or wrap-around . . . tube sockets not mounted in chassis, but wired right on cards. Whatever circuitry you plan, the Alden Terminal Mounting Card System is a logical step because it saves space, speeds production, leads to automation of circuitry mounting and paves the way for printed circuitry.

4. You probably want PLUG-IN CONSTRUCTION

Small circuits wired on Alden Terminal Cards become Plug-in Packages. Using only the basic components listed below, more than 117 tube and circuitry layouts can be accommodated with the Alden Plug-in Package Components.

5. You may wish to CONVERT DESIGNS TO PLUG-IN

If you want plug-in advantages, it isn't necessary to completely re-design equipment already in existence. Let the Alden Serve-a-Unit Kit make your equipment into a plug-in that's easy to service and replaceable in 30 seconds. Alden standard components are ready and waiting and can be furnished to the exact dimensions you require.
New Telechrome equipment designed to provide test signals for precise checking of video facilities.

This equipment is now in use by major networks, TV stations, and the Bell Telephone System. This type of equipment was recently described by H. Gronberg of NBC before the NARTB Engineering Conference in Chicago. These units are available individually or as an integrated system with 75 ohm or 110 ohm balanced output.

Literature on these and more than 100 additional instruments for color TV by TELECHROME are available on request.

The Nation's Leading Supplier of Color TV Equipment
88 Merrick Road Amityville, N. Y.
AMityville 4-4446

October, 1954 — ELECTRONICS
NOTE: INTERNALLY THREADED 1/4"-28 AND EMBOSSED TO PROVIDE "0.0357" PITCH ±.003" TO PROVIDE RUNNING TORQUE WITH 1/4"-28 MPA STANDARD SHALLOW THREAD CORE AS DETAILED BELOW:

THE FOLLOWING MPA STANDARD CORE THREAD FORM DRAWING AND DIMENSION CHART IS THE RECOMMENDATION OF THE CLEVELAND CONTAINER CO. FOR USE WITH TORKRITE COIL FORMS.

<table>
<thead>
<tr>
<th>CORE LENGTH</th>
<th>CORE O.D.</th>
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<tbody>
<tr>
<td>3/8&quot;</td>
<td>.249 ± .001&quot;</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>.248 ± .001&quot;</td>
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<tr>
<td>5/8&quot;</td>
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<td>.247 ± .001&quot;</td>
</tr>
<tr>
<td>1&quot;</td>
<td>.246 ± .001&quot;</td>
</tr>
</tbody>
</table>

The following MPA standard core thread form drawing and dimension chart is the recommendation of the Cleveland Container Co. for use with Torkrite coil forms.

The following MPA standard core thread form drawing and dimension chart is the recommendation of the Cleveland Container Co. for use with Torkrite coil forms.

Torkrite coil forms eliminate torque and stripping problems and are rapidly replacing other coil forms because Torkrite:

- withstands more than required stripping pressure.
- requires no revision other than reduced winding arbor diameter.
- is round and concentric; winds coils at higher speed without wire breakage or fallen turns.
- permits use of lower torque since it is completely independent of stripping pressure.
- recycling ability is unmatched.
- is stronger mechanically because of heavier wall.
- provides 1-6" oz. running torque when used with MPA standard shallow thread core.
- has no holes or perforations thru tube wall which eliminates cement leakage locking cores.
- has smooth adjustment of core without lubricant.
- torque increases less after winding as heavier wall reduces any tendency to collapse and bind core.
- maximum stability results as core cannot move in relation to winding after peaking as it is engaged in internal threads.
- embossings are evenly spaced, with a lead at each end of the form to permit easy insertion of core.

INVESTIGATE this outstanding coil form.

Improved new Torkrite is now available in various diameter tubes. Lengths from 3 4" to 3-1/8 are made to fit 8-32, 10-32, 1 4-28 and 5/16-24 cores.
...that's why IBM uses Sangamo

The amazingly complex IBM "702" electronic calculator is hailed as the fastest and most flexible commercial data processing system ever devised. The central Arithmetical and Logical Unit performs calculations and makes decisions at a rate of more than 10,000,000 operations in an hour. Data and instructions for processing are stored in an electrostatic memory bank of cathode ray storage tubes. Output can be in the form of punch cards at the rate of 100 per minute.

A machine like this needs components that assure maximum performance to meet its exacting demands. That's why several different types of Sangamo Capacitors are used in the 702.

If you need capacitors for demanding electronic applications, Sangamo engineers can help you. You can choose from a complete line of paper, mica, electrolytic and button type capacitors for every industrial, electronic, and radio application.
Longer Life at High Temperatures

Stability Under All Conditions

Capacitors in the new 702

Those who know... choose Sangamo
Your **SPECIAL** requirement may be a **STANDARD** Hudson precision drawn component!

When you need closures—**CONSULT HUDSON FIRST**!

Quality Metal Stampings To Exact Specifications

Simple stamping or complex, multiple-operation sub-assembly, Hudson can produce your parts, quickly and economically. For quotations on specific components, send drawings mentioning quantities required. Call or write today for the new Hudson catalog.

**HUDSON TOOL and DIE COMPANY** Inc
118-122 So Fourteenth St., Newark 7, New Jersey

Want more information? Use post card on last page.

October, 1954 — ELECTRONICS
WALSH PRESSES
Rugged as the Rockies
Some made in 1907 with rugged dependability are still operating at a profit.
Wide selection of sizes from 6-65 tons...STOCK to 4 weeks delivery.
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ELECTRONICS — October, 1954

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> TELEVISION TRIO . . . Just over the horizon are three developments which can, in combination, bring about the production of large-screen color television sets at more reasonable prices—picture tubes employing a variety of new principles, mechanized wiring and assembly, and better transistors.

Tube designers are playing close to the chest, but it is known that substantial progress has been made in the direction of simplification, involving such things as printed phosphor grids, single guns and external deflection. Several radio manufacturers already using mechanized wiring and assembly methods for mass production are working hard to adapt machines to more complex TV circuitry. And military use of transistors has now swelled production to the point where reliability and price should be attractive.

> TRANSISTORS . . . Good as they are, today's transistors are by no means the last word.

Surface contamination still seems to be the primary cause of failure, even in hermetically-sealed units. Oddly enough, point-contact types appear to be least subject to it but, in any case, cleaning of surfaces in the laboratory returns many failed transistors to satisfactory performance.

One prominent engineer says the manufacture of junction types is "like whistling germanium down to a shadow and then plating electrodes on the shadow." This suggests that a method of simulating the action of a thin piece of germanium with a thicker piece operating in some other "mode", casually mentioned in the literature about a year ago, might be the next step.

> LINK . . . As industry moves closer and closer to fully automatic control of its machines and processes the timetable will be determined largely by economics—how much will it cost to install what kind of control and how soon can tangible gains in the marketplace support it?

Meanwhile, it occurs to us that two more or less packaged products can provide a link between manual and automatic control—telemetering devices and industrial television. Both have a very attractive future.

> SHOPTALK . . . Printer's errors that we caught before putting a recent issue to press included Phase Investor and Sleep Front Sawtooth Wave generator . . . .

One of our editors points out that the industry's active Panel On Electron Tubes may be abbreviated to POET . . . . A subscriber obviously keen about clipping and filing items out of ELECTRONICS, suggests that we bind the book with "weaker staples" . . . .

> DEFINITION . . . Military Airplane: Electronics with wings.

> EXTRA . . . In this issue is the third of three editorial "extras" promised (p 129, Jan.) for 1954.

Inserted between pages 192 and 193 is a 64-page special report devoted to the mechanical design of electronic equipment, conceived nearly two years ago and in process of production for the past six months.

In July we started a series of articles spotlighting component design trends, which will continue each month for the balance of the year and well into next spring. And back in March we published a four-color spectrum chart now seen on many walls.

Extras for 1955 are currently under consideration. More about these later.
Automatic Circuit Tester

Final inspection costs can be cut and product reliability improved with test set that automatically checks circuit wiring and components. Plug-in adapters are tailored to particular units in production, for use with console containing universal test circuits.

Like other automatic devices, the circuit tester described in this article is programmed in accordance with the task to be performed. Rotary switches are permanently wired with the pertinent test data. To change from one test program to another, the set of switches is quickly exchanged. These same switches also select the circuit to be tested, as they are mechanically coupled to drives in the circuit tester.

All portions of the tester not subject to change are contained in a standard universal unit; programming devices and test circuits peculiar to the job are permanently assembled into a special plug-in unit. Thus, the universal unit contains all basic measuring circuits, power supplies and automatic controls. The special adapter unit contains all circuits and components needed to adapt the universal unit to the work, including portions to select the circuit to be tested, designate the type of test, establish test conditions, set required values and tolerances and perform auxiliary operations.

Since unattended operation necessitates automatic control, the drive causes the selector switch to advance one step upon satisfactory completion of each test, in accordance with information supplied by the measurement element. The rate of stepping is adjusted to the inherent speed of a given test. A delay period before rejection is provided, to allow for transient conditions that may simulate defects.

The selector switch position is known at all times and this information is available to the printing device which records the test number of any reject.

Basic Test Circuits

The first of the basic test circuits is the continuity test diagrammed in Fig. 1A. This test is designed to detect small discrepancies in wiring resistance and to spot wiring errors and defective connections. The resistance of the circuit continuity to be measured is \( R_c \); \( R_a \), \( R_b \) and \( R_c \) are conventional bridge arms set to accept values of \( R_c \), less than 0.25 ohm and causing a reject on all connections having higher resistance. If a limit other
than this generally suitable value is desired, the bridge ratio is altered by shunt \( R_s \) or \( R'_s \) depending upon whether the limit is to be raised or lowered.

A range of 0.1 to 5 ohms can be covered in this fashion with an accuracy of ±0.025 ohm through use of a 1-millivolt detector sensitivity. Switch \( S \), removes excitation during selector-switch operation to avoid interruption of the up to 100-ma test current.

The leakage test is made with high voltage in order to uncover incipient breakdowns in addition to wiring and component defects. The circuit in Fig. 1B shows the leakage between the conductor under test and all other circuits (which are grounded during this test by a special selector-switch section) as \( R_s \). Resistors \( R_n, R_p \) and \( R \), form the rest of the bridge.

The test voltage is determined by \( S_n \) and is normally 500 v as in Megger practice, but reducible to 250 or 100 v where component ratings limit. Switch \( S \), removes the test voltage during selector operation.

The leakage limit can be lowered from the normal 500 meg to as low as 10 meg by \( R_n \), with all values accurate to about ±5,000 meg shunt. Transients introduced by \( C \), are made as short as possible by keeping \( R_n \) at a minimum.

The resistance test is designed to measure components accurately over a wide range; in conjunction with the continuity and leakage tests all values from 0.1 ohm to 500 megohms can be covered. The resistance being tested is designated as \( R \), in Fig. 1C, while \( R_r \) is the standard, selected in accordance with the limit value of \( R \).

The other side of the bridge is formed by \( R_s \) and \( R_r \) with \( R_r \) selectable by \( S_{kr} \) to change from the 1 to 10,000-ohm range to 0.01 to 10-megohm range (the excitation voltage being simultaneously raised by \( S_k \) to retain maximum accuracy). Through use of 0.1-percent resistors in the bridge, an overall accuracy of better than ±0.5 percent can be maintained.

The impedance test is arranged so that a vector balance is not needed, permitting the use of a
simple resistor, \( R \), in Fig. 2, as the standard. Inconvenient reactive components are thus avoided in most situations. The separate amplifiers and rectifiers supplying the d-c detector inputs remove all phase response from the system, giving a null whenever the scalar values of the two a-c bridge outputs are equal. The division by the permanent arms is \( R_c/(R_2 + R_3) = 1/\sqrt{2} = 0.5 \) so that balance is produced when \( R_c = |Z_d| \), provided \( Z \) is a pure reactance such as a capacitor.

Either the internal 60-cycle supply or an external oscillator of selected audio frequency may be chosen by \( S_5 \). Impedances from 10 ohms to 1 megohm may be thus measured with an accuracy of ±1 percent.

**Voltage Tests**

The d-c voltage test circuit shown in Fig. 3A is used to evaluate circuit operating conditions. The unknown voltage \( E_{dc} \) is supplied through a multiplier \( R \), having a 20,000-ohms-per-volt drop so that loading will be similar to that imposed by multimeters used by technicians. Resistor \( R_5 \) is set to include the tolerance limit.

The selector is protected by \( S_5 \), while \( S_5 \) designates the polarity required of \( E_{dc} \). An external comparison voltage can be chosen by \( S_3 \) for ratio or differential measurements (a limit system can be used to determine either). The range of 1 to 1,000 v may be handled with normal circuits, while higher voltages require special dividers. Lower voltages (down to 10 millivolts) can be accommodated at decreasing accuracy by connecting the external-standard terminal to a known low voltage of similar magnitude. Through use of 0.1-percent resistors in the voltage dividers, an overall accuracy better than 0.5 percent can be held.

The a-c voltage test measures performance. The circuit shown in Fig. 3B permits both absolute and ratio determinations throughout the audio range. The previously mentioned amplifiers and rectifiers convert the signal to the d-c required for the measurement element. A basic sensitivity of 2.5 volts peak at the conventional 1,000 ohms per volt sensitivity avoids most effects of stray capacitance in the wiring.

Switch \( S_5 \) selects either the absolute reference \( E_{ref} \) or a rectified external standard for measuring relative to line voltage or oscillator level. Transformer turns ratio is easily checked at this latter position. A voltage range from 2.5 to 1,000 volts can be covered with an accuracy of ±1 percent.

**Detector**

The detector used in the test circuits of Figs. 1, 2 and 3 closes a pair of relay contacts upon receiving a 1-mv limit signal of selected polarity. The simplified circuit in Fig. 4 shows both input terminals floating with respect to ground because of basic test requirements.

The 6AL5 limits the input signal to 3.5 v while not affecting normal levels, due to bias furnished by the two bias batteries. Current through \( V_c \) passes through the coil of overload relay \( K_3 \), opening contacts \( S_5 \) in the basic test circuits if the overload is of sufficient magnitude and duration and thus protecting the work and the entire tester from damage.

Capacitor \( C_5 \) reduces transients, hum and noise, while the parallel-T filter attenuates any 60-cycle pickup. The chopper converts the 1-mv d-c to 60-cycle a-c so that it can be conveniently amplified by \( V_6 \), \( V_7 \) and \( V_8 \). This floating amplifier is coupled to grounded equipment by \( T_3 \).

Phase detector \( V_3 \) develops a positive d-c output when the plate signal is in phase with the 60-cycle grid reference supplied by \( T_5 \). Phase reversal by \( S_5 \) reverses the required input polarity and hence reverses the sign of the tolerance. The output of \( V_6 \) is filtered by \( C_5 \), \( R_5 \) and \( C_3 \) and applied to \( V_4 \). Cathode bias for \( V_4 \) is set by \( R_5 \) so that relay \( K_3 \) is just closed by a 1-mv input, establishing optimum adjustment between sensitivity and stability.

An input polarity from an acceptable test develops a signal through the chopper which is in phase with the \( V_6 \) grid reference, producing a positive voltage which overcomes bias on \( V_4 \) and thereby energizes \( K_5 \). The output contacts initiate a complete stepping cycle of the automatic equipment. Input polarity from a reject test develops an opposite phase signal which can produce no output from the phase detector.

**Automatic Control**

Figure 5 outlines the basic circuit used to achieve automatic control. Rotary solenoids \( K_8 \) and \( K_9 \) are each coupled to respective selector switches in the adapter.

---

**FIG. 4—Detector used in bridge circuits of Fig. 1, 2 and 3. Note that both input terminals are floating with respect to ground**
Depressing the start button locks in the start relay through the holding circuit and causes \( K_3 \) to step to the first test position. The start relay simultaneously connects the ground return to \( K_3 \), through \( S_{14} \) and connects the phase detector output to relay amplifier \( V_4 \) so that measurement can commence.

A positive (acceptable) signal causes operation of the step relay through relay \( K_3 \). Energizing voltage is thus applied to the first rotary solenoid, causing it to step the switch to the next position. Under usual conditions, stepping occurs at a rate of about three per second.

As coupled switch \( S_{14} \) turns, its circuit is momentarily broken, permitting a positive voltage through \( R \) to fire the thyratron and thereby energize the count relay, causing the counter to register the next step number. This roundabout method for obtaining the step number is used so that the counter reading will always correspond to the rotary-switch position, even if the latter should lose a step for any reason.

On the other hand, the grounding contact on the step relay, which connects to the relay amplifier input, causes the step impulsing to repeat until the cycle is completed. This combination makes for high reliability of stepping and indicating. If a test is unacceptable, so that no positive voltage appears at the relay amplifier input, all stepping ceases. However, if the count relay does not operate at least once every 5 seconds, replacing the negative charge on \( C \), leaking off through \( R_6 \), the 6C4 conducts and causes energizing of the alarm system.

At the completion of the tenth test, rotary switch \( S_{14} \) steps to position \( T \), causing the pulse to be transferred to the next switch, stepping it from the original reset position \( R \) to the first test position. This avoids the necessity of employing separate stepping switches or transfer relays and permits the addition of an indefinite number of selector switches.

Through the series circuit shown, it is not possible for more than one rotary switch to be stepped to a numbered (or test) position at one time.

**Reset**

At the end of the test series, the adapter has the next test position of the selector switch wired to the auto reset terminal, dropping out the start relay. This relay applies a high positive input to the relay amplifier so that the step relay impulses rapidly and continuously.

However, the return path from the rotary solenoids is now through switch \( S_{14} \) instead of \( S_{16} \). Since the former is shifted one step further than the latter, each switch left on position \( T \) (or any other position) is advanced in sequence to \( R \) (reset). When all switches reach \( R \), within 2 seconds after the completion of testing, a ground connection is completed to \( R_6 \), removing the positive input signal and stopping the operation until the start button is again depressed.

**Adapter Design**

A form similar to that shown in Fig. 6 printed with the switch symbols, is used in adapter design to provide a combination of worksheet, schematic and wiring diagram. A separate sheet is used for each selector switch.

In the example shown, the first six tests check minus and plus tolerances of the grid, cathode and plate resistors of a standard resistance-coupled amplifier stage. Position 7 checks the upper impedance limit on the cathode bypass capacitor. The plate voltage operating limits are checked at positions 8 and 9, power being applied to the circuit under test through the relay connections indicated. Finally, the a-c signal at the plate is checked at position 10.
BELGIUM, a country with two languages, French and Dutch, has adopted a bistandard television system: one using 819 lines and the other 625 lines. Thus it is possible to rebroadcast TV programs from France on 819 lines and from other neighboring countries on 625 lines without using a line-converter. However, there are also locations in Belgium where direct reception of foreign television broadcasts is possible; Dutch programs in the North, German programs in the East and French programs in the South. The same holds for other regions along the French and Belgian borders. A receiver was therefore developed which would be capable of receiving four different TV systems: the Gerber (named for chairman of CCIR committee) the French and the two Belgian.

Because f-m as well as a-m sound has to be received, an intercarrier-sound system was out of the question without resorting to complicated switching. In the French system the separation between picture and sound carriers differs from that for the other three systems. It would have been possible to use a separate i-f amplifier with greater bandwidth in the case where the receiver was used for the reception of a French channel. Because the video bandwidth for the Belgian 819-line system is limited by the separation of 5.5 mc between the two carriers, it was decided to use the same i-f picture amplifier.

By W. WERNER

N. V. Philips' Gloeilampenfabrieken
Eindhoven, The Netherlands

In all four systems the number of frames is 25 per sec and a 2:1 interlace is used. Aspect ratio = 4:3

<table>
<thead>
<tr>
<th>Channel width</th>
<th>Gerber</th>
<th>Belgian I</th>
<th>Belgian II</th>
<th>French</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrier separation</td>
<td>7.5</td>
<td>5.5</td>
<td>5.5</td>
<td>11.5 mc</td>
</tr>
<tr>
<td>Picture modulation</td>
<td>neg</td>
<td>pos</td>
<td>pos</td>
<td>pos</td>
</tr>
<tr>
<td>Sound modulation</td>
<td>am</td>
<td>am</td>
<td>am</td>
<td>am</td>
</tr>
<tr>
<td>Number of lines</td>
<td>625</td>
<td>625</td>
<td>819</td>
<td>819</td>
</tr>
<tr>
<td>Sync signal</td>
<td>substantially as RETMA</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Four System Standards

Twenty-two tube receiver operates on Gerber, French and both Belgian television systems. Same i-f picture amplifier is used for all four systems. Sound rejection is necessarily better than 50 db since three of the systems employ a-m sound for all four systems. Several tests proved that the resulting degradation of the picture was far less than would be expected from the reduction of the video bandwidth.

Because three of the four systems use a-m sound modulation, the rejection of the accompanying sound had to be at least 50 db. The available video bandwidth thus became 4.25 mc. A separate i-f sound amplifier had to be used; the sound i-f being taken off directly after the tuner.

Suitable i-f carrier frequencies for an E-channel were found to be 38.9 mc for picture i-f and 33.4 mc for sound i-f. Keeping the i-f picture carrier at 38.9 mc for the reception of a French channel would mean that the i-f sound-carrier frequency would become 38.9 - 11.15 = 27.75 mc.

It is not easy to design an f-m...
detector for a frequency of 33.4 mc. It was therefore decided to convert the sound i-f to a frequency of 7 mc by using a second oscillator with a frequency of 40.4 mc for reception of an E channel and a frequency of 20.75 mc for reception of a French channel. This frequency of 7 mc was chosen because the second oscillator frequency of 40.4 mc then fell in the adjacent sound trap provided in the i-f picture amplifier.

Nevertheless, it was not feasible to put this converter directly after the tuner, because too much oscillator voltage was still coupled into the i-f picture amplifier resulting in a 1.5 mc interference pattern in the picture. Therefore, a buffer i-f sound stage was used between the tuner and the converter. The resonance frequency of the tuned circuits in this stage is switched from 33.4 to 27.75 mc by adding a small trimmer capacitor. Figure 1 shows a block diagram of this part of the receiver.

Figure 2 shows the schematic diagram of the converter. The tube is a triode-heptode with the third grid of the heptode-converter connected to the first grid of the triode-oscillator.

### Sound Switching

Switching from f-m to a-m sound takes place in the sound-detector stage shown in Fig. 3. The triode of a triple-diode triode PABC 80 (6T8) is used as an audio-frequency amplifier. Two of the diodes, \( V_1 \) and \( V_2 \), are used in a ratio-detector circuit tuned to the 7-mc sound i-f. The third diode, \( V_3 \), serves as a delay for the sound age voltage applied to the first sound i-f buffer stage.

In the a-m position of the switches, the resistance in series with the anode of diode \( V_3 \) and capacitor \( C \) is increased. The detected a-m sound is taken off through the germanium diode, which then functions as an interference limiter for pulses above 100-percent modulation level.

Three of the four tv systems under consideration have positive modulation for the picture information. In the anode of the video-output tube the sync pulses are positive when the receiver is switched for reception of the Gerber system. Therefore, the video signal is applied to the cathode of the picture tube. In the reception of a tv signal with positive modulation the

---

### Table II—Channel Allocation in Gerber TV System

<table>
<thead>
<tr>
<th>Channel</th>
<th>Mc</th>
<th>Picture carrier</th>
<th>Sound carrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>E 2</td>
<td>47-54</td>
<td>48.25</td>
<td>53.75</td>
</tr>
<tr>
<td>E 3</td>
<td>54-61</td>
<td>55.25</td>
<td>60.75</td>
</tr>
<tr>
<td>E 4</td>
<td>61-68</td>
<td>62.25</td>
<td>67.75</td>
</tr>
<tr>
<td>E 5</td>
<td>174-181</td>
<td>175.25</td>
<td>180.75</td>
</tr>
<tr>
<td>E 6</td>
<td>181-188</td>
<td>182.25</td>
<td>187.75</td>
</tr>
<tr>
<td>E 7</td>
<td>188-195</td>
<td>189.25</td>
<td>194.75</td>
</tr>
<tr>
<td>E 8</td>
<td>195-202</td>
<td>196.25</td>
<td>201.75</td>
</tr>
<tr>
<td>E 9</td>
<td>202-209</td>
<td>203.25</td>
<td>208.75</td>
</tr>
</tbody>
</table>

Italian channels: E4, E4A, E5, E7A, E8A, E10

<table>
<thead>
<tr>
<th>Channel</th>
<th>Mc</th>
<th>Picture carrier</th>
<th>Sound carrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>E4A</td>
<td>81-88</td>
<td>82.25</td>
<td>87.75</td>
</tr>
<tr>
<td>E7A</td>
<td>191-198</td>
<td>192.25</td>
<td>197.75</td>
</tr>
<tr>
<td>E8A</td>
<td>200-207</td>
<td>201.25</td>
<td>206.75</td>
</tr>
</tbody>
</table>

### Table III—French TV System Channel Allocation

<table>
<thead>
<tr>
<th>Channel</th>
<th>Mc</th>
<th>Picture carrier</th>
<th>Sound carrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>F 2</td>
<td>41.00-54.15</td>
<td>52.40</td>
<td>41.25</td>
</tr>
<tr>
<td>F 3</td>
<td>54.40-67.55</td>
<td>56.15</td>
<td>67.30</td>
</tr>
<tr>
<td>F 4</td>
<td>54.15-67.30</td>
<td>56.55</td>
<td>67.40</td>
</tr>
<tr>
<td>F 5</td>
<td>162.25-175.40</td>
<td>164.00</td>
<td>175.15</td>
</tr>
<tr>
<td>F 6</td>
<td>162.00-175.15</td>
<td>163.40</td>
<td>162.25</td>
</tr>
<tr>
<td>F 7</td>
<td>175.40-188.55</td>
<td>177.15</td>
<td>188.30</td>
</tr>
<tr>
<td>F 8</td>
<td>175.15-188.30</td>
<td>176.50</td>
<td>175.40</td>
</tr>
<tr>
<td>F 8A</td>
<td>173.85-187.85</td>
<td>185.25</td>
<td>174.10</td>
</tr>
<tr>
<td>F 9</td>
<td>188.55-201.70</td>
<td>190.30</td>
<td>201.45</td>
</tr>
<tr>
<td>F10</td>
<td>188.30-201.45</td>
<td>199.70</td>
<td>201.55</td>
</tr>
<tr>
<td>F11</td>
<td>201.70-214.85</td>
<td>203.45</td>
<td>214.60</td>
</tr>
<tr>
<td>F12</td>
<td>201.45-214.60</td>
<td>212.85</td>
<td>201.70</td>
</tr>
</tbody>
</table>

F8A used for Paris and Lille only; F2 not likely to be used.

Any twelve of the channels (Table II, III) can be accommodated in the 12-position turret-type channel selector of the 4-system receiver by inserting appropriate coil strips.
video-output signal is switched to the grid of the picture tube. In both cases no d-c component is present in the signal on the picture tube. Figure 4 shows the switching arrangement and Fig. 5 the switching arrangement for sync take-off.

The first sync clipper, Fig. 6, is of conventional design for positive-going sync pulses. For signals with negative modulation the signal applied to the sync clipper is taken off the anode of the video-output stage, whereas in the case of signals with positive modulation the sync clipper obtains its signal from the cathode of the video-output stage through a grounded-grid triode amplifier. This triode is one half of a double-triode ECC 82 (12AU7); the other triode is used as diode in amplified age circuit.

**AGC Circuit**

The receiver is equipped with amplified picture age. With negative modulation, the sync-tip level of the video signal across the cathode resistor of the video-output tube determines the age voltage. With positive modulation, age voltage is determined by the peak-white level. Figure 5 shows the circuit diagram. The EF 80 (6CB6) age amplifier is used as a grounded grid amplifier with its cathode connected to the cathode of the video-amplifier tube. It has a short grid base (sharp-cutoff), due to the low voltage on its screen-grid. The video-detector is direct coupled to the video-output tube. With negative modulation its anode current at the sync tips decreases with increasing signal strength. The corresponding voltage level at the cathode of the age amplifier also decreases until the age amplifier starts drawing anode current during the sync pulses.

The anode voltage of the age amplifier is obtained by rectifying horizontal flyback pulses by a diode formed by the grid and cathode of one half of a double-triode. When the anode current of the age amplifier increases with increasing signal strength the negative age voltage also increases. In case of signals with positive modulations, the age amplifier starts to draw current on those parts of the signal corresponding to peak-white in the picture. Contrast control is obtained by changing the screen-grid potential of the video-output tube.

**Horizontal Sweeps**

The horizontal-sweep generator, Fig. 7, is of conventional design. A triode-pentode is used in a multivibrator circuit with a stabilizing resonance circuit in the anode. The frequency is controlled by a voltage obtained from a balanced discriminator with two germanium diodes by comparing the phase of the horizontal-sync pulses with respect to a sawtooth voltage from the horizontal-output transformer. When switching from 625 to 819 lines the inductance in the stabilizing circuit is reduced and the time constant in the grid circuit of one of the triodes is altered.

The horizontal-output stage, Fig. 8, is changed from 625 to 819 line operation by shorting out a series dropping resistor in its B+ supply. For 819 lines, the anode-supply voltage is the full B+ voltage of 240 volts. For 625 lines, this anode supply is reduced to 180 volts by the series dropping resistor. When switching from 625 to 819 lines the boosted voltage increases from 500 to 650 volts. As this voltage is also used for feeding the vertical-sweep oscillator and the vertical-output stage, a series dropping resistor is switched in when the receiver is operated on 819 lines.

The high voltage for the picture tube is obtained in the conventional way by rectifying the flyback pulses. No switching is necessary in this part of the circuit. For 625 as well as 819 lines the high voltage is 14 kv at a load of 50 amp. The internal resistance is 10 megohms.

The receiver contains 21 tubes, four germanium diodes, one picture tube and a selenium rectifier for the B+ supply. The photographs show the seven ganged switch wafers and the four-position control knob.

Many engineers have been actively engaged in the development of this receiver, in particular: Messrs. Kerkhof, Berkhout, Jansen and Kollenburg of the television development laboratory.

**Reference**

COMPONENT DESIGN TRENDS

Precision Potentiometers

Resistance elements made from deposited metallic films, conductive plastics or lossy liquid dielectrics give infinite resolution, greatly increasing the scope of applications. Other new design and construction techniques give increased life and reliability.

Precision potentiometers differ from conventional radio volume controls by their inherent features of higher accuracy, freedom from overt electrical noise, longer life (usually 1 million cycles at 60 rpm or less), lower torque and more rigid tolerances on both electrical and mechanical parameters.

Precision potentiometers are generally used to convert mechanical activity—usually rotation but also translation—into an electrical voltage. Whereas volume controls, variable resistors and rheostats, as used in electronic circuits, are made to loose tolerances either because they need not be calibrated or because they operate under such varying conditions as to make calibration meaningless, precision potentiometers are so incorporated in the circuit as to serve a calibrated purpose and to operate under sufficiently stable conditions so that calibration is feasible.

Examples of Applications

Potentiometers can be used in circuits to add, subtract, multiply and divide. Wire-wound units made by Helipot and others have long been available with nonlinear windings which produce logarithmic, hyperbolic, square root and trigonometric functions.

Precision potentiometers are frequently used as mechanical amplitude modulators. For some applications it is desirable that the wiper rotate continuously through 360 degrees in which case the winding may itself be continuous or have an interruption making the electrical contact angle something less than the 360-degree mechanical rotation.

Specialized uses of potentiometers as in analog computers have led to the development of differential computing potentiometers. In such a unit a linear winding is arranged to rotate as well as the wiper, both through 360 degrees. For example, instead of using terminal lug, the Fairchild D-C-P differential computing potentiometer provides external connections to the winding ends and wiper by means of three silver slip rings molded on the body. This arrangement makes possible the measurement of two variables directly in a single instrument. The voltage output is proportional to the sum or difference of the two input variables—the angular movements of the body and of the shaft.

As the reliability of potentiometers increases, they are finding use as information transmitters in place of variable transformers, variable capacitors and photoelectric devices. In such applications,

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Part III: Fixed Resistors Show Stability

FIG. 1—Typical relation between tem-

<table>
<thead>
<tr>
<th>RESISTIVITY OF FAIRCHILD FILM</th>
<th>TEMPERATURE COEFFICIENT OF RESISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>25°C/0 OHMS/SQ. PER SQUARE FOR</td>
<td>25°C/0 OHMS/SQ. PER SQUARE FOR</td>
</tr>
<tr>
<td>1000 OHM UNIT</td>
<td>1500 OHM UNIT</td>
</tr>
<tr>
<td>12.000 OHMS/SQ. PER SQUARE FOR</td>
<td>12.000 OHMS/SQ. PER SQUARE FOR</td>
</tr>
<tr>
<td>1500 OHM UNIT</td>
<td>1500 OHM UNIT</td>
</tr>
<tr>
<td>15.000 OHMS/SQ. PER SQUARE FOR</td>
<td>15.000 OHMS/SQ. PER SQUARE FOR</td>
</tr>
<tr>
<td>1500 OHM UNIT</td>
<td>1500 OHM UNIT</td>
</tr>
<tr>
<td>18.000 OHMS/SQ. PER SQUARE FOR</td>
<td>18.000 OHMS/SQ. PER SQUARE FOR</td>
</tr>
<tr>
<td>1500 OHM UNIT</td>
<td>1500 OHM UNIT</td>
</tr>
</tbody>
</table>

144

FIG. 1—Typical relation between tempera-

1000 OHM UNIT | 1500 OHM UNIT |
| 15.000 OHMS/SQ. PER SQUARE FOR | 15.000 OHMS/SQ. PER SQUARE FOR |
| 1500 OHM UNIT | 1500 OHM UNIT |
| 18.000 OHMS/SQ. PER SQUARE FOR | 18.000 OHMS/SQ. PER SQUARE FOR |
| 1500 OHM UNIT | 1500 OHM UNIT |

October, 1954 — ELECTRONICS

www.americanradiohistory.com
Use New Materials

By FRANK ROCKETT
Research and Engineering Division
Airborne Instruments Laboratory, Inc.
Mineola, N. Y.

Markite conductive plastic rotational and strip-type translational potentiometers provide long life and infinite resolution. For strip-type unit, taps molded into back of resistive element (bottom) leave conductive track (top) clear for slider in center.

Potentiometers are frequently more compact and weigh less than similar information transmitters. Circuits can be arranged to make full use of their inherent accuracy and to avoid cumbersome mechanical lears, cams and linkages.

New resistance materials and new construction techniques have been developed in the past few years to broaden greatly the scope of applications for precision potentiometers. Some of these new designs will be discussed with a representative example in each case, to give a quick picture of what is now available to engineers for incorporation in electronic products.

In a wire-wound potentiometer the resistance to the slider varies in small steps as the slider moves from one turn to the next of the resistive element. The amount of this step change in resistance is the resolution of the potentiometer, and is inherently related to the size of resistance wire used.

**Metallic Film Units**

Newly introduced film potentiometers employ a construction giving what is commonly referred to as an infinite resolution. The film units have therefore served to broaden considerably the scope of applications for potentiometers as transducers for servomechanisms and for telemetering.

With a resistive film there are an infinite number of positions of contact by the slider on the resistance element, with a corresponding infinite number of outputs of electrical voltage. This assures freedom from hunting or oscillation of a servo due to the inability of the

![FIG. 2—Liquid dielectric potentiometer provides infinite resolution. Capacitance to output electrode varies in same ratio as does resistance, hence time constant is substantially unchanged by rotation.](image1)

![FIG. 3—Sine-cosine potentiometer made by Rawson Electrical Instrument Co. uses linear resistance card.](image2)
COMPONENT DESIGN TRENDS

- Metal films thermally evaporated onto glass withstand up to 225°C
- Long-wear conductive plastic elements have integrally molded taps
- Straight-line resistance plastic elements translate linear motion into voltage changes
- Liquid resistance elements approach infinite resolution and have flat response from 50 cps to 1 mc

balancing potentiometer to find a null.

Illustrative of the properties that can be built into a film potentiometer is the recently announced FilmPot of Fairchild Camera and Instrument Corp. This potentiometer is built in an unusually small size, being only 0.75 inch in diameter and 0.5 inch long. Within this case a wide range of resistance is possible. Currently available units include resistances from 100 ohms to 1 megohm ±10 percent. Independent linearity can usually be maintained to 0.5 percent, can probably be improved to half this value by further control, and reduced to 0.1 percent by selection. Noise is rated at 400 mv or less; units can be furnished with torques as low as 0.1 oz-in.

Another outstanding feature of the metallic film potentiometer deposited on glass is its ability to withstand high temperatures. The unit is electrically and thermally stable to hot spot temperatures of 225°C; units with resistances to 500,000 ohms are capable of dissipating 3 watts at 100°C and are derated linearly to 0 watts at 225°C. Due to voltage breakdown limitations, rated dissipation decreases linearly for higher-resistance units to 1 watt at 1 megohm. The potentiometer resists corrosion even at these high temperatures. Materials used in the unit are precious metals, glass and high-temperature plastics and lubricants.

Thermal and electrical stability of a metallic film are better at lower resistivities. The relationship of resistivity to temperature coefficient of resistivity differs for film materials; the curve presented in Fig. 1 is for the material used in one commercial potentiometer. There is an intercept at which films of 600 ohms per square have an average temperature coefficient of zero. Marked on the curve is the range over which temperature coefficient of resistivity is within 0.03 percent of zero.

The state of the film potentiometer art indicates that quantity production of such units is in the foreseeable future. Prices are likely to be within the ratio of their performance compared to the price and performance of wire-wound units.

Using artificial or natural graphite depending on desired characteristics, manufacturers are developing precision adaptations of carbon film potentiometers. Units from Elektro-Serv Co. display a temperature coefficient of resistance of ±0.01 percent per degree C at normal air ambient, are rated for 2 watts to 50°C and are derated to zero at 65°C. Terminal resistances range from 1,000 ohms to 2 meg-ohms, with tolerance of ±1 percent if required; independent linearity is normally ±1 percent. Sufficient pressure (25 to 50 grams) of the gold wire wiper is used to keep noise comparable to the inherently low thermal noise of the controlled composition resistance track, yet the pressure is light enough to achieve a rated life of a million cycles at 100 rpm. Dual takeoff from the buffed silver slip ring of the rotor also contributes to low noise, low inductance and low torque (0.5 oz-in. per section with ball bearings).

Conductive Plastic Units

For applications requiring long wear and high resolution, potentiometers whose resistive tracks are of solid conductive plastic are integrally molded by Markite Corp. with terminals and taps to a rigid mineral-filled phenolic insulator support. The low coefficient of friction combines with extreme wear resistance of the smooth track to permit use of relatively high brush contact pressure without incurring excessive torque or short life. As a consequence such units provide quiet operation even in the presence of substantial vibration and acceleration.

Manufacturer’s tests at 600 rpm showed an increase in resistance of 25 to 30 percent after 236-million revolutions; noise and linearity remained substantially unchanged. As a result of these and of customer tests, units are guaranteed for 5-million revolutions at up to 600 rpm with a resistance change less than 3 percent and a linearity change less than 0.1 percent. Resolution is better than 0.00004 inch. Because taps are molded into the resistive track below the surface contacted by the slider, they introduce negligible tap dead space. Units are rated at 0.75 watt per linear inch of resistive track at 20°C and half this at 80°C. Standard independent linearity is ±0.5 percent to 20,000 ohms, or ±1.0 percent to 100,000 ohms; overall resistance go up 100,000 ohms ±10 percent; torque with ball bearings is below 0.5 oz-in. The plastic resists corrosion even in a moist chlorine atmosphere. Temperature coefficient of resistance from 0°C to 100°C is about —0.00035 ohm per ohm per deg C.

An unusual application of such conductive plastics is in function generators for analog computers. The extreme resolution and long life of the potentiometer element are desirable characteristics. In addition, the unit is not subject to abrupt failure during computation and, if worn excessively in one region because of the nature of a generated function, can be resurfaced with a slight change in overall resistance.

Another approach to infinite resolution is to use a liquid as the resistive element, as in a water rheostat. Depending on the mechanical arrangement, the unit can respond to translatory or rotary
motion. As being developed by Technology Instrument Corp., such a potentiometer employs a lossy liquid dielectric as the resistive element in which are mounted fixed and movable electrodes as shown in Fig. 2.

**Liquid Potentiometers**

Because capacitance to a movable electrode in liquid varies in the same manner as the resistance to it from the fixed electrode, the time constant of the potentiometer remains constant as it is varied, thus providing broad bandwidth. The voltage divider so formed is rated for flat amplitude response and zero phase shift from 50 cps to 1 mc.

In the unit responding to linear motion, one or more electrodes translate. The total excitation voltage is placed between the grounded metallic can and insulated fixed electrode. By shaping the electrodes and the can, linear or nonlinear functions can be produced.

In the rotary type, the excitation is applied across two fixed vanes; a third fixed vane acts as the take-off electrode. The rotating vane thus requires no sliding metallic contact. By shaping the vanes the resistance function of shaft rotation angle can be varied.

A number of liquid dielectrics have been tested successfully. Methyl alcohol is commonly used for its stable impedance level. It produces no corrosion or electrolysis when used with aluminum electrodes at frequencies above 10 cps. By selection of electrolytes, resistances from a few hundred ohms to several megohms have been achieved in units operable to 100 volts.

**Sine-Cosine Potentiometers**

Several types of potentiometers are available whose resistances vary sinusoidally with the angle of shaft rotation. One such precision wire-wound potentiometer provides two output voltages accurately proportional to the sine and to the cosine of the shaft rotation angle. The design in Fig. 3 is based on a wire-wound linear flat card mounted on a rotating platform. The ends of the winding are connected to the excitation voltage through slip rings. Four output brushes are arranged in quadrature on a circle of rotation on the winding. As the card rotates, each pair of brushes traces the circle on the wire, picking up a sinusoidal output voltage or resistance. This construction results in the desired output function from a simple linear winding that can be wound very accurately.

When the winding is excited by direct voltage, the brushes give output voltages that vary sinusoidally as the shaft is turned. The peak value of the output is about 12 percent less than the exciting voltage. The output voltages oscillate plus and minus in polarity and are balanced about the potential at the center of the winding. The potentiometer is thus a mechanical generator of low-frequency sine waves suitable for a variety of research problems.

If excited by alternating voltages up to 155 volts at frequencies up to 1 mc, the excitation signal can be modulated by shaft rotation. The expected life of this potentiometer is 350,000 revolutions; maximum recommended speed of rotation is 1 cycle per second; amplitude accuracy is ±1 percent maximum; the output wave form is within 1 percent of the peak value at any point of a pure sine or cosine wave; resistance within the brush circle is 14,000 ohms ±10 percent; the winding is rated at 1.5 watts at 65°C.

If, by analogy with the linear potentiometer, resolution is considered as the change in resistance from a reference point on the winding (center of the brush circle in this case) to any single brush, for each equal increment of brush rota-
COMPONENT DESIGN TRENDS

- Flat-card windings give sinusoidal output
- Carbon-film sine-cosine units operate at high speed with low noise
- Starting torques can be under 0.5 ounce-inch
- New phasing adjustments improve performance of ganged units

The number of wires crossed will vary from a maximum when the brush is moving perpendicular to the direction of the winding to a minimum when it is moving parallel. However, the resolution which is ultimately of interest is the angular magnitude of the finite steps by which the resultant vector rotates. The poorest resolution occurs when the brushes are moving at an angle of 45 degrees with the winding.

A miniature precision sine-cosine potentiometer recently announced by Computer Instruments Co. is a carbon film unit. The track is laid down by an evaporation technique which, because of the control afforded, is used to produce both linear and nonlinear functions. The infinite resolution and comparatively low noise characteristics of the film enable the potentiometer to be operated at high speeds. As a consequence the potentiometer is guaranteed for a life of a million cycles at 100 rpm. Some engineers have used it to 3,600 rpm. Lowest noise is achieved with these units when operating as pure voltage dividers into relatively high-impedance loads. The potentiometer, 1 1/2 inches in diameter by 1/8 inch in length and weighing only 1 ounce, can be excited with either direct or alternating voltages.

Factors Affecting Torque

Because of the manner in which precision potentiometers cooperate with mechanical movements, their mechanical characteristics are quite as important as their electrical characteristics. The torque necessary to rotate the shaft of a potentiometer is of particular importance. Except in cases where a torque resistor is used to add stiffness in the presence of vibration, low torque is generally desirable. Usual starting torques are less than 1 oz-in. per section. Half of this is obtainable; it rarely exceeds 2 oz-in., but with special seals or locks may be 8 oz-in.

In achieving the inherent precision of a potentiometer, it is desirable that the torque also be free from variations such as binding or extreme differences between starting and running torque. The lower the torque, the less the power required to drive a potentiometer and, in general, the more compact the equipment.

Torque is developed in several ways—by the inertia of the rotating parts of the potentiometer, by the friction of the shaft in its bearings (usually slip rings, although in special applications ball bearings may be used) and by the action of the wiper or sliding contact. The wiper must necessarily bear on the resistance element with sufficient force to assure positive electrical contact, and thus a friction component at the end of an arm of substantial length is developed.

To maintain low torque, parts are precision machined and assembled; materials are used that are congenial in their friction relationship and in their temperature, humidity and other environmental behaviors. The mounting position of the potentiometer may influence its torque; the wear of parts due to operation can either increase or decrease torque. The assembly and alignment of a potentiometer in its mounting and in relation to its drive can vary the torque especially if there is radial shaft play. To obtain low torque a combination of small diameter resistance element, small short shaft and a light contact wiper are used. Lubricants on the winding may reduce torque at some temperatures but usually increase it at others. With stainless steel ball bearings, a starting torque of 0.1 oz-in. is possible.

The requirements of mounting squareness, low radial shaft play and the like are also important in reducing torque. However, unless the conditions under which the potentiometer is to be installed and operated will preserve these refinements, the additional cost of extreme efforts to reduce torque may be unjustified. For example, the mounting squareness of the potentiometer cup on the mounting surface or base plate depends as much on the care with which the potentiometer is mounted in the equipment as upon the construction of the potentiometer itself. If the shaft is not square with the mounting surface, there will be an increased torque. In addition, the wiper arm attached to the shaft will be out of alignment, thereby causing a change or deviation in linearity which may disrupt the electrical function of the potentiometer.

Concentricity of the shaft of a potentiometer in relation to the mounting plane and specifically with relation to the winding is essential so that the winding and pilot bushings have a common center. Even small eccentricities may offset the precision of the potentiometer. Eccentricity causes the indicated rotation to differ from the true rotation by an angle the size of which is a function of the eccentricity. For example, a precision potentiometer with a 2-inch radius and an eccentricity of 0.02 inch has a percentage error due to eccentricity alone of ±0.18 percent. Thus the eccentricity error can nullify the accuracy inherent in the precision winding of a potentiometer.

Radial shaft play has somewhat the effect of a fluctuating eccentricity. It not only causes a change in linearity but a change in torque and, in extreme cases, may vary the electrical contact resistance at the wiper arm. Hunting and backlash in servomechanisms are frequently traced to radial play.

Where more than one output is desired from a single shaft, several potentiometers can be ganged. For this purpose a variety of units are available, including specially cupped units that can be ganged in any combination and are easily
changed or replaced. As many as twenty separate functions are obtained from a ganged unit having a single shaft.

**Ganged Potentiometers**

Ganged units must be phased relative to one another. This can usually be accomplished by loosening the retaining bands on the ganged unit and rotating each cup. In this way each unit of a gang is set so that its zero electrical position corresponds with the zero electrical position of other units in the gang.

Some styles of potentiometers can be ganged by removing one cover plate. The adjacent cup then completes the case so that there is no waste space between cups; the gang approaches a solid structure with its consequent rigidity yet any one cup can be replaced during development or maintenance without dismounting the others. Where the rotation of subsequent units in a gang is produced by a drive through a coupling such as an eccentric pin, backlash between units can be held below 0.05 degree per section.

In use, potentiometers may be rotated at a variety of speeds. At excessive speeds increased wiper wear may produce arcing or loss of contact, along with increased noise. The life of the unit may be shortened as measured in cycles of operation; radial shaft play may increase rapidly due to the higher accelerations, with resultant misalignment. High temperature rise may increase the overall resistance of the winding. (Temperature coefficients of resistance wire are in the vicinity of 0.002 percent per degree C.) The wire of the resistance unit may fail due to the pounding effect of the wiper arm. If it is anticipated that a potentiometer will operate at high speeds, special wiper assemblies and ball bearings for the shaft are desirable.

**Electrical Characteristics**

The most important electrical characteristic of precision potentiometers is the deviation or difference between the actual electrical output and the output specified by the electrical function of shaft angle. Deviation is expressed as the electrical output minus the reference electrical output.

Resolution has been mentioned as a measure of the accuracy to which a potentiometer can be set. The maximum incremental change in resistance or voltage output observed anywhere in the total mechanical motion or rotation of the potentiometer shaft (or a specified portion of it), when multiplied by 100 and divided by the total resistance or voltage (or specified portion of it), is the percentage resolution of a potentiometer.

Linearity is the deviation of the curve of actual resistance of a potentiometer versus shaft angle from a straight line for a linear resistance unit. Various types of linearity are used and are defined and named slightly differently by different manufacturers.

Noise is also an important characteristic of potentiometers, especially in applications that necessitate achieving the ultimate performance from the units. Noise is measured quantitatively in terms of an equivalent, parasitic and transient contact resistance expressed in ohms that appears between wiper and the resistance element when the shaft is rotated. Equivalent noise resistance is considered independently of the total winding resistance; in wire-wound potentiometers it is in the vicinity of 150 ohms maximum.

**Factors Influencing Noise**

In specific instances where noise may be defined as any electrical disturbance or signal which tends to interfere with the generation or indicating characteristics of the potentiometer, noise should be more specifically related to such operating conditions as applied voltage, load resistance, speed of rotation and load current. In such instances noise may be measured in millivolts.

Among the contributions to the noise of a precision potentiometer is contact resistance noise appearing at both wiper contacts and at slipping contacts; this noise is generated through the constriction resistance set up when current flows through two separate pieces of
**COMPONENT DESIGN TRENDS**

- Independent linearity can be as low as 0.1 percent for single-turn units and better than 0.025 percent for multiturn units
- Paliney alloy contacts withstand over 2,000,000 cycles of operation without affecting linearity
- Small load currents help maintain low contact resistance
- Servo-controlled winding machines give greatly improved linearity
- Bellows-driven unit withstands shocks up to 30 g without permanent damage

metal joined only at a point. The load current flowing through a fluctuating contact resistance produces a loading noise, expressed in ohms as a peak variation in that contact resistance.

Shorting noise is the noise due to winding current as the wiper shorts turns in its passage along the winding. It is proportional to winding current, the resistance per turn of wire and the resistance of the contact. Variations in contact resistance also cause noise. Thus, shorting noise is closely connected with resolution.

Resolution noise is the sawtooth voltage superimposed on the functional output of the potentiometer caused by resistance to flow of load current by the winding. Resolution noise is proportional to the resistance per turn of the resistance wire and to the load current; it, too, is expressed in ohms.

Transient noise is that due to foreign material coming between the wiper and winding. Foreign material may be dirt or an oxide film which develops on the winding.

Generated noise is caused by heat or friction of two metals rubbing against each other, such as the wiper contact and the winding. Accompanying this noise is thermocouple noise consisting of the potential developed in a circuit composed of dissimilar metals with junction points at different temperatures.

Noise associated with excessive rotational speed is caused by the sliding contact rising clear of the winding momentarily.

Circuit design influences some of these noises. Wiping action combined with a small load current (about 1 ma) may help to maintain low contact resistance.

**Multiturn Potentiometers**

To increase resolution beyond that obtainable in a single-turn potentiometer, the multiturn design has long been used by Helipot and others. As one example, in the ten-turn precision Mieropot (Borg Equipment Division), the total resistance ranges from 10,000 to 40,000 ohms and linearity from 0.25 percent through 0.025 percent, depending on total resistance and the type of linearity specified. The three-turn unit, with total resistance about a third that of the ten-turn unit, has a percent linearity about 3 times that for the ten-turn potentiometer. Power dissipation in the ten-turn unit is 5 watts at 40 °C; for the three-turn unit it is 3 watts at 40 °C. In the ten-turn unit the helix is about 49 inches long and consists of a Kohlrausch winding (spiral winding on a spiral mandrel) of resistance wire molded and locked in place on a plastic mandrel. Potentiometer units wound on insulated copper mandrels give considerably improved heat dissipation but inherently higher capacitance to ground. The Paliney alloy contact is reported to provide a life of over two million cycles without affecting linearity. Equal life with a phosphor-bronze contact would increase the percent deviation from linearity by twice its initial value.

Constructional features of another multiturn potentiometer are shown in Fig. 4. This unit is based on a design developed by IBM under an Air Force project. The winding is sometimes described as a violin-string type.

**Automatic Winders**

Automatic servo-controlled machines are being used by a number of firms to achieve greater accuracy in winding precision wire-wound potentiometers, although details may differ. The basic principle of one of the machines is essentially as shown in Fig. 5. This machine is used by TIC to produce the IBM design. A self-supporting tightly coiled resistance element is formed by winding uncoated resistance wire about a mandrel which is immediately removed. The result is a flexible spring coil which is mounted on a potentiometer base by a servo correction technique that automatically insures good linearity.

Before the coiled resistance element is mounted, it is placed on an intermediate spool under slight tension. A multiturn potentiometer base is next mounted on a base plate having slip-ring take-off contacts. This potentiometer structure is mechanically complete and its actual slider contact is clamped at a fixed position. One end of the resistance element is attached to this potentiometer structure. An excitation voltage is placed across the resistance element and the voltage of the clamped slider contact is taken off by means of one of the slip rings.

By rotating the potentiometer base and the supporting spool, the potentiometer winding is transferred from the spool to the base. The potentiometer base is coupled to a high-precision multiturn master potentiometer. The voltage from the fixed slider contact is compared with that from the precision master potentiometer. Any difference voltage drives the servo correction motor and causes the payoff spool to speed up or to slow down with respect to the potentiometer being wound. This alters the tension and thus the spacing of the turns of the coiled potentiometer winding.

By this continuous method of servo correction, multiturn potentiometers are wound with lineairies consistently better than 0.025 percent. Because the final potenti-
Precision potentiometers find numerous and varied applications, one example of which is shown in Fig. 6. Here a Baroresistor employs hydraulic bellows to actuate a precision wire-bound potentiometer. The unit withstands shocks up to 30 g; the only observable change in resistance ratio occurs along the axis of the potentiometer winding, the change being in resistance ratio of 2 to 3 percent but without permanent damage.

The instrument operates over a temperature range from −50°C to +80°C over its full-scale pressure range, which is 0 to 14.7 psi. The unit has been tested by the manufacturer up to 200,000 cycles with no evidence of wear or other incipient failure. Measured temperature sensitivity is 0.01 percent per degree C. From 0 to 14.7 psi absolute the accuracy is ±2 percent of full scale. There is hysteresis due to the bellows of less than 2 percent of full scale. Acceleration sensitivity is less than 0.1 percent of full scale per g. The total resistance of the winding is 7,500 ohms ±2 percent rated for 75 volts. Maximum winding current in any part of the winding is 10 ma continuous.

In summary, it can be expected that the development of precision potentiometers will continue under the impetus of entry of an appreciable number of manufacturers into the field. This concerted effort appears to be bringing safe operating temperatures to 150 C, possibly to 200 C. Units are more sturdy today than heretofore; in the future they may operate satisfactorily during shocks up to 100 g and vibration between 1,000 and 2,000 cps.
The MICROWAVE Market Picture

Point-to-point communications systems, exclusive of military, near 100 and extend almost 30,000 miles. Common carriers dominate field and have grown most rapidly. Pipelines still lead private users, with power companies gaining rapidly

By JOHN M. CARROLL
Associate Editor, ELECTRONICS

A major development in post-war electronics has been the application of microwave equipment in point-to-point communications. Successful transmissions across the English Channel were made in 1931, but installations by the Bell System immediately after World War II put microwave on a commercial basis. Today there are nearly 100 civilian microwave systems in the U.S., with over 1,300 individual stations. Total route mileage is nearly 30,000 miles. Table I gives a breakdown of the figures according to FCC records.

It is difficult to compare sizes of different microwave systems. Best common denominator is dollar value but this is not always available and is complicated by the changing value of the dollar, varying land prices and construction costs. Communicators talk about circuit miles—the number of available communications circuits multiplied by the miles over which they extend. This is a good measure of traffic capacity but can be misleading as to the amount of equipment used.

Another measure is the number of stations. This, however, tells little about the traffic capacity of the system. Throughout this report, systems are compared in route miles—the actual distance over which the microwave beam travels. Two guides for further approximation are that the average distance between towers is about 20 miles and that the average cost of a microwave system used by private companies is roughly $1,500 a route mile. Common-carrier systems generally run higher.

There is no general agreement on a definition of microwaves. Design engineers restrict the term to superhigh frequencies and above—3,000 mc and up. In communications, any frequency above 890 mc is loosely termed microwave. The bands allocated to the various services are listed in Table II.

Microwave Frequencies
The short wavelength of microwaves (30 cm and less) provides two important properties. First, the transmissions follow a line-of-sight path and can be focused much like a beam of light by high-gain antennas. This enables nearby systems to operate in the same frequency band without harmful interference. Secondly, a circuit's physical dimensions determine its electrical parameters, and for such short wavelengths a small change in circuit dimensions can produce a wide frequency variation. Thus, microwave equipment can readily have an extremely wide frequency bandwidth compared to lower-frequency communications equipment.

Systems providing 24 voice channels are widely used; common-carrier systems sometimes have several hundred voice channels.

Commercial exploitation of microwave has proceeded in three general directions: common-carrier, private and military. By far the greatest expansion has been in the common-carrier field.

Common-Carrier Systems
As may be seen from Fig. 1 telephone and telegraph companies have more than doubled route mileage in the past two years. Major impetus has been the need to connect television stations for intercity network service. Some television stations are connected by coaxial cable but the current trend is toward greater use of microwave radio relay, which will pass without difficulty the complete 6-mc band required.

Another kind of common-carrier recently appeared when a group in Poplar Bluffs, Mo., sought and received authorization to build a microwave system to distribute tv signals captured from the air to remote community antenna cable systems. Other common carriers include Western Union, one of the oldest. Plans are on paper to extend its system from its present terminal at Pittsburgh to St. Louis when the necessary $42 million is available.

Microwave systems operated by independent telephone companies are usually small—two or three stations. But, there are more than 5,000 independent telephone companies. Figure 2 is a map of common-carrier microwave facilities in the U.S.
Commercially, the keenest competition by far has been in the private, or more properly, the non-common-carrier market. Users include gas and oil pipelines, industrial firms, power utilities, railroads and forest products companies. Also local and state government services such as police, fire, highway maintenance and forest conservation.

**Private Systems**

Microwave systems operated by gas and oil pipelines constitute about two thirds of the total route mileage of all private systems. One manufacturer of microwave equipment believes that 85 percent of the potential market is here. Pipeliners need microwave for telephone communications between pumping and metering stations along their right of way and to tie in with radio-equipped service vehicles. They also need it for telemetering and supervisory control of unattended booster stations, teleprinter and facsimile.

Newest of the right-of-way companies, the pipelines, unlike power companies and railroads, could not rely on existing wire lines. Microwave avoided the problems of securing rights to string pole lines and offered more dependable service—no pole lines to come down in bad weather. Microwave compares favorably in cost with either privately owned or leased wire lines. Figure 3 is a map showing routes of pipeline microwave systems.

Power utilities operate about one quarter of all private microwave. Microwave has steadily gained favor with power men along with wire-line carrier. Microwave’s most attractive feature is the safety angle. During storms, if power lines come down, so do telephone lines, in many cases disrupting both wire-line carrier and leased-line service. Microwave offers a means for maintaining essential communications, telemetering, supervisory control and line-fault locating when most needed. Power-company

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![Supervisory control panel illustrates how microwave operates an unattended remote pipeline booster station. Passive reflector mounted on steel tower is becoming symbolic of a new communications age](image-url)

**Table I—Microwave Communications Systems in the U. S.**

<table>
<thead>
<tr>
<th>Type of Service</th>
<th>Systems</th>
<th>Stations</th>
<th>Route Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common carrier</td>
<td>1</td>
<td>450</td>
<td>12,349</td>
</tr>
<tr>
<td>Amer Tel &amp; Tel.</td>
<td>4</td>
<td>43</td>
<td>1,177</td>
</tr>
<tr>
<td>other carriers</td>
<td>26</td>
<td>516</td>
<td>10,679</td>
</tr>
<tr>
<td>Gas &amp; oil pipelines</td>
<td>33</td>
<td>159</td>
<td>2,763</td>
</tr>
<tr>
<td>Power utilities</td>
<td>2</td>
<td>83</td>
<td>1,147</td>
</tr>
<tr>
<td>privately owned</td>
<td>9</td>
<td>48</td>
<td>712</td>
</tr>
<tr>
<td>U. S. Gov’t</td>
<td>2</td>
<td>20</td>
<td>226</td>
</tr>
<tr>
<td>Police</td>
<td>2</td>
<td>10</td>
<td>184</td>
</tr>
<tr>
<td>Highway maintenance</td>
<td>2</td>
<td>11</td>
<td>175</td>
</tr>
<tr>
<td>Special industrial</td>
<td>2</td>
<td>8</td>
<td>58</td>
</tr>
<tr>
<td>Railroads</td>
<td>2</td>
<td>8</td>
<td>58</td>
</tr>
<tr>
<td>Forest products</td>
<td>2</td>
<td>9</td>
<td>44</td>
</tr>
<tr>
<td>Forest conservation</td>
<td>3</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>93</td>
<td>1,367</td>
<td>29,853</td>
</tr>
</tbody>
</table>

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**Table II—Frequency Bands for Microwave Development**

<table>
<thead>
<tr>
<th>Type of Service</th>
<th>Frequency in MC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common-carrier</td>
<td>3,700–4,200</td>
</tr>
<tr>
<td></td>
<td>5,925–6,425</td>
</tr>
<tr>
<td></td>
<td>10,700–11,700</td>
</tr>
<tr>
<td>Private users</td>
<td>952–950</td>
</tr>
<tr>
<td></td>
<td>1,850–1,990</td>
</tr>
<tr>
<td></td>
<td>2,110–2,200</td>
</tr>
<tr>
<td></td>
<td>2,500–2,700</td>
</tr>
<tr>
<td></td>
<td>6,575–6,875</td>
</tr>
<tr>
<td></td>
<td>12,200–12,700</td>
</tr>
<tr>
<td>U. S. Gov’t</td>
<td>1,700–1,850</td>
</tr>
<tr>
<td></td>
<td>2,200–2,300</td>
</tr>
<tr>
<td></td>
<td>4,400–5,000</td>
</tr>
<tr>
<td></td>
<td>7,125–8,500</td>
</tr>
<tr>
<td>Televisio pickup &amp; STL</td>
<td>1,990–2,110</td>
</tr>
<tr>
<td></td>
<td>6,875–7,125</td>
</tr>
<tr>
<td></td>
<td>12,700–13,200</td>
</tr>
</tbody>
</table>

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**FIG. 1—Common carrier (tel & tel) has enjoyed greatest growth and leads all other microwave services**
microwave systems are shown in Fig. 4.

Other Systems

Other microwave users account for less than one tenth of the non-common-carrier business. Some services, however, offer great possibilities. For example, rumors are current from time to time that this or that railroad will go microwave for so many thousand route miles. Railroaders' interest in microwave frequently ties back to a telephone company's attitude on interconnection. Railroads will invest more heavily in microwave when they are assured that their new systems will be accorded the same interconnection privileges as existing wire lines.

One mining firm has installed an extensive microwave system to help coordinate its widespread operations but, in general, the major industrial microwave market is still in the future. Microwave for police communications, on the other hand, is going hand in hand with the building of new super turnpikes. First the Pennsylvania Turnpike was equipped for microwave communication along the right of way, then the New Jersey Turnpike and, most recently, the Ohio Turnpike as the turnpike network spread across the country.

Strong interest has been evidenced by state governments in microwave networks to handle police, highway maintenance, conservation, civilian defense and general administrative matters throughout a state. This potential market is intimately bound up in the intricacies of politics.

A map of miscellaneous users of microwave is shown in Fig. 5.

Broadcasting

Use of microwave equipment by television stations is increasing. There are 194 microwave studio-transmitter links and 43 stations used for intercity transmission of television signals. The latter are usually private systems set up to provide network programming for a station in cases where common-carrier service is not available.

Security prevents obtaining figures on the use of microwave communications equipment by the armed services. Many installations have, however, been made both here and abroad linking major headquarters and other installations to pass operational and administrative traffic and in some cases radar signals. Truck-carried equipment has been developed to provide the mobility essential to a military communications network operating in what may become a forward area.

The actual amount of military microwave equipment in use has not been revealed but a manufacturer who does a lot of military business claims to have shipped around 1,000 complete equipments —only a fraction of which are accounted for in the civilian market. It seems probable that military microwave is at least as big as private and common-carrier combined.
Germanium Modulator for Infrared Communication

Transparency of germanium to infrared radiation is controlled by injection of charge carriers to provide direct modulation of light beam. Typical design example is given for a-f modulator having response 3 db down at 10 kc

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Numerous infrared communication systems have been devised in the past with limited success.

The systems differed primarily in the transmitter and in particular in the method of modulation of the infrared carrier. A tungsten-filament lamp may be modulated directly by applying the audio signal directly to the filament. Due to the long thermal time constant of the filament, the response time and hence the bandwidth of such a system is limited.

Alternatively a gas-discharge tube, giving emission lines in the infrared region, may be used as the source of transmitter power. Very high modulation frequencies can then be obtained but the available power is seriously limited. Using a tungsten lamp source (a very efficient source of infrared radiation) and a mechanical shutter arrangement, some excellent shutters have been devised, but the high speed of operation required usually implies large size and high cost of construction.

This article describes an electronic replacement for the mechanical shutter making use of the transparency of germanium to infrared radiation. Infrared modulators made with germanium crystals are small, simple to make and reasonably efficient.

A germanium crystal is completely opaque to visible light but at a wavelength of 1.8 microns in the infrared region becomes almost completely transparent. There

Design Example For A-F Modulator

Infrared carrier wavelength = 2 microns
Therefore $\alpha = 1.6 \times 10^{-16}$ cm$^2$
Resistivity of germanium crystal = 1 ohm·cm
Carrier lifetime in germanium crystal = 25 µsec
Length of modulator, $x = 1.2$ cm (Eq. 1)
Thickness of modulator, $y = 0.2$ cm
Width of modulator, $z = 0.2$ mm
Mean transit time = 50 µsec
Therefore bias current is 50 ma (Eq. 2)
Therefore response is down 3 db at approximately 9.5 kc (Eq. 3)
As Eq. 1 is fulfilled it can be shown that the peak modulation depth obtainable is 50 percent.

Reduction in transmitter power due to background absorption in the germanium is about 1½ db and reduction due to reflection, scattering and other uncontrolled factors is about 4 db. Losses of this magnitude are not usually important.
is a small amount of optical absorption left and this has been ascribed to the free electrons or other charge carriers in the germanium. It is known from the theory of germanium transistors that a rectifying contact on germanium, biased in the forward direction, injects charge carriers into the crystal. It follows, therefore, that the transparency of germanium to infrared radiation can be varied by injecting carriers which will give rise to additional optical absorption.

**Effect of Absorption**

In theory the injected carriers give rise to increased absorption at all wavelengths, but in practice the absorption in the visible wavelengths and out to 1.8 microns is so large that the contribution of the injected carriers is quite negligible. Hence germanium modulators can only be used at wavelengths greater than 1.8 microns. No upper limit of wavelength can yet be specified. Modulators have been used up to 12 microns and theoretically the effect should still exist at millimeter wavelengths.

**Modulator Design**

Consider a simple rectangular block of crystalline germanium, as illustrated in Fig. 1. Focused light from a tungsten lamp source enters at one end. The visible and short wavelength components are completely absorbed and the infrared radiation is transmitted through the material. Due to the high refractive index of germanium (about 4) the crystal behaves as a light pipe and the beam is kept in the crystal by total internal reflection off the walls. The carriers injected into the crystal vary its transparency to infrared and hence modulate the amplitude of the transmitted beam.

When a germanium modulator is to be designed for an infrared communication system there are a number of factors affecting the shape, size and construction of the modulator which must be considered. The increase in charge-carrier density in the crystal that can be obtained by injection is not very large. If, however, the infrared radiation has to pass through a sufficiently long crystal even a low density of injected carriers will give rise to an appreciable amount of absorption. Hence the depth of modulation increases with the length of the modulator. The absorption in the germanium without injection is, however, not zero because of the charge carriers (electrons in n-type germanium) already present. Increasing the length of the optical path in the crystal therefore increases the background absorption, with a consequent loss of transmitted power. It follows, then, that there must be an optimum length for a modulator. This is given approximately, for n-type germanium, by

\[ x_a = 1.9 \times 10^{-14} R \mu \text{cm} \]  

(1)

where \( R \) is the resistivity of the germanium in ohm-cm and \( \mu \) is the absorption coefficient per unit length for carriers.

\[ \text{absorption} = \text{injected carriers} \times \text{absorption coefficient} \]

\[ \text{absorption} = 1.9 \times 10^{-14} R \mu \text{cm} \]

Chose a value for \( R \) and \( \mu \) and find the necessary length for the modulator.

**FIG. 1—Modulator uses transistor-type connections. Signal across modulator varies charge density in crystal**

**FIG. 2—Modified design of modulator providing larger acceptance area \( yz \) for improved performance**

**Charge Carriers**

Charge carriers injected into germanium tend to recombine; their average expectancy of life being referred to as the carrier lifetime \( \tau \). The value of \( \tau \) is determined primarily by the purity of the germanium crystal and is usually between a few microseconds and a few milliseconds.

The time taken for the injected carriers to cross the crystal is determined by the voltage across, and hence the current through, the modulator and is given approximately by

\[ t = yz/1 \mu R \text{ seconds} \]

(2)

where \( I \) is the current in amperes and \( \mu \), the carrier mobility, equals 1,700 sq cm per volt-second in n-type germanium. If the transit time \( t \) of the carriers is much less than their lifetime, so that none of them recombine, they will be swept out of the crystal as fast as they are injected. In this condition the number of carriers in the crystal no longer increases with current and the modulator saturates. The condition for saturation can be taken as a measure of the efficiency of the device. The lower the current required for saturation the more sensitive is the modulator. For this reason it is desirable to keep the area \( yz \) as small as possible.

Another feature of the modulator which may influence the choice
of the area ζ is frequency response. When sinusoidal modulation is desired the modulator is normally operated with a steady bias current. This current determines a mean transit time (Eq. 2) and response of the modulator is flat up to a frequency given approximately by

\[ f = \pi + \tau/2\pi \tau t \]  

(3)

If pulse modulation is used, turn-off time \( (I = 0) \) is equal to \( \tau \) and turn-on time \( (I = I_{\text{bias}}) \) is \( \tau/(\pi + \tau) \).

Carrier lifetime in the germanium is also at the disposal of the designer within certain limits and considerations of frequency response, efficiency and maximum rated current will clearly influence the choice made.

The data given refers to simple rectangular modulators, as shown in Fig. 1. Since germanium acts as a light pipe in the infrared region, structures of the type shown in Fig. 2 may be used, coupling the advantages of a large acceptance area with a small value of \( z \) for use in Eq. 2.

Finally it may be noted that Eq. 2 only determines the product \( \tau z \) and not the shape of the acceptance area. The latter can be chosen to suit the shape of the image from the infrared source.

**Electrical Connections**

As in a germanium diode, a low-resistance base connection is soldered along the bottom of the crystal. The injecting contact on the opposite surface may be made with pointed wire contacts, wires laid flat on the crystal and held in place with a rubber pad, evaporated metal contacts or by fabricating a \( p-n \) junction on the germanium surface by indium diffusion. The efficiency of injection of all these contacts is sufficiently near 100 percent for practical purposes. Junction or large-area contacts have a lower resistance and will materially reduce heat dissipation and power necessary to drive the modulator but otherwise the choice is one of convenience.

**Modulator Operation**

Carriers are injected into the germanium only when the modulator, considered as a diode, is biased in the low-resistance direction. The modulation impressed on the infrared beam will therefore be half-wave rectified. To avoid this the modulator must be biased in the forward direction and the signal drive current kept within this limit. At high currents, saturation occurs, therefore the bias current is chosen so that \( t \) (Eq. 2) equals about \( 2\tau \). This implies that, on the average, the injected carriers die off when they are about halfway across the crystal. If operation at higher frequencies is desired, at the cost of reduced sensitivity and increased distortion, the value of the bias current may be increased.

The rate of carrier injection is determined by driving current rather than voltage. Since the forward characteristic of a diode is nonlinear a voltage drive will cause distortion. This difficulty is overcome by feeding the modulator from a high-impedance current source. Distortion also arises from the fact that carrier injection reduces the resistivity of the crystal by a significant fraction. This is also overcome by using a current drive.

By way of example, an infrared communication set will be described. This set was demonstrated at the April 1953 exhibition of the Physical Society in London. The system was by no means ideal since the use of an off-axis optical system is undesirable, but was quite adequate for demonstration purposes.

**Receiver**

The receiver consisted of a 5-cm focal-length spherical mirror which focused the incoming infrared beam on a commercial lead-sulfide cell. These cells decrease in resistance when illuminated by infrared radiation of any wavelength less than about 2.8 microns. The effective carrier wavelength band was therefore about 1.8 microns to 2.8 microns, set by the transmission of the germanium and the sensitivity of the lead-sulfide cell respectively. The frequency response of the lead-sulfide cell and the modulator were about the same, flat from about 25 to about 6,000 cps. The output from the cell was fed to a conventional audio amplifier and loudspeaker. The quality of the transmission under these conditions was determined by the surface noise of the recording.

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Radio Receiver Counts Lightning Strokes

Lightning strokes are recorded automatically on direct-readout counter at output of radio receiver that is adjusted to pick up discharges within predetermined radius. Full-wave semiconductor detector is used for strokes of either polarity in 8 to 20-ke range.

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Techniques for locating and mapping thunderstorm centers have been devised that vary from complex direction-finding networks for long-range charting of thunderstorms to aural observation of thunder by the meteorologist.

There remains the need for an additional method of detecting and evaluating the thunderstorm activity at various points on the earth. International scientific organizations have recommended development of simple apparatus suitable for wide distribution among meteorological stations and intended to replace the human ear for aural observations of electric discharge.

Such an instrument should supply statistical information on the frequency of thunderstorms, detecting discharges over the range of aural detection, or not farther than fifteen miles from the point of observation. It must be inexpensive to produce, maintain and operate. Simple operation and self-calibration must be possible without the use of expensive signal generators or trained personnel.

Stroke Counter

The Atmospheric Noise Research Laboratory of the University of Florida has developed such an instrument described below.

Basically, the counter comprises functional blocks shown in Fig. 1. Output of an antenna is fed into a low-gain amplifier stage, full-wave detector, amplifier and a relay that actuates a mechanical counter. Detailed operation of the counter is described in terms of the circuit diagram shown in Fig 2.

Input Circuit

Since the preponderance of power in a lightning stroke is found in the frequency range from 8 to 20 kc, it was decided to operate the counter in this range. This requires that the input impedance be high, since vertical and horizontal antennas of practical dimensions exhibit high output impedances in this frequency range. Therefore, values of C1 and R1 are chosen such that power-line voltages and their major harmonics will not operate the counter. At the same time, the input impedance is in the order of 1 megohm for the frequency range of interest.

Amplifier and Rectifier

Two amplifier stages employing type 1N5 tubes are used to permit satisfactory operation from either a battery pack or conventional a-c supply. The input tube is operated as a class A voltage amplifier that is transformer-coupled to a bridge rectifier. The necessity for a bridge circuit is understood from consideration of the nature of the lightning stroke. There are conditions under which the polarity of the major portion of the stroke may be either positive or negative. To count most of the strokes, it is necessary to utilize both the positive and negative portions of the stroke.

Duration of a lightning stroke is relatively short. For operating a slow-acting mechanical counter it is necessary to include a short-charge long-discharge circuit that will hold the relay closed long enough for the counter to operate. The charge time of the network is determined by the forward resistance of the diodes of the bridge rectifier, the impedance looking back into T1, and the value of C1. The discharge path through R3 is comparatively long with an actual value of 1 second.

Relay and Counter

Second stage V3 is normally biased to approximately cutoff potential, so that when a pulse of positive voltage appears on its grid relay K1 is closed. This places 90 v d-c across the counter causing a
Counter is initially calibrated against aural and visual observations

Top view of counter chassis shows electromechanical counter on panel

Underside of chassis shows simplicity of wiring and relay at upper right

count to be registered. Adjustment of the control-grid bias on \( V_g \) determines the level at which the relay operates and consequently the overall sensitivity of the counter.

**Calibration**

Calibration of the counter is accomplished by momentarily closing \( S_1 \), which places a d-c voltage of predetermined value on the control grid of \( V_g \). The actual value of the calibrating voltage is determined by the desired sensitivity of the counter which is, in turn, a function of the antenna used and the average intensity of strokes in a given locality.

Adjustment should be determined through a study made at or near the locality at which the counter is to be operated. A sensitivity of approximately 0.1 \( \text{v rms} \) has been found to be satisfactory in Florida when a 100-ft horizontal antenna elevated 30 ft is used. Once the calibration voltage has been set, closing the test switch determines if the counter is functioning properly.

Counting rate is 2 cycles a second maximum using the electromechanical counter shown, which has a total capacity of 99,999 counts. Frequency response is \( \pm 3 \text{ db} \) from 10 to 28 kc. Line-voltage changes from 100 to 120 volts result in only \( \pm 3 \text{ db} \) change in sensitivity.

**Performance Tests**

It is difficult to assess accurately the number of lightning strokes occurring within a given thunderstorm and the range from the receiving antenna to the point of discharge. However, since the device is designed to operate within the aural range of thunder, the method used to calibrate the instrument consists of measuring the elapsed time between the occurrence of the stroke and the time that thunder is heard. From this time measurement the range to the stroke is computed.

Results obtained in Florida indicate that the maximum range at which thunder can be heard is approximately 8 to 10 miles with approximately 90 percent of all local strokes being counted. In several cases strokes were counted when no thunder was heard. The range in these cases is indeterminate, but during one nighttime storm when the flashes were visible, counts were made when the range was estimated to be between 15 and 25 miles.

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**FIG. 2**—Counter unit can be operated from batteries or power line as shown. Input is connected to suitable antenna. Bridge rectifier insures counting every lightning stroke since polarity may be either positive or negative.
Fifty-Watt Amplifier

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 SIZE OF AN AMPLIFIER package and its cost are dependent largely on the efficiency of operation and the power sensitivity of the output stage. Beam power tubes satisfy these two requirements more readily than triodes. The quality of the audio power is improved by the use of push-pull operation and large amounts of feedback. Use of a suitable amount and type of feedback with beam-power tubes overcomes the advantage of inherently low output impedance obtained with triodes. The development of the power amplifier discussed in this article was undertaken with the objective of providing a large amount of good quality audio power in a small package at relatively low cost.

Basic Circuit

The basic power amplifier circuit shown in Fig. 1 is capable of employing large amounts of feedback with good stability. This circuit has been operated with 36 db of feedback without showing any trace of instability. However, since the driving voltage required under these conditions is too great, the circuit is normally used with only 24 db of feedback.

The 12AX7 is used as a phase inverter, amplifier and driver stage. It is direct-coupled to the beam-power output tubes and the operation is essentially class B, since the high-impedance driver stage is incapable of driving the power-tube grids positive. An added advantage of the direct-coupled driver is that it eliminates the possibility of blocking due to excessive input signal.

The two output-tube cathodes are returned to ground and therefore any combination of screen and plate supply voltage may be used. The circuit shown will keep both screen and plate dissipation below the rated values for full-signal class-B operation with either 1614's or 807's. The bias for the output tubes is supplied by the 12AX7 and is normally adjusted to produce a zero-signal plate current of about 15 ma per tube. The high value of cathode resistance makes the driver circuit fundamentally stable.

A test with six 1614's and twelve

FIG. 1—Basic power amplifier has large amount of inverse feedback without trace of instability

FIG. 2—Voltage relations in bifilar output transformer with different primary connections

Fifty-watt amplifier uses 1614 output tubes. Output transformer is shown mounted on chassis in its normal position, but not potted.
for High-Quality Audio

Push-pull amplifier uses transposed-bifilar output transformer to overcome difficulties associated with class-B operation. Quality is enhanced by 24-db feedback. Winding and core data are given for construction of transformer.

12AX7's, of different manufacturers and chosen at random, produced a zero-signal plate current variation ranging from 10 to 25 ma per tube. Full-signal operation was substantially independent of the choice of 12AX7 and beam power output tubes.

The feedback winding is electrostatically shielded from the secondary, but very closely coupled to it. The electrostatic shield greatly increases the amount of feedback that can be used successfully.

The problems encountered with class-B operation are considerably more severe than those occurring in class-A operation, but the higher efficiency makes it possible to increase the power output by a factor of three or more, for the same investment and space.

Bifilar Windings

One of the major problems associated with class-B operation is due to energy stored in the leakage reactance between the two primary windings. This stored energy gives rise to a conduction transfer notch which must be eliminated before class-B operation can be used successfully. Several different winding schemes will reduce the leakage reactance below the critical value but the most successful one is that of using a bifilar winding for the two primary sections.

A significant problem caused by the use of bifilar windings is that appreciable capacitance exists between the adjacent wires and charging current must be supplied to this capacitance before any voltage can be developed between the wires. This charging current must be supplied through the output-stage tubes and is one of the major factors limiting high-frequency power-delivering capacity of an amplifier.

This problem can be understood more readily by examining the circuit of Fig. 2A. The bifilar primary has been separated into two sections and the secondary sandwiched between them to keep leakage reactance between the primaries and secondary low. The four primary sections have been symmetrically interconnected and there is negligible d-c voltage between them. If a peak signal voltage of 250 volts is assumed on each of the primary sections, as shown by the vertical arrows, this will give rise to a peak signal voltage of 500 volts between all adjacent points on the bifilar winding as shown by the horizontal arrows. The undesirable feature is that before this voltage can appear between the two primary windings the interwinding capacitance must be suitably charged and charging current must flow through one of the two tubes.

An experimental transformer of this type, wound with adjacent wire layer bifilar winding, using No. 28 HF wire, was found to have a capacitance of 0.045 microfarad between the two primary windings.

Primary Variations

Figure 2B shows a different connection of the primary sections. The voltage between the lower sections of the bifilar winding has been reduced to 250 volts but the voltage between the upper sections has been correspondingly increased to 750 volts. The total interwinding charging current is the same as before but the insulation burden on the
upper section is greater than before. Further sectionalization and reconnection of the primary will not reduce the charging-current problem and will in most cases increase the burden on the insulation.

The design of the transformer used in Fig. 1 presents a solution to the problem introduced by the primary interwinding capacitance. In the general case of two isolated parallel circular wires an increase of the spacing between the surfaces from 10 percent to 20 percent of the diameter of the wire will reduce the capacitance between these wires by approximately 30 percent. An increase of this spacing from 10 percent to 100 percent of the diameter of the wire will reduce the capacitance by approximately 70 percent.

In the transformer winding the same general principles apply. Each wire will have capacitance to the two wires on each side of it in the same layer and also to the wires in the layers above and below it. The capacitance between wires in the same layer can be cut in half by transposing the two wires of the bifilar wire at every turn. The capacitance between wires in adjacent layers will not be modified by this process. In the nontransposed winding, assuming the same spacing between layer centers that exists between adjacent wire centers in a layer and uniform distribution of electric material, the capacitance between the wires in the layers accounts for approximately two thirds of the total capacitance. Capacitance between wires in adjacent layers accounts for one third of the total capacitance. Since transposition of the wires can halve capacitance between wires in a layer without disturbing the capacitance between wires in adjacent layers, it should reduce the total capacitance to two thirds of its original value. Use of insulating materials such as cotton, varnish and wax and accumulation of moisture will all tend to increase the capacitance.

The safety factor provided by the bifilar type of winding has so far been sufficiently large to avoid the appearance of the conduction transfer notch.

Figure 3 shows the coil buildup of the output transformer used in the circuit of Fig. 1. This figure is drawn in proper vertical scale. The horizontal scale has been modified to show the relative positions of the windings in a reasonable amount of space. This transformer winding was designed to be used with two grain-oriented Hipersil C cores. The nominal impedance levels were intended to be 4, 8 and 16 ohms but the optimum levels obtained with this transformer were 4.63, 9.25 and 18.5 ohms. An optimum value resistor was used on the 9.25-ohm tap in all of the succeeding tests.

The transformer of Fig. 3 had a primary interwinding capacitance of 0.010 microfarad when it was vacuum impregnated with clear baking varnish and baked for the prescribed amount of time. This transformer was potted and has maintained the same value of capacitance since that time.

To obtain the same low-frequency power-delivering capacity with an ordinary non-grain-oriented core it is necessary to increase both the core cross section and the number of turns by about 25 percent. The combined effect of these increases is that the primary interwinding capacitance increases by a factor of approximately 50 percent.

**Amplifier Specifications**

The circuit of Fig. 1 was used with the transformer of Fig. 3 with transformer-coupled input. The input transformer had an electrostatic shield connected to ground. With well-regulated screen and plate supply voltages, the residual hum in the input was 96 db below 50 watts. For this particular amplifier, without any special attempt to obtain good balance, a ripple voltage of 42 volts inserted in series with the plate supply or 9 volts inserted in series with the screen supply was necessary to bring the residual hum level in the output to 80 db below 50 watts.

The power delivering capacity of this amplifier was tested by setting the input signal level at the value necessary to produce 2-percent distortion in the output. Figure 4

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**FIG. 5—Complete fifty-watt amplifier with preamplifier delivers full output with 0.8-volt rms input signal. Voltages indicated are measured with zero-signal input.**
shows the results of this test. In the range below 30 cps the output was limited by the inability of the 1614's tubes to supply adequate magnetizing current to the transformer. Between 30 and 3,000 cps the output was limited by peak clipping due to the inability of the 12AX7's to drive the 1614 grids positive. Above 3,000 cps the output was limited by the inability of the 1614's to supply the charging current required by the primary interwinding capacitance.

Most of the power in speech, song and music is contained in the fundamental tones with frequencies below 3,000 cps. The power levels of the higher frequency fundamental tones and of the harmonics of the lower-frequency fundamentals drop off at a greater rate than the power-delivering capacity of this amplifier.

The amplifier develops its full-power output of 60 watts over most of the middle-frequency range with total plate-circuit losses, including transformer losses, considerably lower than the rated CCS values.

Since transformer-coupled input is not usually available for amplifiers of this type the circuit of Fig. 5, which includes a preamplifier and power supply was developed. This circuit was designed to deliver 50 watts of high-quality power over most of the middle-frequency range. Since the output stage is insensitive to ripple in the screen and plate supplies, very simple power supply filter circuits are adequate.

Preamplifier

The preamplifier consists of a two-stage R-C amplifier with feedback between the second plate and first cathode. This feedback provides good wave shape and low output impedance on the preamplifier.

The preamplifier is coupled to the 12AX7 grid with a 1.25 μf capacitor and a Thordarson T20C51 choke modified by interleaving its laminations. A low d-c resistance is necessary because the 12AX7 has appreciable grid current when the grid voltage becomes more positive than −1 volt and this grid current must not be allowed to change the bias relations of the phase inverter. This coupling circuit has a low-Q resonance between 10 and 15 cps.

Feedback from the secondary of the transformer is incorporated and additional overall feedback introduced from the 4.63-ohm tap to the first cathode in the preamplifier. A complex bridged-T network produced the best high-frequency square-wave response, but the square-wave response was adequate when a simple 15-μf capacitor was substituted in the overall feedback circuit. This capacitor has no effect on the low-frequency response but reduces the tendency of the amplifier to ring slightly with sharp-risetime square-wave inputs. The waveforms of Fig. 6 show how ringing, following the leading edge of a 10-watt 5-μc square wave, is modified by varying the value of this capacitor. The rise time of the leading edge is approximately 7.5 microseconds between the 10-percent and 90-percent points and the ringing frequency is approximately 100 kc.

The complete square-wave response at 50, 500 and 5,000 cps and power levels of 10 and 40 watts is shown in Fig. 7.

The results of tests made to determine the best balance between the various types of feedback are shown in Fig. 8. Curves 1 and 2 have adequate feedback turns to correct for class-B operation at low-power levels. The bridged-T overall-feedback network produced 6-db feedback at operating frequencies so that curve 1 is lower than curve 2 at high-power levels. Curve 3 has much less low-level distortion than curve 2 because of the additional feedback turns, but it requires more drive from the preamplifier and therefore has higher distortion than curve 2 at high-power levels. Curve 4 uses approximately 6-db additional feedback in the pre-
amplifier and its distortion is satisfactory at both low and high-power levels. The 15-muf overall feedback has no effect at these frequencies.

The values of feedback turns and preamplifier feedback resistance used in obtaining curve 4 represent a practical compromise between low-input signal and low-output distortion. Additional reduction in distortion could be obtained by increasing the turns on the feedback winding and reducing the value of the feedback resistor in the preamplifier. Both of these changes would increase the input voltage required to produce full output power. The conditions specified for curve 4 are the ones shown in the circuit diagram of Fig. 5 and are used in all succeeding tests.

**Power-Loss Characteristics**

Figure 9 shows the curves of plate-circuit losses (including transformer losses) and screen dissipation as the output power is varied. The plate-circuit losses are less than the rated CCS values for all operating conditions. The screen dissipation becomes equal to the rated CCS value at the highest power level shown but is less than the rated value at lower levels.

The 2-percent distortion power-delivering capacity together with the corresponding plate-circuit losses and screen dissipation are shown in Fig. 10. The highest plate-circuit efficiency, including transformer losses, occurs at 1,000 cps and is 69 percent. If the transformer losses are considered a part of the tube output, the plate efficiency becomes 72 percent.

The frequency-response characteristics, together with the power-delivering capacity curve, plotted on a db scale, are shown in Fig. 11. The diagram shows that as long as the operating level is below the 2-percent distortion curve the response is flat between 100 and 20,000 cps. Below 100 cps the response rises slightly due to series resonance in the impedance-coupled circuit. This rise can be controlled by modifying the values of the coupling capacitor and choke.

At low levels the response above 20,000 cps depends on the amount of feedback capacitance used. The curve for $C_r = 0$ rises to a maximum at about 85 kc and then drops off rapidly. The curve for $C_r = 15$ muf is almost perfectly flat to 95 kc after which it also drops off very rapidly. A curve for Gaussian response with a $-3$-db point at 75 kc has been shown for comparison. The ringing frequency of approximately 100 kc corresponds closely to the region of maximum deviation of the actual response characteristic from the Gaussian response. This shows also why the use of $C_r = 15$ muf reduces the ringing amplitude obtained with a square-wave input.

**Distortion**

Figure 12 shows the results of intermodulation-distortion tests using 4:1 combinations of 60 and 1,500 cps and 60 and 15,000 cps. The resulting distortion is plotted as a percentage of the smaller of the two signals. The values shown are acceptable beyond the 100-percent peak-to-peak equivalent input.

Good transient response for loudspeaker loads is assured by the low output impedance which is approxi- mately 10 percent of the nominal impedance between 20 and 20,000 cps.

The residual 120-cycle hum in the complete amplifier is slightly greater than that measured in the basic amplifier with transformer-coupled input—about 80 db below 50 watts.

Residual 60-cycle hum is picked up inductively from the power transformer by the unshielded modified choke and is about 66 db below 50 watts.

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Regulated D-C Supply Has High Efficiency

Two-hundred-watt power supply uses magnetic amplifiers to regulate slow line-voltage and load changes and electronic circuitry to regulate rapid changes. Technique may be applied to regulation of d-c generators as well as rectifier power supplies.

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Modern use of electronics often imposes requirements on regulated d-c power supplies that can be met only by high efficiency regulation. These requirements are large power output, small size, low output impedance at all frequencies and reliable operation under conditions of high ambient temperature and low air density.

A method of accomplishing high efficiency regulation is to divide the responsibility between two different high efficiency regulators—namely, a magnetic amplifier which regulates against slow line-voltage and load changes, and a circuit, termed a clamping, which regulates against fast changes of a-c load and line voltage.

Conventional regulated d-c power supplies accomplish regulation with control tubes, which are connected either in series with the d-c output to furnish a variable voltage drop, or in parallel with the load to control the output voltage by drawing a current through the internal impedance of the supply. In either case, these control tubes lower the supply efficiency greatly by their continuous plate and filament power dissipation.

A more efficiently regulated d-c power supply is one using a magnetic amplifier to provide a variable voltage drop in the a-c portion of the supply. Such a device can provide this drop while suffering only the small losses due to power dissipation in the copper, cores and internal impedance of the control and bias power sources. However, the magnetic amplifier has an inherently slow response which destroys its usefulness in many regulated power supplies unless it can be used in conjunction with some circuits which cancel out the fast load and line changes. While this circuitry need regulate only fast changes, it must involve such low losses and little additional space that the gains from using the magnetic amplifier are not lost.

Slow Regulation

Circuits using magnetic amplifiers for regulating against slow changes of load and line voltage in a rectifier-filter type d-c power supply are shown in Fig. 1. Rectifier tubes are employed in Fig. 1A, while selenium rectifiers are made use of in Fig. 1B.

There are other circuit configura-

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FIG. 1—Direct-current power supplies with L-input filters using magnetic amplifiers for regulation: full-wave (A) and bridge (B)

ELECTRONICS — October, 1954
tions which incorporate a magnetic amplifier as a regulator in this type of supply, but the circuits of Fig. 1 make it possible to use an inductor-input filter along with a magnetic amplifier of any type core.

The advantage of an inductor-input over a capacitor-input filter cannot be overlooked when designing a high-efficiency supply. The form factor of the current drawn through the transformer and rectifier can be as high as three with a capacitor-input filter, and as low as one with an inductor-input filter. The current form factor is an indication of supply efficiency, since by definition it is the ratio of the rms to the average value of the current.

The difficulty involved with using a magnetic amplifier with an inductor-input filter arises when using a magnetic amplifier made of cores with rectangular hysteresis loops in the magnetic amplifier and thus making it essentially a gating device. It then must create a discontinuous current while the choke attempts to create a continuous current. This situation is avoided in the circuits of Fig. 1 since they provide a path for a circulating current which passes through the choke, but not through the magnetic amplifier.

Note also in Fig. 1 that a d-c amplifier is used to amplify the error voltage and drive the magnetic amplifier by means of a control tube. Use of electronic circuitry to drive the magnetic amplifier can be defended on the grounds that less gain in the magnetic amplifier is then needed and the magnetic amplifier can thus be made faster and with characteristics more independent of environment and manufacturing tolerances. However, in the complete regulated supply which will be described in this article, the d-c amplifier is a necessary part of the system. By using it to drive the magnetic amplifier it becomes part of a low-pass negative-feedback loop, thus eliminating the drift problem in the d-c amplifier.

Stabilization of the high-vain, degenerative-feedback loop, which includes the magnetic amplifier, is a difficult problem because of the phase shift through the two-section filter provided to attenuate the ripple. A large amount of filtering is necessary when using the regulator, since it will always attempt to remove the ripple in the output and will become saturated if the ripple is too large. The filter can be made smaller by the use of a 400-cps input-power source to increase the ripple frequency. The clamper itself aids the stability of the magnetic-amplifier control loop in several ways. It regulates down to frequencies as low as several cps, thus allowing the magnetic amplifier to have a long time constant. Also, the clamper maintains such a low output impedance at frequencies above several cps that the output capacitor is effectively shorted at these frequencies and the phase shift through the filter is reduced.

**Fast Regulation**

Electronic circuitry to supplement the action of the slow magnetic amplifier is shown in Fig. 2. The name clamper was suggested by the fact that this circuit effectively clamps the output voltage of the supply against a-c load and line changes.

The circuit contains two control tubes operating class B push-pull. The tubes may receive their driving voltage from a d-c amplifier, but are made insensitive to d-c changes by a conventional R-C coupling circuit. One tube is connected across the load (a d-c voltage can be connected in series with this control tube if the output voltage of the supply is not a suitable value for plate voltage) and the other is connected between the supply output and some higher voltage. Conduction by the tube in shunt with the load will cause the output voltage to decrease. The tube connected to the higher voltage is effectively in series with the load, so its conduction causes the output voltage to increase. The error voltage is amplified and then split and fed in phase opposition to the two control tubes.

In Fig. 2, the voltage is split by a phase-inverter circuit. When the output voltage of the supply tends to increase, it is held by the shunt tube being driven into conduction while the tube going to the higher voltage is driven into cutoff. When the output voltage of the supply tends to decrease, it is retarded by the tube (to the higher voltage) conducting, while the shunt tube is driven into cutoff. In either case, the R-C circuit between the inverter and each control tube forces these tubes only to supplement the regulation of the slow, but highly efficient, magnetic amplifier. Proper adjustment of the time constants of these R-C coupling circuits would force the system to lose regulation to a step change at a rate just slow enough to allow the magnetic amplifier to take over the regulation. In other words, the low end of the clamper passband just meets the high end of the magnetic-amplifier passband.

The large power and space saving in this type of regulator is due to the control tubes normally operating near cutoff and drawing large currents only when regulating a-c changes. Thus, the control tubes have a low plate dissipation and small tubes can be used.

The system is used most advantageously with supplies which must provide large direct currents and low ripple. Electronic circuitry usually provides this type of load. If these conditions were reversed, then it would be of benefit to use a series-tube regulator, for a large rms a-c could create undesirably heavy plate dissipation in the control tubes. Also, the system cannot ordinarily tolerate as much ripple from the unregulated supply as can the series-tube regulator, for the clamper removes ripple by drawing current through the internal impedance of the supply. Since this impedance usually is low at the ripple frequency, pro-

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hibitively high currents may be drawn by the two triode control tubes.

The immediate problem in applying the clamer is obtaining the high voltage for the upper control tube. Only a small quiescent current is drawn at this voltage, but large peak currents must be furnished. These requirements can be met by half-wave rectification into a large capacitor. No further filtering should be needed.

In a power supply using a magnetic amplifier and an inductor-input filter, peak voltages in the order of twice the output voltage of the supply appear at the filter input. These peaks can be used to charge a capacitor through a rectifier to a high d-c potential. This latter arrangement is advantageous in that the capacitor is charged at twice the line frequency and the rectifier back voltage never exceeds the voltage across the capacitor. Such an arrangement is used in the supply of Fig. 3.

**Circuit Example**

The circuit of Fig. 3 provides an output of 800 ma at 250 volts with an efficiency of 55 percent. This is an output of 200 watts and a power loss of 162 watts. The output impedance is less than one ohm at all frequencies and less than 0.1 ohm up to 20 kc. This output impedance holds for d-c load changes from zero to full load and for instantaneous load changes as great as 250 ma. Full regulation is maintained as the a-c input voltage varies from 100 to 150 volts and from 380 to 1,000 cps.

**Design Features**

The magnetic amplifier in the supply of Fig. 3 is wound on toroidal cores of a material with a rectangular hysteresis loop. This was done to obtain small size and high performance in spite of the condition that the input voltage can vary from 380 to 1,000 cps.

The 8,000-ohm resistor across the bias winding of the magnetic amplifier is used to adjust to a desired speed of response for the magnetic amplifier.

The relay system allows time for the tube filaments to warm before voltage is applied to the power transformer. It also removes the voltage from the power transformer when the negative 250 volts is not being provided.

The rectifier from the grid of the magnetic-amplifier control tube, V₃, to ground is necessary to prevent the control current from getting so large, under conditions of excessive line voltage, that the magnetic amplifier goes into the negative-gain region of its operation.

Bias for the a-c series-regulator tubes, V₄ and V₅, is effectively obtained from the same point as is the voltage which provides the plate voltage for these tubes. This is necessary since the plate voltages of V₄ and V₅ vary directly with the peak voltage at the input of the filter. This peak voltage, in turn, varies directly with the line voltage (although the average value is held constant by the magnetic amplifier). Thus, the quiescent currents through V₄ and V₅ would vary with line voltage if their biases were constant. However, since the bias voltages here vary with the plate voltages and the tubes are operating in the low-gain region near cutoff, plate currents change little with line voltage.

**D-C Generator Regulation**

The same basic type of regulation can be used for d-c generators as has been described here for a rectifier-filter type supply. Now, however, the clamer can be used either in conjunction with a magnetic amplifier or a carbon pile. If used with a carbon pile, the pile can be made use of either in its usual role of a complete regulator or as an amplifier-control element driven by the error signal existing in the circuitry.
Direct-Reading

Portable instrument using ionization chamber and d-c amplifier measures radiation strength of soft x-rays over ranges of 500, 2,500 and 25,000 roentgens per minute. Battery power source permits portable operation for application in x-ray therapy.

GREENZ-RAY THERAPY has gained considerable prominence for the treatment of a number of diseases and afflictions. These rays are very soft x-rays with a wavelength in the order of a few angstroms. Because the rays are very easily absorbed, even in organic matter, their measurement presents special problems in the design of equipment (dosimeters) with which their dosage rate can be determined. The dosimeter to be described gives an accurate measurement of the Grenz-ray radiation impinging on the area under treatment.

**Design Considerations**

The radiation intensity depends upon the potential and current of the machine producing the radiation, the distance between the source and area under treatment and, especially in the case of Grenz rays, on the window of the tube through which the rays are transmitted.

The physician administering the treatment must know accurately the number of roentgens units applied to the area under treatment. It is therefore necessary to calibrate the output of each Grenz-ray machine in roentgens per minute, for each potential, current and distance. It is also necessary to determine the penetration power or quality of the Grenz rays. This is usually given in terms of the half-value layer in microns of aluminum, which is the thickness that will halve the dosage rate of radiation.

**Ionization Chamber**

To obtain a meter indication proportional to the number of roentgens per minute it is necessary to obtain a small current exactly proportional to the number of roentgens per minute and amplify this current to a value sufficiently high to be read on an indicating instrument.

The first requirement, that of a proportional current, is obtained with an ionization chamber, shown in Fig. 1. The outside element is made of graphite and has the shape of a truncated cone. The larger diameter and height of the cone are about 1 cm and the wall thickness is between 0.5 and 1 mm.

The inner element or collector is a thin graphite rod, about 1 mm in diameter, similar to the lead of a mechanical pencil and insulated with amber from the outer element. A larger diameter of the collector must be avoided in order not to decrease the effective volume of the chamber. A very thin rod would produce too high a field strength near its surface.

The chamber is filled with air. At the top of the chamber is a thin film of organic material, which is coated with colloidal graphite (Aquadag) to render it conductive. Kodapak I, a commercial material, can be obtained in a thickness of 0.001 in. (25 microns) and has proved satisfactory. It is sufficiently strong so that the watery slurry of Aquadag can be easily applied with a brush. The film is chosen for its ability to transmit even the soft radiation with negligible absorption; at 10-micron aluminum half-value layer, less than 10 percent of the radiation is absorbed. In this way, the idea of the window of the Grenz-ray tube is applied to the ionization chamber.

In such an ionization chamber, the current depends only on the voltage applied to the chamber, until saturation is reached. The saturation current is proportional to the impinging dose rate of the ionizing radiation and, if the walls of the chamber are built of a material with the same effective

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FIG. 1—Sectional view of ionization chamber used as sensing element

FIG. 2—Direct-current amplifier uses battery power to achieve portability for maximum usefulness in measuring Grenz rays
Saturation current of graphite ionization chamber (left) produces a meter indication proportional to roentgens per minute. Three meters prevent reading wrong scale.

Grenz-Ray Dosimeter

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atomic number as air, the saturation current readings will be approximately independent of the wavelength of the radiation. This is the reason for the use of graphite as the chamber material.

Saturation current in the ionization chamber is in the order of 5 × 10^−6 amp for a Grenz-ray dosage rate of 1,000 r per min.

**Amplifier**

The amplifier is a conventional d-c feedback amplifier consisting, as shown in Fig. 2, of an input stage utilizing a 5800 electrometer tube, two amplifier stages and a cathode follower.

If the amplifier is simplified to the diagram of Fig. 3, the following analysis shows its performance

\[ e_i = i_i R_1 - i_2 R_2 \]
\[ i_2 = G_1 i_1 - i_1 R_2 \]
\[ i_0 = G_1 R_1 / (1 + GR_2) \]

where \( R_1 \) is the input resistor, \( R_2 \) is the output resistor, \( G \) is transfer function of amplifier, \( i_1 \) is input saturation current (proportional to radiation dosage rate), \( i_2 \) is output current and \( e_i \) input voltage.

If the requirement is met that

\[ GR_2 > 1, \quad e_i = i \frac{R}{R_2} \]

For this amplifier, \( GR_2 > 10,000 \), so that the error introduced by this approximation is negligible compared with the other sources of error, even for considerable variations in \( G \).

**Calibration**

Since the constant of the ionization chamber is difficult to calculate, the whole dosimeter is calibrated against a standard. The instrument described was calibrated by the National Bureau of Standards against an open-air ionization chamber and found to be exact within the usually permissible error.

Calibration values are listed in Table I. The last column shows that the sensitivity is constant, independent of dose rate and operating potential of the Grenz-ray machine. Additional tests have indicated that the error does not increase substantially even up to intensities of 25,000 r per min.

The complete instrument uses three indicating meters to prevent unskilled persons from reading wrong values, which might occur with multiple scales. The scales read directly in r per min. The three ranges of the instrument cover dosage rates to 500 r per min, 2,500 r per min and 25,000 r per min.

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Table I—Calibration of Grenz-Ray Dosimeter

<table>
<thead>
<tr>
<th>Grenz-Ray Potential</th>
<th>Dose Rate</th>
<th>Instrument Reading</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>kv</td>
<td>r per min</td>
<td>ma</td>
<td>r per min per ma</td>
</tr>
<tr>
<td>6</td>
<td>58.7</td>
<td>0.102</td>
<td>578</td>
</tr>
<tr>
<td>8</td>
<td>237.2</td>
<td>0.408</td>
<td>581</td>
</tr>
<tr>
<td>12</td>
<td>378.4</td>
<td>0.652</td>
<td>580</td>
</tr>
<tr>
<td>12</td>
<td>1.065</td>
<td>1.33</td>
<td>582</td>
</tr>
<tr>
<td>13</td>
<td>1.977</td>
<td>3.56</td>
<td>538</td>
</tr>
</tbody>
</table>

FIG. 3—Four-terminal network representation of amplifier in Fig. 2
MAGNETIC AMPLIFIERS have an inherent delay of one-half cycle of the supply frequency for each stage of amplification. The fast-response magnetic amplifier described in this article is capable of being used in several cascaded stages with a total time lag of less than one-half cycle. Ultimate speed of response is limited by the magnetic materials and by power considerations rather than by supply frequency.

The reduction in time lag between input and output signals of the magnetic amplifier results in an increase in the gain-bandwidth factor. This factor is a measure of the performance capabilities of an amplifier. A servo system utilizing a high-speed magnetic amplifier will be capable of greater accuracy and bandwidth than a system using a slower responding amplifier. These improvements in accuracy and bandwidth can be achieved with no reduction in system stability. Consequently, it is possible to design magnetic amplifiers into high-performance servo systems which...
Table I—Core Data For Three-Stage High-Speed Magnetic Amplifier

<table>
<thead>
<tr>
<th>STAGE 1</th>
<th>STAGE 2</th>
<th>STAGE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core—Arnold Eng 5340-81</td>
<td>Core—Arnold Eng 5233-81</td>
<td>Core—Magneetics, Inc. 50041-4A</td>
</tr>
<tr>
<td><strong>Amplifier</strong></td>
<td><strong>Amplifier</strong></td>
<td><strong>Amplifier</strong></td>
</tr>
<tr>
<td><strong>Switch</strong></td>
<td><strong>Switch</strong></td>
<td><strong>Switch</strong></td>
</tr>
<tr>
<td><strong>Winding</strong></td>
<td><strong>Turns</strong></td>
<td><strong>Wire Size</strong></td>
</tr>
<tr>
<td><strong>Signal</strong></td>
<td>360</td>
<td>42</td>
</tr>
<tr>
<td><strong>Load</strong></td>
<td>1,600</td>
<td>38</td>
</tr>
<tr>
<td><strong>Line</strong></td>
<td>2,500</td>
<td>42</td>
</tr>
</tbody>
</table>

Servo Amplifier

Performance of vacuum-tube amplifiers is approached by cascaded high-speed magnetic amplifiers for servo systems. Three-stage unit responds in less than half cycle of supply-voltage frequency, permitting use of error-rate feedback for stabilization.

will approximate the performance of servo loops utilizing vacuum-tube amplifiers. This is especially important when power is available only at 60 cycles per second.

**Circuit Operation**

To achieve fast-response characteristics, input and output of a magnetic amplifier must occur during the same half-cycle of the power-supply voltage. The basic circuit of the high-speed amplifier is shown in Fig. 1A with an idealized hysteresis loop of the cores in Fig. 1B.

To describe the operation of the circuit let the turns ratio between the signal windings $N_s$, the line windings $N_L$, and the load windings $N_R$ be unity. If line voltage $E_{line}$ is chosen so that any winding on one core will support one-eighth of the volt-seconds during one-half cycle of the supply voltage, then the two cores in series will saturate after one-fourth the volt-seconds of the line voltage per half cycle. Waveforms at various points in the circuit are shown in Fig. 2.

During any half cycle of supply voltage, there exist three possible states for the cores; both cores unsaturated, one core saturated and one unsaturated or both cores saturated. If line voltage is applied when both cores are in the minus saturated state ($-B_S$), Fig. 1B, then the line voltage will divide evenly between the cores and both cores will saturate in the plus state ($+B_S$) after one-fourth the volt-seconds in the half cycle. During the remainder of the half cycle, the line voltage will appear across $R_L$, Fig. 1A. The second half cycle will be the same except that the line voltage will have reversed and the cores will return to the $-B_S$ state.

If a signal voltage $E_S$ is introduced at the start of the second cycle of line voltage, the instantaneous voltages on cores 1 and 2 will differ by the signal voltage. For the polarity of signal voltage shown, there will be no current flow into load $R_L$. The signal voltage appears at the load windings, but the rectifier prevents current flow. Thus, the current from the signal source will be the incremental magnetizing current for the cores.

If the line voltage is positive at the top of the line windings at the time of the signal, core 1 will have the greater voltage and will saturate before core 2. When core 1 saturates, core 2 will have to support a number of volt-seconds equal to those of the signal in the time interval between the start of the half cycle and saturation of core 1. If $R_L$ is very large compared to $R_S$, the voltage on core 2 will be the line voltage less the $IR$ drop in $R_L$.

Since the signal source was required to supply only the incremental magnetizing current, it is possible to make $R_L$ rather large without appreciably reducing the effectiveness of the signal voltage. Core 2 will transmit power from the line into load resistor $R_L$, after saturation of core 1 and before saturation of core 2. This results from the fact that the polarity of the voltage at the load winding of core 2 is correct to pass current through the rectifier in series with the load. The volt-seconds delivered to the load will equal the volt-seconds from the signal while both cores were unsaturated.

If the signal continues for the next half cycle, core 2 will saturate first and core 1 will transmit power from the line to the load.

To cascade several stages of...
amplification, $R$, can be replaced by a signal winding of a second stage supplied from the same line voltage. The requirement for the second stage is that the cores should support more voltage than for the first stage. This is necessary since the signal-input period of each stage is the time when both its cores are unsaturated. In the same manner, additional stages of amplification can be achieved within the same half cycle of the supply voltage.

**Full-Wave Operation**

The basic circuit described is useful only as a d-c amplifier because reversing the polarity of the input signal causes signal current to flow into the load resistor and essentially no power gain results. To permit amplification of either polarity of input signal it is necessary to replace the rectifier in the output of the amplifier with a switch which is open when both cores are unsaturated and closed when one core is saturated and the other unsaturated.

This will disconnect the load from the circuit during the signal-input period and the signal source will be called upon to furnish only the incremental magnetizing current for either polarity input. The polarity of the input signal will determine the polarity of the output which, in turn, will make the amplifier-output polarity reversible for d-c signals, and phase reversible for signals at power frequency.

A suitable switching mechanism with magnetic amplifiers is shown in Fig. 3. Amplifier cores 1 and 2 are the same as before and cores 3 and 4 are constructed identically, except that no separate signal winding is used. The operation of the amplifier, cores 1 and 2, is the same as before. When the signal is applied, both cores are unsaturated and the signal voltage is transferred to the load windings of the amplifier.

The path for current flow into the load circuit, resulting from the signal voltage, is through resistors $R$ and $R''$, the load windings of cores 3 and 4 and two rectifiers of the bridge. Since cores 3 and 4 are always in the same state as cores 1 and 2, the signal voltage will result in the incremental magnetizing current flowing into the load windings of cores 3 and 4. The entire signal voltage will be impressed on cores 3 and 4. Load windings of this core pair act as the signal-input windings and the current supplied by the signal source is the incremental magnetizing current for core pairs 3-4 and 1-2. At the time that one core in the amplifier pair 1-2 saturates, one core in the switching core pair will saturate.

Regardless of the polarity of the signal $E_n$, the incremental magnetizing current through the switching cores will always flow in the same direction due to the rectifier bridge. Consequently, the output pulse of the switching-core pair will be of the same polarity and send current into both legs of the rectifier bridge. This current effects the closing of a switch between the load resistor $R$, and the load winding of the amplifier.

If $R'$ is equal to $R$ and $R''$, equal to $R''$, the switch will remain closed, during the period that the amplifier output power is delivered. The voltage across the unsaturated core will be impressed at the load resistor while one core in each pair is unsaturated.

**Three-Stage Amplifier**

A three-stage magnetic amplifier was constructed to energize the control phase of a two-phase, 60-cycle servo motor. The schematic diagram of this amplifier is shown in Fig. 4. Core winding data is given in Table I. The amplifier and switching cores for the first stage saturate after one-quarter of the a-c power volt-seconds have elapsed. The second-stage cores saturate at the one-half point and the third stage at the three-quarter point. To insure a proper sequencing, power for all three stages and their switching circuits comes from the same source. This removes the possibility that line voltage or frequency variations could alter the signal and power sequences for the cascaded stages.

The second and third stages of amplification and their respective switching circuits are operated directly from the 115-volt, 60-cps source. The series line windings in the second stage support 30 volts,
for each core, so that saturation occurs at the midway point for the two cores. The line windings of the third stage support 40 volts each. This causes saturation in both cores slightly before the three-quarter point of the half cycle of supply voltage.

It was impractical to design the first stage to support one-eighth of the line voltage for each core, since the small size of the cores used would make the number of turns prohibitive. For this reason, a reduced line voltage for the first stage was obtained by transformer coupling of the switching cores for stage 3. After both cores of the switching circuit for the third stage saturate, the line voltage of stage 1 drops to zero. This does not alter operation, since the cores in stage 1 are all saturated and no signal is effective until the line voltage reverses and the cores come out of saturation.

Oscillograms were taken, using a dual-beam oscilloscope, to illustrate the fractional-cycle response of the three-stage amplifier. Figure 5A shows the input-output relationship for a 2-volt 60-cycle rms signal. The output starts approximately one-fourth cycle later. Figure 5B shows the maximum delay for the three-stage amplifier. The input signal starts just after the saturation time of the cores in the first stage. The output does not start until the middle of the next half cycle. Figure 5C shows the response to a d-c input step. Output load for the amplifier was a 450-ohm resistor for all cases. Power gain is approximately 100,000.

The damping network used to stabilize the servo system of Fig. 4 serves a dual purpose. In addition to providing error-rate damping for the servo loop, the degenerative feedback around the amplifier reduces amplifier drift. This type of stabilization is made possible by the fast response of the amplifier.

To provide damping for the servo loop, the stabilizing network must have lag. When used with three stages of half-cycle response magnetic amplifiers, the stabilizing network causes oscillations of the amplifier because the lags of the amplifier and stabilizing network are too large to permit much negative feedback around the amplifier.

When used with the fast response magnetic amplifier, a large amount of negative feedback can be used around the amplifier without causing oscillations. This results in a simple stabilizing system and considerable reduction in drift for the servo system.

Although the drift of this type of magnetic amplifier is inherently low, the changing characteristics of rectifiers, particularly those associated with the first stage of amplification, can introduce some drift errors. Tests on the effect of rectifier leakage were made by shunting rectifiers with resistors to simulate leakage currents three times the manufacturer's ratings. With the stabilizing network reducing the effect of drift, the resultant change in the output position of the servo system was 0.1 degree. Without the stabilization, the drift would have been between one and two degrees.

The performance characteristics for the system described are listed in Table II.
High-Speed Counting
With One-Tube Decades

Hundred-kc counter uses decade scaler tube with 6J6 for zero reset. Experimental one-mc
circuit has pulse resolution time of less than one µsec. Diode biasing makes possible
interval timer and other circuits where scaling to less than ten is needed.

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**FIG. 1**—The E1T decade scaling tube

**FIG. 2**—One-tube decade counter circuit with passive elements

Single-tube decade counters have created considerable interest because of their low power
drain, of particular advantage where multiple scaling is required, as in multichannel pulse-height
analyzers.

The E1T decade scaling tube\(^1\), Fig. 1, is designed for the counting of voltage pulses at high speed.
It consists of the necessary electrodes to form a ribbon-shaped beam of electrons, a screen with ten slots,
each of which corresponds to a digit from zero to nine and a fluorescent screen for displaying
the position of the beam. A feedback system using a fine-mesh anode screen causes the beam to be
completely stable in any one of the

ten positions.

The left deflection plate is maintained at 160 volts, while the right deflection plate will vary from
about 245 volts in the zero position to 109 volts in the nine position. Stepping from one position to the
next may be accomplished by applying a positive triangular-shaped pulse to the left deflection plate.
The pulse rise time is fast enough to move the beam from one stable position to the next and the trail-off
time is sufficiently long to allow the beam to stabilize itself in the new position. The tenth pulse
moves the beam to the reset anode, giving rise to a negative pulse which may be used to reset the tube
to zero. The beam strikes the fluorescent screen to indicate its position. The position of the beam is
indicated electrically by the voltage of the right deflection plate.

**Single-Tube Circuit**

It is possible to operate the E1T tube as a decimal counter using only passive elements in the circuit
as shown in Fig. 2. Several of these counters have been constructed and operated with some success. It was
found that of 40 counter tubes on hand approximately one-half operated in this circuit satisfactorily.
When the reset coupling capacitor was increased from 100 µµf to 250 µµf, approximately 30 of the tubes
operated well in this circuit.

The common difficulty encountered was the problem of getting the tubes to reset reliably to zero.
Some tubes reset to position one regularly and others reset to zero most of the time but to position one
occasionally. Since increasing the reset coupling capacitor lowered the maximum counting rate of the
tube, other, more complex circuits seemed justified.

**30-KC Counting**

The circuit shown in Fig. 3, using a 6J6 to reset the tube on the tenth pulse, was observed to have a
maximum counting rate limited by the reset time, as was also true in the one-tube circuit, and by the
resolving time of the input univibrator \(V_2\). The circuits gave reliable reset to zero in a much shorter
time than the one-tube circuit. Tube \(V_2\) was operated as a univibrator, applying a negative pulse to the
control grid when triggered. This cut the counter tube off and allowed the right deflection-plate
voltage to rise, returning the beam to the zero position. The time required was determined by the capac-
itance of the deflection plate and wiring and the one-megohm load resistance.

The univibrator also provided a positive shaped pulse to drive the next scaler tube or the register
driver tube. The counter tube was capable of stepping from one position to the next in about 5 micro-

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seconds but reset required closer to 30 microseconds. For counting speeds of less than 30,000 counts per second this circuit was satisfactory.

**Increased Counting Rate**

Primarily a modification of the previous circuit, Fig. 4 shows a circuit, with the reset mechanism changed, capable of 100,000 counts per second. Since the tube will step from one position to the next in less than 10 microseconds, no modification of this function was made. The plate load resistor was changed on the normally conducting half of the 6J6, so that the voltage at the plate was less than the right deflection-plate voltage in position nine.

When the beam strikes the reset anode, the normally conducting half of the dual triode is cut off and the anode voltage correspondingly rises.

The rise is more rapid than in the 30,000 count per second circuit because of the reduced load resistance (56,000 ohms in series with the resistance of the coupling diode instead of one megohm). Since the diode is then in a conducting condition the right deflection-plate voltage also rises, bringing the beam back to the zero position. The cut off portion of the dual triode begins conducting again, the time determined by its own R-C time constant, and the coupling diode is rendered nonconducting so that counting action can proceed.

This action takes place in about eight microseconds, which is not appreciably longer than the time required to step the counter tube from one position to the next. As in the 30,000 count per second circuit, a shaped pulse is fed from the cathode of the reset univibrator to drive the next stage.

A 6AL5 is used as the coupling diode because of the inverse working voltage required, but it may be possible to substitute a semiconductor diode.

**Scaling to Less Than Ten**

In a number of timing applications it is often desirable to scale to less than ten. A modification of the circuit, Fig. 5, allows the tube to perform this function. The right deflection plate rises only part of the way toward the zero position because of the conduction of the diode and thus resets to whatever position the voltage at the cathode of the diode corresponds. The circuit constants given allow the tube to scale by six. This converts, for instance, 60-cycle pulses into \( \frac{1}{60} \) second pulses for timing purposes.

---

**FIG. 3**—Philips 30,000 counts per second circuit. The 6J6 resets the tube on the tenth pulse

**FIG. 4**—Circuit for driving the tube to 100,000 counts per second incorporates certain modifications
and an additional scale of six converts the rate to 1/100-min pulses. The circuit preceding the scale of six converts the smoothly varying 60-cycle current into sharp voltage pulses capable of driving the univibrator-pulse shaper which in turn drives the counter tube. Coupled with a driver tube and a register, this system then becomes an accurate interval timer. Any scale from one to ten is possible with this circuit. It is probably not economical to use less than a scale of three, except for special applications where a range switch changes the scaling factor of the tube.

Register Driving Circuits

Two register driver circuits have been developed. The first circuit, shown in Fig. 6, uses a 5963 (12AU7) tube as a long time-constant univibrator. This tube is triggered by the final counter tube or by the reset univibrator if the faster circuits are used. The positive output pulse from this tube is fed to the grid of the 6AQ5 driver. This tube, normally cut off, then conducts and causes the mechanical register to advance one count. The 6AQ5 returns to the nonconducting state when the positive voltage is removed from the grid, as determined by the time constant of the univibrator driving it. This circuit is capable of driving the register to its maximum reliable counting rate.

The second circuit, Fig. 7, uses a 2D21 miniature thyratron to perform the register driving function. Unloading of the 2D21 is accomplished by the L-C network from plate to ground. Although this circuit uses one less tube than the first, it has the disadvantage of having two one-microfarad capacitors as part of the circuit. A 600-volt (bathtub) dual capacitor may be used. Both drivers work reliably at 300 volts anode supply and both have the disadvantage of causing a considerable drain on the high-voltage supply feeding them. A regulated supply is adequate for supplying both the counter and the driver circuits, but if two separate power supplies are used neither need be regulated. A register requiring less power than the Vee-Cooler tube used would materially reduce the cost and complexity of the power supplies and would probably allow both systems to be operated from the same unregulated supply.

A third register driving circuit is given in Fig. 8. This is a modification of the circuit of Fig. 7, in which the unloading of the thyratron is accomplished by the application of a 60-cycle a-c signal at the plate. In addition, an inexpensive power supply is provided, using two selenium rectifiers in a voltage-doubler circuit, so that the counter tubes may be operated from a separate unregulated supply.

One-MC Circuit

An experimental circuit, which has been operated at speeds slightly above one megacycle, is shown in Fig. 9. The tube is caused to step from one position to the next by driving the right deflection plate negative. One-half of the 12AX7 performs this function. Double or triple pulse resolving time of this circuit, exclusive of the reset function, is essentially zero. This is due to the fact that if two input pulses appear at the same time the tube will step two positions instead of one. The reset is accomplished in the same manner as in the 100-ke circuit, except that a high-current 5687 univibrator is used to allow reduction of the plate load resistor, and thus shorten the reset time. Reset is accomplished in about 0.8 microsecond.

Random Pulses

If this circuit is used to count random pulses, as from nuclear detection devices, the resolving time is made up of two factors: the stepping time from one position to the next and the reset time. Thus

$$T_r = 0.9 T_s + 0.1 T_r$$

where $T_s$ is the dead time of the circuit, $T_s$ the stepping time and $T_r$ the reset time. If the input circuits are arranged such that two pulses occurring at the same time are presented to this circuit as a single double-size pulse, the stepping time $T_s$ is zero and the dead time becomes simply $0.1 T_s$, or 0.08 microsecond.

The second half of the 12AX7 serves to amplify the pulse from...
The reset anode of the counter tube to trigger the 5687 univibrator. By its conduction, it maintains the first half of the tube at cutoff. Use is made of the change in triode conduction with changing plate voltage to provide smaller and smaller pulses as the position of the beam in the counter tube moves from position zero to position nine, since smaller pulses are required as the right-deflection-plate voltage drops.

The size of the input pulse is quite critical in this circuit, and must be carefully controlled. The shape of the pulse is not too important, as long as the proper charge is delivered to right deflection plate. Two methods have been used to provide this pulse. The first used a saturation amplifier to limit the pulse height and an open-ended delay line to determine pulse width. The second method used a univibrator similar to the reset univibrator. Pulse widths in both cases were limited to about 0.3 microsecond and pulse height to about 20 volts.

Two views of the experimental unit are shown in the photographs. The experimental one-mc strip may be removed for modification. The remainder of the unit consists of the 100-kc circuit followed by three 30-kc circuits and the thyratron register drive. An electronically regulated power supply is used.

**Magnetic Effects**

Because the EIT tube is very similar to a cathode ray tube, the beam is considerably affected by magnetic fields. This was demonstrated in the first scaler constructed when the Veeder-Root register was mounted directly over the counter tubes. The magnetic pulse which occurs when the register is triggered caused a disruption of the counting function. This was overcome by enclosing the register in an iron box about 1/2-in. thick.

The EIT decade counter tube represents an interesting departure from normal electronic development, in that it is designed to perform a single, relatively complex electronic task. Until very recently this function was performed by electronic tubes designed primarily for other purposes. It is therefore not surprising that the tube affords a reliable and comparatively inexpensive means of accomplishing the counting of voltage pulses at high repetition rates. It is encouraging that the design concept of special vacuum tubes for specific functions is being pursued. Although the tube shows some inherent limitations, it is not felt that these are serious.

The counting speed of 100,000 counts per second is satisfactory for most purposes, and speeds above one per second are being demonstrated at this laboratory and elsewhere. With the termination of the U. S. Atomic Energy Commission contract on June 30, 1954, continuation and completion of certain phases of the work will be carried on by the University of California Radiation Laboratory.

**References**

Magnetic Recorder

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Four-channel magnetic record-playback head and turntable

Several methods are available for transient analysis, particularly by means of a magnetic disk recorder. Capturing the waveform permits its study by the more conventional techniques of steady-state analysis.

Among the simplest parameters that can be determined this way are those including the measurement of rise and decay times of electrical circuits, area under curves and peak amplitudes. These measurements are based upon obtaining suitable proportionality constants between the ordinate of the record and a parameter of the transient such as voltage, current or acceleration. It is also necessary to obtain a constant of proportionality relating the independent variable and the abscissa (generally time).

Time calibrating marks and voltage or current standards fix the reference and the procedure thereafter is straightforward. Purely mathematical scaling methods can be used to obtain rise and decay times and slopes. Application of numerical integration methods, such as Simpson's Rule, quickly determine the areas under selected portions of the record.

However, much more general information can be obtained from transient records. Among the most informative are those that depend upon the techniques described below.

The resonant frequency of a series RLC circuit can be written as

$$\omega_0 = \sqrt{\frac{1}{LC}}$$

where $\omega_0 = \frac{\omega_0}{Q}$ and $Q = \frac{\omega_0 L}{R}$

For large Q's this indicates that the natural frequency of the damped circuit does not differ much from the undamped circuit. However, where the Q of the circuit is low, the frequency of oscillation may differ significantly from the undamped case.

The logarithmic decrement of the oscillation is defined as the natural logarithm of the ratio of two amplitudes of the oscillation differing by one period, for example the natural logarithm of the ratio of two successive maximum points shown in Fig. 1. In terms of the Q and the frequencies of the circuit, the decrements can be given as

$$\delta = \pi \frac{\omega_0}{Q}$$

If the damped and undamped frequencies are sufficiently close so that $\omega_0 = \omega + \omega_0$, the logarithmic decrement can be very simply written as

$$\delta = \pi / Q$$

A measurement of $\delta$ can be used to obtain the Q of a circuit producing a damped oscillatory wave from observations of the recorded transient and the natural logarithm of two successive maximum voltages. The corresponding evaluation using steady state methods could be a prolonged procedure.

The spectrum of a transient record is most readily obtained from the Fourier transform of the time function and is given by the integral

$$g(\omega) = \int_0^{+\infty} f(t)e^{-i\omega t}dt$$

This is equivalent to a continuous spectrum for the single transient.

It is the property of the Fourier integral that the effect on the frequency spectrum of the waveform repetition rate is to preserve relative amplitudes between spectral components. Thus recording the transient time function on a magnetic disk or tape will make it possible to obtain the Fourier spectrum through use of a wave analyzer on its recorded output.

Playback Analysis

The spectrum analysis made with a wave analyzer on the output of a transient recorder that plays back the transient at a cyclic rate would consist of a discrete frequency spectrum, with components spaced at intervals corresponding to the repetition rate of the recorder playback. The continuous spectrum of the single transient is the spectrum obtained from this by drawing a continuous curve between peaks of the discrete frequency spectrum. Also, since the sense (positive or negative) of the spectral components is not preserved, the absolute value of amplitudes alone is obtained.

FIG. 1—Waveform shows transient method of determining Q

Frequency spectra can also be obtained from known tables of time-frequency transforms, such as that recently published by Hewlett-Packard Corp. By observation of a cyclic playback transient recorder and the measurement direct from the oscilloscope screen of a few parameters of the time function,
Arrests Transients

Single waveform on magnetic disk can be played back for oscillographic analysis giving corresponding frequency function from parameters of the time function. Equipment includes novel circuit with independent a-c gain and d-c level adjustments.

The corresponding frequency function can be immediately obtained.

A rapid method for the determination of natural modes of vibration of either mechanical or electrical systems depends on the recording of the response to a system excited by an impulse. Briefly, an impulse is a function that is zero except for an arbitrarily small interval around $t = 0$ where it becomes infinitely large such that the area under the impulse function is unity. The unique property of the impulse is that the spectrum of the impulse (obtained from the Fourier integral) has constant amplitude and zero phase for all frequencies.

It is this property of zero phase at $t = 0$ that gives infinite amplitude of the impulse at this point. Thus exciting a system with an impulse is equivalent to exciting the system with all frequencies simultaneously. If the system has a natural mode of vibration at any frequency, it will vibrate at this mode, to produce a damped oscillation at that frequency. True impulses cannot be obtained physically but sufficiently close approximations can be produced to enable rapid determination of vibratory modes in either an electric circuit or a mechanical system. By recording the output of such a system when excited by an impulse the natural modes will be directly recorded.

A transient recorder developed for the recording of four simultaneous transient events over the bandwidth of 0 to 2,000 cycles simultaneously displays any two of these events upon a dual-beam oscilloscope.

The electronic circuits include a means for converting the desired transient signal into a pulse-modulated wave-train, means for recording the pulses upon a circular magnetic surface, playback demodulators to convert the record pulses back into an electrical signal and triggering and synchronizing equipment to stop the recording process after a transient has occurred. A synchronizing system is provided for triggering an oscilloscope sweep at periodic intervals such that cyclic playback is presented on the oscilloscope as a stationary pattern.

Storage Mechanism

Design of the mechanical section was dictated by several considerations. The cyclic playback must be synchronous to prevent speed fluctuations from manifesting themselves as spurious signals. In similar equipment for short-pulse recording, a permanently recorded reference timing track was used to minimize the effects of speed variations. For the present application the consideration of convenient storage of the recording prevented use of this technique. Constancy of speed is attained through the use of a hysteresis synchronous motor with an added disk to provide a large moment of inertia. Vertical runout, that is, up and down motion of the recording surface, would not be a serious problem at very low speeds. At surface speeds of twenty to thirty inches per second used in this equipment the possibility of recording head bounce with respect to the surface (with consequent signal dropouts) was a problem.

A specially machined turntable was fabricated, which includes three vertical screw adjustments spaced symmetrically about the surface to enable holding the static and dynamic vertical runout to less than one-thousandth of an inch. The multiple recording head cassette is mounted on a low-inertia pivoted arm capable of being adjusted for recording head parallelism.

The recording surface is a specially prepared disk, made easily replaceable by providing a boss assembly to clamp the disk against the turntable. To minimize head...

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**FIG. 2**—Common unit includes thyatron trigger, blocking oscillator and phasing-signal generator. Record-playback switching is not shown.
wear owing to friction, a compliant rubber disk is placed between the recording surface and the aluminum turntable. This disk provides additional smooth travel by building up a static charge to hold the recording surface flat. In this manner an easily replaceable recording surface was obtained, which permitted the storage of a four-channel transient recording.

The recording head is a standard Brush multichannel type with wide spacing between the recording heads to decrease crosstalk. A compliant phosphor-bronze member is attached to the recording head arm to provide for adjustment of head pressure and thus prolong disk life.

The common unit (shown in Fig. 2) provides triggering pulses for the individual modulators and generates a phasing signal from a single pulse permanently recorded on the turntable to provide a variable phasing signal for oscilloscope synchronization. A thyatron trigger circuit stops further recording once a transient has been recorded.

The 5.25 kc triggering pulses are generated by a 12AU7 blocking oscillator $V_o$, which is energized only when the function selector switch is in the record position. In this way, possibility of crosstalk from this source when the unit is replaying a recorded transient has been eliminated.

The phasing signal to enable viewing any portion of a recorded transient is generated by a monostable multivibrator $V_s$, which is driven through amplifier $V_i$ from a single pulse generated by a groove filled with red oxide in the turntable. This pulse occurs once during each revolution of the turntable and initiates the period of the monostable multivibrator.

Duration of the period is determined by the R-C time constant of the multivibrator, which can be varied by a front-panel control.

The trailing edge of this square wave is differentiated and used to synchronize an oscilloscope driven sweep. By this means the sweep can be started at any desired point with respect to the recorded transient and thereby any portion of the transient can be viewed using an expanded sweep.

The upper limit to the sweep speed is limited by the persistence of the cathode-ray tube phosphor, but as small as 10 percent of the recorded transient can be expanded in this fashion to cover the entire horizontal sweep of the oscilloscope screen.

**Shutoff Circuit**

Since the instrument was designed to permit the recording of a transient at any time it may occur, means are provided to stop recording once such a transient has occurred and has been recorded. This is accomplished by opening a relay in the output circuit of each modulator after a transient has been recorded. This section of the common unit comprises $V_a$, $V_b$, and $V_c$. A special RECORD SIGNAL terminal is provided on the front panel. When a small voltage is applied to this terminal (such as would occur by connecting to it the output of a modulator that is to receive a transient) the monostable multivibrator $V_i$ is triggered and at the end of its one-second period causes thyatron $V_s$ to conduct. The plate circuit of this thyatron is connected to a relay in each modulator that opens the modulator connection to the recording heads, preventing further recording.

This delay multivibrator thus limits the one-second of recording to that interval immediately following the application of a voltage to its input terminals. These terminals need not be connected to a modulator input only, but provide convenient means for the operator to select the instant at which he wants the recording period to begin. For some applications it may be necessary to begin recording somewhat sooner or later than the
FIG. 5—Demodulator unit converts signal into pulse-width modulated train before demodulation in low-pass filter

actual beginning of the transient.

When the thyratron has been triggered, a front-panel indicator lights, informing the user that a transient has been recorded. A reset button momentarily disconnects plate voltage to the thyratron thus closing the modulator relay circuit.

The pulse modulator shown in Fig. 3 consist of a monostable multivibrator whose period is determined by the d-c level at the control grid of $V_a$. The 5.25-kc signal from the blocking oscillator of the common unit is applied to one grid of $V_a$ and the amplified transient signal to the other grid of this cathode mixer. The sharp pulse from the blocking oscillator triggers the multivibrator and the transient-signal component determines the recycling time of the multivibrator.

Thus, variable-width pulses are generated with a starting time determined by the blocking oscillator pulse and duration determined by the information to be recorded. Since variable-width pulses have a low-frequency component, neon lamps are used for d-c coupling to the output amplifier $V_e$. The d-c amplifier $V_e$ is a novel circuit arrangement permitting independent a-c gain and d-c level adjustment of an amplifier. Its operation can be explained by reference to simplified schematic in Fig. 4.

The input signal is fed to one grid of a cathode-coupled d-c amplifier, whose other grid is grounded. The amplified signal voltage appears between the plates of the coupled amplifier. Potentiometer 2 in this figure is used for eliminating any initial unbalance between tube sections. At the arm of 3 the amplified signal appears at any level up to the maximum gain possible and of either polarity with respect to the input. Potentiometer 1 controls the quiescent voltage at the plates of these tubes and thus provides independent d-c level setting while 3 gives independent gain setting of the amplifier. By adding a neon lamp between the plates to limit the maximum plate-to-plate voltage, 3 also selects any portion of this voltage-limited signal. In this manner, neon tube limiting can be obtained at any voltage reference up to the maximum operating potential of the neon tube. The output signal can thus have independent gain and level setting with limiting if desired.

**Demodulator Unit**

Since the recorded pulses consist of a train with constant-period positive portions and variable-position negative portions, the signal must first be converted back to a pulse-width modulated train prior to demodulation in a low-pass filter. This conversion takes place in the pulse demodulator shown in Fig. 5. Tube $V_e$ amplifies the read-out signal and drives the grid of $V_a$. This stage applies alternate-polarity symmetrical signals to peak selector $V_{1a}$. The peaks are clipped and amplified in $V_{1b}$. One half of $V_{1b}$ comprises a pulse position-to-width converting circuit. The pulse train, now a width-modulated signal, is amplified and applied to the low-pass filter, which eliminates the carrier signal and passes only the information component—that is, the low-frequency component of the pulse train.

From the filter, the signal passes to the grid of a cathode-follower and thence to the output terminals. The output coupling is through an extremely long-time-constant circuit to eliminate the d-c component of the cathode-follower signal without deteriorating the low-frequency components of the recorded transient. Coupling of this type can be safely used on transient recorders that record d-c since the playback signal is cyclic with a period of one second. Thus, any time-constant that will preserve a one-second square wave without serious distortion can be used faithfully to play back signals with d-c components.

When study of the transient is completed, the recorded signals can be erased by pushing the reset button. This action starts recording of the modulator-pulse train over the previously recorded signals, thus effectively obliterating them. In this manner disks can be reused many times. This process of convenient and rapid record and erasure is particularly useful in laboratory investigation where changes are made in equipment and the resultant output recorded and immediately examined.

Thanks are due to K. Wisner for assistance with the mechanical design of the transient recorder.

**References**

Automatically Plotting

Continuous equipotential lines representing electric-field patterns are plotted with two-percent accuracy on resistive paper. Technique avoids disadvantages of electrolytic methods. Typical uses include investigating fields in waveguides and between tube electrodes.

Within recent years attempts have been made to obtain field plots in ways which avoid the disadvantages of an electrolytic method, namely, the polarization effects, surface tension and the use of a spillable electrolyte. Such methods are the use of a resistive network and the use of uniformly resistive paper.

All of these methods involve either the determination of the potential at fixed points, as in the resistive networks, with the consequent interpolation necessary to determine specific field lines or the manual searching for specific field points and the subsequent manual plotting of the lines connecting these points.

In contrast to these methods, the automatic field plotter is capable of producing continuous field lines without manual searching or plotting and of drawing these lines directly on the plot of the electrodes. This is accomplished by using the resistive paper technique in conjunction with an X-Y recorder.

The plotter, is a modified commercial X-Y recorder selected for this purpose because of its large 30-inch square plotting surface.

Principles

The principles of operation may be seen by referring to Fig. 1. Electrodes, shaped as desired, are painted with silver paint or resistive paper. Appropriate connections from the silver-paint electrodes are made to a 1.5-volt battery. This sets up a field pattern in the resistive paper.

The pickup probe resting on the paper senses the voltage at that point and through the sliding contact refers this voltage, $e_r$, to the input of the servo amplifier. The positions of the knobs on the decade potentiometer determine the voltage $e_p$, which is also referred to the input of the servo amplifier. The algebraic difference between these voltages, $e_r-e_p$, determines if the servo motor will move the pickup probe across the paper and, if so, in which direction it will move. Motion occurs until $e_r$ equals $e_p$ at which time the servo system is in balance and no further motion occurs.

To obtain an equipotential field line, the arm on which the pickup probe travels is caused to move perpendicular to the direction in which the voltage is applied across the paper. For a given potentiometer setting, the probe will then trace a single equipotential line. By changing the potentiometer settings and moving the probe back and forth across the paper a complete series of equipotential lines will be plotted.

To obtain a comparison of the performance of the automatic field plotter with manual plotting systems, identical electrodes were silk-screened on commercial plotting paper and on black paper such as is used to interleave photographic film. The equipotential lines obtained by the commercial point-by-point method are shown in Fig. 2, on the left, and the continuous lines drawn by the automatic field plotter are shown on the right. The plots shown indicate that the position of the lines may be depended upon to within 2 percent of the distance represented by the total potential applied.

Modifications

To convert an X-Y recorder to this type of operation several modifications are necessary:

1. The pen must be insulated.
2. Means must be provided for

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FIG. 1—Simplified diagram of automatic electrostatic field plotter setup
Electrostatic Field Lines

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FIG. 2—Typical field plot made with manual method (left) and with automatic field plotter (right)

FIG. 3—Pickup probe details: sliding contact on rail; insulating bracket and pen mount with LeRoy lettering pen

FIG. 4—Field plotter in operation: silver-paint electrodes can be seen at the top and bottom of the field lines

taking the voltage from the pen to the servo-amplifier input.

(3) A pen suitable for use with conducting ink must be provided.

The insulation of the pen is accomplished by substituting a plastic pen-mounting bracket for the metal one provided with the equipment as shown in Fig. 3. Cellophane tape around the metal plate directly behind the pen arm provides the additional insulation necessary to assure isolation of the pen.

The voltage sensed by the pen is transferred to the servo amplifier by means of a sliding contact on the pen carriage, which moves along a rail to the servo-motor end of the cross arm. Appropriate wiring takes the pickup voltage from the pen to the input of the servo amplifier.

The pen provided with the recorder is replaced by an arm designed to hold a LeRoy lettering pen.

Operational Requirements

A paper having uniform resistive properties is necessary. This paper should have a low resistance per square, from several hundred to a few thousand ohms. In addition to its low resistance it should be possible to sense the voltage on it with light contact pressure.

The silver paint used for the electrodes must have a resistance in the order of a few ohms when properly dried. Air-drying silver paint commercially available was found suitable for this purpose. Two kinds were used in the experiments, one suitable for use with brush or pen and the other suitable for use with silk-screen.

Three methods of making contact to the silver-paint electrodes were used with good success. Weighted probes are used with simple electrode patterns where it is desired to change the patterns readily. Cellophane tape may also be used to hold fine wires in contact with the electrodes. For complicated patterns and for the best contact fine wires may be soldered directly to the silver paint using a pencil-type soldering iron.

A number of inks were tried for this application, the most satisfactory being a diluted silver paint. Very satisfactory results have been obtained in the operation of this equipment when two precautions are observed. The plotter should not be expected to work properly when plotting lines within ten degrees of the line of motion of the pen carriage. The sensitivity control (a variable resistor in series with the battery to reduce the voltage applied to the plotting paper) should be adjusted for optimum operation. This requirement is necessitated by the servo system which operates most satisfactorily when the potential gradient across the plotting paper is uniform. If the gradient becomes too steep the probe hunts and if, on the other hand, it is too shallow the probe fails to track the equipotential line properly. For most cases a satisfactory position can be found. The device is shown plottings an electrostatic-lens field pattern in Fig. 4.

The help of Raymond Winfield in setting up the equipment described and performing the initial experimentation with it is gratefully acknowledged.

References

(1) "Vacuum Tube Design," RCA Victor Division, 1940.
Operation of CRT

Practical information for designers on how to obtain optimum operating conditions with various storage tubes. Limitations as well as applications of storage tubes are discussed in detail to facilitate selection.

Within their applicable range, storage tubes possess many advantages. An excellent cockpit display of airborne radar is obtainable by using either a darktrace or a direct-viewing storage tube. These tubes provide excellent visibility in sunlight and store a clear distinct image from one scan to another. Dark-trace tubes require simpler circuitry but require several seconds to erase. Direct-viewing charge-storage tubes have faster erasure and can erase during writing.

In computer use, electrostatic storage tubes provide large storage capacities with rapid access to information while in a special oscillograph, storage tubes allow the recording of single fast transients with extremely wide bandwidths.

Some applications of several different storage tubes are given in Table 1.

Construction

A storage tube consists of an electron gun, deflection circuits and storage elements. Three functions are essential, namely: writing; reading; erasing of information. To perform these functions, tubes are built with one, two or three electron guns. These electron guns are modified conventional cathode-ray tube guns. The output of a storage tube may be visual, electrical or a combination of both.

The storage surfaces are usually a dielectric deposit on a mesh or other metallic surface. These screens have a tendency to flake off with hard handling, which causes possible blemishes, and hence lack of storage capability at certain locations on the storage screen. A continuation of the electron beam following a sweep failure can burn a hole in the storage surface and limit the tube usefulness by creating a blemish. Simple protective circuits such as a relay in the deflection amplifier, which can open the storage tube cathode circuit, can prevent this.

In tubes with mechanically supported meshes, these metallic meshes are free to vibrate with respect to one another. With voltages impressed, the action is that of a condenser microphone or a microphonic audio signal which can obscure the desired video readout. This is illustrated in Fig. 1.

The storage element is the screen itself in a Williams tube or in a dark-trace tube, while in a Grapheen it consists of a copper mesh, a signal plate and an insulator. In the Raytheon storage tube, the storage element has three components, a first screen, storage screen and a collector-reflector, all of which are energized. In this tube, the first screen should be operated at as high a value as possible to obtain the smallest spot size. A screen voltage of 450 volts with an anode voltage of 2,200 volts is optimum.

The storage-screen and collector-reflector voltages vary with the function. For writing, the optimum voltages are 300 volts and -300 volts; for reading, 27 volts and 260 volts and for erasing, 75 volts and -300 volts, respectively. Carefully regulated power supplies are essential for these voltages and additional filtering may be indicated.

Ripple and other noise voltages will modulate the reading and writing beams and will appear in the output where their importance is exaggerated by the low signal levels available. Another source of trouble is any slow drift of these voltages, which will cause a deterioration of the signal quality.

Beam Current

Use of alternating current for filament heating has been found satisfactory, but the filament volt-
Storage Devices

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Readout amplifier for operation with large input capacitance storage tubes. Input cathode follower employs positive cathode feedback.

Storage Devices

age must be held to better than five percent and preferably to one percent. This requirement is important when employing low beam currents, one microampere, in the Williams system or two to six µa in the reading beams of the Raytheon and Graphecon tubes. Larger beam currents would increase the scanning speed. However, in the Graphecon this will be accompanied by a reduction in the time.

Ion Spot

In the QK 245F an ion spot appears in the center of the storage surface and slowly builds up as repeated readings are made. The effect is similar to a blemish except that the area grows with continued use and can be erased. To avoid this effect, very low reading currents must be used. Using a beam current of two µa, more than 30,000 consecutive readings may be made without noticing any harmful effects or deterioration of the stored pattern.

It is estimated that a one-percent change in grid bias will cause a 25-percent change in beam current. The grid bias voltage must be obtained from a well-regulated power supply with 0.1-percent regulation or better. In addition, the ripple and noise must be kept below three millivolts and should be near one millivolt.

Since spot size determines the storage capacity, the highest possible accelerating voltages should be used in order to obtain a small spot size. The equations for estimating the required anode voltage regulation are

\[ R = \frac{4L}{K} \]  
for magnetic tubes and

\[ R = \frac{2L}{K} \]  
for electrostatic tubes where \( R \) is voltage regulation, \( L \) is allowable deflection error as a fraction of spot size and \( K \) is resolution expressed as the number of spots obtainable per line (or the line length divided by spot size).

An idea of the order of magnitude can be obtained by assuming a 100-mm line length with a one-mm spot size and an allowable error of 0.05. Under these conditions a magnetic tube needs 0.2-percent regulation and an electrostatic tube must have 0.1-percent regulation. Higher resolving power can be obtained with magnetic tubes because they require less regulation than electrostatic tubes.

Choice of writing beam current depends upon the rate of informa-

FIG. 1—Monitor screen showing vibration during writing

FIG. 2—Storage-tube input at top, output signal after 15 minutes storage, read out by a 1.20 microampere beam current, middle and 6 microampere beam current at bottom

ELECTRONICS — October, 1954

185
Table I—Storage-Tube Applications

<table>
<thead>
<tr>
<th>Use</th>
<th>Suitable Tube Types</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Aircraft cockpit weather mapping</td>
<td>Dark-trace tube</td>
<td>7 inch available; contrast independent of illumination: shock-mounting required</td>
</tr>
<tr>
<td></td>
<td>Iatron</td>
<td>New development; very-high brilliance direct-view screen; high anode voltage</td>
</tr>
<tr>
<td>(2) Television-film conversion or radar-scan conversion</td>
<td>Iatron and tv camera</td>
<td>See use No. 1 Iatron</td>
</tr>
<tr>
<td></td>
<td>Dark-trace tube and tv camera</td>
<td>Use erase filament with slow erase voltage applied</td>
</tr>
<tr>
<td></td>
<td>OK 245F and tv camera</td>
<td>Low light output</td>
</tr>
<tr>
<td></td>
<td>Knoll's storage tube</td>
<td>Recent development</td>
</tr>
<tr>
<td></td>
<td>Graphecon</td>
<td>Registration problem of two-electron guns; electrical input and output; extreme care required in deflection and focus-coil alignment</td>
</tr>
<tr>
<td>(3) Digital computers</td>
<td>Hauff-tube types, barrier-grid tube types, OK 357A, Radecon, Selectron and Graphecon</td>
<td>Low power-supply ripple required; anode-voltage regulation; careful switching and detection circuitry design; selection of blemish-free tubes</td>
</tr>
<tr>
<td>(4) Analog computers</td>
<td>Hauff-tubes, OK 357A, Radecon and Graphecon</td>
<td>Limited tonal range</td>
</tr>
<tr>
<td>(5) Moving-target indication radar</td>
<td>QK 245F</td>
<td>Low visible output; requires large element voltage switching, requires gain change between writing positive and negative; regulate anode voltage</td>
</tr>
<tr>
<td>(a) Single-tube system</td>
<td>OK 357A</td>
<td>Electrical output; sensitive to vibration (also see QK 245F, last three items)</td>
</tr>
<tr>
<td></td>
<td>Iatron</td>
<td>See use No. 1; positive and negative writing characteristics may not match</td>
</tr>
<tr>
<td>(b) Two-tube mti operation</td>
<td>All digital and tonal tubes</td>
<td>For best results, tonal ranges should not be used</td>
</tr>
<tr>
<td>(6) Radar signal-to-noise dark-trace tubes improvement</td>
<td>Simple ciruquitry; place bias on erase filament during writing to prevent shadow; optical surfaces give multiple reflections; see use No. 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iatron</td>
<td>Excellent tonal range; variable persistence; see use No. 1</td>
</tr>
<tr>
<td></td>
<td>Graphecon</td>
<td>Two-gun registration; two electron-gun voltage; see use No. 2</td>
</tr>
<tr>
<td></td>
<td>OK 357A</td>
<td>See use No. 5 a</td>
</tr>
<tr>
<td>(7) Bandwidth reduction (tv and radar)</td>
<td>All tube types</td>
<td>This can be accomplished in two ways, sampling and transmitting difference between successive stored scans.</td>
</tr>
</tbody>
</table>

Reading Current

The reading current is generally a compromise. Typical readout signals for 1.2µA and six µA are shown in Fig. 2. To achieve the largest signal output, a high reading beam is required. However, ion effects tend to cloud or distort the signal, reducing its amplitude and tones. In magnetic tubes this starts by an erasure at the center and moves out. In electrostatic tubes a deterioration over the whole stored pattern ensues. Since the ion effects depend upon current and time, fast single readouts permit high read currents while long repetitious readouts require low beam currents. Storage tubes with tonal ranges are designed particularly for low reading currents.

The small beam currents used during the reading operation require anastigmatic focus coils. The astigmatism found in most commercial focus coils is objectionable. The focus-coil positioning is very critical and no skewing to achieve centering can be tolerated. Centering must be achieved by suitable deflection circuitry and the focus coil located at the optimum-focus point.

Limitations

A basic limitation in most storage tubes is the registration, the ability of the electron beam to repeatedly strike the same point on the storage surface. For a 0.05 deflection error with a one-mm spot size and 100-mm line, a 0.1-percent regulation is needed. This can be estimated from the equation $R = 2L/K$.

The deflection errors caused by anode voltage and deflection voltage (or current) variation are additive and estimates of 0.1-percent and 0.2-percent regulation should be considered as maximum.

Superimposed on this amplitude variation is the jitter in the scanning raster. A rule-of-thumb value
for the maximum allowable jitter is given by

\[ \text{jitter} = 0.2sT/D \]  
where \( s \) is spot size, \( T \) is period of the line scan and \( D \) is the effective tube diameter or usable line length. During writing, this jitter will produce smears instead of distinct lines. Due to pairing, a 525-line television interlaced raster is less satisfactory than a 200-line non-interlaced raster. A stationary raster is necessary for good operation and single-frame writing should be employed wherever possible.

Jitter in the system can be mistakenly attributed to poor focus. A case in point actually occurred in a field application of a dark-trace storage tube, where excessive deflection-system jitter produced a condition diagnosed by field personnel as poor focus in a gassy tube.

A similar effect in magnetic tubes is produced by mechanical vibration of the deflection yoke or the focus coil. When attempting to use storage tubes under conditions where shock or vibration may be encountered, careful shock mounting is recommended.

Blemishes on the storage surface limit storage tube operation by producing spurious signals. Little can be done except to try to reduce their effect by suitable band-rejection filters or by relocating the stored pattern elsewhere on the storage surface.

Application

Successful operation of the storage tube requires relatively noise free and distortionless amplifiers. The design of low-noise broadband amplifiers with Gaussian frequency response is described in the literature. The bandwidth employed depends on the application but should be no wider than necessary.

At the present time adequate low-level performance can be obtained with existing tubes, provided that careful design of equipment and good engineering practice is followed. The operation of storage tubes is difficult even under laboratory conditions. Experience indicates that they are delicate and must be handled and mounted carefully. Vibration or jarring can cause permanent damage to the screens and storage surfaces. Each tube is different and the results obtained vary from tube to tube.

A block diagram of a complete equipment arrangement for experimental operation and evaluation of magnetic deflection storage tubes is shown in Fig. 3.

In utilizing storage tubes, the system distortion and noise producing elements must be minimized. Operation of the storage tube and the readout preamplifier should be carried on inside a shielded cage, as shown in Fig. 4. Mu-metal shielding of the tube is necessary to reduce magnetic defocussing effects. Good regulation and filtering of power supplies are essential.

A 20-db signal-to-noise ratio is a workable figure and a bandwidth of six to ten megacycles is attainable. Signal-to-noise ratios of 20 to 30 db have been attained in practice and an increase in this figure should be possible with better electron guns and improved manufacturing techniques. It can be expected that signal-to-noise ratios of 40 to 50 db will be achieved and the operating bandwidth extended to 20 megacycles in the near future.

Although at the present time random noise is a negligible factor, the ultimate limitations will come from electron-gun performance and storage-surface characteristics.

The authors wish to acknowledge the contributions of W. S. Treitel and P. R. Liegey, who participated in the experimental program. Many thanks are due to D. H. Andrews and F. R. Darne for their encouragement and support.
Servocoupler Matches

Automatic antenna-matching unit transforms impedances presented by all ordinary aircraft antennas to a 52-ohm resistive impedance for coupling to the transmitter in the range from 2 to 25 mc. Sensing unit controls servomotors that vary L and C function. The first of these is that an antenna impedance containing both resistance and reactance may be made to appear purely resistive by series-resonating the antenna. That is, an antenna with the impedance \( r + jx \) may be made to appear as \( r + j0 \) by inserting in series with it a reactance equal to the antenna reactance, but of opposite sign.

The second basic matching principle is that exhibited by the T-section shown in Fig. 1. To establish a comparison between the circuit elements shown in this figure and their ultimate representation in the complete impedance-matching network, they are defined. Element \( r \) denotes the antenna resistance after the antenna reactance has been canceled according to the first matching principle. Element \( R \) is representative of the resistive impedance presented to the transmitter by the impedance-matching network, \( X\) is the reactance of a fixed capacitor and \( X_1 \) and \( X_2 \) are variable tuning elements.

If the impedance equation is written for the circuit and set equal to \( R + j0 \) it is possible to obtain two simultaneous impedance equations in which \( r \) and \( X \) are variables.

\[
R + j0 = r^2 + \frac{r}{r^2 + (X_1 + X_2)^2} + \frac{r X^2}{r^2 + (X_1 + X_2)^2} + X_1 \quad (1)
\]

\[
r^2 + X^2 + r \left( \frac{-X^2}{R} \right)
+ X_1 (2X_2) + X^2 = 0 \quad (2)
\]

\[
r^2 + X^2 + \frac{X_1 (2X_1 X_2 + X_2^2)}{(X_1 + X_2)}
+ \frac{X_1 X^2}{(X_1 + X_2)} = 0 \quad (3)
\]

Fortunately, these simultaneous equations (Eq. 2 and 3) have the basic form of circles and, therefore, their solutions may be readily obtained by plotting the circles and noting their points of intersection. Such a plot is shown accompanying the circuit in Fig. 1.

It is important to realize exactly how the plot is determined. All
variables and constants are expressed in terms of the value of $R$. That is, they are expressed in terms of per-unit values with $R$ as the base. Since it represents a fixed capacitance, $X_c$ can be considered constant at a given frequency. In this particular example, it is considered to have the value of $-j4R$. Plotting this information yields the $X_c$-circle, which is the plot of Eq. 2.

Other circles are drawn on this graph using the second simultaneous impedance equation (Eq. 3) for various values of $X_c$, wherein the value of $X_c$ is expressed as a per-unit value of $R$.

The locus of the intersections of the circles, indicated by the solid line, represents the solutions of the simultaneous impedance equations for various values of $X_c$. This plot, therefore, reveals that any value of antenna resistance $r$ on the locus of solutions may be transformed to $R$, the required transmitter load. Reactance $X_c$ is a variable tuning element and $X'_c$ and $X''_c$ are tuning elements arranged so that the sum of $X'_c$ and $X''_c$ is a constant for any particular frequency.

Since the circuit is still basically a T-section, the same types of equations are used for the solution of the third matching principle as was used for solution of the second.

$$R + jO = \frac{r(X)^2}{r^2 + (X'_c + X''_c)^2} + j\left[\frac{X'_c(r^2 + X'_c X''_c + X''_c)}{r^2 + (X'_c + X''_c)^2} + X''_c\right] \quad (4)$$

Again, the simultaneous equations (Eq. 5 and 6) exhibit the general form of circles. The differences between the second and third basic matching principles result primarily from the fact that $X''_c$ is now an inductance rather than a capacitance and that though now both $X'_c$ and $X''_c$ are variable tuning elements, their sum is a constant.

As before, it is important to realize how the plot is established. In this example, $X'_c + X''_c$ is a constant and is set equal to $+j4R$. Graphical simultaneous solutions are obtained by first assuming that $X'_c = +j1R$ and $X''_c = +j3R$, then $X'_c = +j2R$ and $X''_c = +j2R$, and so on. The intersections of the
able tap is in some position below the fixed tap of the autotransformer, as indicated by the dashed-line position in the figure. The $X_i$ portion of the autotransformer is eliminated from the circuit and $X', X_2'$ appear. Again the presence of $X_i$ tends to produce some variation in the matching theory by altering the value of $r = jX$, which it shunts. However, a slight readjustment of $X_i$ and the variable tap position of the autotransformer from the theoretical will cancel its effect. The presence of $X_i$ complicates the circuit slightly, but does not alter its basic operation.

The mutual inductance existing between $X_i$ and $X_2'$ has been neglected in the foregoing circuit analysis. Its only real effect would be that of altering the assumption that $X_i' + X_2'$ is a constant at all variable tap positions that are below the fixed tap. This is not particularly serious, however, since at the limits when $X_i' = 0$ and $X_2' = +j4E$, or when the reverse is true, the mutual inductance is zero. Therefore, the end points of the locus of matchable values of $r$ (Fig. 2) would not be altered. The only effect would be that the shape of the locus between its end points would deviate slightly from that shown.

The complete radio-frequency matching network is shown in Fig. 3B. It differs from the previous circuit in that a variable inductance as well as a variable capacitance are inserted in series with the antenna. These are the reactive elements used to series-resonate the antenna. The variable capacitor serves the dual function of series resonating any inductive antenna and providing $X_i$.

**Discriminator Unit**

The source of information used to direct the operation and ultimate tuning position of the various r-f matching network components is an impedance-monitoring device called a discriminator. It is connected between the transmitter and the r-f matching network, as shown in Fig. 3C, to perform the function of constantly monitoring the impedance presented to the transmitter. The impedance monitoring is done with respect to the ideal 52/0 ohm transmitter load. That is, the discriminator monitors both magnitude and phase of the impedance presented to the transmitter and submits its measurement in terms of two d-c voltages. These voltages have polarity dependent upon the direction of impedance deviation from 52/0 ohms.

**Sampling E and I**

The phase of the impedance presented to the transmitter by the r-f matching network in monitored by noting the phase relationship between the transmission line voltage $E$ and line current $I$. To determine the phase relationship existing between $E$ and $I$ it is necessary to sample each. The means of sampling is important since it must be accurate throughout the wide frequency range over which the system is required to operate.

Line current $I$ is sampled by inductive coupling to the transmission line. The center conductor of the coaxial line is passed through the center of a ¥frac{1}{2}$-inch diameter

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**FIG. 4—Elements of complete motor-controlled automatic antenna-matching unit**

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*October, 1954 — ELECTRONICS*
powdered iron ring. A center-tapped five-turn toroid winding about the ring serves to provide the inductive coupling to the line. Induced voltage produced in the five-turn winding is proportional to line current and 90 degrees out of phase with it. Line voltage \( E \) is sampled by a capacitive divider consisting of \( C_I \) and \( C_o \).

The means of sampling \( E \) and \( I \) provides the essential voltages at the proper phase so they may be added vectorially in the same manner as that employed in the ordinary Foster-Seeley discriminator circuit. That is, if the vector sum of \( E_1 \) and \( E_2 \) is rectified and added and in polarity opposition to the rectified vector sum of \( E^* \) and \( E^* \), zero d-c output voltage is obtained if \( E \) and \( I \) are in phase. If \( E \) and \( I \) are not in phase, the circuit will provide d-c output voltage of a polarity dependent upon whether \( E \) leads or lags \( I \).

With this type of \( E \) and \( I \) sampling it is practical to obtain phase monitoring of \( E \) and \( I \) to within \( \pm 5 \) degrees over the 2-to-25 mc frequency range.

One portion of the discriminator is sensitive to the magnitude of the impedance presented to the transmitter. It was previously stated that the induced voltage across the five-turn toroid winding is directly proportional to the magnitude of \( I \). It is also directly proportional to frequency since the voltage drop across the portion of the line to which the toroid is coupled (primary) is directly proportional to frequency.

The same proportional properties can be made to exist between \( E_j \) and \( E_1 \) through the use of a simple circuit containing \( C \) and \( R' \), when \( R' << Xo \).

With the frequency denoted by \( f \), the magnitude of \( E_1 \) is \( K \), \( j \). The magnitude of \( E^* \) is \( K \), \( j \). Through the choice of component values it is possible to make \( K \) and \( K \) constants that will allow \( E^* = E \), when \( (E_1/I) = 52 \) for all frequencies. Then if rectified \( E_1 \) is added in polarity opposition to rectified \( E_2 \), zero d-c output voltage is obtained from this portion of the discriminator when \( (E_1/I) = 52 \). If this ratio is not true, the discriminator will provide d-c output voltage of a polarity dependent upon whether the ratio of \( E \) to \( I \) is greater than or less than 52. With this type of \( E \) and \( I \) sampling it is practical to obtain ratio monitoring of \( E \) and \( I \) to within \( \pm 10 \) percent of 52 over the 2-to-25 mc frequency range.

**Operation of Network**

The manner in which the impedance-matching network operates in combination with the servo-system is shown in Fig. 4. Elements \( C \) and \( L \) are termed phasing elements. Together they provide the large range of reactance that is necessary to series-resonate the antenna reactance and provide the \( X_1 \) reactance that is essential to the impedance-matching properties of the T-section. The reactance of this element would be such that \( X_1 = X_2 = X_3 \). For any particular tuning operation, only one of these reactive elements is necessary. This is accomplished in the actual unit by control circuits that retain \( C \) at its maximum value when \( L \) is required for tuning and \( L \) near its minimum value when \( C \) is required for tuning.

Examination of Fig. 5 indicates that the chopper coils and the fixed phases of the servomotors are all excited from a common 400-cycle source. The servomultipliers themselves are merely 400-cycle amplifiers which in addition to amplification provide a 90-degree phase shift to the signal that is passed through them.

As an example of operation, assume the various impedance-matching network tuning elements are in such a position that only a slight discrepancy exists between the actual impedance presented to the transmitter and the required impedance of 52/0° ohms. For the sake of explanation, assume that this impedance is 60/10°.

**Error Detection**

At the instant the transmitter delivers r-f energy, both the impedance-sensitive and phase-sensitive portions of the discriminator will detect this error from the ideal impedance and will each provide a d-c voltage of a particular polarity at its output point. The d-c voltage at the output of the phase-sensitive discriminator is applied to a 400-cycle chopper that converts the d-c voltage to 400-cycle a-c having phase in accordance with the polarity of the d-c voltage. The 400-cycle a-c is then amplified, shifted 90 degrees in phase and used to excite one phase of a two-phase motor. With the particular 10-degree impedance-phase-angle error assumed, the motor would operate the phasing element \( L \) or \( C \) to increase the value of capacitive reactance in the phasing circuit and reduce the phase angle of the impedance presented to the transmitter to zero degrees.

At the same time, the d-c voltage
Discriminator is formed from transmission line surrounded by powdered-iron toroid to which is coupled five-turn, center-tapped loop.

appearing at the output of the impedance-sensitive discriminator is applied to another chopper, servo amplifier and two-phase motor that mechanically moves the variable autotransformer tap nearer ground to correct for the assumed 8-ohm error in impedance magnitude.

This is the basic operation of the system, with one exception. The explanation was indicative of a tuning sequence wherein the matching elements were only slightly mistuned from their ultimate positions.

Upon further examination of the circuit it becomes apparent that a more complex condition can, and usually does, exist.

Assume that the antenna-phasing elements L and C are considerably mispositioned from their ultimate tuning points. Under these conditions very little antenna current is able to flow. In fact, most of the r-f current sampled by the discriminator is the inductive current flowing from the fixed tap of the autotransformer to ground. It may also be current flowing from the fixed tap through capacitor C to ground, depending upon the starting position of the autotransformer variable tap. The problem exists of trying correctly to tune the phasing elements L and C to series-resonate the antenna with information obtained from a discriminator, which under these conditions cannot detect antenna current because of its relative absence.

This is the usual tuning condition and results in the necessity of forcibly operating the phasing elements at the beginning of each tuning operation by automatically applying a voltage to the motors until such time as they are near enough to resonating the antenna to allow the discriminator to assume control of the situation and complete the tuning function.

**Shunt Capacitor**

Owing primarily to practical considerations with regard to component minimum and maximum values it is still possible to present an antenna to this network, as it is thus far described, which the network is not capable of transforming to 52 ± 90. Since this cannot be tolerated, in these instances a relay-operated fixed capacitor C is provided within the antenna-matching unit and permitted to shunt the antenna and change its effective impedance to a matchable value.

Whenever C, is required for the solution of a matching problem, it decreases matching efficiency. Its use, therefore, is restricted to antenna impedances that represent limits of tuning range and for which the construction of a series-resonating reactance or autotransformer would be impractical. The necessity for use of C is determined automatically by providing switches at the extreme limits of L and C and the autotransformer, such that if any one of these elements reaches the limit of its tuning range it will operate the relay to connect C, in shunt with the antenna.

The unit as constructed is capable of operation with antennas from 25 to 90 feet in length over the 2-to-25 mc frequency range. The antennas may have their remote ends either grounded or ungrounded. Tuning accuracy of the entire unit is approximately equivalent to a 1.3-to-1 standing-wave ratio.

The efficiency of the unit is dependent primarily upon the relationship existing between the antenna Q factor and the Q factors of the phasing inductance L and autotransformer. The greater the value of coil Q with respect to antenna Q, the greater is the matching efficiency of this network.

The time involved in matching any particular antenna depends upon the antenna and the starting position of the various tunable elements. Time values from 1 to 25 seconds represent the limits in time that will elapse from the instant the transmitter is keyed to the moment the antenna has been completely tuned.

For antennas and frequencies within design limits, no further information is required by the unit except a grounding pulse from the transmitter whenever a new frequency is selected. Control circuits within the automatic antenna-matching unit perform the function of keying the transmitter prior to tuning, and unkeying the transmitter when the antenna has been properly tuned.

Some changes in antenna characteristics occur during operation, particularly in aircraft, wherein antenna-impedance variation occurs between ground operation and flight. The unit is designed to monitor the impedance presented to the transmitter and continually correct for this type of variation.

The techniques exemplified in this paper represent the efforts of many. In particular the author wishes to acknowledge the advice and guidance of D. W. Weber and the contributions of J. Sherwood, S. Morrison, M. Ludvigson and V. Newhouse.

See p 194, after Mechanical Design insert, for this month's Electronics Reference Sheet

October, 1954 — ELECTRONICS
MECHANICAL DESIGN
of electronic equipment.......

An electronics
Special Report
OCTOBER - 1954
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DESIGNING THE CHASSIS involves selecting materials, laying out the work and specifying the finish. Operator is punching out subassembly chassis with a 75-ton geared press.

MAKING SMALL PARTS requires processes such as machining, casting, brazing and welding. Operator pictured uses a hand milling machine to trim rods on variable capacitor.

The Importance of Mechanical Design

By JOHN M. CARROLL
Associate Editor, ELECTRONICS

Good design is reflected in increased production of reliable equipment. This special report gives a rundown on the latest in methods, machines and materials.

Mechanical Design of Electronic Equipment

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designing the Chassis</td>
<td>John Lesser</td>
</tr>
<tr>
<td>Making Small Parts</td>
<td>K. B. Clarke and J. W. Courage</td>
</tr>
<tr>
<td>Shielding and Potting</td>
<td>S. J. Burrano and E. F. Bailey with S. Cramer</td>
</tr>
<tr>
<td>Moving Parts</td>
<td>Elliott Guttman</td>
</tr>
<tr>
<td>Power Devices</td>
<td>H. Sabath, S. R. Sporn and J. Y. Kaplan</td>
</tr>
<tr>
<td>Assembly Techniques</td>
<td>Fred T. Schick</td>
</tr>
<tr>
<td>Wiring and Soldering</td>
<td>Charles Seelig and Charles F. Schultz</td>
</tr>
<tr>
<td>Designing the Cabinet</td>
<td>John T. Muller</td>
</tr>
</tbody>
</table>

M-2 October, 1954 — ELECTRONICS
M.ECHANICAL DESIGN can be either the strength or the weakness of electronic systems engineering. Considerations such as price, rate of production, reliability, ease of operation and maintenance depend heavily upon the mechanical layout and construction of the equipment.

Modern trends in mechanical design are directed in general toward two objectives: automatizing manufacturing processes to increase production rates and reduce cost, and improving equipment reliability to achieve optimum, trouble-free operation under even the most severe environmental conditions.

**manufacturing processes**

In consumer products, mechanical design largely determines the competitive price position of the finished set. The configuration of parts and the mechanical layout of the chassis usually decide whether fabrication and assembly operations will be economical or costly.

In the design of an audio preamplifier a few minor changes in layout permitted the chassis to be stamped from a single piece of sheet metal rather than fabricated from three separate pieces by riveting. Savings in direct labor and cost of materials were 30 percent.

Such savings are magnified when indirect labor and overhead charges are applied percentagewise and serve significantly to reduce the selling price. Thus a minor change in mechanical design that permits a small metal part to be broached, extruded or die cast, avoiding expensive machining operations, will have an important influence on gross sales of the finished product.

Military planners are interested in design from the standpoint of reducing production time. In design of military equipment, cost necessarily must defer to optimum performance and maximum reliability. But time is an important factor and production bottlenecks can be costly in lives as well as equipment cost.

**reliable equipment**

Reliability is an important objective in military equipment design. The most advanced electronic gear is worse than useless if it cannot be depended upon to function in emergencies.

Toward the end of World War II, the Navy installed an advanced type of radar to control the main battery fire aboard some of its latest warships. The equipment provided exceptional gunlaying accuracy. However, usually only the first salvo could be fired under electronic control. The recoil shook electron tubes loose and, while technicians scrambled about pushing them...
back into their sockets, optical fire control equipment had to be relied upon—often this was rendered hopelessly inadequate by fog or darkness.

In another type of radar equipment designed for use on destroyers, chassis were mounted in removable drawers for ease of servicing. Ashore, the equipment performed well but when subjected to the intense vibration caused by marine turbines it often developed accordion pleats in the cabinet that jammed drawers shut and rendered servicing all but impossible.

**recent problems**

Modern equipment such as that used in high-speed aircraft and rocket-powered guided missiles places even more exacting requirements upon the equipment designer's art. For example, much airborne gear must pass vibration tests at 500 cps and higher. This has required development of new means for vibration isolation.

High sound levels have also been found injurious to electron tubes and other components and acoustic techniques are becoming important in airborne equipment design.

Stockpiling weapons such as missiles has brought up the problem of hermetic sealing to avoid corrosion and insure that the weapon will deliver 100-percent performance when taken from the shelf.

Other problems involve subminiaturization to cram essential electronic gear into ever-smaller equipment spaces, heat dissipation to permit operation under high ambient temperatures and space-heating and deicing schemes where low ambient temperatures are expected. There is, also, explosion proofing of equipment required to function in explosive atmospheres, waterproofing, splash proofing and drip proofing, resistance to salt spray, high humidity and fungus growth, and pressurization for operation at extremely high altitudes.

The mechanical engineer has been, for some time, a full-fledged member of the electronic design team. He may be a full-time worker in a research and development group along with electronic engineers and possibly physicists, chemists and mathematicians, or he may be assigned to a department where his specialized knowledge is available to several project engineers.

**designer's role**

In some organizations, mechanical engineers may be grouped in a separate department that functions as a clearing house for the mechanical problems of all design task forces. In others the mechanical engineer may be summoned in a consulting capacity, or the project engineer may be required to guide his electronic engineers in solving mechanical problems.

However the mechanical engineer may be represented, mechanical design plays a vital part in the design of electronic equipment. The following eight articles represent a compendium of recent design trends, production processes and manufacturing techniques aimed primarily at giving the electronic engineer the mechanical information he needs to articulate his particular problems and either solve them independently or intelligently seek the aid of a mechanical design specialist. It is also aimed at providing the trained mechanical engineer new to the field of electronic equipment design an insight into the particular problems, techniques and processes he will encounter while working with electronic equipment.

The editor thanks the Hammarlund Manufacturing Co., Westinghouse Electric Co., General Electric Co., Sperry Gyroscope Co., Grant's Pulley and Hardware Co., International Business Machines Co., Signal Corps Engineering Laboratories, Naval Electronics Laboratory and many other friends in industry and government whose advice, comments and criticism were most helpful in the planning and preparation of this report.
MATERIALS used in manufacturing chassis include both metals and plastics. The metals may be ferrous or nonferrous. Plastics include acrylic and phenolic plastics, fiber board and laminates.

Selection of material is based on the service requirement of the equipment. Important factors are: weight, tensile strength, electrical properties, resistance to corrosion, magnetic properties and cost.

Table I indicates weight per square foot in various gauges for various metals. Carbon steel is commonly used because of low cost, good tensile strength and economy of fabrication. It has the disadvantage of poor resistance to corrosion and must have a protective coating of paint or plating.

size and shape

The chassis designer must keep in mind the following: electrical interference between components, distribution of weight throughout the chassis, wiring distance between terminals of components and overall dimensions of the equipment. With the current emphasis on miniaturization, the designer must place his components as closely together as possible. To facilitate wiring and assembly, chassis can be designed with removable top decks or removable side skirts as shown in Fig. 1.

Chassis can be made sectionally of subchassis that can be wired and assembled on separate production lines. These subchassis can be inspected and tested rapidly. There has been an increasing trend to plug-in chassis and sub assemblies, particularly in military equipment, since they greatly facilitate servicing and repair.

For the manufacturer who has limited production runs there are available stock blank chassis from many sheet metal fabricators.

laying out the work

In conventional mechanical drafting tolerance occupies an important place. To maintain interchangability...
of parts, close tolerance must be observed. Such tolerance, however, increases the cost of fabrication. Critical dimensions are usually indicated decimally with plus or minus 0.005-in. tolerance. Dimensions of overall size and locations of holes to an edge are usually located fractionally with a tolerance of plus or minus \( \frac{3}{64} \) in.

Since it takes more labor to fabricate sheet metal to close decimal tolerances, they should be used only where the relative location of holes and bends is critical. Unless a chassis is to be enclosed in a tight-fitting case, the overall dimensions should be expressed fractionally. In a group of holes dimensions between mounting holes should be expressed decimally, but the whole group or cluster can be located fractionally from the edge of the chassis. See Fig. 2.

Where quantity justifies tooling costs, it is advantageous to use cluster dies which pierce the critically dimensioned holes at one time, insuring correct location.

Mounting holes can be dimensioned fractionally, however, if the holes are slotted or made slightly larger than clearance to accommodate the greater tolerance.

The chassis designer must specify the radius of bends in the part. If the radius is too small, the bend will fracture. Although most drawings of chassis are three-angle projections, it is sometimes convenient to draw a development of a sheet-metal part. A hole dimensioned past a bend will be located incorrectly on a development if allowance for the stretching or shrinking of material at the bend is not considered. The allowance for a 90-deg bend can be determined from the relationship

\[
L = \left( \frac{\pi}{2} \right) (R + \frac{1}{2} T) \quad \text{where} \quad L = \text{length}, \quad R = \text{inside radius} \quad \text{and} \quad T = \text{thickness}.
\]

Many engineers find it convenient to use a blank chassis of the required overall dimensions and move their components about on the top, checker fashion, until they find the optimum location. To make a marking surface on the top of the chassis, template blueing can be applied or, if the chassis is aluminum, the surface can be satin etched or sandblasted.

**cutting sheet metal**

The first step in chassis manufacture is cutting the blank. Unless the blank is accurately cut, the location of all the subsequent operations will be incorrect. In conventional shearing practice, Fig. 3 (left), the blank is shoved against a gage behind the blade and held secured until the blade cuts the piece. For greater accuracy the blank should be front sheared or held against a gage in front of the blade and trimmed to the correct size. See Fig. 3 (center). For shearing rectangular pieces or for straight line shearing, this type of machine is used, but for cutting radii or circles a circle shear or a nibbler must be used, Fig. 3 (right). In large quantities, dies like that shown in Fig. 4 (top) are made which blank out the entire shape in one blow.

**making holes in sheet metal**

Although some drilling is necessary in most chassis construction, chassis are pierced where practical using punch and die sets. Generally, any round hole which has a diameter less than the thickness of the metal...
used should be drilled instead of punched. Punches should be kept sharpened to minimize burrs on the underside of the hole. Special piercing dies are made which will knock out specially shaped holes in one blow instead of chewing them out with a series of blows. Figure 4 (center) illustrates one such die.

Machinery is available to blank, pierce and form chassis, delivering a complete unit on each blow of the press. However, in production runs that are not of sufficient quantity to amortize high cost of such dies, it is necessary to use other machinery.

Movable punch and die sets can be used to great advantage. The bed of the die is either slotted for bolting down small piercing dies (Fig. 4, bottom) or the dies are held in place magnetically.

Turret presses utilize a turret which holds a number of die sets and can be rotated quickly to the correct size. The hole is located in the blank either by placing the blank against a gage (Fig. 5, left) or piercing through a template clamped to the piece.

Another type of turret press utilizes a master template fastened to the bed of the press. A moving carriage firmly holds the blank and is registered to the template with a pantograph section as shown in Fig. 5, right.

Kick presses and small power presses are used in limited quantity production runs; see Fig. 6.

**bending sheet metal**

Piercing, cutting, blanking and notching should be completed before bending or forming. Bending is done on a brake. These range from manually operated devices such as fingerbrakes to powered brakes shown in Fig. 7. These are known as press brakes. Press brakes range in length from 3 to 12 ft and more. Sequence of bending is important. If the wrong bend is put in too soon, it is impossible to finish bending the chassis. A Dutch bend illustrated in Fig. 8A can be used at the edge of sheet metal to strengthen the edge when working with light gages. Corner construction of chassis varies with the service requirement of the equipment. Various corner configurations are shown in Fig. 8.

**fastening methods**

Joints assembled with bolts and screws can be readily disassembled and reassembled. Thus, they are widely used as mechanical fasteners. The use of nuts can frequently be eliminated. Methods include threading holes previously pierced in the chassis. When the gage of metal is too thin to provide enough land for threads, the hole can be extruded to add extra thickness for the threads. See Fig. 9A. Self-tapping screws, Fig. 9B, are used to great advantage since they cut their own thread on initial insertion. A chassis can be lanced at its edge as in Fig. 9C to provide holding surface for sheet metal screws for fastening the chassis in a cabinet or for holding on a bottom plate.

Special screw fasteners are available for many applications. The locking types fall into four general groups: wedge, spring seating, spring stop nut and interference stop nut. The wedge type (Fig. 10A) is locked by wedging one part against the other.

Spring seating fasteners, Fig. 10B, are free running because the locking action does not occur until seating begins. The locking is due to a lever or spring action.
within the periphery of the nut or bolt head. Locking action of the spring stop nut shown in Fig. 10C is also due to a spring clamping action. These fasteners differ from previous types in that the clamping action is continuous.

The interference stop nut employs a plastic or fiber collar to provide the locking action. See Fig. 10D. These collars are not threaded and when placed on the bolt are elastically deformed. Thus they tend to return to their original shape, squeezing against the threads and holding the nut in place. Quick-release fasteners, illustrated in Fig. 10E, are used for doors, panels and covers where intermittent closing and opening is required and a positive lock is necessary.

rivets

Riveting is a popular method for permanently fastening parts together. It is inexpensive and produces a sound joint without locking devices. Riveted joints are of two general types: lap joints and butt joints. Lap joined plates overlap while butt joined plate ends but at each other and one or more cover plates or straps are employed. Both types of joint can be single riveted, double riveted, etc. depending on whether one row, two rows, etc. of rivets are used. Figure 11A illustrates several rivet types. Rivets are usually placed on lines parallel to the edge of the sheets. Lines which pass through the center of the rivet are gage lines. The distance from the edge of the plate to the first gage line is the edge distance. The distance between the centers of two adjacent rivets on the same gage line is the pitch of the rivet. Improperly riveted joints fail because of shearing of the rivet, tearing of sheet or cover plate, tearing or shearing between rivet hole and edge of sheet and crushing of the rivet or sheet at the edge of the hole.

Other failures may occur, such as popping of the head and head pulling through the sheet. These can be controlled by correct proportioning of the joint and by proper driving of the rivets. Correct proportioning of the joint involves factors of rivet size, material and spacing as well as hole size and edge distance.

methods

Where head protrusion is not desirable, countersunk-head rivets are used and driven in such a manner that the top of the head is flush with the surface. The top sheet must be dimpled or countersunk to the correct head dimensions during fabrication either in a press or by machine countersinking.

Rivets are driven by placing the driving tool against the head and a bucking bar against the shank end of the rivet. The driving tool is a rivet set attached to a pneumatic hammer or struck by hand. Riveting machines are also available which feed rivets by a raceway. Rivets can be also set with a squeeze action.

When using solid rivets of small diameter in thin sheets, the bearing area is so small that buckling of sheet may occur. To increase the bearing area without appreciably increasing rivet weight, tubular rivets are often employed. Use of tubular rivets also minimizes damage to the sheet. Two types of tubular rivets are available: the sleeve type and the solid head and a hollow shank rivet. See Fig. 11B.

Many standard fasteners require access to both sides of the assembly. Several types of blind rivets have been developed for special applications.

welding

Welding is the joining of two or more pieces of metal by application of heat and sometimes of pressure. The welding processes include: gas welding, arc weld-
ing, resistance welding, brazing, induction welding, forge welding, flow welding and thermit welding.

Gas welding produces coalescence by heating with a gas flame with or without the application of pressure and with or without use of filler material. Gas welding covers many processes employing different fuel gases. They generally require oxygen to support combustion. Within certain limits the flame temperature increases with the oxygen in the mixture. A widely used fuel gas is acetylene. Oxyacetylene welding is used on the whole range of commercial ferrous and nonferrous metals and alloys.

An oxyhydrogen flame supplies a source of heat for low-temperature operations such as welding low-melting-point metals, brazing and braze-welding. The oxyhydrogen flame finds extensive use in welding aluminum and its alloys, particularly in the thinner gages.

**materials for welding**

Welding rods vary greatly in composition. For the thin gages of metal used in chassis construction, filler material is not always necessary. Thin materials, particularly aluminum, are often joined by flanging the sheet and melting this flange into the joint as filler.

A flux is usually used to combine with products of the welding operation which would interfere with the operation. The oxides of most alloyed metals generally have higher melting points than the metals themselves and remain as solids when the base metal is in the fluid state. Appropriate fluxes form a fusible slag with the oxides which tends to flow away from the weld area. The slag also forms a coating to protect the molten metal from oxidation. Fluxes are cleaning agents but should never replace proper cleaning of the base metal. Excess flux should be removed.

In arc welding coalescence is produced by heating with an electric arc. Its advantages are ease of edge preparation, fast welding speed and the elimination of flux. It also provides a concentration of heat which prevents excessive expansion and reduces distortion.

Metal-arc welding is done with flux-coated electrodes using direct current and reverse polarity (work negative). In gas-shielded tungsten-arc welding coalescence is produced by an arc between a tungsten electrode and work, shielded by an inert-gas envelope. This method has its greatest application when aluminum is the base material. It is capable of making clean, sound welds without use of corrosive fluxes. An inert gas such as argon shields the arc and the molten metal from the air, preventing oxides from forming. Such welding uses an h-f alternating current superimposed on 60-cycle welding current. The low-intensity arc produced by the h-f current provides a path easily followed by the main welding current, which makes the arc easier to start and maintain. Filler material is used.

**other welding methods**

Resistance welding is a process in which a current is conducted through the parts to be joined. Heat is generated at the junction due to resistance. When this heat is combined with pressure applied by associated equipment, fusion is produced. Figure 12 illustrates operation of resistance welding equipment.

Spot welding and seam welding are resistance welding processes. Seam welding is spot welding with spots spaced so closely that they overlap to produce a continuous joint or seam. Timing is important in the spot-welding process. Pressure must be applied, maintained during the period of current flow and the cooling period afterward.

A spot weld must first resist shear stress. The strength of a joint depends not only on the strength
of the spot but also on the number and position of the spots. Because of partial short circuiting of welding current by a previous spot, it is necessary to maintain a minimum weld spacing (pitch) of the spots.

Minimum edge spacing is also important to prevent bulging and forcing out of the metal between the spot and the edge. Each spot weld tends to expand the sheet, so that correct weld sequence should be observed to prevent warping. The weld size recommended is three times the thickness of the thinnest outer piece, plus 0.06 inch. The specific sizes vary for each metal.

Penetration of the weld metal into the outer sheets of a joint is important. Weld penetration of less than twenty percent into one or both sheets will result in low weld strength. If the weld penetrates more than eighty percent, cracked welds can result.

The shape of the electrodes is also important. The contour of the tip depends upon the thickness of metal being welded, welding process and surface appearance desired. Materials of high thermal and electrical conductivity such as aluminum require higher welding current than steel. Aluminum and its alloys can be spot-welded satisfactorily only if the surface of the material is cleaned to remove the oxide coating. These oxides offer high resistance and prevent good welding. They can best be removed with alkaline cleaners. Since these chemicals also attack the aluminum and may produce a film with as much electrical resistance as the oxide film, they must be neutralized and washed from the aluminum.

**brazing**

In brazing coalescence is produced by heating to temperatures above 800°F and using a filler of nonferrous metal having a melting point below that of the base metals. The filler metal is distributed by capillary action. In making joints, the following factors should be considered: design of the joint, cleaning and preparation, fluxes, jiggis, filler material and heating.

The strength of the joint can be controlled by the length of the lap. A reasonable length of lap is three times the thickness of the metal being joined. Maintaining a clearance of 0.001 to 0.003 in. is important to insure even flowing of the filler material. In aluminum the filler is aluminum alloy. The oxide coating of aluminum requires a flux which will melt below the brazing temperature and prepare the surfaces so that the filler material will flow. Parts may be spot welded before brazing to hold them in place. Parts to be brazed can be heated in a furnace, by gas torch or by induction heating.

**metal finishing**

Coatings are required either for protection from corrosion or enhancing of appearance.

Steel cannot ordinarily be used in its primary condition because it has little resistance to corrosion. Prior to finishing, dirt, grease, oils used in fabrication and surface scales and oxides must be removed.

Oils and greases can be removed with solvents. Washing by hand or wiping with a cloth or brush soaked with solvent is inefficient because the operator often spreads the impurity instead of removing it. Immersion in a tank of solvent is not effective because the oils and greases float on the surface and lifting the part out redeposits the contamination.

An effective method of degreasing is use of chlorinated solvents such as trichloroethylene and perchloroethylene. These are heated until they vaporize. Since these vapors are heavy as compared to air, they tend to stay in the container. The part to be degreased is suspended in the vapor for about thirty seconds. The
vapor condenses on the piece and streams off, washing the greases away.

If the final finish is to be an electroplate, no other surface treatment may be required. However, if paint is to be used, further chemical treatment of the surface will increase adhesion qualities of the material. One type of coating is Bonderizing. This coating is composed of zinc phosphates and has a strong affinity for paint. It also protects the surface against corrosion. Iron oxides (rust) have an alkaline reaction with moisture. These alkalies react with paint to form soaps which prevent adhesion between the steel surface and the paint. The phosphate coating prevents oxidation. Phosphate coatings are produced by several manufacturers.

Excessive scale and rust can be removed from steel by pickling in acids or by sandblasting.

finishing aluminum

Aluminum must also be cleansed of impurities on its surface. Vapor degreasing is an efficient method of removing oils and greases. Aluminum has high corrosion resistance as compared to steel. The natural oxide film protects the material but offers poor adhesion to paint. Proprietary solutions are available which not only chemically remove this film but also leave a phosphate deposit which aids adhesion.

Certain oxide films are deliberately added to the surface of aluminum either for additional corrosion resistance, increasing adhesion qualities or both. One process specifies immersion of material in a hot solution of 2-percent sodium carbonate and 0.1-percent potassium dichromate, with a subsequent bath of 5-percent potassium dichromate, and offers an excellent base for paint.

Another process produces an insoluble phosphate

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**FIG. 9**—Holes extruded in sheet metal can be threaded (A), self-tapping screws utilized (B) or the chassis lanced at its edge (C)

**FIG. 10**—Special fasteners are widely used in commercial equipment such as television sets and home radios. The several varieties illustrated include: wedge type (A), spring seating fasteners (B), spring stopnuts (C), interference stopnut (D) and quick release fasteners (E)
coating which is corrosion resistant and a good base for paint. Another offers a coating which can be used as a final finish or is a good base for paint. Another provides excellent corrosion resistance and is electrically conductive. It offers protection without interfering with electrical grounding of components.

Phosphatizing is an economical chemical treatment for aluminum. It consists of immersion of the part in a 5-10 percent solution of phosphoric acid. It is a good preparation of the surface for paint.

Electrolytic oxide finishes of aluminum (anodizing) are important because they offer a hard, inert, durable protective film. Anodic films, however, have high dielectric strength and interfere with electrical grounding. Anodizing takes its name from the fact that the aluminum is made the anode instead of the cathode as in electroplating. An electrolyte capable of yielding oxygen is used.

When current is passed, an initial oxide film forms on the aluminum surface and progressive oxidation takes place beneath this film. Hence, the film formed last is next to the metal and the oldest part of the film is on the surface. This outer part of the film is less dense and is softer than at the metal interface, since it has been subjected to the most severe solvent action. The aluminum oxide film produced is minutely porous. Thus current is able to pass through the electrolyte in the pores to the metal without too much resistance and heavy oxide films can be built up.

After formation, the film is treated with boiling water, which closes the pores and destroys the absorptive characteristics of the coating. This is known as sealing. Chromic acid and sulphuric acid are commonly used in anodizing processes, although other acids can be used.

The chromic acid method produces an absorptive film which can subsequently be colored by dipping in dye baths. Assembled parts can be anodized without the corrosion resistance being effected by acids that may be trapped in the joints. The film also offers a good base for paint.

Sulphuric acid anodizing is an economical process. It is not ordinarily used in an assembled or spot-welded part where acid may be trapped under a lap or joint. Such retention of acid would cause deterioration of the aluminum.

**electroplating**

The deposit of metal on the surface of another metal by electrolytic process is called electroplating. Steel can readily be electroplated after degreasing and cleaning. Where corrosion resistance must be provided but electrical conductivity maintained for grounding of components or soldering, zinc or cadmium plating are common methods. Plating may oxidize on prolonged exposure to the atmosphere. To protect the plating from oxidation and increase the adhesion quality, a subsequent dip in a chromate solution is recommended.
Steel surfaces can be made more electrically conductive by plating with copper or the noble metals, silver, gold, etc. The material should be copper-plated prior to the latter platings.

Chromium plating is used when a hard abrasion resisting surface is required. It is also used as a decorative finish. The high polished appearance of chromium is based on buffing the surface underneath the chromium plating. Aluminum can be electroplated after the part has been zinc coated. This process is an immersion type coating. The material is chemically cleaned and dipped into a solution of caustic soda and zinc oxide. This coating provides excellent adhesion for subsequent electroplatings. Both copper and brass plating on aluminum are used for applications requiring joining with soft solder. Aluminum in its natural state does not solder easily because of its natural oxide film and high thermal conductivity. Aluminum can be plated with chromium, nickel, cadmium, silver, to provide specific decorative or corrosion resistant finishes.

**paint, varnish and enamel**

Paint is a general term covering lacquers, varnishes and enamels. Lacquer is usually a cellulose nitrate or acetate base that can be pigmented if desired. In its clear state, it is used as a protective film over plated surfaces to prevent tarnishing. These films are economical to apply, because they air-dry and become hard without baking. Lacquers are water resistant but will not withstand salt water. They may also become brittle and discolor upon exposure to sunlight.

Varnishes can be formulated to provide special protection such as moisture, mildew or fungus resistance and are used for this purpose in electronic equipment.

Enamels, sometimes called synthetic because the resins are manufactured rather than natural, are produced in a variety of textures and appearances.

Wrinkle enamels have a crinkly appearance which has the chief advantage of covering minor surface imperfections in the base metal such as scratches and nicks. They are also widely used as a finish for sand castings because they cover the porous surface and have great hiding quality.

Hammer finishes have the appearance of hand-hammered metal. They are pigmented in a variety of colors, including the metallic.

Paints are classified by the degree of gloss desired. This can range from lusterless to a high gloss approaching mirror quality. Lusterless finishes tend to show fingerprinting. Semigloss materials are desirable since the high-gloss paints can cause eye fatigue to the operator. Paints can be applied by brush, dipping and sprayed. Spray painting is acceptable because the resulting surface is even and smooth without brush marks.

In dipping, the paint drains off the piece and sometimes leaves an unsightly buildup at the lower edges. Spray painting must be done in a booth suitably ventilated and with an exhaust that will draw the excess sprayed material away from the work. Spraying is accomplished by a spray gun with a cup containing paint thinned to spraying consistency.

**graphic processes**

Electronic equipment must be labeled to instruct the operator in the use of controls, identification of the power requirements, identification of the manufacturer and for labeling the components. Marking must be legible and permanent. It must be easily read and understood; lettering should not be too small.

Engraving is a technique in which the characters are cut into the base material and filled with paint to
Etching is a good method of producing production quantities of nameplates. They are manufactured by imprinting the required design in reverse on aluminum or brass using a lithographic process. The printing ink is resistant to the etching solution. The etchant eats away the surface of the material not covered by the ink. The material is removed from the etching solution and neutralized. The nameplates are then sprayed with paint of the desired color and baked. The tops of the plates are then scraped down to the printing ink.

Since the etched areas are depressed, they retain the sprayed finish, resulting in a plate that has raised characters with a painted background. Entire front panels can be etched. All fabrication must be done after etching because the etchant would undercut holes pierced into the material. Small nameplates are etched in sheets containing many plates and sheared to size.

The use of rubber stamps is common for marking of nomenclature on chassis or parts. The inks used must usually be covered with lacquer or varnish.

**Stenciling**

Stenciling requires a mask, cut with the required characters and held against the work while paint is applied either with a brush or by spraying. The marking can then be protected with an overcoat.

Silk-screen process printing is an efficient method of applying nomenclature to electronic equipment. A film positive with the desired nomenclature is placed against a bichromate gelatin film with a vinyl backing and an exposure to light made.

The bichromate emulsion becomes solid and insoluble when exposed to light. The areas of the film not affected by light are soluble and the emulsion is washed away. The bichromate gelatin film is then adhered to a tightly stretched silk or mesh stencil and the vinyl backing removed. By placing this stencil on the surface of the part to be printed, pressing paint of the desired color through the openings of the silk will give an imprint of the desired nomenclature.

Figure 13 depicts chassis which have been imprinted using the screen printing method. Screen printing inks and paints are formulated of synthetic baking enamels which when correctly cured offer excellent adhesion to metals and resistance to abrasion and corrosion.

The printing on the panels illustrated has been overprinted with clear fungus resistant varnish to give additional protection. Screen printing is also used extensively in marking front panels.

There is also technique of screen printing on wrinkled enamels in which the printed character is inlaid and embedded into the background and gives the appearance of engraving. Figure 14 shows screen printing on a hammer-finish background and illustrates how design can be introduced to enhance appearance.

Much of the material and some of the illustrations for this article were prepared by the engineering staff of Multi-Metal Wire Cloth Co., New York.
Making Small Parts

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Brackets, mounts, insulators, meter cases and other small parts of metal and plastic must be rugged, economical and have close dimensional tolerance. Fabricating processes include machining, casting, brazing and welding.

Use of the lathe as a production machine is illustrated by the manufacture of a tuning-pin support. It was necessary to machine 10 angular radial convolutions in oxygen-free, high-conductivity copper rod to tolerances of ±0.001 on a 0.248-in. diameter. Production requirements were too high to justify machining the grooves individually on a lathe and too low to justify the cost of providing automatic equipment.

As shown in Fig. 1, a skiving tool of modified design with a special tool holder did the job. The skiving tool cutting member was made from nonferrous alloy and the work put on a 10-in. power-feed lathe. The large end of the part was held in a collet and the small end supported with a revolving center in the tail stock. This center was used to eliminate any possibility of the center spinning out due to friction and tool pressure. The skiving tool was clamped, adjusted in the holder and mounted on the front cross slide. The tool was power fed tangentially across the top of the part to machine the grooves. No trouble was encountered in holding specified dimensions. Tool life was about 24 hours between

TURNING IS ONE of the primary machining operations used in parts manufacture. It offers the advantages of single-point tooling for maximum metal removal and good finish accuracy, with production speed equal to the fastest processing equipment. Turning equipment includes the basic engine lathe and automatic lathes such as turret lathes and automatic screw machines, also tracers or shape turners that use templates.

lathes

The lathe removes material by rotating the work against a cutting tool. Parts are held between centers, attached to a face plate, supported in a jaw chuck or held in a draw-in chuck or collet. The machine is adapted to cylindrical work but may also be used for other purposes. Plain surfaces can be obtained, or workpieces centered, drilled, bored or reamed. The lathe can also be used for cutting threads, turning tapers and milling or grinding operations. In mass production, lathe work is done on turret lathes and automatics.

FIG. 1—Ten special grooves are machined in tuning-pin support, using Stellite skiving tool and 10-in. power-feed lathe

ELECTRONICS — October, 1954
milling machines

A milling machine consists of a power-driven spindle or arbor to which the cutter is attached. The part is cut by moving the table toward the tool by hand or power until the tool has bitten into the work a specified distance.

Milling machines are made so that the table will raise or lower, move right or left, in or out or swivel at an angle. The cutter may be mounted so that it is horizontal or vertical to the table or any angle. With indexing attachments, straight or helical cuts may be made on cylindrical pieces. Standard cutters are made in widths 1/2 to 8 in. and in all shapes and styles.

Milling machines may be classified as plain, universal, hand and vertical. Plain milling machines have the cutter revolving about a horizontal axis and the table traveling past the cutter at right angles to its axis. A hand miller is one type of plain milling machine. A universal milling machine has a table moving in a swivel carriage which allows it to travel past the cutter at different angles with its axis. Vertical milling machines have the cutter revolving about a vertical axis.

An operation indicative of the adaptability of the milling machine is the milling of 32 cooling-fin slots in a copper electron-tube shell as shown in Fig. 2. A horizontal-type milling machine is used. The machine is equipped with a fixture designed to hold two parts located at the specified angle. Sixteen slots are cut simultaneously on one side of each part using carbide-tipped cutters arranged in a gauge and mounted on a single-spindle arbor. When this operation is completed the parts are turned 180 deg, located in an alternate position in the fixture and the slotting is completed. The tolerance of the width of the grooves is ±0.002, −0.002 and ±0.005 for the depth and location.

Table I — Presses for Forming Small Parts

<table>
<thead>
<tr>
<th>Type of Press</th>
<th>Size</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incliable</td>
<td>4.90 tons</td>
<td>Blanking, bending, stamping, forming and assembling light gage sheet metal</td>
</tr>
<tr>
<td>End-wheel gap</td>
<td>Small to 50 tons</td>
<td>Blanking, forming, notching, piercing and cutting long, narrow strips</td>
</tr>
<tr>
<td>Double-crank</td>
<td>Small</td>
<td>Blanking, cutting and piercing large pieces of sheet metal</td>
</tr>
<tr>
<td>overhanging</td>
<td>Small</td>
<td>Blank, cutting and piercing large pieces of sheet metal</td>
</tr>
<tr>
<td>Straight-side high-speed</td>
<td>10-400 tons</td>
<td>Blanking and stamping for high production rates</td>
</tr>
<tr>
<td>Dieing machine</td>
<td>Small</td>
<td>Progressive die operations on small parts</td>
</tr>
<tr>
<td>Oscillating die</td>
<td>Small</td>
<td>Blanking and cutting light gage material</td>
</tr>
<tr>
<td>Multislde</td>
<td>Small</td>
<td>Combined operations—blanking, forming and bending light gage metal</td>
</tr>
<tr>
<td>Double-action</td>
<td>Small, medium or large</td>
<td>Blanking and drawing applications requiring two related operations</td>
</tr>
</tbody>
</table>

Swiss automatic screw machines are often used in precision turning of small parts. The single-point tools
used are placed radially around the carbide-lined guide bushing through which the stock is advanced. Most diameter turning is done by two horizontal tool slides while the three other slides are used principally for operations such as knurling, chamfering, cutting off and recessing. Diameters can be held to tolerances of 0.0002.

Multispindle automatics are fully automatic and are made with two, four, five, six or eight spindles. All spindles operate simultaneously and one piece is completed each time the tools are withdrawn and the spindles indexed. Attachments can be added that increase the range of cutting conditions or make possible special operations that otherwise could not be performed. Frequently, multispindle setups eliminate secondary operations with considerable savings in direct labor and overhead. Production materials in all shapes and up to 7/₃ inches in diameter can be worked.

Almost any machine operation is available. Both solid and self-opening dies and taps may be applied. Taper turning, combined taper turning and boring or recessing attachments are applied to the end tool slide. A spindle-stopping mechanism can be arranged for such operations as milling, slotting and cross drilling. The multispindle automatic in Fig. 3 drills, reams, chamfers, faces and taps 750 telephone-dial frames per hour. It uses a 12-position die and drills the center hole to a tolerance of +0.003 in., -0.000.

broaches

Broaching is the removing of metal by an elongated tool having a number of successive teeth of increasing size which cut in a fixed path. A part is completed in one stroke of the machine, the last teeth on the cutting tool conforming to the desired shape of the finished surface. In most machines the broach is moved past the work, but effective results are also obtained if the tool is stationary and the work is moved. A broach consists of a work-holding fixture, tool, drive mechanism and a supporting frame.

Broaching machines are of horizontal or vertical design. Vertical machines are adapted for surface broaching although both pull and push internal broaching machines are made. Horizontal machines pull the broach and are often used on internal broaching in small and medium sized work. However, they too have many surface broaching applications. Broaching machines have been adopted for mass manufacturing because of their exceptionally high rate of production.

An application of broaching is seen in Fig. 4. The parts are cored forgings of vacuum-tube shell inserts and waveguide parts made of oxygen-free, high-conductivity copper and to fairly close tolerances. The forgings are machined such that the excessive stock is removed to insure pure oxygen-free, high conductivity material.

The shell insert blank is first turned in an automatic turret late by chucking in the rectangular opening using specially designed centralizing jaws mounted on an air chuck. Turned diameters and the rectangular hole are concentric within 0.004 of center.

The rectangular opening in the shell insert is broached in two operations. The narrow width is first machined to size using a guided broach. Grooves located on the narrow side and running the length of the broach fit onto keys and guides mounted centrally in the work-holding fixture and thus maintain concentricity regardless of previous hole location. Broach shift is prevented and any existing eccentricity between the rectangular hole and turned diameters corrected.

The long axis of the hole is then broached to size
by rotating the work-holding fixture 90 deg and using a guided broach as in the previous operation.

**metal forming**

Cold-forming processes are used in making end-use products because of their economy in producing the desired shape. For most cold-forming operations a press is used. Although some presses are better adapted for certain types of work than others, most of the forming, punching and shearing operations can be performed on any press if the proper dies and punches are used. A list of presses commonly used in making small parts in the electronics industry is given in Table I. Other cold-forming processes of importance include bending, extruding, deep drawing and spinning.

Bending is a plastic deformation as performed on a brake, in contrast to forming which is a process making one or more bends about a linear axis by making the metal conform to a die shape. The inner radius of curvature in forming is generally specified. The machine commonly used in bending operations is called a press brake. It is suited for long bending or forming operations not adapted to regular presses.

Extruding is causing metal to flow through a shaped opening in a die to impart that shape to the metal. Extrusion can be worked by impact or continuous pressure. Both methods are commonly limited to non-ferrous metals. In impact extrusion the pressures required and consequent tool duty are severe compared to stamping and deep drawing. However, this method offers unique possibilities in the manufacture of cups, shells or tubular shaped parts. Common applications include cans, cases, tubular parts with straight or tapered walls, capacitors and shielding cans.

Spinning is the operation of shaping thin metal by pressing it against a form while it is rotating. The nature of the process limits it to a symmetrical article of circular cross section. This work is done on a speed lathe similar to the ordinary wood lathe except that in place of the usual tail stock it is provided with some means of holding the work against the form. The forms are usually turned from hard wood and are attached to the face plate of the lathe although smooth steel chucks are recommended for production jobs.

Parts are formed by blunt hand tools which press the metal against the form. The cross slide has a hand or compounded-tool rest in front and some means for supporting a trimming cutter or forming tool in the rear.

**casting**

Resin-bonded shell molding is a sand-casting technique which uses, in place of the clay to bond the sand as in conventional practice, a plastic resin. This provides a strengthened bond which permits the mold to be made as a thin shell. After the plastic binder is cured, two mating halves of the mold are clamped together and placed in a pouring flask backed up with sand or steel shot for support. As the metal solidifies, the mold and the casting are drawn from the flask and the shell stripped off. Special venting is not required as the gases readily escape through the shell mold. Production tolerances of 0.002 to 0.004 in./in. are readily obtainable and large castings have been made with less than 0.0015 in. per in. deviation. Metals cast include brass, bronze, aluminum, iron and steel.

Plaster-mold casting uses plaster as a casting investment. It has recently been accepted as a production casting method. Compared with sand molds, it has a higher molding cost but close tolerance, fine detail and good surface finish make it economically practical for short and medium production runs. The molds are destroyed by removal of the castings.

Patterns are made of free-machining brass and are held to close tolerance. They are assembled on bottom plates of standard-size flasks and before receiving the plaster are sprayed with a parting compound. The plaster is poured over the patterns with vibration used to insure filling the cavities. The plaster sets quickly and is removed from the flask by a vacuum head. Moisture is removed by baking. Plaster molds are used for
Table II — Plastics Used in Parts Fabrication

<table>
<thead>
<tr>
<th>Material</th>
<th>Applications</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenol-formaldehyde</td>
<td>Wire-spring relays, jack mountings, insulators, plug shells, handset handles</td>
<td>High resistance, dimensional stability, low cost</td>
</tr>
<tr>
<td>Resin solution (phenolic varnish)</td>
<td>Insulators, spool heads</td>
<td>High resistance, dimensional stability, low cost</td>
</tr>
<tr>
<td>Cast polyester</td>
<td>Terminal strips, cable terminal blocks, encasements</td>
<td>Good aging, adherence</td>
</tr>
<tr>
<td>Reinforced glass fiber</td>
<td>Wiring supports</td>
<td>High resistance, mechanical strength</td>
</tr>
<tr>
<td>Polyvinyl chloride acetate</td>
<td>Loading-coil cases, wire insulation, capacitor coverings</td>
<td>High resistance, flexibility, toughness</td>
</tr>
<tr>
<td>Cellulose acetate</td>
<td>Coil interleaving, coil wrappers, relay and jack bushings</td>
<td>High resistance, film strength, close dimensional tolerances</td>
</tr>
<tr>
<td>Cellulose acetate butyrate</td>
<td>Combined-set housings, number plates</td>
<td>Impact strength, light weight, good surface finish</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>Crossbar frame dust covers</td>
<td>Transparency, low cost</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>Cable sheathing</td>
<td>High resistance, flexibility, chemical inertia, light weight, ductility</td>
</tr>
<tr>
<td>Polymethyl methacrylate</td>
<td>Wire-spring relay dust covers</td>
<td>Transparency, mechanical strength, good aging properties</td>
</tr>
<tr>
<td>Polyamide</td>
<td>Message register gears, combined set dial cam and pawl</td>
<td>Toughness, abrasion resistance, high resistance</td>
</tr>
<tr>
<td>Polyethylene terephthalate</td>
<td>Aluminum-foil capacitor dielectric</td>
<td>Film strength, dielectric strength, moisture resistance</td>
</tr>
<tr>
<td>Polytetrafluoroethylene</td>
<td>Deposited-carbon resistor sleeves</td>
<td>Nonflammable, heat resistant, almost transparent</td>
</tr>
<tr>
<td></td>
<td>Relay armature stops</td>
<td>Nonsticking, wear resistant</td>
</tr>
</tbody>
</table>

nonferrous alloys having casting temperatures up to 2,100 F. While plaster has proved an excellent mold material for yellow brass, certain bronzes, aluminum and magnesium may also be used.

Permanent mold casting utilizes molds machined from cast iron or tool steel but in some cases ceramic or refractory material is used. The mold must withstand high temperatures. Because of high cost, permanent molding should be used only for large-run production of small and medium nonferrous castings.

Castings produced by gravity in permanent molds are free from sand and have good finish and surface detail with tolerances of 0.0025 to 0.010 inches.

**Other casting techniques**

Investment casting is used when dimensional control is important, such as in making waveguide components. It uses patterns of beeswax, frozen mercury and polystyrene plastic. Molds are made with an investment of silica and clay. As it is not necessary to open the mold to remove the pattern or to use cores, the process is used to cast complicated shapes. Variations of this basic process include the lost-wax process and frozen-mercury casting. In the former, a wax object is covered with a plaster investment. When the plaster hardens, the mold is heated to melt the wax while further drying and hardening the plaster. The remaining cavity is then filled with molten metal. Upon cooling, the plaster investment is chipped away leaving the desired casting. Thermoplastic polystyrene resin is sometimes used in place of wax.

A casting process using frozen mercury has been developed for production of precision castings. A metal mold or die is made of the part to be cast. When assembled and ready for pouring, it is partially immersed in a cold bath and filled with acetone which acts as a lubricant. Then mercury is poured into the mold, displacing the acetone. Freezing takes place in a liquid bath held at around —76 F in about 10 minutes. Patterns are removed from the mold and invested in a
cold ceramic slurry by repeated dippings until a shell about 1/4 inch thick is built up. Mercury is melted and removed from the shell at room temperature and after a short drying period, the shell is fired at a high temperature resulting in a hard permeable form. The shell is then placed in a flask, surrounded by sand, preheated and filled with metal.

In die casting, molten metal is formed under pressure in a metallic mold. Pressures vary from 80 to 40,000 psi and are maintained until solidification is complete. Die-casting machines consist of a press and an injection mechanism and are designed for speed so the cycle of operations resulting in a casting can be as brief as possible. The die halves are bolted to opposing platens of the press in perfect register and other moving parts are integrated with the press such that they operate automatically in proper sequence as the press opens and closes. Die casting is done by both the hot-chamber and cold-chamber methods. In the former, a melting pot is part of the machine and the machine injection cylinder is immersed in the molten metal at all times. The process is normally confined to relatively small parts. The advantages of die casting include rapid production, good finish, close tolerances and minimum machining. The high production rates result in low-cost parts providing the rate is sufficient to offset a high initial tooling cost. Die casting as a production process is limited to zinc, aluminum, copper and magnesium-base alloys.

plastics

Characteristics of plastics, such as ease and speed of forming into desired shapes in large quantities, moisture resistance and electrical resistivity have led to their increasing use in the electronics industry replacing materials such as wood, metal, ceramics and natural fibers. One company is currently using polyethylene at the rate of 6 million lbs per year, replacing lead as cable sheath with considerable cost savings. Tables II and III give applications for plastics and their more important properties. Plastics can be divided into thermoplastic and thermosetting types. Thermoplastics are heat softening. After heating, forming and cooling they can be remelted and molded again. The thermosetting plastics are heat-hardening and, once having been heated under pressure, the synthetic polymerizes and will not become plastic upon reheating.

Thermosetting plastics include: phenolics, amines, melamines and polyesters. Thermoplastics include: acetates, butyrates, ethyls, vinyls, acrylics, polystyrenes, nylons, polyethylene and nitrates. Plastics are further subdivided according to the processes by which parts are produced: molding, laminating or casting. The molding methods include compression, transfer, injection, extrusion or jet molding.

production processes

Compression molding uses powder or preformed shapes fed directly into a heated metallic mold where under heat, (250-400 F) and pressure (100 to 20,000 psi) it becomes plastic and fills the mold. The mold remains closed until the piece is cured and hardens into its final shape. Compression molding is largely used for thermosetting materials. The telephone handset in Fig. 5 is made by this method.

Transfer molding is used for thermosetting materials and makes use of a pressure chamber, separate from the mold cavity, in which the compound is plasticized by high-frequency current and pressure prior to being injected into the heated, closed mold cavity where it is cured and hardened. Transfer molding was developed for intricate-insert and slender-core parts not easily molded by compression.

Injection molding is used for molding thermoplastics and uses chilled dies to solidify liquid plastic material. Powdered material is fed into heating cylinders where it becomes molten. A plunger forces it through a nozzle under pressure (10,000 to 30,000 psi) into mold cavities. The chilled mold after a short cooling period hardens the material into final shape. No curing time is required.

Jet molding is an adaptation of injection molding for thermosetting materials. The plastic is forced by ram or screw through a heated jet where it is softened before entering the closed die. The method is particularly applicable to good flowing materials with long flow periods.

Extrusion molding is used to produce continuous rods, tubes, strips of almost any cross section from thermoplastic material. Granulated material is fed by hopper into a heating cylinder through which it is forced by a screw into a shaping die. Continuous lengths are usually produced by this method at a rate of 500 to 1,000 ft per hour, the hot material cooling and hardening on takeoff belts. Die requirements are relatively inexpensive and equipment is much simpler than for other methods of forming plastics. Generally, thermoplastic materials are extruded.
Casting is often used when the number of parts desired is not sufficient to justify making die equipment. It is usually used with phenolic resins in lead molds. The molds are hand-filled with the prepared resin in a liquid state and baked until the material reaches the required hardness. Casting is recommended for preparing short rods, tubes and various shapes to be used in later machining operations. Machined surfaces have a dull white appearance which may be removed by tumbling with wood blocks and abrasive particles or by buffing. Cast products include terminal strips, instrument cases, and terminal blocks.

Laminated plastics consist of sheets of paper, fabric, asbestos, wood or similar material impregnated or coated with resin and combined under heat and pressure. These materials are hard, strong, impact resisting and unaffected by heat and water and have desirable properties for numerous electrical applications. They may consist of a few sheets or over a hundred depending on the thickness and properties desired. Although most laminated stock is in sheet form, rods, tubes and special shapes are available. The material has good machining characteristics which permit its fabrication into many types of small parts.

In manufacture the resinoid material, usually thermosetting, is dissolved by a solvent to convert it into a liquid varnish. Reels of paper or fabric are then passed through a bath for impregnation. This is a continuous operation and as the sheet leaves the resinoid bath, it goes through a dryer which evaporates the solvent leaving a fairly stiff sheet impregnated with plastic.

**welding and brazing**

Welding includes pressure, nonpressure and brazing processes. In pressure welding both pieces of metal are forged together while in a plastic state; actual melting may or may not occur. In nonpressure welding the metal is fused or melted together. In brazing, a filler metal of lower melting point is used to join the parts; no forging action is present nor do the parts melt. Brazing, resistance welding, arc welding and gas welding are of primary importance to the electronics industry in the manufacture of small parts.

Brazing is similar to soldering but in brazing parts are joined by copper, zinc or silver alloys having melting points below that of the parent metal but above 800 F. The filler metal is introduced in a liquid state between the surfaces of the joint by capillary attraction. Temperatures range from 1,100 to 1,983 F. Four types of filler are commonly used: copper, copper alloys, silver alloys and aluminum alloys.

The melting point of copper, 1,982 F, limits its application to ferrous metals and other high-melting-point alloys including high-speed steel and tungsten carbide. Copper is frequently used in furnace brazing at 2,000 to 2,100 F with a protective atmosphere. Joints in steel parts brazed with copper have high strengths resulting from copper penetration and grain flow. Copper alloys for brazing are brass and bronze alloys having melting points ranging up to 1,980 F.

Silver-alloy brazing employs melting temperatures from 1,165 to 1,550 F. Pure silver is seldom used because alloys of silver such as silver and brass have a lower melting temperature and better melting and flowing characteristics. The silver brazing alloys are intended for use where higher physical strengths are required than are obtainable with soft solder or brazing spelter. Silver-brazed joints may be subjected to temperatures up to 425 F without appreciable loss in strength or to temperatures up to 200 F below their melting points if used only for sealing.

Aluminum alloys have melting temperatures ranging from 1,025 to 1,785 F and are used for brazing aluminum. The filler metal is usually applied in the form of wire or sheet-metal washer. The brazing temperature is above the recrystallization temperature so that cold-worked alloys are annealed.

There are four methods used in heating the metal to complete a joint: dipping in a bath of filler metal or flux, furnace brazing, torch brazing and electric brazing—resistance, induction or arc. The magnetrons in Fig. 6 are having their cathode structures brazed by the high-frequency induction technique.

The joint must first be cleaned of all oil, dirt or oxide and the pieces properly fitted together with appropriate clearance for the filler metal. Mechanical or chemical cleaning may be necessary in addition to the use of flux. Borax, either alone or in combination with other salts, is commonly used as flux and is applied as a thin paste. Borax and boric acid mixtures are suitable above 1,400 F. Commercial fluxes are available for use with lower flow point alloys for brazing stainless steels and for aluminum bronze.

The filler metal is frequently prepared in rings, washers, rods or other special shapes to fit the joint being brazed. Joints may be of the lap, butt, sleeve or scarf type or of various shapes obtained by curling, upsetting or seaming. Brazing is important in vacuum-tube appli-
Table III — Comparative Properties of Plastics

<table>
<thead>
<tr>
<th>Material</th>
<th>Tens (psi X1,000)</th>
<th>Flex (psi X1,000)</th>
<th>Compr (psi X1,000)</th>
<th>Izod Impact (ft-lb per in.)</th>
<th>Dielectric Str (volts per mil)</th>
<th>Resist. (ohm-cm X10^4)</th>
<th>Arc Resist. (sec)</th>
<th>Water Absorp. (percent)</th>
<th>Therm Expan Coeff (X10^-5 per deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenol-formaldehyde</td>
<td>7</td>
<td>14</td>
<td>20</td>
<td>0.3</td>
<td>350</td>
<td>12</td>
<td>5</td>
<td>0.2</td>
<td>4</td>
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<tr>
<td>Urea-formaldehyde</td>
<td>9</td>
<td>12</td>
<td>30</td>
<td>0.3</td>
<td>350</td>
<td>13</td>
<td>125</td>
<td>1.9</td>
<td>3</td>
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<tr>
<td>Melamine-formaldehyde</td>
<td>5</td>
<td>14</td>
<td>40</td>
<td>0.3</td>
<td>350</td>
<td>13</td>
<td>145</td>
<td>0</td>
<td>5</td>
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<tr>
<td>Cast phenol-formaldehyde</td>
<td>7</td>
<td>14</td>
<td>15</td>
<td>0.3</td>
<td>375</td>
<td>11</td>
<td>225</td>
<td>0.4</td>
<td>7</td>
</tr>
<tr>
<td>Cast polyester</td>
<td>6</td>
<td>13</td>
<td>20</td>
<td>0.3</td>
<td>450</td>
<td>14</td>
<td>125</td>
<td>0.4</td>
<td>9</td>
</tr>
<tr>
<td>Cast epoxy</td>
<td>12</td>
<td>19</td>
<td>15</td>
<td>0.5</td>
<td>400</td>
<td>14</td>
<td>115</td>
<td>0.1</td>
<td>6</td>
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<tr>
<td>Polyvinyl chloride</td>
<td>8</td>
<td>14</td>
<td>2</td>
<td>0.5</td>
<td>600</td>
<td>16</td>
<td>0</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Polyvinyl chloride-acetate</td>
<td>8</td>
<td>14</td>
<td>10</td>
<td>0.5</td>
<td>425</td>
<td>16</td>
<td>70</td>
<td>0.1</td>
<td>7</td>
</tr>
<tr>
<td>Polyvinyl butyral</td>
<td>6</td>
<td>10</td>
<td>10</td>
<td>0.8</td>
<td>400</td>
<td>14</td>
<td>0</td>
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<td>15</td>
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<tr>
<td>Polyvinylidene chloride</td>
<td>5</td>
<td>16</td>
<td>2</td>
<td>2</td>
<td>350</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>19</td>
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<tr>
<td>Celullose acetate</td>
<td>6</td>
<td>12</td>
<td>25</td>
<td>2</td>
<td>275</td>
<td>12</td>
<td>180</td>
<td>4</td>
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<tr>
<td>Celullose acetate butyrate</td>
<td>5</td>
<td>7</td>
<td>15</td>
<td>3</td>
<td>325</td>
<td>11</td>
<td>2</td>
<td>2</td>
<td>14</td>
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<tr>
<td>Ethyl cellulose</td>
<td>5</td>
<td>8</td>
<td>15</td>
<td>5</td>
<td>425</td>
<td>13</td>
<td>175</td>
<td>1.3</td>
<td>15</td>
</tr>
<tr>
<td>Polystyrene</td>
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<td>9</td>
<td>15</td>
<td>0.3</td>
<td>600</td>
<td>18</td>
<td>100</td>
<td>0.4</td>
<td>7</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td>450</td>
<td>14</td>
<td>135</td>
<td>0</td>
<td>17</td>
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<tr>
<td>Polymethyl methacrylate</td>
<td>7</td>
<td>15</td>
<td>15</td>
<td>0.4</td>
<td>475</td>
<td>15</td>
<td>0</td>
<td>0.4</td>
<td>9</td>
</tr>
<tr>
<td>Polyamide</td>
<td>10</td>
<td>12</td>
<td>15</td>
<td>1</td>
<td>400</td>
<td>13</td>
<td>140</td>
<td>1.5</td>
<td>10</td>
</tr>
<tr>
<td>Polyethylene terephthalate</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>19</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Polytetrafluoroethylene</td>
<td>6</td>
<td>8</td>
<td>50</td>
<td>4</td>
<td>400</td>
<td>18</td>
<td>360</td>
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<tr>
<td>Polytetrafluoroethylene</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>475</td>
<td>16</td>
<td>700</td>
<td>0</td>
<td>10</td>
</tr>
</tbody>
</table>

cations, manufacturing magnetrons and for special uses where high ductility and malleability are required.

Resistance welding is a production process adapted to joining light-gage metal that can be lapped. Spot welding is a form of resistance welding. It is the welding of two or more sheets of metal held between metal electrodes, applying pressure and then passing high current between the electrodes and through the work. The current is on just long enough to melt the metal under the electrodes so that the pressure of the electrodes will forge the metal together. The current is high, the voltage is low and there is no danger of shock from the welding current. In an average job the current is on only about 2/10 second and the pressure is about 500 lbs. The electrodes must be in firm contact with the work before the current comes on and the current must go off before the electrodes leave the work to avoid dangerous arcing.

Spot welds are really forge-welds, so usually there will be marks left by the electrodes that exert the forging pressure—at least on one side. Spot welds in steel up to 0.078 in. can be made relatively free of marks on one side if a flat electrode is used on that side. To make a markless spot weld requires that the material be welded without heating the surface opposite the weld. Markless spot welding can be made with special equipment for which capacitor discharge power is required. This welder makes a spot weld so quickly that only the surface of the metal right in the weld reaches welding temperature.

Seam welding is used in making liquid-tight joints. The work is put between two large but thin copper rolls and the seam is passed between these roll edges. As the seam rolls through, this current is turned on and off rapidly making a series of overlapping spots. For a tight seam in 0.031-in. material, the electronic timer would keep the current going at 3 cycles on and 2 cycles off making ten welds per inch at the rate of 72 in. of seam per minute. A seam-welding operation is illustrated in Fig. 7.
Cathode-ray storage tube for large digital computer requires magnetic shielding to exclude stray fields. Shield is fabricated from magnetic alloy by sheet-metal development.

**Shielding and Potting**

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**ASHIELD** is a metallic barrier to attenuate or decrease radio-frequency energy (either electric or magnetic fields) passing through it. Shields are either electrostatic or electromagnetic. The electrostatic shield is used primarily against interference or fields of the electric type, such as those produced by a charged capacitor.

Electrostatic shields are normally of high-conductivity material such as aluminum, brass or copper (Table I). The thickness of the material to be used may be determined from an equation giving the energy absorbed by the material

\[ \text{Loss} = 3.34S (\mu_r \sigma_r)^{1/2} \]  

(1)

Where \( S \) is thickness of material in mils, \( \mu_r \) is relative permeability, \( \sigma_r \) is conductivity relative to copper and \( f \) is frequency in mc.

Another method of expressing the penetration loss is to define the thickness which reduces the voltage at the shield barrier to 37 percent of its original value

\[ d = 1,980 \left( \frac{R}{\mu f^2} \right)^{1/4} \]  

(2)

\[ \text{penetration loss in } \text{db} = \frac{8.686}{d} \left( \frac{f}{f_0} \right)^{1/2} \]  

(3)

Thus calculation of the thickness of material for a given loss is greatly simplified.

There is also associated with the metallic material used, a reflection loss

\[ \text{reflection loss in } \text{db} = \left( \frac{f}{R} \right)^{1/4} \]  

(4)

The combination of these losses (Eq. 3 and 4) is the total loss for a given field offered by the solid sheet of metal.

**Electrostatic Shielding**

In most cases of shielding against electric fields, however, the mechanical engineer must consider other factors such as rigidity of the chassis for the purpose of meeting shock and vibration specifications. Conse-
quently, a sufficient thickness of aluminum or other nonmagnetic material is usually provided which precludes the field energy's radiating from the equipment.

Very often a mesh material must be used between chassis to permit the flow of air for cooling. So long as the flange mounting the screen does not permit the leakage of energy, the screen material will offer almost the same loss as a solid sheet. Normally a No. 20 mesh copper, aluminum or bronze screen will suffice for suppressing frequencies above 150 kc.

Rigidity requirements of the chassis usually dictate use of metal thick enough for adequate shielding—except in the case of small subchassis. However, it is possible that if the unit does not have continuous metal-to-metal contact at all seams and joints, serious leakage can result. Fastening screws spaced a maximum of two inches apart on centers will provide a good contact. The mating surfaces must be clean and free of paint and any other insulating material.

**metal gaskets**

Many times, metal-to-metal contact of surfaces is insufficient to contain the fields generated within an equipment. Here metal gaskets or spring fingers find wide use. Beryllium copper fingers are utilized primarily on flat rectangular surfaces for sealing doors or small chassis such as radar receivers or i-f strips.

Conductive metal gaskets find use in almost all sealing applications whether the assembly is a sheet-metal cabinet, heavy casting or waveguide flange. One good type of gasket has as a base material a knitted wire mesh that can be made from any metal or alloy that can be drawn into wire. Being metal, the mesh is conductive; being knitted, it is flexible and resilient. A monel gasket is especially resilient and corrosion resistant. Where shielding and sealing both are required, metal gaskets are combined with neoprene or a similar material.

Figures 1 and 2 illustrate how use is made of the resiliency of a metal gasket. Figure 3 shows its application on a flange joint. The joints may be roughly machined with the gasket supplying the necessary complete surface-to-surface contact. In this type of application the gasket should be higher than the depth of the flange groove to insure good contact and should be located inside the bolt hole when possible to prevent leakage through the holes.

Figure 4 shows a compression curve as height relative to nominal height versus applied pressure in psi for a gasket of flattened 0.0045-in. monel wire. Figure 5 shows the shielding effectiveness of the monel metal gasket in decibels versus applied pressure. Frequency is 30 mc.

A new application is being tried in which knitted mesh provides flexibility under vibration, air flow for cooling and at the same time shielding against an intense electric field.

Problems in magnetic shielding occur primarily in the low-frequency range—60 cps to 30 mc. Usually ferromagnetic materials are employed for shielding against magnetic fields.

**magnetic shielding**

Magnetic fields are generally produced by transformers and coils. Nonmagnetic materials find little utilization in shielding against such low-frequency fields, since the reflection and penetration losses are low at low frequencies. In designing against magnetic fields the induction or near field is the energy source to be shielded against even though external fields may be present due to other equipment radiation.

The parameters useful in defining depth of penetration and relative electric thickness of materials are $\sigma =$ conductivity, $\mu =$ permeability, $\omega = 2\pi f =$ angular frequency of the field, $d =$ thickness of shield, $P =$ relative electric thickness, $d_0 =$ depth of penetration and $\beta = 1/d_0$

$$P = d\beta = d (\omega \mu \sigma / 2)^{1/2}$$

(4)

The depth of penetration as previously defined is the distance, from the surface of the shield, at which the field is attenuated to 37 percent of its surface value. Shields where $d/d_0 = p \ll 1$ are called electrically thin shields. Shields where $p >> 1$ are electrically thick. The delineation between an electrically thin and electrically thick shield occurs at the critical frequency $f_*$. At this point $d = d_0$ or $p = 1$

$$f_* = \frac{1}{\pi \mu \sigma}$$

(5)

Quantity $p$ may be calculated for any frequency. It is essential however in all cases to know the effective permeability and conductivity at the frequency of interest. At present, an attempt is being made to develop a standard technique for frequency and attenuation evaluation of ferromagnetic materials.

In general, the problem of shielding against internally generated magnetic fields by transformers and coils requires either shielding the source or shielding the com-
It controls yield and tensile strengths. The larger the grain size the less the hardness and the greater the permeability. Grain orientation is important because crystallographically magnetism is anisotropic in nature.

Silicon serves another purpose inasmuch as iron alloys containing more than 3½ percent silicon do not exhibit the allotropic transformation which causes recrystallization to occur in some iron alloys during cooling. Thus the large grains formed at high temperatures are maintained. Just as a larger grain size means a lower yield point in tensile testing so also does a larger grain size mean that less energy is required for magnetization. For maximum permeability, the rolling direction must be kept nearly parallel to the direction of the magnetic field. Increased efficiency may be had by making duplicate or triplicate shields of thin material and orienting each shield so that the magnetic field in all three axes is absorbed.

Another important alloying element used with iron is nickel. The characteristic of nonnickel alloys that gives them such high permeability is the difference of the directions of the magnetostriction of nickel and iron. Iron has a positive magnetostriction; nickel a negative one. Thus by proper alloying, less magnetostriction occurs with concomitantly less energy necessary for maximum permeability. Important iron-nickel alloys are around 50 percent nickel and 80 percent nickel. Minor amounts of other alloying elements are added to commercial alloys.

The addition of silicon in iron, followed by proper cold reduction and annealing, causes an alignment of the <100> or family of 100 planes parallel to the rolling direction. This crystallographic direction is also the direction of easy magnetization for body centered cubic crystals. Thus a minimum of energy is needed to align the domains.

**Manufacturing Processes**

Shielding devices are made largely by sheet-metal techniques with little or no machining. There are, however, instances where machining is necessary. Machining of magnetic shield materials employs techniques similar to those developed for nickel and monel. Lubrication
is necessary during machining but must be removed prior to heating so as not to allow free sulfur to embrittle the nickel alloys.

The materials can be stamped and formed into simple shapes but not without a great deal of caution. Generous curves should be allowed during forming. Each manufacturer has his own tooling and equipment problem and must shape the material accordingly. A successful way of producing e-t tube shields of both silicon and nickel alloys is sheet-metal development. Normally the shield is made of three parts, front ring, cone and yoke shield. The conical piece is developed from sheet material. Normal practice is to blank out a semicircular sheet. The curved sides are serrated by V notches the roots of which have a generous radii. Lands between these notches are later bent to form the flange over the front ring and the yoke shield are slid. The developed cone is spot welded together. The spot welding schedules are similar to those for steel. When making the shield of grain-oriented silicon-iron, the rolling direction and the direction of the magnetic field must be nearly parallel for maximum permeabilities. A magnetic shield for a color tv tube is pictured. This form is developed by winding a thin ribbon of magnetic material.

There are two different types of heat treatment given to both iron-silicon and iron-nickel alloys: for formability and for permeability. One thing common to both alloys and heat treatments is that all parts must be thoroughly degreased prior to heat treatment. Not only is this necessary because of the carbon present but also because of the sulfur which could cause severe grain-boundary attack in the iron-nickel alloys. Also, heat treatments must be carried out in a reducing atmosphere—usually hydrogen. The recommended temperature for formability annealing both silicon and nickel alloys is 1,400 to 1,600 °F.

**Heat Treatment**

The heat treatment for magnetic permeability is performed after all fabrication operations. Any forming, bending or sandblasting after the magnetic annealing will necessitate a reanneal. If the parts are to be in contact with each other in the heat-treating furnace they should be powdered with dried calcined alumina, 400 mesh or finer, to prevent sticking. The normal safety precautions for working in a reducing (hydrogen) atmosphere must be observed.

Iron-silicon alloys fall into two groups, the oriented and nonoriented material. The former material is annealed at 1,350 to 1,400 °F since higher temperatures result in breakdown of the preferred orientation. The preferred orientation and enlarged grain size already exist in the material by virtue of a mill anneal after cold rolling. The nonoriented material is usually annealed at 1,850 °F. The usual holding time is two to four hours.

The annealing of the iron-nickel alloys to develop their full permeability properties must be closely controlled. They must be annealed in a sealed retort in the presence of dried electrolytic hydrogen (dew point, -60 °F at 2,000 °F for times of saturation plus two-four hours). The cooling rate must not exceed 100 °F per hour to 1,100 °F; below that temperature the cooling rate is not important. The parts must be loaded with care to prevent distortion since any cold adjustment of the distortion after annealing will immediately impair the desired magnetic properties.

In many instances simultaneous electrostatic and

---

**Table 1 — Nonmagnetic Metals for Electrostatic Shielding**

<table>
<thead>
<tr>
<th>Metal</th>
<th>Relative Conductivity</th>
<th>Minimum Thickness (mils)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>0.61</td>
<td>13</td>
</tr>
<tr>
<td>Brass</td>
<td>0.25</td>
<td>20</td>
</tr>
<tr>
<td>Copper</td>
<td>1.00</td>
<td>10</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.29</td>
<td>18.5</td>
</tr>
</tbody>
</table>

---
electromagnetic shielding is desired. A common installation is a trilayer construction with the electromagnetic material as the top and bottom surfaces.

The proper material to use is a function of the protection needed. An efficient material is the 80 percent nickel-iron type alloys. There are instances, however, where even iron will give adequate protection from magnetic fields. Should nickel become scarce, many shielding devices using alloys of high nickel content, especially those in commercial equipment such as color tv might substitute a trilayer construction of grain-oriented silicon-iron.

REFERENCES


(2) Design Techniques for Interference-Free Operation of Airborne Equipment, Frederick Research Corp. rpt to USAF, Dayton, Ohio.


Potting, Embedding and Encapsulating

Sealing materials may be used for encapsulating, embedding or potting. Encapsulating involves coating the part by dipping or brushing. Embedding means creating a self-supporting structure of the part and its resin jacket, while potting entails placing the part in a shield can or other enclosure.

Bituminous compounds are used to obtain high efficiency from power transformers and chokes by providing good heat transfer from the windings.

Bituminous compounds for potting have low stam and a high softening point—265-275°F. The compounds should also have low viscosity at a convenient pouring temperature—about 425°F.

One of the first compounds for potting components such as audio transformers and tuned circuits was beeswax. The part was wrapped in Kraft paper to prevent shorting to the case and molten beeswax poured in. Microcrystalline waxes produced in petroleum refining have been found an economical and adequate substitute for beeswax and are more widely used today. Microcrystalline wax can be poured at 133°F.

Thermosetting resins

Polyester resins are unsaturated alkyds combined with a reactive monomer such as styrene or diallyl phthalate. They can be solidified by use of an organic peroxide catalyst with or without heat. When the catalyst is added the reaction proceeds slowly at room temperature but after a period called the tank or pot life solidification or gelation occurs. The process then continues more rapidly and with the evolution of heat until the plastic is fully cured. During curing the resin shrinks 7-10 percent. Ordinarily polyester resins are cured at 225-250°F to reduce cure time. Production cycles vary with the type of resin, proportion of catalyst and temperature but cycles for potting and embedding electronic components can be in the order of minutes.

Epoxy type polymers solidify upon addition of a curing agent and, in most cases, application of heat. Pot life of 4 to 6 hours is not uncommon. The curing temperature varies widely but some epoxies can be cured by temperatures of about 150°F in a few hours. Some curing agents used with epoxy resins are toxic and the precautions suggested by the manufacturer should be followed. Shrinkage can be as low as 2 percent before gelation and 2 percent after. Shrinkage of both epoxy and polyester resins can be reduced by adding filler material such as glass fibers, asbestos, silica or alumina.

Techniques

Embedments are made by pouring the resin into removable shells. Mold materials and release agents often
Table II—Mechanical and Electrical Properties of Typical Sealing Compounds

<table>
<thead>
<tr>
<th></th>
<th>Microcrystalline Wax</th>
<th>Bituminous Compound</th>
<th>Polyester Resin</th>
<th>Epoxy Resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td></td>
<td>1.45-1.55</td>
<td>1.22</td>
<td>1.19</td>
</tr>
<tr>
<td>Hardness</td>
<td></td>
<td>15-22</td>
<td>45-50</td>
<td>36</td>
</tr>
<tr>
<td>(Barcol impressor)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile Strength (psi)</td>
<td></td>
<td></td>
<td>7,000-8,000</td>
<td>8,000</td>
</tr>
<tr>
<td>Compressive Strength (psi)</td>
<td></td>
<td></td>
<td>21,000-23,000</td>
<td>18,400</td>
</tr>
<tr>
<td>Notched Izod Impact Strength (ft-lb/in.)</td>
<td></td>
<td></td>
<td>0.17</td>
<td>0.36</td>
</tr>
<tr>
<td>Heat Distortion Point (264 psi)</td>
<td>135 F (melts)</td>
<td>245-300 F (softens)</td>
<td>190 F</td>
<td>189 F</td>
</tr>
<tr>
<td>Linear Coefficient of Thermal Expansion per deg C</td>
<td></td>
<td>7.2-9 \times 10^{-5}</td>
<td>6.7 \times 10^{-5}</td>
<td></td>
</tr>
<tr>
<td>Dielectric Strength (v/mil; ¼-in. thickness)</td>
<td></td>
<td>480</td>
<td>400-500</td>
<td></td>
</tr>
<tr>
<td>Dielectric Constant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at 1 kc</td>
<td>2.3</td>
<td>2.66</td>
<td>3.15</td>
<td>3.8</td>
</tr>
<tr>
<td>at 10 mc</td>
<td>2.3</td>
<td>2.57</td>
<td>3.03</td>
<td>3.8</td>
</tr>
<tr>
<td>Loss Factor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at 1 kc</td>
<td>0.0006</td>
<td>0.0035</td>
<td>0.011</td>
<td>0.0023</td>
</tr>
<tr>
<td>at 10 mc</td>
<td>0.0004</td>
<td>0.0010</td>
<td>0.054</td>
<td>0.019</td>
</tr>
<tr>
<td>Arc Resistance (seconds)</td>
<td></td>
<td></td>
<td>125</td>
<td>240</td>
</tr>
<tr>
<td>D-C Volume Resistivity (ohm-cm)</td>
<td></td>
<td></td>
<td>3.3 \times 10^8</td>
<td>8.7 \times 10^{14}</td>
</tr>
</tbody>
</table>

must be selected with care. Both metal and plastic molds are used—plastics used include Teflon and polyethylene. Release agents used include carnauba wax, cellulose acetate and silicone greases. However, some resins may react with certain release agents or the use of some agents may create problems if the embedment is subsequently to be painted. The advice of the manufacturer of the resin should be sought.

When parts are encapsulated, curing is sometimes done in ovens or under banks of infrared lamps. In pouring embedments or in potting it is important that no air bubbles be trapped. This can be avoided by careful pouring which includes tilting the mold. In some cases a centrifuge may be employed. Some mechanical and electrical properties of representative sealing compounds from each of the four groups discussed are given in Table II.

**Steps in Sealing**

Steps to be followed in potting, encapsulating and embedding may now be summarized.

(1) Select the proper compound and determine if a filler is needed. Fillers and plasticizers may be used if shrinkage is a factor. Fillers may also be used for coloring, varying the coefficient of expansion, improving high frequency characteristics, changing viscosity and improving low-temperature operation.

(2) Where two or more ingredients are used, measure carefully the portions. The ratio of hardener or catalyst to resin is particularly important.

(3) Make sure that the coils, transformers or other components are free from moisture by preheating them; keep moisture from resin compounds.

(4) Do not use air-drying varnishes except for surface impregnation. Use internal curing varnishes for impregnation only, not for hermetic sealing.

(5) Check the adhesion of the resin to be used to the metals of which the leads, bushings and shield cans are made. Where leads are to be brought out of the assembly, it is often best to use bare metal. Some resins may react with copper or other metals and care also must be exercised to prevent this type of corrosion.
Kinematic systems used in field of electronics range from antenna drive system of giant airborne radar equipment (left) to tiny computer elements (right) used in ground-position indicator

**Moving Parts...**

By ELLIOTT GUTTMAN

W. L. Maxson Corp., New York, N. Y.

**Input and output systems of electronic equipment almost invariably involve moving parts. Mechanical design of such systems is particularly important in radar, computers and automatic control devices**

**B**asically there are two modes of motion, rotation and translation. The former of these is in much more widespread use, possibly due to the comparative ease in containing the motion. Included in the field of pure rotary parts are pulleys, gears, bearings and universal joints, while there are but a few cases of pure translational movement.

**Shafting and remote control**

Probably the most commonly used component in the field of moving parts is the shaft. It is used in practically all cases of rotation and in many instances involving translation. Basically, there are two types of shafting, rigid and flexible. The former of these is used quite extensively, especially the round shaft, which is a component so common that it is often taken for granted. There are many shapes of shafts, but costs (especially those of mating parts) dictate the use of the round shaft. Fabrication is relatively simple since stock is available in all standard sizes and simple turning can usually result in any desired shape. In using solid round shafting, the basic design problems are tolerances and materials. Tolerances are usually determined by the shaft supports or by the components that mount on the shaft. All grades of shafting are commercially available, even accurately ground stock, so that final determination can be made on the function versus cost basis.

**Rigid shafting**

Nonround shafts are being used more and more, especially in cases where the elimination of keys, set screws etc is desired. However, it should be pointed out that this design is usually more costly unless
stamped parts are used extensively in mounting components on the shaft.

Of course, in the precision field there may be many cases where a nonround shaft is the answer to the design problem, especially where positioning is important.

Round shafting is also used for transmitting translational movement. Actually any solid link would work equally as well, but designers have used the round rod since round bearings are readily available and it is easy to turn or drill mating parts. However, in cases where stampings can be made and no turning of the shaft is desired, a nonround shaft is used. Actually, in cases where stamping is either not available or not desired, keys on a round shaft solve both the support and rotational problems quite well.

Another variation is that of the hollow shaft, which is designed to meet the same basic demands to which the solid shaft is subject. It can be used in cases where weight is of extreme importance or where the space inside of the shaft is needed for a fluid, wiring or even another shaft. This design, being used in mechanisms where compactness is the key to the design, necessitates care in insuring proper supports for each shaft.

**Flexible Shafting**

In contrast to rigid shafting, flexible shafting is used extensively for transmitting both rotational and translational movements. Flexible shafts can be used to take up misalignment between shafts, to allow for relative movement between parts, or to connect two shafts without using gearing. In precision designs, care must be taken since there is some inherent backlash in using a flexible shaft for transmitting rotation. Most manufacturers’ catalogs are fairly complete and should be consulted in reference to the dos and don’ts of flexible shafting. For the best results, it is usually better to contain the shaft within a sheath, protecting the moving member and giving greater support in general.

**Supports and Bearings**

When considering shafting, it follows that supports and bearings are topics that are closely allied. Actually there are many types of bearings whose use are dictated by the precision versus the cost criterion. The simplest support is a hole in the mating piece that is large enough to contain the shaft. Of course precision is poor, cost is little and the friction is high if the piece be made from common materials.

The next refinement is to bore the hole accurately and to keep closer tolerances on the shaft. This approach results in a lapped hole and a finely polished shaft that afford good precision, moderately high costs and a moderate amount of friction.

Another approach is the use of a bearing material that is usually either a soft, ductile material or a harder...
material that is self-lubricating. For cases where both precision and friction are the important factors, there is the ball bearing with all of its many extensions. Sizes of ball bearings are quite varied and there are several different grades of precision that are available.

**Small bearings**

At this point it would be well to make mention of the subminiature and inch bearings, a field that has sprung up in recent years. There are commercially available small, precise, radial ball bearings with o.d.'s as small as 0.0100 in. and bores as small as 0.0197 in. Pivot bearings are available with o.d.'s of 0.043 in. and widths of 0.028 in.

Bearings of this type have helped immensely in the field of instrumentation and should be used in the precision field wherever possible. When using bearings with very small bores, it would be well to be careful with the shaft design, since these shafts are extremely delicate and can be damaged by common handling.

Most small bearings have their outer races pressed into the supporting pieces. However, this practice is not too good when loads get high or when bearing sizes get too large. For such cases, the designer should rely on bearing supports or pillow blocks that are marketed by the bearing manufacturers. These supports are especially designed to take the larger torques prevalent between the outer races and the housings. The designer, of course, can design his own housing if the problem warrants it. However, he must be careful not to rely on press fits when this torque gets too high.

Another consideration in bearing design is that of maintenance. To obtain satisfactory operation, the bearing must be kept free from dirt and properly lubricated. Sealed and shielded bearings are available to take care of this problem, but when an open bearing is used, the design must contain provisions for keeping the bearing clean and properly lubricated. The latter problem is especially difficult if the bearing will be operated at elevated temperatures.

A device that should be considered with shafting and supports is the universal joint. In the use of this component, care must be taken in the design, since the relative position of the input shaft with regard to the output shaft is not fixed. See Fig. 1A.

This is an important consideration in the design of a precision positioning device such as a servo gear train. However, a universal joint is an excellent device for transmitting rotation between two nonparallel shafts and if position is desired, the designer should use two joints, having them properly positioned with respect to each other. See Fig. 1B.

**Belts, chains and friction drives**

This category of components has a somewhat limited use in the electronic equipment field, being better suited for power equipment. There are, however, several instances where they have been quite useful.

One particular case is that of controls such as tuning dials, where the transmission of rotary motion is desired, with no regard to slippage and where costs

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**Table 1—Materials Used in Fabricating Gears**

<table>
<thead>
<tr>
<th></th>
<th>Cast Iron</th>
<th>Stainless Steel</th>
<th>Heat-Treated Steel</th>
<th>Brass</th>
<th>Aluminum</th>
<th>Nylon</th>
<th>Plastic</th>
<th>Fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strength</strong></td>
<td>Fair</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
<td>Fair to Good</td>
<td>Fair</td>
<td>Poor to Good</td>
<td>Poor to Good</td>
</tr>
<tr>
<td><strong>Wear</strong></td>
<td>Fair</td>
<td>Fair</td>
<td>Good to Excellent</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair to Good</td>
<td>Poor to Fair</td>
</tr>
<tr>
<td><strong>Machinability</strong></td>
<td>Good</td>
<td>Fair to Good</td>
<td>Fair to Excellent</td>
<td>Excellent</td>
<td>Good</td>
<td>Good</td>
<td>Poor to Good</td>
<td>Fair to Good</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Heavy</td>
<td>Heavy</td>
<td>Heavy</td>
<td>Heavy</td>
<td>Light</td>
<td>Light</td>
<td>Light to Heavy</td>
<td>Light</td>
</tr>
<tr>
<td><strong>Dielectric Strength</strong></td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Good</td>
<td>Fair to Excellent</td>
<td>Good to Excellent</td>
</tr>
<tr>
<td><strong>Resistance to Heat</strong></td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Poor</td>
<td>Poor to Good</td>
<td>Fair to Good</td>
</tr>
<tr>
<td><strong>Resilience</strong></td>
<td>Poor</td>
<td>Fair to Good</td>
<td>Fair to Good</td>
<td>Good</td>
<td>Fair</td>
<td>Poor to Fair</td>
<td>Poor to Good</td>
<td>Poor to Good</td>
</tr>
<tr>
<td><strong>Corrosion Resistance</strong></td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good to Excellent</td>
<td>Good to Excellent</td>
<td>Good</td>
<td>Poor</td>
</tr>
</tbody>
</table>

ELECTRONICS — October, 1954
should be kept low. If slippage is not desired, chains and timing belts can be used; however, there is an increase in costs due to more complex belting and sprockets.

Belting is best used in transmitting power from the prime mover, but this is done usually in cases where more than 1/5 horsepower is involved. In these cases a V belt is usually used and again if slippage is not desired, a timing belt or the like can be used.

Chain drives have not been used too extensively since they are somewhat heavy and fairly costly. There are cases however, where the interference of other components presents problems that the use of chains and sprockets can easily solve.

The principle of friction drives has been used to a greater extent. The majority of clutches use this principle to transmit power, since a drive of this type is the easiest to engage and disengage. This article will not attempt to start to mention the many possible designs using a friction type clutch.

A characteristic of the disk and wheel friction drive shown in Fig. 2 is its ability to multiply two inputs together with very simple controls. This feature is often used for mechanical integrators, or simpler still, a reversible, variable speed drive.

gears

Probably one of the most versatile items in the field of moving parts is the gear. The primary purpose of the gear train is to transmit power or position from one shaft to another. This can be accomplished with a change in speed, whether or not the shafts are parallel, and without slippage between the driver and the driven members. Gear trains can also combine inputs algebraically by using combinations of mating gears.

There is no limit to the number of materials that can be used for gearing. The major requirements are those of hardness and ability to absorb wear. Gear trains are usually used to transmit relative position.

If the gear train is one designed primarily for positioning, the wear factor is usually small and material consideration is based on material and fabrication costs tempered by the design criteria.

For the transmission of power, the factor of tooth strength becomes important since there is considerable bearing of one gear upon the other with resulting wear and local heating problems. Metals have been widely used for gearing and for the most part have proved very satisfactory. However, in recent years, plastic and other nonmetallic gears have been used in increasing numbers. In many cases, the latter have proved as good, if not better, than the metallic gears.

types

The simplest form of gearing is the spur gear, Fig. 3A. Because of its comparative ease of manufacture and its versatility, it is the most widely used of all of the forms of gearing. Spur gearing is used extensively in small precision devices since the smallest gears are now available in this form.

The form of gearing which is probably the second most widely used is the worm gear and worm wheel illustrated in Fig. 3B. The worm and worm wheel are capable of large reductions in speed with but one stage of gearing. This reduction is done between two noninterseecting shafts that are perpendicular to each other. This form of gearing has the feature of non-reversibility since it is difficult and at times impossible to drive the worm by turning the worm wheel. The effectiveness of this feature depends on the design of the lead angle of the worm gear.

Other forms of gearing include bevel gears, helical gears, spiral gears, differential mechanisms, rack-and-pinion gears and planetary or epicyclic gear trains. Bevel gears, Fig. 3C are used for the transmission of rotation between two intersecting shafts. They have the disadvantages of cantilever type shaft supports, noninterchangeability and difficulty in assembly and disassembly.

Helical gears portrayed in Fig. 3D are used to transmit power from one shaft to another. They are usually used to transmit relative position.
heavier loads at higher speeds with quieter operation. They are capable of transmitting rotation between two parallel shafts. Their disadvantage lies in the transmission of axial thrusts to the gear shafts and inherently high fabrication costs.

Spiral gears, Fig. 3E, allow for the transmission of rotation between two nonintersecting, nonparallel shafts. Planetary or epicyclic gear trains shown in Fig. 3F are used for small or large speed changes where the input and output shafts are in line and where no fixed idler shaft is required.

Differential mechanisms, Fig. 4A, are widely used in electronics. They consist of combinations of bevel and spur gears. Actually a differential mechanism is an epicyclic gear train in which the fixed gear is now allowed to move, giving the effect of a double epicyclic train. The purpose of an ordinary differential is the algebraic combination of two inputs.

Rack and pinion gears, Fig. 4B, transform rotational motion to translation and vice versa by the use of gearing. Spur, bevel and helical toothforms can be used for this type of mechanism. The latter has the advantage of being able to vary the angle between the shaft of the pinion and the line of action of the rack.

Another series of components that should be considered in this section are the noncontinuous types such as the intermittent gears and the Geneva mechanism. These components are capable of changing constant speed rotation to intermittent rotation. There are many variations in the design of these devices and Fig. 4C and 4D show typical designs of each of these types. These components have found much use in computer mechanisms and counting devices, but their use is somewhat limited since, unless large quantities are made, the design and fabrication costs are quite high.

**toothform**

The most important factors in the design of gears are those involving the toothform and include the type of teeth, the pressure angle and the pitch. Some degree of standardization has occurred in recent years, with the result that both the pressure angle and the type of teeth have been more or less tied down.

At the turn of the century, there were many forms of gearing which included conjugate, cycloidal and composite toothforms. However, at present, in electronic devices, the involute toothform is almost the only one used. The major reasons for this evolution of this standard are the inherently superior rolling contact of the teeth, the comparative ease in manufacture and the fact that inaccuracies and wear can occur without seriously damaging gear action.

Of course there are variations of the involute system such as extended addendums or shortened teeth such as those found in stub-tooth systems; however, these
are used in electronic mechanisms primarily to avoid interference.

Two pressure angles, $14\frac{1}{2}$ and 20 deg, have been used as standards. The former has been widely used and is present in most commercially available stock gears. In recent years, especially in electromechanical devices, the trend has been for smaller parts and naturally smaller gearing. This has caused a demand for gears with a 20-deg pressure angle since a pinion with fewer teeth can be used without fear of interference. See Fig. 5. Another advantage of the 20-deg pressure angle is its greater tooth strength since the increase in the angle of obliquity results in a tooth a little broader at the base. This author feels that we are now in a transition period and that in time, the 20-deg pressure angle will become the only standard.

**pitch**

The pitch of a gear can be greatly varied. A long time ago when gears and gear teeth were large, the circular pitch was used to specify the pitch. Since the circular pitch is the distance in inches on the pitch circle between corresponding points on adjacent teeth of a gear, it is easily seen that for large gears this number is an integer and for small gears it becomes fractional.

To keep the pitch a whole number, the parameter diametral pitch was evolved, which is the number of teeth on the gear per inch of pitch diameter. Thus a gear with a diametral pitch of 24 and a 2-in. pitch diameter would have 48 teeth. This same gear would have a circular pitch of 0.131 in. Since gears used in electronic mechanisms are usually small, the diametral pitch is primarily used to denote pitch.

For use in instruments, stock gears with diametral pitches of 20, 24, 32 and 48 have been commercially available for some time. In the quest for smaller, more accurate gearing, gears are now being stocked with diametral pitches of 64, 72 and 96. Although not stocked, gears have been used whose diametral pitches have gone as high as 120, 144 and 200.

The advantages of a high diametral pitch are the obvious reduction in size and the inherent decrease in backlash which is primarily a function of the circular pitch. The disadvantages of large diametral pitches are the increased difficulty in manufacturing and the necessarily weaker tooth. For a gear with a diametral pitch of 200 the height of the tooth is 0.0108 in. while the thickness is only 0.00785 in.

The designer has to compromise between these factors. This author believes that for precision, it is usually not necessary to have a gear with a diametral pitch higher than 96, and only in very rare cases, would it be advisable to exceed 120.

**interference**

The final problem of gearing is interference. As can be seen in Fig. 5, if the pinion gets too small, interference will occur when the upper part of the addendum of a tooth on the larger gear contacts the addendum of a tooth of the pinion gear. If the designer finds it necessary to work in this interference range, he has several methods of eliminating the trouble. If this problem occurs with gears whose pressure angle is $14\frac{1}{2}$ deg, change to a 20-deg pressure angle. See Fig. 5.

A second solution would be to relieve the addendums of the teeth on the larger gear, but this is not easily done in a shop. The same results could be obtained by undercutting the dedendum of the pinion gear, but this weakens the strength of the teeth.

Continuing along this approach the designer could use a stub toothform which is a modification of the tooth profile achieved by decreasing the tooth height while leaving the diametral pitch and the number of teeth on the gear unchanged. Another solution is the modification of the toothform by increasing the addendum and decreasing the dedendum of the pinion while decreasing the addendum and increasing the dedendum of the larger gear. The effect of this is to make the pinion’s teeth stronger and the large gear’s teeth weaker. The designer will have to decide which course to follow, basing his decision on the design criteria and the capabilities of the manufacturing plant.

**springs**

Springs are used extensively throughout electronic equipment, most notably in relays, limit switches, contact arms, vibrators and solenoids. There are two basic design functions for a spring, both of which are used in electromechanical devices. The first, and possibly the more common of the two, is the use of a spring to give return action to a unidirectional device. This can best be shown in a cam mechanism where the spring

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*October, 1954 — ELECTRONICS*
keeps the roller in contact with the cam surface as shown in Fig. 6A.

The second basic function of a spring is to provide a displacement that is proportional to the applied force. Secondary features of this function are that with comparable ease, it is possible to have the displacement directly proportional to the applied force and that this displacement can be both positive and negative about a determined mean point. A self-centering device is shown in Fig. 6B demonstrating this basic function.

There are innumerable uses involving both these functions and it would be impractical to attempt to discuss them in this article. Springs have been used in many different forms, among these are helical, leaf, flat, spiral and many more. Several of the larger spring manufacturing companies have available a jointly prepared book concerning the design and use of springs. Included in this book are discussions of the various cross-sections that are available for springs along with all of the formulas necessary to design the spring properly. This book also includes a section on materials. However, a designer may find the data given in Table II useful. If the spring is to experience stresses close to the elastic limit, it would be wise to test a sample of that material to be used to see if it will withstand those stresses for the specified life of the parent device.

cams and bar linkages

One of the most useful components and yet probably the least used in electronic devices in proportion to its capabilities is the cam. Fundamentally, the cam converts reciprocation and rotation to reciprocating motion, multiplying the input by some predetermined factor. Evidently, this type of device can impart innumerable complicated motions to the driven elements. This feature makes a cam quite useful since special mechanical movements can easily be obtained.

The design of cams is not too difficult and all basic machine design and kinematics textbooks are fairly adequate on the subject. The main problem in cam design is to have the driven element capable of following the driving element. This is a function of the design criteria since rapid accelerations and decelerations are difficult to follow, and if the parent device demands this, it would be better to go to linkages to obtain the desired motions.

Most cams have to be designed with a spring to enable the follower to have return action. In some cases, the force of gravity is sufficient to do this. Cams can be double-acting using a groove to contain the follower instead of having the follower ride upon the cam surface. This is done to control motions in both directions without the use of a spring.

Another type of mechanism, similar in function to the cam, is the bar linkage. This mechanism has the advantage of supplying positive action at all times, not relying on a spring for return action, and the disadvantage of occupying a larger space for its operation. Its uses are also innumerable since it is possible to achieve many different kinds of motion using rotating or reciprocating inputs. Several different types of linkages will be illustrated in this article to illustrate a few of the many possibilities. Figure 7A shows a simple slider-crank mechanism where rotary motion is converted into reciprocation. The Scotch-yoke, shown in Fig. 7B, converts rotary motion into simple harmonic reciprocation. Figure 7C is an example of a 4-bar chain where rotation is converted to rotary motion modified by a

FIG. 7—Various bar linkages: slider-crank mechanism (A), Scotch yoke (B), four-bar linkage (C), pantograph (D), wrapping-paper mechanism (E) and stone-crusher mechanism (F)
lubricating bearings usually take care of themselves. Regular sleeve bearings, although not used extensively in electronics, are usually cases of thin-film lubrication, requiring a pump to supply fluid to the acting surfaces.

Ball and roller type bearings should be packed with some sort of grease or oil to give a condition between greasy surface and thin-film lubrication to their moving parts. The actual coefficient of friction of these antifriction bearings is quite low and should not be confused with the condition of lubrication that is intended. Too often a designer will forget that these bearings need some form of lubrication and neglect the grease in their designs. This can result in hot spots and shortened bearing life. The manufacturers of ball and roller type bearings usually supply a bearing containing some form of lubrication; however, the designer should stretch this point to insure satisfactory operation, especially under severe operating conditions such as extreme heat or cold.

The lubrication of pivot points has been considered more and more through the years. Greases and oils have been used with the difficulties of maintaining the lubrication at the critical areas.

More recently, oils containing graphite have been used. In these, the graphite is deposited on the working surfaces, giving the effect of greasy friction as found in a bearing material.

Another innovation in recent years is the use of silicone oils as a lubricant. These oils have proven quite versatile since they can withstand large pressures and operate through a wide temperature range. Another interesting use of high viscosity silicone oil is on instrument pivot points where flutter and transients are filtered out while slower movements are transmitted through the junction.

**Conclusion**

This article has been prepared to give the electronic designer a summary of the various components used in the field of moving parts. It is also meant to provide the electrical engineer a better insight into the design problems that the man on the board faces, enabling the engineer to work more closely with the designer during the basic concept phase of the design. At best, this article is a summary and for more precise information the designer or engineer will have to resort to a library or to the various manufacturers in the particular field of interest.

**Bibliography**


Power Devices

Electronic control instrumentation requires use of motors and associated devices such as clutches, brakes and clamps. Several of these are discussed and selection criteria given.

One of the popular motors for control application is the two-phase induction servo motor.

The servo motor is normally operated on unbalanced terminal voltage. One phase, called the main field, is excited by constant voltage while the other, called the control field, is excited from a variable source such as a high-gain amplifier. The control field may be varied from rated value of one polarity through zero to rated value of the opposite polarity. Thus the command signal can control speed, torque and direction of rotation.

Performance requirements are: high torque at speeds near zero; negative slope of the speed-torque characteristic around zero speed; and, when the command signal is reduced to zero, the servo motor should not run as a single-phase motor. These are met by a high-resistance rotor designed so that maximum torque is developed at a reverse speed of approximately one-half synchronous speed. Figure 1A shows the effect of rotor-resistance on the speed-torque characteristic.

parameters

An important figure of merit for the two-phase induction motor is the ratio of stalled torque to rotor

Inspecting instrument-motor chassis. This device forms part of a supervisory control system by which heavy equipment such as oil-refinery pumps can be regulated by signals from a central location.
The motion of the motor is affected by the inertia of the rotor. To achieve low inertia a small diameter rotor is necessary. The highest torque-to-inertia ratio is obtained for minimum diameter rotors. The simplicity of a die-cast squirrel-cage rotor lends itself to small diameter design.

The negative slope of the speed-torque characteristic contributes to the stability of a servo. As seen from Fig. 1A, as the speed increases the torque decreases almost proportionally. This internal motor damping is referred to as the viscous motor friction. The magnitude is equal to the reciprocal of the speed-torque curve. Figure 1B shows a family of speed-torque curves for various values of control-field voltage. In the region of low control-field voltage viscous friction is about half that obtained in the high-voltage region.

Typical motor performance is illustrated in Fig. 1C.

The capability of a motor to respond to rapidly varying inputs is determined by its time constant expressed as the ratio of rotor inertia to viscous motor friction. This time constant is important in closed-loop stability.

Maximum starting voltage is a measure of the static friction of the motor. In a positioned servomechanism, a sufficient break-away voltage must be developed to overcome static friction. Static friction includes bearing friction and slot effect. Slot effect is caused by varying reluctance torque with rotor position due to magnetic nonuniformity of the slot openings.

In critical applications, slot effect can be eliminated using a drag cup-type rotor if the accompanying decrease in torque can be tolerated.

With rated voltage on the main field, starting voltage is the minimum control-field voltage necessary to cause the motor to rotate.

Starting Torque = (Control Field Starting Voltage/Control Field Rated Voltage) × Stalled Torque

The determining limitation is the maximum operating temperature the motor can withstand. This includes the temperature rise within the motor plus the ambient temperature. The temperature rise depends on the heat conduction of the mounting, radiation of the exterior finish, type of cooling and average power input.

Proper mounting on a metal surface can reduce the temperature rise approximately 50 percent. If radiation is the main source of heat dissipation, a motor with a brightly polished finish may run 10°C hotter than one with a dull black finish. Cooling with fans can increase the power rating 2 or 3 times.

**Applications**

The temperature rise above ambient is directly proportional to the average power input. If the temperature rise for a given power input and mounting is known, the temperature rise for a new power input is

\[
\text{Temp Rise} = \text{Average Power Input} \times (\text{Known Temp Rise/Known Power Input})
\]

Table I is a guide to maximum operating temperatures obtainable with various classes of insulation. The range of class A insulation can be extended by potting motor windings instead of using varnish impregnation. The potting material is a thermosetting resin which adds to the individual wire insulation and helps dissipate heat.

Voltages impressed on a two-phase motor should be 90 deg out of time phase. The main field voltage may be shifted 90 deg from the command signal by a series capacitor. The quadrature voltage that will appear across the motor terminals will be \( Q \) times the line voltage. It is, therefore, necessary to reduce the \( Q \) of the motor to unity by inserting a shunt capacitor.

![FIG. 2—Servo motor connections. Phase shift may be obtained with capacitors (A) or by using two phases of three-phase supply (B). Split-field motors are available for plate-to-plate operation (C)](image-url)
C₂ (Fig. 2A) across the motor and readjusting C₁ for 90-deg phase shift.

Where three-phase voltage is available, any two of the three phases may be used for two-phase excitation with a 15-percent reduction in torque (Fig. 2B).

**advantages and disadvantages**

The two-phase induction servo motor has no brushes to require inspection and replacement. Quiet operation is characteristic. A high torque-to-inertia ratio is possible and low starting torques can be obtained with drag cut-type rotors.

The principle disadvantage is the inherent inefficiency of a squirrel-cage motor running at a high slip (low speed). The efficiency is lowered further by operating with unbalanced voltages. The standby condition, main field constantly excited with rated voltage, increases the heating problem.

The conventional polyphase motor, of which the two-phase motor is a type, develops a smooth nonpulsating torque and is essentially a constant speed motor. It finds use for driving such things as gyro wheels and blowers. The running speed is less than the synchronous speed, Speed = 120 f/p.

As seen from a typical speed-torque curve, Fig. 1A, stable operation takes place where the slope is negative. Although speed is proportional to frequency, some blower motors will run at constant speed over range of input frequencies from 400-2,000 cycles.

The starting performance of a squirrel-cage induction motor is characterized by low torque and high starting current. Wound-rotor motors with slip rings are used where frequent heavy starting with low current is required. As can be seen from Fig. 1A, as rotor resistance is increased the starting torque can be increased. However, this is not common for small sizes and requires an external controller.

The advantage of the squirrel-cage polyphase induction motor is its reliability, simplicity, absence of commutator sparking and economy. The disadvantages are difficulty in obtaining polyphase power, poor speed control, low starting torque and high starting current.

Single-phase motors are more numerous than any other fractional horsepower motor because usually only

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**FIG. 3—Single-phase motor characteristics. Curves illustrate split phase (A), capacitor start (B), permanent split (C) and capacitor start-capacitor run (D) motors. Configuration and characteristics of shaded-pole machine are given in (E) and (F)**
single-phase power is available. The single-phase induction motor is probably most common.

**single-phase motors**

The outstanding problem of a pure single-phase motor is that it is not self-starting. Single-phase induction motors are usually referred to by names descriptive of starting methods.

To produce a rotating field, a starting winding in the stator is necessary. The axis of the starting winding must be displaced from the main winding and the current in it must be out of phase with the current in the main winding.

The single-phase motor is characterized by relatively poor efficiency, low power factor, noisy operation and poor reversibility characteristics. A single-phase motor must be brought to rest before it can be reversed. Reversal is achieved by reversing connections to either main or auxiliary winding.

**motor types**

Split-phase motors have the auxiliary winding displaced 90 deg. The auxiliary winding has a higher resistance-to-reactance ratio than the main winding so that the two currents are out of phase. This is equivalent to an unbalanced two-phase motor, and the rotating field causes the motor to start. After the motor starts, the auxiliary winding is disconnected by a centrifugal switch that operates at about 75 percent sync speed.

Connection of a split-phase motor for plate-to-plate operation is given in Fig. 2C while operating characteristics are shown in Fig. 3A.

The capacitor start-induction run type is also a split-phase motor, but the time-phase displacement between the two currents is obtained by a capacitor in series with the auxiliary winding. The auxiliary winding is disconnected after the motor has started. The outstanding feature is high starting torque. Its performance data are given by Fig. 3B.

In the permanent split or capacitor motor the auxiliary winding of a capacitor-start motor is not cut out and the motor operates essentially as a two-phase motor. The power factor and efficiency are improved and the reduction in torque pulsations makes the motor quiet. Starting torque is sacrificed as the capacitance is a compromise between the best running and starting values. Figure 3C shows operating characteristics.

Capacitor start-capacitor run motors (Fig. 3D) use two capacitors. The permanent capacitor is the best for running. The shunt capacitor for best starting is cut out by a switching device after the motor is started.

The shaded-pole motor is essentially a split-phase method with power supplied to the auxiliary winding inductively. A shading coil, made of a heavy copper loop, is placed about a portion of each of the salient poles as shown in Fig. 3E. Induced currents cause the flux in the shaded portion of the pole to lag the flux in the unshaded portion. This produces a shift of the field axis across the pole face that acts like a rotating field. See Fig. 3F for performance data. Starting torque is very low. Because of poor efficiency this motor is used for small fans and for starting clock motors. Bidirectional control may be achieved by using two shading coils on each pole and remotely shorting the desired coil.

**reluctance motor**

The squirrel-cage induction motor can be converted into a self-starting synchronous motor of the reluctance type by salient pole effect in the rotor. This is achieved by removing some of the teeth from the rotor and leaving the remaining bars and end rings intact. Figure 4A shows a lamination of such a rotor for use with a four-pole stator. The motor starts as an induction motor and accelerates to a speed approaching synchronous. If the reluctance torque is sufficiently large to bring the rotor from slip speed to synchronous speed, the rotor will lock in with the rotating field and run as a synchronous motor. If
the inertia of the rotor and its load is too high to be pulled in, the motor can run only as an induction motor. To operate synchronously, a given size reluctance motor must have 1/2 the output of an induction motor.

The main disadvantage of the reluctance motor is that its pull-in characteristics limit its application to light loads. In clock motors, this is overcome by manually spinning the rotor above sync speed. As the rotor coasts down, it pulls into step and continues to rotate.

Another disadvantage is the high starting torque and hunting characteristic inherent in all salient pole synchronous motors.

**hysteresis motor**

A relatively new type small synchronous motor is the hysteresis motor. It utilizes magnetic hysteresis to produce torque.

The rotor is a simple, smooth, nonsalient ring of permanent magnet material. The stator has a polyphase or permanent-split capacitor-type winding. The magnetic field produced by the stator winding induces magnetic poles of opposite polarity in the rotor. As the rotating stator field slips past the rotor, the rotor tends to retain its polarity of magnetization. Figure 4B shows magnetization in the hysteresis motor. The axis of the magnetic field produced by the stator is along line A-B while the rotor axis of magnetization lags behind by the angle δ and is along line C-D. As a result of this lag torque is produced. The torque accelerates the motor until it pulls into synchronism with the rotating stator field. At synchronism the rotor behaves like a permanent magnet rotor locked in with the synchronously rotating field. The speed-torque curve of a hysteresis motor is shown in Fig. 4C.

The constant hysteresis torque will pull into synchronism any load that it is capable of accelerating. Miniature hysteresis motors are widely used to synchronize gyro wheels. Another feature is reduced hunting due to the absence of salient poles.

The advantages of low noise level, continuous nonpulsating synchronizing torque and reduced hunting make the hysteresis motor highly desirable in phonograph and recording drives.

Where minimum size and maximum efficiency are required, as in miniature gyro's, the efficiency of 1 to 2-inch diameter hysteresis motors does not compare favorably with the approximately constant speed induction motor. This disadvantage has been overcome in many miniature applications by overexcitation. This consists of using increased excitation voltage for a short time to overmagnetize the rotor after it has pulled into synchronism.

**d-c motors**

Direct-current machines are more adaptable to adjustable speed service than a-c machines. Direct-current motors provide a given output power in a smaller volume than a-c motors and have higher starting and reversing torques. Their major application is in aircraft control systems.

Series motors have high starting and reversing torques and poor speed regulation. As shown in Fig. 5A the speed-torque characteristic has a high negative slope.

For control applications this contributes to stability as it is equivalent to a high viscous damping torque. The series motor is a nondirectional device unless switching is used. This has led to the development of the split series field motor (Fig. 5B) which has two oppositely poled field windings, one for each direction of rotation. Bidirectional control can be obtained with a single-pole relay.

Series motors are ideal for fans and blowers, step positioning devices and other constant torque loads where speed is relatively unimportant.

**shunt motor**

The shunt motor has from low to medium starting torque and fairly good speed regulation. With a series field (compound motor) the full-load speed at
FIG. 6—Associated motor devices. Clutch and brake applications, top, and servo damping devices, below

<table>
<thead>
<tr>
<th>Table 1—Temperature Ratings of Motor Insulation</th>
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can be made to be equal to, smaller than or greater than the no-load speed. Control of speed and torque can be achieved by the armature circuit resistance method, by field control or by armature control.

Field control can be achieved by driving from a d-c amplifier. To prevent time delay between buildup of field current and application of control signal, a current amplifier should be designed. A disadvantage of field control is difficulty experienced at low or zero signal levels by residual flux due to hysteresis.

Armature control utilizes a change in armature terminal voltage to provide an equal change in counter emf and a proportional change in speed. The field flux is constant. If a d-c amplifier is used for the armature, it must be capable of delivering full motor power. This system gives good linearity and operates satisfactorily in high-gain systems.

Permanent magnet motors are similar to shunt motors. They are characterized by light weight, economy, high efficiency and armature control. Their chief disadvantage is that the field may be demagnetized or the pole axes shifted if the motor is badly overloaded. Figure 5C shows the characteristics of a permanent magnet servo motor.

The basic disadvantage of all d-c machines is the prob-
lem of commutation. Commutation generates radio noise and interference and often requires noise suppressors. Uneven brush wear causes apparent brush axis shift.

**clutches**

A practical instrument control clutch can achieve torque coupling and control by three methods: mechanical contact between friction surfaces as in an automobile; electrical, generation of eddy currents; and fluid coupling, control of the shear and viscosity characteristics of a fluid between the input and output members. Figure 6A illustrates one typical clutch coupling application.

Fluid couplings of the torque converter type do not generally exist in instrument sizes. A straight fluid coupling offers a convenient answer for open-loop applications where considerable slippage at low speeds can be tolerated and where maximum smoothness in torque pickup is needed.

The fluid magnetic clutch is versatile since it combines the smoothness of the eddy-current clutch with the large torque controlling ability of the friction clutch.

To circumvent the problems in utilizing an inherently abrasive mixture as the high-speed coupling agent in a fluid magnetic clutch the synchronous-induction clutch was recently developed. This clutch is similar to a hysteresis motor with the stator excited with d-c and spin. Its characteristics are much like those of the direct friction clutch, no slip below a certain torque determined by the excitation. After pull-out the clutch slips and behaves like the eddy-current clutch.

Since a clutch need not generate torque, the input power for control can be made a small percentage of the peak capability of the clutch.

The disadvantage of a clutch in servo control applications is that for maximum torque output with zero velocity all the input power to the clutch goes into heat. From the standpoint of heat dissipation there is little basis for choice between the clutch types.

**brakes**

Brakes are devices for dissipating kinetic energy. Dissipation may be achieved by utilizing the energy for some useful purpose as in dynamic braking or by converting the energy to heat; for instrument units no economy is gained by dynamic braking. Figure 6B depicts an instrument braking system.

Many instrument brakes utilize cork on steel as the braking surfaces since this combines economy with...
Table II — Family Tree of Associated Motor Devices

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<th>Clutches</th>
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<td>Electric</td>
<td>Eddy current</td>
<td>Fluid magnetic</td>
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<td>Synchronous</td>
<td>One-to-one slip</td>
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<td>induction</td>
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<td>Tuning clamping</td>
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<td>Brakes</td>
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<td>Viscous to ground</td>
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<td>Viscous to ground</td>
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<td>Fluid coupling</td>
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<td>Flywheel</td>
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relatively long wear. If extremely longer wear is desired as in sealed units sintered bronze on steel may be used.

Like clutches, brakes may be direct friction, fluid or electromagnetic although the first two are mostly in use today. Fluid brakes are used to provide viscous friction for damping.

damps

The ideal servomechanism damped centrifugal control error to zero simultaneously in the smallest possible time with no overshoots. One means to accomplish this is to build some anticipation into the servo controller so that the net driving torque can be reversed sufficiently in advance of null to decelerate the servo to zero velocity at the instant null is reached.

A viscous friction damper offers a good method of improving instrument performance. Viscous friction can cause no static positional servo error and improves following performance at low rates. However, the unwanted energy is still dissipated as heat. A schematic of a fluid viscous coupled flywheel damper appears in Fig. 6C. It consists of a shell and an internal flywheel coupled to the shell by viscous friction of oil in which the flywheel is immersed.

Among the problems of fluid viscous coupled flywheel dampers are: sealing of units against leaks over a wide range of ambient conditions, variation of damping characteristics with temperature, and lack of simple means for continuous damping adjustment.

The variation of damping characteristics with temperature has been partially overcome by using silicone fluids instead of oil. To overcome two of the detrimental characteristics of the fluid viscous dampers, the electrical viscous damper has been developed. A thin extruded copper or aluminum cup is coupled to the motor. The cup is mounted on a plane of the electromagnetic elements providing a low reluctance return flux path. Eddy currents induced in the cup provide viscous coupling between the cup and the magnet which is flywheel mounted. A diagram of the electrical viscous damper appears in Fig. 6D.

The inherent damping characteristics of most servo motors can be increased by allowing a direct current flow through the motor windings. For the smaller motors, however, flux paths are usually operated so close to saturation that not much additional damping can be bought by power expenditure.

synchros

Fundamentally synchros consist of a wound stator and rotor which may be cylindrical or have salient pole structure. The windings may be single phase or three-phase wye.

Figure 7 shows the classes of synchros in common use.

The cascading of a synchro generator and synchro motor produces the primary self-synchronizing system.

In any rotor position, the rotor coils and stator coils constitute two windings of a transformer.

When the rotors are aligned and excited with equal voltages in the absence of load torques, the induced voltages in the secondaries cancel, and no stator current flows. If misalignment occurs, voltage is developed causing current to flow through both stator.

Torque synchros in self-synchronism do not amplify. Therefore the energy delivered mechanically at the output of the motor must be supplied mechanically at the generator input.

Because of the inherent transient overshoots and the lack of torque amplification simple transmitter-repeater data systems are generally used to drive only light dials. In driving heavy loads, torque amplification can be obtained by feedback.

Another useful component is the differential synchro which may be either a motor or generator. It can modify the angle indicated between a standard generator or motor or control transformer by adding or subtracting another angle. The differential motor gives mechanical rotation equal to the sum or difference of the signals from two generators.

October, 1954 — ELECTRONICS
TO ASSEMBLE the components that make up electronic equipment industry has devised numerous methods and devices.

In television set production the emphasis is on speed and economy. In military equipment, fastening methods are usually delineated by specifications. Fasteners must allow for easy replacement of parts under difficult circumstances.

Machine screws are widely used in military equipment. The machine screws mostly used are ASA coarse thread sizes 6-32 and 8-32, class 2 fit after plating.

**machine screws**

The most commonly used material is steel. Brass screws are also used, usually where parts must be mounted in a magnetic field such as in mounting the neutralizing coil around the face of a cathode-ray tube.

Small machine screws size 4-40 are occasionally used in fastening small parts. Two uses for machine screws in production of commercial equipment are mounting speakers and fastening heavy parts such as yokes of color sets. For heavy fastening 4-20 screws are used.

A widely used screw head is the hexagonal head, chosen because of the wide application of screw-driving guns. On military equipment slotted pan-head screws are used for ease of maintenance. When hex-head screws are not specified, industry often uses cross-head screws which avoid tool slippage. Countersunk-head screws are not often used; their use is restricted largely to military equipment.

**set screws**

In military equipment set screws are frequently used to fasten knobs, collars and couplings to shafts. These screws usually have recessed heads and are designed to be tightened by special wrenches. One wrench has a six-sided stock while another is fluted. Most common set-screw size is ASA coarse 8-32.

In equipment designed for the mass market knobs are usually of the slip-on type held in place by spring fasteners.

A nut commonly used with machine screws is the hexagonal nut, usually the chamfer type. Military specifications often call for nuts having a plastic insert. This nut is self-locking.

An interesting device used where secure fastening is
desired is shown in Fig. 1A. It combines a nut and lockwasher as one unit; these are called keeps. In building military equipment lockwashers are generally used under screws. Commercial equipment occasionally uses lockwashers, generally under screws holding the chassis to its wooden cabinets.

Fiber washers or plastic inserts are used for insulation.

**self-tapping screws**

The self-tapping screw is a widely used device. The A type is a pointed sheet-metal screw, easy to insert and used to fasten components and brackets to chassis. Type A screw is used in sizes 6, 8 and 10, depending upon the size and weight of the component.

The type Z self-tapping screw is a multifluted screw resembling a tap shank. It is used in assembling plastic parts and in making connections through extruded holes in sheet metal.

The Type F/Z self-tapping screw is also fluted but has a wider thread than the Z type and is specifically designed for assembling plastic parts.

**riveting**

Riveting and eyeleting are widely used, especially in fastening parts that do not usually need replacement, such as tube sockets, terminal strips, capacitor mounting plates, etc.

A special type of rivet in common use is the shoulder rivet. The connection is made by a shank of smaller diameter than the body of the rivet to provide free-turning mounting of idlers and pulleys, and mounting of springs and spacers.

Blind rivets are used in closed places where bucking is impossible. One type is a hollow rivet with a pin to drive the rivet. The head of the pin exerts a squeezing force. Some blind rivets are of self-plugging type and some of the pull-through type. Designers attempt to avoid closed places in their layouts. Therefore, blind rivets are largely used in putting on trim. Where insulated rivets are required plastic blind rivets are available. See Fig. 1B.

Common rivets are used in subassembly operations such as where a bracket is riveted to mounting strap for a television picture tube. Here riveting is done on a machine similar to the eyeleting machine.

Most widely used eyelets are 0.088 and 0.122 in. in diameter. Eyeleting is usually done by eyeleting machines. These are commonly equipped with automatic feeds; some provide for inserting two eyelets at one time. Figure 2 illustrates use of eyelets in a multiposition wafer switch.

**special fasteners**

The spring-steel fastener reduces parts handling and speeds production. It consists of a flat piece of spring steel bent in a bow. Basically it is a one-thread holding device that fits over the screw and grips it in place. The spring-steel fastener can also fit over studs, rivets, nails, tubing or wire.

Where ease of disassembly is important, spring-steel fasteners can be slipped over studs of D-shaped cross-section. The stud is gripped on two sides by the fastener and locked in position. The part may be released by turning the fastener one-quarter turn.

When spring-steel fasteners are used with machine or self-tapping screws, the screws can be unfastened just as when they are used with machined nuts. In Fig. 3 use of spring-steel fasteners in assembly of a portable radio cabinet is illustrated. Studs die cast on the dial frame are inserted in holes in the plastic cabinet and the fasteners then slipped over the studs.

Figure 4 illustrates the self-retaining feature of a spring-steel fastener. The fastener is U-shaped and fits over the chassis edge to provide a self-retaining nut for fastening the cover.
Spring-steel fasteners are available in several shapes including brackets, tubular fasteners, compression rings, wire and cable clamps. Also included are wood anchors, turning fasteners and a wide variety of clamps, retaining rings and special mounting fixtures.

Another special fastener is the nut retainer shown in Fig. 1C. It can be used for holding nuts in blind locations and requires no welding or clinching. One common application is mounting the television chassis in the cabinet. The nut retainer is housed in a spring-steel cage and provides play to compensate for manufacturing tolerances.

use of Glyptal and cement

Glyptal is a fast-setting liquid compound used to coat critical tuning adjustments to prevent tampering. Cements are used in several assembly operations. Some of these include affixing sound baffle material inside the cabinet and fastening voice coils to speaker cones.

Several cements have been developed to meet special needs. A rubber-base cement is often used. Special cements known as dope have been developed for coating coil forms to help them retain their shape while not affecting the electrical performance.

Cement is not often used in what was formerly its most important application cementing labels to pieces of equipment. Labels used today are largely of the pressure-sensitive type.

fittings and connectors

Where a ground connection must be made to the chassis this is usually done by a ground lug. In military practice the ground lug may be a combination lug and lockwasher. The lug is fitted under the machine screw holding, say, a tube socket and connections made directly to the lug.

In commercial practice, it is customary to lance the ground lug out of the chassis—actually punch a small piece of steel partially out and make the connection by soldering to it.

Terminal strips show a considerable difference between military and commercial practice. A commonly used terminal strip for commercial practice is a thin piece of phenolic resin about $\frac{1}{2}$ in. thick and $\frac{3}{4}$ in. wide. See Fig. 5A. This is equipped with mounting feet at right angles, one or more depending upon the length. Solder lugs are connected to the strip by eyelets forming the lower part of the lug. Solder connections are made directly to the lugs.

In military practice a common terminal board (Fig. 5B) is a $\frac{3}{4}$-in. strip of $\frac{1}{4}$-in. phenolic resin appropriately fungus proofed and equipped with rows of turret lugs. The terminal boards are usually fastened to the chassis by machine screws. Also used is the pancake component board, shown in Fig. 5C. Figure 6 shows a chassis using eyeleted pancake component boards and wafer-type tube sockets.

plugs and receptacles

The military-type connector consists generally of a die-cast shell inside of which there is an insulator holding male or female metallic parts. The insulator may be phenolic resin or of polystyrene or other materials for better insulation.

In commercial practice plugs consist of thin phenolic resin forms with the metallic connectors fastened directly to them. The so-called phonograph connector lends itself well to connection to shielded leads. The plug contains a center prong which carries the signal. The prong is centered by a disk of insulating material, which is in turn surrounded with a small metal shell that provides ground contact.

high-voltage connectors

Use of voltages of 12,000-14,000 v on cathode-ray picture tubes has brought about the need for carefully

FIG. 4—Self-retaining U-shaped fasteners fit over edge of chassis to permit attaching dust cover

FIG. 5—Component board types include free-standing type (A), turret (B) and pancake types (C)
insulated anode connectors. The connector consists of a plug button designed for corona-free operation, which fits into a small recessed cavity in the cathode-ray tube. The anode connector is surrounded by a wide circular shield of Neoprene or silicone since the high voltages used in this work have a deteriorating effect on natural rubber. Anode connector leads are often equipped with polyethylene-enclosed single-prong connectors. Where electronic equipment is built up of several interconnected chassis, need exists for multiconductor cable and corresponding plugs and receptacles. In commercial equipment for the mass market, multiconductor cable is sometimes terminated in an octal-base tube socket acting as the female receptacle and a corresponding eight-prong male plug. In military equipment, a wide variety of multiconductor connectors is used. These include types having tubular prongs arranged in clusters and knife-like prongs.

tube sockets

Most common types of tube sockets are the miniature 7, 9-prong and octal-based sockets. Special types include 4-prong, 8-prong, loktal, 5, 6 and 7-prong subminiature sockets, 3-prong transistor sockets, special sockets for the klystron and various transmitter tubes and cathode-ray tube sockets with up to 20 prongs to accommodate new three-gun color tubes.

There are two basic types of sockets, the wafer type, (Fig. 6), usually made of laminated phenolic material, and the molded type made of either plastic or ceramic. The wafer socket is riveted to the underside of the chassis while the molded type is mounted by a metal saddle either above or below the chassis. The saddle often incorporates a ground lug.

Tube shields are often used, particularly on miniature tubes. In one type the saddle of the tube socket forms the base of the shield. See Fig. 7A. The base has a bayonet connection to the upper part of the shield. The upper part of the shield also includes a spring. Another type, shown in Fig. 7B has a spring bead on the lower part, which fits into a rim on the upper part.

Tube clamps or tube holders are used where excessive vibration is encountered or where tubes are mounted horizontally or inverted. One type of tube holder exerts cutting-edge action on tubes having molded bases and may readily be released by slight pressure of fingers on the holder in the direction of the chassis. This holder is of 0.015-in. annealed spring steel in the form of a ring, fastened to the chassis in two places and bent upwards to form two bows. This type of clamp is illustrated in Fig. 7C. Another type, shown in Fig. 7D, widely used in military applications consists of spring-steel collar and buckle welded to an upright post. For octal and loktal-based tubes, the collar is tightened around the plastic base. For miniature tubes, the post is longer and the tube is held by a cap that fits over the top of the envelope and exerts downward spring tension. Subminiature tubes may be held in a cylindrical clamp that fits around the tube and serves to conduct heat.
Wiring and Soldering....

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Efficient wiring and soldering methods together with choice of proper materials cut direct-labor cost and improve performance in military and commercial equipment. Special techniques point way to fully automatic production.

TELEVISION receivers may contain over 90 feet of wire, while a complete radar system may have over 4,000 feet. Although the cost of wire and flux-solder in a television receiver represents only a small fraction of the overall cost, wiring and soldering may represent 30 to 40 percent of direct labor cost.

Both tinned copper wire and insulated wire are used. Figure 1 shows various kinds of wire used in set production. Solid copper wire tinned and bare of insulation is used in sizes ranging from 38 gage (0.003465 in. in diameter) to 6 gage (0.1620 in. in diameter). Wire of 22 gage (0.0253 in. in diameter) is commonly used. Stranded wire is used to provide flexibility where movement may be required in dis-assembly and reassembly. Occasionally flat woven copper braid or solid flat copper is used where low resistance contacts are required such as common ground connections between chassis. See Fig. 2. Types of insulated wire include plastic covered, cotton covered, lacquered, nylon covered, glass fiber insulated and the film insulated type. Plastic covered wire is in wide use.

insulation

A common type of plastic covering is polyvinyl chloride 3/16 or 1/4 in. in thickness. This insulation will resist temperatures up to 80 to 90°C and breakdown voltage to 10,000 v with a usual rating of 600 v. This wire has good resistance to abrasion and humidity and is easy to strip. Glass fiber insulated wire shows
and durable, will withstand bending and require no additional thickness due to covering. They are used in winding coils, particularly the horizontal size and horizontal linearity coils and deflection yoke coils for the television receiver.

Teflon is made from tetrafluoroethylene resin. Its most outstanding characteristics are high insulation value, resistance to moisture, heat and abrasion. The plastic in dispersion is applied to glass fiber cloth by dipping. It is then dried and fused at elevated temperatures. Glass fabric laminates withstand 250 C continuously and up to 300 C intermittently. Teflon suffers no apparent degradation from oxygen, tends to repel water and has the property of shedding dust. It is used for critical wiring such as high-voltage leads in television receivers where the wire goes through several metal shields incurring abrasion and danger of arc over. High-frequency work in government equipment often requires its use.

Special types of wiring include twin lead used primarily to transmit signals from the antenna to the TV or FM chassis. Twin lead may consist of two conductors of No. 22 gage stranded copper wire set parallel in a casing of brown polyethylene. This wire has a dielectric strength of 5,000 volts rms for one minute and a capacitance per foot of 5.5 micromicrofarads at one megacycle.

Special purpose shielded cable used for audio and pulse circuits consists of an inner conductor of tinned copper wire 0.0228 to 0.0256 in., an insulated film of polyvinyl chloride and circumferential shield of 32 to 36 strands of 0.0057 to 0.0072 in. tinned copper wire. It may also have a spiral wrap and an outer jacket 0.010 in. thick of polyvinyl chloride. This cable will withstand up to 600 volts rms at 90 C.

Silicone is a relatively new hydrocarbon applied as a varnish or additive to the outside covering of insulation. It is outstanding for its waterproofing properties.

**spaghetti**

Sleeving insulation known as spaghetti is slipped over tinned copper hookup wire to prevent shorts. One type consists of braided cotton, rayon, nylon or glass sleeving impregnated with an oleoresinous varnish and will withstand 800 v average and 1,500 v short-time dielectric test. It comes in sizes from 24 gage to 1 inch in diameter. A second type is braided glass tubing coated with a continuous film of oleoresinous varnish. This type of sleeving will withstand 2,500 v average, 4,000 v short-time dielectric test. It comes in sizes from 24 gage to \( \frac{3}{8} \) in. inside diameter.

**wiring**

In point-to-point wiring, as shown in Fig. 3, all wiring should be neat, sturdy and as short as possible. In high-frequency circuits it is often necessary that point-to-point wiring be used. Servicing can sometimes be completed in less time with point-to-point wiring.
wiring because the direct path can be traced easily. Less wire is used and there is no need for identification of wire ends.

Basic wiring, or the connections of tinned copper wire to the chassis after mechanical parts have been assembled, is usually point-to-point wiring. Figure 4 shows use of point-to-point wiring in a TV receiver.

When specifications require it, wires are grouped and laced into a cable. Wires in a cable must be neat and tightly bound. Leads should be of a length to provide slack to prevent stress on individual wires and terminal connections. There must be sufficient slack to enable removal of parts for inspection, adjustment or repair without disconnecting or damaging other parts. The wires are placed separately on a cable board in a predetermined sequence. After all the wires are laid, twine, linen or lacing cord is used to form a solid unit. Cables are almost always made bottom side up so that the lacing knots will not be visible. Figure 5 illustrates use of cabled wiring.

**wire stripping**

The outer covering of wire such as nylon, cotton or enamel must be separated from the conductor to provide a clean, shiny surface for the soldered connection. Poor stripping will result in poorly tinned copper ends and a poorly soldered or noisy connection.

Wire stripping can be accomplished chemically, mechanically or electrically. Preparations having the consistency of heavy syrup or free-flowing paste are available that can be used to strip lacquer, enamel or other film insulation. These preparations are composed of ingredients such as chlorinated solvents, having good solubility properties, ammonia and phenolic fractions which are excellent solvents for resins. An interval of time must elapse between the application of the stripper and the reaction or blooming time. This time element is a cost consideration.

A common method of wire stripping is mechanical stripping. Precision machines, Fig. 6, have been designed to cut to lengths up to 15 in. and strip 3,000 wires per hour. Stripping length on both ends can be the same or the ends can be stripped to different lengths.

Another mechanical stripping method employs an electric motor and one or two wire wheels. This method can be used on various gages of wire and types of insulation and a long stripping length is possible. A variety of stripping wheels are made, including a fine-gage crimped wire or wire and glass fiber wheel. Insulation is stripped by inserting leads between rotating wheels. The entire unit can be moved to the work position. The wheels must be changed, depending upon the wire to be stripped. In some cases wheels with 50 percent of their useful life remaining must be replaced to achieve satisfactory quality of stripping.

Still another type of mechanical stripper uses a motor to revolve the stripping blades. The wire to be stripped is fed through a hole in the front cover and, by depressing a foot pedal, the two stripping blades, which revolve at a high rate of speed, are brought in contact with the insulation. The blades stop short of the conductor and as the wire is withdrawn the insulation is separated from the conductor.

This type of stripper can be used only on insulation other than the film or plastic type. It must be bolted to the bench and the pedal secured to the floor. Its advantages are that it operates quietly and safely; stripping length adjustment can be made quickly. Blade cost is low and blade life high.

**marking and coding**

Once the wire is cut and stripped to the required length it is tin dipped, generally in a solder pot containing 50-50 (tin/lead) bar solder. When used in cabling the wires may require identification or coding.

In point-to-point wiring such as that used in radio and television receivers the exterior color of the insula-
tion is used for coding. This may be either a solid coloring or a secondary or tracer color along with the principal color.

Recently, printed vinyl tape has been used for identification of wire, cable and conduit. It is composed of a thin printed pressure-sensitive vinyl tape having an efficient adhesive on the back. It is available in rolls of various widths. The ink is sealed into the vinyl backing to provide an abrasion-resisting material. The tape can be fed from a machine or cut to required length by hand.

Insulated plastic tubing is also used on individual or grouped wires. To identify both ends of a large quantity of wires, plastic tubing is purchased in lengths as required. Printing is done on the exterior parallel to the length. In a particular cycle of the operation a length of the imprinted tubing is slipped over the end of the wire before terminating it.

A self-adhesive tape is available in cut-to-size strips or labels from 1 to 6 inches in length and from \( \frac{1}{8} \) to 3 inches in width. It can be written on with any dry, blunt point such as pencil or stylus. Writing appears beneath a layer of transparent plastic due to pressure of the writing instrument.

**component boards**

Component or terminal boards are used as tie points in the circuit of a television receiver. They are usually mounted to the metal chassis by rivets, eyelets or screws. Some have only one or two terminals while others may have eight or more. The material used may be phenolic NEMA grade XP, vacuum wax impregnated, or it may be of phenolic, grade X, chocolate brown surface with a tan core. Table 1 lists materials for terminal boards.

The material itself is a laminated thermosetting plastic made by bonding together two or more piles of impregnated stock. The base material may be paper or fabric made from cotton, asbestos, glass or synthetic fiber. The binder in most cases is a phenolic in the form of a varnish with which the material is treated in the early stages of manufacture. This material is also available with a binder of melamine or silicone if required.

Standard sheet sizes are 18 \( \times \) 24, 36 \( \times \) 67, 36 \( \times \) 44, 36 \( \times \) 36 and 39 \( \times \) 49 inches. Thickness runs from 0.010 in. to \( \frac{1}{8} \) in. Terminals fastened to these boards may be of the single-ended type riveted or eyeleted on. By staking and spinning, terminals of a double-ended type may be attached.

Prototype fabrication and short-run production is facilitated by a mounting system that consists of terminal cards, unit planning cards, miniature terminals and tube sockets. The terminal cards are prepunched, multihole cards that have flexibility to take a number of circuit variations.

**soldering fluxes**

To join metal by soldering, it is necessary that the surfaces be clean and free of all oxides. This is done by employing a flux that will dissolve the oxides on the surface, permitting the molten solder to wet, spread and take. The flux reduces surface tension of the solder and the metal, allowing the solder to penetrate into the pores of the metal, and creates a protective covering to preclude the now clean surface from becoming reoxidized due to the heat required in soldering.

Fluxes are either noncorrosive or corrosive. The degree of corrosion indicates its activity with pure water. Rosin is noncorrosive while hydrochloric acid is corrosive but has great fluxing power.

Rosin consists chiefly of abietic acid and related substances. At ordinary temperatures it is a solid and does not cause corrosion but it reacts mildly at soldering temperatures. Rosin is easily crushed into powder and melts rapidly at about 125 °C. The usual solvent for rosin is methylated or denatured alcohol. Powdered rosin is mixed with from two to four parts by weight.
of alcohol. In addition to either methyl, ethyl, propyl or butyl alcohol, oil of turpentine or carbon tetrachloride are sometimes used as solvents. Rosin itself is a relatively poor flux since it will take only on relatively clean copper, brass, hot-tinned or tin-dipped surfaces.

Various acid additives are added to rosin to make it a more active flux. In activated solders the active ingredient employed will volatilize upon being heated, accomplish its extra fluxing job and leave only a plain rosin residue.

**soldering techniques**

To join metal with soft solder the proper flux must be applied and the metal heated to liquify the solder alloy. Tools used for soldering include: electric and gas-fired soldering irons, torches, induction heating machines, oven soldering, radiant heat, electrode soldering, steam heating, resistance soldering and hot-plate soldering. Figure 7 illustrates a soldering operation using a torch.

The tip is the heart of the soldering iron and is generally made of copper because of its exceptional ability to absorb and transfer heat rapidly. Electric soldering irons are available in power ratings of 40, 60, 100, 125, 150, 200, 250, 300 and 500 watts. The higher the wattage the more heat the tip can hold and transfer and, in general, the higher the wattage the heavier the soldering iron. For production soldering, which is often done by women, a frequently used iron runs between 125 and 150 watts.

Irons of 200 watts or more are used where a number of ground lances are to be soldered. On long cycle operations without a temperature-regulation device service life of soldering iron heater elements may be upwards of four months. Use of a heavy soldering iron for parts assembly is shown in Fig. 8.

Much of the bar solder used in industry is used in soldering pots. See Fig. 10. Solder pots are used where the tinning of wires or components is necessary. The electrically heated solder pots make the solder molten. The part is dipped in flux and then immersed in the solder bath.

A soldering pot should be operated at a controlled temperature, generally not in excess of 125 to 150 F above the melting point of the solder being used. Table II gives melting temperatures of various solder alloys. Bar solder is available in 50/50, 60/40, 40/60, etc. Consideration must be given to the amount of heat withdrawn due to parts being dipped. By doing drossing and scaling on the top of solder in pots will be kept to a minimum and brighter finish obtained on the part. To maintain proper temperature during dipping a thermostatically controlled soldering pot may be employed. Use of virgin tin-lead solders is important for good pot soldering. Virgin metals contain far less impurities than smelted or refined solder.

In dipping copper parts into a tin-lead solder bath the affinity between tin and copper results in tin-copper crystals that may form a sludge at the bottom of the pot. This is removed from the bath and deposited upon the surface of the article being tinned. It is good practice occasionally to cool the solder bath to 10 F above melting temperature, remove these crystals from the pot and refill with fresh solder.

**other joining processes**

Welding involves joining metals with high heat—2,200 F and higher. This results in strong connection but is used primarily in joining very heavy metals to avoid buckling and warping of the basic material.

Silver soldering and brazing are methods of joining metals using hard solders that contain high percentages of silver, copper, etc.

The temperature for silver soldering or brazing runs from 1,150 F upwards and fills the need for a process
of joining of metals at a lower temperature than that of welding. Soft soldering employing tin-lead is the lowest temperature (360 to 600 F) method of joining metals. It permits joining thin metal sheets or delicate parts without buckling or warping.

Tensile strengths of soft solders vary from 17,000 lbs per square inch to approximately 29,000 lbs per square inch. An alloy of tin and lead will melt at a lower temperature than either of the two metals by themselves. Pure tin has a liquidus temperature of 450 F, while pure lead has a liquidus temperature of 620 F. Any combination of the two metals has a lower melting point.

**solderless connections**

Solderless connectors are available in a wide variety of sizes and types. Tools are available for manual, pneumatic, hydraulic and electric operation that compress the barrel of the connector onto the conductor.

Advantages of solderless connectors include uni-
### Table 1 — Characteristics of Materials Used in Terminal Board Fabrication

<table>
<thead>
<tr>
<th>NEMA Classification</th>
<th>Colors</th>
<th>Filler</th>
<th>Binder</th>
<th>Application and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>Natural, black, walnut &amp; brown</td>
<td>Paper</td>
<td>Phenolic</td>
<td>General purpose paper-base grade for panels, contactors and terminal blocks where high mechanical strength, low-cost material is required</td>
</tr>
<tr>
<td>XXP</td>
<td>Black &amp; natural</td>
<td>Paper</td>
<td>Phenolic</td>
<td>Excellent insulator; can be machined readily and punched hot. May be used in switches, relays, vibrators and where a low dielectric loss material is required</td>
</tr>
<tr>
<td>CE</td>
<td>Black &amp; natural</td>
<td>Medium cotton drill</td>
<td>Phenolic</td>
<td>Best canvas base, electrical grade</td>
</tr>
<tr>
<td>AA</td>
<td>Natural only</td>
<td>Asbestos fabric</td>
<td>Phenolic</td>
<td>Has high heat resistance, low coefficient of thermal expansion, low water absorption, fairly high impact resistance and good resistance to wear and chemical corrosion. It has low dielectric strength</td>
</tr>
<tr>
<td>XXX</td>
<td>Black &amp; natural</td>
<td>Paper</td>
<td>Phenolic</td>
<td>Excellent electrical grade. Preferred grade where low dielectric loss and stability upon exposure to moisture are of primary importance. Used on equipment involving high voltages at temperatures up to 130°C</td>
</tr>
<tr>
<td>XXXP</td>
<td>Black &amp; natural</td>
<td>Paper</td>
<td>Phenolic</td>
<td>Compares favorably to XXX as regards electrical properties. Preferred where a paper-base punching grade of high insulating value is required</td>
</tr>
<tr>
<td>XP</td>
<td>Black, natural, walnut &amp; brown</td>
<td>Paper</td>
<td>Phenolic</td>
<td>General purpose paper-base grade of low cost for punching. For use at temperatures up to 100°C and moderate humidity in applications such as spacers, terminal boards and crossbars for knife-type switches</td>
</tr>
</tbody>
</table>

![FIG. 9—Printed circuit techniques include use of conductors sprayed on dielectric plate, left, and stamped from metal foil and embedded in plastic, right](image)

Formity of installation, simple operation by unskilled operators and optimum rate of attachment. Savings in manufacturing are obtained by elimination of solder, soldering iron with its replacement and maintenance costs and a saving of the electrical power required to operate soldering equipment.

Development of a solderless wire-wrap connection provides a new technique for making solderless electrical connections. The wire is wrapped around the terminal using a specially designed air or electric tool. Sufficient tension is developed so that the resulting bond becomes permanent, both electrically and mechanically. This method not only eliminates all need for solder, but since it is made with a power tool, less time is required than for hand wrapping.

**special techniques**

Modular design for electronic equipment is aimed at breaking a potential bottleneck that might occur in an all-out emergency and at simplifying equipment.
heart of one system is a ceramic wafer, \( \frac{3}{4} \) inch square and \( \frac{1}{8} \) inch thick. After being stamped and pressed, the wafers are oven cured. Notches on all four sides are silver-painted for circuit connection use. After fabrication they are sorted automatically for proper positioning of capacitors or resistors of the required value. Complete assembly of the wafer-mounted parts is done on a single machine. They are then fed into a machine for automatic soldering. The final modules, which may consist of four to six wafers with their associated resistors and capacitors, are assembled, soldered and then connected automatically to a tube base. In turn, connections are made to a base plate produced by a printed circuit process to form the final subassembly.

Another automatic production technique revolves around a machine that solders many joints at one time by dipping an inverted television chassis in a solder pot of sufficient size. Preceding the dip soldering operation, a chassis has ground pins and spring washers installed by semiautomatic machinery. The chassis are then fed into a large press which inserts a large quantity of rivets into pin plates and terminal strips in one stroke. The terminal pins receive the components designed for them and the chassis is dip-soldered.

**printed circuits**

When a circuit is produced upon an insulating surface by any process it is termed a printed circuit. There are six main classifications: painting, spraying, chemical deposition, vacuum processes, stamping and dusting. In painting, conductive and resistive paint is applied by brush or stencil. Later capacitors and tubes are added. Resistive and conductive paint may also be applied by spraying. In chemical deposition, a chemical solution is poured over an insulating surface covered with a stencil and a metallic film precipitated out to form the circuit. The circuit may also be electroplated. In vacuum processes, the conductors and resistors are distilled onto the surface.

Other methods include die stamping in which conductors are punched out of metal foil and then attached to the insulating panel and dusting wherein conductive powders are dusted onto a surface through a stencil and then fired. The powder may befield electrostatically or by a binder. In addition to these printing processes, photoetched circuits are also referred to as printed circuits.

A printed circuit replacement for waveguides is composed of some base metal which is a fairly good conductor such as aluminum or copper. On to this is securely fastened by pressing, a material such as polyethylene. Next to this insulator is the foil, photoetched in particular a design together with the components, resistors, connections, etc. Sometimes a double arrangement is made resulting in a sandwich. It is used principally in microwave circuits as a substitute for the plumbing generally used.

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**Table II — Melting Characteristics of Solder**

<table>
<thead>
<tr>
<th>Solder Alloy Composition</th>
<th>Temp at Which Solder Becomes Plastic in deg F</th>
<th>Temp at Which Solder Becomes Liquid in deg F</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% Tin 90% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>15% Tin 85% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>20% Tin 80% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>25% Tin 75% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>30% Tin 70% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>35% Tin 65% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>40% Tin 60% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>45% Tin 55% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>50% Tin 50% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>55% Tin 45% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>60% Tin 40% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>65% Tin 35% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>70% Tin 30% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>75% Tin 25% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>80% Tin 20% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>85% Tin 15% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>90% Tin 10% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>95% Tin 5% Lead</td>
<td>361</td>
<td>437</td>
</tr>
<tr>
<td>100% Lead</td>
<td>—</td>
<td>450</td>
</tr>
</tbody>
</table>

*Eutectic alloy is formed having one sharp melting point and no plastic range*
Designing the Cabinet...

By JOHN T. MULLER
Consultant
Livingston, New Jersey

Environmental conditions strongly influence design of military and commercial electronic equipment. Some cabinets even permit operation underwater, in explosive atmospheres or while subjected to severe shock, vibration and extreme climatic conditions.

Mechanical design of cabinets for electronic equipment depends primarily upon the size and function of the equipment and the environment in which it must operate. Environmental conditions include shock, vibration, extreme temperatures, salt spray and high humidity. Equipment may also be designed for operation at high altitudes, underwater and in explosive atmospheres.

Construction

Stationary equipment such as large-scale computers and telephone amplifiers is not ordinarily required to function under conditions of shock and vibration. Such equipment is designed primarily from consideration of static loading.

Equipment built as a single unit, such as the power amplifier of a transmitter, presents an individual design problem. However, heavy components such as power and modulation transformers, filter capacitors and chokes should be mounted near the bottom of the cabinet to reduce static loading of upright structural members.

Heat dissipating components such as power amplifying and rectifying tubes should be mounted clear of other objects to permit convection cooling. A blower may have to be installed to provide necessary movement of cooling air. The air intake should be located near the bottom of the cabinet with the outlet provided by perforated side panels or louvers near the top.

When locating shelves or other functional supports within the cabinet consider their effect as baffles in the air cooling system. The air intake should be furnished with a glass fiber or other filter to avoid dust deposits within the cabinet that may cause short circuits. In many transmitter locations it may be necessary to install ducting connecting the air intake, outlet or both to the...
outside of the building. Liquid cooling is necessary for some large transmitting tubes but modern practice is to restrict its use as much as possible, especially in military equipment.

**relay racks**

When equipment is broken down into individual chassis as with telephone amplifiers, diversity receivers, frequency meters and laboratory equipment, relay rack construction is popular. The standard rack stands 76 in. high, is 19 in. wide and 14 in. deep. It has a rectangular framework of welded angle sections. Smallest structural angle is $3 \times 3 \times \frac{3}{16}$ in. However, for cabinet construction, bar angles of mild steel are commonly employed. A list of sizes and weight per linear foot is given in Table I.

Side panels and back panels or doors are pressed from sheet steel. Gages and weight per square foot together with mill tolerances are given in Table II. Mild steel is usually adequate for cabinet work. Where corrosion is a factor, copper-bearing sheet steel may be employed. Where appearance is important use of galvanized steel may be economically justified by its ease of finishing. Note that in U.S. gages galvanized sheet steel runs 2.5 ounces heavier per square foot. Where additional strength or hardness is required in structural members, steel of higher carbon content may be employed. Use of galvanized steel is commonly avoided in designing government equipment because of difficulties experienced in welding it.

Chassis are mounted in relay racks by either panel or vertical mounting. In panel mounting, the chassis is bolted to a front panel and the panel attached to parallel upright members of the rack by countersunk bolts. The broad side of the chassis is supported in the horizontal plane by cantilever action. Heavier chassis may require angle brackets for additional support. Panel mounting has the advantage that the tubes are operated in an upright position.

When subdividing equipment into chassis, functional design is the major consideration. However, mechanically the front panel should be an integral number of inches high. For ease of servicing each unit should weigh no more than about 40 pounds. Military specifications require that chassis or single units weighing in excess of 150 pounds be equipped with hooks for use with mechanical hoisting equipment.

Size restrictions are imposed on marine equipment by hatch and door sizes. Surface vessel hatches are 30 × 30 in. with round corners on a 7.5-in. radius. Doors are 26 × 45 in. with round corners on 8-in. radius. Submarine hatches are circles 25 in. in diameter. Doors are 20 × 38 in. with round corners on 10-in. radius. In both cases the height restriction is 72 in.

In military airborne equipment, panels are usually multiples of 5.5 in. in width and an integral number of inches in height.

One disadvantage of panel mounting aside from the difficulty of servicing is heat dissipation. Often each heat dissipating chassis must be equipped with its own blower. In equipment where more than one relay rack is to be employed, install rectifiers and other heat dissipating units in one rack, mounting the units vertically, and provide an adequate blower if such a layout does not make the cabling too complicated.

**vertical mounting**

In vertical mounting each chassis is provided with a flange along its narrower dimension. The chassis is bolted to parallel upright members in the rack so that its broad dimension is in the vertical plane. This has the advantage that both the tubes and the components and base wiring are available for adjustment and servicing without removing the chassis from the rack. This type of construction is commonly used for television video equipment.

Single blowers can be installed for a whole relay rack or the front and rear panels left off and cooling equip-
ment installed for the whole operating space. There is some disadvantage when tubes are mounted on their side, which subjects their internal structure to abnormal static loading.

**means of access**

Accessibility for servicing may be achieved by mounting chassis in removable sliding drawers. This is required quite frequently in military equipment. Where drawer type construction is employed the Christmas-tree frame illustrated in Fig. 1 is used to construct the overall cabinet. Here, mild steel angle sections form the basic rectangular framework that may be strengthened by straps of channel section. Channel sections also divide the cabinet sections vertically and provide support for the drawer mechanisms. The smallest structural channel section is \( 3 \times 2 \times \frac{3}{16} \) in. But bar channels are usually used in cabinet construction. Table I lists sizes and weight of bar channel sections.

Among the drawer mechanisms commercially available is one in which the chassis may be tilted upwards after being withdrawn from the cabinet, forming an angle of 30 degrees with the horizontal. Another type is the vertical slide in which the broad dimension of the chassis is vertical in the cabinet. Choice of whether to use a horizontal or vertical slide will depend upon the functions of the chassis themselves and upon their linear dimensions. Horizontal and vertical slides are shown in Fig. 2 and 3.

Where drawer construction is used in portable or mobile equipment precautions must be taken to prevent the chassis rattling in its drawer. The drawer can be driven onto tapered guide pins that lift it off its rollers and lock it in place. This may be done by a tie rod having a knurled knob or a cam rod with a handle. Vertical drawers or slides usually have less depth than horizontal ones. Thus there is less room for the locking mechanism and the drawers may not be secured as well.

Other means for gaining access include hinged chasis, doors and removable panels. The equipment illustrated in Fig. 4 is a radar indicator. The chassis rotates about the axis indicated; its broad side may be swung down to a 60-degree angle with the vertical.

Electronic business machines are designed with doors on the inside of which components are mounted, with servicing test points readily available. In television cameras, components and wiring are mounted on both side panels and on either side of a vertical plate midway between the sides. The side panels fold away, exposing all circuits for servicing or adjustment.

Equipment built as a single unit may be equipped either with doors or removable side and back panels. Where extremely wide equipment racks are employed care should be taken that the door is not too wide to permit opening it in confined quarters. Alternative methods include double doors latching to an upright member in the center of the cabinet's rear face, sliding doors or fold-away doors. These three latter means of gaining access may, however, become sources of vibration trouble in mobile equipment. Thus many marine transmitters still use back and side panels that are secured by captive bolts having knurled or slotted heads.

**other materials**

Where weight is a factor, as in airborne radio and radar equipment, cabinets may be made from aluminum or magnesium. Aluminum cabinets may be either fabricated from sheet stock and structural sections or cast. Aluminum alloys are available for either sand or permanent-mold casting. Magnesium alloy cabinets are usually cast.

Commercially pure aluminum, 2S, is quite soft and used largely for panels where strength and hardness are not prerequisite. Aluminum alloys, formed by adding small percentages of copper and other metals, provide greater strength and hardness. However, aluminum's natural resistance to corrosion is diminished by alloying. This corrosion resistance may be recovered.
to some degree by rolling a coating of commercially pure aluminum onto the structural alloy when the alloy is in the ingot stage.

Structural sections are generally made from alloy 14S. Available sections include angles, unequal angles, channels and flats. Sheet aluminum is available in grades 2S, 3S, 52S, 24S and others. The characteristics of various alloys are given in Table III.

Where strength and hardness only slightly better than 2S is required, 3S may be used without additional cost. However, where strength and hardness are prime considerations 24S is often used.

Commonly used alloys for sand casting are 112, 113 and 212. For permanent-mold casting, alloys 113 and 113 are available. Where only a short production run on cast aluminum chassis is desired, sand casting may be used although for longer runs, permanent-mold casting provides increased production and better finish.

Choice of the proper alloy for casting cabinets is a critical business best done in consultation with either an aluminum supplier or staff metallurgical engineer.

appearance

The external appearance of the cabinet deserves consideration from both esthetic and functional points of view. Modern practice is to avoid sharp corners on cabinets as a safety measure. Doors should have rounded corners and be furnished with stay-open latches for

FIG. 6—Cabinet for radio transmitter designed to function underwater; gasket provides waterproof seal

FIG. 7—Three methods utilizing O-rings to seal cabinets of waterproof or pressurized equipment

FIG. 8 (left)—Isolation, basic mechanical system of handling vibration (A), three typical methods of applying shock mounts, (B, C, D) and one form of acoustic isolation (E)

FIG. 9 (above)—Military equipment employing modern cabinet design principles. Heavy components are mounted at bottom
the protection of maintenance personnel. Finish is often dictated by military or customer specifications but a dull crinkly finish is preferred both for appearance and to reduce operator fatigue from glare. Shatterproof and glareproof glass for windows in cabinets is often required, as is the use of clips to hold the glass in place-augmenting cement commonly applied. Designers of military equipment must be concerned about light leaks in cabinets. Military equipment must also be furnished with means of dimming panel lights. Use of transilluminated plastic lighting panels is one preferred way to illuminate dials and meters.

**controls and indicators**

In placing controls and indicators, it is generally desirable to group dials and meters in clusters of no more than five. The controls must be so placed that their manipulation does not interfere with reading dials and meters. The indicators must be legible, which requires that printing be done in strong contrasting colors; it should also be large and without serifs or other distracting embellishments. Counter-type indicators are sometimes preferred to pointer type indicators.

Indicators should be at eye level and controls within convenient reach of the operator. The most frequently used controls should be placed behind the front panel or in other locations available to the technician. Controls more frequently used but not necessary used for normal operation should be located behind hinged doors to reduce operator confusion from too vast an array of controls. Factory adjustments must be clearly indicated, such as by painting, and daubed with Glyptal or a similar compound to prevent tampering. A well-designed control panel is illustrated in Fig. 5.

Cabinets for marine equipment or other gear designed to function while exposed to the elements are either drip proof, splash proof or waterproof. Drip proofing is provided by avoiding openings in the top of the cabinet, crowning the top surface for good drainage and designing louvers so that water will drain off. Splash proofing involves design of baffles to prevent water from reaching the circuits.

**waterproofing**

These methods stop short of actual waterproofing, which is reserved for equipment that is to function while submerged. This includes radio equipment for mounting on decks of submarines (Fig. 6), underwater television equipment etc. Waterproofing is achieved by use of gaskets and specially designed flanges as illustrated. Similar techniques are used when it is necessary to pressure seal equipment for operation at high altitudes or in explosive atmospheres. The gaskets used are often synthetic rubber O-rings. These may be backed up by leather or fiber washers where high pressure sealing is required. Sealing rings are available in special cross

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**Table I - Structural Steel Forms for Cabinet Construction**

<table>
<thead>
<tr>
<th>Size (in.)</th>
<th>Weight (lbs per ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHANNELS</td>
<td></td>
</tr>
<tr>
<td>$\frac{1}{2} \times \frac{1}{4} \times \frac{1}{4}$</td>
<td>0.28</td>
</tr>
<tr>
<td>$1 \times \frac{1}{2} \times \frac{1}{4}$</td>
<td>0.84</td>
</tr>
<tr>
<td>$2 \times 1 \times \frac{1}{4}$</td>
<td>2.32</td>
</tr>
<tr>
<td>ANGLES</td>
<td></td>
</tr>
<tr>
<td>$1 \times \frac{1}{8} \times \frac{1}{8}$</td>
<td>0.64</td>
</tr>
<tr>
<td>$1 \times \frac{3}{4} \times \frac{1}{8}$</td>
<td>0.70</td>
</tr>
<tr>
<td>$1 \times 1 \times \frac{3}{16}$</td>
<td>0.80</td>
</tr>
<tr>
<td>$1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{16}$</td>
<td>1.23</td>
</tr>
<tr>
<td>$1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{8}$</td>
<td>1.80</td>
</tr>
<tr>
<td>$1\frac{1}{2} \times 1\frac{1}{2} \times \frac{3}{16}$</td>
<td>2.34</td>
</tr>
</tbody>
</table>

---

**Table II - Weight and Thickness of Commonly Used Gages of Sheet Steel**

<table>
<thead>
<tr>
<th>USS Gage</th>
<th>Thickness (in.)</th>
<th>Order Limits</th>
<th>Weight (lbs per sq ft)</th>
<th>Weight (galvanized)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0.1196</td>
<td>0.1121</td>
<td>5.0</td>
<td>5.156</td>
</tr>
<tr>
<td>12</td>
<td>0.1046</td>
<td>0.0972</td>
<td>4.375</td>
<td>4.531</td>
</tr>
<tr>
<td>13</td>
<td>0.0897</td>
<td>0.0822</td>
<td>3.75</td>
<td>3.906</td>
</tr>
<tr>
<td>14</td>
<td>0.0747</td>
<td>0.0710</td>
<td>3.125</td>
<td>3.281</td>
</tr>
<tr>
<td>16</td>
<td>0.0598</td>
<td>0.0568</td>
<td>2.5</td>
<td>2.656</td>
</tr>
<tr>
<td>18</td>
<td>0.0478</td>
<td>0.0449</td>
<td>2.0</td>
<td>2.156</td>
</tr>
<tr>
<td>19</td>
<td>0.0418</td>
<td>0.0389</td>
<td>1.75</td>
<td>1.906</td>
</tr>
<tr>
<td>20</td>
<td>0.0359</td>
<td>0.0344</td>
<td>1.5</td>
<td>1.656</td>
</tr>
<tr>
<td>21</td>
<td>0.0329</td>
<td>0.0314</td>
<td>1.375</td>
<td>1.531</td>
</tr>
</tbody>
</table>
sections as well as the usual O shape. Three common ways of making an O-ring seal are illustrated in Fig. 7. Sealing inhibits ventilation and cooling the equipment may become a serious problem. Fins are added that increase the surface area exposed to the water, so that heat may be dissipated.

Where equipment is to be operated in an explosive atmosphere, means must be provided to eliminate sparking in the equipment and to insure that if sparking does occur resulting hot gases will be contained and not spread to the outside atmosphere.

Sparking may be reduced by using mercury switches and nonarcing relays. To contain any explosion that may occur, equipment can be housed in domed-shaped cast steel structures. These are equipped with wide flanges so that escaping hot gases will be cooled before reaching the explosive atmosphere outside.

An air purge may also be used. Here inert gas or air free of explosive gases is supplied to the equipment housing or, in some cases, to the entire equipment space under a static pressure greater than atmospheric. This technique keeps the explosive gases away from sources of flame.

As in the case of waterproof equipment, explosion proofing increases the cooling problem. Solutions include separating equipment that might spark from heat dissipating circuits and mounting the latter outside the housing, furnishing the housing with cool air under pressure, providing the housing with cooling fins and derating components to be located within the housing.

Equipment, such as missiles, which may be stored for an indefinite period but must give 100-percent performance when taken from the shelf is often hermetically sealed and filled with dry nitrogen to prevent corrosion.

**Mobile equipment**

In a sense, all modern equipment must be transportable. Formerly, large transmitters were erected on the site but today even these units and items such as large scale computers are broken down into smaller units and shipped to point of use. In such cases, however, protection from shock and vibration while in transit is the responsibility of the packaging engineer.

Equipment designed for installation aboard ships, planes or motor vehicles must maintain its functional performance under varying conditions of shock and vibration. Such mobile equipment is subjected to both primary and secondary motions. The former are the motions of the vehicle while the latter include motions of equipment or component parts induced by the primary motion. A prime function of the cabinet designer is to eliminate secondary motion or to limit it so that fragile electronic parts will not be damaged or their life unduly shortened by fatigue.

**Vibration**

Basically vibration is a periodic motion that occurs when an elastic system is displaced from its equilibrium position and released. When a mechanical system is excited at its natural resonant frequency, the disturbance is apparently amplified, by a means analogous to the voltage amplification across a parallel resonant circuit excited at its resonant frequency.

A piece of electronic equipment is an aggregation of simple mechanical systems. For a complex system there are a great number of natural frequencies or modes of vibration. If excitation is applied, all these modes will appear—some to a greater extent than others. If the excitation is too great the amplitudes of the various modes may be sufficient to cause failure of electronic components.

If equipment is designed so that its lowest mode of vibration occurs at a frequency higher than any anticipated forcing frequency (primary motion) no modes of vibration will be excited in the equipment. This is the principle of rugged design.

**Vibration isolators**

When equipment must function in the presence of primary motions having such high frequencies that it

---

Table III — Mechanical Characteristics of Aluminum Alloys

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Tensile Strength (lbs per sq in.)</th>
<th>Yield Strength (lbs per sq in.)</th>
<th>Brinell Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>WROUGHT ALLOYS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2S</td>
<td>13,000</td>
<td>5,000</td>
<td>23</td>
</tr>
<tr>
<td>3S</td>
<td>16,000</td>
<td>6,000</td>
<td>28</td>
</tr>
<tr>
<td>14S</td>
<td>27,000</td>
<td>14,000</td>
<td>45</td>
</tr>
<tr>
<td>24S</td>
<td>27,000</td>
<td>11,000</td>
<td>47</td>
</tr>
<tr>
<td>A51S</td>
<td>48,000</td>
<td>43,000</td>
<td>100</td>
</tr>
<tr>
<td>52S</td>
<td>27,000</td>
<td>12,000</td>
<td>45</td>
</tr>
<tr>
<td>61S</td>
<td>18,000</td>
<td>8,000</td>
<td>30</td>
</tr>
<tr>
<td>75S</td>
<td>33,000</td>
<td>15,000</td>
<td>60</td>
</tr>
<tr>
<td>SAND-CAST ALLOYS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>112</td>
<td>19,000</td>
<td>15,000</td>
<td>70</td>
</tr>
<tr>
<td>113</td>
<td>19,000</td>
<td>15,000</td>
<td>70</td>
</tr>
<tr>
<td>195</td>
<td>29,000</td>
<td>16,000</td>
<td>60</td>
</tr>
<tr>
<td>212</td>
<td>19,000</td>
<td>14,000</td>
<td>65</td>
</tr>
<tr>
<td>PERMANENT MOLD CAST ALLOYS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>113</td>
<td>24,000</td>
<td>19,000</td>
<td>70</td>
</tr>
<tr>
<td>C113</td>
<td>25,000</td>
<td>24,000</td>
<td>80</td>
</tr>
<tr>
<td>B195</td>
<td>33,000</td>
<td>19,000</td>
<td>75</td>
</tr>
</tbody>
</table>

---

October, 1954 — ELECTRONICS
is impossible to design equipment all of whose modes of vibration occur at higher frequencies, vibration isolators must be employed.

In equipment for conventional aircraft, the effects of vibration may be limited by use of soft isolators such as shock mounts.

A vibration isolation system using shock mounts is shown in Fig. 8A. It consists of resilient cushions such as steel springs, rubber mounts or mounts of composition material. Also shown is a method for snubbing or limiting the maximum excursion of the system under extreme overloads. Captive features in the mounts will prevent the unit becoming a missile should the spring or rubber be destroyed or disintegrate. Two typical systems of mounting are shown. Center-of-gravity mounting, Fig. 8C, is commonly used for military equipment. Double shock mounting, Fig. 8D, has sometimes proved ineffective.

Equipment for use in modern military aircraft must undergo vibration tests up to 500 cps or higher for pulse jets and rockets. At such high frequencies of vibration conventional isolation methods are sometimes ineffective. The problem may become an acoustical one. One method of vibration isolation, shown in Fig. 8E, involves the use of a laminated framework in which fiber or asbestos is introduced between metallic laminations to provide an acoustic block.

**rugged design**

In the case of shipborne equipment, Navy specifications call for vibration test in the range 5 to 23 cps at an amplitude of 0.03 in. and at a greatly reduced amplitude up to 35 cps. Resonance will be avoided in these tests only if the lowest mode of vibration is above these frequencies.

Mounting the cabinet on shock mounts may be ineffective since the resonant frequency of some shock mounts is about 30 to 35 cps and no isolation is provided below 50 cps. Rather than attenuation of vibration amplitudes, there is an amplification. One answer is to design the equipment so that all modes of vibration are above the test range. This implies that the stiffness of supporting structures such as brackets, clamps and chassis should be checked so that the natural frequency is within the correct range.

Simple mechanical systems like a transformer and its supporting bracket, or a transformer in the middle of a chassis may be checked by load deflection tests. For example, if a transformer-bracket combination should have a resonant frequency not lower than 50 cps then the static deflection of the bracket at the load should not exceed 0.004 in. This is obtained from

\[ D = \frac{10}{f} \]

where \( f \) is the natural frequency.

When assemblies become more complex, frequency response can be investigated on a vibration table. This may be done early in development. It is good practice to require components to pass a vibration test; every chassis should be subjected to similar treatment.

Such procedures will often reveal failures recognized at once as design shortcomings and at other times construction or assembly weaknesses.

Among design failures must be counted the so-called oil-canning of transformers and other solid massive components on the chassis. Motion of these components causes the broad side of the chassis to vibrate in a two-dimensional mode. The effect is similar to that produced by displacing and releasing the sides of a large rectangular oil can. It is extremely destructive of fragile electronic components.

Oil-canning can be reduced by dividing a chassis into several subchassis possibly held together by a rigid framework. Also, heavy components such as transformers and chokes should be mounted near corners to derive added support and transmit secondary vibrating motions of the part to the framework where the motions will be damped out.

The supporting framework and the various drawers or chassis assemblies make up another resonant system. For example, a drawer that contains transformers may be considered to be a solid mass compared to the framework of the supporting cabinet. The stiffness of this framework must be sufficiently high so that it does not have a low mode of vibration. Providing vibration
or shock mounts for such a cabinet is sometimes ineffective since the lowest mode of vibration of the cabinet itself is below the minimum allowed. Therefore the framework of a cabinet should be sufficiently rigid to be compatible with the subassemblies which it must support. Rigid frames do not imply heavier frames but frames designed to make better use of the cross-sectional areas.

It should be noted that the amplifying effect of cabinet resonances requires that component subassemblies be tested on the vibration table at amplitudes higher than that of the cabinet as a whole.

**shock resistance**

Protecting electronic gear against shock is related to the modes of vibration. Shock is a transient motion with a finite time interval. If there is a proper ratio between this time interval and the period of the mode the chances are excellent that no interruption of the functional operation of the equipment will occur. It is impractical, however, to protect equipment against any and all shocks. It has been shown that shock mounts giving a natural period of 30 to 35 cps and a displacement capacity of about \( \frac{1}{4} \) inch provide excellent shock protection for shipborne equipment.

Some of the important steps in designing a cabinet may be summarized. Design a substantial, rigid frame compatible with the weight it must support. Put heavy components such as transformers near the base. Locate fragile components like tubes and relays in the center of the cabinet away from locations where vibration and shock disturbances are transmitted to the cabinet. Select rigid supporting brackets and tie them in properly with the frame. Make all clamping positive and avoid springs for holding parts in place.

Although such requirements may seem incompatible with weight saving, they are actually conducive to such a program. Rigidity and light weight are both associated with higher natural frequencies and any procedure that considers the dynamic response of a system will automatically result in weight saving. Selection of lighter materials is also part of the design procedure. The equipment illustrated in Fig. 9 bears out many of the foregoing suggestions.

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CINCH produces the component for the need

TERMINAL STRIPS:

"special miniaturized" strips available, actual size shown.

(Below) Miniaturized Micro Connectors that save space, weigh less and are more efficient... 14, 21, 34 and fifty contacts available in low loss material for chassis mounting applications.

CINCH components available at leading electronic jobbers—everywhere.

The number of CINCH "firsts" that met the need and continue to serve year after year, even through industry changes, is an indication of engineering skill and production experience. It is an assurance that CINCH produces the component for the need.

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Circular Waveguide Chart

Aids in determination of guide wavelength for various modes of propagation in circular waveguide, gives cutoff wavelength for each mode and may also be used to calculate attenuation beyond cutoff for any shape guide.

Given a circular copper tube of inner diameter 9 centimeters, find: (a) what modes will propagate at a frequency of 3,000 mc; (b) what the cutoff wavelength is for these modes; (c) what guide wavelength is at this frequency for each mode.

A frequency of 3,000 mc corresponds to a free-space wavelength $\lambda$ of 10 cm; calculate $\lambda/ID$ to be 1.11 ($ID$ is the inner diameter); find this value on the base of the chart and project it vertically. The two only diagonal straight lines that intersect this value are marked $TM_a$ and $TE_{01}$. Thus these two modes provide the answer to (a).

Project these intersections horizontally on the chart to find that $\lambda/\lambda_a$ is 0.85 for the $TM_a$ case and 0.65 for the $TE_{01}$ case.

Dividing 10 (the free space wavelength $\lambda$) by these figures in turn will give cutoff wavelengths $\lambda_a$ of 11.77 cm for the $TM_a$ mode in 9-centimeter tubing and 15.39 cm for the $TE_{01}$ mode.

Where these horizontal projections intersect the curved line, read the horizontal scale on the chart to find that $\lambda/\lambda_a$ is 0.522 for the $TM_a$ mode and 0.757 for the $TE_{01}$ mode. Dividing 10 by these factors will indicate that $\lambda_a$ is 19.15 cm for the $TM_a$ mode and 13.20 cm for the $TE_{01}$ mode.

A further use for the chart is the calculation of attenuation constant for any waveguide beyond cutoff where, as usual, copper losses are neglected. The following example will explain this method of using the chart.

Given a waveguide of any cross-section with $\lambda_a$ known to be 2.5 cm, what will be the attenuation for a wave of free-space wavelength = 5.9 cm?

Calculate $\lambda/\lambda_a = 0.424$ and assume that the ordinate scale of the chart marked $\lambda/\lambda_a$ reads $\lambda_a/\lambda$.

Find 0.424 on this scale and determine its intersection with the curved line as 0.905.

Call this value $A$ and multiply it by $54.6/\lambda_a$, giving a value $54.6A/\lambda_a = 19.75$. This is the required attenuation in db per cm.
Smooth finish retention makes Taylor Bobbin Fibre ideal for textile bobbins. High impact strength and easy machining add to its value.

Flexibility gives long life to abrasive discs backed with Taylor Vulcanized Fibre, which retains strength under repeated bendings.

Toughness of Taylor Vulcanized Fibre slot wedges protects motor windings...gives dependable electrical insulation.

Also available from Taylor—
...a varied line of high-quality laminated plastics, including phenol, melamine, silicone, epoxy and combination laminates...and polyester glass rods.
...complete fabrication service, on an economical, prompt-delivery basis, for your vulcanized fibre or laminated plastic parts.

Your new designs can profit with Taylor Vulcanized Fibre

When you're looking for a material to fill a tough assignment...in your new designs or in present products...don't overlook the many unique qualities of Taylor Vulcanized Fibre. It offers a combination of physical characteristics, electrical properties and economic advantages that you may find add up to the best answer for your product.

It's tough, flexible and strong. It withstands impact, resists wear and abrasion...and is a good electrical insulator. And it's exceptionally economical to machine...cuts, drills and bends readily. It comes in sheets paper-thin to several inches thick...rolls...strips...rods...and in a variety of colors. A wide selection of grades probably includes a type that exactly meets the requirements of your particular application.

Taylor specialists will be glad to help you apply Taylor Vulcanized Fibre in your production. Or, you may find it pays to have Taylor's Fabricating Division furnish the completed part to your specifications.

TAYLOR FIBRE CO. Plants in Norristown, Pa., and La Verne, Calif.
Branch offices in Atlanta; Boston; Chicago; Cleveland; Dayton; Detroit; Indianapolis; Los Angeles; Milwaukee; New York City; Philadelphia; Rochester; San Francisco; St. Louis; and Tolland, Connecticut. Distributors in Grand Prairie and Houston, Texas; Jacksonville, Florida; New Orleans, Louisiana; and Toronto, Ontario.

TAYLOR Laminated Plastics Vulcanized Fibre

Electronics — October, 1954

Want more information? Use post card on last page.
Military Carrier Telegraph Equipment

By J. Edwin Boughtwood and Clifford H. Cramer

New carrier telegraph equipment specifically designed for long-distance military communications, superior in performance and adaptability to equipment currently available, will soon be produced in quantity for military radio communication networks.

Telegraph terminal AN/FGC-29 provides 16 frequency-shift carrier channels spaced 170 cycles apart from 425 to 2,975 cps, capable of teletypewriter operation at speeds up to 100 words a minute. Each carrier channel employs a dual receiver arranged for operation in conjunction with two-path diversity radio transmission, either space or frequency diversity or both. Diversity operation is commonly used on long-distance radio circuits to mitigate the effects of selective fading.

Signals incoming over the two radio paths are received by the dual-channel receiver of the new terminal and are then combined by a new method, called ratio squaring. Systematic time phase difference in the two paths is corrected by use of adjustable time-delay equalizers. This method of combining provides a 3-db improvement of signal to noise in addition to the normal diversity improvement factor. Under ad-

Illegal Radio Shocks Bettors

Compact radio transmitting and receiving equipment shown above was seized by New York police in a raid on country-wide gambling operation. Radio transmitter built into suitcase (left) provided an intermediate step for a lipshift system that sped racing information direct from track to vicinity of betting parlors. Official holds tiny receiver that gave coded shocks to user through dimes placed against skin. Another type of portable equipment (right) small enough to fit in the palm of the hand formed a further link in the illegal communications chain. Circuit details of such equipment are not released for publication.
MPB miniature ball bearings offer a ready solution to many difficult miniaturization projects involving space, weight and friction.

### RADIAL SERIES

<table>
<thead>
<tr>
<th>Bearing Number</th>
<th>O.D.</th>
<th>Bore Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0.000&quot;</td>
<td>0.520&quot;</td>
</tr>
<tr>
<td>2</td>
<td>1.000&quot;</td>
<td>0.520&quot;</td>
</tr>
<tr>
<td>2½</td>
<td>0.550&quot;</td>
<td>0.520&quot;</td>
</tr>
<tr>
<td>3</td>
<td>1.187&quot;</td>
<td>0.550&quot;</td>
</tr>
<tr>
<td>4</td>
<td>1.250&quot;</td>
<td>0.550&quot;</td>
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### PIVOT SERIES

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<tr>
<td>2½P</td>
<td>0.590&quot;</td>
<td>0.20&quot;</td>
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<tr>
<td>3P</td>
<td>0.181&quot;</td>
<td>0.30&quot;</td>
</tr>
<tr>
<td>4P</td>
<td>0.157&quot;</td>
<td>0.40&quot;</td>
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### SUPER-LIGHT RADIAL SERIES

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<tr>
<th>Bearing Number</th>
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<tbody>
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<td>418</td>
<td>0.250&quot;</td>
<td>0.125&quot;</td>
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<tr>
<td>518</td>
<td>0.3125&quot;</td>
<td>0.125&quot;</td>
</tr>
<tr>
<td>5532</td>
<td>0.3125&quot;</td>
<td>0.1562&quot;</td>
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### GROOVED RADIAL SERIES

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<th>Bearing Number</th>
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<td>3G</td>
<td>0.2188&quot;</td>
<td>0.550&quot;</td>
</tr>
<tr>
<td>4G</td>
<td>0.2182&quot;</td>
<td>0.550&quot;</td>
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### FLANGED RADIAL SERIES

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<th>Bearing Number</th>
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<tbody>
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<td>2½F</td>
<td>0.1562&quot;</td>
<td>0.065&quot;</td>
</tr>
<tr>
<td>3F</td>
<td>0.1875&quot;</td>
<td>0.065&quot;</td>
</tr>
<tr>
<td>4F</td>
<td>0.2500&quot;</td>
<td>0.065&quot;</td>
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### RADIAL RETAINER SERIES

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<td>0.1562&quot;</td>
<td>0.069&quot;</td>
</tr>
<tr>
<td>3C</td>
<td>0.1875&quot;</td>
<td>0.069&quot;</td>
</tr>
<tr>
<td>4C</td>
<td>0.2500&quot;</td>
<td>0.069&quot;</td>
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### ANGULAR CONTACT SERIES

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<td>0.032&quot;</td>
</tr>
<tr>
<td>3A</td>
<td>0.1875&quot;</td>
<td>0.032&quot;</td>
</tr>
<tr>
<td>4A</td>
<td>0.2500&quot;</td>
<td>0.032&quot;</td>
</tr>
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### THRUST SERIES

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<th>Bearing Number</th>
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<td>2T</td>
<td>0.1250&quot;</td>
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<tr>
<td>3T</td>
<td>0.1875&quot;</td>
<td>0.0400&quot;</td>
</tr>
<tr>
<td>4T</td>
<td>0.2500&quot;</td>
<td>0.0400&quot;</td>
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### SPRING SEPARATOR SERIES

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<td>5S</td>
<td>0.3125&quot;</td>
<td>0.0938&quot;</td>
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<tr>
<td>518S</td>
<td>0.3125&quot;</td>
<td>0.1250&quot;</td>
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### SEPARABLE MAGNETO SERIES

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<tbody>
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<td>3M</td>
<td>0.1875&quot;</td>
<td>0.1562&quot;</td>
</tr>
<tr>
<td>4M</td>
<td>0.2500&quot;</td>
<td>0.1562&quot;</td>
</tr>
</tbody>
</table>

Prefixes indicate material: Standard is chrome bearing steel (SAE 52100); use no prefix. All bearings also available in 440 stainless, except 2½F and 7½F. Use prefix "SS" in ordering stainless. ▲ indicates also available in 25 berillium. Graft with prefix "NG". Suffixes indicate type of bearing: F-flange, G-groove, M-magnetico, C-retainer, S-spring separator, T-thrust, P-pivot. A-angular contact, FC-flanged with retainer, GC-grooved with retainer. Complete load ratings are given in catalog. ▲ Shaft (S); G.D. clearance of opposite race .002"; ▲ Bore clearance of opposite race .002".

MPB ball bearings are available in ten design series and in more than 120 different types and sizes which normally can be supplied from stock for prompt installation. Instrument manufacturers and users of small precision mechanisms can now utilize all the well known extra advantages of anti-friction bearings (accurate alignment, low wear, freedom from attention) universally accepted in larger quality equipment. For more than 20 years MPB ball bearings have contributed to the successful operation of precision mechanisms. A pioneer in designs and dimensions now being internationally standardized, MPB has also originated many precision manufacturing techniques. All MPB ball bearings are ground, lapped and/or bushed in accordance with highest quality practice for optimum operating characteristics. Inspection limit tolerances are equal to ABEC 5 or better. The most extensive engineering knowledge in miniature bearing applications is available to you. More than a million MPB ball bearings have been installed in precision mechanisms. Catalog 53 giving complete specifications, and additional data sheets mailed to you on request.
verse fading conditions, further improvement is obtained by combining two dual channels (4 paths), reducing the number of telegraph circuits per terminal to eight.

In addition to carrier telegraph equipment the terminal includes multiplexing equipment to derive two 3-kc voice-frequency bands from each of the two 6-kc sidebands of the radio facility. These bands can be used simultaneously for telegraph, telephone or facsimile transmission. Equalizers and amplifiers are also provided to permit operation over cable pairs to remotely located radio stations.

Mechanically, terminal AN/FGC-29 is ruggedized to withstand the rigors of military transportation and service. Requirements include unusual resistance to shock and vibration, storage without damage at temperatures from minus 80 F to plus 160 F and satisfactory performance under ambient temperatures from 32 F to 122 F and relative humidities to 95 percent.

A complete terminal, shown in Fig. 1, comprises six cabinets, two (left) for transmitting equipment and four for receiving equipment, each 75 inches high, 224 inches wide and 24 inches deep. Sending and receiving units are completely independent and need not be installed in the same location. Installation is simple, involving little more than provision of a-e power and telegraph loop circuits. Interconnections between and within cabinets are made with plug-in multiconductor cables; neither wiring lists nor soldered connections are required.

Drawer-type chassis construction is used for maximum accessibility and drawers can be drawn out for maintenance work on top or bottom of the chassis without interrupting service. Drawers associated only with specific channels can be removed from the cabinets without interfering with the rest of the system. Drawers containing multiplexing equipment and equalizer-amplifier equipment are independ-

FIG. 1—Complete carrier-telegraph terminal. Two transmitting cabinets are at left. Four others are for receiving circuits

FIG. 2—Channel transmitter drawer is typical of chassis construction

ent units complete with power supply. They can be removed from the drawer slides and installed at a remote location by front-panel mounting on any standard 19-inch relay rack. No wiring changes are required at the terminal when this is done; circuit connections are restored by use of dummy connector panels.

A channel transmitter drawer containing sending equipment for two channels and typical of chassis construction is shown in Fig. 2.

FIG. 3—Subassembly is representative of unitized construction

The drawer chassis forms a framework on which are mounted unitized subassemblies, filters and other sealed units in the center, electronic units such as amplifiers, oscillators and modulators on either side. Power supplies are in a separate compartment across the rear. A representative subassembly (Fig. 3) is a miniature amplifier used throughout the terminal for various circuit applications. Design is compacted to a degree consistent with requirements on performance, maintenance and flexibility.

The advantage of ratio-squaring combining was determined in a study of a number of methods by Crosby Laboratories, Inc., under contract with the Signal Corps.

Publications Present Problems

RECENT PUBLICATIONS issued by the U. S. Department of Commerce reveal the need for invention and development, and present information
Once your name was Og. You tired of shouldering mastodon steaks...of dragging your mate by her hair.
You invented the wheel.

Later, your name was Watt. Steam made your kettle-lid dance...and the Industrial Revolution was on.

Yesterday, you were a bicycle mechanic named Henry...today, your brainchild’s descendants are counted in millions.

Your name is legion. You created every linkage...every device...every system.

You’re an engineer.

You make things work better...faster...more accurately...more economically.

Next week...next month...next year...some system will need a better, faster, more accurate or more economical means of recording...or indicating...or computing...or controlling a process.

You’ll want precision potentiometers.

You’ll discover that Helipot makes the most complete line...linear and non-linear versions...in the widest choice of sizes, mounting styles and resistances.
Air Navigation” has recently been made available. It includes the technical and economic characteristics of nondirectional beacons, standard loran, Consol, Navarho, Decca, Gee, the four-course radio range, vhf omnidirectional range (VOR) and distance measuring equipment (DME). Compiled by a panel of the Air Coordinating Committee, the 52-page report is available from U. S. Department of Commerce, Office of Technical Services, Washington 25, D. C. as publication PB 111344 at $1 a copy.

It is not unusual for an engineer to invent a circuit or device that has already been patented. Although such a situation cannot always be avoided, much time might be saved through a system of making information more easily available. The Federal Government owns many patents, 775 of which deal with instruments and date from the end of 1953. A list and brief description has been compiled in “Patent Abstracts No. 1, Instrumentation.” Among the items listed are a gain-measuring device (Army) for a multiple-channel radio receiver, electrolytic resistors (Commerce Dept.) and fluorophotometer (AEC).

The 65-page listing is available at $2 from Office of Technical Services, under the publication number PB 111464.

Isoecho Spots Storm Intensities

Limited range of light intensities in cathode-ray tube screen makes storm display appear uniform throughout with ordinary circuits

Intense portions of storm where rainfall is heaviest are seen as black holes using new isoecho circuits in Bendix RDR-1 radar

Weather Radar Operates in C Band

Resolution of radar, which depends upon wavelength, increases directly with frequency or inversely with wavelength. Operational tests using X-band wavelengths (3 cm) show that while it gives excellent pictures of the front of storms, it is incapable of penetrating moderate to heavy rainfall. At least, it cannot give the pilot sufficient information as to what lies behind the front portion.

Theoretical studies indicate that for weather mapping a wavelength between 3 and 10 cm (the latter has less inherent resolution but greater penetrating power) may prove optimum.

Special equipment operating in the C band (5.5 cm) has been flown a total of 133 hours, 80 of which were in the immediate vicinity of, or through corridors of thunderstorms. From the results, it has been concluded that such equipment will permit a pilot to avoid moderate and heavier turbulence associated with thunderstorm and precipitation areas, usually by detours in the order of five miles or less from the planned flight path.

Pilots were able to penetrate visually 15 miles or more of heavy rain that was falling at a rate of not less than 60 mm an hour. There was no evidence, however, that the radar equipment was capable of identifying a tornado or tornado
and how

Los Gatos 719A's
shape them for Marchant

In developing a new Signal Corps thyratron-testing unit, engineers of Marchant Research, Inc. (controlled by Marchant Calculators, Inc.) needed a pulse diode combining high average and peak current capabilities with a high inverse voltage rating. Los Gatos 719A diodes were chosen to serve as both the charging diode and the clipper diode, shown in the circuit above.

Tube VT\textsubscript{1} charges the pulse-forming network to 10 kv with 1 megawatt of power, 270 ma average current. Tube VT\textsubscript{2} eliminates overshoot at the bottom of the pulse. The driver unit, as illustrated, supplies accurately controlled pulses to a hydrogen thyratron under test. Facilities are provided, in the balance of the test set, for measuring all parameters of the thyratron. The complete equipment, Mod 20MV Jr\textsubscript{3}, is part of a Signal Corps program of thyratron development for high-power hydrogen thyratron tubes.

When unusual electron tube problems face you, let Lewis and Kaufman engineers make recommendations. Consult your nearby field representative or write direct to:

LEWIS and KAUFMAN, Ltd.

LOS GATOS 1  CALIFORNIA

Expo't Representatives:
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15 Moore St., N.Y. 4, N.Y., Cable: Minhorne

In Canada:
THE RADIO VALVE COMPANY OF CANADA, LIMITED
189 Dufferin Street, Toronto 1, Ontario, Canada
in INDUSTRIAL'S
complete line of oil, wax, electrolytic, Stabelex® and special capacitors

New 8 mfd. and dual 4 mfd. (600 vdc.) and dual 2 mfd. (1000 vdc.) units have been added to Industrial's series of small case size inverted single-stud-mounting tubular oil-filled capacitors for applications where ease of mounting and limited space are factors. Similar important units of the same type in the 600, 1000 and 1500 v. range make this series one of the most extensive in its class. Case sizes range from 1½" dia. by 2¾" ht. to 2" dia. by 4½" ht.

Manufacture of oil, wax, electrolytic, Stabelex® and unusual capacitors is our special business. Our research and engineering facilities are geared to meet your needs, special or standard, in the quantity you require. Send now for full technical information, including illustrated catalogs.

ELECTRONS AT WORK

(continued)

thunderstorm, although satisfactory warning was provided of hail shafts.

Isoecho contour circuitry appears essential for determining which corridors in a storm area may be flown through with safety. Isoecho circuits show which part of a storm is most turbulent (where the change from no rain to heavy rain is likely to occur in the shortest distance). The indication is a dark spot or patch within a bright display on the cathode-ray tube.

In the equipment used, transmitter frequency was 5,435 mc; peak power, 80 kw; duty cycle, 0.0008; pulse repetition frequency, 400 cycles; pulse width, 2 micro-seconds. The receiver had a sensitivity of 101.2 dbm; 3-db bandwidth, 0.9 mc; noise figure, 14.5 db; i-f, 60.2 mc; i-f voltage gain, 85 db and preamplifier voltage gain of 27 db.

Information on employment of this hitherto unused radar band comes from the United Air Lines, Inc. publication, "Evaluation of C Band (5.5 cm) Airborne Weather Radar" prepared by Henry T. Harrison and E. A. Post.—A. A. McK.

In-Phase Indicator

BY JOHN H. PORTER
Niagara Falls, N. Y.

IT IS POSSIBLE to determine whether two voltages are in phase or 180 degrees out of phase by the simple circuit shown in Fig. 1A. Two voltages to be examined, E₁ and E₂, are applied simultaneously to a transformer, setting up independent flux patterns in the core and inducing separate voltages in the secondary. Net voltage in the secondary is at all times the sum of the individual voltages. If the two flux patterns are out of phase and of equal strength, there will be zero flux at all times and the output voltage becomes zero. Conversely, if the flux patterns are in phase, and of equal strength, the output will be twice the individual values. Suitable transformer ratios can be found such that a neon indicator is just ignited when the voltages are in phase.

Signals of different amplitudes
NOW

172 SERIES

a true

HERMETIC SEAL connector

built-in "shock absorber!"
Thousands of tiny air bubbles act as an effective shock absorber in the improved glass seal of the new 172 series of Hermetic Seal Receptacles! Under a new manufacturing procedure which at last provides the electronics industry with a tough leak-proof hermetic connector, "hard" glass is heated to around 1800°F and cooled under compression. The glass assumes a cellular structure which has a leakage rate of zero and a strength which will withstand thousands of pounds of pressure per square inch!

corrosion-resistant surface!
A sealing treatment of the electro tin-coated shells of the 172 series receptacles gives them a surface which will resist salt-spray for a period of 100 hours! This sealing treatment also offers an excellent soldering surface. Connectors are available in individual glass contact bead and complete glass insert bead. They mate with standard AN plugs with female inserts.

For more information on the 172 series of Hermetic Seal Receptacles write and request Amform 2399

AMERICAN PHENOLIC CORPORATION
chicago 50, illinois
In Canada:
AMPHENOL CANADA LIMITED

www.americanradiohistory.com
... for Tenney Test Chambers are precision-engineered for maximum efficiency and can be designed to simulate the complete range of temperature, atmospheric or pressure conditions found anywhere on earth – or above it to altitudes of 120,000 ft. plus! They attain sub-zero temperatures quickly, maintain them efficiently and provide full instrumentation for accurate evaluation of complete test data.

**TEMPERATURE AND HUMIDITY CHAMBERS**

**Model TR** – Precision recorder controllers permit accurate simulation and check of temperatures to +200°F. Meets all Mil and JAN specs for low- and high-temperature requirements by incorporation of temperatures down to -100°F. Humidities within 20%-95% range. Variety of standard sizes.

**Model TH** – Designed for a temperature range of +35°F. to +185°F., and a humidity range of 20% to 95%. Accurately simulates, controls, and checks all above-freezing temperatures. Program control to meet a wide variety of Mil specs optional. Manufactured in a wide range of standard sizes.

**TENNEY SUB-ARCTIC INDUSTRIAL CABINETS**

Designed for low-temperature testing of metals, radios, instruments, plastics, liquids, chemicals and pharmaceuticals. Temperature ranges of -40°F., -80°F., -100°F., -120°F., -150°F., -170°F. are standard for each size.

For further information write Dept. A 104

Los Angeles Representative: George Thorson & Co.

**ELECTRONS AT WORK** (continued)

can be accommodated by use of a double-diode limiter in the circuit

![Diagram](image)

**FIG. 1**—Phase detector (A) uses double-winding filament transformer with neon bulb to indicate when two a-c signals are in phase. Graph (B) shows variation in output voltage with phase relationship of greater voltage to reduce it to the level of the smaller one. It is better to provide limiters in both primaries so that both flux patterns will be of the same general shape for effective cancellation of out-of-phase signals.

In the application for which this circuit was used, a 115-volt filament transformer with two identical 6.3-volt windings was employed. A half-watt neon bulb was used to

**Transistors Select Routes**

Card translator unit recently installed in Richmond, Va., telephone toll center uses transistor amplifiers and electromagnetic relays to aid operator dialing of long-distance calls. The equipment automatically picks the suitable cross-country route for transcontinental calls in which the local operator dials the number of the called party in a distant city and obtains that party.
KAYDON BALL RADIAL BEARING — 16.875" x 17.625" x 0.375"
DESIGNED FOR PRECISION RADAR MOUNTS

ACTUAL SECTION: ONLY ¾" x ¾"
NET WEIGHT: 1 pound, 10 ounces

KAYDON Real-Slim--World's thinnest bearings provide precision answer for electronic applications

Precise Thin-Section bearings on a production basis! That's why the electronics industry makes KAYDON its headquarters for extra-light, thin-section bearings. A perfect example is this Real-Slim 16.875" x 17.625" x 0.375" ball radial bearing.

If you're manufacturing electronic equipment that includes rotating parts, there's a Real-Slim bearing designed to meet your requirements starting with 1/4" cross section and 1/4" width—either in small or large diameters.

Fortified with engineering know-how, years of manufacturing skill and electronic application experience, KAYDON has modern facilities for metallurgical analysis, microscopy, physical testing, atmospheric controlled heat treating, hardening, as well as sub-zero stabilizing. This all adds up to more compact, more precise, lighter equipment with built-in long life and precision.

For unusually small or large Real-Slim bearings for electronic applications, contact KAYDON of Muskegon.

GET THIS CATALOG!
24-pages of engineering and application data — specifications on size, seals, separators and design ideas. Ask for KAYDON engineering catalog No. 54.

KAYDON Types of Standard and Special Bearings:
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TWO VERSATILE Electronic Voltmeters

A Sensitive VOLTMETER and NULL DETECTOR

AS A VOLTMETER

Model 310A

Frequency Range .................................. 10cps—2mc
Voltage Range ...................................... 100µv—100v
Input Impedance .................................... 2meg shunted by 15µf
Accuracy ............................................. ±3% 10cps—1mc
5% elsewhere

Votages as low as 40 microvolts can be measured.

AS A NULL DETECTOR

Frequency Range .................................. 5cps—4mc
Threshold Sensitivity ................................ <10µv
Max Scale Sensitivity ................................ 10µv/scale
division down to 40µv

Can be used also as wide-band preamplifier with
max gain of 600B and 500 — output impedance.

A Sensitive VOLTMETER and DECADE AMPLIFIER

(Battery Operated)

Model 302B

Frequency Range .................................. 2cps—150 kc
Voltage Range ...................................... 100µv—100v
Input Impedance .................................... 2meg shunted by 15µf
Accuracy ............................................. ±3% 2cps—100 kc
5% elsewhere

Ideal for measuring voltages in circuits above
ground potential.

Switch provided for high meter damping.

AS A DECADE AMPLIFIER

Frequency Range .................................. 2cps—150 kc
Voltage Gains ....................................... 1000, 100, 10, 1
Output Impedance ................................... approx 3000 —
Equivalent Input Noise ............................ <10µv

Both Instruments Feature

Single logarithmic voltage scale with decade range switching.
Same accuracy of reading at ALL points on the scale.

WORLD'S LEADING ELECTRONIC VOLTMETERS

Write for FREE DB calculator and for complete
information on these and other Ballantine instruments.

BALLANTINE LABORATORIES, INC.
100 FANNY ROAD, BOONTON, NEW JERSEY

ELECTRONS AT WORK (continued)

indicate phase relationship between
two 5,400-cycle signals, each of 2-
volts that. The device was cali-
ibrated as a phase meter using two
400-cycle signals and Fig. 1B illus-
trates the general shape of the re-
sults. The reference signal was
1.8 volts while the unknown varied
in level and phase as a rotor re-
evolved in a 3-phase field. The
unknown signal was clipped with crys-
tal diodes, each biased to 1.5 volts,
and the indicator was a vtm.
The effect of clipping the unknown sig-
nal did not apparently upset the
flux patterns as evidenced by the
close similarity between Fig. 1B
and the expected results of adding
two sine waves of equal amplitude
and varying phase.

While this device is not a precise
indicator, it provides a go-no-go
measure of phase relationships.

Current-Limited Variable Power Supply

BY CHARLES R. DEMING
Hughes Research and Development
Laboratories
Culver City, California

To protect equipment from excess-
sive currents in regulated high-
voltage supplies, the circuit shown
in Fig. 1 has been developed. Per-
formance curves are shown in Fig.
2. Current-limiting action is ob-
tained by using the constant-cur-
rent properties of a pentode series
tube, $V_m$, resistor $R$, and the diode
in the cathode circuit of the series
tube.

FIG. 1—Current-limiting circuit for a
variable voltage power supply

The voltage regulator functions
normally, as current is increased,
until the voltage drop across $R$
equals the bias supplied to the
series tube from amplifier, $V_m$.
Further increase in output current
will cause the additional bias de-
Alloy Wire, Rod and Strip...

Design Engineers are taking advantage of the outstanding mechanical and electrical properties and excellent formability of Alloy Wire, Rod and Strip. Results: Better products, smaller and lighter products, products that are more corrosion-resistant, more heat-resistant, more attractive—and more economical.

Alloy Metal Wire Division can supply you with high quality wire, rod and strip in Stainless Steels, Nickel Alloys and Electrical Resistance Alloys. Why not put these versatile materials to work for you?

For a Better Design...
Use Wire, Rod, & Strip

For Better Product Performance... Use Alloys

Among the alloys we fabricate, you will surely find one with just the right combination of properties for your specific application. And you can profit from the fabrication advantages and material cost and weight savings of wire, rod and strip parts and assemblies. Select the alloy you need from these three functional groups:

Stainless Steels—

Alloy Metal Wire Division can provide you with more than 20 different grades of stainless steels. These include the chromium-nickel Austenitic grades with their outstanding corrosion resistance and good mechanical properties; the high chromium Ferritic grades with their high heat resistance, corrosion resistance, and outstanding cold working properties; and the lower chromium Martensitic grades which can be heat treated to obtain exceptionally high strength and hardness in addition to good resistance to corrosion and high temperatures. Stainless steel Wire, Rod and Strip, are used extensively for high strength and corrosion-resistant fasteners, springs and mechanical parts and for welding wire, woven and knitted wire parts, and many other applications.

Nickel Alloys—

A wide variety of Nickel alloys are also available for hundreds of electrical and mechanical applications. The excellent electrical characteristics of nickel are especially advantageous for electronic tube parts, such as grids, cathodes, support rods and pins. Monel, because of its excellent corrosion resistance and good mechanical properties, is also used for many mechanical parts, fasteners and springs. Inconel provides the valuable combination of outstanding heat resistance, corrosion resistance and high strength required in many applications.

Resistance Alloys—

Five grades of electrical resistance alloys are now in production in wire, rod and strip form. These are: Alray A—20 Cr, 55 Ni; Alray C—15 Cr, 62 Ni, bal Fe; Alray D—18 Cr, 35 Ni, bal Fe; Excelsior—45 Ni, 55 Cu; and Ni—Fe alloys.

These high quality alloys find extensive applications in the electrical and electronic fields.

Special Wire Shapes—

You can cut costs and improve product performance with Alloy Metal's Special Shaped Wire. Almost any cross-sectional shape can be made on our wire drawing equipment. These shapes can save you tons of metal and many hours of machining time. Shaped wire can be held to close tolerances and has a smooth, tough, flaw-free surface.
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IN CANADA: R. D. FLECK & CO., LTD., OSHAWA, ONT.
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ELECTRONS AT WORK

(continued)

veloped across $R_e$ to be applied through the diode to the grid of the series tube. This raises the d-c resistance of the tube causing the output voltage to drop and limiting the current. With different values of $R_e$, this limiting action will begin at different currents, so that a potentiometer at $R_e$ will give a con-

FIG. 2—Curve shows limiting action for various output voltage levels

venient adjustment. The positive side of the amplifier plate resistor is connected to the series-tube screen supply, giving a convenient bootstrapping action. Several types of receiving tubes (6AG5, 6BF5, 6S4) have been operated in this type of power supply with good results.

Thyratrons Protect Unloaded Amplifier

BY ROBERT W. WOODS
Biophysicist
College of Medical Evangelists
Los Angeles, Calif.

AUTOMATIC PROTECTION for the output transformer of a 250-watt oscillator-amplifier, used as a variable frequency power source, has been designed for no-load conditions.

The circuit shown consists of two 5557 type thyratrons connected across the 500-ohm output coil in parallel, but in reverse polarity. The 5557 is rated at 0.5 amp and two of them will handle the 0.7 amp flowing in the 500-ohm circuit at 250-watts output.

Since 250 watts across a 500-ohm line should give a 500-volt peak, the circuit was designed so that the tubes would not fire with less than 600 volts. The characteristic firing curve for the 5557 indicates that this should occur when $E_s = -9$ volts. A fixed bias of $-9$ volts is satisfactory. However, to make the

October, 1954 — ELECTRONICS
NOW! the new

Eliminates extra manpower requirements

opaque and transparency projector

REMOTE OR LOCAL CONTROL CHECK THESE NEW FEATURES

- Completely automatic... utilizing features contained in the now famous Telop and Telojector... Slides change by push button control.
- Sequence of up to 50 slides can be handled at one loading... additional pre-loaded slide holders easily inserted in unit.
- Remote control of lap dissolves... superposition of two slides... and slide changes.
- Shutter type dimming permits fades without variation of color temperature... opaque copy cooled by heat filters and adequate blowers... assembly movable on base which permits easy focus of image.

SCREEN OUT HIGH PRODUCTION COSTS FOR LOCAL SPONSORS

Telop III by the elimination of extra manpower assures the production and projection of low-cost commercials that local sponsors can afford. It can be used with any TV camera including the new Vidicon camera. Telop III projects on single optical axis opaque cards, photographs, artwork, transparent 3¼" x 4" glass slides, strip material, and 2" x 2" transparencies when Telojector is used with optical channel provided. Telop III eliminates costly film strips and expensive live talent.

WRITE FOR: Illustrated bulletin describing Telop III specifications. Your request will receive prompt response.
Write today for one or all of Florida’s ten new folders which set forth in plain, unvarnished form the basic facts about Florida’s opportunities for new industry. These folders have been prepared in convenient individual file-size form for ready reference.

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Plan national sales conventions, sales conferences and state and regional meetings for Florida. Exceptional facilities for any type of meeting. Get double value . . . successful meetings in delightful surroundings plus colorful recreational activities.

The Governor of Florida and his Council for Industry & Commerce cordially invite you to investigate the special opportunities Florida offers Industry.

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October, 1954 — ELECTRONICS
For gasketed parts like these...

This FREE BOOK CAN HELP YOU CUT COSTS!

There's something new in electronics this year...

IT'S THE DAREX Flowed-in GASKET PROCESS!

And this fact-filled brochure gives you the whole Flowed-in Gasket Story. Here are a few samples of the things you'll read in this informative new book:

ABOUT COSTS

Using the DAREX Flowed-in Gasket Process, a major electronics manufacturer is saving $50,000 per year in labor and materials on a single gasketing operation. As a result of this striking cost reduction, the firm has recommended the DAREX Process for several more gasketing operations.

ABOUT THE PROCESS

The Flowed-in Gasket Process is a new application of a method of sealing developed by Dewey and Almy researchers over 30 years ago, and successfully used in food container manufacture ever since.

The DAREX Flowed-in Gasket Process is more than a sealing compound . . . more than a machine . . . more than an engineering service . . . it's a complete Process! So when you switch to Flowed-in Gaskets, you get all three.

Compounds—Over 800 formulations available to meet most needs. Or Dewey and Almy chemists will develop a "job-tailored" compound for you.

Machines—To apply the compound, Dewey and Almy designs and builds machines based on more than 30 years' field experience.

Service—Every machine is precisely adjusted to your specifications before it leaves the shop. When it arrives, a Dewey and Almy Engineer is on hand to install and adjust the machine. Then he trains your operators to full proficiency. And whenever you need him, the Dewey and Almy Man is at your service.

DEWEY and ALMY
Chemical Company
Cambridge 40, Mass.


Discover what DAREX "Flowed-in" GASKETS can do for YOU

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Dept. E-10
Cambridge 40, Mass.
Please send me the new DAREX Flowed-in GASKET Book.
Name
Firm
Street
City
State

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ANOTHER EXAMPLE OF Katerman PIONEERING...

The WATERMAN TWIN POCKETSCOPE, model S-15-A, presents a new concept in multiple trace oscilloscopy with independent vertical channels each having a sensitivity of 10 millivolts rms/inch, and a response within -2 db from DC to 200 KC—a pulse rise time of 3 microseconds. These features combined with the provisions for intensity modulating either, or both, traces, results in greater flexibility. The sweep generator is operated either in the repetitive or triggered mode from 0.5 cycles to 50 KC with synchronization polarity optional. All attenuators and gain controls are of the non-frequency discriminating type. Remember that portability has not been overlooked! The amazing small size of the S-15-A tips the scales of opinion heavily in its favor. Imagine, all of these essential characteristics in an instrument weighing only 16½ lbs. You can carry it to any job, anywhere!

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PHILADELPHIA 25, PA.
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S-5-A LAB PULSESOCPE
S-6-A BROADBAND PULSESOCPE
S-11-A INDUSTRIAL PULSESOCPE®
S-12-B JANized RAKSCOPE®
S-14-A HIGH GAIN POCKETSCOPE
S-14-B WIDE BAND POCKETSCOPE
S-15-A TWIN TUBE POCKETSCOPE
RAYONIC® Cathode Ray Tubes
and Other Associated Equipment

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212

ELECTRONS AT WORK (continued)

the absorber.

Noise, in this type of system, has two causes. These are the random nature of the secondary-emission processes in the photomultiplier, and fluctuations of x-ray intensity. Photomultiplier noise may be reduced by special circuit arrangements or by decrease of bandwidth.

![Graph showing variation of phototube output with line voltage](image1)

FIG. 1—Variation of phototube output with line voltage

The effect of x-ray intensity fluctuations, however, cannot be easily eliminated. Voltage regulators are sometimes employed but where motor-driven, these are slow and where electronic, considerable circuit complications are encountered.

![Circuit diagram](image2)

FIG. 2—Test circuit for single-stage nonlinear impedance (A). Curve (B) shows impedance variation with change of line voltage

This is particularly so in the case of self-rectifying x-ray tube circuits, where the x-ray tube is fed with raw alternating current. In these cases, x-ray output depends on the waveform as well as on the amplitude of the anode voltages.

In the system described here, no effort is made to keep the voltages on the x-ray tube constant. Instead,
The precise pitch of this wire helix, in its glass tube, is accurately measured by Hewlett-Packard Company, using a Kodak Contour Projector.

**to make the difficult easy**

...the easy economical

Using the same contour projector, Hewlett-Packard checks spacing and parallelism of this special tuning condenser.

**Hewlett-Packard relies on the Kodak Contour Projector**

Here is an on-the-job demonstration of how projection gaging can solve difficult problems in inspection, slash costs in checking parts to close tolerances.

Using a Kodak Contour Projector, Hewlett-Packard Company measures the pitch of a precision wire helix for a unique electronic tube. Surface and shadow illumination provide a 20X enlarged image of the minute and delicate part. "Without the Kodak Contour Projector," say Hewlett-Packard officials, "it would not be practical to make the measurements necessary to get a satisfactory instrument."

Using the same contour projector, Hewlett-Packard also checks spacing and parallelism of a special tuning condenser for electronic test equipment. Conventional shadow projection provides a 10X enlarged image of the leaves. "Use of the projector," the company reports, "permits economical measurements of parallelism to an accuracy impossible to obtain by other methods."

Diverse jobs like this are easily done with a Kodak Contour Projector. A twist of a dial provides whatever magnification is needed. A flick of a switch brings surface illumination to supplement shadow projection. Easy to see, isn't it, how a Kodak Contour Projector quickly pays for itself in use.

For more information on how you can use projection gaging in your own work, send for a free copy of "Kodak Contour Projectors."

**EASTMAN KODAK COMPANY**

Special Products Sales Division
Rochester 4, N. Y.

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Look to G ...the only full line of phonomotors!

There’s no problem in selecting the phonomotor that best meets your requirements when you choose from the GI Smooth Power line. It’s the most complete line in the industry... backed by the fifty-one-year-old reputation of America’s leading manufacturer of phonomotors, recording motors, tape-disc recording assemblies and disc recording assemblies.

HIGHEST QUALITY—Model DSS

4-pole motor, 115 volts a.c., 60 cycles

For three-speed applications in which compactness is secondary to need for absolute minimum of stray field radiation. Ideally suited for all types of pickups, including magnetic.

Features include precision construction throughout, oilless motor and turntable bearings, dynamically balanced rotor. Moving lever to "OFF" position automatically disengages idler wheel from motor shaft, and cuts off current.

LOWEST COST—Model AX

2-pole motor, 115 volts a.c., 60 cycles

Low-priced, single-speed, rim-drive motor suitable for installations where size and cost are prime factors. Incorporates features found in more expensive motors.

OTHER MODELS

A complete line of 78 r.p.m., two-speed and three-speed motors. The popular Model SS (not shown) is a compact 3-speed phonomotor incorporating the vertical idler shift principle and shift lever which disengages idler wheel from motor shaft during non-operating periods.

Write for catalog containing dimensions and specifications of these and many other single-speed, dual-speed and 3-speed models in the Smooth Power phonomotor line.

THE GENERAL INDUSTRIES CO.
DEPARTMENT MA • ELYRIA, OHIO

ELECTRONS AT WORK (continued)

a signal depending on line voltage is applied to a nonlinear circuit whose output is subtracted from the output of the x-ray absorption gage. When sensitivity and time constant of the nonlinear circuit, designed to have an approximately fifth-power output-input relation, are properly adjusted the output of the compensated x-ray gage remains substantially unchanged as x-ray voltage is reduced from 200 kilovolts peak to zero.

FIG. 5—Circuit of three-stage nonlinear compensation circuit

In a single-channel x-ray absorption gage a variation of 3 volts in 110 is sufficient to give the same change of output as a change of 0.005 inch of sample thickness. Variation of gage output is plotted against relative line voltage in Fig. 1.

Output is not proportional to line voltage. The variation may be expressed by as $v_{out} = a (V_{line})^n$ where $5 < n < 6$. A characteristic of this nature must, therefore, be produced in the compensating circuits.

A square-law input-output voltage variation may be obtained from a potential-divider network of which one element is a metal rectifier. To maintain symmetrical characteristics, it is desirable to use two rectifiers back-to-back. The simple circuit of Fig. 2A gives the results plotted in Fig. 2B.

Several nonlinear stages of this kind may be connected in cascade to give characteristics that are the product (subject to a constant multiplying factor) of the indi-
Consumer demands shape manufacturers' requirements... to fail to measure up is to lose the sale... incorrectness in one component often makes the difference... because of this, KEYSTONE custom-engineers each transformer it produces for the individual requirements of each manufacturer... KEYSTONE'S unique system of evaluating data supplied by manufacturers on the new reply sheet, enables KEYSTONE engineers to specify the correct transformer type for all operating conditions... this functional fitting increases consumer acceptance and sales... proving over the years that confidence placed in KEYSTONE is well placed. For free information about how the KEYSTONE transformer reply sheet can help you, write box E-10 today!
Heiland's new 700C Recording Oscillograph enables the testing engineer and scientist to solve a wide variety of industrial and laboratory problems involving the measurement and correlation of strains, stresses, vibrations, accelerations, pressures, impacts, temperatures, etc.

The 700C Oscillograph provides up to 60 separate recording channels, has record widths of 8 to 12 inches, record speeds as high as 144 inches per second and as low as .030 inches per second. The 700C accommodates Heiland's new Sub-Miniature Galvanometers and temperature controlled magnet assemblies in which a new high in stability and sensitivity has been attained.

Color Filter for Monochrome Broadcasts

Broadcast TV Transmitters that are, as yet, incapable of meeting FCC requirements for color trans-
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HIGH COMPRESSION Glass-to-Metal Vacuum Seals

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You always make the right move when you specify L. L. Constantin Glass-to-Metal Vacuum Seals. Sturdy high compression construction assures high standards of performance. Sturdy high compression eliminates problems of failures during and after assembly even with the abnormal abuse of mass production techniques. This is possible because the glass is encased in low carbon and special alloy steels under hundreds of pounds of pressure. The seals are tested for pressure and vacuum tightness, shelf life, corrosion and insulation resistance, dielectric and mechanical strength.

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Also manufacturers of Kovar-to-glass headers, terminals and end seals, transistor and crystal bases and covers.

ELECTRONICS — October, 1954

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Silicon Diodes Replace Klystron in CW Radar

by HAROLD B. GOLDBERG

Engineer, Laboratory for Electronics, Inc.

Boston, Massachusetts

The klystron local oscillator and AFC system in a 9000 mc CW radar are eliminated by the use of a quartz crystal controlled 60 mc source modulating a small portion of the transmitter power by means of two silicon diodes in a magic-Tee. Side bands of 9060 and 8940 are generated and the desired band is selected by a filter cavity. If the transmitted frequency changes from 9000 mc to 9001, the selected side band changes by the same amount, thus achieving AFC. The use of one reversed polarity diode paired with one regular polarity diode allows the carrier and IF signals to be supplied in the same relative phase generating side bands in phase opposition which add in arm 4 of the mixer.

Thirteen milliwatts of "local oscillator" signal can be generated by feeding 150 milliwatts of carrier power into arm 3 of the Tee dividing equally between the MICROWAVE ASSOCIATES 1N23C and 1N23CR silicon diodes on arms 1 and 2. Four volts of 60 mc is impressed across the two diodes in parallel. Each side band issuing from arm 4 contains 13 milliwatts of energy indicating a conversion efficiency of 10.5 db with respect to the input carrier. Carrier leakage is down 10 db from the selected side band level. Noise is comparable to klystron oscillators. This system has operated for 250 hours with no decrease in side band output power.

---

**FIG. 1—Color remover filter for transmitter input**

For stations desiring to remove the color subcarrier the filter shown in Fig. 1, inserted in the line to the transmitter, will attenuate the fundamental of the 3.58-mc subcarrier approximately 23 db. Absence of this signal allows the color receiving set to operate as a black-and-white device. Sidebands are attenuated as little as possible in order to prevent removal of high-frequency luminance information.

**FIG. 2—Characteristics of the input filter**

Insertion of such a filter in a line carrying an RETMA test-pattern signal cuts the vertical wedge from about 300 lines to 250 lines. It also adds one or two rings after all sharp transitions. Complete elimination of ringing would require many additional filter sections that would complicate adjustment.

The filter is adjusted using a video sweep generator at the input and a detector probe at the output. Inductors \( L_1 \) and \( L_2 \) are set for maximum attenuation at the subcarrier frequency. With at least 100 ohms in series between sweep generator output and filter input, \( L_n \) is then adjusted for constant in-
**RADIAL TYPES**

### Retainer

<table>
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<th>Brg. No.</th>
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### Retainer Extra Light

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### Flanged Retainer

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### Other Types

**Angular Contact**

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**Self Aligning**

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**Flanged Shielded**

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**Pivot**

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<td>5/64 (.0781)</td>
<td>1/4 (.2500)</td>
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<td>.0300</td>
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<td>7/64 (.1166)</td>
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<tr>
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<td>5/32 (.1625)</td>
<td>7/64 (.1166)</td>
<td></td>
</tr>
<tr>
<td>5/32 (.0937)</td>
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**Full**

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**Spring Separator**

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**Self Aligning**

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<td>216</td>
<td>1/8 (.1250)</td>
<td>5/32 (.1625)</td>
<td>7/64 (.1166)</td>
</tr>
</tbody>
</table>

Write for MICRO Catalog for complete data on the more than 150 available MICRO bearings. Our Design Engineering Department is at your service.

FIRST FOR Microscopic PRECISION
THE NORDEN
DIGITAL CONVERTER

In answer to the far reaching cry for a simple, accurate means of transposing mechanical information into comprehensible numerical digital notation, the Norden Digital Converter, now available, ranks supreme.

UNAMBIGUOUS OUTPUT OF 13 BINARY DIGITS,
LOW TORQUE LOAD
Requiring no additional equipment, this unit, with an unambiguous output of 13 binary digits (total count of 8,192), instantaneously converts shaft position information into direct digital notation. The torque load of the input shaft is 0.2 in-oz.

MINIMUM SIZE,
MAXIMUM ACCURACY
Weighing less than 7 ounces, only 1.75" in diameter and 2.75" long, the Norden Digital Converter is able to maintain accuracy within ±0.006% . . . or 1 count in 16,384.

CLOCKWISE OR COUNTER
CLOCKWISE OPERATION
Either D.C. or pulse-operated, the converter can be wired to supply an increasing count for either clockwise or counter clockwise rotation. Where requirements necessitate an output greater than 13 binary digits, a special unit can be designed.

COUNTLESS APPLICATIONS
With a possible rate of 25,000 counts per minute, the uses of the Norden Digital Converter as a counting device are innumerable. It may be used to convert shaft position to digital notation or as an output device for shaft positioning.

In an era when scientific achievement is attaining unprecedented heights, there is no end to the ways in which the use of Norden precision products can simplify the search for progress . . . from the smallest, most sensitive element to the expensive, Navigational, Fire Control and Bomb Director systems.

The solution has been to design...
LABORATORY DELAY LINE STANDARDS

The Millen delay line kit effectively provides a means for the development and design engineer to check the effect of various delays in their actual developmental setups without the time loss and expense of producing separate lines for each trial. Increased requirement for time delay circuits in radar, color television and other modern electronic applications has presented a problem to the design and development engineer as it has been both time consuming and expensive to obtain delay lines for developmental work as each line was necessarily cut to the estimated delay and any change in requirements necessitated the fabrication of a new delay line. The Millen delay line kit is designed to provide a ready means of obtaining various delays from .10 microseconds through 2 microseconds in increments of .05 microseconds except at the extreme ends of this range. The lines may be used repeatedly without deterioration as they are hermetically sealed, the smaller lines in glass tubes, the 1 microsecond line in a metal container.

Each set consists of:

<table>
<thead>
<tr>
<th>NOMINAL DELAY</th>
<th>TOL.</th>
<th>CALIBRATION TOLERANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 — .05 µs</td>
<td>± .01 µs</td>
<td>± .002 µs</td>
</tr>
<tr>
<td>2 — .25 µs</td>
<td>± .005 µs</td>
<td>± .002 µs</td>
</tr>
<tr>
<td>1 — .30 µs</td>
<td>± .005 µs</td>
<td>± .002 µs</td>
</tr>
<tr>
<td>1 — 1.00 µs</td>
<td>± .005 µs</td>
<td>± .002 µs</td>
</tr>
</tbody>
</table>

Actual delay as measured by phase shift method are marked on each delay line. The laboratory calibration of each delay line is accurate to ± .002 microseconds on all of the .10 microsecond, .25 microsecond and .3 microsecond lines and ± .01 microsecond on the 1 microsecond line. Combination of delay lines supplied makes possible the following delays:

- 0.10 µs
- 0.20 µs
- 0.25 µs
- 0.30 µs
- 0.35 µs
- 0.40 µs
- 0.45 µs
- 0.50 µs
- 0.60 µs
- 0.65 µs
- 0.70 µs
- 0.75 µs
- 0.80 µs
- 0.90 µs
- 1.00 µs
- 1.10 µs
- 1.20 µs
- 1.25 µs
- 1.30 µs
- 1.35 µs
- 1.40 µs
- 1.45 µs
- 1.50 µs
- 1.55 µs
- 1.60 µs
- 1.65 µs
- 1.70 µs
- 1.75 µs
- 1.80 µs
- 1.90 µs

Characteristic impedance — 1350 ohms ± 20%.

PHYSICAL DIMENSIONS:

- 0.1 µs — 1/2" dia. x 4 1/4" long
- 0.25 µs — 1/2" dia. x 7 1/2" long
- 0.30 µs — 1/2" dia. x 7 1/4" long
- 1.00 µs — 1/2" dia. x 4 1/4" x 1"

All seven lines are mounted in a metal case 9 3/4" x 5" x 1 1/2" for convenience in storing and safety in handling.

JAMES MILLEN MFG. CO., INC.
MAIN OFFICE AND FACTORY
MALDEN, MASSACHUSETTS, U.S.A.

ELECTRONICS — October, 1954

Want more information? Use post card on last page.

221

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Amerac's new, versatile... “C” BAND WAVEMETER

Precision manufactured—just like its sister model for the “S” Band—Amerac’s new, Model #230, “C” Band Wavemeter is a co-axial line instrument covering the frequency range from 3500 MC to 6500 MC, by either the transmission or absorption method.

FEATURES

• High frequency stability through the temperature range 10° C to 40° C.
• Extreme mechanical stability.
• High accuracy of measurement (+/-0.02%)
• Sloping panel for easy observation.
• Tri-plating of all surfaces.
• Large knurled control knobs, for simple operation.
• Rugged components, for long service life.
• Golden anodized aluminum panel and cabinet of fine hand-rubbed walnut, for pleasing appearance.

SPECIFICATIONS

Type N constant impedance input connectors.
BNC or UHF co-axial fitting for external video connection.
Power handling capability (absorption)—0.5 mw to 1 watt.
Power handling capability (transmission)—1 mw to 1 watt.
Peak power—up to 25 watts (transmission).
Approximate loaded Q = 2500.
Cabinet size—8” wide, 6 1/2” deep, 5” high.
Net weight = 4.6 pounds.

This unit can be modified for your own specific requirements. Send for bulletin E.

ELECTRONS AT WORK

(continued)

good amplifier stages and operate them at all times with constant bias and gain. They are followed by gain controls that introduce a minimum of distortion. However, the device should not include a servodriven potentiometer for rapid (1/10 sec or less) response must be possible.

The first solution investigated is shown in Fig. 1. It comprises a fixed resistor, $R_s$, in series with the signal source and a variable shunt to ground provided by the dynamic plate resistance $R_p$ of the control tube. Maximum transmission is obtained when the control tube is cut off. As the control voltage $E_c$ decreases the dynamic plate resistance of the control tube becomes less and the tube acts as a greater conductance shunt to ground. This results not in a true potentiometer, but in an attenuator with a fixed series arm and a variable shunt arm.

FIG. 2—Attenuator circuit for low-level signals

Operating limits are usually established by the maximum resistance that can be tolerated for the series resistor $R_s$ owing to stray capacitance and the shunting effect of $R_p$ in parallel with the output load impedance. Of course, the minimum resistance of the control tube determines the maximum attenuation and the tube should be selected with this in mind. Tube types 12AY7, 12AT7 and 2CS1 were found to combine good control range with relatively low distortion.

The circuit shown in Fig. 2 is a basic form of the electronic attenuator and may be used at low levels. The first section of the tube is a voltage amplifier operating at constant bias level and gain. The second section is the attenuator and derives its d-c plate voltage from the first section through the series
BORG MICROPOTS

the NEW STANDARD of precision multi-turn potentiometers

BORG 900 SERIES 3-TURN AND 10-TURN MICROPOTS

3-TURN MODELS 931-935

10-TURN MODELS 901-903

Standard models of Borg 900 Series Micropots offer such flexibility that they meet special design needs. Borg has created a new standard for high-precision, multi-turn potentiometers. Advantages of the Borg 900 Series include greater accuracy, finer resolution, lower torque, longer life, better performance under severe and excessive vibration, greater adaptability and versatility of application.

Standard models include: 10-turn precision Micropots in 1 to 5 gang models, 3-turn in 1 to 5 gang models, single or double shafts, servo or bushing mounts on either or both ends. Available to designers and engineers in any quantity.

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1000 SERIES 2 POLE AND 4 POLE MODELS

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These Borg-Motors were designed specifically for instrumentation, control and timing devices. They are recommended for all applications where low torque, constant speed and long life are positive requirements.

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Borg-Motors

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BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

For more information, use post card on last page.

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NEW HUBBELL Interlock
TRADE-MARK
SUB-MINIATURE CONNECTORS
FOR WIRING PRINTED CIRCUITS!

Made for each other! Hubbell Interlock’s sub-miniature connectors make wiring of printed circuits fast and safe. Note how Interlock Type “C” Connectors pass through set-in eyelets from back and lock automatically on opposite side. Eyelets manufactured by United Shoe Machinery Corp. Eyelet setting machines are available.

Hubbell Interlock sub-miniature Type “C” Connector. Simplicity of design is the key to its constant low contact resistance and ease of installation features.

Hubbell Interlock’s latest development, the sub-miniature Type “C” Connector, featuring low contact resistance, automatic locking — quick disconnect wiring, found immediate application to another recent advancement in the electronic field — the “printed” circuit. The tiny connectors met every requirement for wiring the illustrated rotary switch plate circuit manufactured by Photocircuits, Inc. of Glen Cove, N.Y. Their automatic locking — quick disconnect feature eliminated difficult soldering and made possible fast, easy wiring maintenance. The exclusive Hubbell Interlock locking mechanism assured a vibration-proof, constant low contact resistance.

For Difficult Wiring Problems Requiring Sub-Miniature Connectors, Our Development Laboratory Will Cooperate With Your Engineers To Adapt Interlock For Your Specific Applications.

For Further Information, Write Dept. A:
HARVEY HUBBELL, INC.
Interlock Dept., Bridgeport 2, Conn.

ELECTRONS AT WORK (continued)

attenuator resistor R.

Values in the order of 270,000 ohms may be used with the 12AY7 resulting in a control range in the order of 17 db (+13 to −4 db net gain). With an applied signal of 0.3 volt rms at the input, the maximum observed distortion was 0.4 percent over the total control range.

A version of the circuit shown in Fig. 3 has been used in military equipment to provide a 40-db attenuation range with about 3 percent maximum distortion at 0.2 volt rms output. The value of R, shown is rather high, but a resistance in the order of 47K can also be used. Control tube V1 produces a variable shunt impedance to ground. In this case, however, the grid is coupled directly to the output and this results in voltage negative feedback having an effective gain a, which is the gain of V1 at any particular operating bias.

FIG. 3—Circuit providing 40 db attenuation with about 3 percent distortion

The value β is unity and this results in a reduction of the dynamic plate resistance by the gain factor of V1. Tube V2 acts as a cathode clamp, establishing a well-regulated plate potential for V1. In addition, when V2 is drawing a large current, V1 acts as an added shunt conductance to ground. The net impedance presented by the two tubes to ground is

$$Z_\text{net} = \frac{1}{2} G_m$$

where Z, is the minimum impedance shunting the signal to ground, and Gm is the manufacturer’s rating for the tube under normal operation. Values of Z, in the order of 500 ohms are readily obtained.

The writer expresses appreciation to A. O. Dority, John Barney, Robert Crane and to General Pre-
WIDER RANGE
BEAM:
200 to 2000 volts @ 0 to 100 Ma
1800 to 3600 volts @ 0 to 65 Ma
REFLECTOR:
0 to 1000 volts
CONTROL GRID:
Positive; 0 to 150 volts @ 0 to 5 Ma
Negative; 0 to 300 volts
MODULATOR:
Squarewave; 250 to 2500 CPS @ 0 to 200 volts
Sawtooth; 40 to 120 CPS @ 0 to 200 volts
LOWER RIPPLE
3 MV RMS maximum from any point to ground
GREATER STABILITY
The stability is insured by the use of the 5651 as a reference tube
OPTIMUM REGULATION
All DC voltages regulated to 0.03%, for input variation from 105 to 125 volts

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Used as a basic tool, the FXR Universal Klystron Power Supply has proved its ability for a wide variety of microwave problems. Dependable performance gains its full meaning with the application of this highly versatile, compact unit in the laboratory and for production testing. It is typical of the complete line of FXR Precision Microwave Test Equipment available to science and industry now . . . with the promptness of assembly line production, with the quality of one-of-a-kind design.

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Addition UHF-TV Coverage

TECHNIQUES PROPOSED for filling in shadowed areas in uhf-TV coverage include picking up the signal close to the area of shadow using a highly directive receiving antenna and rebroadcasting the signal. The method requires a high-gain, directive antenna, carefully placed in relation to the area to be given better service. Such an antenna is energized from a very low power transmitter that is inexpensive to run and maintain.

Recently, the Federal Communications Commission approved the use of low-power satellite tv broadcast transmitters that operate on a different ultrahigh frequency from that assigned to the main station. Since the booster-type station operates on the same frequency as the parent station it requires a more exacting performance. Where experimental boosters have operated successfully, satellites might be expected to work as well with less difficulty.

Field tests conducted by RCA in the Vicksburg, Miss. area have been successful in bringing television programs broadcast from station WJTV on channel 25 to the area about 37 miles from the main transmitter.

According to a report filed with FCC, the station received an effective increase in power by 200 times in the shadowed area since the...
### High Voltage Discaps

In addition to lower initial cost, RMC high voltage DISCAPS, offer the advantages of smaller size and greater mechanical strength for faster production line handling.

Rated at 2000, 3000, 4000, 5000 and 6000 volts DC, RMC DISCAPS assure the voltage safety factor required in deflection yoke or special electronic applications. They are available in any capacity between 5 MMF and 10,000 MMF.

RMC engineers are prepared to help you with your problems on standard or special ceramic capacitors. Write us today about your specific requirements.

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**DISCAPS with a dielectric of 1200 K or over are not recommended for deflection yokes or other 15,750 cycle applications.**

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**CERAMIC CAPACITORS**

**RADIO MATERIALS CORPORATION**

**GENERAL OFFICE: 3325 N. California Ave., Chicago 18, Ill.**

**FAC TORIES AT CHICAGO, ILL. AND ATTICA, IND.**
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In klystrons, it's **megawatts** and VARIAN has it...

Here are a few of the VARIAN big tubes that answer high power klystron requirements:

**FOR**: High power microwave communication

**USE THE V-42 SERIES** (L-band)

<table>
<thead>
<tr>
<th>Power output</th>
<th>15 kw CW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency ranges</td>
<td>350 to 1250 mc</td>
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<tr>
<td>Power gain</td>
<td>27 db</td>
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</tbody>
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**FOR**: Pulse coherence
Linear accelerators
High power radar transmitters

**USE THE VA-80B** (S-band)

<table>
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<tr>
<th>Pulsed power output</th>
<th>1 megawatt</th>
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</thead>
<tbody>
<tr>
<td>Power gain</td>
<td>30 db</td>
</tr>
</tbody>
</table>

**FOR**: Navigation aids
Medium power pulsed systems

**USE THE V-82** (X-band)

<table>
<thead>
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<th>Pulsed power output</th>
<th>5 kw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power gain</td>
<td>57 db</td>
</tr>
</tbody>
</table>

**HIGH POWER PLUS**

- Unsurpassed frequency stability
- Built-in tuned circuits
- Freedom from maintenance and adjustment
- Reliability and long life

**THE BEST IN BIG TUBES**

These outstanding klystrons exemplify VARIAN design leadership... engineering and production skill that consistently delivers quality, economy and unsurpassed performance... the reason why VARIAN is the most respected name in klystrons.

**FOR COMPLETE SPECIFICATIONS**
and application data on these and other VARIAN klystrons, write today to our Application Engineering Department.

*IN KLYSTRONS, THE MARK OF LEADERSHIP IS VARIAN associates*

Palo Alto 1, California

Representatives in all principal cities

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**FIG. 2**—Experimental transmitting antenna undergoing tests found later use in uhf booster installation for channel 25 booster system employed a 23-db improvement in field intensity in at least 50 percent of the total receiving areas.

The booster transmitter, with a power of about 10 watts provided acceptable service in an area partially shadowed by intervening terrain.

In the test area, it was determined that an effective radiated power of 1,000 watts was needed for adequate coverage. This power was obtained from the 10-watt transmitter by using a special transmitting antenna with a gain of 100.

**Testing Signal Equipment**

New Signal Corps radio transmitter AN/TRC-24 undergoes Western Electric tests in shielded room. Equipment, to which engineer is making adjustments (right hand on knob) is part of multi-channel communication relay system that links points up to 30 miles apart by radio.

*October, 1954 — ELECTRONICS*
Can your containers pass these tests?

To protect costly aerial cameras and other precision instruments, the U.S. Air Force has developed a special Fiberglas case, now being manufactured in quantity by Koch of California.

In one test, this special case was submerged in 43 feet of water without leaking. In another, the case was dropped by parachute from a plane flying 250 miles an hour at 600 feet altitude (equivalent to a free fall of 25 feet). Both case and contents were undamaged.

Koch Fiberglas cases double as shipping cases, carrying cases and storage cases. No crating or other outer protection is necessary for overseas shipment. Vapor and moisture transmission rate is zero. The cases are fungus and mildew proof. They won't dent—are actually lighter than steel, yet much stronger.

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ELECTRONICS — October, 1954
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STRONG AND NON-MAGNETIC!
Plus resistance to corrosion, abrasion and high temperatures—longer life! Precision-made to the closest of specifications!

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LOWER COST! Superior production capacity and know-how means lower costs, helps you stay within production budgets! Remember, Anti-Corrosive is America's oldest and largest firm dealing exclusively in stainless fastenings.

Write for FREE Product List 541 — lists complete range of items, sizes and analyses available from stock or by special order.

Pertinent Patents

By Norman L. Chalpin
Hughes Aircrft Co.
Culver City, Calif.

While communications and industrial applications of electronics vie with each other among patents granted, the majority reported in this month's collection shows the broadening importance of the non-communications phase.

Counting Tube
Patent 2,638,541 has been granted to John T. Wallmark of Bromma, Sweden for an Impulse Counting Tube. The patent is assigned to the Radio Corporation of America.

Figure 1 shows the internal structure of the tube. There is a plurality of dually stable discharge devices in the envelope of the tube. Where ten such devices are included in the tube it becomes a decade impulse counter. Each dual-stable device comprises a secondary emitter or dynode and a collector element, but there is a common squirrel-cage control grid and cathode-emitter for all ten secondary emitter-collector pairs.

Each of the collectors is positioned to be within the shadow of the grid wires. The secondary emitter of each pair is between the shadows of adjacent grids in the path of rectilinear electron flow from the cathode emitter. This structure results in a beam of electrons from cathode to secondary emitter between two collectors. Thus there are ten radial electron
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for single units or complete control assemblies

in any combination of electronic parts to your specifications, packaged (hermetically sealed), harnessed, cabled, ready to plug-in...

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CHICAGO 12, ILLINOIS

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GUARDIAN SERIES 595-P Relay
GUARDIAN SERIES 210/120 Relay Interlock
GUARDIAN Hermetically Sealed AN-3312-1 Relay

GUARDIAN STEPPERS
GUARDIAN M.E.R. Electrical Reset Stepper
GUARDIAN *Series S-120

GUARDIAN SWITCHES
GUARDIAN UNIT "A" Snap-Action Reversing Switch

GUARDIAN SOLENOIDS
GUARDIAN SERIES 11 Solenoid
GUARDIAN SERIES 18 Solenoid

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GUARDIAN 200 Amp. NAF-1204-3

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for your application.

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for single units or complete control assemblies
new... precision
Continental Connectors*
simplify your connector problems

34 CONTACT SERIES "20"
with polarizing screwlock
guide pins and sockets
Hoods with either top (illustrated) or side cable opening
available for most models

Series "20" Miniature
with POLARIZING SCREWLOCK (PAT. PEND).

Polarizing screwlock guide pins and sockets provide this connector with positive means of locking plug and receptacle against vibration or accidental disconnection. Connector is easily opened without prying or forcing. Available in 14 different contact arrangements for 7 to 104 circuits, and in choice of Melamine, Plaskon-Alkyd and Dialyl Phthalate insulating materials. All models can be ordered with aluminum hood (as illustrated).

Note: New series "14" power connectors also available with polarizing screwlock.

For complete illustrated engineering literature, and assistance on special or unusual connector problems, write Dept. E, DeJUR-Amico Corporation, 45-01 Northern Blvd., Long Island City 1, N. Y.

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DeJUR
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*World's largest manufacturer of miniature precision connectors

ELECTRONS AT WORK (continued)

beams directed at ten secondary emitters. The grids shield the collectors from primary electrons.

Operation of the decade impulse counter may be followed from Fig. 2. This is a plot of the conditions of a single pair of the elements connected with one of the dynodes. Resistor $R_1$ is a dynode load. Component $R_2$ is the collector load resistor. When the pushbutton switch in the output circuit is closed the resistors to the source are connected together at their cold ends. They form a voltage divider placing the collector and dynode to which they are joined at a common potential at the divider voltage point. This potential should be higher than $V_1$.

The values of resistance are so chosen. As a result of the positive potential on the dynode now energized, a beam of electrons will flow towards it from the cathode between the two adjacent grid wires. This results in secondary electron emission, which will return to the emitter as long as the switch is closed. As soon as the switch is opened, the collector electrode potential will rise and that of the secondary emitter will drop to $V_2$. Electron current will now flow from the emitter to collector because of the potential difference and the polarity of that difference between them. The electron space discharge resulting will now provide the low-impedance path from secondary emitter to collector in place of the switch contacts.

While the secondary emitter will draw primary current it will release a greater secondary electron current. The total current will therefore be negative. The drop across resistor $R_2$, as a result is of the proper polarity to maintain the secondary emitter sufficiently positive to continue drawing current and remain stable in this condition. The voltage versus total electron current for the dynode is shown in Fig. 2.

As in all secondary emitters there exist two stable operating points, 0 and $V_1$. The stable-current condition may be cut off by the application of a pulse to the input that is impressed on the grid. Cutoff of the electron beam results in a return
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A waveguide scanning drum is passed over the opening in the spherical mirror to receive the waves and carry them to a waveguide pickup at the center of the drum. The positions of the radially arranged waveguides of the drum are such as to produce a scanning action over the opening. This portion of the system is reminiscent of the Baird mirror-drum TV pickup and reproducer.

The drum and scanning are synchronized with a sweep circuit and the signals received at the waveguide pickup are detected and converted to light intensity signals on a cathode-ray tube to reproduce the image picked up by the spherical mirror. Figure 4 illustrates the system for reproducing the radiowave image.

**Textile Recorder**

An Indicating and Recording Device for Yarn Diameters was granted patent 2,641,960. The inventor, Fred P. Strother, of old Greenwich, Conn., has assigned the patent to Deering-Milliken Research Trust, of New York.

The circuit of the system is shown in Fig. 5. A pair of phototubes is employed with the anode of one connected to the cathode of the other. This connection is in the grid circuit of one half a d-c push-pull amplifier. Two batteries of equal potential are connected in series. An unbalance current resistor $R$ is connected between the phototube junction with one grid and the junction of the two batteries with the second grid.

A common light source feeds the two phototubes. One tube receives a constant light through a
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average variation. This second amplifier has isolating grid resistors and the output circuit is damped with capacitors. The capacitors integrate the variations and drive the second pen motor to produce an average diameter record.

Frequency Discriminator

In a patent awarded Leo Stoshover, 2,667,576 for a Frequency Discriminator Circuit a novel arrangement is disclosed. The patent is assigned to International Standard Electric Company of New York.

The discriminator circuit is shown in Fig. 6. Its particular novelty resides in the network inserted between the source of f-m waves and the detector. The network may be a T or pi configuration; the T type is shown. Another feature is the use of a unity-coupled transformer in which the primary and secondary are interwound on a common form.

The advantages claimed are that a wide band of frequencies may be covered in the tuning range of the discriminator, while at a particular frequency setting there is a narrow band of operation. A further advantage claimed is ease of tuning. The inventor claims the improved result to be obtained by impedance rather than magnetic coupling as in conventional discriminators.

Microwave AFC


Microwave receivers generally employ a local oscillator of the velocity-modulated type such as a reflex klystron. These tubes may be adjusted in frequency by changing the potential on the repeller. This has been accomplished in the past.
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ELECTRONS AT WORK (continued)

by a separate AFC crystal detector for use in a system mixing local oscillator and transmitter frequencies to develop the appropriate AFC voltage that in turn is applied to the repeller. Crystal detectors, because of their nonlinear characteristics, produce harmonics that interfere with proper operation of AFC circuits.

This inventor has found that by eliminating the separate AFC crystal detector and mixing within the reflex klystron oscillator’s resonant cavity, he has been able to accomplish an improved AFC action. The output of the klystron has a circuit tuned to the i-f resulting from the mixing of a portion of the transmitter-oscillator frequency in the klystron cavity with the local-oscillator frequency. The resultant difference frequency appears in the beam current of the oscillator. The resonant circuit in the local oscillator output is tuned to the difference frequency and the voltage applied to the AFC voltage generating circuits. The resultant AFC volt-

FIG. 7—Microwave superheterodyne eliminates separate AFC crystal

age is applied to the local-oscillator klystron repeller.

Figure 7 is a simplified diagram of the inventor’s circuit.

Color TV Tube

E. O. Lawrence has been awarded patent 2,609,675 for a Display Surface for Color Television Tubes. The patent is assigned to Chromatic Television Laboratories, Inc. of San Francisco, California.

Dr. Lawrence’s color-tube inventions have been written up in many publications since their initial public demonstrations. This new development provides a somewhat different approach to the solution
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ELECTRONS AT WORK (continued)

of the problem presented by the perforated screen type of color picture tube.

In the present invention, Lawrence applies the principles of his earlier tubes in both the horizontal and vertical planes for more accurate control of the position at which the cathode-ray beam impinges upon the proper color area of the screen in synchronism with the transmitted color-image signal.

Figure 8 shows the structure of a lens grid screen employed in this invention to direct the beam to the

FIG. 8—Lens-grid screen for color tubes directs beam to desired area

FIG. 9—Method of energizing color-tube grid with vertical and horizontal oscillators controlled by receiver

FIG. 10—Three-gun tube used to demonstrate how beam can be directed to a common point on screen area

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ELECTRONS AT WORK (continued)

desired color area of the picture surface, as the beam is swept by the deflection circuits.

The block diagram of Fig. 9 shows the circuits by which the lens-grid structure is excited by a vertical and a horizontal oscillator. While the arrangement essentially describes a field-sequential application of the system to an electrostatic deflection tube, there is a likelihood that the vertical and horizontal color oscillators can be so phased as to provide operation in the manner of the dynamic convergence coil of the electromagnetic systems now in use in the present NTSC system.

An arrangement of the principle of this invention applied to a three-gun electromagnetic cathode-ray tube structure is shown in Fig. 10. Here all three guns are tied together to direct the beam to a common point on the lens grid screen area.

Figure 11 shows the positions of the color areas with respect to the vertically and horizontally controlling deflection meshes of the lens grid. By appropriate polarities of voltages applied to the meshes the beam may be positioned to impinge on a greater or lesser proportion of the areas of each color section within the grid square to provide the appropriate color in the combination, or the beam can be spun inside the mesh with brightness changes effected by control-grid excitation of the beam.

Piezo Voltmeter

In patent 2,667,104 issued to W. E. Buck and assigned to the
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ELECTRONS AT WORK (continued)

U.S. Atomic Energy Commission, there is described a piezoelectric voltmeter, although the title of the invention is Light Valve.

Figure 12 is an end-view illustration of the piezoelectric voltmeter arranged with an optical film recorder. The top view of the piezoelectric structure is shown in Fig. 13.

The piezoelectric crystal shown has a chamfered edge that is coated to form a partially reflective surface. The surface of the plate glass nearest the crystal is partially coated also. Since the crystal and

![Piezoelectric crystal voltmeters](https://example.com/piezoelectric-crystal-voltmeters)

![End view of piezoelectric voltmeter](https://example.com/end-view-of-piezoelectric-voltmeter)

![Top view of piezoelectric structure](https://example.com/top-view-of-piezoelectric-structure)

Light from the monochromatic source when passing through the coated surface of the glass is reflected by the chamfered edge of the crystal to the film recorder. As the crystal is deformed by the voltages applied to it the thickness of the pattern formed is a measure of the voltage applied to the crystal. The response of the system is best from 1,000 to 50,000 cycles.

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ELECTRONS AT WORK

source under measurement.

Mass Separator


Mass separators resolve beams of ions into separate distinguishable groups of like mass-to-charge ratios and provide visual indications of the ratios and abundance of ions in each group.

The present invention is a velocity-focused mass separator. Figure 14 illustrates the electronic system of this invention as utilized in a chamber into which is inserted a material to be studied.

An ion source bombarding an accelerating plate sends a beam of ions down a crescent-shaped enclosed electric field area towards an anode and ion collector. The crescent-shaped area has strip electrodes arranged concentrically within the area. There is an equal number on each side of the beam area with respect to center. That is, there is an equal number in each of the positive and negative areas as the area is swept by a saw-tooth voltage; the ion beam is swept to focus ions of like mass-to-charge ratios in succession. The saw-tooth voltage is also connected to the horizontal plates of an oscilloscope and the output of the mass separator to the vertical plates of the oscilloscope. A trace is thereby provided of the magnitude versus mass-to-charge ratio on the oscilloscope screen.

The calibrations of the screen with respect to the saw-tooth voltage make possible the identification of elements and their isotopes present in the source material and the comparison of relative abundance.

FIG. 14—Electronic portion of focused mass spectrometer.
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DIVIDING wire harness boards into labeled rectangular coordinates much as for maps permits specifying individual wires by means of an origin coordinate square and a destination coordinate square. This simplifies placement of wiring and improves accuracy in the North Hollywood, Calif. plant of Pacific Bendix Division.

Wood frames for supporting harness boards are constructed in sections that sit on top of benches and can easily be removed or shifted as the work load varies. Each standard eight-foot-long workbench is equipped with sliding breadboards at each end and in the middle on both side of the bench. These boards, made from five-ply plywood, can be pulled out as required to support cut wire racks and tools at the most convenient locations for the operator regardless of lacing board size.

The racks for cut wires are made by drilling holes in a sheet of tempered pressed wood and mounting this sheet at an angle on a wood frame. Wires are inserted in pairs of holes. The operator grasps a wire at its center and pulls it out; this eliminates the annoyance of prickling fingers on sharp ends of stripped wire. Strips of masking tape are run across the board and holes are identified by lettering on the strips. Lettering can thus be changed easily by putting on new strips.

Chassis components are wired into the harness wherever possible, to avoid more difficult wiring later in the chassis. Even tube sockets and resistor subassembly panels are wired into the harness and later riveted or bolted to the chassis.

Scribing Dial Windows

THE PROBLEM of inscribing lines evenly in transparent plastic dial windows for electronic apparatus when the plastic varies in thickness is a tricky one. The line must be evenly cut, because illumination of the dial when the apparatus is in use shows up any irregularities.

Hewlett-Packard in Palo Alto,
Whether it's shells or beads — or good old American dollars, for that matter — you just can't operate successfully without showing a profit. That's why so many progressive companies depend on Kester quality and performance to insure maximum results in production at the lowest possible cost. And we'll bet Kester Solder can mean more "wampum" in your "wigwam," too!

An engineered adaptation can be made to your specific requirements with Kester "44" Resin, "Resin-Five" or Plastic Rosin-Core Solder... varied core sizes or flux-contents are available in many different diameters.

WRITE TODAY for Kester's NEW 78-page Informative Textbook, "SOLDER... its fundamentals and usage"
Vacuum Cleaner Cleans Drill Press

A CLEANING tool operating from a compressed-air supply and using the principle of the Venturi tube contributes to good housekeeping in metal-working departments of electronic plants. When permanently mounted on a drill press, the unit picks up chips as fast as they appear and shoots them through a rubber hose into a waste barrel.

With a bag attached in place alongside of a rubber hose, the unit can be used as a hand vacuum cleaner for lifting lathe cuttings out of a lathe and for cleaning other machines employed in the production of electronic components. Absence of moving parts in the cleaner minimizes clogging, and absence of electrical contacts permits use in locations having fire hazards.

The new cleaner can be attached to grinding wheels, belt sanders and other machines that produce lint, grit or filings during operation. By placing appropriate sizes of screens on the nozzle, it can be used to separate particles of different sizes or to clean stock bins without picking up parts.

Another shop use is picking up liquids. The cleaner will empty a 50-gallon drum of water in 60 seconds and transfer the liquid through a rubber hose to any other container. Since the aluminum housing of the cleaner is essentially acid-proof, electroplating tanks can be emptied with it.

Exclusive of air hose, the unit weighs less than 24 pounds, permitting easy cleaning of overhead areas without operator fatigue. When operated from a compressed-air line at approximately 90 pounds pressure, the vacuum produced at the nozzle is about twice that of the largest domestic tank cleaners. The unit is distributed by Merchandising and Manufacturing Associates, Inc., Lancaster, Pa. and is available in several models to meet a variety of industrial cleaning problems. Recent redesign to take standard}

October, 1954 — ELECTRONICS
NEW LOW PRICES MAKE AVAILABLE GROWN JUNCTION RF TRANSISTORS for use in New Fields!

Tetrode Type

1. No change with age
2. Greater power gains
3. Hermetically sealed
4. No temperature hysteresis
5. I_C lowest available
6. Better frequency response

REPRESENTATIVE APPLICATIONS
D.C. amplifiers, multivibrators and high speed switches, pulse amplifiers, radar timers, computers, radio receivers, transmitters, etc.

NPN GROWN JUNCTION RADIO FREQUENCY TRANSISTORS

**NPN GROWN JUNCTION TRIODES (Typical Characteristics)**

<table>
<thead>
<tr>
<th>Type No.</th>
<th>Type No.</th>
<th>Type No.</th>
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<tbody>
<tr>
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<tr>
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<th>Power Gain</th>
<th>Collector Capacity (uf)</th>
<th>Alpha Cutoff Frequency (mcs)</th>
<th>Collector Resistance (megohms)</th>
<th>Base Resistance (ohms)</th>
<th>Alpha</th>
<th>Rise Time (us)</th>
<th>Noise Figure</th>
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**NPN GROWN JUNCTION TETRODES (Typical Characteristics)**

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<table>
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<tr>
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<th>Power Gain at 1000 cps (db)</th>
<th>Collector Capacity (uf)</th>
<th>Input Impedance (ohms)</th>
<th>Output Impedance (ohms)</th>
<th>Oscillator Frequency (mcs)</th>
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<td>25</td>
<td>9000</td>
<td>15</td>
<td>10.00</td>
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**GERMANIUM PRODUCTS CORPORATION**

S U B S I D I A R Y  o f  R A D I O  D E V E L O P M E N T & R E S E A R C H  C O R P O R A T I O N

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ELECTRONICS — October, 1954

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NO DERATING even at 50° C ambient

Vickers Selenium Rectifier

New Vickers Rectifiers operate in ambient temperatures up to 125° C. WITH NO DERATING UP TO 50° C. This means smaller rectifiers and lower costs. Vickers new High-Ambient Rectifiers continue to operate at temperatures that would destroy ordinary rectifiers... withstand temperature excesses due to accidental overload.

HIGH VOLTAGE
- 40-volt inverse cell rating
- Leakage and inverse loss are one-half that of ordinary rectifiers
- High dielectric—withstanding surges up to twice rated voltage

LONG LIFE
Vickers' newly-developed inorganic barrier is inherently stable, gives longer rectifier life. Inverse characteristics actually improve with use.

WRITE TODAY FOR COMPLETE INFORMATION

VICKERS ELECTRIC DIVISION

October, 1954 — ELECTRONICS
Five Reasons why this Company is sold on the G-E Midget Soldering Iron

A. E. FINGERHUT, PLANT SUPT., PICKER X-RAY CORP., SAYS:

"We use General Electric soldering irons one-hundred percent. For close quarter soldering of electronic and x-ray components, we use the G-E Midget and we're completely sold on it."

1. "We're saving the replacement costs." Since switching to the G-E Midget five years ago, Picker X-Ray hasn’t had a heating element burn out. That’s because the Midget offers a long-life Calrod heater installed in the tip.

2. "We're saving maintenance time." Because the G-E Midget is equipped with a durable Ironclad tip, Picker X-Ray operators have eliminated tip filing. As a result, the company saves twenty to thirty minutes per day per operator in maintenance time. A Midget iron equipped with an Ironclad tip will give service up to ten times longer than irons equipped with ordinary tips.

3. "We're realizing increased production." Weighing only as much as a pack of cigarettes, the G-E Midget helps boost Picker X-Ray’s production because operator fatigue is reduced.

4. "We're cutting damage costs." Small diameter tips, 1/4 in., 1/8 in., 3/32 in. available with the Midget enable Picker X-Ray operators to solder small connections without burning adjacent wire insulation.

5. "We're getting the right amount of heat." Too much heat from a soldering iron causes varying quality in soldered components. Picker X-Ray finds that the G-Midget produces the right amount of heat for soldering delicate connections.

Picker X-Ray’s experience shows how you can profit by using the G-E Midget soldering iron for precision soldering. And to meet any of your soldering requirements, General Electric offers twenty-four different irons with ratings from 25 to 1250 watts. Contact your General Electric Sales Office today for more information. And for a free bulletin on industrial soldering irons, mail the coupon below.

Five Reasons why this Company is sold on the G-E Midget Soldering Iron

GENERAL ELECTRIC

ELECTRONICS — October, 1954
If we haven’t already made it we’ll design it for you...

To solve your specific potentiometer problem, send an outline of your specs to Gamewell. You’ll get prompt service on your order for a prototype to meet your requirements.

Linear and non-linear Gamewell Precision Potentiometers are described in the booklet shown below. We’ll be glad to send you a copy.

THE GAMEWELL COMPANY
NEWTON UPPER FALLS 64, MASSACHUSETTS
In Canada: Northern Electric Co., Ltd., Belleville, Ont.

Oven Heat Recorder for Picture Tubes

A DUMMY PICTURE-TUBE pumping cart, equipped with a temperature recorder in place of the vacuum pump, is used to monitor temperatures in straight-line exhaust ovens at RCA’s Lancaster, Pa. picture-tube plant. The high temperatures
These precision made components for transistors and other assemblies requiring hermetic sealing are available in three electrode, two electrode and single wire types. Where other than the standard types illustrated are required, E-I can custom design, and economically produce, special types in square, round or rectangular shapes. For complete information, call or write E-I — here is no obligation.

*PARENT PENDING ALL RIGHTS RESERVED
Here is an example of the numerous types of precision equipment produced by Caystrom for our many contract customers. It indicates our exceptional facilities, experience and skill in the design, production and testing of electro-mechanical units:

- cylinders are machined and polished to a 1 1/2 micro-inch finish; silver, palladium and rhodium plated to .0002 tolerance.
- backlash of stainless steel gear train is held to ± or 1° at the counter pinion. Each cylinder resets to within .0005 of pre-determined point on counter.
- all aluminum parts anodized; stainless steel parts are machined and passivated.

A cable assembly section offers you the efficiencies gained through years of making all types of cables and harnesses at lower cost.

We will be glad to send you detailed information on our facilities and organization as they might relate to some phase of your own production.

CONTRACT SALES DIVISION
DAYSTROM ELECTRIC CORP.
753 MAIN STREET
POUGHKEEPSIE, N. Y.

Want more information? Use post card on last page.

PRODUCTION TECHNIQUES

must be rigidly controlled for each type of picture tube to avoid strains in the glass, particularly at the faceplate and wall of the tube.

A sample tube on the cart has five thermocouples attached externally and connected to a Honeywell electronic recorder. At intervals during the day the guinea-pig cart travels through the exhaust ovens, emerging with a charted temperature picture for the particular tube in production. Temperature deviations are quickly spotted and necessary adjustments made immediately.

Corrections can be made quickly because the recorder indicates the exact location in the oven of such temperature deviations. Exhaust schedules for new tube types can be readily established and evaluated by running a new tube through on the recorder cart.

Cleaning and Oiling
Completed Components

Washing tank for potentiometers

ALL MULTITURNS precision potentiometers are processed in a specially designed washing device at Helipot Corp., South Pasadena, California, as part of the regular manufacturing procedure, after the resistance coil has been assembled into the case. A special cleaning solution is run into the tank, deep enough to cover the brush. The operator places the potentiometer over the shaft and moves it up and down against the brush. Then the potentiometer is held over the jet through which the same cleaning solution is sprayed under pressure. The inverted glass bowl prevents
N.B. — The different mechanical designs shown were selected from one day's quantity production.

each of these HOLTZER-CABOT motors solved a special problem!

Holtzer-Cabot specializes in motor and generator design, and is tooled to produce both AC and DC motors and generators, in a wide range of frames, with unlimited varieties of mechanical and electrical features.

Quality motors correctly designed result in lowest ultimate cost.

Bring your small-motor application problem to Holtzer-Cabot. Our experience in developing custom-built motors assures you of a prompt and expert solution.

NATIONAL PNEUMATIC CO., INC. AND HOLTZER-CABOT DIVISIONS

125 Amory St., Boston 19, Mass.
Sales Service Representatives in Principal Cities throughout the World

Designers and manufacturers of mechanical, pneumatic, hydraulic, electric and electronic equipment and systems
Air conditioning in Long Beach is done by nature! The air is fresh, and cleared by invigorating ocean breezes. Mechanical cooling devices are not necessary. The excellent working conditions result in lower absenteeism and reduced turn-over, as well as higher working efficiency. Naturally the famed climate of Long Beach makes for happier employees.

The "industrial climate" also offers fair weather the year 'round. Really low-cost utilities, excellent transportation including America's most modern port, advantageous tax-structure, lower costs for land and building, and an exceptional labor pool — all add up to sunshine on your profit ledger.

Write today for full and confidential information.

CHAMBER OF COMMERCE • DEPARTMENT OF INDUSTRY
200 East Ocean Boulevard, Long Beach 2, California

Oil-spraying setup

splattering of the cleaning solution.

To complete the cleaning process, the potentiometer is then placed on a fixture in the middle of an adjacent tank, and a foot-pedal-controlled air jet dries the pot completely. Finally, the pot is held in front of an atomizer and a light mist of lubricating oil, also controlled by a foot pedal, is sprayed into the pot.

Quality Control Sets
Factory Traffic Lights

In front of each tube production unit in the Bloomfield, N. J. plant of Tung-Sol Electric Inc. are red, yellow and green traffic lights. These are turned on and off by the quality control department to tell production how it's doing. The green light means OK — go ahead; the yellow means caution; the red light means stop the machine. No more tubes may be shipped to the
From COLLINS outstanding research and development facilities come these contributions to industry

Collins' new research and development facility in Cedar Rapids (pictured top above) houses 12 ultra modern laboratories, with especially designed equipment required by Collins in its diversified development program. It brings together, under one roof, highly trained engineering teams and the most advanced electronic research tools. This new Collins facility in Cedar Rapids is supplemented by Dallas and Burbank laboratories for the development of specialized electronic components for industry.

In addition to the finest facilities, Collins places even greater importance on engineering personnel. Some of the best engineering talent in the nation is at work on Collins' development projects. So today, with greatly expanded research and development laboratories, Collins is better equipped than ever to assist the Electronic Industry. Technical literature is now available on the Collins components shown, and your inquiry is invited.

COLLINS RADIO COMPANY CEDAR RAPIDS, IOWA

261 Madison Ave. 1930 Hi-Line Drive 2700 W. Olive Ave.
NEW YORK 16 DALLAS 2 BURBANK

Collins Radio Company of Canada, Ltd., 74 Sparks St., OTTAWA, ONTARIO

ELECTRONICS — October, 1954

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FREE!

- Samples of IN STOCK wire for your breadboards, prototypes, pilot models, laboratory tests, development work and experimentation.
- Plus—Alpha's latest 28-page Electronic Engineer Catalog E-10 gives you complete specs—your GUIDE to all electronic wire.
- WRITE FOR SAMPLES AND FREE CATALOG NOW.

MR. AL PHA says:

We offer you production-proven quality...superior plastic insulation that doesn't "creep back" from heat of soldering iron...greatest number of IN STOCK wire items in the industry...shipment within 24 hours...special wire constructions to your own specs.

Test us—and see how it pays YOU to buy ALPHA WIRE!

First in Quality Wire for over 30 years
ALPHA WIRE CORP.
450 BROADWAY, NEW YORK 13, N. Y.

The strip charts are arranged in groups on a holder in such a way that a strip can be advanced by pulling the end with the left hand. Labels or crayon markings on transparent plastic guides identify the tube represented by each strip chart. These markings are easily changed when a different tube type is placed into production.

The cumulative averages for the last 1,000 tubes produced are transferred regularly from the strip charts to a bulletin board type of chart, the composite results of which determine the settings of the traffic lights. This chart is four-sided and is mounted on a vertical pipe for easy rotation, much in the manner of postcard display racks in stores. Small horizontal strips of wood divide each side of the rack into 16 areas in which the
Miniaturization
with
Hughes
Diodes

New computer matrix has high component density

This experimental reading gate matrix for airborne computers effectively utilizes the subminiature size of Hughes Point-Contact Germanium Diodes*. Developed by the Miniaturization Group of Hughes Research and Development Laboratories, the unit measures 3 ¼ by 3 3/8 by 1 1/2 inches (excluding plugs and frame). It contains 504 diodes, 209 resistors. Average component density: 94.5 per cubic inch!

Frequently, space requirements of conventional wiring techniques will not permit electronic equipment to be miniaturized to the same extent as the components. However, spot-welded connections can effectively reduce wiring space . . . and it is easy to spotweld the dumen leads of Hughes diodes. There is no adverse effect on diode characteristics, even when the connections are welded close to the diode body. With Hughes diodes, designers can take full advantage of advanced packaging and wiring techniques.

Hughes diodes are easy to mount in conventional assemblies or in subminiature equipment. In service, these diodes have earned a reputation for reliable performance and stability under severe operating conditions. Make your selection from the many standard and special types available—all listed and described in our new Bulletin, SP-2A.

Reprints of a paper describing the packaging techniques of the subminiature matrix are available, too. Your copy will be sent promptly on request.

---

Hughes
Aircraft Company, Culver City, Calif.

SEMICONDUCTOR SALES DEPARTMENT

New York Chicago

Want more information? Use post card on last page.

*Actual size, diode body: 0.265 by 0.130 inches, maximum.
Impossible? Not for Tubular Rivet

**Problem**
Set a rivet in an "impossible" position, fastening two aluminum extrusions. Usual high production requirements. Obstructions: 3/4" below clinch, 1/4" from side wall, 1/4" from back wall.

**Solution**
Special solid anvil form on offset holder applied to TUBULAR'S automatic riveting machine. Form locates workpieces and rivet is "shot blind" i.e. without positioning work on conventional spring pin anvil.

Customer has since found another application (formerly "impossible") for this machine. If you have an inaccessible fastening location let us see if we can solve it by production riveting on one of our riveting machines. Forward prints or samples to TUBULAR RIVET, Dept. E.

---

**Turret Socket Fixture**

Wiring of turret sockets is expedited in the plant of The Edo Corp., College Point, N. Y. through use of a fixture that supports the turret while permitting rotation. An empty turret is plugged into a standard seven-pin socket that is bolted to the rotatable head. The data cards are placed. Transparent plastic sheets hold the cards in position. To record a value, the operator pulls out a card just far enough to give room for marking the point and extending the curve, then slides the card back in. Each point on this curve represents the quality of the last 1,000 tubes produced.

If the curve on a particular card is 0.2 percent or better, the green light for that particular tube type is turned on by means of a three-position selector switch on the control panel in the quality control department. If defects run over 1 percent, the red light is turned on. In-between values get the orange caution light. Two-position toggle switches on the sides of the master control panel actuate other signal lamps that tell the factory whether the rejects are electrical or mechanical in nature.
CONQUERING the Time Barrier

COMPUTERS translate split-second decisions into instant action beyond any human ability... in bombing, in fire-control, in navigation. Maxson has been developing and building these computers for nearly twenty years.

MAXSON develops and manufactures systems, subsystems, and components in armament, navigation, electronics, and special devices. Ask for facilities report.

THE W. L. MAXSON CORP.

460 WEST 34TH STREET, NEW YORK 1, N. Y.

396 WEST 34TH STREET, NEW YORK 1, N. Y.

ELECTRONICS — October, 1954

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VLF
...Very Low Frequencies

- RADIO INTERFERENCE
- and FIELD INTENSITY*
- measuring equipment

Stoddart NM-10A • 14kc to 250kc
Commercial Equivalent of AN/URM-6B
VERSATILITY...The NM-10A is designed to meet the most exacting laboratory standards for the precise measurements, analysis and interpretation of VLF radiated and conducted radio-frequency signals and interference. Thoroughly portable, yet rugged, the NM-10A can be supplied with accessories to fulfill every conceivable laboratory and field requirement.
EXCELLENT SENSITIVITY...The NM-10A sensitivity ranges from one microvolt-per-meter to 100 microvolts-per-meter, depending upon whether rod or shielded loop antennas or line probe are used.
ACCURACY...Each equipment is “hand calibrated” in the Stoddart Test Laboratories by competent engineers. This data is presented in simplified chart form.
DRIPPROOF...Sturdy dripproof construction allows long periods of operation in driving rain or snow without adverse effects.
FLEXIBLE POWER REQUIREMENTS...The ac power supply permits operation from either 105 to 125 volts or 210 to 250 volts ac, at any frequency between 50 cps and 1600 cps.

Stoddart RI-FI* Meters cover the frequency range 14kc to 1000mc
HF NM-208, 150kc to 25mc
Commercial Equivalent of AN/PRM-1A. Self-contained batteries. A.C. supply optional. Includes standard broadcast band, radio range, WWV, and communications frequencies. Has BFO.
VHF NM-20A, 20mc to 400mc
Commercial Equivalent of AN/URM-47. Frequency range includes FM and TV bands.
UHF NM-50A, 375mc to 1000mc
Commercial Equivalent of AN/URM-17. Frequency range includes Citizen's band and UHF color TV band.

Method of using fixture for supporting turret socket during assembly. Finished chassis is shown in nest on other part of fixture

Other end of the turret is supported by a hinged arm which is under spring tension. This arm is easily bent back out of the way for insertion or removal of a turret.

On the same wood base is an additional fixture that serves as a nest for supporting the subassembly chassis on which the turret is later mounted. The chassis is used in the Fishscope transmitter designed for use on commercial fishing boats to locate schools of fish deep under water.

Pneumatic Lift Serves as Assembly Worktable

By BERT GOLODRATH
San Mateo, Calif.

Wiring and assembly of electronic instrument panels is simplified at the Lenkurt Electric Co. plant in San Carlos, Calif. by use of a pneumatic lift which holds work at different heights for maximum convenience during progressive stages of the operation. The work platform can be rotated through 90 degrees for maximum accessibility. Two quick-acting clamps (manufactured by the Desta Co.) on each upright member of the jig hold the unit in place against positioning pins. Two more quick-acting clamps hold the platform which,
Look

at the extra features that assure
dependability in ADLAKE Mercury Relays!

- **Dependability** is the sum of many things... and ADLAKE's dependability is built on engineering skill, exhaustive testing, and quality construction features like these:

Positive leak-proof sealing—assured by the use of properly selected metals and glass components with properly matched thermal expansion characteristics.

Arc-resisting ceramics—ceramics with great temperature-resistance are used to reduce any destructive effect caused by the arc.

Liquid mercury-to-mercury contacts—completely eliminates failures caused by low contact pressure, contact burning, pitting and sticking—and the inherent high surface tension of mercury imparts an ideal snap action to the contacts.

And, of course, ADLAKE Mercury Relays are hermetically sealed, require absolutely no maintenance, and are silent and chatterless. Write for your free copy of the ADLAKE Relay catalog today... The Adams & Westlake Company, 1171 N. Michigan, Elkhart, Indiana. In Canada, address Powerlite Devices, Ltd., Toronto.

"Mighty Midget" ADLAKE Relay—Contact normally open or closed.

EVERY ADLAKE RELAY IS TESTED—AND GUARANTEED—TO MEET SPECIFICATIONS!

THE Adams & Westlake COMPANY

Established 1857 • ELKHART, INDIANA • New York • Chicago

Manufacturers of ADLAKE Hermetically Sealed Mercury Relays
YOU can't afford to be without the
HATHAWAY S14-C OSCILLOGRAPH

the world's most complete and versatile

LOW COST OSCILLOGRAPH
for recording electrical quantities, processes,
flight functions, dynamic pressure, strain,
vibration, acceleration, temperature...
for testing relays
for testing welding equipment
for biological recording
for analysis of high-speed engines and compressors

GALVANOMETERS are available for current, voltage, power, covering a most extensive range of characteristics.

ATTACHMENTS available for almost any recording need—
automatic transient recording
wave-shape measurements
wave-shape scanning
long records to 100 inches per second
short records to 1,000 inches per second

PROVE TO YOURSELF THAT THE S14-C IS...
• The Most Versatile
• The Easiest to Maintain
• The Easiest to Operate
• The Finest in Craftsmanship

WRITE FOR BULLETIN No. 2D-1K AND
YOUR FREE COPY OF HATHAWAY ENGINEERING NEWS

PRODUCTION TECHNIQUES

(continued)

Using lift at knee level for initial stages of assembling parts on a panel.

Completing assembly at bench height, using cleats and brackets on uprights to hold wiring harness and attached parts when released, rolls out onto a dolly with pieces too heavy to handle.

Operated off the plant air line through a four-way valve, the elevator is equipped with ratchet safety stops so that the operator's legs won't be endangered in event of air pressure failure. Valve and
Specify Bridgeport Phosphor Bronze to make better spring parts...

for longer service life in switches, relays and other electronic equipment

Bridgeport Phosphor Bronze (Alloys 35 and 36) has excellent resiliency, high flexural strength, good conductivity with superior corrosion resistance and ability to resist wear.

To use these advantages of Bridgeport Phosphor Bronze for your applications, contact your local Bridgeport Sales Office. Our technical service is always available to help you with your metals or methods problems.

One of the many Bridgeport Metals with High I.Q. (Inner Quality) for economical fabrication and improved products.

Bridgeport Brass Company • Bridgeport, Connecticut
Serving Industry with a Nationwide Network of Conveniently Located Sales Offices and Warehouses
Mills in Bridgeport, Conn, Indianapolis, Ind., and Adrian, Mich.
In Canada: Noranda Copper and Brass Limited, Montreal

ELECTRONICS — October, 1954
Magnecorders are the most widely used professional tape recorders in the world! These versatile, dependable units are ideally adapted for research, testing, data recording, and many other uses—delivering the highest performance characteristics available at any price level. The proof—and the truth—is on every Magnecord tape.

Magnecord dealers are listed under "Recorders" in your classified telephone directory.

1101 SOUTH KILBOURN AVENUE CHICAGO 24, ILLINOIS DEPARTMENT E-10

Want more information? Use post card on last page.

October, 1954 — ELECTRONICS
New "video pair" manufactured by Western Electric for the Bell System uses cellular polyethylene on copper conductors, twisted together with two strands of fiber glass, also insulated with cellular polyethylene. A wrapping of polyethylene tape, two layers of copper tape, two wrappings of crepe paper and spiral wrappings of colored cord complete the assembly. The whole unit measures only 5/32 in. in diameter.

"Video pair" has a big job to do! The two slender copper wires carry impulses from camera to studio on remote pick-ups, and from studio to telephone central office for transmission via coaxial cable or radio relay.

Extruded insulation of cellular polyethylene now replaces the spiral plastic spacer and tape used on earlier models. The results—lower cost, superior transmission, and improved reception—all important to forthcoming color telecasts.

Cellular polyethylene consists of unconnected hollow cells. Its moisture resistance approaches that of solid polyethylene. It can be formed to about half the specific gravity of solid polyethylene, and provides reduced dielectric constant, lower line losses and lower costs for material.

Bakelite Company is a major producer of polyethylene. Learn more about the possibilities of Bakelite Polyethylene for your insulating jobs. For technical information, write Dept. ZE-79.

BAKELITE TRADE-MARK
Polyethylene

BAKELITE COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N.Y.

In Canada: Bakelite Company
Division of Union Carbide Canada Limited
Belleville, Ontario
In the performance of microwave systems this equation also applies...

\[ \sum \left( E_e + M_d + Q_p \right) = R \]

where

- **R** = reliability of product
- **E<sub>e</sub>** = good electrical engineering
- **M<sub>d</sub>** = sound mechanical design
- **Q<sub>p</sub>** = quality of production facilities

All these functions are so interdependent in this field, it's most important to entrust them to a close-working staff of specialists.

Whether your problem involves special components, or complete microwave transmission systems, we're set up to design and produce them with a high degree of precision from performance specs or your blueprints. Our engineering staff, laboratories, and fully equipped shop are busy on government contracts, but our unique facilities may enable us to work with you on special components for military or other microwave systems. We shall be happy to talk with you about your present and/or future needs.

---

**Air-Operated Vise**

**Seals Off Magnetrons**

After evacuation of magnetrons in a combination oven and exhaust station in the Hicksville, Long Island plant of Amperex Electronic Corp., an air-actuated crimping tool resembling a vise is used to compress the metal tubulation to a feather edge with sufficient pressure to achieve a vacuum seal and cutoff simultaneously.

The operator uses both hands to hold the tool, since it is quite heavy.
Based on the famous University model WLC Theater System used so successfully and extensively in deluxe stadium and outdoor theater installations... auditoriums, exposions, concert halls and other important applications where only the highest quality equipment is acceptable—University engineers now bring you a smaller, compact version—the BLC—for general application in public address work. The BLC is the New standard for both voice and music, indoors and outdoors. The BLC is now yours, at the low low price of

ONLY $75 LIST

SPECIFICATIONS
Response 70-15,000 cps
Power Capacity 25 watts
Impedance 8 ohms
Dispersion 120 degrees
Mounting 180° adjustable "U" bkt.
Dimensions 22½" diameter, 9" depth

Better Lows: BALANCED"COMPRESSION" TYPE FOLDED HORN, starting with eight inch throat and energized by top quality low frequency "woofer" driver provides more lows than other bulky designs.

Better Highs: DRIVER UNIT TWEETER with exclusive patented "reciprocating flares" wide angle horn transmits more highs with greater uniformity... high frequency response that you can hear!

More Efficient:
DUAL RANGE THEATER TYPE SYSTEM permits uncompromising design of the "woofer" and "tweeter" sections for greatest efficiency. Hear it penetrate noise with remarkable fidelity and intelligibility.

Less Distortion: SEPARATE LOW AND HIGH FREQUENCY DRIVER SYSTEMS with electrical crossover reduces intermodulation and acoustic phase distortions common to other systems which attempt to use different horns on a single diaphragm.

More Compact: EXCLUSIVE WEATHERPROOF DUAL RANGE COAXIAL DESIGN eliminates wasted space. Depth of BLC is only 9"; can be mounted anywhere, even flush with wall or ceiling.

More Dependable: EXPERIENCED MECHANICAL ENGINEERING AND CAREFUL ELECTRICAL DESIGN meet the challenge of diversified application and environmental hazards. Rugged, and conservatively rated—you can rely on the BLC.

Write desk No. 18 for full descriptive literature
Closeup of air-operated vise

and must be held in a horizontal position. A foot-operated valve, generally operated by an assistant, controls the movement of the vise jaws.

**Totem-Pole Jigs-Cut Wiring Costs**

*By Dean E. Wiseleder*

*Saukano Electric Co.*

*Springfield, Ill.*

> Through use of a new vertical terminal strip known as a totem pole, over 90 percent of the connections and leads for an amplifier were produced faster and more efficiently in the subassembly stage by semiskilled wiremen working from models and simplified diagrams, than could have been done by skilled wiremen using conventional wiring techniques. The use
CHATHAM advance-designed yesterday — in industry-wide use today!

AMPLIFIERS • REGULATORS • INERT GAS AND MERCURY RECTIFIERS • MERCURY, INERT GAS AND HYDROGEN THYRATRONS

CHATHAM SPECIAL-PURPOSE TUBES

STANDARD TYPES DIRECT FROM STOCK
PLUS SPECIAL DESIGNS BUILT TO REQUIREMENTS

Chatham specializes in the development of general and special purpose tubes for both electronic and industrial applications. Many of the tubes originally developed by Chatham to fill a specialized need, now number among the most widely used tubes in the industry. For complete information on Chatham tubes — either stock items or types built to your requirements — call or write today.

CHATHAM ELECTRONICS CORP.
Executive and General Offices: LIVINGSTON, NEW JERSEY
Plants and Laboratories: NEWARK and LIVINGSTON, NEW JERSEY

ELECTRONICS — October, 1954

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www.americanradiohistory.com
**The New SHURE “TWIN-LEVER” CERAMIC PICKUP CARTRIDGE for High Fidelity systems**

PC Series for 33⅓, 45, 78 r.p.m.

AN “AB” LISTENING TEST WILL PROVE THAT THIS CARTRIDGE SURPASSES ANY OTHER HIGH QUALITY COMMERCIAL CARTRIDGE!

A new frontier for the Ceramic principle has been crossed by the development of this cartridge. Designers of high fidelity phonograph systems and hi-fi radio or tv phono combinations, who have been “test piloting” this new “Twin-Lever” ceramic development, report an amazing superiority in tone quality that can be easily heard before the cartridge is even measured.

This “Twin-Lever”, high fidelity ceramic cartridge represents the ultimate in commercial high fidelity reproduction—without compensating preamplifiers! Smooth, wide range response from 50 to 12,000 c.p.s., plus or minus 3 db. Other features which help to make this new cartridge so outstanding in performance are: high compliance that virtually eliminates tracking distortion ... extremely low effective mass provided by new specially-designed needles and new coupling ... tailored needles on separate needle shafts, functioning independently for best 78 rpm response, too—as well as the superior microgroove performance.

The new unique design eliminates “turnover” of either the cartridge or the needles. Both needles are in the same plane, and an ingenious, lever-operated shift mechanism gently moves each needle in and out of playing position.

**RADICAL NEW DESIGN FOR NEEDLE REPLACEMENT!**

Needle replacement is now so simple it can be done blindfolded!! This is a feature that will be of special interest to the ultimate users of your original equipment. Anybody can replace the needle, without tools, in a few seconds—while the cartridge remains in the pickup arm!

**TECHNICAL DATA for MODELS PC4 and PCS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Level at 1,000 c.p.s.</td>
<td>40 volts (33⅓, 45 rpm)</td>
</tr>
<tr>
<td>Output Level at 1,000 c.p.s.</td>
<td>65 volts (78 rpm)</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>50-12,000 c.p.s.</td>
</tr>
<tr>
<td>Compliance</td>
<td>1.30 x 10-6 cm/dyne</td>
</tr>
<tr>
<td>Tracking Force</td>
<td>5 to 8 grams</td>
</tr>
<tr>
<td>Net Weight</td>
<td>7.3 grams</td>
</tr>
<tr>
<td>Dimensions</td>
<td>1½” overall length; ⅛” wide ⅛” high</td>
</tr>
</tbody>
</table>

** ALSO... **

New High Output Ceramic Cartridges NO LESS OUTSTANDING IN THEIR CONTRIBUTION TO LOW COST, FINE QUALITY REPRODUCTION ARE THE HIGH OUTPUT CARTRIDGES: MODELS PC2 and PC3.

** Totem poles may be assembled with or without ground terminal and spacer pillar. Terminals are of solid bronze, heat-solder-coated and staked into the melanine post of semiskilled wiremen opens up a lower-cost and more widely available labor supply, cutting production costs and reducing assembly time for a job. **

The new terminal provides adequate mounting support for small components such as resistors, capacitors, diodes and transistors at their operating point. Critical leads to components such as grid suppressor resistors can be reduced to pigtails. Space is saved through more effective under-chassis arrangement, thereby reducing chassis size. Fewer leads, cables and soldered joints are needed. Approximately 5 ft of wire was saved per totem pole in one revised chassis. Cooling of under-chassis components is improved. Socket terminals and all other terminals are exposed for easier test, inspection and accessibility with tools.

In general, each subassembly includes one or more totem poles and includes the associated tube socket as well, thereby assuring short leads and proper configuration of critical coupling or suppressor components. This also provides maxi-
from Hydrazine...
new light on old soldering problems

For greater efficiency and economy in the production of electrical and electronic components, a remarkable new series of soldering fluxes has been developed by McCord Corporation.

Based on compounds of hydrazine, these fluxes—called CORONIL—are non-corrosive and can be used without hazard. They remove oxides and other films from most commercially used metals such as copper and brass—as well as others—to permit more effective work and fewer rejects. In addition to their use by electrical and electronic equipment manufacturers, these hydrazine-based CORONIL fluxes are being successfully applied in the production of automotive radiators and other heat exchangers, carburetor floats, oil strainers, and various other products where safe, non-corrosive soldering is essential.

** A new data sheet containing the latest information on hydrazine-based soldering fluxes is now available; it refers specifically to the removal of oxides and other films from copper and brass. Write for your copy today. **

OLIN MATHIESON CHEMICAL CORPORATION
Baltimore 3, Maryland

ELECTRONICS — October, 1954

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MEN WITH BS, MS, and PhD DEGREES

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AIRBORNE INSTRUMENTS LABORATORY has challenging design and development problems that will excite the engineering talents of men with B.S., M.S. and Ph.D. Degrees. If you have initiative and the desire to express it without reservation, you'll find AIRBORNE INSTRUMENTS LABORATORY the place best suited for your professional advancement... with job security assured by a wide variety of commercial and government contracts. We are presently seeking qualified men in the following fields:

Radar Systems
Microwave Components
I.F., R.F. and Video Circuity
Navigation
and Communication Devices
Analog and Digital Computers
Transistor Circuit Development
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High Speed Data Processing

Ideally situated on Long Island for suburban living with access to graduate study... and still close enough to reach New York City in less than an hour... AIRBORNE INSTRUMENTS LABORATORY might prove to be "the spot you are looking for."

Employee benefits include paid vacations and holidays, insurance, pension and hospital plans, tuition refunds, etc.

Howard Gresens,
Director of Personnel

AIRBORNE INSTRUMENTS LABORATORY INC.
160 OLD COUNTRY ROAD, MINEOLA, L. I., N. Y.

October, 1954 — ELECTRONICS

PRODUCTION TECHNIQUES (continued)

mum wiring economy because a high percentage of the connections made in the chassis are controlled by the tube sockets and totem poles and are therefore included in the subassembly.

Although the location of a totem pole on a chassis is rather well fixed, practically no planning is necessary except in the breadboard stage. Here the design engineer, using four-terminal units only, locates a sufficient number of them under the breadboard chassis to be sure that they will do three things:

(1) Support one or both terminals of coupling and suppressor components as near their socket terminals as possible. This usually means a totem pole between sockets of succeeding tubes, favoring the grid-plate terminals of the sockets.

(2) Support all components which can not be adequately supported by point-to-point wiring. This means complete elimination of conventional component boards and the cabling to them.

(3) Expedite breadboard modifications and testing by providing insulated terminals for test equipment, power supplies and extra components.

After a breadboard has received final approval for performance, the totem poles are examined to see which can be removed, combined or reduced to the three-terminal type. These changes are included in the preproduction model.

Skilled wiremen make the first units of each subassembly. These serve as models for production units which follow. A semi-skilled production wireman, ready to make a quantity of a subassembly, receives a model and an assembly diagram. The diagram includes a plan view of the component layout.
PERMASEAL accurate wire-wound resistors are ideal for point-to-point wiring, for terminal board mounting and for use on processed wiring chassis. Encapsulated for protection against high humidity, these resistors will stand up in military and industrial electronic service. The protective housing also guards against physical damage during installation and during equipment maintenance.

Standard designs are available in seven different physical sizes for operation at full rated wattage at ambient temperatures of 85°C and 125°C. Special units can be made for operation at 150°C ambient with full rated wattage dissipation.

Unusual long-term stability of resistance is another plus feature of Sprague Permaseal Resistors—as the result of careful matching of winding forms, resistance wire and encapsulating material—together with a thoroughly controlled aging process during manufacture. Permaseal Resistors are available in resistance tolerances down to 0.1%, when necessary.

FOR COMPLETE DATA, WRITE FOR COPY OF SPRAGUE ENGINEERING BULLETIN NO. 122, WITHOUT DELAY.

SPRAGUE ELECTRIC COMPANY,
PRODUCT PERFORMANCE AND ACCEPTANCE REQUIRE CAREFUL COMPONENT COMPARISON

Compare RELAYS

A WIDE VARIETY OF SPRING AND COIL COMBINATION, OPERATING POTENTIALS AND CONTACT RATINGS.

How do you compare relays? Comparison can be made on the basis of craftsmanship, uniformity of performance, dependability ... and AEMCO invites such comparison. Comparative quality is relative but absolute quality is more certain!

We believe that the long and continuous servicing of more than one hundred top names of American Industry establishes the uniform dependability of AEMCO 'Engineered' RELAYS.

If one of the hundreds of stock AEMCO Relays does not exactly fit your requirements, we will design and manufacture to meet your particular needs ... to exceed your specifications!

WRITE TODAY for complete information on AEMCO Relays to meet your requirements and exceed your expectations!

AEMCO Automatic Electric MFG. CO.
62 STATE STREET · MANKATO, MINN.

Jig facilitates production of two-post subassembly, using sample and diagram as guides. Note accessibility of terminals for inspection and wiring.

With jigs removed, subassemblies are stored in cardboard box until needed in final chassis.

plus a semi-pictorial wiring diagram. Code colors are added by the draftsmen in crayon for further simplification. With these tools the wireman can proceed with efficiency whether he prefers to work from the model, the diagram, or both.

When subassemblies are completed, they are removed from their jigs and stored in layers in a cardboard box until needed for final assembly. No trouble has been experienced in storing with the jigs removed. Extensive handling is unnecessary in this case because the storing and final assembly take place in the same building. Plywood and aluminum jigs have been equally satisfactory. Simplified wiring diagrams are used to complete the wiring on the chassis.

Totem pole jig wiring will show cost savings when production quantities exceed fifty units or...
IMPROVED SOLDERING OF SMALL PARTS AND ASSEMBLIES

Typical of the Marion developments that have helped make Marion stand for "advancement in instrument design" is the Marion Model PM1 Induction Soldering Unit. Originally designed and presently used by Marion for true glass-to-metal hermetic sealing of Marion meters, it also has proven to be a valuable production tool for many purposes. Illustrated above, for example, is Marion's use of the PM1 in the soldering of magnet assemblies where quality and uniformity result.

Other manufacturers use Marion PM1 units in the production of magnet assemblies, relay armatures, connectors, capacitors, transformer cans, etc., as well as in other fields such as jewelry, watches, toys, and automotive parts. Shown here is a battery of Marion PM1 units at the Clyde, N.Y. plant of the General Electric Company where, on the whisker diode line, a small pellet of germanium metal is soldered to the end of a nickel pin.

The Marion Model PM1 speeds up production, reduces costs and improves quality. Heat is generated within the work itself—even in parts otherwise inaccessible. Oxidation, scaling and damage to surface finish are minimized. Soldering of an entire seam or several jig-located parts at one time is readily accomplished.

This is an example of how Marion's belief in "Advancement in Instrument Design" has produced a production tool which not only improves Marion instruments but also provides other manufacturers with better soldering equipment. Marion Electrical Instrument Company, 481 Canal Street, Manchester, N. H.
when repeat orders for smaller quantities are likely over a period of time. Most electronic equipment for government and industry falls within this range.

**Soldering Stand With Automatic Solder Feed**

SOLDERING operations on small parts for the 2.75-inch Mighty Mouse aerial rocket are performed with a soldering tool that leaves both hands of the operator free for handling the components. The soldering iron is rigidly mounted under the bench in one installation, with the heated tip projecting up through an asbestos disk set in a hole in the bench. A foot pedal advances the solder and simultaneously brings the iron up to the correct position for the soldering operation. A curved copper tube can be easily bent to make the solder feed precisely to the desired point.

Another soldering setup that is also used in this Pasadena, California plant of Hycon Manufacturing Co. has the iron mounted above the bench, point downward. The parts to be soldered are held together on a small fixed anvil and the foot pedal is actuated to bring...
We've Whipped TD*!

TD Proofed Servo Motors

... Another Flight-Improving First

by Greenleaf

WHERE QUALITY CONTROL WORKS ON THE PRODUCTION LINE

* TD MEANS TORQUE DECAY. TD in a single servo loop can keep an airplane grounded for hours, even days. TD is like Cancer in the human body. It is the gradual merciless wasting away of torque due to internal changes of components in a servo motor. It shortens life, destroys accuracy, ends efficiency.

New Life for Servo Motors

Now Greenleaf offers you servo motors that are TD-proofed. Actually, Greenleaf methods and ingenuity have reduced TD by as much as 1500%. This is true for all Greenleaf electro-magnetic rotating devices.

This is another example that shows why Greenleaf is regularly selected as a prime or sub-contractor by the following: U.S. Air Force, U.S. Navy, McDonnell Aircraft, Boeing, Emerson Electric Company, Eastman Kodak, Avco Mfg. Corporation and other leading organizations.

See Greenleaf for Servo Motors and for Gyros, Pressure Transmitters, Accelerometers, Synchros, Air Speed Indicators, Actuators and other precision units and components.

THE Greenleaf... MANUFACTURING COMPANY

7814 Maplewood Industrial Court • St. Louis 17, Missouri
UNION Miniature Relays

Now resist vibration up to 1000 cycles at 15 G's!

vibration is your problem, this new line of UNION Miniature Relays is the answer. Severe laboratory tests have proved that these relays will withstand vibration up to 1000 cycles at 15 G's acceleration. That's performance!

Compactly, precisely and ruggedly constructed, they were especially designed and developed to do a job where continuous operation is absolutely necessary. Under rigid test the Type M relay actually operated over one million times—and still remained in top working condition!

They meet all the requirements of Military Specifications MIL-R-5757 A&B, and are available in either 6-pole or 4-pole double-throw models— for plug-in or solder-lug connections.

Send for literature.

DRY CIRCUITRY APPLICATIONS

In grid switching applications where the relay contacts must operate at low-voltage, low-current levels, special alloy contacts can be furnished. These contacts maintain extremely low resistance through hundreds of thousands of operations. They are available on the complete line of UNION miniature relays.

GENERAL APPARATUS SALES

UNION SWITCH & SIGNAL

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY

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NEW YORK CHICAGO ST. LOUIS LOS ANGELES SAN FRANCISCO

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PRODUCTION TECHNIQUES (continued)

the iron down on the work and simultaneously feed solder to the work.

In both cases, the soldering stand is a commercial unit built by Electric Soldering Iron Co., Deep River, Conn., modified to meet the requirements for the job.

Soldering setup in which iron mounted vertically under bench moves up to work when foot pedal is pressed. For some operations, the iron can be rigid in this mounting with foot pedal serving only to feed solder.

The setup permits mass production of rocket parts that meet the most exacting tolerances and critical inspections. Results are uniform because the operator's duties have become routine and the soldering iron angle is constant.

Automatic Metallizer for Picture Tubes

Virtually automatic production of the vacuum-metallized coating on the inner surface of television picture tubes can be achieved with a new self-contained metallizing unit developed by the F. J. Stokes Machine Co. The compact, completely self-sufficient package with integral vacuum-pumping system is mounted on four wheels for incorporation in
Exciting New Development in Printed Circuits!

New CuClad® copper-clad laminate offers unequalled bond strength, heat resistance, solderability, punchability, electrical performance!

Here's the foil-clad laminate you've been waiting for! It's CuClad LamicoID®—made possible by an entirely new concept in bonding material, specially designed equipment developed exclusively by Mica Insulator Company. This new bond and unique bonding method give you unequalled performance that's consistent and dependable from sheet to sheet, lot to lot.

You get all these advantages:

A STRONGER BOND WHICH IMPROVES WITH AGE AND HEAT
BETTER HEAT RESISTANCE
BETTER REACTION TO HOT SOLDER
BOND ELECTRICALLY EQUAL TO LAMINATE
IMPROVED ARC RESISTANCE
SUPERIOR PUNCHABILITY
UNIFORMITY

and CuClad LamicoID® is competitively priced!

CuClad LamicoID® is available NOW, in several grades. Tell us your requirements or problems—or ask to have a Mico Sales Engineer call.

Photo courtesy Methode Manufacturing Corp.
Chicago, Ill.

**Look at these typical production run values on 6028 XXXP CuClad LamicoID:**

**Bond Strength**—Guaranteed min: 6 lb.; avg. 9 lbs. (90° peel at 2 lbs/min.)

**Solder Test**—Guaranteed no blisters @ 230-240° C, for 10 seconds, 1” square floated on molten solder

**Heat Resistance**—Guaranteed no change at 150° C for 1/2 hour in air-circulated oven, air flow parallel to specimen

**Punchability**—Excellent

<table>
<thead>
<tr>
<th>Surface Resistivity, megohms</th>
<th>7.3 x 10^9</th>
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<tr>
<td>G-96/35/90</td>
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<table>
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<tr>
<th>Volume Resistivity, megohm cm</th>
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<tbody>
<tr>
<td>G-96/35/90</td>
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<table>
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<tr>
<th>Water Absorption</th>
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</thead>
<tbody>
<tr>
<td>Copper an</td>
<td>0.3%</td>
</tr>
<tr>
<td>Copper removed</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

MICA Insulator COMPANY
Schendectady 1, New York
Offices in Principal Cities
In Canada—Micanite Canada, Ltd., Granby, Quebec

LAMICOID® (Laminated Plastic) • Micanite® (Bull-up Mica) • EMPIRE® (Coated Fabrics and Papers) • FABRICATED MICA • ISOMICRA®

ELECTRONICS — October, 1954

Want more information? Use post card on last page.
merry-go-round or in-line production setups, and can also be operated as a stationary unit to minimize vibration during the metallizing cycle.

Chief design feature of the new metallizer is completely automatic control over all stages of the metallizing cycle. Closing and opening of the valves, starting and stopping of the two vacuum pumps, and switching on and off of the vaporizing current are controlled by a standard sequence-type electrical timer, settings of which are adjustable to 10-second intervals over a 10-minute cycle.

Once the settings have been determined on the basis of preliminary tests, they need not be changed. One operator can easily supervise the operation of as many as 10 units in addition to loading and unloading tubes.

The production pattern reduces to this simple sequence:

1. The uncoated tube is lowered, neck down, into the vacuum-metallizing unit by an automatic lowering device. The operator then pushes one button to start the timer.
2. The rough pumping stage of
Plus or Minus errors are expensive when valuable aircraft equipment is being started, serviced, or tested. Consolidated load banks provide a wide range of protection for electrical systems and components.

Foolproof and portable, Consolidated load banks assure stable DC, and/or AC, testing for shop, field, and line. They are compact, self-contained, self-cooled, and available in many types and capacities.

Consolidated research and development engineers can assist in solving testing problems in many fields and are available for consultation without obligation.
PRODUCTION TECHNIQUES

Overshoot, Rise-Time Duration Measurements

WIDE-BAND ELECTRONIC SWITCH
DC to 15 MC
Dual Trace Oscilloscope Presentations

Model ES-180

- Signals displayed on alternate sweeps, switched at sweep-end, rate to 100 kc
- Amplifier rise-time .023 microseconds, megohm input, 93 ohms load impedance
- Unity-gain, feedback, regulated power supplies for linearity and stability
- Index trace calibrated in volts and % amplitude eliminates parallax errors
- Time-signal input allows accurate and rapid measurement of pulse parameters

TELETRONICS LABORATORY, INC.
54 Kinkel St., Westbury, L. I., N. Y.

Visit us at the NEC Show—Booth-119, Chicago

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October, 1954 — ELECTRONICS

the cycle automatically begins. A vacuum valve opens between the evacuation chamber of the unit (into which the tube neck has been inserted) and the 10-cfm rotary mechanical vacuum pump which is running continuously. The pressure in the tube is reduced to about 200 microns in approximately 2½ minutes.

3. At this pre-set time, the 4-inch water-cooled oil-diffusion vacuum pump is cut in automatically and reduces the pressure within the tube to the desired pressure for vaporizing the aluminum to be deposited. This pressure is easily reached within 4 or 5 minutes.

4. At the appropriate pre-set time, the timer trips a switch which sends a 25-ampere pulse through a stranded tungsten filament. This filament spans the gap between two electrodes which extend up through

Placing picture tube in counterweighted yoke of automatic lowering device that lowers tube accurately into position, neck first

Pushing start button initiates complete sequence of metallizing

Visit us at the NEC Show—Booth-119, Chicago

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MIFILM CAPACITORS
WITH
MYLAR* DIELECTRIC

Built to Your Specified Sizes

SUBMINIATURE SIZES OVER THE COMPLETE CAPACITY AND VOLTAGE RANGE. Typical is the .173" dia. x ¼" long (.001 mfd, 600 VDC). We can put these subminiature capacitors into any case style or type of mounting and still provide the same extremely small space factor—approximately ¼ of paper capacitors.

HEMERICALY SEALED—METAL ENCLOSED. These MIFILM Capacitors are unaffected by extreme climatic changes.

MYLAR* DIELECTRIC—retains extreme high insulation resistance over complete temperature range of -65° C to 150° C. Special sizes can be made to withstand even higher temperatures.

*MIFILM Capacitors are also available in commercial type construction—Types 620 and 621. Specify type when ordering.

SPECIAL TOLERANCES as low as ±1%.

Write for complete catalog covering all types of Good-All long-life capacitors. We invite sample orders for your evaluation. Our engineers are always ready to work with you on any capacitor problem.

So Superior... They are being used extensively by leading Electronic, TV, and Radio Manufacturers throughout America.

GOOD-ALL ELECTRIC MFG. CO. Good-All Bldg.,
114 W. FIRST ST., OGALLALA, NEBRASKA • PHONE 112 OR 113—CABLE ADDRESS "GOODALLA"
**NEW TUBE ACCESSORIES and ELECTRONIC HARDWARE**

Molded phenolic plugs, with seven pins, 45° apart on .375" centers, mate with economical standard miniature sockets. Designed to save space and competitive in price with bulky wafer pin plates, these units are ideal for base assemblies on plug-in components or quick disconnect harness assemblies. Plugs are available with or without vinyl caps or mounting saddles. General purpose or mica phenolic insulators with cadmium plated brass pins are standard.

"Wire Wrap" sockets have terminals adapted for high speed solderless attachment of leads at considerable savings in assembly and inspection time. Miniature seven and nine pin units available in both laminated and molded types.

"Ventilator" shielding not only improve "hot" tube performance by dissipating heat but are the most economical shields in Methode's extensive line. Easily handled and compression fitted to ground terminals on Methode laminated or printed circuit sockets, shields are available in lengths of 1-11/16" or 2-1/16" with one standard diameter which fits either seven or nine pin tubes. Available with tin or black oxide finish.

For high voltage tubes these corona caps and socket combinations for both octal and noval sizes feature generously rolled outer surfaces. Assemblies are designed for screw mounting to condenser studs or stand offs and are available with general purpose black or low loss mica phenolic insulators. Noval caps available with 1-5/16" or 1-1/2" major rim diameter. Octal units have insulating fibre liners.

Interior of metallizer. Operator is changing timer setting that controls duration of flashing current

METHODE Manufacturing Corp.
2021 West Churchill Street • Chicago 47, Illinois

Geared to produce Plastic and Metal Electronic Components

The neck of the tube. The filament carries several short bent strips of aluminum ribbon which supply the metal source for the coating to be deposited. Heated by this current, the filament melts the ribbon. At the low pressure now in the chamber, the molten aluminum vaporizes and takes flight in molecular form, depositing as a thin coating over all of the inner surface of the tube. Location of the metal source within the tube has been carefully determined to provide uniform coverage by the metal film. The duration of the flash is controlled by a separate micrometer adjustment on the timer, calibrated in seconds, and lasts as long as desired to give the required thickness of coating. The power supply for the filament is a standard stepdown transformer and rheostat, which converts the normal 115-volt a-c supply to a low voltage, adjustable from 0 to 17 volts.

5. After flashing the filaments, the electrical timer closes all the vacuum valves and breaks the vacuum in the chamber and tube, which thus releases the tube. The automatic lowering device then
This BALANCED INSULATION gives you WINDINGS for MOTORS at Lowest Overall Cost

LOW IN EXTRACTABLES

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RESISTS ABRASION

- takes pounding pressure winding abuse

WINDABILITY

- smaller coils

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WIREMAKER FOR INDUSTRY

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For carrying cooling water which must undergo a change in potential, use of Lapp porcelain eliminates troubles arising from water contamination and conductivity, sludging and electrolytic attack of fittings. Permanent cleanliness and high resistance of cooling water are assured—for positive cooling and long tube life.

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Inside diameters ¾" to 3", in straight pipe, 90° and 180° elbows, fittings. Swivel-type connections. Standoff insulators attach directly to fitting bolts.

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Twin-hole and single-hole models in sizes to provide flow of cooling water from 2 to 90 gallons per min. Cast aluminum mounting bases; lead pipe or flexible metal hose for attachment.

WRITE for Bulletin 301, with complete description and specification data. Lapp Insulator Co., Inc., Radio Specialties Division, 230 Sumner St., Le Roy, N. Y.

**Air Control Improves Quality of Relays**
AIR CIRCULATION, temperature, humidity and cleanliness are automatically controlled at exact points essential to precision manufacturing of relays in the new Chicago plant of C. P. Clare & Co. The entire plant design is aimed at eliminating the hazards of dust and dirt as the major cause of electrical relay failures both in production and in the field.

Washable ceramic tile walls,
All the economies of series string design, with no sacrifice in reception quality, are available to TV set manufacturers who engineer their sets around this new line of Tung-Sol Receiving Tubes.

The competitive position you achieve through savings in transformer and circuitry costs will be strengthened by the long life and high performance of these Tung-Sol Tubes.

The statistical quality control methods by which Tung-Sol maintains outstanding uniformity in tube production, make these new types your best assurance of utmost economy in series string TV set manufacture. For more information, write to Commercial Engineering Department, Tung-Sol Electric Inc., Newark 4, New Jersey.

Sales Offices: Atlanta, Chicago, Columbus, Culver City (Los Angeles), Dallas, Denver, Detroit, Newark, Philadelphia, Seattle.

Tung-Sol makes All-Glass Sealed Beam Lamps, Miniature Lamps, Signal Flashers, Picture Tubes, Radio, TV and Special Purpose Electron Tubes and Semiconductor Products.

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25 data channels

on a 1-inch tape!

The Vic-Dar, produced by Victor Adding Machine Company, Chicago, Illinois, provides a new and faster method of data accumulation and storage with magnetic recording. For the first time, up to 25 channels of information can be stored on a tape only 1 inch wide.

This is accomplished by using two Brush magnetic heads, one a 13-channel and the other a 12-channel model. These heads are positioned so that the channels interlace. The required high dimensional accuracy is achieved by Brush's advanced production techniques and workmanship. The precision gap alignment of the Brush heads also permits recording tapes on one unit and playing them back on another, with all signals in perfect relationship.

Can precision Brush heads help you open new frontiers in magnetic recording? For bulletin describing our complete line, write Brush Electronics Company, Dept. K-10A, 3405 Perkins Avenue, Cleveland 14, Ohio.

Sheet metal hood mounted on vertical pipe draws soldering fumes off through underfloor ducts to maintain cleanliness during relay manufacture.

PRODUCTION TECHNIQUES (continued)

acoustical steel ceilings and asphalt tile floors enclose the windowless production area to assure maximum cleanliness with minimum maintenance. All dirt, odors and heat created by manufacturing processes are drawn off at the source through under-floor air exhausts. Air is electrostatically cleaned with a bank of self-cleaning electronic precipitators and then heated or cooled, humidified or dehumidified before it is circulated through the plant. To increase the supply of fresh air to working areas, about six times the usual number of directional grilles are mounted in the plant ceiling. This is comparatively low, being but 91 feet from the floor.

Since all supplies of power and air for benches and machines are carried through an elaborate system of ducts and outlets in the floor, there is nothing suspended from the ceiling to catch and hold dust.

The lighting system selected for hand assembly of the many small parts going into precision relays consists of slim-line fluorescent tubes in continuous rows on four-foot centers. This provides 75 foot-candles at workbench level.

Power Transformer Tester

A UNIVERSAL test panel in the incoming inspection department of Motorola's Chicago plant permits checking any of about 200 different types of power transformers for adherence to specifications. Eight
New CLARE Type LG Relay increases life expectancy of electromechanical latching relays to millions of operations

**TYPICAL CIRCUIT FUNCTIONS**

1. Hold contacts operated any length of time without consuming power.
2. Operate contacts over one lead; release them over another.
3. Act as overload relay—electrically reset from remote point when tripped.
4. Act as interlocking relay pair on either a-c or d-c—or on combination of both.

CLARE Type LG Electromechanical Latching Relays were designed to meet the punishing service requirements of an internationally known business machine manufacturer. Where other such relays measured their life cycles in thousands, Type LG a-c relays are still operating satisfactorily at well over 15,000,000 operations.

The assembly shown consists of two CLARE Type GAC a-c relays with interlocking armatures. They are aligned one above the other on a common mounting bracket to save chassis space. The assembly may also consist of two Type G d-c relays, or one a-c and one d-c relay.

*Relay operation is as follows:*

1. When either relay is energized while the other, deenergized, relay is latched up, it will unlatch the other relay, allowing it to restore, and will latch itself up.
2. When either relay is energized while the other is already energized, it will operate its own contacts without latching up, and without affecting the other relay. It will release as soon as its coil circuit is opened. The two relays, however, can be interlocked electrically so that both coils cannot be energized at once.
3. When either relay is deenergized while the other relay is energized, the other relay will become latched up.

For full information on this new relay or for consultation on any relay problem, we invite you to contact your nearest CLARE sales engineer or write to C. P. Clare & Co., 3101 West Pratt Blvd., Chicago 45, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13, Ontario. Cable Address: CLARELAY.

Write for Bulletin 118

---

**CLARE RELAYS**

**FIRST IN THE INDUSTRIAL FIELD**

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**Specifications**

**MECHANICAL:**

- **COILS:**
  - D-c, single-wound, up to 25,000 ohms; double-wound—(concentric only) to 5000 ohms each winding.

- **MAGNETIC CIRCUIT:**
  - Armature and heel piece of low-loss iron provide efficiency comparable to that of Type G or Type GAC relay.
  - Cores of a-c coils are of laminated silicon steel. Copper shading rings fitted to pole faces to prevent armature chatter.

- **ARMATURES:**
  - Single-arm. A-c relays have precision-ground, heavy-duty armature bearings and stainless steel bearing pins.

- **RESIDUALS:**
  - Fixed (plate) or adjustable (lock nut) on d-c relays.

- **ARMATURE LATCH:**
  - Arm projects downward from armature of upper relay and engages latch projecting outward from armature of lower relay. Stop on lower latch prevents overthrow. Retractable spring helps restore upper armature when latch is disengaged. Latching members specially treated by most modern metallurgical methods for maximum wear resistance.

- **CONTACTS:**
  - Forms A to E available. Maximum of 6 springs per relay.

**WEIGHT:**

- Net (approx.) 1 lb. Shipping—2 lbs.

**ELECTRICAL:**

- **COIL VOLTAGE:**
  - (Maximum) a-c, 220 volts, 20 to 120 cycles; d-c, 220 volts.

- **COIL RESISTANCE:**
  - a-c, wound to number of turns specified, plus or minus 5%; d-c, resistance as specified, plus or minus 5%.

- **COIL DISSIPATION:**
  - (Maximum) For continuous duty: a-c, 10 va; d-c, 6 watts.

- **AMPERE TURNS REQUIRED:**
  - (d-c relay) with two Form C contacts, 500.

**HIPOT TEST:**

- Standard, 1000 volts rms.

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Subject: solder

As far as cost is concerned, solder is a relatively small item in any manufacturing operation. But solder does a big job. You should have the best solder you can buy...Federated solder.

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Universal power transformer tester

ammeters and eight 100-watt rheostats permit individual loading of secondary windings. Other meters measure primary voltages, secondary voltages and breakdown voltages.

High binding posts are arranged in a semi-circle around the metal grounding plate on which the transformer under test is placed. Transformer leads are connected to the correct posts according to previously prepared tables, for making a test.
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THE THREE basic types of threaded coil forms used with shallow-thread or V-type iron cores are shown in Fig. 1. In general, these coil forms should be custom-made to fit the particular iron core application. This is necessary to insure perfectly round windings and uniformity of windings to the iron core, as well as accurate alignment of the core itself.

The triangular or cloverleaf form is illustrated in Fig. 2 before and after forming. Dimensions are for a standard 1-28 screw having a

The calibrating procedure involves placing each meter movement in turn in a test fixture located between two large demagnetizing coils, and varying coil current appropriately to adjust the permanent magnet in the movement until the reading of the meter under test corresponds with that of the standard at preselected points in the operating range.

Selecting Coil Forms for Threaded Cores

By Hugh T. Blair
President, Resinite Corp.
Division of Precision Paper Tube Co.
Chicago, Illinois

5-7" oscilloscopes; TV oscilloscopes; all-purpose probes; panel instruments.

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The triangular or cloverleaf form is illustrated in Fig. 2 before and after forming. Dimensions are for a standard 1-28 screw having a
RCA OSCILLOSCOPES

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Engineered, manufactured, and factory-tested to insure dependable, trouble-free performance at low cost.

New RCA WO-78A 5" OSCILLOSCOPE FEATURING DUAL BANDWIDTH
VERTICAL RESPONSE: Wide-band, flat within —1 db from 3 cps to 4.5 Mc; sensitivity, 0.1 v p-p/in. Average rise time 0.1 µsec, with overshoot less than 5%. Frequency-compensated, voltage-calibrated attenuator. Narrow-band, flat within —3 db from 3 cps to 500 Kc; sensitivity, 0.01 v p-p/in.
HORIZONTAL RESPONSE: Flat within —6 db, from 3 cps to 1 Mc; sensitivity, 0.2 v p-p/in.
FULL-SCREEN DEFORMATION over entire rated frequency ranges.
PUSH-BUTTON voltage calibration.
HIGH INPUT IMPEDANCE, 10 megohms input resistance; 14 µf input capacitance, with low-capacitance probe.
HORIZONTAL SAW-TOOTH SWEEP, 10 cps to 100 Kc.
PHASE CONTROL for phasing sync and sweep voltages.
SYNC LIMITER provides automatic leveling.
FLAT-FACED POST-DEFLECTION TYPE TUBE enclosed in mu-metal shield. Operates at post-altor voltage of 3800 v for very sharp trace. RCA-SABP1 (medium persist.) supplied. User may install SABP1 (long persist.), or SABP11 (short persist.).
COMMERCIAL CAMERA ADAPTORS at cathode-ray-tube bezel.
Suggested User Price $425.00

RCA WO-56A 7" OSCILLOSCOPE, WITH IDENTICAL VERTICAL AND HORIZONTAL DIRECT-COUPLED PUSH-PULL AMPLIFIERS
 FREQUENCY RESPONSE, V and H. Flat within —2 db from 0 to 500 Kc, within —6 db to 1.0 Mc. Vertical sensitivity 0.03 v p-p/in. Horizontal sensitivity, 0.06 v p-p/in. Rise time approx. 0.45 µsec, with overshoot less than 2%. Frequency-compensated attenuator. BUILT-IN VOLTAGE CALIBRATION: HIGH INPUT IMPEDANCE, 10 megohms input resistance; 9.5 µf input capacitance, with low-capacitance probe.
HORIZONTAL SAW-TOOTH SWEEP, 3 cps to 30 Kc, with preset TV "V" and "H" positions.
SYNC: Internal "+" and "—", external, and line.
PHASE CONTROL for phasing sync and sweep voltages.

Suggested User Price $274.50

RCA WO-88A GENERAL-PURPOSE LOW-COST 5" OSCILLOSCOPE
VERTICAL RESPONSE: Flat within —3 db from 0 to 500 Kc; sensitivity, 0.07 v p-p/in. Average rise time approximately 0.5 µsec. Direct-coupled vertical amplifier. Frequency-compensated, voltage-calibrated attenuator.
HORIZONTAL RESPONSE: Flat within —6 db to 300 Kc; sensitivity, 1.7v p-p/in.
BUILT-IN VOLTAGE CALIBRATION: HIGH INPUT IMPEDANCE, 10 megohms, input resistance; 9.5 µf input capacitance, with low-capacitance probe.
HORIZONTAL SAW-TOOTH SWEEP: 15 cps to 30 Kc.
SYNC: Internal "+" and "—", external, and line.
PHASE CONTROL: for phasing sync and sweep voltages.

Suggested User Price $149.50

RCA WG-291 DEMODULATOR PROBE "Slip-on" probe for use with these RCA oscilloscopes. Input frequency 0.5 — 250 Mc. Input capacitance 2.23 µf. For modulation frequencies, 30 — 5000 cps. Max. input voltage 20 v rms. Max. dc rating, 250 v.
Suggested User Price $7.95

*Furnished with instrument.

For design, production, and maintenance — specify an RCA oscilloscope. See your RCA Distributor for complete details.
3 RCA OSCILLOSCOPES

Designed, built, and factory tested to insure dependable trouble-free performance under the most critical testing conditions. These scopes are especially suited for industrial applications, including: research, development, production, maintenance, and general servicing.

**5-inch 'SCOPE**

**Model WO-78A**

Wide Band: Frequency response is flat from 3 cycles to 4.5 mc, within 1 db, with direct sensitivity of 0.1 volt peak-to-peak per inch (0.035 volts rms per inch).

Narrow Band: Frequency response is flat from 3 cycles to 500 kc, within 3 db, with direct sensitivity of 0.01 volt peak-to-peak per inch (0.0035 volts rms per inch).

Full screen deflection is obtained over the entire rated frequency ranges of the vertical and horizontal amplifiers.

**5-inch 'SCOPE**

**Model WO-88A**

An efficient and reliable scope combining essential features with low price. Has built-in voltage calibrating facilities which permit simultaneous wave shape observation and peak-to-peak voltage measurements. Has sync-polarity reversal switch, and an input resistance of 10 megohms when used with low capacitance probe.

Net price complete with matched probes and cables including the WG-293 Low Capacitance Probe...

**7-inch 'SCOPE**

**Model WO-56A**

Identical vertical and horizontal direct-coupled, push-pull amplifiers have frequency-compensated and voltage-calibrated attenuator networks. Horizontal trace expansion is 3x screen diameter with comparable vertical centering to permit observation of minute trace details. Frequency response of vertical amplifier is flat from 0 to 500 kc, within 2 db, and from 0 to 1 mc, within 6 db.

Net price, complete with matched probes and cables including the WG-2168 Low Capacitance Probe...

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**PRODUCTION TECHNIQUES (continued)**

**FIG. 1**—Types of internally threaded coil forms and mating threaded iron cores

**FIG. 2**—Typical triangular or cloverleaf type coil form

major diameter of 0.249 inch plus or minus 0.001 inch. Due to the shape of this type of form, extreme care must be taken in production to avoid its being placed on a mandrel larger than the iron core. This is important because a slightly loose coil winding and slightly undersize core will give practically no torque. Conversely, a slightly oversize core and tight winding will bind, because reduction of torque depends on returning of the tube to its original shape or size, which the tight winding prevents.

A typical embossed form before and after forming is illustrated in Fig. 3. With this type, the form is the correct size before forming, since there is no decreasing or deforming of the diameter in manufacture. Strain to control torque
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Electronics — October, 1954

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does not depend on the return of the form to its original size when an iron core running to the high side of tolerance is used. An iron core running to the low side has three-point control and cannot lose torque or strip.

An iron core running to low limits is compensated for by the bosses at 0.220-inch diameter riding between threads at one place and over and between threads at two other points in any given 360-degree section. An oversized core is easily adjusted, as the embosses are merely forced back within close tolerances, automatically ad-

FIG. 4—Recommended winding arbor

justing torque by insertion. Control of the land on the thread peak is not required, since this has no bearing on the controlled torque—as long as it is controlled within reason.

With an internally threaded form, the depth of thread is a maximum of 0.006 inch. Only the outer 0.006 inch of the peak of the iron core engages the thread of the tube. The width of the thread in this type of coil form is necessarily very narrow. Precaution must be taken with regard to any increase in the radius at the peak (caused by wear of grinding wheels in thread grinding), since this might result in binding.

In the case of resin-impregnated tubes, which like the iron cores are abrasive, the possibility of undue wear on grinding and tapping tools exists. This can be controlled in the manufacture of the iron cores by close inspection of peak and by holding the land to a minimum. The danger here is in causing a weak point on the iron core as the result of two abrasive materials working against each other. In this event, before the core is inserted to the correct position in the coil, the peak may either be worn to a point where the iron core will bind
The new Type M Dynograph Recorder is a high speed direct writing oscillograph providing exceptionally high, absolutely stable, d-c or a-c amplification. It may be used with reluctance type pick-ups without auxiliary equipment. The exceptional stability, sensitivity, and versatility of the Dynograph allow simultaneous direct recordings of a very wide variety of transient variables such as temperature, speed, position, pressure, acceleration, vibration and strain.

The Type M employs individual plug-in amplifiers; and input panels provide all connections for various types of signal pick-ups. It is the most advanced equipment for your direct-writing recording problems.

**NEW**

**OFFNER TYPE M DYNOGRAPH RECORDER**

**WHY THE DYNOGRAPH?** For almost every application of direct writing oscillographs, those who have compared features of competitive instruments have chosen the Dynograph—because:

- The Dynograph provides thirty times the d-c sensitivity of competitive instruments.* Instead of a barely readable record like this:
  
- Yet while competitive recorders drift 1 mv per hour* or more the Dynograph is absolutely non-drifting.

- Other recorders require additional amplifiers or preamplifiers for moderate gain d-c; for high gain d-c; for carrier applications (strain gauges or reluctance bridges).
  
- With the Dynograph, one amplifier covers all applications—and does a better job on each!

- Pen friction and low torque gives hysteresis on many recorders.
  
- There is no measurable hysteresis on the Dynograph.

- Limited pen travel makes recording of large dynamic variations difficult.
  
- Over 8 cm of pen excursion is available in the Dynograph.

- Even at moderate sensitivities, other assemblies require considerable warmup time for stabilization.
  
- The Dynograph is stable as soon as it is working.

* Based on manufacturer's published claims.

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Eight page, 2 color bulletin describes technical details and application information. Write for your copy of Bulletin L-742.

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CdS Crystal Photocells
(CADMIUM SULFIDE TYPES)

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- NO AMPLIFICATION REQUIRED in 4 out of 5 applications. Cell activates inexpensive sensitive relay directly.
- FAST RESPONSE TIME — 5 milliseconds. Better than most fast relays.
- SENSITIVITY per unit area comparable with conventional photo-multipliers.
- LINEAR RESPONSE ... TINY 2MM\(^2\) SENSITIVE ELEMENT means greater accuracy for delicate measuring devices.
- SMALLER IN SIZE ... FAR LOWER IN COST.

From counters, headlamp dimmers, burglar alarms, process control and inspection devices to sensitive photoelectric measuring devices, these new Standard Piezo CdS Crystal Photocells pave the way to drastic cost and size reductions—even to the point of making photoelectric automation feasible for many home and industrial users where equipment costs have been prohibitive in the past.

Using a special cadmium sulfide sensitive element, these tiny photocells deliver from 1 to 2 milliamperes when illuminated with 50 to 100 footcandles and with a bias of approximately 100 volts. Inexpensive sensitive relays and the smallest batteries or power supplies can readily be used.

Standard Piezo CdS Crystal Photocells are supplied in two hermetically-sealed glass types and one subminiature type measuring only 1/4" in diameter by 1/4" long, including built-in lens. Still smaller styles with identical characteristics can be made to order.

FIG. 5—Methods of positioning embossed threads on coil forms

Under tension of the winding or become loose because of change in diameter due to wear at these weak points.

Specifications for iron cores should cover exact major diameter with tolerances, threads per inch, type of thread (full, shallow, etc) and breaking torque (on hex-hole or screwdriver slot).

Design Details

Figure 3 also illustrates the important factors in fitting a round into a round. Even a variation of 0.001 inch in core diameter makes a big difference in fit. The peak is also important, in that it will wear rapidly if sharp and thin. A peak of 0.007 to 0.015 inch is recommended. Increasing the pitch diameter will provide more material in the core and give more land at the peak. Always specify the length of the iron core to be used. This is a matter of friction; the longer the core, the greater the resistance.

The correct winding arbor must be used with any threaded form. Oversize arbors distort the thread formation during winding. Undersize arbors may cause collapse of the coil during the winding operation. A winding arbor should give
The dependable precision and stability built into TIC potentiometers is inherent in the new standardized line. In keeping with the trend to miniaturization of servo drive assemblies, these compact low torque potentiometers require minimum power from the driving source. Applications in airborne electronic equipment, guided missiles and computers as well as broad industry applications in conjunction with automatic control now enjoy simplified production through standardized assemblies.

Specifications common to the entire line of standardized potentiometers:

- Ball bearings for rigid, precise shaft support at low friction level.
- Ambient temperature range: -55°C to +80°C, standard. Special to +140°C in all sizes.
- Temperature coefficient resistance wire: 0.002% per degree C. Taps available.
- Rugged construction, low noise and long life plus conformity to stringent military specifications for humidity, salt spray, shock and vibration are but a few of the features of the new TIC standardized line.
- Versatility of unitized construction is available in the type STC18 permitting variable ganging and individual phasing as required. Modified for plug-in convenience — specify TYPE RVBC 1½.

STC18 UNITIZED CONSTRUCTION

Specifications of STC18, for example, offer:

- Resistance Range: 100 ohms to 100k.
- Independent Linearity: ±0.5% of total resistance, standard. ±0.2%, special.
- Electrical Rotation: 320° ± 2°, standard. Special angles and closer tolerance available.
- Power Rating: 3 watts @ 25°C.
- Torque: 0.5 oz. in., standard. Lower torque available.

TIC offers Type ST09 (1¾"

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<th>Type</th>
<th>Length</th>
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<tr>
<td>ST09</td>
<td>1¾&quot;</td>
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<tr>
<td>ST11</td>
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</table>
| ST15   | 1½"
| ST18   | 1¾"    |
| ST20   | 2"     |
| ST30   | 3"     |

All in either linear or non-linear functions

The TIC policy of setting and maintaining the highest standards of precision potentiometer manufacture assures your confidence and satisfaction. Whether for standardized potentiometers or custom design your inquiry is invited.

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ELECTRONICS — October, 1954
Are your High-Cycle Alternator requirements special?

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AMERICAN ELECTRIC REVOLVING FIELD ALTERNATORS

CAPACITY RANGE—15 KVA to 40 KVA (in stock). Up to 75 KVA on special order.

FAST RECOVERY—Better than .2 seconds.

LOW VOLTAGE OVERSHOOT—Less than 10%.

TOTAL HARMONIC CONTENT—Under 5% on unbalanced 3-phase loads.

These characteristics apply to general uses, where applications are specific, even better characteristics can be developed.

Where lowest possible maintenance, combined with excellent wave form characteristics are required, it's hard to match American Electric's Inductor-Type Alternators. But occasionally special requirements arise which may be better served by American Electric's Revolving Field Alternators.

EXCITER REGULATING SYSTEM

Employs American Electric's trouble-free, direct-connected, high-cycle Inductor Alternator—which has no commutator, slip rings, brushes, springs, etc. Output is rectified and exciter-regulated by either electronic or magnetic amplifier means, then returned to the rotating field of the main alternator.

MANY MODELS

American Electric Revolving Field Alternators are available in STATIONARY and PORTABLE TYPES, open and totally enclosed models, for all laboratory, production and testing applications.

Write for details and quotations outlining requirements.

Vibration and Heat Test for Two-Way Radio

MOBILE two-way radio communication equipment is put through a combination of vibration and heat cycling to bring out defects that might cause early failure of the equipment, in the Communications and Electronics Division plant of Motorola Inc. in Chicago. Each unit in turn is placed on a Syntron vibrator for one-half minute. A wood rail mounted on the platform of the vibrator prevents the chassis from sliding off. After this, the chassis is lifted onto a conveyor belt for its trip through an oven containing 24 250-watt infrared heat lamps. For some tests the lamps are cycled on and off every 20 minutes during a 2-hour trip through the oven.
Allies' Precision Deposited Carbon RESISTORS

Ambient Temperatures from $-70^\circ$ to $+250^\circ$ C

One Per cent Standard

Allies' Products precision carbon deposit resistors are replacing wire wound resistors in many circuits requiring high precision at low cost.

Allies' Products resistors are the standard of many computer and missile manufacturers.

Typical temperature coefficient characteristics for Allies' Products carbon deposit resistors.

Typical derating curves for 1/2 watt Allies' Products carbon deposit resistors.

VALUES and SIZES

<table>
<thead>
<tr>
<th>RESISTOR</th>
<th>WATTS</th>
<th>OHMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>APT-5</td>
<td>5</td>
<td>20 ohms to 20 meg. ± 1%</td>
</tr>
<tr>
<td>APT-2</td>
<td>2</td>
<td>10 ohms to 50 meg. ± 1%</td>
</tr>
<tr>
<td>APT-1</td>
<td>1</td>
<td>100 ohms to 50 meg. ± 1%</td>
</tr>
<tr>
<td>APT-1/2</td>
<td>1/2</td>
<td>10 ohms to 10 meg. ± 1%</td>
</tr>
<tr>
<td>APXT-1/2</td>
<td>1/2</td>
<td>5 ohms to 2 meg. ± 1%</td>
</tr>
<tr>
<td>APT-1/4</td>
<td>1/4</td>
<td>1 ohm to 3 meg. ± 1%</td>
</tr>
<tr>
<td>APXT-1/4</td>
<td>1/4</td>
<td>5 ohms to 1 meg. ± 1%</td>
</tr>
</tbody>
</table>
NEW PRODUCTS

Edited by WILLIAM P. O'BRIEN

65 New Products and 57 Manufacturers' Bulletins Are Reviewed... Control, Testing and Measuring Equipment Described and Illustrated... Recent Tubes and Components Are Covered

SIGNAL GENERATOR
for one color presentation

KAY ELECTRIC CO., Pine Brook, N. J. Model Uni-Chrome Chromabar is for single color presentation. Colors generated are: green, yellow, red, magenta, blue, cyan, white and black. A switch on the panel selects any color desired. Black and white bars are provided simultaneously with each other and a dot generator providing small, sharp dots is built in to permit checks on convergence and linearity of color receivers. Output at video frequency is variable to 1.4 v peak-to-peak positive and negative, into a 75-ohm load. It includes a crystal controlled color subcarrier and built-in horizontal sync generator. Price is $395.

TRANSDUCER
for industrial automation

GENERAL CYBERNETICS ASSOCIATES, P. O. Box 987, Beverly Hills, Calif. Model 154 linear motion transducer is completely free from changes in scale factor with variations in frequency, excitation voltage and temperature over wide ranges of these parameters. It is designed for application in industrial automation as an electronic gage, monitor and control system sensor. It operates from excitation voltages of 28 v to 115 v, 60 to 600 cycles. Output voltage is a function of input voltage and ranges from 3 v with a 28-v input to 30 v with 115-v input. Output voltage is linear with armature displacement from 0 to 0.12 in. with 0.25-percent accuracy and up to 0.25 in. with 0.5-percent accuracy. This output is symmetrical about a mechanical null position or can be in one direction.

TAPING GUN
with slender curved tip

MINNESOTA MINING AND MFG. CO., 900 Fauquier St., St. Paul 6, Minn. Electrical harness wrapping can be speeded up from 2 to 10 times using plastic tape dispensed by the model E-2 taping gun. It is specifically designed for 3/4-in.-wide Scotch brand plastic electrical tape No. 33. Weighing less than 20 oz with a 36-yard roll of tape in the circular magazine, the lightweight gun makes it possible to bundle the wires and cut the tape in a single easy motion taking about 1 second. In use, the tape protruding from the end of the gun is stuck to the wires by the thumb, threaded around the bundle by the curved tip, and then cut with a touch of a thumb button. The end of the tape is pressed down to complete the wrap. The slender 10.5-in., curved tip serves as a convenient needle to thread the tape around wires on a cable layout board or in spots that would be difficult to reach.

CERAMIC CAPACITORS
are voltage-sensitive

MUON CORP., 9 St. Francis St., Newark, 5, N. J., announces development of voltage-sensitive capacitors, a group of subminiature cera-
Big Savings Ahead

2 New SYLVANIA SOCKETS save Assembly Time... Cut Costs ... Improve Performance!

1. New Sylvania 7-pin Miniature Printed-circuit Sockets. Contacts and center shield are shaped so that sockets can be stacked one upon another for automatic feeding and assembly. Small slots are used on the circuit board to receive the contacts, resulting in stronger chassis construction. Only one socket assembly need be stocked since terminals can be interconnected by printing the circuit on the chassis board rather than using a metallic connector on the socket itself.

Insulator is molded of general-purpose or low-loss phenolic. Contacts are brass or phosphor bronze, plated to suit your specification. Supplied with or without center shield. Now available in 7-pin construction with 9-pin miniature and other types to follow. Tube Shield Ground Strap can also be furnished.

2. New Sylvania Solderless-type Sockets for wire-wrapped connections are now being made in all 7 and 9-pin miniature sizes. Contacts are shaped to provide reliable connections with the use of present wire-wrapping tools.

For full information concerning these or other Sylvania parts, or special quality components engineered to your own specifications, write to Dept. 4A-1610, Sylvania today.

See the full story of Sylvania's Fabricating Services in Sweet's Catalog—Product Design File. Look for 1b Sy

SYLVANIA
Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.
In Canada: Sylvania Electric (Canada) Ltd., University Tower Building, St. Catherine Street, Montreal, P. Q.

LIGHTING • RADIO • ELECTRONICS • TELEVISION

ELECTRONICS — October, 1954
mic capacitors whose capacitance may be varied by a change in applied d-c potential. The capacitance may be decreased as much as 60 percent by the application of potential up to 500 v d-c. Inasmuch as these units are also temperature-sensitive, two types are available: type VSR, whose voltage sensitivity is maximum at room temperature, and type VSE whose voltage-sensitivity is maximum at approximately 70 °C. The latter is intended for use in a controlled environment, such as a small crystal-type oven, to avoid problems caused by variations in ambient temperature. Body sizes start at approximately 6 in. square by 0.080 in. thick; leads are normally No. 26 gage tinned copper wire arranged axially. Capacitance values of approximately 300 µf and larger may be obtained.

**BALANCED MODULATOR**

*for pulse applications*

GENERAL RADIO Co., 275 Massachusetts Ave., Cambridge 39, Mass. Type 1000-P7 balanced modulator has a modulation-frequency response flat from d-c to 20 mc, thus making it suitable not only for short pulses but for any wide-band modulation. The usable carrier-frequency range extends from 60 to 2,300 mc and 100-percent a-m can be obtained throughout this range. Double-sideband suppressed-carrier modulation, and pulse modulation with 60-db carrier suppression between pulses are also possible throughout the entire carrier frequency range. Television video is easily handled by the balanced modulator even through the uhf tv band. Other applications include tests on microwave relay systems using multiplex pulse-code modulation, on omni-range and DME equipment, on telemetering circuits and on high-resolution radar.

**SOLDERING TOOLS**

*have lead-pencil weight*

TELEVISION ACCESSORIES Co., Box 6001, Arlington 6, Va. Weighing as little as 1/2 oz, the new line of ORYX miniature soldering instruments offer unusual advantages to manufacturers of precision equipment. A length of only 6 in. combined with a weight comparable to that of an ordinary lead pencil means increased production by reducing hand fatigue. These soldering instruments have no ceramic or mica formers to flake or break. They heat in as little as 20 sec and are available in a variety of voltages and tip styles as small as 3/8 in. diameter. The ORYX soldering tools, a product of Great Britain, are used throughout the world by manufacturers, laboratories and service technicians. Write for a catalog sheet and full details on the model 6 transistor soldering tool.

**NEUTRAL BAR**

*is strong and adaptable*

ILSCO COPPER TUBE AND PRODUCTS, INC., Mariemont Ave., Cincinnati 27, Ohio. The CAN neutral bar is compactly built and actually saves many minutes of time as compared to the old style washer head screw neutral plates commonly used. By forging the circuit bars into the main line connectors at a 20-deg angle for easy wire insertion of every branch circuit wire these neutral bars have been developed into units of unusual strength and adaptability. The illustration shows the neutral bar on a plastic block to be used for mounting. (It is sold with or without the mounting block). Quick, excellent connections are assured as wires are inserted in the V-shaped hole when the screw is pulled down. Larger wire range is offered as circuit taps take No. 14-6 and the main line load is 250 MCM-6. A 100-percent extra hard drawn seamless copper tubing is used to build CAN neutral bars for better conductivity and required maximum strength. Samples, detailed information and prices will be furnished on request.

**CARRIER AMPLIFIER**

*has wide frequency range*

CONSOLIDATED ENGINEERING CORP., 300 N. Sierra Madre Villa, Pasa-
Working for You—on Raytheon's Payroll

In tackling new system design problems, what counts is to have the right answers at the right time. Here's where you can lean heavily on the help of Raytheon Application Engineers—gratis!

Teamed together, your engineers working with ours can determine the tube requirements of your proposed microwave system: Which Raytheon Klystron is best suited? Which Magnetron? Should an existing tube be modified? Is an entirely new design called for?

Obviously this teamwork lessens the burden on your systems engineers, lets them concentrate on equipment designs, while our engineers assist you in selecting the right tubes. Raytheon specialists help you all along the line—on design, production and quality control—without cost to you.

It pays to consult the leader about Magnetrons and Klystrons right from the start. And, wherever you are, Raytheon is ready to assist you with both military and commercial equipment plans. Write for Raytheon's valuable Tube Data Booklets—and ask for details of our free Application Engineer Consultation Service.

RAYTHEON
Excellence in Electronics

RAYTHEON MANUFACTURING COMPANY
Microwave and Power Tube Operations, Section PL 05, Waltham 54, Mass.
Another NEW Fairchild Precision Potentiometer

The basic Type 910 rectilinear potentiometer is flexible in design to accommodate dual resistance elements, various stroke lengths, double shaft extensions, external fixed resistors, various methods of actuating, and a broad range of shaft speeds. It meets or exceeds military specifications for vibration and high and low temperature exposure. A mandrel resistance element of all-welded construction, aged and stabilized for accuracy and long life, provides small diameter, uniform cross section and a smooth operating surface for the new one-piece wiper design. Rigid mechanical construction maintains initially-tight electrical tolerances throughout stringent environmental and performance conditions.

Another reason why Fairchild can supply ALL your precision potentiometer needs

Fairchild makes a complete line of precision potentiometers to fill all your needs—linear and nonlinear potentiometers, singly or in ganged combinations... single-turn, helical and linear motion... and with resistance elements to meet your requirements.

Fairchild guarantees accuracy of ±1% or better in nonlinear types and ±0.5% or better in linear types. Highly accurate production methods and close mechanical tolerances, plus thorough type-testing and quality control, provide high resolution, long life, low torque and low electrical noise level in every Fairchild potentiometer. For more information, or for help in meeting your potentiometer problems, call on Fairchild Camera and Instrument Corporation, Potentiometer Division, 225 Park Avenue, Hicksville, L. I., N. Y., Department 140-57A1.

GRID-DIP OSCILLATOR for uhf-band applications

Measurements Corp., Boonton, N. J. Model 59-UHF megacycle meter covers the range of 430 to 940 mc. It incorporates a unique oscillator with a split-stator tuning capacitor arranged so that a fixed coupling point is at the center of the oscillator inductance. Coupling sensitivity is excellent and grid current variation is minimal over the entire band. The oscillator output is either c-w or 120-cycle modulated. Linear calibration is provided with a calibration point every 10 mc (individually calibrated) and accuracy is better than 2 percent. The unit has many uses, such as measuring resonant frequencies of passive circuits; as an auxiliary signal generator for alignment and tuning of uhf receivers and trans-
EXCLUSIVE* ELECTRO TEC TECHNIQUES

insure closer tolerances, absolute uniformity, and the ultimate in miniaturization

Electro Tec units are the product of an exclusive manufacturing technique that results in accuracy unattainable by conventional fabricating methods. In this process a plastic is molded around the wire leads. Accurate machining reduces this blank to the proper shape, complete with grooves. Hard silver is deposited into the grooves by electroplating to produce the required rings. Final machining insures concentricity and dimensional accuracy. The result is one-piece, unitized construction with conducting rings of 60 to 70 Brinell hardness.

Diameters of these assemblies range from .045" to 24.0" cylindrical or flat. Cross-sections may range from .005" to .060" or more. Rings are polished to a jewel-like finish and can be held to 4 micro-inches or better. Even the smallest sizes withstand a 1000 V.A.C. breakdown test. Most types easily withstand rotational speeds up to 12000 rpm.

ELECTRO TEC Assemblies are Specified by the Nation’s Leading Precision Instrument and Equipment Manufacturers for Proven Greater Dependability, Longer Life, Smoother Functioning.

The uniformly superior performance of Electro Tec slip ring and commutator assemblies in thousands of industrial and governmental applications has resulted in wide adoption of these component units by most leading manufacturers of precision instruments and equipment. Although these products provide improved performance and extra dependability, prices are strictly competitive. Write today for fully illustrated literature.

ELECTRO TEC CORPORATION
30, HACKENSACK NEW JERSEY

PRODUCTS OF PRECISION CRAFTSMANSHIP BY A NEW AND REVOLUTIONARY PROCESS
Since **WHEELER** has had long experience in manufacturing precision-controlled insulated magnet wire so fine you can barely see it, it is only natural that our engineering people have been working with miniature and sub-miniature coil and transformer units from the inception of miniaturization.

The important NEW TINY-MITE series of transformers is one result of this work. Tiny-Mite Transformers, with unusually excellent typical characteristics, are ideal for use in transistor and printed circuits, control, guided missile, and similar applications where space, weight, and size are prime factors.

Tiny-Mite Transformers are assembled with nickel alloy laminated cores, with fine wire coils wound on nylon bobbins. Windings are terminated with special care and technique to insure maximum protection to leads.

Tiny-Mite Transformers are varnish-treated and can be supplied open frame with 3" color coded leads, or in metal shells, hermetically sealed, and with #22 tinned leads soldered to header terminals to facilitate assembly.

Tiny-Mite Engineering Data Sheets are available on request to Wheeler — producers of fine gauge magnet wire, specialized coils, and transformers. Your own special needs can almost certainly be met by standard units in this new series, or by possible modifications. We will welcome your inquiry.

**THE WHEELER INSULATED WIRE COMPANY, Inc.**
Division of The Sperry Corporation
1101 East Aurora Street, Waterbury 20, Connecticut

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**NEW PRODUCTS** (continued)

mitters; as an oscillating or absorption marker for use with a sweep-frequency-generator; and as a low-sensitivity receiver or field-strength meter for tracing sources of spurious oscillations in receivers and transmitters. It is encased in an octagonal metal box 2½ in. deep and 4½ in. wide.

**PLUG-TERMINALS**

meet MIL-T-27 requirements

**Triad Transformer Corp., 4055 Redwood Ave., Venice, Calif.** Type A-4098 hermetic seal terminals are fitted with an octal plug which mates with a standard octal socket. They feature gold alloy plated solid brass pins to promote easier soldering and prevent corrosion and are available with either rolled or flat flanges. The rolled flange will fit either a 1-in. or 1¼-in. o.d. round can.

**TERMINAL BLOCK**

with from 1 to 7 contacts

**Elcon Electronics, Inc., 840 Fifth Ave., Brooklyn 32, N. Y.** The molded feed-through terminal block illustrated is available with from 1 to 7 contacts (¾ in. to 2½ in. long). It features one-piece solid terminals of brass, gold plated over silver plate. Plated brass bushings molded into mounting recesses provide added strength for mounting and reduce breakage. They are supplied in four different JAN specification thermosetting materials and a choice of seven...
**makes PERFECT PREFORMS from MOLDED POWDERS**

*custom-made to exact specifications*

**INVESTIGATE MANSOL'S TECHNICAL KNOW-HOW TODAY AT NO COST OR OBLIGATION**

Mansol's engineers are at your service, ready to discuss your powder molding problems, whether they be seals, spacers, or lead through bushings.

If you are still making your own preforms, Mansol would like to show you how to save money and eliminate rejects.

Research, Engineering and Manufacturing skills guarantee the highest standards of: QUALITY — UNIFORMITY — CLOSE TOLERANCES.

**FAST DELIVERY**

**GLASS PREFORMS** — The ideal preforms for Iron Sealing, and Kovar Sealing, matching the expansion of these metals over their entire working range. They resist mercury attack, have ample mechanical strength, and seal readily. Our laboratory is prepared to assist you in selecting the proper glass for any metal.

**FORMULA 800 PREFORMS** — An Epoxy Resin in preforms to improve production efficiency. Possesses extremely high bonding strength, with no shrinkage, on metals to metals and metals to non-metals. This is a new chemical resistant material of construction that warrants consideration when the properties of standard resin cements and coats are not adequate for the service desired.

**STEATITE PREFORMS** — We specialize in small die-pressed ceramic parts held to closest tolerances. All tools and dies are made in our own shop to assure quick delivery. For immediate attention to your order, contact Mansol today.

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**MANSOL CERAMICS COMPANY**

140 LITTLE STREET, BELLEVILLE, N. J.

**CABLE ADDRESS**

MANSOL
TAPE RECORDER
is portable, battery-operated

AMPLIFIER CORP. OF AMERICA, 398 Broadway, New York 13, N.Y. The VU Magnemite, battery-operated, spring-motor recorder is designed for extreme simplicity of operation. One, two, three and four-speed models are available utilizing consecutive speeds from 1½ ips to 15 ips. Models employing speeds of 7½ and 15 ips meet primary as well as secondary NARTB standards and record or play-back frequencies up to 15,000 cycles. The unit discussed measures 6½ x 9½ x 14 and weighs only 19 lb complete with flashlight-type batteries which have an operating life of 100 hr. Constant tape speeds with low flutter of ±0.1 percent over the full winding cycle is achieved by a centrifugal ball-bearing balance triply compensated flyball governor on the spring motor. Equalization for different speeds is automatic.

SCOPE CALIBRATOR
measures peak-to-peak voltage

SERVICE INSTRUMENTS Co., 422 S. Dearborn St., Chicago, Ill., is manufacturing an oscilloscope calibrator for quickly and accurately measuring peak-to-peak voltages. The system employed is a comparative method where the line voltage is calibrated and compared in amplitude to the unknown waveform on the scope. Two mounting bars are provided so that the meter can be
Takes 22,000 sparks per minute at 140-mph... without electrical loss!

Top of Wells' new "Super Go" ignition coil, C-1850, is molded of Resinox 3700. This coil out-performed all others in racing car tests on Utah salt flats... losing no spark power at speeds up to 140-mph! Manufacturer claims this coil on passenger cars will give same heat and spark at 80-mph as at 40-mph, saving gas and giving same pickup at both high and low speeds.

RESINOX 3700

Wells Manufacturing Company of Fond du Lac, Wisconsin, needed an ignition coil top that combined tremendous arc and heat resistance with outstanding dimensional stability and toughness. After extensive tests, they selected Monsanto's thermosetting molding powder, Resinox 3700. Speed test results proved the wisdom of their choice!

Resinox 3700 is the ideal all-around material for magneto ignition, motor control and electronic circuits, and other electrical applications.

1. It combines high arc-resistance with excellent dimensional stability. Eliminates undesirable after-shrinkage.
2. It has relatively good impact resistance and outstanding moldability, including good transfer molding properties.
3. It offers superior heat resistance.

Perhaps Resinox 3700 is exactly what you need to solve an electrical equipment problem. Write today for full information!

Monsanto Chemical Company, Plastics Division, Room 2505, Springfield 2, Mass.

Please send me complete information on Monsanto's new Resinox 3700 arc-resistant material.

Name & Title
Company
Address
City, Zone, State

Want more information? Use post card on last page.
SPECIALS may match the prices of STANDARDS

If ordered in fair quantities, recessed hex head screws cost no more than standard machine screws, and actually much less than trimmed hex head screws.

The saving results from elimination of one production operation, without loss of mechanical values. The difference is in appearance. And even that may be in favor of the recessed head.

To order only, made to standard dimensions in sizes to suit your needs or to your specifications.

Get our prices and deliveries on your requirements. In fact write us about special upset, and rolled thread products of any kind. The cost may be lower than you think.

MACH NUMBER COMPUTER is light and accurate

SERVOMECHANISMS, INC., 500 Franklin Ave., Garden City, L. I., N. Y. The CA-500 force-balance mach number computer, requiring no external pressure transducers or vacuum tubes, is designed for use in commercial and military aircraft. It weighs only 4½ lb and provides accuracy of 0.01 mach for 95 percent of lab test points. It measures approximately 5½ × 5½ × 4 in. high. The unit features simple design and maximum versatility. It is a precision 400-cycle instrument and solves the equation for mach number through the utilization of a force-balance linkage, mechanically comparing differential and static pressures.

MODULATION METER for 25 to 500-mc range

LAMPKIN LABORATORIES, INC., R.F.D. No. 1, Bradenton, Florida. Model 205-A f-m modulation meter has a frequency range of 25 to 500 mc. While primarily designed for 2-way radio maintenance, it has many uses in the laboratory. It measures f-m deviation ±0-25 kc, with an accuracy within 10 percent at full scale on a 3-in. meter cali-
The outstanding capacitor for high fidelity and high frequency applications

To the long list of Cornell-Dubilier “firsts” add another important development: the C-D Budroc* steatite-cased tubular capacitor. It is unquestionably the finest paper tubular ever made for the initial equipment manufacturer.

Budroc capacitors are non-inductively wound and housed in a tube of the finest ceramic (steatite) completely fabricated in our own plant, under close and constant supervision and quality control from start to finish. The specially developed C-D end fill will not soften, melt or flow at any rated operating temperature.

Send for engineering samples of this superb humidity proof, new C-D capacitor! Use our Technical Advisory Service for your special application problems. Bulletin NB-154 on request.


THERE ARE MORE C-D CAPACITORS IN USE TODAY THAN ANY OTHER MAKE

CORNELL DUBILIER Capacitors

PLANTS IN SOUTH PLAINFIELD, N. J.; NEW BEDFORD, WORCESTER AND CAMBRIDGE, MASS.; PROVIDENCE AND HOPE VALLEY, R. I.; INDIANAPOLIS, IND.; TOOGOOD SPRINGS AND SANFORD, N. C.; AND SUBSIDIARY, THE RADIANT CORPORATION, CLEVELAND, OHIO

ANTENNAS ROTORS CAPACITORS VIBRATORS CONVERTERS

ELECTRONICS — October, 1954

Want more information? Use post card on last page.
We have been making polarized relays for a number of years and at the present time find, to our own surprise, that we have seven basic types in production, ready for production, or in the prototype stage. We have analyzed their relative usefulness for our own information. The condensed result may be of interest.

First, as to polarized relays in general, a word or two. All of them respond according to polarity of a direct current applied to their coils, or “follow” (if they can) an alternating current. All of them can be wound with two separate coils, responding to the magnitude and polarity of the difference between the two (opposed) coil currents.

Depending on arrangements, some “latch” or “remember”, occupying either of two switch positions indefinitely until a new pulse of opposite polarity is received in the windings (our “Form Z”). If to this type, spring bias is added so it will remain in only one of the two positions unless current of proper polarity is applied to oppose the spring, it is called “biased polar” (our “Form Y”). Finally, if some other involved centering mechanism are added, it will stay in neither position without coil signal but occupies one midway between. Of course, a simple stiff spring would do this but in an undesirable way. (Treatise available.) The result is a “5-position” or “null-seeking” relay (our “Form X”).

**TINY TUBULARS**

with right angle leads

**NEW PRODUCTS (continued)**

brated in kilocycles. It can also be used as a relative field-strength meter, and has a built-in speaker and a jack for an oscilloscope. Its small size (7 in. x 12 in. x 7½ in. deep) and light weight (less than 14 lb) make it ideal as either a laboratory or portable instrument.
"SELLING ENERGY"

and HOW TO MOVE ELECTRONIC PRODUCTS

From the mathematical problems worked out on a scratch pad to the prototype in the experimental lab, the electronic product, ready for the production line, has involved many man hours and dollars. As a manufacturer, you have spared nothing in time and money perfecting your product.

But, does it end there?

From a hard-headed businessman's point of view, (getting dollars returned for dollars invested) selling the product demands the same expert attention that is required during product design and development. The fact of the matter is: when the CORRECT market is found, prospective buyers will KNOW about your product and then "the mountain will come to Mohammed."

There is one way ... the expedient, efficient way of getting to the correct market and its buyers. You direct your sales effort throughout the industry with sure-fire directness in the sales pages of ELECTRONICS and reach the ones who design-in your products and the ones who will find new uses for your products. The more than 35,000 selected subscribers ... less than a cent apiece to reach each potential purchaser, in the pages of ...
These fly-back transformer coils look alike. But they're not.
Their mission in life is slightly different.
Their specs are different.
Their manufacture by Stone involved a completely different sequence of steps because the end use of each is slightly different.

This is a splendid illustration of the versatility of materials used by Stone. Because of this, Stonized spiral wound phenolic impregnated paper tubes have a distinct advantage over other basic materials which have to follow a rigid sequence of steps of manufacture.

Let one of our conveniently located representatives call on you. He will quickly show you how Stone can adapt its wide range of materials and manufacturing processes to your problem.

MINIATURE PENTODE
for use as wide-band amplifier

RAYTHEON MFG. Co., 55 Chapel St.,
Newton 58, Mass., Type CK6485
miniature pentode is now available
for all applications where the tube
must be capable of good life while
operating under very small or zero
cathode current. Electrically it is
like the 6AH6 which has high
mutual conductance and a good
figure of merit. A recently pub-
ished bulletin gives mechanical
and electrical data and characteris-
tics charts.

H-V CONVERTER
weighs less than 3 oz

PRECISE MEASUREMENTS Co., 942
Kings Highway, Brooklyn 23,
N. Y., has available a tiny h-v con-
sector that delivers any voltage
from 0 to 7,000 v by simply connect-
How the right tapes speed coil winding at Minneapolis Honeywell

Applications like these are typical:
1. "Scotch" Electrical Tape No. 11 insulates and holds coil lugs in place.
2. "Scotch" Electrical Tape No. 29 fastens down valve coil leads for gas furnaces.
3. "Scotch" Electrical Tape No. 38 anchors and insulates five leads to relay coil.
4. "Scotch" Electrical Tape No. 38 holds start and finish leads on stick-wound relay coils.

WANT TO KNOW which "Scotch" Electrical Tapes are right for your coil-winding operations? Write Minnesota Mining and Manufacturing Co., Dept. E-34, St. Paul 6, Minnesota.
BOURNS instruments feature the finest design and workmanship in wire-wound potentiometry. Their precise electrical signals, requiring no amplification, are used in control systems, telemetering networks and recording circuits. Rugged construction guarantees accurate and dependable performance during the severe shock, vibration and acceleration conditions encountered in aircraft and industrial applications.

Physical variables such as linear displacement, acceleration and pressure are measured to an accuracy of 0.25% of instrument range. Single or dual potentiometers and linear or functional outputs are a few of the many characteristics that can be provided. Besides the hundreds of standard models and ranges available, special designs may be developed for individual requirements.

BOURNS TRIMPOT®—the ultimate in subminiaturization—are used for circuit trimming in miniaturized assemblies subjected to extreme environmental conditions.

BOURNS many years of experience in specialized potentiometer instrumentation, plus modern production facilities, assure you of the highest quality instruments attainable.

CONDUCTIVITY CELL
for lab applications

INDUSTRIAL INSTRUMENTS, INC., 89 Commerce Road, Cedar Grove, N. J. Improved model conductivity cells of the jacketed type for dip-use are now available for laboratory applications. The cells are designed for conductivity measurements under specific temperature requirements. A Pyrex glass tapered stopper is incorporated as an integral portion of the cell, while an oversize special test tube serves as a jacket. The cell is available in constants from 0.01 to 100.

A-C DECADE BOX
for wide resistance

ELECTRO-MEASUREMENTS, INC., 4312 S. E. Stark St., Portland 15, Oregon. A versatile new a-c decade box provides more than a mil-
POINT-TO-POINT FM

VHF RADIO-TELEPHONE LINK

This Equipment will provide first-class single channel point-to-point facilities and, at the same time, possesses the necessary capacity for extension to six channels if required.

**ABBREVIATED SPECIFICATION**

- **Frequency range:** 60–216 mc/s
- **Transmitter output Power:** 10 watts or with Amplifier Unit — 50 watts
- **Maximum Deviation:** 50 kc's
- **Receiver Bandwidth:** 6 db down + 120 kc/s
- **Overall Transmitter-Receiver Performance**
  - **Frequency Response:** 300 c/s — 6 kc/s ± 3 db; 6 kc/s — 36 kc/s ± 1 db
  - **Intermodulation Level:** At least — 55 dbm for 2 tones applied each at 0 dbm

**Telecommunications**

CAMBRIDGE | ENGLAND

**PYE LIMITED • • CAMBRIDGE • • ENGLAND**
This does not tell the whole story by any means, but it does indicate the growing acceptance of this powerful motor for all types of instrument and control applications which require constant speed and dependability even under adverse environmental conditions. The complete story is yours for the asking. Write today.

SQUELCH UNIT
is completely self-contained
THE HAMMARLUND MFG. CO., INC., 460 W. 34th St., New York 1, N. Y., has designed a Codan squelch unit that activates a normally silent Super Pro-600 receiver at a predetermined signal strength. The unit's threshold of operation is adjustable to any predetermined level within the range of r-f signal inputs of 0.5 to 100 μV. A change in signal carrier level of 2 dB or less will complete the switching action of the squelch regardless of threshold setting. Once the receiver is operating it will function as long as the signal continues. The unit is completely self-contained and is available separately for use with...
WHAT ARE YOUR SLIP RING ASSEMBLY REQUIREMENTS?

list them on the dotted lines:

- **size**...

  Complete PMI Slip Ring Assemblies we have made range in size from .080" diameter by .450" long to 40" diameter by 8' high, weighing as much as 3100 lbs. We can make them smaller or larger — tailored to your exact requirements.

- **application**...

  PMI Slip Ring Assemblies surpass severe shock, vibration and water test conditions of MIL-E-2036A and MIL-T-17113 . . . provide trouble-free operation at 60,000 feet, resist fungus and corrosion.

- **electrical data**...

  PMI Slip Ring Assemblies have a Voltage Range from microvolts to more than 20,000 volts corona free; Current Range from microamps to more than 600 amps; number of circuits more than 500; typical Brush life 14 million linear feet; Frequency from DC to more than 60 mc.; Noise Level under all customer specifications has been met or bettered.

- **quantity**...

  Production on small Synchro Slip Ring Assemblies runs as high as 1000 per day. Ample manufacturing facilities make low-cost large runs possible.

- **mail this page TODAY for immediate attention to your problem**...

  NAME  POSITION

  COMPANY  ADDRESS

  If your requirements are in the specification stage or in production, PMI engineers will submit, at your request, a design layout or evaluate your present design layout for possible measures of economy or efficiency. Our diversified experience in designing and manufacturing Slip Ring Assemblies can save you time and money. Mail this page today.

P M INDUSTRIES, INC., - STAMFORD • CONN.
DESIGN • DEVELOPMENT • PRODUCTION • ELECTRO-MECHANICAL ASSEMBLIES

ELECTRONICS — October, 1954

Want more information? Use post card on last page.
Development and equipment. Leach has become the leader in electro-mechanical products, made for industrial applications and manufacturing background. They serve the organization of scientific and economical operations.

4... Specialized electrical equipment

4 individual, electrical companies geared to mesh for efficient, economical operations... modern production facilities, outstanding scientific and engineering talent co-ordindated by a stable corporate organization to benefit the customer as well as the industries which they serve. **Customer satisfaction** is the prime consideration that governs policy and practice at Leach.

These companies are all pioneers in electrical progress with a total background of more than 100 years of leadership in designing and manufacturing precision equipment for aircraft, commercial and industrial applications... proud of the many advancements their products have made possible in the field of electrical, electronics, electro-mechanical systems, communications and instrumentation.

For aircraft, commercial and industrial efficiency and safety... Leach has become The Most Trusted Name in Specialized Electrical Equipment.

Research
Development
Design
Production

**DIELECTRIC HEATER**

... is crystal controlled

**ERICO ENGINEERING CORP., Addison, Ill.**, has developed a dielectric heater to be used with automatic machines for more efficient plastic sealing, packaging, dehydration, food processing, deinfestation, tobacco processing and instantaneous drying of foundry cores. It is a new r-f generator which is crystal controlled and cannot deviate from the assigned frequency. All shielding is completely eliminated. Standardized units are now in production in 1, 2, 3 and 5-kw output. The company is presently engineering units in sizes up to 100 kw. The electronic unit illustrated is composed of 3 chassis, each of which may be removed or replaced individually. The entire unit is housed in a cabinet that occupies only 23 in. x 24 in. floor space. The simplified controls are designed to provide easy operation, with complete operator safety and trouble-free maintenance.

**PHOTOELECTRIC CELLS**

... use junction transistors

**STANDARD TELEPHONES AND CABLES LTD., Warwick Road, Boreham**
new ARC course indicator gives you two instruments in one!

Now users of the light, compact ARC Type 15D navigational receiving equipment can employ a single panel instrument that performs the work of two units previously used. The cross-pointer meter and the course selector have been combined into one part that fits a standard 3½" instrument hole.

This saving in instrument panel space is important, particularly now that dual VOR installations are so popular. In addition to the space saving, installation costs are cut.

Ask your dealer to specify the new #16706 Course Indicator as part of your 15D installation – whether single or dual. The indicator may be purchased separately for use with older Type C and D equipment. Write for complete data.

Aircraft Radio Corporation
BOONTON • NEW JERSEY
new
RAYTHEON
2KVA

VOLTAGE STABILIZER

with Magnetic Amplifier Control

This latest advance in voltage stabilizer design by Raytheon gives you these outstanding advantages of Magnetic Amplifier Control: (1) lower harmonic content (2) better no load to full load regulation (3) less cubic space required and (4) ability to take heavy overload without damage.

Write for complete information.

NEW
Model W-6710
Voltage Stabilizer
OPEN TYPE CONSTRUCTION
FOR CHASSIS MOUNTING

Insures constant 6 volts output at 25 watts, stab-
iliized to ±10% from an input of 95 to 130 volts. Designed for 6-volt incandescent reference lamps; for colorimeter or spectrophotometric instru-
ments and for stabilized filament voltages to tubes used in electronic apparatus within its rating.

SPECIFICATIONS

- Output voltage stabilizations:
  Fixed load, ±1% for line change.
  ±1% for frequency change.
  No load to full load (85% P.F.), 1% maximum.
- Temperature rise of components; 50°C maximum.
- Harmonics (at 60 cycles input); less than 5% total.
- Efficiency at full load (100% power factor); 90% minimum.
- Mounting: Bench, floor, wall or relay rack.

Wood, Hertfordshire, England, is manufacturing a line of photoelectric cells in which germanium junction transistors are the light-sensi-
tive elements. The light-sensitive germanium is enclosed in a her-
metically sealed metal case which has a window at one end. When
light strikes the germanium through this window, the current
passing through the germanium increases in direct proportion to the
quantity of light which reaches it. The cells are more sensitive to
normal light than most gas-filled or vacuum-type cells, and can be used
where the amount of light to be measured is low. They have an
output of current sufficient to operate a cold-cathode trigger tube.

ARBOR PRESS
of close tolerance design

QUEENS TOOL ENGINEERING AND MFG. CO., 15 Front St., Rockville
Center, N. Y. The Micro arbor press is a precision bench tool
designed specifically for use by instrument makers where close toler-
ances are involved in the press fitting of bearings and gears in gear
chains such as are used in cameras and computers. The end use is not
single purpose in that it does an ex-
cellent job of piercing, broaching,
forming and burnishing. Complete
technical specifications are avail-
able from the company.

REGULATOR
is a-c line voltage unit

THE POWER EQUIPMENT CO., De-
troit, Mich., has introduced a new

NEW CATALOG
Gives performance data for the complete line of Raytheon Volt-
age Stabilizers. Write for it.

RAYTHEON
Excellence in Electronics
MANUFACTURING COMPANY
EQUIPMENT SALES DIVISION
Dept. 6120A WALTHAM 54, MASS.

October, 1954 — ELECTRONICS
ACCELERATE YOUR
DEVELOPMENT OR PRODUCTION PROGRAM

with cost cutting

REEVES
Instrumentation
Breadboard
Parts

ELIMINATE DRAFTING TIME
With Reeves Breadboard Parts you can build
working models or permanent setups directly
from schematics.

ELIMINATE DESIGN TIME
Reeves Breadboard Parts are so versatile that
most types of high precision equipment such as
servomechanisms, control devices and computers
can be developed without designing and fabricating
special parts.

ELIMINATE DRAFTING TIME
With Reeves Breadboard Parts you can build
working models or permanent setups directly
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ELIMINATE DESIGN TIME
Reeves Breadboard Parts are so versatile that
most types of high precision equipment such as
servomechanisms, control devices and computers
can be developed without designing and fabricating
special parts.

REDUCE ASSEMBLY TIME
Slotted mounting plates, shaft hangers and compo-
nent hangers give the Reeves breadboard meth-
ood of assembly its speed and versatility. Components can be mounted quickly and easily in
any desired position.

REDUCE MODIFICATION TIME
Reeves Breadboard Parts eliminate the enormous
waste incident to making modifications of exper-
imental models built with special parts.

STANDARD AND MINIATURE SIZES AVAILABLE
Reeves Breadboard Parts are available in standard (3/8" shaft) and miniature
(1/4" shaft) sizes. The latter are ideal for applications where small size and light
weight are important factors.

SEND FOR YOUR FREE FULL SCALE MINIATURE BREADBOARD TEMPLATE.
With the breadboard template you lay out a tentative setup using cutouts of
the components. It’s easy. It’s practical. When the cutouts have been secured in
place, turn the template over to the shop and you should have your setup in a
matter of hours.

REEVES INSTRUMENT CORPORATION
201 East 91st Street
New York 28, N. Y.
Telephone: TRafalgar 6-6000

REED ELEKTEK
201 East 91st Street
New York 28, N. Y.
Telephone: TRafalgar 6-6000
Frenchtown's new single metallic coating on refractory ceramic bodies provides a surface to which solders with melting points from 275°F to 1600°F may be applied. No expensive, intermediate nickel and/or copper plating is needed to form a strong, firmly adhering bond with both hard and soft solders.

Now is the time to reexamine your requirements and specifications. Look to Frenchtown's new METALLIZED CERAMICS to save you production time and money. Phone or write for help on any problem involving the bonding of ceramics to metal parts or ceramics to ceramics.

*Patent Applied For

**NEW PRODUCTS**

**METALLIZED**

FOR USE WITH BOTH HARD AND SOFT SOLDERs

High-pass filter reduces tv interference

Regency, a division of Industrial Development Engineering Associates, Inc., Indianapolis, Ind. Model HP-45 high-pass filter reduces tv interference caused by interfering transmitters. It is a constant-K type filter with a cutoff frequency of approximately 45 mc in a 300-ohm balanced line. Attenuation at 29 mc is approximately 20 db. At frequencies of 14 mc and below, the attenuation is 40 db or more. Signals above 55 mc are passed through the filter without loss. Installation of the filter is easy and each unit is accompanied by an instruction sheet. List price is $1.65.

Magnetic amplifier for servo motor uses

The United Transformer Co., 150 Varick St., New York 3, N. Y., has released a new series of magnetic amplifiers for servo motor applications. Four sizes have been made available, which will handle 2, 4, 6 or 9-w servo motors when used with a 115-v, 400-cycle supply. These units are extremely compact, hermetically sealed, and magnetically shielded. The output is simu-
soidal, amplitude variable, and phase reversible. Control is provided by a dual triode such as a 12AU7 operating at 400 cps or higher. The signal to the triode grids can be polarity reversible d-c or phase reversible 400 cycles. Response time is approximately 7.5 milliseconds.

QUARTZ CRYSTAL has outstanding stability

JAMES KNIGHTS Co., Sandwich, Ill., has developed a precision quartz crystal design which, according to tests, varied in frequency less than 1 part in 100,000,000 when measured continuously for 2 weeks. Considered in terms of the measurement of time, this corresponds to a rate of change of less than 1 second in more than 3 years. The G-12A Glasline crystal was developed to meet demands for better frequency control necessary to minimize the rapidly increasing congestion in the radio spectrum.

SIGNAL GENERATOR is accurate to ± 2 percent

GRANCO PRODUCTS Inc., 36-17 29th Ave., Long Island City 5, N. Y. Model SL-200 portable uhf signal-
Meeting still more critical requirements...

**ceramic-cased Carbofilm**

**PRECISION RESISTORS HERMETICALLY SEALED**

To the two previous types now in general use—Type CP (resin-film coated) and Type CPH (metal-cased)—there is now added the new Type CPC (ceramic-cased) Carbofilm.

Here’s the finest in precision resistors. Ceramic case with metallized end seals means permanent hermetrical sealing. No capacitance effect between element and casing. Longest leakage path. Insulated body squeezes among other components without electrical complications. Withstands extremes in humidity and temperature.

Guaranteed tolerance of ± 1%. Excellent stability re. temperature and voltage coefficients, ageing, noise, etc.

In ½, 1 and 2 watt sizes.

*Reg. trade-mark

Get the Facts...

Literature on request. Write on business letterhead, stating particular precision-resistor interest, for sample. Let us quote.

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ACME ELECTRONICS, INC.
MONROVIA, CALIF.

CINEMA ENGINEERING CO.
BURBANK, CALIF.

In Canada: AEROVOX CANADA LTD., Hamilton, Ont.


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**RECORER**

**with nylon gear drives**

EDIN Co., Worcester, Mass., has announced the model 8082, two-channel oscillograph recorder. Noise has been eliminated by the use of nylon gear drives. Recording shifts to any one of six speeds, from 2.5 to 100 mm per second, may be made easily, higher or lower, on this model, while the unit is operating and while it is turned off. A deposited-metal drive roll and positive nonslip paper adjustments permit the use of rolled or folded paper with equally high efficiency. The unit transcribes in ink, drawn...
through a non-clog ink system, on true circulinear coordinates.

**TENSION ANALYZER applicable to all textiles**

Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio, has announced a new tension analyzer for accurately measuring and recording instantaneous tension loads in filamentary materials. The complete unit is equally applicable to all textiles and to fine wire of reasonable flexibility. The tension analyzer will measure both static tension levels and dynamic tension variations while the material is running at high production speeds. In operation, the filamentary material, whose tension is to be measured, is placed over the three pulleys of the transducer. The tension in the material causes mechanical displacement of the center pulley. These displacements, both static and dynamic, are converted into electrical signals which are amplified and recorded on the direct writing oscillograph. Special hardware and fittings have been designed so that the transducer may be positioned on any plane at any level, from approximately 1 ft to 8 ft above the floor.

**SERVO MOTOR features high performance**

Infra Electronics Corp., 553 Eagle Rock Ave., Roseland, N. J., has announced a new servo motor de-

---

**DURANITE**

MOLDED TUBULAR PAPER CAPACITORS

The new and improved Duranite (Type P88N) paper tubulars still feature Aerolene*—the solid impregnant—combining the advantages of wax and oil impregnants. No need of stocking both types. No risk of shelf deterioration.

And now Duranites are molded in blue non-inflammable plastic. Top eye appeal—and outstandingly rugged. Pigtails, centered and firmly imbedded, won't work loose or pull out.

Units essentially immune to moisture penetration. Exceptional performance characteristics—insulation resistance; power factor vs. temperature; 100° C. operating temperature. Get the FACTS!

Descriptive literature on request. Write on business letterhead for sample. Standard values stocked for immediate delivery. Let us quote on your needs.
NEW VOLTAGE REGULATING CIRCUIT

Offers these Design Advantages in Power Supplies!

★ Greater provision for heavier power requirements.
★ Need for fans, blowers or other moving parts eliminated.
★ A VR-105 single voltage regulating tube is only tube used. This has an alternate VR-105 which is used as a ready standby to assure continuous power flow.
★ Filtered to hold ripple voltage in D-C output to less than 0.5% RMS at full load.
★ Not dependent upon accurate maintenance of line frequency. Successfully used with emergency, portable or standby units.
★ New supplies listed in standard sizes.

These new Peco power supplies are designed to do a better job simply, inexpensively and with less maintenance. Write for free bulletin listing specifications and standard sizes.

POWER EQUIPMENT

Signed to give maximum flexibility for ready adaptation to many military and commercial applications. The type M-130 servo motor, built in the popular 1.062 o.d. size, features a hermetically sealed stator providing high operating stability, and a high torque-to-inertia ratio for rapid acceleration and deceleration service as encountered in servomechanism and computing applications. The unit is designed to be inoperative under single-phase conditions, and a sloping speed-torque characteristic provides viscous damping in control applications.

REFERENCE CAVITIES cover 6 frequencies

BOMAC LABORATORIES, INC., Salem Road, Beverly, Mass., announces a new line of high-precision reference cavities covering six different frequencies. The cavities are essentially fixed-frequency, vacuum-sealed, transmission-type tubes. They are used primarily as frequency determining references and frequency stabilizers in radar.
NEW PRODUCTS (continued)

beacon applications. Temperature stability from 100°C is ± 0.3 mc; 0°C to −55°C is ± 1.0 mc. By cushioning the tube within the block, resonant frequency is held to ± 0.1 mc under vibration and shock up to 50 g.

OUTPUT TRANSFORMER for ultralinear operation

CHICAGO STANDARD TRANSFORMER CORP., 3501 Addison St., Chicago 18, Ill., has announced a high-fidelity output transformer, BO-13, designed for ultralinear operation. It features sealed-in-steel construction. Extremely compact, its drawn steel case measures only 3 11/16 in. × 3 5/16 in. × 4 11/16 in. high. It has pin-type terminals and is designed with studs for flush chassis mounting. Complete details, including performance curves, are given in bulletin No. 33.

RECTIFIER for h-v and current operation

AMPEREX ELECTRONIC CORP., 230 Duffy Ave., Hicksville, L. I., N. Y., announces a new mercury vapor rectifier tube, to meet the demand for a comparatively inexpensive
Profitable low-cost production starts on the drafting board. That's why electronic designers should know about EASY-FLO and SIL-FOS brazing. This widely used process is the key to amazing strength, speed and economy in the production of metal assemblies. And for many electronic assemblies, low-temperature EASY-FLO and SIL-FOS brazing offers these further important advantages: high electrical conductivity—strong resistance to corrosion—minimum danger of overheating when joining thin metals.

BEST WAY TO GET THE FACTS is from a field service engineer. He has the know-how to help you from design right through to production. Glad to send him, entirely without obligation. Just write and say when.

RESISTORS in three wattage ranges

DALE PRODUCTS, INC., Columbus, Neb., announces the production of a new hermetically sealed, ruggedized, deposited carbon resistor for the ultimate in precision. Type HC Dulohm resistors are completely solder sealed in a newly developed envelope of nonhygroscopic ceramic, and are ruggedized for incorporation into snap-in component clips. They are production tested for resistance to thermal shock, saltwater immersion and humidity. The resistors are available in 3 wattage ranges (1, 1 and 2) and in resistance ranges to 200 megohms. Standard tolerance is 1 percent.

SLOTTED SECTIONS are precision built

UNIVERSAL MICROWAVE CORP., 380 Hillside Ave., Hillside, N. J., offers a new series of precision slotted sections. The units are constructed of normalized aluminum precisely machined and fitted with watch-like precision. The carriage is of hardened and ground high quality tool steel. Its unique support and the elimination of backlash in the drive mechanism offers exacting measurement regardless of carriage posi-
NEW PRODUCTS

tion. The slotted sections are available in 4 waveguide sizes ranging in frequency from 2.60 to 12.40 kmc. They are designed to accommodate a broadband probe which can readily be replaced with a special micrometer probe quickly to change the unit to a variable susceptance transformer.

TV CAMERA
for one-hand operation

GENERAL PRECISION LABORATORY INC., Pleasantville, N. Y. A new tv camera enables an operator on one-chain show to handle all camera work from the control room with one hand. Image orthicon camera is mounted on remote control pan-and-tilt pedestal, with a GPL-Watson vari-focal lens. This zoom lens, with a 5-to-1 ratio and total range of 3 to 30 in., is operated by two buttons on the pan-tilt handle of the remote controls box (left). The camera can be made to pan and tilt to follow action, zoom in for extreme closeups or out for full scene, or switched instantly to any of 6 preset positions by pushing but-

PRECISION PAYS

Precision may look expensive at first, but it saves money in the long run. You may have learned the cost of working with parts that almost fit—sheet metal or machined parts. We stand for "profitable precision in industry."

ELECTRONICS — October, 1954

Want more information? Use post card on last page.
miniature—in size only

When your design says miniature and your specifications say quality
—here’s the combination...

The Corning Fixed Glass Capacitor is approximately one third smaller than other kinds of equal capacity. In performance, the Fixed Glass Capacitor has most of the advantages of mica—plus some special features of its own.

You’ll find a lot about their performance in the way they’re made. Layers of conductor and dielectric are sealed together at high temperature and pressure to form a rugged monolithic unit. The seal cannot be altered nor can properties be changed short of destroying the capacitor.

You can use Corning Fixed Glass Capacitors at temperatures to 125°C and higher, with proper voltage de-rating. The temperature coefficient remains the same after repeated temperature cycles and it is held within narrow limits over a wide temperature range with very little variation between capacitors. Capacitance drift is close to zero. Usually it’s less than the error of measurement.

Moisture cannot enter these Fixed Glass Capacitors. Insulation resistance is high. Dielectric absorption is low.

And you can get a variety of sizes and shapes. Because of its unique construction, the Corning Fixed Glass Capacitor allows wide latitude of equipment design. We can make capacitors to your electrical and physical specifications. What’s more, single, self-supported units can be designed for high voltages or high capacitances. Series parallel combinations extend the range still further.

For more information about the remarkable advantages of Corning Fixed Glass Capacitors, please write, wire or phone us.
NEW PRODUCTS  
(continued)

An annealing oven for CRT button stems

STEINER-IVES CO., 309 Springfield Rd., Union, N. J. To reduce heat strain in CRT button stems an annealing oven has been developed that holds the stems in a vertical position during the heating process. The oven is of a conveyor type and has 3 heat zones, each of which can be controlled separately (or as a unit) to provide the proper heat curve. Speed of operation can be varied by means of variable rheostat controls and the electronic pyrometer-type controls hold the temperature variance to a minimum. Hourly production of annealed stems is about 300. The oven, designated K-1, reduces shrinkage, practically eliminates spoilage from nonuniform heating and improves the quality of the stem.

The receiver for TV rebroadcasting

CLARKE INSTRUMENTS, Division of NEMS, Inc., 919 Jesup-Blair Drive, Silver Spring, Md. Model TR-1 has been designed specifically to meet the requirements for a high-quality receiver for use in direct pickup.

In quantity production... available for immediate delivery... is this high performance series of standard Size 11 Synchros... 1.062" diameter.

Minimum weight—1 full oz. lighter! Magnetics of optimum proportions are built into:

- Transmitters
- Differentials
- Receivers
- Control Transformers
- Resolvers
- Sine-Cosine Generators

Another product of the engineering team which pioneered precision synchros.

LOOK TO cppc FOR SYNCHRO PROGRESS

CLIFTON PRECISION PRODUCTS CO., INC.

CLIFTON HEIGHTS PENNSYLVANIA
for a better grasp of any fastener problem

QUARTER-TURN FASTENERS

MEAN QUICK ACCESS. On panels, doors or covers, Camloc Fasteners provide positive locking by a quarter-turn with a screw driver or wing head. They're vibration-proof, because the action of cam, spring and detent creates a uniform locking torque that grips firmly. Camloc Quarter-Turn Fasteners cost less to install... minimize replacement... fewer do the job.

HEAVY DUTY LATCHES

SAFELY AND EASILY OPERATED. Where high shear-tension capacity is a factor... where opening and closing must be done under heavy loads—Camloc has the answer. Spring-loaded handle, retracting sheer pin, positive locking are among the many design advantages.

SUITED TO YOUR NEEDS. In the electronics, aircraft, machinery and many other fields, leading original equipment manufacturers are calling on Camloc's Engineering Department to design special fasteners that increase accessibility.

STRESSED PANEL FASTENERS

A complete departure from conventional fastening. Write for illustrated brochure.

Camloc Fastener Corporation
75 Spring Valley Road, Paramus, N. J.

West Coast Office: 5410 Wilshire Blvd., Los Angeles, Cal.

VTVM

measures complex waveforms

Electronic Measurements Corp., 280 Lafayette St., New York, N. Y.
Model 107 vtvm directly measures capacitance, resistance and complex waveforms peak-to-peak. It measures capacitance from 50 μf to 5,000 μf, inductance from 1.4 henries to 140,000 henries in 4 ranges, in 6 ranges all peak-to-peak voltages of complex waveforms between 0.2 v and 2,800 v, rms values of sine wave voltages between 0.1 v and 1,000 v, resistance from 0.2 ohm to 1,000 megohms. The supplied d-c probe has a 1-megohm isolating resistor. The vtvm uses an and re broadcast of tv signals. The mechanical construction is the same as that normally used in tv transmitter input equipment. Bathtub construction provides maximum accessibility to all tubes and controls, the other components being readily accessible on terminal boards located on the rear of the chassis. Three outputs are provided — video, audio and sync. The video signal is available at the normal level and polarity provided by network interconnection. The response of the receiver extends to 4 mc, and it is adaptable to color reception without modification. The sound channel, separate from the video channel, features wide frequency range and low distortion. The third output provides a stripped-sync signal free of noise. Effective acf makes the receiver very stable, with oscillator drift held to a very low value. Complete specifications and prices are available.
NEW PRODUCTS (continued)

electronically balanced push-pull circuit and peak-to-peak rectification, and 1 percent multipliers for voltage, capacitance and resistance measurements. Also incorporated is a zero center position for f-m discriminator alignment.

PANEL METERS are sealed-ruggedized

SIMPSON ELECTRIC Co., 5200 W. Kinzie St., Chicago 44, Ill., has announced new sealed-ruggedized panel meters made with d-c ranges showing any practical scale from 300 ya to 800 ma. The meters are available in two sizes—2 1/2 in. and 3 1/2 in.

VACUUM COATINGS of metallized glass

METAVAC INC., 45-68 162nd St., Flushing 58, N. Y. A variety of metals are applied by high vacuum evaporation to form precision resistance films. Evaporated metal films deposited on glass are extremely stable, controllable as to resistance and reproducible.

PRECISION PARTS TO PRODUCTS WEIGHING TONS—
... A Range of Unusual Versatility

FROM DRAWING BOARD TO FINISHED PRODUCT—
... All Under One Roof

In Daystrom's 350,000 sq. ft. plant the very finest modern machinery and equipment has been acquired for the manufacture, assembly and test of these products. Daystrom's research, development, engineering and manufacturing specialists have a collective experience that embraces electronics, nuclear instrumentation, computing and electro-mechanical devices. To supplement these creative skills Daystrom also has specialists in metallurgy and welding, as well as organic and plated finishes. Daystrom Instrument has earned its place in the expanding Daystrom Incorporated family.

DAYSTROM INSTRUMENT
ARCHBALD, PENNA.

WRITE TODAY FOR OUR FACILITIES REPORT

Want more information? Use post card on last page.

ELECTRONICS—October, 1954

345

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SPECIAL PRECISION
WIREWOUND POTENTIOMETERS
...engineered and manufactured to meet your mechanical and electrical needs.

The special 2-section potentiometer, illustrated by the curves and schematic diagram above, combines more engineering techniques than is likely to be required in any one potentiometer. Yet even complex projects like this are no problem for Vectron's design engineering staff or for their production department.

Vectron will design and manufacture precision wirewound potentiometers to your specifications...give you the results you want...high linearity, small size, low torque and the ability to maintain performance under extremes of temperature, humidity, vibration, shock and other unusual environmental conditions.

For further information, write:

Precision Components Section
Vectron, Inc.
404 Main Street
Waltham 54, Mass.

Vectron's Potentiometer Bulletin (at left) includes 3 basic types available with many variations. These 3 types are suitable for a wide range of electrical and electronic uses.

PULSE TRANSFORMER
is hermetically sealed

Berkshire Laboratories, 506 Beaver Pond Road, Lincoln, Mass.
Type PT-4 hermetically sealed pulse transformer is a versatile four-winding unit with 2:2:1:1 turns ratios. Measured characteristics includes 120 ohms characteristic impedance, 0.03-μsec rise time, 20-percent droop at 1 μsec, 40-percent droop at 2 μsec. As a pulse or trigger generator it may be used in many different blocking oscillator circuits. It may also be used for coupling and impedance matching. The core is of the wound type, using high quality magnetic material, uncut. The windings are brought out to 8 terminals provided with solder lugs. The transformer is designed and constructed to meet MIL-T-27 specifications.

CHASSIS SLIDES
are ultrathin

Chassis-Trak Corp., 6252 E. Iona Road, Indianapolis 3, Ind., announces a new series of ultrathin (9/32 in.), heavy-duty chassis slides. Four stock sizes fit all standard electronic chassis, cabinets and

New products (continued)

ness of a few millionths of an inch make these elements ideally suited for microwave resistors even at the highest practical microwave frequencies. The company has been awarded Signal Corps approval on rectangular elements to MIL-A-11052A. Other rectangular as well as coaxial and disk elements are custom fabricated to customer requirements.
NEW PRODUCTS (continued)

racks. They feature automatic out position locks (especially useful for sloping cabinets) and instant push-button return or chassis removal from cabinet for bench servicing or unit replacement. The slides support 175 lb in the full extended position and allow the chassis to be tilted back for servicing bottom components. They are permanently dry lubricated and meet JAN slide specifications. All attaching hardware, installation templates and instructions are included with each pair of slides.

RESISTOR is epoxy-encapsulated

CINEMA ENGINEERING Co., Division of Aerovox, Inc., Burbank, Calif., has added an encapsulated resistor to its line. The wire-wound resistive element is precisely positioned in the epoxy body for consistent and accurate capacitance effect to chassis. The unit itself is mounted directly on the chassis with two 8-32 machine screws. Terminals are turret type. Resistance values are 0.1 ohm to 3 megohms. Type 38042 resistor measures 2 in. x 1 in. x 1½ in. It offers complete closure from the elements, the ter-

Auto-Shift tables help get the work done

with 30 - 50% more space efficiency

About 250 square feet accommodate two more Auto-Shifts than separate boards and desks. Auto-Shift puts a large reference surface and drawer directly behind each draftsman for maximum space and operating efficiency — especially effective in row installations.

with much less draftsman fatigue

Auto-Shift has greater flexibility. Note the foot and hand releases (circled above) to adjust board height and slope instantly. Fully counterbalanced top moves effortlessly. Draftsman can change working position often — fatigue is sharply reduced — and the work gets done with Auto-Shift.

For the whole important Auto-Shift story, mail the coupon below today.

DRAFTING EQUIPMENT DIVISION

Hamilton MANUFACTURING COMPANY
Two Rivers, Wisconsin

Hamilton Manufacturing Company, Two Rivers 7, Wisconsin
Please send me the new Auto-Shift booklet (ADR-97)

Name

Firm

Address

City State

Want more information? Use post card on last page

www.americanradiohistory.com
These new plug-in hermetic seals mate with a standard octal socket. They have the desirable feature of all Triad terminals: heavy moulded construction of mineral-filled MIL-P-14 approved phenolic, high dielectric strength, high conductivity gold alloy plated pins, hot-tinned solder rings, and resistance to “tracking” and fungus growth. They meet MIL-T-27 requirements.

These terminals may be had with either rolled or flat flanges. Rolled flanges are available to fit either a 1" or 1½" O.D. can. Cans in either CRS or nickel alloys are available on special order.

For specifications and prices on these plug-in terminals and for a wide range of other single and multiple hermetic seals write for Bulletin TH-54G.

TERMINATIONS
for calorimetric wattmeter

CUBIC CORP., San Diego, Calif., has extended its series of primary standard calorimetric wattmeter terminations to cover the spectrum from 100 to 26,500 mc. Model MC-1B, with associated adapters, covers the range from 2,600 to 26,500 mc; the MCX-1A, a coaxial type, covers from 100 mc to 3,000 mc, and the MCL-1A L-band termination, with adapters, covers from 1,120 to 2,600 mc. All models feature a very low residual vswr, primary standard accuracy, and direct-reading of average power up to 600 w, over a plurality of expanded scales. The wattmeter terminations are supplied with an associated liquid circulator which can be modified, on request, to permit metering of high average powers.

SELENIUM RECTIFIER
is constant-voltage type

RICHARDSON-ALLEN CORP., 39-15 Main St., Flushing, N. Y., offers a rectifier rated at 28 v 30 amperes being the only exposed metal parts.
which is adjustable from 21.8 to 30.8 v. An electronically controlled saturable-core reactor is used to obtain fast recovery and close regulation. Recovery times is 0.2 sec and regulation of 0.2 percent with a fixed load and variable line of ±10 percent or a fixed line and variable load of 3 to 30 amperes; for no load the regulation will be slightly higher. Output is filtered for a maximum of 0.5 of 1-percent ripple. The unit is designed to be operated from a line source of 115 v, single phase, 50-60 cycles. Ambient temperature range is from —20 C to +25 C.

**TANK COILS**

operate at 1,000 rpm

WHITE INDUSTRIES, 421 W. 54th St., New York, N. Y., is manufacturing high precision electronic tank coils. They contain about 225 miniature precision parts, some of which are manufactured to as low as 1/10,000 tolerance. These extremely flexible tuning units operate at approximately 1,000 rpm and have a built-in brake to prevent coasting. Low operating torque (3 in.-oz has been made possible by meticulous assembly of close tolerance parts.

**CRT TESTER**

is quick-action device

AUTHORIZED MANUFACTURERS SERVICE CO., 919 Wyckoff Ave., Brooklyn, N. Y., is producing a lightweight, portable crt tester. Model 101 is so designed as to provide a positive test indication within 90 seconds for continuity and emission. All phases of potential trouble and breakdown are clearly outlined on the front panel. No additional computations are necessary. Computations are...
**NEW PRODUCTS**

**Design accessibility into your equipment**

When repairs and maintenance of electronic equipment are needed, wasted time costs money! Alert manufacturers have totally eliminated the laborious step of "getting at" vital components by installing Grant Industrial Slides. Is your equipment mechanically up to its high electronic standards? If not, Grant offers you:

- **Stock Slides.** A great variety of types, suitable for most needs is in stock and available for immediate delivery.
- **Custom Slides.** Our engineering staff will assist you at your plant and develop slides that fit your requirements perfectly. Write today for our complete Industrial Slide Catalog.

**Grant Industrial Slides**

Grant Pulley and Hardware Corporation
31-73 Whitestone Parkway, Flushing, New York

---

**A-C MOTOR**

**has low-inertia rotor**

*The Electric Indicator Co., Inc., Springdale, Conn.* This precision-built two-phase two-pole induction servo motor with double-ended shaft has a low-inertia squirrel cage rotor designed to eliminate cogging at low speeds. The type DPJJD-764-38 provides a high torque-to-inertia ratio, low starting voltage, and linear torque-speed characteristics with maximum torque at stall. It can be wound with 2 or 4 poles. Characteristics at 60 cycles are: 5 w output, 5 in.-oz stalled torque, and control phase stalled impedance 5,000 ohms. Weight is 23 oz. The unit can be made to operate from a single phase source by splitting the phase with a capacitor. It is avail-

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Want more information? Use post card on last page.

October, 1954 — ELECTRONICS
enable for 400 cps operation, or can be designed to meet specifications.

PICTURE TUBE is shorter and lighter
RAYTHEON MFG. Co., 55 Chapel St., Newton 58, Mass., announces the 17-in. monochrome picture tube 17AVP4. It is 3½ in. shorter in overall length and approximately 4 lb lighter than present 17-in. tubes. The tube incorporates a new 90-deg deflection bulb with a 1-in. shorter neck length and achieves maximum compactness with conventional viewing area. It has electrostatic focus and magnetic deflection and is the ideal tube for modern, low cost, compact, tv designs.

WIDE-RANGE FREQUENCY METER
85-1000 MEGACYCLES

TS-175A/U
Government Approved
Calibration Accuracy:
.005 %
Stability:
.0025 %
Resettablity:
.0025 %

A VERSATILE PRECISION MEASURING INSTRUMENT
Recommended Applications:
- Precise Measurements of Frequencies
- Production Testing
- Alignment of Transmitters and Receivers
- Laboratory Testing
- Portable Field Testing
- A Secondary Frequency Standard
- Signal Generator Calibration
- U.H.F. and V.H.F. Television Alignment

Calibration: Each instrument is individually calibrated, without interpolation, at 50 Kilicycle intervals throughout its range.
Frequency Range: The unit covers the calibrated range of 85 to 1000 megacycles. The fundamental of the precision variable frequency oscillator is 85 to 200 megacycles.
Sensitivity: The Frequency meter can detect a radio frequency signal of 20 microvolts with an audio power output up to 50 milliwatts depending on the frequency.
Internal Modulation: When desired, amplitude modulation of 1000 cycles in frequency can be employed. The modulation percentage is approximately 30%.
Radio Frequency Output: The output voltage from a 50 ohm source, varies from 300 to 100,000 microvolts, within the range of 85 to 1000 megacycles.
Secondary Frequency Standard: A 5000 Kc. oscillator incorporating a CR-18/U crystal can be used as a secondary frequency standard with harmonics of 5 megacycles up to 200 megacycles.

Territories for representation available.
We offer a complete automatic recalibration service on all frequency meters.

WANT MORE INFORMATION? USE POST CARD ON LAST PAGE.
ECLIPSE-PIONEER AUTOSYN* SYNCHROS

And there's a type to meet every need!

Our Autosyns provide the perfect answer to synchro requirements for three good reasons. First, they’re priced attractively to keep down your initial cost. Second, they can be delivered in prototype quantities at once. Third, they’re available in all standard types in production quantities . . . as well as practically any special type you could ever need. And, of course, military specifications are used as design objectives in all cases. Only at Eclipse-Pioneer can you find the combination of experience, facilities, and production techniques that make possible all these important advantages. So, whatever your synchro requirements, it will pay you to see Eclipse-Pioneer.

OTHER STANDARD AND SPECIAL ECLIPSE-PIONEER AUTOSYN SYNCHROS INCLUDE models 1, 11, 15, 18, 23 and 2R as well as high temperature, high frequency, linear, and other types for special needs.

NEW PRODUCTS

CALIBRATOR is triple-purpose unit

BALLANTINE LABORATORIES, INC., Boonton, N. J. Model 420 calibrator is a triple-purpose instrument combining highly stable d-c and a-c voltage sources and having an output range of 0 to 10 v for 3 selectable outputs: d-c, rms and peak-to-peak of a 1,000-cps sine wave. A decade control provides steps of 1,000 mv to which is added the setting of a 10-turn potentiometer. Dividing factors up to 1,000 are obtained with a 4-position push-button switch. This control combination has a setting resolution of 0.01 percent for outputs above 10 mv and of 1 μv below 10 mv. Long-

*REGISTERED TRADEMARK  ECLIPSE-PIONEER CORPORATION.

FLEXIBLE INDUSTRIES

Bendix

Division of Bendix Aviation Corporation

ECLIPSE-PIONEER

TETERBORO, NEW JERSEY

West Coast Office: 117 E. Providence Ave., Burbank, Calif. Export Sales: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.

October, 1954 — ELECTRONICS
term accuracy is 0.5 percent and short-term stability is better than 0.05 percent per hour, while distortion and hum on a-c are less than 0.5 percent. Internal impedances on a-c are very low thus minimizing loading errors.

SELF-CLEANING SWITCH for testing equipment

INDUSTRIAL INSTRUMENTS, INC., 89 Commerce Road, Cedar Grove, N. J., has available a precision self-cleaning switch designed for use in test equipment. It is a 12-position, continuous rotation, detent-action type with phosphor bronze wiper contacts. Internal resistance of the unit is extremely low permitting its use in the most precise equipment.

TURNOVER PICKUP has new stylus combination

PICKERING & Co., INC., Oceanside, L. I., N. Y. The model 260 turnover pickup cartridge is now available with a diamond stylus for long-playing recordings and a sapphire stylus for standard 78 recordings. The diamond stylus is of 0.001 in. radius for 1-p records and the sapphire stylus is of 0.0027 in. radius for standard groove 78-rpm

A long alloy list is an excellent indication of long alloy experience! That's why Cannon-Muskegon is regularly called upon by the electronics industry to furnish a great variety of alloys for remelt or reprocessing. MasterMet alloy control gives you exactly predictable electrical, chemical and physical properties. And, depending on the form specified, alloys may be cast, forged, extruded or machined.

In regular production are the complete range of ferrous alloys including carbon steels, low alloy steels, chromium and chromium nickel stainless steels, cobalt and nickel-base alloys. The 300 and 400 series stainless and certain carbon steels are immediately available from stock.
FOR THE MAXIMUM IN LEGIBILITY

meet all requirements of specifications
MIL-P-7788 and AN-P-89

Produced by the “Lackon” process, the photographic reproduction method which incorporates the better features of all other panel and dial processing methods. The “Lackon” process combines simplicity, flexibility, adaptability, reproducibility, accuracy and economy.

Regardless of whether your interest is in general appearance, uniformity of lighting, legibility, wear or weather resistance, long life or economy — it will be to your advantage to investigate the best.

May we furnish additional information and make available our engineering and lighting experience?

Write Dept. E-10.

UNITED STATES RADIUM CORPORATION
535 Pearl St. New York 7, N. Y.

NEW PRODUCTS
(continued)

records. Except for the sapphire stylus, this unit is identical in all respects to the model 260 double diamond turnover pickup which features: lower overall distortion, higher compliance, lower moving mass, minimum tracking force and higher output.

A-C CAPACITORS for space conservation

CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J., announces a new series of oval and flat-oval shaped capacitors designed for a-c applications where need for space conservation is a factor. The four new styles, identified as KK, KA, KD and KV are all metal-cased paper dielectric capacitors. Each is smaller in size and lighter in weight than comparable rectangular shaped cases. Many newly developed features make them ideal for use in motor-starting and motor-running applications, fluorescent lighting, power-factor correction, and all general purpose a-c applications.

TWIN TRIODE TUBE for digital computer use

GENERAL ELECTRIC Co., Schenectady 5, N. Y. Type GL-6463 is a
NEW PRODUCTS

A miniature twin triode tube whose higher perveance and plate current will allow the design of electronic computers faster than many in current use. It was developed primarily for amplifier or counter service in digital computers. Plate dissipation of 4 w per plate and 7 w total for the tube assures long and dependable operation. Average characteristics (each section) under conduction conditions are: plate voltage, 100 v; grid voltage, approximately 0 v (with grid current adjusted for approximately 200 ma); plate current, 29 ma. Under cutoff conditions plate voltage is 200 v; grid voltage, 11 v; and plate current, 1.0 ma. Average characteristics (each section) in amplifier service with 250 v on the plate and cathode bias resistor, 620 ohms: amplification factor, 20; plate resistance, approximately 3,850 ohms; transconductance, 5,200 ambos; plate current, 14.5 ma.

CLASS-B IGNITRON for industrial control

NATIONAL ELECTRONICS, INC., Geneva, Ill. Type NL-1051 is a metal, water-cooled, mercury pool tube designed especially for welder control and similar a-c control application. Its rating is approximately equivalent to a 300-ampere magnetic contactor. It utilizes a thermostat mount brazed to an all-copper cooling system that provides exceptional cooling efficiency. The inner can, copper cooling coil and thermostat mount being brazed together in a single unit assure a rugged, dependable and adjustment-free temperature control system that operates directly on inner can tem-

Original Thinking plus Precision Components

Kearfott Firsts

1947 First with "Penny Size" Servo Motors 938" diam. x 31/32" long.
1948 First with Servo Motors in Navy BuOrd Sizes 15 and 18 featuring straight-thru bores and integral "potted"* stator-housing assemblies.
1949 First with Navy BuOrd Size 17 Synchros featuring "potted"* stator construction and straight-thru bores.
1950 First with Navy BuOrd Size 11 Servo Motors featuring "potted"* stator construction and straight-thru bores.
1951 First with Navy BuOrd Sizes 15 and 18 Servo Motor—Rate Generator combinations featuring "potted"* stator construction and straight-thru bores.
1952 First with temperature stabilized Drag Cup Motor-Integrator Generator combinations in Navy BuOrd Size 15 featuring "potted"* stator construction and straight-thru bores.
1953 First with Servo Motor-damping Generator combinations in Size 11 featuring "potted"* stator construction and straight-thru bores.
1954 First with 3/4" Diam. "Penny Size" Servo Motors and Synchros. First with 0.05% linearity Tachometer Generators in Size 18. First with 115 volt Servo Motor Generator, 980" in diameter. All featuring "potted"* stator construction and straight-thru bores.

*"Potted" construction for optimum performance at lowest cost.

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

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www.americanradiohistory.com
AND it might well be yours! For if you are now buying the components for servo systems from several manufacturers, you are probably wasting time, labor, machinery, and material, modifying the various units for better coordination. And you still end up with only the inferior performance that such a hodge-podge delivers.

Transicoil experience proves that you can save the time and trouble of secondary operations and end up with a better system by merely using assemblies made up of matched Transicoil components. The units comprising these assemblies are designed and constructed to work with each other for optimum efficiency, top performance, and actually cost less when assembled than the total purchase price of individual components acquired from several sources.

If you are now purchasing servo components from several manufacturers, a serious talk with Transicoil will pay you dividends in lower costs and a better system. But if you require only one component, you can be sure of optimum performance from the Transicoil units you specify.

SHOCK-PROOF CRYSTAL for low-frequency ranges

REEVES-HOFFMAN CORP., Cherry and North Sts., Carlisle, Pa., announces a 1-mc crystal unit in an HC-6 holder which assures the utmost stability in low frequency ranges. The crystal is firmly secured against shock in a nylon mount without hampering its oscillating quality. This radically different nylon mount allows the company to go down to 500 kc, AT cut, in an HC-6 holder. The 1-mc shock-proof crystal is built to meet all the requirements for the following MIL types: CR18, 19, 27, 28, 35, 36 and 48/u.

SERVO SYSTEM PARTS are truly miniaturized

KEARFOTT Co., Inc., 1378 Main Ave., Clifton, N. J., has available a complete line of servo system components measuring only 1/2 in. in diameter but providing performance equal to or better than similar units twice as large. They feature straight-through bore and integral stator-housing construction providing very high accuracy. Windings are hermetically sealed. The servo...
motor illustrated has the following performance characteristics: no load speed, 6,500 rpm; stall torque, 0.1 in. oz; power input per phase, 1.5 w; voltage input per phase, 18 v; and weight, 1.2 oz.

**SAMPLING SWITCH for multichannel use**

General Devices, Inc., P. O. Box 253, Princeton, N. J. The new 4000 series multichannel Roto-Speed switch unit involves unique wiper design and selected contact material. It is d-c motor driven at any standard voltage, has a compact planetary gear reduction unit and provides sampling at rates up to about 100,000 contacts per minute. It features sturdy soldering terminals and semimolded contact plates as well as individually machined contact pins to achieve the highest performance. It is small in physical size and may be obtained with up to 90 shorting contacts. The unit shown has 60 contacts with alternate contacts brought to the terminals. It is available with subminiature connectors in place of terminals. A similar drive unit in the 6000 series is available without motor drive.

**Literature**

Products Catalog. E. F. Johnson Co., Waseca, Minn., has issued a 20-page general electronic products catalog No. 975. It illustrates and describes a line of capacitors, inductors, sockets, in-

**in frequency meters it's NARDA**

Why? Electronically . . . and mechanically . . . Narda offers highest specifications at lowest cost. Compare Narda specs/cost ratios with any other. You'll agree that in frequency meters it is Narda!

**FOUR NARDA MODELS COVER 5.85 to 18.0 kmc**

<table>
<thead>
<tr>
<th>Model</th>
<th>Frequency (kmc)</th>
<th>Waveguide Size</th>
<th>Price F.O.B.</th>
</tr>
</thead>
<tbody>
<tr>
<td>812</td>
<td>5.85-8.20</td>
<td>11/2 x 3/4</td>
<td>$120.00</td>
</tr>
<tr>
<td>811</td>
<td>7.05-10.0</td>
<td>7/8 x 5/16</td>
<td>115.00</td>
</tr>
<tr>
<td>810</td>
<td>8.2-12.4</td>
<td>1 x 5/8</td>
<td>110.00</td>
</tr>
<tr>
<td>807B</td>
<td>12.4-18.0</td>
<td>.702 x .391</td>
<td>150.00</td>
</tr>
</tbody>
</table>

All Narda models offer 0.1% accuracy with 0.05% on special order . . . 0.05% precision . . . 10% reactive dip minimum . . . low insertion loss. Calibration plates are clearly etched for permanent legibility.

**NARDA MODEL 802: 2,400-10,200 mc**

A self-contained instrument with two coaxial resonators tuned by a single control, type N input connectors, crystal detectors, and crystal current meter for resonance indication. Features 0.2% accuracy, high loaded Q, frequency reading from a universal calibration chart in the removable cover (not illustrated). No correction charts are required. The entire frequency range is free from spurious responses or other ambiguities.

Narda manufactures a complete line of microwave test equipment, thermistors and bolometers. Write or call for technical literature . . . and use the Narda advisory services without obligation.

**THE NARDA CORPORATION**

66 Main Street • Mineola, New York
Pioneer 6-4650
Precision Attenuation to 3000 mc!

TURRET ATTENUATOR featuring "PULL-TURN-PUSH" action

SINGLE "IN-THE-LINE" ATTENUATOR PADS and
50 ohm COAXIAL TERMINATION

FREQUENCY RANGE:
dc to 3000 mc.

CHARACTERISTIC IMPEDANCE:
50 ohms

CONNECTORS:
Type "N" Coaxial female fittings each end

AVAILABLE ATTENUATION:
Any value from .1 db to 60 db

VSWR:
<1.2, dc to 3000 mc., for all values from 10
to 60 db
<1.5, dc to 3000 mc., for values from .1 to
9 db

ACCURACY:
±0.5 db

POWER RATING:
One watt sine wave power dissipation

Send for free bulletin entitled
"Measurement of RF Attenuation"

Inquiries invited concerning pads or
turrets with different connector styles

STODDART AIRCRAFT RADIO Co., Inc.
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NEW PRODUCTS (continued)
sulators, plugs, jacks, knobs, dials, pilot lights and amateur equipment. Included are an alphabetical index and prices.

Rectangular Miniature Connector. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. New illustrated literature includes schematic drawings, electrical and mechanical specifications, contact availabilities and complete description of Continental connector series 20T. The reverse page of the bulletin shows special design receptacles specially fabricated by Continental for customers with unusual requirements.

Time Delay Relays. The A. W. Haydon Co., 230 N. Elm St., Waterbury, Conn., has released a revised bulletin on its line of miniature hermetically-sealed time delay relays for either a-c or d-c units. Time delay settings are available from 2 sec to 3 hr. Bulletin TD400 gives design features and mentions detail characteristics and factors which might determine type of timer to be used.

Resistor Engineering Guide. International Resistance Co., 401 North Broad St., Philadelphia 8, Pa. Over 130 types of the resistors and special products manufactured by the company are listed in a revised 1954-1955 Official Resistor Engineering Guide. Data given for each type include JAN or MIL equivalent, rated wattage, standard tolerances, temperature rise at rated load per deg C, temperature coefficient, maximum operating temperature, ohmic values available, dimensions and approximate prices.

Reclaiming Solvent. Ram Chemicals, 200 E. Olive St., Gardena, Calif. A descriptive data sheet deals with De-Solv 292 which permits the reclaiming and salvaging of electronic components from reject units encased with epoxy or polyester resins. The solvent discussed has been found suitable for use on parts based on nylon, Formvar and linen wrapped wires; all metallic components; ceramic capacitors and resistors; as well as miniature and subminiature electronic tubes. It is not harm-
NEW PRODUCTS (continued)

ful to phenolic base systems such as printed circuits.

D-C Power Supply. Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif. Bulletin No. L453A illustrates and describes the model MR532-15 magnetic amplifier regulated power supply. Regulation of the unit described is ±1.0 percent from 5 to 32 v d-c. Special features and tabular technical data are included.

Microwave Gas Tubes. Roger White Electron Devices, Inc., Route 17 and Erie R. R., Ramsey, N. J. A 6-page folder, bulletin A-20, covers a line of backward wave oscillators, traveling-wave amplifiers and microwave gas control tubes. Included are information on the nature and purpose of microwave gas tubes, and descriptions of absorption attenuators, reactance modulators and switches, and phase shifters. Specifications are given.


Custom Wire Leads. Manger Electric Co., Miller St., Stamford, Conn., announces publication of a catalog of its services. These include end stripping, center stripping, counterstripping, stripping of shielded wire and multiple conductors, coding, terminating, solder dipping, straightening, packing, shipping, wire supply and engineering.

Invoice Preparation. Remington Rand Inc., 315 Fourth Ave., New York 10, N. Y. The complete preparation of an invoice from the pricing to the final printing is presented in "Application of the UNIVAC System to Invoicing." The 24-page brochure describes the electronic data processing system that replaces most of the manual and mental processes required from the maintenance of a master price list to the printing of an invoice. Flow charts, sample
Sealectro has pioneered the use of Teflon in its "Press-Fit" stand-off and feed-thru terminals. And the "Press-Fit" technic of simplified mounting reflects years of specialized engineering in closest collaboration with designers and assemblers who want the very best. Such "know-how" is available to you, through Sealectro.

Here, briefly, is why Sealectro "Press-Fit" Teflon terminals are so popular in so many line assemblies:

**INSULATION** Typical electrical characteristics: Dielectric Strength, 400 to 500 V/mil. Volume Resistivity, ohm-cm, less than 10⁹. Surface Resistivity, 100%; R.H. 3.6 X 10⁸. Dielectric Constant, 60 cycles, greater than 0.0005. 10⁴ cycles, greater than 0.0005. Excellent Temperature Stability of dielectric properties. Non-adhesive Surface. No Shelf Deterioration. Etc.

**IMMUNITY** Unaffected by widest range of climatic conditions. Immune to chemicals and salts. Unaffected by corrosive atmospheres or fungus. Zero water absorption. Will not melt, burn, char. No breakage or damage from vibration, mechanical shock, rough handling. No acute strain point as with fused glass and metal seals with different thermal expansion rates. Resists collection of dust and dirt to non-adhesive surface, prolonging use of maximum terminal ratings.

**MINIATURIZATION** Teflon's superior insulating properties enable quick and easy miniaturization. Minimum material for maximum insulation. Replaces glass and ceramics.

**ASSEMBLY** "Press-Fit" means pressing insulator into chassis hole, with inexpensive Sealectro insertion tool. No hardware needed such as nuts, washers, screw-threads, glands, gaskets. Precision-machined insulator press-fits into chassis hole for immediate yet permanent mounting. Withstands 10 lbs. pull test.


*Write for sample and literature, on your company stationery. Let us collaborate on your insulated terminal requirements and problems.*


--

**NEW PRODUCTS** (continued)

forms, and the equipment used in the UNIVAC invoicing application illustrate the test. Ask for brochure EL 180.

R-F Filters. Balco Research Laboratories, 49-53 Edison Place, Newark 2, N. J. The complete line of r-f filters—low-pass, high-pass, band-pass, band-rejection and complementary—is described with the characteristics of each in a new 4-page bulletin. Actual size, photographs of units and typical response curves illustrate what can be done in extremely compact units to give maximum attenuation over the desired stop band with minimum insertion loss and vswr over the pass band.

Rotating Coil Deflection Yoke. Syntronic Instruments, Inc., 100 Industrial Road, Addison, Ill., has released a catalog page picturing and describing its new rotating coil deflection yokes with deflection angle up to 52 or 70 deg. Complete data include four advanced design features, three dimensional drawings and tables of electrical and mechanical characteristics with full explanations to assist design engineers. A table listing a wide variety of coil inductance combinations is also shown.

High-Voltage Connector. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y., has published 2 pages in color with schematics, mechanical and electrical ratings, photos and detailed description of the new series FHIL Continental connector designed for h-v operation. It shows the equipment designer a miniature component that is excellent for these critical applications: voltage breakdown at sea level, 4,000 v rms; at 60,000 ft, 1,800 v rms.

Beryllium Copper Strip. American Silver Co., Inc., Industrial Division, 36-07 Prince St., Flushing 54, N. Y. A new 4-page bulletin covers the principal beryllium copper alloys. Basic information is provided for those who have never before worked with beryllium copper. Included here are the precision mill limits to which beryllium copper strip is produced by the company—thicknesses as
NEW PRODUCTS (continued)

low as 0.0005 in., and thickness tolerances as close as + 0.0001 in. Charts and graphs describe engineering properties and metal tempers supplied. One section discusses, in simple nontechnical terms, how to heat treat these alloys. Listed also are typical industrial applications of very close tolerance and thin gage beryllium copper strip.

Automatic Wave Analyzer. The Davies Laboratories Inc., 4705 Queensbury Road, Riverdale, Md. Completely automatic reduction of vibration, seismic, power-line transient noise, shock and similar data can now be made on the new heterodyne type automatic wave analyzer covered in bulletin 54-C. The analysis discussed is a Fourier analysis—amplitude versus frequency. The complete unit described consists of 6 basic units which are available individually as well as in an assembly—input switching panel, oscillator-controller, modulator-filter, recorder, power supplies and rack.

Temperature Test Chamber. Statham Development Corp., 12411 West Olympic Blvd., Los Angeles 64, Calif. A 4-page bulletin illustrates and describes the model TC-2 temperature test chamber that is completely portable and ideally suited to production line tests of small products such as basic instruments, electronic sub-assemblies and components. Specifications operating instructions and maintenance information are given. Also included is a replacement parts list.

Electronic Generators. Communication Measurements Laboratory, Inc., 350 Leland Ave., Plainfield, N. J. A 16-page catalog covers a line of variable frequency and variable phase regulated electronic audio power generators. The company's products and services are illustrated and described. Specifications and prices are included.

Transformer Catalog. Chicago Standard Transformer Corp., 3501 Addison St., Chicago 18, Ill. Catalog CT-554 lists the full line of the company's Sealed-in-Steel transformers. The 32-page book

NOW

FCC APPROVED!

Berkeley

Model 5570

Frequency

Meter

★ Direct reading in digital form
★ 0-42 mc, with extension to 515 mc
★ Accuracy ± 1 cycle, ± crystal stability 10%
★ New low price!

First digital-reading meter FCC-approved as a standard broadcast station frequency monitor, the BERKELEY Model 5570 offers outstanding advantages for rapid, precise determination of unknown frequencies or frequency stability. Its basic 0-42 megacycle range is readily extendable to 515 mc with BERKELEY VHF and UHF Converter Units.

BERKELEY Model 5570 Frequency Meter, 0-42 mc range. Dimensions, 32" x 21" x 16"; price $1650.00 f.o.b. factory.

BERKELEY Model 5580 VHF and UHF Converter Unit extends range of Model 5570 to 515 mc by use of plug-in units (below). Dimensions 21" x 11" x 15"; price $300.00 f.o.b. factory.

Plug-in units covering 13 fixed bands from 42-515 mc eliminate costly wide-band amplifiers. Price, $100.00 each except for 42-155 mc Model 5581/4, which is $150.00 f.o.b. factory.

BERKELEY technical representatives throughout the U.S. and Canada gladly offer prompt and practical assistance on your instrumentation problems. Wire now for Model 5570 specifications, and name of nearest representative.

Please address Dept. G-10

BERKELEY

INSTRUMENTS INC.
2200 WRIGHT AVE., RICHMOND, CALIF.

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ELECTRONICS — October, 1954
contains detailed descriptions of over 500 stock transformers for military, new equipment, general replacement and power and control circuit applications. A simplified classification system makes it easy to locate any particular unit and the dimensions of all cased units are shown diagrammatically. Almost 100 new transformers are listed, including many not previously available as stock units.

Thermocouple and Extension Wire. The Claud S. Gordon Co., 3000 S. Wallace St., Chicago 16, Ill., has issued a new bulletin illustrating and describing its complete line of Serv-Rite thermocouple wire and thermocouple extension wire. Listed are the various sizes, metals, insulations and prices. Included also are general application data for the various type wires.

Wind Speed and Direction Recorder. Beckman & Whitley Inc., 913 San Carlos Ave., San Carlos, Calif. A new leaflet describes model 170-2 instrumentation for meteorological research—particularly microclimatology. The literature shows how the equipment serves these applications by combination of low threshold, rapid transient response, and self-contained portability. Linearity data are given in curve form, and the data sheet contains complete specifications on the wind-speed recorder, wind-direction recorder and the accessories. It also includes specifications of recording meters required. Ask for Form 170.

Vector Impedance Bridge. Republican Engineering Co., Inc., Beltsville, Md. A 4-page folder illustrates and describes the model 100-B vector impedance bridge for use in laboratory, field requirements, quality control and production testing. Chief features, a long list of applications, technical specifications and price are included.

Electrical Indicating Instruments. DeJur-Amasco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. A new 4-page technical brochure is devoted to the company’s line of standard range electrical indicat-
ing instruments. The instruments illustrated and described are available in round, square and rectangular models, and are adaptable to most panel uses. Included are technical specifications, dimensional drawings and ordering information.

Variable Toroids. Burnell & Co., Inc., 45 Warburton Ave., Yonkers, N. Y., has published a technical bulletin on a new series of Rotoroids (variable toroidal inductors) that provide a continuous 3-to-1 maximum-to-minimum inductance range with 180-deg shaft rotation. The hermetically sealed units described employ a permeability tuning method and require no d-c saturating current. The choice of nominal inductance is virtually unlimited.

Induction Heating Equipment. Electric Aire, Inc., 152 Jelliff Ave., Newark 8, N. J. The newly developed Kilotron, a high-frequency (400 kc) induction heater, is the subject of an interesting 4-page brochure. Coverage is factual and includes discussion of the range of production line application of this relatively new and advanced technique. The description of the equipment covers both the 10 kw and 20 kw models of the Kilotron.

Sound Equipment. David Bogen Co., Inc., 29 Ninth Ave., New York 14, N. Y., has published a new catalog of p-a amplifiers, sound systems and sound accessories. A new addition is a section, “Hints for Selecting the Proper Sound System”, which discusses the more important factors involved in determining what equipment to use. Ask for catalog PA554.

Modular Electronic Unit. The Epsilon Co., 48 Circuit Ave., Newton Highlands 61, Mass. A single-page bulletin introduces the Centri-Tube for electronic packaging. It illustrates a single-tube plug-in unit for 7 or 9-pin miniatures. Mechanical, thermal and electrical features are outlined. By panel mounting of the Centri-Tube units discussed, chassisless construction becomes feasible in many applications—particularly those in which a panel would normally serve primarily as a
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200-500 CFM (NAFM)
115-220 VOLTS • 50-60 CPS
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Schoonmaker Lane Woodstock, N.Y.

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SCRANTON 2, PENNA.

NEW PRODUCTS (continued)

structural member only. Multiple-tube units having similar features to those described are available to order.

VHF Signal Generators. Hewlett-Packard Co., 3099D Page Mill Road, Palo Alto, Calif., has available a 4-page folder illustrating and describing models 608D and 608C vhf signal generators. Outstanding features, complete technical specifications and prices are given for both instruments.

Receiving Tube. Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y. A recent mailing piece illustrates and describes the improved 6BQ6GTA receiving tube that features wafer stem construction, no waste envelope space, high temperature top can solder, one-piece beam confining plate, and a plate designed with folded edges that prevent bulb bombardment. The tubes discussed give top performance in tv circuits.

Bridges, Slidewires and Ratio Sets. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa. Complete information about Wheatstone and Kelvin bridges, slidewires and ratio sets for d-c resistance and conductance measurements is now available in a series of data sheets, group E-53, recently published in booklet form. The group of data sheets fully describes the use of these instruments for research, testing and teaching in laboratories, plants and schools. They list all pertinent data, and show adequate photographs and circuit diagrams illustrating design and operating features. Complete specifications for each instrument as well as for recommended accessories make the selection of equipment easy. How-to-order instructions and a listing of replacement parts complete the sheets.

Solder Reference Text. Kester Solder Co., 4201 Wrightwood Ave., Chicago 39, Ill. An 80-page treatise, entitled "Solder—its fundamentals and usage," is intended to rectify the basic literature inadequacies on solder and to provide the solder user with a thoroughly scientific study of the industrial
a new achievement in fast-print oscilloscope recording...

Simple to Operate. Uses standard Polaroid® magazine and fast self-developing film. Delivers finished black field print in 60 seconds. Automatically Records 3 to 16 traces per print. Provides full size image on 3" scope, half-size image on 5" scope. No reversal of image.

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a fully automatic oscilloscope camera that reduces engineering time and costs... improves results.

Sturdy Camera Mount with swing-a-way adapter hood. Camera easily swung aside when not in use. Provision for data card exposure. Versatile... one camera can service several 3" and 5" scopes of different makes when provided with adapter mounts and hoods. Can be interchanged in seconds. Exposure plus automatic movement to next trace position can be accomplished in three ways: (1) manual shutter release, (2) cable release, (3) remote operating switch.

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RECORDOSCOPE

The manually operated version of the RECORDOSCOPE 1185 offers many of the precision engineered advantages found in the companion automatic model. Though basically designed for manual release and advance of film, this camera can be factory modified for automatic operation.

The Aremac

RECORDOSCOPE 1073

a 35 MM Synchronous Camera for Continuous Motion or Single Frame Oscilloscope Recording

The Aremac 1073 RECORDoscope is a compact self-contained unit mounting on f/2 six element 50 mm lens and special 400 foot Aremac powered magazine. Shutter interlock system prevents film motion when shutter is closed. Synchronous film speeds range from 256"/sec. to 1/8"/sec. in 12 steps of 2:1 ratio. The camera can be stopped and restarted with practically instantaneous speed synchronization. Periscope mounts camera vertically. Provision for automatically illuminated data cards and strobe contacts.

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application and usage. Charts, tables and photographs are included.

Metal Powders. Plastic Metals Division, The National Radiator Co., Johnstown, Pa. Bulletin No. 1 provides a brief introduction to the art of powder metallurgy. It also describes the general types of metal powders offered by the company and stresses the large number of grades required for different applications. Also included are references to some of the other major uses for metal powders such as in cutting tools, chemical applications, flame-cutting, welding rods, pyrotechnics and the fabrication of special electronic and magnetic parts.

Crossover Networks. The R. T. Bozak Co., Stamford, Conn., has released a data sheet on crossover networks for their B-302, B-305 and B-310 speaker systems. The networks described have a slow crossover rate of 6 db per octave, which is permitted by the fact that the Bozak B-199A woofer, B-208 midrange, and B-200X dual tweeter are all direct-radiating units with equal velocities of sound propagation.

Boron-Carbon Resistor. Shalleross Mfg. Co., Collingdale Pa. Engineering bulletin L-33 gives charts, tables and dimensions on all performance characteristics of Boron boron-carbon resistors. In preparing the bulletin, samples were chosen at random from production runs of 1, 2 and 2-watt Boron types designed to MIL-R-10509A styles RN20R, RN25R and RN30R. The resistors described were subjected to standard temperature cycling, load life, short-time overload, moisture resistance, vibration, low temperature exposure and temperature coefficient tests as prescribed by MIL-R-10509A. Average electrical performance data for each resistor style was then computed. The results of these tests are compared side by side with MILR-10509A. Average electrical performance data for each resistor style was then computed. The results of these tests are compared side by side with MILR-10509A.

Laminates for Printed Circuits. The Richardson Co., 2661 Lake St., Melrose Park, Ill. A new, 4-page bulletin gives information on...
**Digital Computer Techniques**

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**Military Radar Fire Control Systems**

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**NEW PRODUCTS (continued)**

grades T-725 and T-812 copper clad Insurok laminates for use in printed circuits. The two electrical grades described are high quality, paper-base phenolic laminates which are bonded to copper foil of 0.0014 in. and 0.0028 in. thicknesses. The bulletin devotes one page to important design considerations in the production of printed circuits and gives complete specifications on the two laminates: characteristic properties, punching information, and sheet size and thicknesses.

Vibration and Shock Control. Robinson Aviation, Inc., Teterboro, N. J. Advanced developments in vibration and shock control mounting systems are now being released in semimonthly bulletins. These technical bulletins entitled "Vibration and Shock Control Trends" are in the form of 2-page news sheets containing illustrations and detailed information about latest models of mountings and equipment installations. Performance, construction, load ranges dimensions and other engineering data are included in each bulletin. Specific mountings described cover airborne, shipboard, mobile, industrial and packaging applications.

Conelrad Alarm. Trinity Industries, P. O. Box 71, Redwood City, Calif. A single-page bulletin illustrates and describes the Wiens Conelrad alarm, a concise, long life unit which attaches readily to any radio receiver for immediate operation. The unit discussed will give a visual indication whenever the radio station goes through the required FCC radio alert procedure. In addition to the visual indication, the audio volume of the station, in case of loudspeaker muting will automatically come up to full audio output and the radio tone signal will serve as a second alarm indication. Technical data and price are given.

Miniature Electrical Resolver. Ford Instrument Co., Division of The Sperry Corp., 31-10 Thoman Ave., Long Island City 1, N. Y. A 2-page bulletin illustrates and completely describes a new size 1S Telesyn resolver. Of miniature
size and light weight (5 oz), the resolver described continuously performs trigonometric operations involving resolution of input voltages in sine and cosine components. It has many computer, controls system and data transmission applications. Full data on the different models available, specifications, dimensions and information on operation and construction are provided in the bulletin.


Magnetic Computer Tape. Minnesota Mining and Mfg. Co., 900 Fauquier St., St. Paul 6, Minn. "Sound Talk" bulletin No. 28 covers recent progress in the production of error-free magnetic computer tape. The 4-page illustrated bulletin discusses the physical causes of signal dropouts in modern digital computers designed to use magnetic tape as a long period storage medium. In addition, it covers the reasons why errors arise from such defects, steps taken to eliminate errors, and a summary of progress made during 1955.

Magnetic Amplifier Systems. Federal Telephone and Radio Co., 100 Kingsland Road, Clifton, N. J. A 4-page folder describes a line of magnetic amplifier systems that are varied and versatile in design and performance. It lists a few of the many uses for magnetic amplifiers and outlines other applications for units of similar design. The company's engineering service is discussed.

Electronic Voltmeter. The Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif. Wider range and higher stability of the new 4-rc voltmeter are described in Vol. 5 No. 9 of the Journal. Included are illustrations, chief

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**ELECTRICAL CHARACTERISTICS**

<table>
<thead>
<tr>
<th>POLYSTYRENE</th>
<th>TEFLON</th>
<th>H.V.</th>
<th>MINIATURE MYLAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temp. Range</td>
<td>-55°C to +85°C</td>
<td>-55°C to +200°C</td>
<td>-55°C to +125°C</td>
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<tr>
<td>Voltage Range, D.C.</td>
<td>100 to 3000</td>
<td>100 to 3000</td>
<td>2 KV to 60 KV</td>
</tr>
<tr>
<td>Capacitance Range</td>
<td>1 to 20 MF</td>
<td>1 to 20 MF</td>
<td>1 MF to 1 M</td>
</tr>
<tr>
<td>Power Factor</td>
<td>.952% @ 1 K</td>
<td>.952% @ 1 K</td>
<td>.3% @ 1 K</td>
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<tr>
<td>Dielectric Absorption</td>
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<tr>
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<tr>
<td>Voltage Derating at 150°C</td>
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</tr>
<tr>
<td>Temperature Coefficient</td>
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<td>-100 PPM/°C</td>
<td>-50 PPM/°C</td>
</tr>
<tr>
<td>Capacitance Stability</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

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ELECTRONICS — October, 1954
features and technical specifications of the model 400D vtvm.

**Precision Interval Timers.** Potter Instrument Co., Inc., 115 Cutter Mill Road, Great Neck, N.Y. Data sheet No. 400 describes techniques and equipment for measuring time intervals from a fraction of a μsec to 1 sec (or longer if desired) with accuracies as high as ±5 μsec by electronically counting the exact number of pulses produced by a highly-stable crystal-controlled h-f oscillator during unknown interval. Illustrations, specifications and optional features are given for 5 types of counter chronographs. Information on photoelectric screens is included.

**Compression Connectors.** Burndy Engineering Co., Inc., Norwalk, Conn. To facilitate selection and identification of Hydent connectors, convenient, multicolored wall charts (23½ in. x 35 in.) are available listing the company's insulated and uninsulated compression terminal and link sizes up to 2/0. Each connector is listed with the conductors accommodated, tooing required for installation, and, for terminals, the screw sizes accommodated. There are three charts in the series.

**Loudspeakers.** Jensen Mfg. Co., 6601 South Laramie Ave., Chicago 38, Ill., has issued a new catalog, No. 1040, and two new data sheets, No. 164 and 165. The catalog covers the company's line of general purpose and commercial sound loudspeakers, as well as accessory cabinets, volume controls and transformers. Data sheet No. 164 introduces the Weather Master drive-in theater speaker line and No. 165 lists the latest of the company's high-fidelity equipment.

**Epoxy Resins.** Bakelite Co., a Division of Union Carbide and Carbon Corp., 260 Madison Ave., New York 16, N.Y. Three new technical bulletins on type C-8 epoxy resins have been issued. The resins described, with the proper hardeners, can be used in tooling, casting, laminating, potting, encapsulating, embedding and adhesive applications. Specific data
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Going far beyond the limitations of stepping switches that operate in only one direction, STERLING'S new Type SS Stepping Switch operates in both directions!

This bi-directional stepping switch, having two driving magnets, is normally equipped with a 4-level, 12-position bank and wipers. The wiper shaft is rotated—either clockwise or counterclockwise, in 10° increments—by an intermittent ratchet-and-pawl action, depending on which of the electro-magnets is energized. Interrupter contacts act as an interlock to protect against partial steps and to permit self-stepping. Limit switches stop rotation at the end of the bank travel. Coils are available for DC currents up to 120 volts.

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Without wipers, the impulse-operated "motor" may be adapted to position servo-motors or potentiometers. Designers of automatic machinery will undoubtedly find many more uses for this versatile, new STERLING product.

For further details, write STERLING ENGINEERING COMPANY, INC., 54 Mill Street, Laconia, N. H. (Subsidiary of American Machine & Foundry Company).

NEW PRODUCTS (continued)

are given on the physical properties of individual resins and hardeners, together with the physical, chemical and electrical properties of recommended resin-hardener combinations. Included in each bulletin is a list of experienced compounders who are equipped to render technical assistance and to supply specially formulated compounds for particular end uses.

Air Data Computer. Servomechanisms Inc., 500 Franklin Ave., Garden City, Long Island, N. Y., has compiled an 8-page technical brochure on its master air data computer. The publication points out that the computer provides a single coordinated source of information, eliminating much duplication. Schematic diagrams show how the plug-in type computer permits calculation of complex function with a minimum of equipment.

X-Band Catalog. Transline Associates, A Division of EDDCO, 57 State St., Newark, N. J. Catalog X-3 is a 4-page folder dealing with a line of X-band waveguide components and test equipment. Included are illustrations, application and design information on variable flap attenuators, waveguide terminations, fixed waveguide attenuators, slide-screw tuners and waveguide T-junctions. Ordering information, sales conditions and warranty data are given.

Germanium Diodes. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif. The 4-page bulletin, GD-1A, lists ratings and specifications on the company's germanium diodes. Included is a complete replacement guide of IRC germanium diodes for replacing RETMA type diodes, and ratings and characteristics for new Red Dot germanium diodes for 100 C applications.

Wire-Stripping Solutions. Fidelity Chemical Products Corp., 470 Frelinghuysen Ave., Newark, N. J. Various types of X-Var wire-stripping solutions are discussed in a 2-color, detailed sheet. Strippers for formex, formvar, enamel, nylon and nyl clad wire are described. The types of X-Var stripping solutions are described as to applications, corrosion resistance, con-
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NEW PRODUCTS

(continued)

sistency, safety precautions and illustrated instructions for each. The stripping solutions mentioned are used by electronic firms and government agencies to remove organic finishes from wire.

Audio Products. The Astatic Corp., Conneaut, Ohio, now has available a new, complete products catalog. Included among other stock items of the company's manufacture are phonograph pick-ups and needles, recording heads, microphone stands, TV receiver uhf converters and boosters. The new catalog stresses brevity of general descriptions and completeness of specifications, performance and replacement data. It is in simple form for easy reference.

Wires, Cables and Components. Birnbach Radio Co. Inc., 145 Hudson St., New York 13, N.Y., has released a 44-page catalog of electronic wires, cables and components. It lists practically every type of wire and cable now in use for microphone, intercom, broadcast and other electronic uses, with detailed technical information on each type. The section on plugs, jacks and connectors contains schematic diagrams and full descriptions for every item. The back cover is devoted to complete charts of commonly used engineering data.

High-Voltage Regulator Tube. CBS-Hytron, a Division of Columbia Broadcasting System Inc., Danvers, Mass. Bulletin E-226A covers the 6BD4A h-v regulator tube designed for anode and convergence supplies of color TV receivers. The tube illustrated and described in the bulletin has a large bulb that provides long leakage paths and prevents corona effects. Included are mechanical and electrical data, maximum ratings and characteristics charts.

Picture Tube Chart. Reon Tube Corp., 58-15 57th Drive, Maspeth, L.I., N.Y., has published a new TV picture tube replacement guide chart. It includes a list of all type TV picture tubes, their descriptions, Reon replacements and direct substitutions. It also lists characteristics and changes for the substitutes. Printed in 2

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BL-2109 Audio Frequency Spectrometer
BL-2304 Level Recorder
BL-2423 MegOhmmeter and D.C. Voltmeter
BL-3423 MegOhmmeter High Tension Accessory
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BL-4120 Microphone Calibration Apparatus and Accessory
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October, 1954 — ELECTRONICS

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THE 4-118 MINIATURE SELF-GENERATING VELOCITY PICKUP is ultra compact and lightweight. Electromagnetically damped, its design permits operation at temperatures up to 500° F. Its output (100 mv./in./sec.) equals that of pickups many times its size and weight (1.3 oz.), and it may be operated in any plane of orientation. Frequency range is 50 to 500 cps. Common applications include gas turbines, jet engines, superchargers and automobile engines.

THE 4-102A VELOCITY PICKUPS' high output (110 mv./in./sec.) permits direct oscillographic recording and direct modulation of telemeasuring sub-carrier oscillators without use of amplifiers. It will stand transverse acceleration to 35 g's, and positive scaling of damping fluid allows operation at extreme altitudes and at temperatures of from 0° to 150° F. Frequency range is 8 to 700 cps. The 4-103 is similar to the 4-102A, but is designed for ambient temperatures of 150° to 250° F. Unique, patented seismic suspension design eliminates friction, permits accurate measurement of minute amplitude in any plane of orientation.

THE 4-106V (VERTICAL VIBRATION) velocity pickup as well as the 4-1064 (horizontal vibrations) are identical except for sensitivity and the plane of orientation. Widely used for many years, their light weight makes them advantageous for many applications. Frequency range is 7 to 1000 cps.

THE 9-102 TORSIOGRAPH (TORSIONAL VELOCITY PICKUP) detects and measures transient or cyclical deviations from average rotational velocity. Collet-type mounting to shafts from 15/16" to 1-1/4" diameter. Usable from 2 to 1000 cps. This instrument is widely used for the evaluation of reciprocating engine performance.

NEW PRODUCTS (continued)
colors, the 4-page chart was planned to have all pertinent data available at a glance. The chart also shows a cross section of a picture-tube gun illustrating its complete structure. Another page consists of a Reon tube base chart, which is also fully illustrated.

Repeat Cycle Timers. The A. W. Haydon Co., 230 N. Elm St., Waterbury, Conn. Bulletin RC200 contains complete information on a new line of miniature hermetically-sealed repeat cycle timers. It describes cycling time, timing accuracy detail characteristics and determination of timing tolerances. Illustrations and design features are included.

Automation. T.A.B. Engineers, Inc., Milwaukee and Ogden Aves., Chicago 22, Ill. A pamphlet entitled "Cut Costs with Automation" is an evaluation chart that will help top executives rate the automation possibilities and potentials of their own plants. It gives a complete analysis of products, production, costs and future markets. The brochure reviews the meaning of automation, its history and its future.

Magnetic Laminations. Magnetics Inc., Butler, Pa. Catalog ML-101 illustrates and describes a line of magnetic laminations that are performance guaranteed. An index and individual specification sheets list both the window area and the cross-section area for a square cross-section of laminations. Tolerances for the various types are also listed. Ordering information is included.

Iron Powder. Plastic Metals Div., The National Radiator Co., Johnstown, Pa. Iron powder data sheets No. PMS-12-A-R2 and B-R2 give the composition and characteristics of electronic iron core materials as submitted to the Metal Powder Association. Electronic engineers will find helpful information in the data sheets such as particle size, apparent density, frequency range, relative permeability and Q value, and itemized electronic uses for various iron powders.

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October, 1954 — ELECTRONICS
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This unique tubing clamp provides an inexpensive method to protect open wiring used in connection with a standard AN TYPE CONNECTOR.

It is an easy and quick way to attach flexible plastic tubing to a connector—without the use of hand tools. When used in conjunction with a gasketed adapter, a waterproof joint is provided between connector and tubing.

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Lockheed Plans $10 Million Missile Research Lab

LOCKHEED AIRCRAFT has appropriated a fund of $10 million to finance establishment of a new scientific laboratory for advanced research by its missile systems division in Van Nuys, Calif.

Tentative organization of departments in the missile systems division is as follows: Theoretical Physics and Chemistry, Electronics and Telemetering, Computers and Controls and Radar and Systems.

The lab's aim will be to explore new scientific fields for new weapons. The end objective of their research will be reliable, producible missile systems.

Research in the nuclear field will also receive heavy emphasis in the new laboratories.

Products of Lockheed's scientific research will be determined only after exploration of many "promising recent developments which must now remain secret," according to E. R. Quesada, vice-president of the company.

Heading the research laboratory will be E. H. Krause, nuclear physicist, who resigned as associate director of research at the Naval Research Laboratory in Washington to join Lockheed.

Dr. Krause directed the nuclear weapons research program conducted jointly by the Los Alamos Scientific Laboratory in New Mexico and the Naval Research Laboratory in Washington, D.C. He was in charge of scientific experimentation, including complex instrumentation, on the atomic test program conducted at Eniwetok during Operations Sandstone, Greenhouse and Ivy.

Krause will be joined in the research laboratory by Montgomery H. Johnson, named associate director. Dr. Johnson has worked on atomic and nuclear physics, quantum theory, electro-dynamics, absorbent materials, atmospheric physics and ionosphere research. Formerly at the University of California Livermore Laboratory, he has served on the Radiation Laboratory staff of the University of California since 1952, working on nuclear weapons research. He also served on the MIT Radiation Laboratory staff during the war and later at Naval Research Lab.

Another scientist joining Krause is Eric Durand, who came to Van Nuys from Chicago Midway Laboratories, where he was associate director. Dr. Durand is a specialist in solid state physics, radiation, infra-red navigational systems, test range instruments, rockets, bomb-
TRANSMITTER TYPES—SPECIALLY "TAILORED" FOR MOBILE DESIGNS

For the 450-470 Mc Mobile Band
RCA-6524
RCA-6524 is a new twin-beam power tube well-suited for fixed and mobile UHF design—as a balanced push-pull rf power amplifier or frequency tripler. The tube can deliver 20 watts (approx.) in class C cw and fm services—at 462 Mc! Max. plate dissipation is 25 watts (ICAS). A common cathode for the two units reduces cathode inductance to a negligible value.
Max. length, 3-9/16"
Max. diameter, 1-13/16"

For the 152-174 Mc Mobile Band
RCA-2E26
RCA-2E26 is a beam power tube well-suited as an rf or af amplifier, frequency multiplier, or oscillator. Max. plate voltage for class C service is 400v. As a class C plate-modulated amplifier, the tube takes 27 watts (ICAS). As a class AB2 amplifier/modulator, two RCA-2E26's will deliver 54 watts (ICAS) of audio power at a dc plate voltage of only 300v. Heater voltage, 6.3v.
Max. length, 3-21/32"
Max. diameter, 1-5/16"

For the 152-174 Mc Mobile Band
RCA-5763
No bigger than your thumb, RCA-5763 fills your need for a compact "miniature" beam power tube capable of taking 13.6 watts input at 175 Mc—in mobile, portable, or fixed services. Useful as a frequency multiplier, oscillator or rf power amplifier. Max. plate voltage as multiplier 300v. Heater voltage, 6.3v. (For 12.6v heater circuits specify RCA-6417, identical in all but heater characteristics to the 5763.)
Max. length, 2-5/8"
Max. diameter, 7/8"

For the 152-174 Mc Mobile Band
RCA-6146
RCA-6146 is a versatile beam power tube capable of handling 60 watts (ICAS) at 175 Mc at a plate voltage of 400v. Will handle 90 watts input (ICAS) at frequencies up to 60 Mc at plate voltage of 750v. Heater voltage, 6.3v. (For 26.5v heater circuits, specify RCA-6159, identical in all but heater characteristics to the 6146.)
Max. length, 3-13/16"
Max. diameter, 1-23/32"

For Color-TV—New RCA Color-Bar Generator
RCA WR-61A Color-Bar Generator is designed for testing color-TV receivers and monitors. FOUR crystals—more than any other make—provide the high accuracy necessary for color TV. Generates signals for producing 10 bars of different colors simultaneously (without manual switching) including bars corresponding to R-Y, B-T, G-Y, I, and Q signals for adjusting phase and matrix circuits in all makes of color receivers. Luminance signals at bar edges for checking color "fit" or registration. Adjustable sub-carrier amplitude for checking color sync action.

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ELECTRON TUBES • SEMICONDUCTOR DEVICES • BATTERIES • TEST EQUIPMENT • ELECTRONIC COMPONENTS
Quam of Quam-Nichols Co. in Chicago was reelected treasurer for her eighteenth term. Kenneth C. Prince of the law firm of Prince & Schoenberg was renamed executive secretary.

EP&EM is a trade group consisting of 118 electronic firms in the midwest.

Raytheon Produces Transistor Portable

MASSACHUSETTS GOVERNOR Christian A. Herter, right, received from Charles F. Adams, Jr., president of Raytheon, an all-transistor portable radio using seven transistors. It is an experimental handmade model containing no tubes. It is able to operate from four standard flashlight batteries for several times as long as a standard portable operates from its A and B batteries. Raytheon recently made its millionth transistor. It is estimated that commercial transistor portables may be on the market next year.

Ketay Joins In Forming Nuclear Firm

KETAY MANUFACTURING CORP. and American Metal Co. with Lehman Brothers, investment bankers, participated in forming a new company, Nuclear Science and Engineering Corp. Gordon Dean, former chairman of the Atomic Energy Commission, is board chairman of the new firm. The company intends to provide a variety of technical services to firms engaged in nuclear power development and to industries interested in the application of radioactivity to industrial products and processes. It will supplement firms engaged in nuclear reactor design and engineering, and those which manufacture radiation detection gear.

American Metal and Ketay Manufacturing have subscribed to a substantial portion of the capital stock of Nuclear Sc.

Headquarters of the new company have been established in Pittsburgh. It is headed by Ronald A. Brightsen, president. He was previously associated with the atomic power division of Westinghouse, as were the company's vice-president and technical director, Ralph L. Ely, and the company's secretary-treasurer, Richard S. Frankel.

IT&T Forms New Divisions, Names Officials

A new domestic research and manufacturing division, the Farnsworth Electronics Company, has been formed by IT&T.

Farnsworth Electronics will take over and expand the research and production activities in the field of industrial and defense electronics, formerly carried on by IT&T's Capehart-Farnsworth division. The creation of the new division will establish within the IT&T system another source of supply in the fields of advanced electronics and the application of atomic energy to industry.

Former Capehart-Farnsworth officials staff the new electronic company. Harvard L. Hull, who was general manager of research and development, becomes president. Dr. Hull, who joined Capehart-Farnsworth last year, has been active in atomic research from 1948 and served as director of remote control engineering at Argonne National Laboratory. Philo T. Farnsworth will act in the capacity of vice-president and technical director for the new company and W. F. Hoepnner, who was assistant to the president of Capehart, has been appointed vice-president.

Capehart-Farnsworth Company will concentrate on the design, manufacturing and distribution of its television and radio receivers, high-fidelity phonographs and phonograph combinations and allied lines. A new president has been appointed, Lawrence G. Haggerty, who joined the company in 1950 and has been vice-president in charge of the technical products division since 1953.

Two new vice-presidents have also been named for the company—general sales manager E. W. Gaughan and comptroller Paul H. Hartman.

Fred D. Wilson, who headed Capehart-Farnsworth Company for five years, has been elected IT&T vice-president in charge of industrial relations.

IT&T's Federal Telephone and Radio Co. has also formed a new division, an instrument division for the manufacture and distribution
—provides a stabilized 10-10,000 c/s supply

A vibration generator depends for its accuracy largely upon the suitability of its driving equipment. Goodmans have now produced a self-contained drive unit consisting of oscillator, amplifier and power pack. Although primarily intended for use with Goodmans Model V.47 shaker, it will also find wide application in the laboratory and in industrial processes where a high quality source of audio frequency is required. A brief specification of this latest Goodmans product is given below, and full circuitry details are available on request to "Vibration Dept. W".

**Brief Specification**

- **Frequency range**: 10-10,000 c/s, in 3 ranges.
- **Power output**: 5 watts into 3 ohms.
- **Output Level Stability**: ±0.05 db at 10,000 c/s.
- **Distortion**: Less than 0.2%.
- **Hum level**: 72 db down on 5 watts.
- **Power supply**: 100/115 v, 200/225 v, 225/250 v, 50-60 c/s, 75 watts.
- **Weight**: 45 lb.
- **Dimensions**: 16 1/2 in. x 15 in. x 11 in.

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Cables: GOODAXIOM, WEMBLEY, MIDDX.
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**Bowser’s Completely Redesigned “L” Series**

They're the answer to all your environmental test needs... temperature, altitude, relative humidity... in any combination. Bowser, pioneer in the development of environmental test equipment, has incorporated the most advanced engineering features in these redesigned units.

All interior walls are of stainless steel for rust prevention and long life. Bowser’s unique “Humi-Coil” system (humidifier plus dew point coil) provides the most practical design yet developed for humidity simulation. Semi-hermetic compressors, air or water cooled condensers, safety thermostats... these are just a few of the other plus features of Bowser’s new units.

All units are factory tested under conditions simulating those in the customer's own plant.

The Bowser sales engineer in your area will be glad to help on your environmental test problems.

---

The director of the new Federal division is Rudolph Feldt. He was formerly in charge of the cathode ray instrument division of the Allen B. DuMont Laboratories, which he joined in 1942. Before that he was employed by IT&T associates in France and Germany.

Federal Telecommunications Laboratories appointed I. W. Gleason as sales manager for systems and commercial research and development. He has been with the company for 14 years.

**GE Plans Stanford Tube Lab, Appoints Engineers**

A NEW ELECTRON tube development laboratory will be established by GE in a building to be built on Stanford University land in Palo Alto, Calif.

Work at the laboratory will be concentrated on developing and exploring the application of microwave electron tubes which, according to W. R. G. Baker, GE vice-president, promise to revolutionize the broadcast, communications and radar industries over the next ten years. Lab operations have already started in temporary space near Stanford.

The laboratory to be completed in
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PLANTS AND PEOPLE  (continued)

October initially will be a 10,000 sq ft structure equipped with facilities necessary for applied research and development on microwave tubes.

In the determination and interpretation of the fundamental principles of the operation of new microwave tubes, personnel of the new G-E laboratory will work closely with the Stanford Electronics Research Laboratory, directed by Dean F. E. Terman of the School of Engineering, and the Stanford Microwave Laboratory, directed by Edward L. Ginzton.

H. R. Oldfield, Jr.

H. R. Oldfield, Jr., has been appointed manager of the new G-E laboratory.

He is a former manager of the G-E Advanced Electronics Center at Cornell University, Ithaca, N. Y. and, until his new appointment, was manager of plans and product applications laboratories department.

Approximately half of the new laboratory staff, now being recruited, will be scientists and engineers. Skilled technicians, including glass blowers, model makers and draftsmen, also will be employed.

In GE’s cathode raytube sub-department Leonard C. Maier was appointed manager of engineering and Harry R. Hemmings was named to the newly created position of manager of manufacturing.

Dr. Maier has been with GE in

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L. C. Maier, Jr.

Syracuse since 1950, most of the time in engineering positions in the electronics laboratory. Previously, he was a research associate at MIT’s electronics lab.

In his new position he will be in charge of all cathode ray tube product engineering for GE monochrome tv picture tubes, color tv picture tubes, and special purpose cathode ray tubes.

H. R. Hemmings

Hemmings, who joined GE in 1937, has been manager of the sub-department’s Buffalo picture tube plant for the past three years.

He will be succeeded as Buffalo plant manager by Willard L. Male, manager of employee relations for the sub-department.

The new position of manager of manufacturing was created to integrate the Buffalo and Syracuse tv picture tube manufacturing operations, in preparation for GE’s eventual production of color TV picture tubes.

Victor H. Fraenckel, former liaison scientist in physics at the GE

---

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15-Ampere Relay

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Write for S-D Relay Data Bulletin 2215.

Specifications

Ratings:
15 amperes at 115 volts AC or low-voltage DC.

Contacts:
Single- and double-pole; single- and double-throw.

Coils:
AC to 230 volts; DC to 115 volts.

Sensitivity:
Normal AC, 3 va.; minimum AC, 0.5 va.; normal DC, 2 watts; minimum DC, 0.1 watts.

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research laboratory, has been appointed consultant on scientific relations.

He will be responsible for informing and counseling the management of the research laboratory regarding scientific work underway outside the company. He will evaluate and forecast the probable future trends in external scientific activities of significance to the firm.

Prior to joining GE in 1937, he was engaged in electronics research for Farnsworth Television in Philadelphia and as a physicist for HyGrade-Sylvania in Emporium, Pa. During World War II he was appointed an expert consultant to the Secretary of War and served in Europe on special missions concerned with electronic countermeasures and scientific intelligence.

Firestone Tire Builds Guided Missile Plant

A new $2 million plant is being built in Los Angeles for the Firestone Tire & Rubber Co. to be used for the production of the Corporal, the Army's guided missile. The plant will provide 350,000 square feet of manufacturing space. It is located next to the firm's present tire plant.

Meinken Buys Electronic Tube Firm

KENNETH C. MEINKEN, former president of National Union Radio Corp., has purchased the Electronic Tube Corp. of Philadelphia. Meinken has acquired control of the company and was elected by the board of directors to the presidency of the corporation.

Meinken had been connected with National Union since 1941.
Low noise level
Precision
Stability

AS White 65X
MOLDED RESISTORS

RATING—1 watt.
TEMPERATURE COEFFICIENT—From approx. +0.1%/°F for 5000 ohm values to approx. −0.2%/°F for 10 megohm values.
VOLTAGE COEFFICIENT—Rated at less than 0.02%/Volt.
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- An attenuator whose performance is free of Frequency, assuring you that the Output Envelope is the same as that indicated by the Internal Monitor.

- A simple switching operation to permit examination of either Envelope of the Swept Frequency Signal.

- Durable, compact, lightweight Output and Detector Probes, either of which can be detached easily and replaced by cables having standard connectors.

**Specifications**

<table>
<thead>
<tr>
<th>Model</th>
<th>Center Frequency</th>
<th>RF Output</th>
<th>Sweepwidth</th>
<th>Frequency Marker</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM I</td>
<td>100 KC to 11 MC</td>
<td>1 volt RMS</td>
<td>150 KC to 14 MC</td>
<td>100 KC to 11 MC</td>
</tr>
<tr>
<td>SM II</td>
<td>500 KC to 50 MC</td>
<td>0.2 volt RMS</td>
<td>150 KC to 80 MC</td>
<td>500 KC to 50 MC</td>
</tr>
<tr>
<td>SM III</td>
<td>500 KC to 75 MC</td>
<td>0.1 volt RMS</td>
<td>150 KC to 90 MC</td>
<td>500 KC to 75 MC</td>
</tr>
</tbody>
</table>

Flattens: Less than 1 DB variation over maximum sweepwidth range.
Frequency Marker: Engraved calibration accurate to ± 2%.

* 75 ohm available when specified

Horizontal Deflection: A 60 cps sine wave for application to horizontal input of oscilloscope is supplied.

Blanking: The RF signal may be operated continuously or blanked out for 1/2 of each 60 cycle period.

External Detector: Blocking capacitor of 400 volt breakdown capacity

Write for complete information.

Ramo-Wooldridge Builds New Plant

Ramo-Wooldridge Corp. of Los Angeles has started construction on a 150,000 sq ft plant addition which represents a $1,750,000 investment. When the project is completed by November, is finished Ramo-Wooldridge will move in with a staff expanded from 150 to 1,000.

Since its incorporation in September, 1953, the company has accumulated a backlog of $4 million. Work is in electronic computers and guided missile control systems research for commercial and military projects.

Recent additions to the staff are W. W. Cooper, professor of economics and industrial administration, and Abraham Charnes, associate professor of mathematics and industrial administration, both of Carnegie Institute of Technology Graduate School of Industrial Administration. Cooper and Charnes will work through the summer on new methods of mathematical analysis of industrial management...
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ELECTRONICS—October, 1954

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CAPLESS

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5% Tolerance

Maintains close tolerance under critical conditions. The most economical resistor of its type available. Comparable in size and price to fixed composition resistors. Offers greater reliability at lower cost.

Wattage Ratings: 1/2w, 1w, and 2w.

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The STEMGAM CHEMO-CARBON Process provides for the carbon film to be impregnated with selected chemical materials immediately after the depositing of the carbon under high vacuum.

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Also specify STEMGAM CHEMO-CARBON RESISTORS

• Sub miniature and miniature
• High Temperature and Fungi-proof
• Hermetically sealed
• High Wattage
• Low and non-inductive

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'Diamond H' Miniature, Hermetically Sealed, Aircraft Type Relays

HAVE A WIDER RANGE OF PERFORMANCE CHARACTERISTICS

Shown Actual Size

IF YOU need a relay that will operate consistently under extremely critical or downright adverse conditions, there's an excellent possibility your requirements can be readily met by one of the multitude of variations possible with the basic "Diamond H" Series R relay. Originally designed to meet all requirements of USAF Spec. MIL-R-5757B, they far surpass many. They're adaptable to a wide variety of applications—guided missiles, jet aircraft, fire control and detection, radar, communications, high speed camera, geophysical and computer apparatus, for example.

TYPICAL PERFORMANCE CHARACTERISTICS

Vibration Resistance: 10-55 cycles at 1/16" double amplitude
55-500 cycles at 15 °C
55-1,000 cycles at 15 °C
55-2,000 cycles at 10 °C

Temperature Range: −55° to +85°C
−65° to +125°C
−65° to +200°C

Coils: Resistances—1 ohm to 50,000 ohms
Arrangements—single coil; two independent coils, either or both of which will operate unit

Insulation Resistance: 1,000 megohms at room temperature
100 megohms at 200°C

Dielectric Strength: 450 to 1,250 V, RMS

Operating Time: 24 V, models 10 ms. or less; dropout less than 3 ms

Minimum 100,000 cycles life.
Low interelectrode capacitance — less than 5 mmm. contacts to case, less than 2½ mmf. between contacts.
Special Ratings: to 350 V, D.C., 400 MA, or other combinations including very low voltages and amperages or amperages to 20.

Operational Shock Resistance: 30, 40 and 50 "G" plus

Mechanical Shock Resistance: up to 1,000 "G"

Mounting: 9 standard arrangements to meet all needs — plus ceramic plug-in socket.

Size: 1.6 cu. in.

Weight: 4 oz. or less

Call on "Diamond H" engineers to work with you in developing a variation to meet your specific requirements.

THE HART MANUFACTURING COMPANY
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---

RICHARD A. HUMPHREY has been appointed chief of research and development of the Clifton plant of Mycalex Corp.

The research on synthetic mica, in which Humphrey has been active for the past eight years, has led to the manufacture of this strategic mineral on a commercial scale. The Mycalex Corporation is now in the process of establishing a synthetic mica production facility.

Clevite Buys Counter Firm, Names Weckler

CLEVITE'S Brush Electronics has purchased the assets of the Digital Instrument Co. of Coral Gables, Florida, manufacturer of electronic counters. Meryl C. Burns, former president of the Florida concern, will serve as manager of the digital instrument department of Brush Electronics.

The products formerly manufactured by Digital will be integrated into the Brush line.

Herman L. Weckler has been elected general manager of Clevite Corp.

Weckler has been vice-president—operations of Clevite since July.
JELLIFF
ALLOY 800 RESISTANCE WIRE
for miniaturized precision-instrument components

the ideal resistance wire for
fixed and variable resistors of high ohmage — resistance boxes and bridges — voltmeter and wattmeter multipliers — and other miniature wire-wound units.

Where space is at a premium and performance is a "must" — these outstanding qualities of Jelliff Alloy 800 will assure that your products conform to the tightest specs.

High resistivity, 800 ohms/cm — Low Temperature Coefficient, ±20 ppm per °C — Non-Magnetic — Highly Stable Electrically and Mechanically — Diameters from 0.0009" to 0.0056" — Bare, enameled or oxidized, or insulated with silk, Nylon or cotton — Solders and Winds easily.

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Department 17

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You can get beautiful gold inlay knobs, pointers, instrument controls ... thousands of styles and varieties ... in any quantity from Gee-Lar—-The House of Knobs. They're available in both knurled and spring types, in either walnut or ivory backgrounds. For faster service and lower cost ... plus the widest selection ... get your Gold Inlay Knobs from GEE-LAR!

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0.001 MICROSECOND RISE TIME SQUARE PULSE GENERATORS for the millimicrosecond to microsecond range.

0-10 MC DECADE AND BINARY SCALERS FULLY AUTOMATIC 0-10 MC NUCLEAR SCALERS with predetermined count, predetermined time operation, precision high voltage power supplies, preamplifiers and discriminators.

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ELECTRICAL AND PHYSICAL INSTRUMENT CORPORATION
Engineering Division
42-19 27th Street, Long Island City 1, N. Y.
PLANTS AND PEOPLE (continued)

1953, when he first joined the corporation. For thirteen years he had been vice-president and general manager of Chrysler Corp., where he was also a director.

During the past year, he has had general responsibility for the operations of Clevite's manufacturing and selling units. In his new position as vice-president and general manager, he will have general responsibilities in all Clevite activities, including the central staff and its research and development units.

New Research Center
For GPL Underway

CONSTRUCTION has started on a research center, covering 29,000 sq ft, for General Precision Laboratory in Pleasantville, New York. It will house staff and equipment for design work on television cameras and other commercial tv units, plus experimental work in electronics for military application. The building is on the grounds of the 80-acre one-time Mandeville estate which is now the main headquarters for GPL.

The center will be ready for occupancy about the first of the year.

Philo Promotes Top Officers

WILLIAM BALDERSTON, president of Philco for the past six years, was elected chairman and James H. Carmine, executive vice-president for the past five years, was elected president. John M. Otter was elected executive vice-president. He was previously vice-president in charge of consumer products divisions.

Balderston succeeds James T.
STOP RF LEAKAGE ON THE DRAWING BOARD

WHEN YOU DESIGN METEX ELECTRONIC WEATHERSTRIPPING INTO YOUR EQUIPMENT YOU GET ITS POSITIVE SHIELDING EFFECTIVENESS — AT MAXIMUM OVERALL ECONOMY

Plan now to take full advantage of Metex Electronic Weatherstripping's unusual effectiveness in shielding all types of electronic equipment. Because it is made of knitted wire mesh, Metex Electronic Weatherstripping is both conductive and resilient. It assures positive metal-to-metal contact between all mating surfaces. And being resilient it accommodates itself positively to surface inequalities.

In reality, Metex Electronic Weatherstripping can do more for you than just shield RF leakage. It can cut the cost of machining mating surfaces to close tolerances. It can eliminate the need for extra fasteners and many other costly means of making joints RF tight.

Applications in which Metex Electronic Weatherstripping has already proved its effectiveness include pulse modulator shields, wave-guide choke-flange gaskets, local oscillators on TV sets, dielectric heaters, etc.

For detailed information on METEX ELECTRONIC PRODUCTS, write for FREE copy of "Metex Electronic Weatherstrips" or outline your SPECIFIC shielding problem — it will receive our immediate attention.

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The Augat clamp ring is a sure grip in multiple ganging of precision potentiometers.

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All rings normally supplied without screws. Samples, specifications and prices on request.

For smaller diameters, use Augat standard double-fold non-serrated clamps.

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P.S. Stanley Electric Soldering Irons now available with replaceable heating element.

Call your Industrial Supply Distributor for Armor Clad Tips, or write Stanley Tools, 108 Elm Street, New Britain, Conn. Your name and address plus "Armor Clads" on a postcard will bring you a 36-page booklet — "Expert Soldering" by return mail. We'll include a folder showing the complete line of Stanley Armor Clad Soldering Tips and Electric Soldering Irons. Do it today.

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PLANTS AND PEOPLE

(continued)

Buckley, who declined re-election as chairman after 42 years service with the company, Balderston, as board chairman, will devote himself to broad areas of finance, manufacturing, research, engineering and legal and license activities. Carmine, in his 31 years with Philco, has specialized in sales, distribution, merchandising and advertising. Otter, who joined Philco in 1926, became a vice-president of the firm in 1948.

General Mills Appoints Soucek

ZEUS SOUCEK has been appointed as general manager of General Mills' mechanical division.
Since 1950, Soucek has served as government sales manager for DuMont Laboratories. Between 1929 and 1950, he was successively engineer in charge of research for Bendix Aviation; vice-president of W. L. Maxson; vice-president of Brewster Aeronautical Corp.; president of Philharmonic Radio and president and owner of the Arpin Construction Company.

Chance Vought Appoints Missile Chief

CHANCE VOUGHT Aircraft has appointed Samuel Oliver Perry, Jr., as chief of missile design, to head this activity in the company's California plant. He joined Chance Vought in 1941. Prior to his new appointment, he was chief of field
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All military specifications met:
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0.115 volt d-c range.
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ELECTRONICS — October, 1954

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Here's a typical example. A standard non-magnetic S.S. White flexible shaft is used to connect the focusing knob mounted on the back plate of a TV to the focusing coil on the tube. The fact that the shaft eliminates alignment problems is a distinct advantage which results in important savings in manufacturing and assembly costs.

SIMPLIFY YOUR CONTROL PROBLEMS

S.S. White remote control flexible shafts are available in a wide range of sizes and characteristics to enable you to meet almost any control requirement. You'll find them extremely useful especially where you have to transmit control around turns or where alignment is a problem.

Seidel Succeeds Elliott at RCA

ROBERT A. SEIDEL has been elected executive vice-president of Consumer Products for RCA. He succeeds J. B. Elliott who resigned to become president of Schick. Seidel, who joined RCA as a vice-president in 1949, was formerly vice-president and controller of the W. T. Grant Co.

Stanford Research Names Benedict

DONALD L. BENEDICT has been appointed director of physical sciences research at Stanford Research Institute. He was formerly assistant director of the engineering division.

He will supervise all project work and Institute-sponsored research in the fields of chemistry and chemical engineering, metallurgy, ceramics, biochemistry and physics.

With SRI since 1949, Dr. Benedict has supervised programs in test and flight operations conducted at two California bases for the Regulus guided missile built in the Dallas aircraft plant for the U. S. Navy.

He has been associated with the company's missile programs since 1946. He carried out a large portion of the analytical work on servo-mechanisms for the successful Regulus program.

In 1950, he was transferred from Dallas to California, where he served as assistant to the chief of missile design and later assumed responsibility for testing and flight operations at two bases.
CONVERT MOTION TO ELECTRICAL ENERGY WITHOUT CONTACT

New Electro Proximity Pick-up System
Acts Electronic or Electro-Mechanical Devices for counting parts, indicating position and distance, detecting presence of metallic mass, sequence timing, limiting control. Operates from 0 to over 12,000 times a minute at distances up to 3/4.

Produces Constant Electrical Output in Excess of 5 Volts when any metallic mass approaches the pick-up. Output voltage is independent of the speed or proximity of the actuating mass and remains constant while near the pick-up and drops to 0 when removed. $66.50 complete. Special Types for extended range and size.

Electro Magnetic Pick-up
Indicates Without Mechanical Contact RPM rate of speed or motion. For acceleration and velocity studies, precision ignition timing, ballistic research, many others.

Produces Variable Electrical Output in proportion to any magnetic object's rate of speed. It can be actuated by displacement of vibration of magnetic material in the field of the pick-up, such as a keyway in a shaft, gear tooth, pin or slot in the moving part. $22.50 less mating connector. Special Types for high temperature and deep space. Available with AN type connectors.

New Electro Miniature Magnetic Pick-up
For Small Space and Light Weight Applications. Controls electrically operated devices, rockets, guided missiles, etc. For mechanical or electrical counting. Indicates rate of travel, angular or linear speed, vibration. Similar performance characteristics to "3010-A" with 25% voltage output. $16.50 complete.

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Electro Dynamic Micrometer Measures Without Mechanical Contact vibration in heat exchangers, motors, shaft whips, radial expansion due to high RPM, rate of acceleration, valve travel, independent of acceleration or frequency of displacement.

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Whether in storage or in transit anywhere, absolute protection against strain, stress, shock, vibration, temperature or humidity fluctuations, moisture— or even skin damage—is assured by Cargo Packers' individual attention to every job. For recommendations on specific packaging problems, call or write our Sales-Engineering Department today.

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electronic research and has participated in theoretical and technical work in the application of new materials to electronic components.

He has served as consultant to Raytheon Manufacturing Co., advising on microwave tubes, design of equipment for microwave cooking and dielectric heating.

In 1945 he was named a research fellow in Harvard University's department of engineering science and applied physics. Earlier he was a research physicist with Sylvania's research laboratory at Flushing, L. I.

Hans Hollman Joins Hydro-Aire

HANS ERICH HOLLMAN, a German engineer in microwaves and transistors, has joined the engineering staff of the electronics division of Hydro-Aire of Burbank, Calif. In 1928, Dr. Hollman developed a microwave link in Germany and in 1936, he published an encyclopedia on microwaves, a forerunner of the MIT Radiation Series. Since his arrival in the U.S. with a group of German scientists seven years ago, Hollman has been working at the Naval Air Missile Test Center, Point Mugu, Calif. He will head the company's research and development program in the field of semi-conductor applications.

Kay Electric Names Oncley

THE KAY ELECTRIC COMPANY of Pine Brook, New Jersey, manufacturer of test equipment, has appointed Paul Oncley as audio de-
RAWON
SINE-COSINE
POTENTIOMETER

TYPE RL11C

Ingenious design uses linear winding to generate sine function and cosine function. May be used as a variable resistor or as a generator with separate excita-
tion. Resistance, 16,000 ohms. This unit has numerous uses.

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WIRE STRIPPER

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Disc Cutting Mechanism centers cable for accuracy, gives more and better cutting edge. 1/4 H.P., 110 volt single phase AC motor. Imme-
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FOR OUTSTANDING QUALITY

Rheem Subminiature Instrumentation Amplifier — designed for gains of as high as 1000.
Output — 5 V rms
Frequency response — 5 to 100,000 cycles
Model Rel 12

Rheem RF Power Amplifier — a ruggedized telemetering band amplifier designed for higher outputs.
Output — 18 watts
Frequency — 215 to 225 mc
Model Rel 06

Rheem Miniature RF Power Amplifier — specifically designed to cover the telemetering band.
Output — 10 watts
Frequency — 215 to 235 mc
Model Rel 09

Rheem Subminiature Voltage Regulator — engineered for critical power requirements.
Regulates 0.1%
Load variations 25%
Model Rel 11

(Under development)
Rheem Electron Tube Tester — designed for qualifying electron tubes dynamically while tubes are subjected to environmental tests as required by military specifications.

For complete information on these and other quality units in the fields of military aircraft and laboratory instrumentation, write:
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Government Products Division
9236 East Hall Road, Downey, California

PLANTS AND PEOPLE (continued)

Development engineer.
During World War II, Dr. Oncley was affiliated with the Division of Physical War Research at Duke University, where he designed special instruments for outdoor acoustic transmission tests and for micro-meteorological measurements. He joined the research staff of Bell Telephone Laboratories in 1945, working on the acoustics of speech and music under Harvey Fletcher and R. K. Potter. In 1949, he began a program of research on the acoustics of the singing voice under a grant from the Research Corporation, at Westminster Choir College and Columbia University. During the year 1951-53, he was also a research associate in electrical engineering and lecturer in the acoustics of speech and music at Columbia University. He has served as a special consultant for Rangertone, Regal Electronics and Radionics Laboratory.

At Kay Electric, Oncley will devote his time to development and expansion of the line of acoustic measuring instruments.

Carboloy Opens New Development Lab

Circuit used in developing an automatic magnet tester is analyzed in the new lab

NEW LABORATORY for measuring and analyzing magnetic materials was recently opened by Carboloy department of GE in Detroit.
It is the hub of activities for
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Senior engineers to handle design and development projects and provide technical direction of other top-level engineers working on microwave circuits and microwave plumbing in the development of military airborne electronic equipment. Should have 5 years' experience in such work and at least a BS degree.

INTERVIEWS BY APPOINTMENT
Don Bradley, Personnel Manager, Boston Engineering Lab. Dept. B

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ELECTRONICS — October, 1954

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If you have a problem calling for a periscope or for any precision optical system, check with us. For nearly half a century Kollmorgen has designed, developed and manufactured precision optical products including Industrial and Naval Periscopes, Fire Control Devices, Projection Lenses and Navigational Instruments for Industry and for the Armed Services.

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Transmitters of RPM information from remotely located shafts

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- Aircraft Actuators—Linear and Rotary
- Fractional HP Motors, DC
- AC Drive Motors

Oster Avionic Products are designed to meet military specifications for altitude, humidity, temperature, shock, vibration, fungus, salt spray and life.

Mathes Named Chief Engineer Of Rosen

RICHARD E. MATHES has been named director of engineering of Raymond Rosen Engineering Products, electronics manufacturer in Philadelphia.

Mathes was formerly a research and development engineer with RCA for approximately 18 years; section head of electronic counter-measures of the design branch of the electronic division, Bureau of Ships; plant manager and chief engineer of Finch Tele-Communications Corp. and later was chief engineer and assistant general manager of Gray Research and Development Co.

Brew Appointed Chief Engineer

RODERICK A. BREW has been appointed chief engineer of Richard D. Brew and Co. of Concord, N. H.

For the past three years he has been associated with Western Union in their engineering department.

Karp Metal Affiliates With H and B Machine

FORMAL AFFILIATION with the west coast division of the H and B American Machine Co. at Culver City, California, was made by the Karp Metal Products of Brooklyn, New York.

The 20,000 sq ft Culver City
PRECISION
A-C Rate Generators and single-shaft servo packages

- offered in 60cy and 400cy models
- extremely stable, linear units with high voltage output
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These a-c rate generators are designed for any use which requires a high degree of accuracy in the linear translation of rotational motion into voltage. They are especially valuable in servo systems to stabilize responses, and can be provided in convenient single-shaft packages with a wide variety of precision servo motors.

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ADVANCE builds 'em for heavy loads and long service!

Crammed quarters don't cramp the style of ADVANCE midgets and miniatures. You can use them on loads up to 5 amperes continuously...and at three times their rating intermittently—with complete safety. They'll resist shock and vibration...stand up under temperature extremes. You'll find them readily adaptable to any mounting need...any type of duty. Here are a few examples:

"TINY MITE"
MM & MP SERIES
This ultra-small d-c relay occupies less than ½ cu. in., mounting space! It's stable under vibration and shock...plated to prevent corrosion. Operate time is 5 milliseconds. Contact rating: .5 amp., or 1 amp.

MINIATURE TELEPHONE TYPE
TQ SERIES
Only .94 cu. inches in size, yet this relay carries 5-amp. loads in any combination up to 4 PDT. Mechanically secured throughout, it's extremely efficient. No gassing or bubbling. Withstands 10G vibration. Temperature range: -55° to +125° C.

Hermetic enclosures on these types are impervious to varying climatic conditions...are sealed and carefully checked against leakage.

Write for literature on any of the above series, or the complete ADVANCE line.

ADVANCE ELECTRIC AND RELAY CO.
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BURBANK, CALIFORNIA

Sales Representatives in Principal Cities of
U.S. and Canada
NEW! POLYPENCO® Teflon Spaghetti Tubing

- The ultimate in insulation for wire conductors, leads, tube plugs, etc.
- Unaffected by heat from soldering operations
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- Available in a choice of 7 different colors for color coding

Now you can obtain the excellent dielectric properties of POLYPENCO Teflon in a spaghetti tubing that slips easily over AWG conductors...permits fast soldering of connections...and simplifies wiring and trouble-shooting in miniaturized UHF circuits. POLYPENCO Teflon Spaghetti Tubing also offers many desirable mechanical properties and resists weathering, chemicals, fungi, and high temperatures. Like other shapes of POLYPENCO Teflon, its quality is uniformly high in every shipment.

You can now get this new spaghetti tubing in natural, black, brown, red, green, blue and yellow colors. There's also a full range of internal diameters corresponding to American Wire Gauges 22 through 8. For convenient use, all POLYPENCO Teflon Spaghetti Tubing is supplied on reels in lengths of 100, 200, 500 or 1000 feet.

Write for price list and tubing samples
The POLYMER CORPORATION of Penna. • Reading, Penna.
In Canada: Polypenco, Inc., 2052 St. Catherine W., Montreal, P.Q.

PLANTS AND PEOPLE (continued)

plant, which is already in operation, will be used in manufacturing sheet metal products for west coast customers.

Reason for the affiliation, according to Dan Karp, vice-president in charge of sales, engineering and production, is the tremendous growth of the electronic industry on the west coast.

Although the Karp Company manufactures no standard product of its own, it sells approximately $5,000,000 worth of equipment annually to its more than 400 customers throughout the world.

The company was founded in 1925 and by 1942 was operating four separate plants. In 1948 operations were consolidated into the present 88,000 sq ft Brooklyn plant that has 400 employees.

New Auricon Camera Plant Completed

THE NEW PLANT of Berndt-Bach, manufacturer and distributor of Auricon 16-mm sound-on-film cameras and equipment, has been completed in Hollywood, Calif.

The facilities were planned for the design, development and production of motion picture cameras and kinescope recording equipment for the film and television industries. Special facilities have been provided for research and development of natural-color film equipment for television, film studio and educational use.

Nachtigall Leaves
Mark Simpson

SALO NACHTIGALL, production manager and executive engineer with Mark Simpson Manufacturing for 11 years, has left the company to
**Reliance Mica Co., Inc.**

**MICA SPECIALTIES**

- RADIO and TV TUBE SPACERS
- CAPACITOR FILMS
- HEAT RESISTANCE WASHERS

Reliance are specialists in the fabrication of Mica parts. For 27 years, they have met industry's specifications for critical tolerance and quality control. Our years of experience meeting close tolerance work can help you whenever you are faced with tight specifications and our quality control will meet the increasing rigid specifications of today's design.

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**NEWLY DEVELOPED**

**SUB MINIATURE TYPE 10**

**HYCOR**

**TYPE 10 PRECISION RESISTOR**

**TYPICAL 1 WATT CARBON RESISTOR**

**H-SERIES**

**PRECISION WIRE-WOUND RESISTORS**

The new Hycor “H” Series Precision Resistors incorporate unique design features that make it possible for the resistors to meet performance requirements far beyond those required by military specification.

The “H” Series Precision Resistors are encapsulated in a tough plastic compound. The result is a solid, homogeneous unit with unparalleled ruggedness, impervious to the effects of moisture, thermal shock and mechanical shock. The plastic is filled with heat conducting mineral which dissipates the heat and equalizes the “hot spots” in the resistor winding. The sealed-in terminal connections are welded.

**SPECIFICATIONS...**

**MILITARY SPECIFICATIONS:** Performance characteristics satisfy all requirements of MIL-R-93A and JAN-R-93.

**TEMPERATURE COEFFICIENT:** ±0.002% per °F or °C.

**OPERATING TEMPERATURE:** -65°C to +125°C.

**RESISTANCE ACCURACY:** Standard resistance tolerances are 1%, 0.5%, 0.25% and 0.1%.

Type 10 (illustrated): 1/4" dia x 1/2" long.

Resistance range: 1 ohm to 35 meg.

Send for Bulletin H for complete description on other physical sizes and wattage ranges.

**DISTRIBUTOR**

Hycor Sales of California, 11423 Yarnell St., No. Hollywood, Calif.

**REPRESENTATIVES**

- Beebe Associates, 1155 Waukegan Road, Glenview, Illinois
- Burlingham Associates, 103 Lafayette Street, New York City
- Harrison J. Blind, 1616 Cord St., Indianapolis 24, Indiana
- G. M. Howard & Associates, 724 Bryant St., San Francisco 7, Calif.

**EXPORT DIVISION**

- Marson Exporting Corporation, 458 Broadway, New York 13, N. Y., U. S. A.

- Cable: “MORHANEX”

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Quality Performance
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The Alliance Tenna-Rotor is a product of The Alliance Mfg. Co., Alliance, Ohio

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CS-106 DF Brown

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CORNER OF COMMERCIAL STREET, WORCESTER, MASSACHUSETTS
Southern Plant: MONTICELLO, MISS.
Insulated Wire and Cables — Cord Set Assemblies

October, 1954 — ELECTRONICS

devote full time to his own firm, The Fanon Electric Co. Fanon has been a contract manufacturer of electronic equipment, wiring harnesses, cable assemblies and electromechanical assemblies. Plans are to manufacture a complete line of audio amplifiers and inter-oms. A line of electric phonographs is being prepared for delivery.

Gamewell Names Engineering Supervisor

THE GAMEWELL COMPANY of Newton Upper Falls, Mass. has appointed Edward S. Ruth to the position of supervisor of industrial signaling engineering.

Ruth comes to Gamewell from Edwards Co. of Norwalk, Conn. where he was for many years director of research engineering and development.

General Transformer Names Walovich

GENERAL TRANSFORMER Co. of Homewood, Ill., has appointed John Walovich as chief engineer succeeding Conrad E. DeHorn, who is no longer active with the company.

Walovich has been assistant chief engineer since 1951.

Hauman Instruments Elects Friedman

HAUMAN INSTRUMENTS has elected Bernard L. Friedman as president and general manager, and appointed him chief engineer of the
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MR. PURCHASING AGENT  
MR. ENGINEER  
Sick of repairing others' errors?

Illustrated MODEL VPS-500 Power Supply

MERLIN—Designers & manufacturers of complex electronic equipment such as converters, communications equipment, power supplies, etc., is well aware of the importance of precision mechanical design & fabrication as delineated in this issue of 'ELECTRONICS.'

MERLIN . . . . . is one of the few electronic plants in the country that does its own metal fabrication. Consequently, we are in a position to know YOUR problems. Our recent plant expansion makes it possible to help you.

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ELECTRONICS—October, 1954

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Wheeler Laboratories is an engineering organization offering consulting, research and development services in the fields of communications and radar.

To fill the present need of the industry for a measureable, reproducible, and recognized standard of microwave power capacity, the simple waveguide spark gap pictured above has been developed and promoted by Wheeler Laboratories.

At present, Wheeler Laboratories comprises a staff of twenty engineers under the personal direction of Harold A. Wheeler, with supporting facilities including a group of designers and a model shop.

A brief summary of our work will be sent on request, and comprehensive engineering reports on some of our developments are available. Inquiries are welcomed regarding your particular problems in microwave design and development.

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The "Mach Master," when combined with a temperature bulb and relative wind detectors, produces outputs proportional to Mach number, true air speed, true angle of attack, true angle of yaw, altitude, air density and free air temperature. These outputs are readily usable in other computer equipment or may be made available for visual indication.

The highly efficient and rugged equipment meets all appropriate military specifications.

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SERVOMECHANISMS INC.
EL SEGUNDO DIVISION...316 Washington St., El Segundo, Calif.
WESTBURY DIVISION...Post & Stewart Aves., Westbury, N.Y.

NEWLY FORMED PHOTONICS DIVISION

The parent organization is engaged in the design and manufacture of electronic instrumentation equipment, while the photronics division designs and produces electronic-flash equipment for the photographic field as well as photo-electric control systems.

Friedman was most recently associated with Sanborn Co. of Cambridge, Mass. as assistant to the director of engineering.

Louis Rosenblum of Photon, in Cambridge, Mass., has been elected a director and consultant to the photronics division. Rosenblum has been associated with Polaroid Corp. as assistant to the vice-president in charge of engineering.

Mason Named Ray-O-Vac Director of Research

H. J. Mason has been named director of research and development for Ray-O-Vac Co.

Mason has been associated with the company since 1930 and in 1952 was named assistant director of research.

Stromberg Appoints Captain Bergeson

Andrew H. Bergeson, who recently retired from active duty in the U.S. Navy with the rank of Captain, has been retained by Stromberg-Carlson as a consulting engineer.

He was head of the aviation electronics branch of the Navy's Bureau of Ships from 1941 to 1944.

He was director of the electronics division of Navy's Bureau
when there's a soldering job to be done...

On industrial assembly lines
...in home workshops...
in electronic labs...
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ing irons is on the job,
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of Aeronautics from 1946-1949. From 1951 to 1954 he represented the Navy in the operation of Project Lincoln.

Little Appoints Computing Head

LESLIE G. PECK has joined the staff of Arthur D. Little of Cambridge, Mass., where he will be in charge of the computing laboratory. Among Dr. Peck's previous appointments were a professorship at John Hopkins, where he taught mathematics, and a position at Los Alamos Scientific Laboratory, where he was responsible for much of the success of their computing program. Immediately before joining ADL he was a research associate at New York University. He conducted research in hydrodynamics and numerical analysis making use of the UNIVAC.

Tempel Expands Plant

A NEW administration building has just been added by Tempel Manufacturing of Chicago, manufacturers of magnetic steel laminations. Tempel now has 14 buildings comprising 43,000 sq ft on an 8½ acre tract.

Fairchild Recording Names Suiter

FAIRCHILD RECORDING EQUIPMENT COMPANY has appointed Lyman E. G. Suiter as assistant to the vice-president. He will assist in general manufacturing problems. Suiter was previously with the radio division of Westinghouse.
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such Performance!

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Fully automatic, this BOESCH Toroidal-Coil Winding Machine provides industry with the ultimate in toroidal-winding equipment.

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Model TW-200-A
Makers of the world's most versatile winding machines
Now Available...

MICROPHONE CORD
with newly-developed
TEXTILE SHIELD for
longer service life, improved flexibility

This is a completely new cable design in which a close semi-conducting textile wrap and a stranded flexible drain wire replace the conventional braided copper shield. Conductors are cadmium copper for improved flex life. This new construction is not subject to damage by twisting or by the pressure of heavy equipment rolling over it. The shield will not break as a result of continued flexing.

Additional Features

- Super Flexible
- Light weight
- Long Flex Life
- Excellent Electrical Characteristics
- Tough, abrasion-resistant brown neoprene jacket

This improved construction is the result of years of development work by Whitney Blake laboratory to find the best answer to the needs of the broadcasting companies and equipment manufacturers. The semi-conducting textile shield construction has already been used successfully for over a year on nationally famous dictating machine microphones where extreme flexibility, long flex life and freedom from noise are cord essentials.

Available in 2 conductor, #18 A.W.G. and 3 conductor, #20 A.W.G. Order some and take advantage of the newest development in microphone cords.

Well Built Wires Since 1899

WHITNEY BLAKE COMPANY
New Haven 14, Connecticut

where for the last 14 years he has served in a variety of manufacturing supervisory positions on both military and commercial equipment. Most recently, he directed the firm's home radio production line activities.

Guideline Associates Changes Its Name

GUIDELINE ASSOCIATES has changed its name to Transline Associates to avoid confusion with the products of another manufacturer. Only the name of the company has changed and no delays in shipping schedules will result, according to the firm.

Mossman Completes New York Move

DONALD P. MOSSMAN, manufacturers of multiple-circuit lever, turn and pushbutton switches, has completed the transfer of all manufacturing facilities from Joliet, Ill. to the company's new Brewster, New York plant. All sales and administrative functions are also now located at Brewster.

Beltone Names McNabb Director Of Research

LOUIS A. McNABB was appointed director of research and chief engineer of the Beltone Hearing Aid Co. of Chicago.

Formerly director of the electronic division of Bell and Howell, McNabb participated in the de-
**14 REASONS WHY VARIABLE TRIMMER PISTON CAPACITORS ARE PREFERRED**

1. Vernier Micrometer Adjustment
2. Ultra Linear Tuning
3. Freedom from Microphonics
4. No Tuning Slackishness
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6. High Dielectric Strength
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13. Dust-proof Construction
14. Meet Strictest Military Demands

**AIR EXPRESS DELIVERY ON STANDARD MODELS**

<table>
<thead>
<tr>
<th>MODEL</th>
<th>CAP, MFD</th>
<th>TEMP. RANGE</th>
<th>DIAM.</th>
<th>ELECTRODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VC 5</td>
<td>.5 to 5</td>
<td>approx. zero</td>
<td>Quartz</td>
<td>Invac</td>
</tr>
<tr>
<td>VC 11</td>
<td>1 to 10</td>
<td>approx. zero</td>
<td>Quartz</td>
<td>Invac</td>
</tr>
<tr>
<td>VC 12</td>
<td>10 to 20</td>
<td>approx. zero</td>
<td>Quartz</td>
<td>Invac</td>
</tr>
<tr>
<td>VC 1G</td>
<td>.5 to 8</td>
<td>±50 ± 100</td>
<td>Glass</td>
<td>Invac</td>
</tr>
<tr>
<td>VC 3G</td>
<td>.7 to 8</td>
<td>±600 ± 100</td>
<td>Glass</td>
<td>Invac</td>
</tr>
<tr>
<td>VC 4G</td>
<td>1 to 18</td>
<td>±600 ± 100</td>
<td>Glass</td>
<td>Invac</td>
</tr>
<tr>
<td>VC 11G</td>
<td>.7 to 12</td>
<td>±100 ± 50</td>
<td>Glass</td>
<td>Invac</td>
</tr>
<tr>
<td>VC 11GR</td>
<td>.7 to 10</td>
<td>±250 ± 100</td>
<td>Glass</td>
<td>Invac</td>
</tr>
<tr>
<td>VC 11GR</td>
<td>.7 to 10</td>
<td>±375 ± 100</td>
<td>Glass</td>
<td>Invac</td>
</tr>
<tr>
<td>VC 13G</td>
<td>1 to 10</td>
<td>±100 ± 50</td>
<td>Glass</td>
<td>Special Alloy</td>
</tr>
</tbody>
</table>

Other models available for ungrounded operation, larger ranges, fixed standards, etc.

Consult with JFD Engineers for piston capacitors designed to meet your specifications. Write today to be placed on the JFD Capacitor Bulletin mailing list.

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Here is a motor driven generator built by Homelite to meet U. S. Army Spec. F71-3279. It has a dual output of 120 v., 1400 w., 400 cycle, 1 ph. + 27 v., 400 w., DC. For simplicity, compactness and light weight, this inductor type alternator has the alternator rotor, the DC generator armature and spark-wheel assembly all mounted on a common shaft. Designed for operation of military radar, this unit has also been successfully used for many years for operating ground approach systems both at commercial and military airports. The same complete generator end is also available with gasoline engine drive.

From experience come results. And Homelite is rich in experience...more than thirty years of it...designing and building hundreds of thousands of lightweight generators of many different types.

No matter how tough the specifications may be for a generator...either gasoline or motor driven...the chances are that Homelite either has the answer or will find the answer for you faster than anyone else.

Our engineers are ready for your call.

Homelite builds generators in sizes from .15 KW up to 5 KW in all voltages and frequencies...with either gasoline engine or electric motor drive.

PLANTS AND PEOPLE (continued)

development of that company’s miniature electronic equipment for 15 years.

He was chief engineer of the Victor Animatograph Corporation of Davenport, Ia., from 1948 to 1950.

Later, as a consultant in product design, McNabb worked on hearing aids, miniature recorders, speech reproduction and transistors.

India Sets Plans For Electronic Plant

A MILITARY electronic factory is being set up near Bangalore, India, to make radio and radar equipment for the Indian armed forces. Set up as the result of an agreement last year between the Indian Government and France's Compagnie Generale de Telegraphie, the new plant will be called Bharat Electronics. A French three-man technical team has had consultations with India's Secretary of Defense and its factory board. As a result, nine junior Indian officers are being sent to France for further training.

Also attached to the plant will be a French-supervised training school, expected to open its doors by the end of the year. The whole operation is under Brigadier B. D. Kapur from the weapons and equipment section at General Headquarters, New Delhi.

Hosterman Named By Sylvania Electronics

CHARLES W. HOSTERMAN has been appointed to the newly created post of assistant general manager of
Precision molded products with exacting tolerances in precious and non-precious solid metals of all alloys. All types of Thermo-Plastic and Thermo-Setting materials.

Slip Ring Assemblies fabricated or one-piece precision molded to your specifications in Nylon, Kel-F, Mineral filled Mellamine, Phenolic and other materials. Rings and leads spot welded or brazed together for positive electrical circuit.

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The new EFCON® plastic Film Capacitor, Type MH, is produced with tolerances of ±5%, ±2% and ±1% in standard production! High stability without derating. DuPont’s “Mylar”® polyester film capacitor with low dielectric absorption. Leads soldered directly to foil. Hermetically sealed in metal cases. Also available: Type MC “Mylar” polyester film capacitor in wax impregnated cardboard tubes; Type S—Molded silvered mica capacitor. Write Dept. C for informative brochure.

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ELECTRONICS — October, 1954

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from -65° to +550° F.

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high temperature ACCELEROMETER

Now, Pacific Scientific presents a unique new high temperature accelerometer, designed by Humphrey to give accurate, clear signals at temperatures from -65° to +550° F. — far in excess of former operating ranges! The rugged stainless steel and ceramic construction provides long life and allows precision tolerances for maintaining repeatability.

For the higher temperatures encountered in missile work, as well as for use in all types of aircraft where heat dissipation is a problem, this new unit provides the ideal answer.

SPECIFICATION DATA:
- Environmental—Temperature: -65° to +550° F. Shock: 60 G’s in any direction without damage to the instrument.
- Accuracy—Within ±5% to ±2% depending upon G range and potentiometer resistance. (Including linearity, resolution and environmental conditions.)
- Range—Any range from -1 G +1 G and -50 G +50 G. Also available in asymmetrical ranges.
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Resistoflex will certify each shipment of "electrical grade" Fluoroflex-T products on six vital physical and electrical properties. Qualification tests are performed on all incoming Teflon powder to determine whether it will yield rods, tubes and sheets which are in conformance with specification AMS-3651 "Polytetrafluoroethylene." Processing under a quality control and inspection system approved by the USAF under MIL-Q-3323 specification maintains the identity of each lot of material through all stages of manufacture - from virgin powder to finished product.

An affidavit accompanies each shipment attesting to its conformance with AMS-3651. Certified test reports of the actual properties of any shipment will be furnished whenever they are requested.

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Want more information? Use post card on last page.

PLANTS AND PEOPLE (continued)

the electronics division of Sylvania. Manager of the radio tube division's plant at Shawnee, Okla., since 1960, Hosterman joined the Sylvania organization in 1943 and served in supervisory personnel capacities in various plant locations until 1947, when he was appointed manufacturing superintendent at the radio tube plant in Huntington, W. Va. He left Huntington to become manager at Shawnee.

Volkert Names Schell Plant Manager Assistant

CHARLES E. SCHELL has been appointed assistant to the plant manager of John Volkert Metal Stampings of Queens Village, New York.

Schell had been associated with Sylvania for 26 years. He served as plant manager of Sylvania's parts division.

AMF To Acquire Potter & Brumfield

AMERICAN MACHINE & FOUNDRY expects to acquire Potter & Brumfield Manufacturing as a wholly-owned subsidiary for 92,000 shares of AMF common stock in exchange for all of Potter & Brumfield's stock.

Makers of electrical relays, fractional horsepower motors and electro-mechanical assemblies, Potter & Brumfield has three plants with a total of 41,000 sq feet in Princeton, Ind., employing approximately 600 people. An addition of 20,000
HERE IT IS!
Hermetically Sealed
CLASS H
Open Type Transformer
POSSIBLE ONLY WITH

Designed for long life at "Hot Spot" temperatures of 200°C, permitting weight and size reductions over class A designs. Hermetically sealed (MIL-T-27) Grade 1, using exclusive FormFlex process.

AIRCRAFT TRANSFORMER CORPORATION
Manufacturers of Inductive Equipment
2 West Avenue Long Branch, N. J.

HERE'S BIG HELP IN TERMINAL WIRING!
The correct wire to correct terminal every time!

The New
JONES FANNING STRIP
Connections are made through Fanning Strip, on bench or anywhere apart from barrier strip, and quickly slipped into assembly.

Use with Jones Barrier Terminal Strips, Nos. 141 and 142, for 1 to 20 terminals.

SIMPLIFIES SOLDERING. INSURES CORRECT CONNECTIONS. SAVES TIME. IDEAL FOR HARNESS OR CABLE ASSEMBLY. BRASS TERMINALS, CADMIUM PLATED. BAKELITE MOUNTING. SEND FOR COMPLETE DATA.

LOWEST SET-UP TIME FOR UNSKILLED LABOR

ENGRAVE
NAME PLATES • PANELS • DIALS
in your own shop

10,000 IN USE Accepted by all leading manufacturers as the speediest, most versatile portable engraver. Only the NEW HERMES has these patented features:

- Adjustable for 15 ratios.
- Self-centering holding vise.
- Automatic depth regulator.
- Adjustable copy holders.

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NEW HERMES ENGRAVING MACHINE CORP.
13-19 University Pl. New York 3, New York

Measure FREQUENCY AND FM DEVIATION To 500 MC!
For development...production...and communication testing!

LAMPKIN 105-E MICRO-METER FREQUENCY METER
Heterodyne-type, uses one crystal to measure all transmitters from 0.1 to 175 mc., and crystal-controlled transmitters to 500 mc. Accuracy better than 0.005%. Reads in absolute frequency, or percentage of error from desired frequency. Useful as precision, low-level, C.W. signal generator, 20 mc. up. Price $220.00.

MEET FCC SPECS—for mobile-radio maintenance. SMALL SIZE—less than 13" wide, less than 14 lbs., apiece.

For technical data, mail coupon today!

LAMPKIN LABORATORIES, INC.
Bradenton, Florida

LAMPKIN LABORATORIES, INC.
INSTRUMENTS DIVISION
BRADENTON, FLORIDA

Without obligation, please send me data on Lampkin meters.

LAMPKIN LABORATORIES, INC.
BRADENTON, FLORIDA

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NEW STANDARD OF PROFESSIONAL TAPE RECORDING

Now for the first time

Write for details and bulletin

... a professional tape recorder that offers both
MAXIMUM OPERATING CONVENIENCE
plus UNMATCHED DEPENDABILITY

Dynacord is engineered to exceed the rigid requirements of broadcast stations, sound studios, industry and government. Its wide dynamic range and many convenient operating features amaze engineers and audiophiles alike. Compare it in every way with any other professional tape recorder and see why Dynacord sets the new standard of professional recording.

Model DTM Tape Transport Mechanism, $350 net.
Model DP-100 Broadcast Amplifier, $150 net.
Model DS-10 Audiophile Amplifier, $75 net.

Exclusive 2-speed, inside-out Hysteresis synchronous motor. Direct capstan drive.

Exclusive dynamic braking, fast, positive, fool-proof.
Frequency Response: 50-15,000 CPS at 15 in./sec. ± 2DB
Signal to Noise Ratio: better than 55 DB

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777 South Tripp Avenue, Chicago 24, Illinois, Dept. E-10
Canada: Atlas Radio Corp., Ltd., Toronto
Largest exclusive makers of tape recorders and accessories

Hear the "ALL ELECTRONIC ORCHESTRA"—CHICAGO HI-FI SHOW
Sept. 30—Oct. 2 • NEW YORK AUDIORAMA Oct. 14-17

Want more information? Use postcard on last page.

Salkover Metal Moves To New Plant

SALKOVER METAL PROCESSING of Illinois has moved to its new plant in Franklin Park, Ill.
The copper brazing and bright annealing organization formerly occupied two buildings. Both of the old plants have been discontinued and all operations are now concentrated in the Franklin Park building which has practically twice the floor area of the other two plants combined.

Resdel Engineering Names DeDiemar

J. L. DEDEMAR, former Convair design specialist, has been appointed chief engineer of Resdel Engineering.
DeDiemar joined Convair's engineering department at the firm's Vultee field division, Downey, Calif., in 1946. In 1947 he was transferred to the company's San Diego division. He has been an electronics project engineer there for the past year. For several years he was a staff assistant in the electronics section.
Before joining Convair, DeDiemar was an electronic engineer with Gilfillan Bros. in Los Angeles.
DeDiemar will have charge of engineering for Resdel's projects which include electronic research

October, 1954 — ELECTRONICS
UNIVERSAL meets exacting DESIGN REQUIREMENTS in TOROIDAL COILS

Our specially designed machines now wind Toroidal Coils quicker and with more accuracy than other standard methods. Universal Toroidal Coils in any size wire to your specifications—are economical in materials and possess the smallest external leakage field of all other shapes. Universal Toroids wound to Mil-T-27 specs. Wire sizes #42 (.00249 mils) to #10 (.1019 mils). Excellent Delivery in small or large quantity.

Engineering Service Available.

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UNIVERSAL MANUFACTURING COMPANY, INC.
410 Hillside Ave., Hillside, N. J.

IN-RES-CO
TYPES SM-15 & SM-30 WIRE WOUND RESISTORS

Type SM-15 and SM-30 Resistors offer three vital advantages—sub-miniature size, weather resistant construction, and high resistance. The elimination of center hole mounting and the inclusion of axial leads increases winding area and results in 25% greater resistance value than resistors of standard design. Special coating is moisture and fungus proof and designed to meet JAN-R-93 specifications. Sealed in Bakelite construction affords additional climatic protection. As ratings are conservative, types SM-15 and SM-30 can be specified with confidence for service under rigorous conditions.

ASK FOR THE NEW RESISTOR HANDBOOK—Contains complete data on resistors for every purpose and their recommended applications. Please make request on company letterhead.

APPLICATION-DESIGNED RESISTORS FOR ELECTRONICS AND INSTRUMENTATION

let Williams help you apply FERRIC OXIDES to the manufacture of your FERRITES

You’ll be well repaid by getting the facts on a special group of Pure Ferric Oxides, developed by Williams especially for use in the manufacture of ferrites.

Williams Ferric Oxides analyze better than 99% Fe₂O₃. They contain a minimum of impurities. They are available in a broad range of particle sizes and shapes. Among them, we’re certain you’ll find one that’s "just right" for your requirements. The proper application of Ferric Oxides to the manufacture of Ferrites is our speciality.

Tell us your requirements ... we’ll gladly send samples for test. Chances are good that our Ferric Oxide "Know How" can save you considerable time and money. Address Dept. 25, C. K. Williams & Co., Easton, Pa.

INSTRUMENT RESISTORS CO.

C. K. WILLIAMS & CO.
Easton, Pa. • East St. Louis, Ill. • Emeryville, Cal.

P.S. We also produce IRN Magnetic Iron powders for the Electronic Core Industry, the Magnetic Tape Recording Industry and others. Write for complete technical information.
Where dependability, long life and uniform performance are all-important ... select

**Bendix**

**HARD GLASS**

Miniature Beam Power Amplifier

Here's another advance in the Bendix Red Bank "Reliable" Vacuum Tube program. Featuring a hard glass bulb and stem with gold-plated pins . . . plus a conservative design center of cathode temperature . . . the Bendix Red Bank RETMA 6094 can operate at temperatures up to 300° C. compared to an average of only 175° C. for soft glass bulbs. Thus, this new tube ideally meets aircraft, military and industrial applications where freedom from early failure, long service life, and uniform performance are essential.

The Bendix 6094 uses pressed ceramic spacers, instead of mica, for element separation. In other tubes, deterioration of mica in contact with the hot cathode causes loss of emission which is greatly accelerated under shock and vibration. Ceramic eliminates this problem and greatly reduces damage caused by fatigue failure of parts.

For complete details on our special-purpose tubes, write today.

**ELECTRICAL RATINGS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heater voltage (AC or DC)**</td>
<td>6.3 volts</td>
</tr>
<tr>
<td>Heater current</td>
<td>0.6 amps</td>
</tr>
<tr>
<td>Plate voltage (maximum DC)</td>
<td>275 volts</td>
</tr>
<tr>
<td>Screen voltage (maximum DC)</td>
<td>275 volts</td>
</tr>
<tr>
<td>Peak plate voltage (max. instantaneous)</td>
<td>550 volts</td>
</tr>
<tr>
<td>Plate dissipation (absolute max.)</td>
<td>12.5 watts</td>
</tr>
<tr>
<td>Screen dissipation (absolute max.)</td>
<td>2.0 watts</td>
</tr>
<tr>
<td>Cathode current (max. instantaneous peak value)</td>
<td>100.0 ma</td>
</tr>
<tr>
<td>Heater-cathode voltage (max.)</td>
<td>450 volts</td>
</tr>
<tr>
<td>Grid resistance (max.)</td>
<td>0.1 megohm</td>
</tr>
<tr>
<td>Grid voltage (max.)</td>
<td>+5.0 volts</td>
</tr>
<tr>
<td>Cathode warm-up time</td>
<td>45 seconds</td>
</tr>
<tr>
<td>(Plate and heater voltage may be applied simultaneously.)</td>
<td></td>
</tr>
</tbody>
</table>

*To obtain greatest life expectancy from tube, avoid designs where the tube is subjected to all maximum ratings simultaneously. **Voltage should not fluctuate more than +5%.

**MECHANICAL DATA**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>9 pin miniature hard glass—gold plated tungsten pins</td>
</tr>
<tr>
<td>Bulb</td>
<td>Hard glass—165°C</td>
</tr>
<tr>
<td>Max. over-all length</td>
<td>27.2&quot;</td>
</tr>
<tr>
<td>Max. seated height</td>
<td>27.2&quot;</td>
</tr>
<tr>
<td>Max. diameter</td>
<td>4/5&quot;</td>
</tr>
<tr>
<td>Mounting position</td>
<td>any</td>
</tr>
<tr>
<td>Max. altitude</td>
<td>80,000 feet</td>
</tr>
<tr>
<td>Max. bulb temperature</td>
<td>300°C</td>
</tr>
<tr>
<td>Max. impact shock</td>
<td>500g</td>
</tr>
<tr>
<td>Max. vibrational acceleration</td>
<td>50g</td>
</tr>
</tbody>
</table>

(100-hour shock excited fatigue test, sample basis)

**PLANTS AND PEOPLE (continued)**

and development work for the armed forces and commercial firms. The company's current products include electronic test equipment, radar units, and dielectric and induction heating devices.

**Wilton Tool Starts New Plant**

WILTON TOOL MFG. CO. broke ground for a new 65,000 sq ft general office and factory building in Schiller Park, Illinois. The expansion will cost approximately half a million dollars. The plant will be located on a five acre tract.

Wilton plans to move to the new plant in January of 1955. No major interruption of production or delivery schedules is anticipated.

**I-T-E Circuit Breaker Appoints Corwin**

JEROME CORWIN has been named to head the new design and development section on electromechanical devices, servo mechanisms and computers in the special products division of I-T-E Circuit Breaker Company. It was indicated that the addition of this new section was undertaken to further complement future activities of the division in the radar field. Corwin was previously chief of the mechanical engineering section of the U. S. Army Signal Corps Laboratories at Fort Monmouth, N. J. His background covers work on mechanical structures and electromechanical instrumentation in both the electronic and physical science fields. He has also directed a program for

**EATONTOWN, N. J.**

West Coast Sales and Service: 117 E. Providencia Ave., Burbank, Calif.

Export Sales: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.

Canadian Distributors: Aviation Electric Ltd., P.O. Box 6102, Montreal, P.Q.
UNI-CHASSIS BREADBOARD
Pays for Itself the First Time Used

CUTS BREADBOARD TIME 50%

The Uni-Chassis Method for breadboarding experimental or semi-permanent electronic circuits results in large time savings throughout the electronics laboratory. The aluminum Uni-Chassis is 7½ x 8½ x 11 inches, drilled to accommodate 16 tube sockets of various sizes and provided with extra mountings for switches, potentiometers, and heavier components—almost any practical electronic circuit can be assembled without further drilling or special mountings. Four grooved and plated brass bus bars are mounted on insulated strips and run the full length of the Chassis. They are ideal for supplying common potentials by way of short leads to any part of the circuit.

PRICE: Together or separately: $7.50 Uni-Chassis only; $13.50 Uni-Lead Set; $19.50 Complete

UNI-PRODUCTS, div. of Uni-Science, Inc.
Rockville, Maryland

UNI-LEAD SET

Twenty-two flexible test leads and an assortment of fittings—test prods, alligator clips, banana plugs, etc.—comprise the Uni-Lead Set. Each lead is fitted with beryllium copper terminals of special design which make tight spring contacts with all fittings and with chassis terminals.

PRICE: $19.50 Complete

A Resinite Certified Laboratory Test Report, sent with your shipment of specification vinyl tubing, is your positive assurance that your shipment has been tested by us and conforms exactly with its applicable specification.

Certified Laboratory Test Reports, in addition to the usual certificates of compliance, are supplied by Resinite Industries, at no extra cost to you, whenever you order Resinite EP-69 (MIL-7444) as well as certain other Resinite Specification tubings.

Here is an added service to you, designed to speed your processing of each shipment. It is one more reason why it pays to order specification vinyl tubing from Resin Industries, Inc.

Write today for samples and performance data.
Burlock Electrocardiograph
Made by the Burdock Corporation
Featuring Standard Control Knobs
By Raytheon

Make it look worth the price

with

Standard Control Knobs

by Raytheon

Fine electric and electronic equipment is easier to sell when it looks like the money it represents.

Raytheon standard control knobs add the appeal of custom styling at standard cost — make the outside reflect the quality of the inside.

These injection molded knobs are available in an integrated family of 54 items — in a choice of six basic types and five widely used sizes.

Made of tough, durable “Tenite II” (cellulose acetate butyrate) with anodized aluminum inserts and dual setscrews. All types and sizes available in black with gleaming mirror finish or with non-reflecting matte finish for government equipments. Also available in color or with knob parts assembled in striking color combinations.

Write for complete information.
Address Dept. 6120 A Raytheon Manufacturing Company, Equipment Sales Division, Waltham 54, Massachusetts.

Dress up your product

Want more information? Use postcard on last page.

Plants and People

the development of a series of supporting structures, drives, controls and data recording systems.

Byron Jackson
Acquires Rollin

Byron Jackson Co. of Los Angeles has purchased Rollin Co. of Pasadena, Calif., manufacturers of high-precision test equipment for electronic devices. Plans are under way for a new plant to house the added engineering and manufacturing facilities. Byron Jackson has been in pump manufacturing since 1872. Only in the past three years has the company branched into electronics.

Brew Moves
To New Plant

Richard D. Brew Co., designers, developers and manufacturers of delay lines, moves into its new plant of 12,000 sq ft, adjacent to the Concord Airport in Concord, N. H.
Facilities include an electronic laboratory for design and testing of delay lines and associated components, a development engineering department, a machine shop for specialized tooling and a production department.

Loasby Promoted
By Raytheon

Frank Loasby has been named director of sales engineering and service of Raytheon’s television and radio operations.
Prior to joining Raytheon in 1952 as manager of the sales engineer-
PYRAMID

Glass-enameled hermetically-sealed sub-miniature paper tubular. Manufactured to the highest commercial standards and designed to the existing performance requirements of Military Specification MIL-C-25-A.

Oil-paper capacitors of finest possible commercial quality, meeting MIL-C-25A and Jan-C-25 standards of precision.

Electrolytics of superior commercial performance characteristics, meeting Jan-C-25.

Write for Catalog J-8 for further detailed information. Or call your Pyramid Sales Representative or write to:

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Dept. 121, 1465 North Hudson Blvd., North Bergen, New Jersey

New aids for Thermistor use

Send for application kits and 52-page manual

Two special application kits of Carboloy® Thermistors (negative temperature coefficient resistors) are now available for design and application work. Each kit contains a selection of the most widely used styles and sizes.

The new, free 52-page technical manual includes latest information on the use of Thermistors in the automatic detection, measurement and control of energy.

The manual also contains comprehensive descriptions of Thermistors’ properties, revised static and dynamic characteristic curves, specifications and order information. Send coupon, today.

Kit No. 1, $20.00 FOR ENGINEERING APPRAISAL Contains 18 thermistors: two of each, in three styles and three sizes.

Kit No. 2, $125.00 FOR APPLICATION DEVELOPMENT Contains 104 thermistors: twenty-six sizes and four styles. Also contains steel, lead and fiber washers, and tubing for building assemblies.

CARBOLOY

DEPARTMENT OF GENERAL ELECTRIC COMPANY

"Carboloy" is the trademark for products of the Carboloy Department of General Electric Company

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CABLE CLIPS

Hold that wiring with these all Nylon cable clips

* Lightweight  * Tough  * Strong
* Chemically resistant
* No metal to corrode or cause short circuits
* Easy to apply  * No sharp edges
* May be used from  -60° to 250° F.

Send for samples and literature

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ELECTRONICS — October, 1954
Engineer assembles pulse system in 30 minutes, using Burroughs "do-it-yourself" units

Standard, matched units, performing basic functions, connect together to form even the most complex pulse systems.

1. START
Engineer studies time chart of the desired pulse sequence. This is the output he wants the pulse system to produce.

2. PLANNING
He determines which Burroughs units he needs and how they should be connected together. This can be done by means of a simplified block diagram. Time: 10 minutes.

3. ASSEMBLING THE UNITS
Using standard coaxial cables, he completes his pulse system by connecting the units together according to his block diagram. Time: 20 minutes.

4. JOB COMPLETED
System now produces the exact pulse sequence desired. Engineer saves weeks of breadboard engineering, vital time, uncertainty, and considerable equipment cost. And his Burroughs "Unitized" pulse handling equipment can be used over and over again on different future projects.

GET THE FACTS
No matter how complex the pulse sequence you need, you can produce it quickly and at relatively low cost with Burroughs "Unitized" pulse handling equipment. If you prefer, send us a timing diagram of the pulse sequence required, and we'll advise you what Burroughs units you need and the cost. Immediate delivery from stock. Write Burroughs Corporation, Electronic Instruments Division, Dept. 3 K, 1209 Vine St., Phila. 7, Pa.

Neomatic Names Clifton Davis

CLIFTON H. DAVIS has been appointed assistant chief engineer of Neomatic, sub-miniature relay manufacturer in Los Angeles, California. He will serve directly under T. Ross Welch, president and chief engineer.

Hobson Named President Of Honor Society

J. E. HOBSON, director of Stanford Research Institute, has formally succeeded to the national presidency of Eta Kappa Nu Association, electrical engineering honor society with some 22,000 members throughout the world.

Retiring president is Eric T. B. Gross of the Illinois Institute of Technology.

Hobson was director of the department of electrical engineering at the University of Pittsburgh and professor of electrical engineering at Illinois Institute of Technology. He was director of Armour Research Foundation, Chicago, for four years before assuming leadership of Stanford Research Institute in March, 1948.

Dr. Hobson will preside at Eta
Rugged, streamlined, accurate wrenches for every torquing problem! Based on patented non-friction principle, so will give years-longer, dependable service. Used in major auto, aircraft plants.

(A) New Livermont "ROTO-TORO" screwdriver. For low torque electronic-or similar-precision assembly work. Fits 50 standard bits.

(B) Only "HI-LO T O R O" has adjustable and reversible ratchet head! 16 models, 10 to 500 foot pounds. Also plain square drive.

Write Dept. E for complete price catalog.

Opportunities for Distribution

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ELIMINATE:

all types of ANODE LEAD RETAINERS

with "INDUSTRIAL"

"FISH HOOK" ANODE CONNECTORS

Designed specifically to eliminate any supporting harnesses which were needed in the past to prevent dangerous "Buggy Whip". This unit is absolutely slipproof, once connected to the picture tube. The connector is manufactured from tempered steel, hot tinned, with vinyl insulation, and is wired to customer specifications.

Further information and samples will be sent on request. Dept. F-10

ELECTRONICS — October, 1954

Want more information? Use post card on last page.

HOPKINS

"HY-THERM"

New sub-miniature high temperature CAPACITOR

Hermetically sealed and metal encased, new HY-THERM capacitors have been designed to meet or exceed military requirements (Mil-C-25A). Example: At 125°C the minimum insulation resistance is 20 megohms-microfarads and maximum insulation resistance is 500 megohms. Available in all standard values and tolerances. Variety of mounting and circuit combinations. Special units designed to meet individual requirements.

Have a special problem? Write, wire or phone for details, TODAY! Catalog available.

CONTINUOUS TUNING

FROM 50 TO 200 Mc

No time lost in switching from one frequency range to another. Has 72-inch direct reading dial, masked so as to show only the frequency region of interest.

This highly-sensitive, selective AM-FM receiver delivers full professional quality performance in airways, police and other general communication applications...in direction finding...and in laboratory work. Speaker and all features normally needed are included as integral parts of the receiver.

In addition, special outputs are provided for the operation of an external speaker and auxiliary units to facilitate use of the receiver as a component in complete communication, telemetering and direction finding systems.

It's compact—8½" high by 19" wide.

For detailed specifications, write Dept. E-10.

ELECTRONICS — October, 1954

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423
Your eyes will open, too, at this new concept of
VIBRATION and SHOCK CONTROL
applied to electronic equipment mechanical design

First to recognize the advantages of all metal mounting systems, Robinson launched an entirely new concept of vibration and shock control. This new concept offers the answer to many of today's unusual and exacting engineering problems.

Outstanding feature of Robinson systems is the employment of resilient load-carrying cushions of metal wire (Met-L-Flex). These metal cushions are actually knitted so as to form a multiplicity of interlocking springs continuous from top to bottom. The result is that mounted equipment literally floats on a cushion of thousands of tiny springs.

Performance is unaffected by extreme temperatures, grease, oil, water or dust. Inherent high damping assures complete control of shock and vibration at all times.

Highest standards of performance proven by years of severe testing in airborne installations, the Robinson concept is now available in industrial fields and other fields.

Send for free booklet
For full information about this new concept of vibration control, whether your problem involves delicate instruments or heavy machinery, send for booklet 850. Write or wire today. Dept. E3.

Kappa Nu's assembled convention at the time of its Golden Anniversary observance at the University of Illinois, Urbana, on October 15 and 16.

Ward Products Forms Antenna Lab

Ward Products of Cleveland has established a new antenna research laboratory in Ashtabula, Ohio, for the design and testing of all types of television and automotive antennas. W. H. Rickards is director of engineering at Ward.

The new testing laboratory will supplement the facilities of Gabriel Electronics in Needham, Mass., for antenna research and development. Walter Domoracki, formerly with Philco, is the engineer in charge of the laboratory.

Florida Distributors Form Association

A state-wide group of electronic distributors has been formed in Florida to be known as the Florida Electronic Distributors Association. Officers for election when by-laws are adopted are: Harvey Herman, chairman; Sidney Lucker, treasurer and Theodore J. Sharaf, secretary.

Electro Moves, Names Levy

ALECTRO moved into a new 6,000 sq ft plant in Los Angeles. The company, founded last year as National Development Co., is primarily a service organization de-
Round Wire to 0.00015" diameter. Ribbon rolled to 0.0001" in thickness. Close tolerances held on all specifications.

Round • oval • flat • grooved ribbon •

precision small wire

bare • insulated plated •

for highly engineered applications

all metals • all alloys

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NEW UHF MEGACYCLE METER

With the Widest Frequency Coverage in a Single Band

FEATURES
- Excellent coupling sensitivity.
- Fixed coupling point.
- Small grid current variation over band.
- Calibration point every 10 Mc.
- Uses split-stator tuning condenser with no sliding metal contacts.
- Standard camera socket for tripod fixtures.
- Octagonal case for convenient positioning.
- Useful in television transmitting and receiving equipment.

MODEL 59 UHF

SPECIFICATIONS
FREQUENCY RANGE: 430-940 Mc in a single band
FREQUENCY ACCURACY: ±2% (Individually calibrated)
OUTPUT: CW or 120-cycle modulation
POWER SUPPLY: 117 volts, 60 cycles, 30 watts
DIMENSIONS: Oscillator Unit 4½" x 2½"
        Power Unit 5½" wide x 6½" high x 7½" deep

Three different basic constructions—to meet almost every installation requirement. Unsurpassed electrical properties under deformation. They are advanced in design, proven in service. Write for literature and/or consult with our field Engineers.
Technicraft also produces custom built microwave plumbing, and a line of microwave test components.
Write for literature.
Only the manufacturer of genuine Bead Chain offers you a new, more versatile belt drive that will accurately time and control the movement of all types of devices. Among such applications are radio and television tuners, recorders, air conditioners and timing devices. Costly gearing mechanisms can be eliminated and efficiently replaced by the specially designed sprockets that accurately fit the individual beads without slippage and backlash. Friction is at a minimum and tensile strength of the Bead Chain belt (from 15 to 200 lbs.) is very high in proportion to size and weight.

Write to us today for detailed information about sprockets and Bead Chain belts. It can save you a lot of time and money later.

THE BEAD CHAIN MANUFACTURING CO.
88 Mountain Grove St., Bridgeport, Conn.

Please send me information about Bead Chain sprocket drives.

NAME: ____________________________

TITLE: ____________________________

ADDRESS: ________________________

McNamee Heads
Dressen-Barnes Research

B. F. McNamee has been appointed chief of research and development.
VIBRATION and SHOCK CLIPS

MINIATURE and SUBMINIATURE TUBE and COMPONENT HOLDERS

Tested to withstand 20 G's at 500 cycles, without resonant frequencies. Made of Cadmium-plated Spring Steel, 180° contact surface full length of component. Sizes — .175, .195, .235, .260, .312, .375, .391, .400, .500, .562, .670, .750, 1.00, 1.12 diameters, with lengths up to 2". Available serrated, for sub-miniature tubes — with or without shields.

CRYSTAL DIODE CLIPS

Silver-plated phosphor-bronze, miniature size. Hold a variety of diode sizes with a 2-pound gripping force, yet allow diode to be removed easily for replacement. Contact resistance as low as 0.00075 ohms; very low capacitance for UHF applications. Three types for through-panel, rear-of-panel, and surface-panel connections. Single clips cost less than a penny.

Fuse and resistor clips of all types — locking clips — molded Lucite cap nuts — Nylon machine screws and rivets. Send for catalog E2.

ATLAS E-E CORPORATION
BEDFORD, MASSACHUSETTS

PRINTED CIRCUITS

We wish to announce the availability of experienced personnel for the setting up, management and operation of complete Printed Circuit manufacturing.

We are primarily interested in contacting the following principals.
(1) Interested in establishing and financing a Printed Circuit company.
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All inquiries will be held in strict confidence. Complete resumes and interviews at your convenience. Write

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"CONDENSER SPECIALISTS SINCE 1923"

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AND PAPER TUBULAR
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For A.C., D.C. Sets-Phonographs
etc.

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ELECTRONICS — October, 1954

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This type 310A Z-Angle Meter measures impedance directly in polar coordinates as an impedance magnitude in ohms and phase angle in degrees, Z/A.

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Accuracy: ±1%

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Phase Angle Range: 0° to 90° Direct reading on panel meter. Meter is also calibrated in D and Q.

Phase Angle Accuracy: Within 2° of meter indication.

Internal Oscillator: 60 cycles and 400 cycles. Terminals are provided for an external, variable frequency signal generator for measurements at other frequencies.

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429
thorne, Calif., where he designed computer systems and installed and tested the BINAC—one of the first high-speed digital computers.

Convair Works On Missile Test Facility

CONSTRUCTION has started for a new $250,000 test facility on Point Loma, Calif., for one of the U. S. Air Force's guided missile programs.

Ground has already been broken on the five-acre government site on Fort Rosecrans. One of the major structures will be a steel tower covered with aluminum sheeting on three sides. Other structures will include two sheds and a horizontal testing fixture for vibration and air-pressure tests. The facility is not designed for firing missiles, but for testing components and systems.

Convair engineers are in charge of the project. They are H. A. Smith, chief plant engineer, and Charles U. Giusti, construction engineer.

Polarad Forms Computer Division

POLARAD ELECTRONICS has formed a computer division under the direction and supervision of Leroy Packer. The organization will be located at the firm's Brooklyn plant and will be concerned with the development and application of electronic computer techniques, services and equipment for industrial and government applications.

From 1948 to 1950, Packer was a research engineer on the staff of
HUMAN ENGINEERING GUIDE FOR EQUIPMENT DESIGNERS
by WESLEY E. WOODSON
Human Factors Division, U.S. Navy Electronics Laboratory, San Diego, Calif.
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MODULATION MONITOR
The Model 252 Modulation Monitor measures the percentage of modulation of AM transmitters operating from 100-225 mc, or 225 mc-400 mc. It features: wide VHF range; over-modulation indicator; carrier level indicator; audio output monitoring; low noise and hum.

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Complete with ½ H.P. Motor
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48-Page Booklet on Welch Duo-Seal Pumps has just been issued. A complete description, including performance curves of the Duo-Seal Pumps ranging from 21 liters per minute to 375 liters per minute, is given, as well as a greatly enlarged listing of Diffusion Pumps, Vacuum Gauges and accessories.

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This is a versatile line-up, as indicated by the specifications below. It gives you a wide range of floated gyro accuracies, in a variety of weights and sizes. Honeywell HIGs can be used as rate gyros, platform gyros, directional gyros, free gyros, or precessible gyros.

For full details on the HIG "family" and on our full gyro line, write Honeywell Aero Division, Dept. EL-10-163, Minneapolis 13, Minnesota.

Specifications of new Honeywell HIG "family"

<table>
<thead>
<tr>
<th></th>
<th>HIG-4</th>
<th>HIG-5</th>
<th>HIG-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angular Momentum</td>
<td>$10^4$</td>
<td>$10^5$</td>
<td>$10^6$</td>
</tr>
<tr>
<td>Threshold</td>
<td>$1^\circ$ per hr</td>
<td>$.2^\circ$ per hr</td>
<td>$.01^\circ$ per hr</td>
</tr>
<tr>
<td>Trimmed Drift Rate</td>
<td>$5^\circ$ per hr</td>
<td>$1^\circ$ per hr</td>
<td>$.05^\circ$ per hr</td>
</tr>
<tr>
<td>Maximum Precession Rate</td>
<td>3 radians/sec</td>
<td>1 radian/sec</td>
<td>1 radian/sec</td>
</tr>
<tr>
<td>Characteristic Time Constant</td>
<td>3.3 millisecond</td>
<td>2.8 millisecond</td>
<td>3.1 millisecond</td>
</tr>
<tr>
<td>Damping Ratio – Output Axis/Input Axis</td>
<td>1 to 1</td>
<td>1 to 1</td>
<td>2.1 to 1</td>
</tr>
<tr>
<td>Torque Generator Scale Factor</td>
<td>1 or 10</td>
<td>2.5 or 35</td>
<td>.025 or 1</td>
</tr>
<tr>
<td>Signal Generator Scale Factor</td>
<td>25 volts/radian</td>
<td>34 volts/radian</td>
<td>25 volts/radian</td>
</tr>
<tr>
<td>Spin Motor Excitation</td>
<td>10 volts, 2 phase</td>
<td>10 volts, 3 phase</td>
<td>115 volts, 3 phase</td>
</tr>
<tr>
<td>Weight</td>
<td>1.5 lbs.</td>
<td>2.75 lbs.</td>
<td>4.5 lbs.</td>
</tr>
</tbody>
</table>

Du Mont Tube Division Promotes Scott

ROBERT G. SCOTT has been named assistant sales manager of the cathode-ray tube division of A. B. Du Mont Labs.

As well as assisting in the management of the tube sales department, Scott will continue to contact television receiver manufacturers in the dual capacity of technical consultant and home office sales representative.

Scott joined Du Mont in 1948, as a senior engineer working on the design and development of important picture-tube innovations such as large screens, short necks, and wide-angle deflection. He later transferred to product engineering, where he followed these developments through their initial mass-production stages.

For the past two years, Scott has been manager of sales engineering of the c-r tube division.

Buckingham To Receive Wetherill Medal

A JOHN PRICE WETHERILL MEDAL will be awarded to William D. Buckingham of Western Union Telegraph Company by The Franklin Institute of Pennsylvania. The Medal is awarded for discovery or invention in the physical sciences. With the award is a citation which...
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433

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The text reads: "In consideration of his invention of the Zirconium Concentrated-Arc Lamp, a device capable of producing a high intensity, sharply defined, extremely small beam of light and with modulation characteristics heretofore unobtainable in practical devices."

Buckingham joined Western Union in 1925. In 1927 he was transferred to the Electronics Research Division Laboratory at Water Mill, Long Island, where he has been active in applying electronic techniques and equipment to land line and cable devices. He has to his credit 19 United States patents in addition to the patents on concentrated-arc lamps.

George Norman Joins Sprague Electric

GEORGE H. L. NORMAN has joined Sprague Electric as coordinator of the company's activities in the field of electronic computer components. He was general sales manager of the new products division of Corn ing Glass.

Previously, Norman spent a total of 17 years with Aerovox Corp. He was at one time chief engineer and factory manager of Aerovox Canada, and was later chief engineer of the mica division of the firm's main plant at New Bedford, Mass. During World War II, he spent five years with the Canadian Air Force and was deputy director of airborne radar development.

AIEE Broadcasting Committee Named

J. B. EPPERSON of Scripps-Howard Radio in Cleveland, Ohio, has been appointed chairman of the television and aural broadcasting committee of the AIEE. He succeeds C. E. Dean of Hazeltine Laboratories. C. M. Braum of the Joint Committee on Educational Television is the new vice-chairman and R. K. Hellmann of Hazeltine Laboratories is secretary.

Technicraft Labs Appoints Eddy

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is a laboratory quality instrument comprised of six separate pulse generators which are accurately triggered by an internal reference generator. Each pulse may be independently varied in amplitude, time, and width without interaction.

- Stable
- Accurate
- Reliable

Four of the pulses are variable in time by calibrated front panel controls with provision for PTM and PCM by external signals.

Easily synchronized by external sine wave or pulse generator.

Two sync pulses are provided for triggering associated equipment.

- Pulse Jitters < .005 μ sec.
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- Impedance 50 Ohms
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Phoenix, Arizona

Telecomputing Plans
New California Plant

TELECOMPUTING CORP., of Burbank, California, computing equipment and service firm, will start construction on a 50,000 sq ft, $430,000 plant in San Fernando Valley, Calif. The plant, expected to be complete by the year's end, will employ 500 workers for manufacture of Telecomputing's 'o Sole Recorder, an automatic sales recording device that sorts sales information for inventory control.

Sessions Clock Forms
Industrial Division

AN INDUSTRIAL products division of The Sessions Clock Company has been established. It consolidates all former sales activities for clock radio timers, clock movements and industrial timing motors. Establishment of the division is designed to increase selling and service efficiency to industrial customers. As a result of this move, there are now two main product divisions at Sessions of equal importance—the clock division and the industrial products division.

Vernon A. Lee has been named manager of the division.

Scintilla Celebrates
Plant Expansion

BENDIX AVIATION formally opened its new electronics building at the Scintilla division in Sidney, N. Y. Production operations in the new 30,000 sq ft building will be devoted to the manufacture of coils, capacitors, filters, spark gaps and jet ignition units.

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437
NEW BOOKS

Introduction to Microwaves and Their Scientific Applications

By H. H. Klinger, S. H. Uenzel, Stuttgart, Germany, 1953, 118 pages, $6.00 German marks.

According to the preface, this little book was written for students and physicists familiar with electronic fundamentals but not so well versed in the technique of high frequencies. The main subject of the book is the use of microwaves as a tool in physics, chemistry, astronomy and biology; a highly condensed but thoroughly readable review of principles and practices employed in microwave work (wave guides, cavity resonators, generators, detectors, methods of measurement) occupies the initial forty pages.

In the main part—the applications of microwaves in science—a remarkable amount of useful information can be found. In microwave spectroscopy, for instance, rotational spectra are discussed in great detail; inversion spectra, Stark and Zeman effects, etc. are explained and many examples are described. Other chapters discuss magnetic-resonance effects, dispersion and relaxation phenomena in polar liquids and high-frequency metallic conduction at low temperatures. There is also much interesting material in the chapter on biological effects of microwaves.

A few pages on radio astronomy and astrophysics, severely limited by lack of space, report measurements of solar and lunar radiation. A chapter on typical microwave experiments may appear, at first glance, to be merely a collection of well-known laboratory devices, but even here many readers will learn things they had overlooked, as for instance the distinction between two radically different types of metal array lenses. A final chapter on particle accelerators using microwaves is too short even for such a highly condensed book.

The bibliography, which lists 85 titles, gives an incomplete but truly international collection of references up to about 1952.

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440

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Canadian Representative: Atlas Radio Corp. Ltd., 550 King St. W., Toronto 2B, Canada. Phone Waverly 4761

NEW BOOKS (continued)
hundred-twenty-page book rather rough reading; surprisingly, this is not at all true. Readers with a fair knowledge of German will find this a pleasant and sensible introduction to some highly interesting fields of research in physics. One is inclined to reverse the author's recommendation and suggest this little book to the attention of students and engineers who know a lot about microwaves but would like to learn more about physics.—ROBERT ADLER, Research Department, Zenith Radio Corporation

Electronics


Electronics


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Active Networks


Four new books on electronics to serve the oncoming generation of engineers, each with somewhat different viewpoints, each useful as texts, each pointing up the vast expanse that continues in this amazing field.

Professor Brown's Book

After 35 years of teaching courses in tubes and their applications the author of this text ought to know what he wants, what he has found to be the most satisfactory arrangement and the best order in which to take up the many and varied subjects, even if that order is not too logical. Professor Brown has not been completely satisfied with what he has had to use during this teaching period, and his present text is the result of searching but not finding his ideal.

This is really a combined text and laboratory manual. The third paragraph in the book is a demonstration of diode current, not secured
A new high-speed production Soldering Iron

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150 watts 3/8 diameter Plug type tip Only 12.5" overall (including foot)

- Designed for FAST production lines
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by the old method of plotting, laboriously, the current point by point as a function of anode potential but by the modern method of using an oscilloscope to see visually the entire characteristic. Throughout the text will be found demonstrations and laboratory experiments. One of the features of the opening chapter is a derivation of Child's law.

Following chapters on conventional subjects, the final part of the book deals with electronic instruments, oscilloscopes, voltmeters, bridges etc., and finally several appendices giving tube data, advice on planning and equipping a laboratory, derivation of the Schottky effect and closing with crystal rectifiers and transistors.

The Corcoran-Price Book

This, too, is a first-course book, somewhat more mathematical than Professor Brown's text, expending more space on the fundamentals of field concepts, mobile charge behavior, thermionic emission, diode behavior and is perhaps more orthodox in its arrangement.

Progress is steady from diodes to more complex tube structures and behavior, to linear and nonlinear amplifiers, feedback circuits, gas-filled tubes and applications, with some 65 pages on germanium diodes and transistors. The final chapter deals with oscillators.

Many problems and many examples of circuits with realistic constants aid in giving the student a feel for practical electronics.

Active Networks

For the reader who has studied the physics of vacuum tubes and related devices (or who is not especially interested in this aspect of electronics) this book of Professor Rideout covers the fundamentals of all networks capable of amplification, that is, tube circuits, transistors, magnetic amplifiers, and, to a much lesser extent, servos.

After a first chapter on fundamental concepts—networks, lines, communication systems—the book really begins with amplifiers of the several types. It is interesting that magnetic amplifiers and transistors are introduced with no fanfare

NEW BOOKS

(continued)
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ELECTRONICS — October, 1954
NEW BOOKS

(continued)

whatever. Then follow low-pass amplifiers, transient response of amplifiers, and after several chapters dealing with the several well-known divisions of amplifiers, such matters as oscillators, modulation systems, wave-shaping circuits including trigger circuits and finally a chapter on noise and information theory.

In appendices will be found a brief exposition of Fourier analysis, Laplace transformation and charts of characteristic tube and transistor curves and data.

All of these books provide the instructor with distinctly teachable texts, with "Active Networks" somewhat out of the conventional pattern and with the other three "Electronics" more conventional but distinctly up to date.

Starr's Electronics

This is a typically British text with emphasis on the analytical treatment of circuits and tube functions rather than on engineering applications. It should be very useful as an undergraduate text or for an engineer who wishes terse mathematical discussions of basic material.

It has more on the fundamental aspects of electronics—wave theory, electron ballistics, semiconductors, gaseous discharges, energy levels—than the other texts noted herein and the entire treatment is mathematical rather than descriptive. The mathematics involves ordinary calculus, some usage of Heaviside notation, Laplace transforms, Fourier analysis but with sufficient explanation so that the tyro can use it. Appendices give mathematical formulas, steady-state a-c theory, Maxwell's equations and other useful material.

Chapter headings are Physical Fundamentals, Valves, Rectification, Circuit Theory, Amplifiers, Oscillators and Detectors, Electronic Applications (32 pages), plus the seven appendices.

The American reader will run across terms not employed here such as trigatron, the nomotron circuit, long-tailed pair, megslip, velodyne and others but they are quickly identified with their American equivalents.—K.H.
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ELECTRONICS — October, 1954
Theory and Design of Electron Beams


PIERCE's book has, no doubt, become a standard reference for tube engineers whose job it is to design electron tubes employing high-current electron beams. It contains in one volume all the necessary basic theoretical material, obviating any need to search the scattered literature. It is this convenience and the knowledge that an authority has collected the material which justify the existence of this book. An engineer suddenly confronted with the task of designing beam generating and guiding structures will, therefore, find it very useful.

Electron Optics

Chapter I, "Properties of Electric and Magnetic Fields", deals with the fields which are found in such devices as cathode-ray tubes, triodes and some microwave tubes employing means of focusing electron streams. In other words, it deals with the theory of quasi-static fields.

Chapter II, "Forces and Equations of Motion", discusses the Lorentz equation for non-relativistic motion and contains a paragraph on scaling.

In Chapter III, "Simple Motions", the general equations of motion are applied to the special cases of motion in uniform electric and/or magnetic fields and in the electric field produced by hyperbolic electrodes.

In Chapter IV, "Some General Relations", a few more simple cases of electron motion are discussed, and some general laws such as the conservation of angular momentum, Busch's theorem and Liouville's theorem are treated. The concept of "index of refraction" for purely electric fields is also introduced.

Chapter V, "Some Typical Special Problems", deals principally with a discussion of analogue devices useful in the solution of problems of electron motion.

Chapter VI, "The Paraxial Ray Equation", is a chapter on elementary electron optics or the motion of electrons in rotationally symmet-
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The material of the last chapter on beam focusing and the effects of the magnetic field and the electric field is contained in most books. This edition contains a more detailed treatment of these subjects. Also, some more elementary electron optics is included.

Chapter VII, "Magnetic and Electric Fields", contains some more elementary electron optics. This chapter covers the fundamentals of magnetic and electric fields and their effects on electrons. It also includes a discussion of the behavior of electrons in electric and magnetic fields.

Chapter VIII, "The Effect of the Magnetic Field on the Flow of a Beam of Electrons", discusses the effects of the magnetic field on the flow of a beam of electrons. It covers topics such as the deflection of a beam of electrons in a magnetic field and the focusing of a beam of electrons in a magnetic field.

The material of Chapters IX and X is contained in most books. This edition contains a more detailed treatment of these subjects. Also, some additional material on the subject is included.
Introduction to Electric Fields


Designed to provide a text for a one-semester or one-quarter course for junior and senior electrical engineering students taking either communications or power option, this book indeed constitutes an adequate introduction to the subject of electromagnetic field theory. As such, it presumes no prior training in vector analysis and only a nodding acquaintance with differential equations.

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Another case solved by Watlow Electric Heat.

NEW BOOKS (continued)

page treatment of elementary operations with vectors. The concepts of gradient, divergence and curl, however, are introduced later in connection with discussion of electric potential, Gauss’ law and Ampere’s law, respectively. Methods for solving the necessary differential equations are described in some detail as the equations are encountered.

Approach
In the main, the book furnishes an approach to Maxwell’s equations through a study of electrostatic and electromagnetic fields. Vector methods are employed throughout. The book is long on providing practical experience in working with field problems.

A valuable contribution is the graphical presentation of field configurations. These presentations are obtained using both the fluid-mapping methods developed by A. D. Moore of the University of Michigan and a membrane-analog method developed by the author. This latter method makes use of a taut rubber sheet suitably deformed and illuminated. An appendix describing both methods in some detail is provided for use by instructors who desire to plan laboratory work to accompany a course taught from this text.

The text’s approach to Maxwell’s equations is by way of studying Coulomb’s law, the concept of potential, the field of an electric current, Gauss’ law, the equations of Poisson and Laplace, the magnetostatic field and time-varying electric and magnetic fields. Also included is material on solution of field problems by the method of images and on the properties of dielectrics and insulation. The final chapter discusses the vector potential.

The text is adequately indexed and particularly strong on problem material both inserted in running text to explain the concepts introduced and for assignment to the student.—J.C.

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NEW BOOKS
(continued)
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Controllers for Electric Motors


This book is primarily intended for maintenance personnel engaged in work with industrial motor-control systems. Main emphasis is placed on electrical control systems; electronics comes into the picture only in the form of conventional magnetic amplifier controls.

The book gives a good technical description of the factors involved in motor controlling and describes the electrical engineer's way of achieving control by the means at his disposal. It should be of value to electronics engineers in showing him the limitations of nonelectronic systems and in teaching him basic concepts for applying electronic controls.—J.D.F.

The Cyclotron


This is a new edition of a book first published in 1940, when Professor Ernest O. Lawrence wrote (in the Preface), "Let us cherish the hope that the day is not far distant when such a great cyclotron will be built!" The dream which was the object of this sentiment was a cyclotron capable of accelerating helium ions to 100 or possibly 200 million volts. That dream has been eminently fulfilled, notably at Professor Lawrence's own laboratory in Berkeley, California, where a 184-in. synchrocyclotron has accelerated alpha particles to 400 Mev.

The author, formerly associated
with Imperial College at the University of London, is at present a member of the staff of the U.S. National Bureau of Standards. In publishing a 4th edition of this now classic monograph, Methuen is filling a real gap in the literature of high-energy machines. There is, in fact, no other book-length treatment of this subject in English.

Dr. Mann's text is not highly mathematical, and can be easily followed by anyone who has ever sat in on an undergraduate course in atomic physics. If the discussion of cyclotron applications is neglected, college freshman mathematics becomes sufficient for an understanding of this largely qualitative text, which was actually aimed at readers working outside the realm of high-energy physics.

The fact that the book was originally written during a period when the designers of high-energy machines first began making great strides adds another facet to the interest with which this volume should be received—as an important contribution to the history of modern physics.

That is not to say that the book is of historical interest only: an epilogue, added in 1953, manages to bring the reader up to date. Moreover, as an exposition of the basic principles underlying the design and operation of cyclotrons, the book is not likely to be soon obsolete.—Charles Susskind, Stanford University, Stanford, Calif.

Electron Optics

THROUGH ERROR, the review of O. Klemperer's book, published in September 1953 ELECTRONICS, contained the statement that the book had no index. The reasons for this error are as follows: the publishers sent ELECTRONICS a proof copy of the book; this was duly furnished to E. G. Ramberg, the reviewer, who noted that there was no index and properly commented on this fact. The book as published, however, does contain an index and this fact was not checked by the editors before Mr. Ramberg's review was published. This mis-statement is regretted.

The Editors
**BACKTALK**

**Ionic or Iontic?**

**Dear Sirs:**

In most cases, non-Greek scientists have adopted Greek words to express scientific conceptions with such success that they have drawn the admiration of the Greek scientists themselves. . .

However, the basic term ion is the neuter of the present participle of the Greek verb *iēnai*, to go. This term ion is quite correct as regards English pronunciation, spelling and meaning. But its derivatives and compounds, as they are used by non-Greek authors are not only incorrect but they are also confusing . . .

Introducers of the derivatives or compounds have added to the original word ion the respective suffix, or additional word, to form new words having new meanings; the terms ionic, ionization, to ionize and ionosphere have been formed.

But the correct spelling of the first of them ought to be ionic to retain its proper meaning and not ionic because the adjectival ionic comes from the Greek adjective *ionikos* having the meaning: “Of or pertaining to Ionia or the Ionians”, an ancient Greek land and race, respectively. . .

Ionic is also a synonym of ionian which, in addition to having the above meaning, refers to the Ionian Islands of to-day . . . no relation whatever to the electrically charged atoms, molecules or radicals . . .

When we wish to produce a composite word relating to ion we have to use the root of the word, which is ion- (or ionto- for euphony) adding to it the suffix or the second constituent word . . . it has been done for *iontophoresis*. Can it not be done for a few more terms?

There is also the new radioactive isotope ionium, which should be spelled and pronounced: ionium, unless the introducer had in mind to honor the memory of the mythical Io, the ancient Greek priestess whose name is borne by the Ionian Sea.

So it follows that we should use the correct spelling and pronunciation.

**MARKWIK**

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DIONYSIUS J. BATAIMIS
Member of the Technical Services
Hellenic National Broadcasting Institute
Athens, Greece

Editor's Note: Mr. Bataimis certainly presents a strong case. We wonder who so correctly introduced the word "iontophoresis" for the medical introduction of ions into tissues of the body?

Feedback

DEAR SIRS:
I was interested in Joseph Diamond's article, p 148, Nov. 1953 ELECTRONICS, and I would offer these comments on some of the points your contributor makes.

In his very first column he says, "a tetrode stage . . . raises a stability problem that has not been discussed before".

Now in point of fact P. J. Baxendall discussed this very problem (of applying over 30 db N.F. to 6L6's to get less than 0.1 percent distortion) in Wireless World of January 1948. This article was subsequently reprinted with others as a booklet, "High Quality Amplifiers."

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<td>Input</td>
<td>Sinewave 0.1 to 100 y peak-peak.</td>
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<td>Positive pulses</td>
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<td>0.1 to 100 y peak.</td>
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<td>Input Voltage</td>
<td>0.1 Volt Minimum</td>
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<td>Peak-Peak</td>
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<tr>
<td>Input Impedance</td>
<td>1 Megohm Shunted by 50 mmfd.</td>
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<tr>
<td>Counting Interval</td>
<td>1 or 10 Seconds</td>
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<tr>
<td>Interval Accuracy</td>
<td>±0.0005 Percent</td>
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<td>1, 2, 5, 10 Seconds or Manual Reset</td>
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ELECTRONICS — October, 1954
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(Classified Advertising)

Continued on pages 460-494

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(Continued on the following page)

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251-18th 23rd Ave., Bayside, L. I., N. Y.

**SEARCHLIGHT SECTION**

(Classified Advertising)

Continued on pages 460-494

**MINNEAPOLIS OPPORTUNITIES**

Transformer Design, BEE .......................... $7200

Transformer Test Tech ............................... $4200

Walker Employment Service

537 N.W. Bank Bldg., Mpls.

REPLIES (Box No.). Address to office nearest you.

NEW YORK 1, N.Y. 39 W. 40th St. (36)

CHICAGO 38, Ill. Michigan Ave. (11)

SAN FRANCISCO 68 Polk St. (1)

**POSITIONS VACANT**

**ELECTRONIC DEVELOPMENT** Engineer needed by Ohio company manufacturing commercial electronic equipment. Must have had 5 or more years experience at designing pulse circuits and power servo systems. Must be capable of both system and detail design of electronic and electrical controls for customer equipment. Also must be capable of the design and development of production test apparatus. Salary approximately $11,000 per year. Allowance for moving expenses. Replies held in confidence. Submit resume to P-3534, Electronics.

ENGINEERS-SCIENTISTS: Research and Development Laboratories at our Anaheim, California Division provide opportunities for creative work in aircraft and missile guidance and controls. Engineers, Physicists, and Metallurgists with proven experience and Associates with superior educational records are needed. Our company has a long history of successful research, development, and manufacturing of precision control devices. Permanent employment and recognition of high quality workmanship are characteristics of company policy. Address inquiries to: Director of Research and Development, Robertshaw-Fulton Controls Company, Anaheim, California.

ENGINEER with academic and considerable practical background in electronics and communication circuit design to do development work on complex military electronic systems. Unusual opportunity for advancement and growth in this newly organized development staff. Address reply to P-378, Electronics.

**SELLING OPPORTUNITY OFFERED**


**POSITIONS WANTED**


**MODEL MAKER**, experienced machinist also experienced in development of labor saving equipment, having been particularly successful in the line of nuclear instrumentation. Desires contact with manufacturers or research organization where 40 years of highly diversified experience can be used. Prefer New England area. P.W.-3833, Electronics.

(Continued on the following page)

**RESEARCH OR PRODUCT DEVELOPMENT**

Engineer-Physicist, Age 44, 19 yrs. experience in radio, TV, and operation of electronic or engineering groups in research, design, and development of electronic equipment. Extensive sales experience. High standards of integrity and professional ability. Desires employment in research or manufacturing products. High standards of integrity and professional ability. Desires employment in research or manufacturing products. Desires to take on an additional line of components or instruments.

R.A.-3954, Electronics

320 W. 42 St. New York 36, N. Y.

**NEW ENGLAND REPRESENTATION**

Technical quality manufacturers representative selling electronic components and instrumentation to industry and universities. Interested in New England desires to take on an additional line of components or instruments.

R.A.-3954, Electronics

320 W. 42 St. New York 36, N. Y.

**CONTRACTS**

Supplements other advertising in this issue with these additional announcements of products essential to efficient and economical production and maintenance. Make a habit of checking this page, each issue.

This CONTACTS Section

** Auricon Hollywood**

16mm SOUND-ON-FILM EQUIPMENT FOR TELEVISION NEWSREEL, TV FILM INSERTS AND KINESCOPE RECORDINGS...SOLD WITH A 30-DAY MONEY-BACK GUARANTEE. YOU MUST BE SATISFIED!

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Precise BLACK ANODIZING

Specializing in black anodizing, both sulphuric and chromic, on all alloys and castings.

All other colors as well.

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**CINEMA'S TAPE AND FILM**

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Noise & program erasure. Use the best. Cinema's Bulk-Tank Type Degauss 9205 Economically priced. Buy yours today!

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251-18th 23rd Ave., Bayside, L. I., N. Y.
UNDISPLAYED RATE
$1.80 a line, minimum 3 lines. To figure advance payment count 5 average words as a line.
POSITION WANTED: undisplayed advertising rate is one-half of above rate, payable in advance.
BOX NUMBERS count 1 line additional.
Send NEW ADVERTISEMENTS to N. Y. Office, 330 W. 42 St., N. Y. 36, for the November issue closing October 1st.
The publisher cannot accept advertising from manufacturers of resistors, capacitors, rheostats, and potentialmeters or other names designed to describe such products.
INFORMATION
DISCOUNT 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).
EQUIPMENT WANTED OR FOR SALE Advertisements acceptable only in Displayed Style.
DISPLAYED—RATE PER INCH
The advertising rate is $16.18 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.
AN ADVERTISING INCH is measured 7/8 inch vertically on one column, 3 columns—30 inches to a page.

PHYSICISTS and ENGINEERS
Electronic
Mechanical
Chemical
Interested in Research, Advanced Development and Product Design involving
TRANSISTORS AND SEMI-CONDUCTOR DEVICES
COMMERCIAL AUTOMOBILE RADIO
MILITARY RADIO AND ELECTRONIC EQUIPMENT
ELECTRONIC COMPONENTS
INTRICATE MECHANISMS (tuners, mechanical linkages, controls, etc.)
Diversified and challenging work in an informal friendly atmosphere with congenial associates and modern equipment and facilities. Liberal employee benefits. Opportunities available for recent graduates and for experienced men with Bachelor or advanced degrees.
All inquiries treated confidentially and given prompt attention. Relocation expense allowed for those employed.
WRITE OR APPLY
DELCO RADIO DIVISION
GENERAL MOTORS CORPORATION
Kokomo, Indiana

DESIGN ENGINEERS
The Pacific Division, Bendix Aviation Corporation has openings for design engineers in development of radar, sonar and telemetry offering excellent opportunities for growth with the corporation and the opportunity to live in Southern California. Positions are open at several levels.
Please Address Inquiries to
W. C. WALKER
ENGINEERING EMPLOYMENT MANAGER
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MANUFACTURERS DISTRIBUTOR REPRESENTATIVE AVAILABLE
One of the oldest and largest Industrial Electronic Distributors in the country will now assume full responsibility as Manufacturers Representative and Distributor in the Metropolitan New York-New Jersey area.

MANUFACTURERS REPRESENTATIVE

FOR DETAILS ON AN ENTIRELY NEW SALES PLAN COVERING COMBINED REPRESENTATION AND DISTRIBUTION WRITE
RA-3989, ELECTRONICS,
350 W. 42 St., New York N.Y.

HAVE YOU A BETTER MOUSETRAP?
Let us introduce it at GRIFFISS AFB, center for all AF ground electronic equipment and see that you no longer miss any AF business.

FOR LEASE
ELECTRONICS LAB
Adjacent Pentagon Bidg., in Arlington, Va., 18,000 sq. ft. in one floor masonry bidg.; Offices, 440 volt current, fluorescent lighting, partly air conditioned, long lease. See Mr. Norris.

WEaver Bros., Inc.—REaltors
Washington Bldg. Wash. 5, D.C.
GOODYEAR AIRCRAFT CORPORATION, pioneer and leader in lighter-than-air craft, offers you a new employment opportunity with a well-established and fast-growing company where "careers are planned."

DESIGN AND DEVELOPMENT engineering opportunities are available for capable and imaginative men and women in the field of airships, aircraft and aircraft components.

RESEARCH AND DEVELOPMENT projects — missiles, electrical and electronics systems, servomechanisms, new special devices, fiber resin laminates — all present an urgent need for engineers with fresh talent, aptitude and ambition.

POSITIONS ARE OPEN at several levels in various fields with salaries based on education, ability and experience.

Physicists
Civil engineers
Mechanical engineers
Electrical engineers
Aeronautical engineers
Technical editors
Welding engineers
Technical illustrators

AKRON, THE HOME OF GOODYEAR AIRCRAFT, is located in the lake region of northeastern Ohio. Cosmopolitan living, year-round sports and recreation, cultural and educational advantages make this thriving city an ideal spot for a pleasant home.

YES, BUILD YOUR FUTURE — TODAY! Write, giving your qualifications, or requesting an application form.

C. G. Jones, Salary Personnel Department

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advanced electronics developments create new opportunities for engineers at General Electric

New revolutionary developments are under way at General Electric. Behind each advance are the General Electric engineers ... working with the finest facilities ... exploring the most challenging aspects of their field ... knowing the sense of stability and progress their work provides.

And, with each new advance, broadening the scope of electronics ... new challenges, new opportunities constantly arise.

The opportunity is ever-growing at General Electric. And, an excellent salary and liberal benefits are other advantages worth knowing about.

Experience required in the following fields:
Advanced Development, Design, Field Service and Technical Writing in connection with:
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MULTIPLEX MICROWAVE
MOBILE COMMUNICATION
COMMUNICATIONS
ELECTRONIC COMPONENTS
TELEVISION, TUBES & ANTENNAS
Bachelor's or advanced degrees in Electrical or Mechanical Engineering, Physics, and/or experience in electronics industry necessary.

Please send resume to: Dept. 10-4-E, Technical Personnel
GENERAL ELECTRIC
ELECTRONICS PARK, SYRACUSE, N. Y.

ENGINEERS
with EXPERIENCE
in electronic development

... are you EXPERIENCED in
RADAR - MISSILE CONTROL
AIRBORNE COMMUNICATIONS
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... does an analysis of your background show that — at present — you are employed at THE HIGHEST LEVEL OF YOUR SKILL?

... Send us a resume of your background. We may have a higher level position open for you!

Send resume to Mr. L. H. Noggle, Dept. J

BENDIX RADIO

Division of Bendix Aviation Corp.
Baltimore 4, Md.

CORNELL AERONAUTICAL LABORATORY, INC.
BUFFALO 21, NEW YORK

462

October, 1954 — ELECTRONICS
Your future's on the rise when you're an aviation electronics engineer with RCA!

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Specialize in: Radar ... Analog Computers ... Digital Computers ... Servo Mechanisms ... Shock & Vibration ... Circuitry ... Heat Transfer ... Remote Controls ... Sub-Miniaturization ... Automatic Flight ... Transistorization ... Design for Automation.

You should have 4 or more years' professional experience and a degree in electrical or mechanical engineering, or physics.

In these positions at RCA, there's a real engineering challenge. You'll enjoy professional status ... recognition for accomplishment ... unexcelled facilities ... engineering graduate study with company-paid tuition ... plus many company-paid benefits. Pleasant suburban and country living. Relocation assistance available.

Look into the RCA career that's waiting for you! Send a complete resume of education and experience to:

Mr. John R. Weld, Employment Manager
Dept. 300J, Radio Corporation of America
Camden 2, New Jersey

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Engineering Careers with a Future

• Positions are available in our organization at all levels for qualified personnel in the following fields:

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Our rapidly expanding interests in these and other fields opens many opportunities for experienced electrical engineers as well as recent graduates.

Chicago location offers excellent opportunities for further study and graduate work in the electronics field.

Personal interviews will be arranged at the convenience of qualified applicants.

We suggest you write Mr. Walter Wecker, Personnel Department to get more information on career opportunities, advanced educational plans, and other advantages.

Admiral Corporation
3800 W. Cortland St.
Chicago 47, Illinois

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Applicants must have Bachelor, Masters or Ph.D degrees and a minimum of two years' experience in experimental research, design and development of control equipment and instruments.

Positions are of immediate and permanent importance to our operations. Southwestern location in medium sized community. Excellent employee benefits. Reply by letter giving age, experience and other qualifications.

Employee Relations Manager
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PHILLIPS PETROLEUM COMPANY
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With a progressive, expanding, well established corporation. Interviews will be arranged for qualified applicants. Send complete biographical resume, experience and education to

Mr. J. E. Richardson
Personnel Director
MARYLAND ELECTRONIC MFG. CORP.
5009 Calvert Road
College Park 9, Maryland

464 October, 1954 — ELECTRONICS
ENGINEERS

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What a Career at
General Precision Laboratory
Can Mean to You?

Electronics, systems, analogue computer, field, environmental test and related engineers will find few opportunities which can match the advantages at General Precision.

It's a growing research laboratory, subsidiary of the large and diversified General Precision Equipment Corporation. Work is on a variety of interesting long-range projects, and men with initiative and ability are given prompt recognition for their achievements.

Living and working conditions are of the best. The modern laboratory is located in New York's Westchester County, known throughout the country for its beautiful surroundings and high standard of living... and only one hour from metropolitan New York city with its wealth of cultural and educational activities.

If you're interested in a permanent, satisfying career, send your resume to Mr. Hollis F. Ware, Personnel Director. Expenses will be paid for qualified applicants who come for interviews.

GENERAL PRECISION LABORATORY INCORPORATED
A subsidiary of General Precision Equipment Corporation
63 Bedford Road
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- Dynamics Testing
- Telemetering
- Servomechanisms
- Electron Tubes
- Radar Design
- Digital Computers
- Test Equipment
- Miniature Circuits

Generous travel allowances to those accepted. For free brochure, write Mr. H. T. Brooks, Engineering Dept. 900

CONVAIR
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Division of General Dynamics
3302 PACIFIC HIWAY
SAN DIEGO 12, CALIFORNIA
Raytheon offers CAREER-FUTURE

We can offer engineers with bachelor, masters, or PH. D degrees and at least 2 years of experience in design and development an opportunity to establish themselves with a growing division of a leader in Electronics.

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Please send a complete resume with education, experience, and salary requirements to

T. F. COLLINS

RAYTHEON MANUFACTURING COMPANY
CHICAGO DIVISION, EQUIPMENT OPERATIONS
4132 W. BELMONT AVE. CHICAGO 41, ILLINOIS

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Has permanent positions for Engineers and Physicists with experience in one of the following fields:
- Analysis and design of search radar systems
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- Antenna theory and design
- Circuit theory and design
- Analysis of missile guidance systems
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- Microwave techniques
- Infra-red for detection and tracking
- Inertial guidance
- Communications

Please send resumes to
MANAGER OF PERSONNEL
All inquiries will be answered within two weeks

SYLVANIA ELECTRIC PRODUCTS INC.
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Bendix Aviation Corporation

YORK Division . . .
This NEW division of our nationally-famous corporation has openings for . . .

ENGINEERS

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Top-flight men in advanced fields of electronic research, development and product engineering are needed for challenging work under ideal conditions in our new, modern plant. You benefit at Bendix York from our location in the heart of a beautiful suburban area, from high wages, paid vacations and holidays . . . and excellent opportunities for advancement. Openings at all levels.

Write, Wire or Phone
Department Y-1

Electronic and Mechanical Engineers!
Motorola Research Laboratories, located in the healthful climate of Arizona's Valley of the Sun, has several openings for experienced engineers in the following fields:

Electronic research and development for missile guidance, radar and VHF communications.
Mechanical design of missileborne and vehicular electronics equipment.
Analysis and laboratory work involving development of new types of airborne and ground radiators and waveguide components.
VHF and microwave antenna waveguide circuitry.
Transistor development.


WRITE: J. A. Chambers, Manager
Motorola Research Laboratory
3102 North 56th Street
Phoenix, Arizona

Antenna development program at Lockheed expands

Lockheed's diversified development program presents Electronic Engineers qualified for airborne antenna design with a wide range of assignments in communication, navigation and microwaves. Antenna design is one of the fastest growing research and development areas at Lockheed.

Studies embrace virtually all types of aircraft, including the Super Constellation radar search plane—a type of aircraft developed and produced exclusively by Lockheed.

Career Positions at Lockheed

Lockheed's expanding development program has created a number of positions for Electronics Engineers and Physicists to perform advanced work in antenna design.

Lockheed offers you increased salary rates now in effect; generous travel and moving allowances; an opportunity to enjoy Southern California life; and an extremely wide range of employee benefits which add approximately 14% to each engineer's salary in the form of insurance, retirement pension, sick leave with pay, etc.

Those interested are invited to write E. W. Des Lauriers for a brochure describing life and work at Lockheed and an application form.

Electronics Research Engineer Irving Aline records radiation antenna patterns. Twenty-two foot plastic tower in background eliminates ground reflections, approximates free space. Tower is of Lockheed design, as are pattern integrator, high gain amplifier, square root amplifier, logarithmic amplifier.

Electronics Research Engineer F. R. Zboril measures input impedance of a scale model helical antenna array used for ground tracking of missiles. Most of Lockheed's other antenna work involves advanced research studies on flush mounted antennas.

E. O. Richter, Electronics Research department manager (seated), W. R. Martin, antenna laboratory group engineer (standing), and J. L. Rodgers, electronics research engineer, discuss design of corrugated surface antenna.

LOCKHEED
AIRCRAFT CORPORATION
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Electronic Engineers

Your Move

The men we seek are experts in their specialized fields; capable of filling responsible engineering positions with Melpar, a leader in research and development. Perhaps one of these men may be you. We invite you to learn about our long-range military and industrial programs.

If you are experienced in one or more of the fields listed, write us about yourself, and let us tell you during a personal interview about our past record of success and how you can successfully fit into our future plans.

Technical Personnel Representative

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A Subsidiary of the Westinghouse Air Brake Co.
452 Swann Ave., Dept. E-10, Alexandria, Virginia
or 11 Galen St., Watertown, Mass.

ELECTRICAL & ELECTRONIC ENGINEERS

Moderate expansion of Kollsman's research and engineering facilities has created several excellent opportunities associated with the development, testing and field servicing of precision airborne navigation systems. Some previous experience with electronic and electro-mechanical computers and instruments is essential. Among the advantages at Kollsman are a congenial atmosphere, the most modern facilities and interesting and diversified assignments in the design and development of America's finest aircraft instruments.

For Appointment, Please Write Employment Manager

KOLLSMAN Instrument Corp.
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control engineers

A further expansion of Honeywell's Aeronautical Division has created the following unusual opportunities. If you are interested in a permanent position, with America's largest control manufacturer, consider these challenging opportunities now available at top salaries.

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New positions open in the design of mechanical components of gyros, accelerometers, synchros and other related devices. Requires minimum of 5 years' experience in mechanical design.

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New opportunity in design of hydraulic components and systems involving servos, valves, actuators for automatic flight controls. Requires engineering degree or equivalent and 3 years' design experience.

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Unusual new position open in Research Department for engineer to work on extremely low friction, low error and high precision multi axis gyro platforms. Position requires a Mechanical Engineer or Physicist with experience or advanced training in machine design, gyro principles and analytical mathematics.

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New position open as methods engineer working primarily on the assembly of precision gyros and other small devices. College degree or equivalent desirable plus 3 years' experience in similar or related work.

SERVOMECHANISM RESEARCH ENGINEER

Newly created position open in our Analytical Section studying control operations as simulated on our "Reac" computer. Work will be primarily in field of jet engine controls and will require an understanding of jet engine operation and control problems. Analog computer experience is necessary.

If you are interested in any of these well paid positions located in Honeywell's new Aeronautical Plant in Minneapolis, send your resumes to—

J. Arthur Johnson
Director of Engineering Placement
Dept. EL-10
Minneapolis-Honeywell Regulator Co.
Minneapolis 8, Minnesota

Electronic Engineering Company of California

The Electronic Engineering Company of California is an independent firm engaged in the design, development and fabrication of electronic equipment for private industry and the Armed Forces. Founded and managed by electronic engineers, the Electronic Engineering Company offers a broad background of experience, highly trained personnel, excellent facilities plus a well integrated, expanding organization.

The Electronic Engineering Company has openings for engineers with experience and background in industrial and military electronics.

Please send resume of experience and education with salary requirements for

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No charge for our services.

Please submit complete resume giving details of education, experience, and past earnings. All replies will be held strictly confidential.

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SEND RESUME TO EMPLOYMENT MANAGER, 1201 CASS AVENUE, ST. LOUIS 6, MO.

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The Cook Research Laboratories, one of the Nation's most progressive research and development laboratories, has openings for qualified engineers and physicists at both Senior and Junior levels.

A Growing Company
Excellent Personnel
High Starting Salaries
Excellent Working Conditions

There are immediate openings in the following fields:

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Pulse Systems
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MR. D. M. HALLIDAY

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A Division of
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Chicago
Electrical and Mechanical Engineering and Manufacturing Since 1897

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Every advertisement printed in the Searchlight Section is duly authorized.

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Classified Advertising Division
McGRAW-HILL PUBLISHING CO., INC.

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P-3340, Electronics
520 N. Michigan Ave., Chicago 1, Ill.

October, 1954 — ELECTRONICS
ENGINEERS ELECTRONIC

WORK FOR THE LEADER IN THE INDUSTRY

E.E. Degree required. Experience helpful in any of the following:

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TWO WAY RADIO
ADVANCE CIRCUIT DESIGN
MICROWAVE
FIELD ENGINEERING

High starting salary plus many company benefits including profit sharing

WRITE, GIVING COMPLETE RESUME OR APPLY IN PERSON 8 TO 5 DAILY.

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With Experience in VHF and UHF Frequencies

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EXCELLENT SALARIES
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2 years technical school in communications and 3 years experience

Must be willing to travel in United States and Europe.

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Qualified Electronic and Electro-Mechanical engineers find happy association with a Western electronics pioneer and leader.

design
development
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Commercial and military projects. Radar, DME, Communications, Noise, Test Equipment including color TV.
—Many others with real interest & challenge. Relocation expenses — excellent working conditions — Central location, Scheduled reviews & advances. Fine insurance plan. Move should not disturb urgent military projects.

Address replies to Mr. R. M. Fairbrother
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An opening exists in a growing company located in suburban Boston for a microwave engineer to head a group engaged in system and component development of air-borne equipment. A real challenging, interesting position with a future.

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eased, approx. 4" dia.
x 6" long. Mfg. by
Diehl and Bendix.
110 volt. 60 cycle,

12602-1-A. Includes CH -5 Servo motor coupled to output
shaft thru 125:1 gear
reduction train. Output
shaft coupled to autosyn follow-up (AV -43). Ratio of output shaft to
follow-up autosyn Is 30:1. Includes base mounting type cover for motor and gear train.

10563 LELAND ELECTRIC
Output: 115 VAC;
75

$20.00 ea.
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TRANSMITTER, BENDIX C-78248: 115 Volt, 60
$25.00 ea.
Cycle
$5.00
Differential -C-78249: 115 V. 60 Cy
REPEATER, BENDIX C-`78410: 115 Volt, 60
le
REPEATER, AC synchronous 115 V., 80 cyycle

$15.00 ea.
C-78863
REPEATER, DIEHL MFG. No. FJE 22-2: 115 Volt;
$27.50
400 Cv., Secondary 90 V
5G GENERATOR (115/90) 60 cycles
$45.00
7G Synchro Generator (115/90 volts; 80 cycle $75.00
6G Synchro Generator (115/90 volt; 60 cycle) 960.00
6DG Synchro Differential Generator (90/90 volt; 60
$50.00
cycle)
215F1 Selsyn Control Transformer: 105-55 Volta;
$22.50
00 Cycle
21D5HAI Selsyn Generator: 115-105 Volts; 60
$50.00
cycle
400
57.5 Volt;
2JIFI GENERATOR: 115

-

cycle:
12

3 -phase,

VA:

115

amp

$59.50

$34.95 ea.

26 volts; 400 cycles;
Phase. INPUT: 24 VDC; 1 amp

OUTPUT:

-

eye.

400

PF. Input: 28.5 VDC;

PIONEER 12117

General Electric MOD. 2J15M1; 115-57.5 Volts 400
$22.50 ea.
Cycle
AUTOSYN MTR. KOLLSMAN Type #403; 32 VAC;
$9.95
60 cycle; single phase
VAC; 80
#851;
32
Type
AUTOSYN MTR, BENDIX
$9.95
cycle; single phase
$15.00
MICROSYN UNIT. Type 1C -006-A
615.00 ea.
IF Special Repeater (115V-400 Cy.)
$10.00 ea.
211F 3 Generator (115-400 cyc.)
5CT Control Transformer: 90-50 Volt; 60 Ci...945.00
$45.00
5F Motor (115/90 Volt -60 cyc.)
400
5SDG Differential Generator (90-94 volts

6

volt amperes.

1

-

MAGNETIC
AMPLIFIER
UNIT

$25.00 ea.

ALTERNATOR, CARTER

Mfr. Pioneer Instrument
Type 12071-1-A; 110
Volta, 400 cycles; 26
Volte, 400 cycles; 4 -Tubes
(12ÁH7-GT) ; take - of
for four autosyns.
$29.95 ea.

Mfg. Carter Motor Co.; OUTPUT: 7 VAC; 9.7 amp.;
650 cycles, and 295 VDC, 200 amps. INPUT: 28.5
$49.50 ea.
VDC; 10.5 amps; 6500 rpm

PE 218 LELAND ELECTRIC
Output: 115 VAC; Single Phase; PF 90; 380/500
cycle; 1500 VA. INPUT: 25-28 VDC; 92 amps; 8000
RPM; Exc. Volta, 27.5
$39.95 ea.
BRAND NEW

TELEGON
OSCILLATOR

109 LELAND ELECTRIC

PE

Output: 115 TAC. 400 cyc; single phase; 1.53 amp;
$65.00
8000 RPM. Input: 13.5 VDC; 29 amp

MG 153 HOLTZER-CABOT

INPUT: 115 Volts, 60
OUTPUT: 26.5
Volts, 400 cycle, 3 -watts
@ 250 ohm load.
Ideal
for laboratory use
approx. 10" a 7" x 8", wt.
16 lbs.
$29.95 ea.
cycle.

-

-

400
Input: 24 V, DC. 52 amps. Output: 115 volts
400 cycle, 250
cycles, 3 -phase, 750 VA. and 26 Volt
$95.00 ea.
VA. Voltage and frequency regulated

PIONEER 12130-3-B

$12.50 ea.

Output: 125.5 VAC; 1.5 amps. 400 cycle single phase,
141 VA. Input: 20-30 VDC, 18-12 amps. Voltage and
$75.00
frequency. regulated

$7.50 ea.

12116-2-A PIONEER

DIFFERENTIAL GENERATOR: 57.5-57.5
$12.50 ea.
Volt; 400 cycle
21 IGI CONTROL TRANSFORMER: 57.5-57.5 Volt;
211H1

400 cycle
215H1 SELSYN
Volts, 60 Cycle

UNITS
Type

Quantities Available.

viole

PIONEER
TORQUE

INVERTERS

SELSYNS

GENERATOR: Mfg. O. E 115-105

$27.50

Manufactured by SOLA
REGULATION ± 1%

Output: 115 VAC; 400 cyc.; single phase; 45 amp.
$65.00
Input: 24 VDC 5 amp

Primary voltage 210-270.

Output: 115 Volts AC. 750 V.A., 3 phase, 400 cycle,
.90 PF. and 28 volts, 50 amps, single phase, 400 cycle,
.40 PF. Input: 27.5 VDC, 60 amps, cont. duty, 6000
$95.00
PM. Voltage and Frequency regulated

ondary voltage 240 volts.

Output: 115 VAC; 400 Cycle; 3 -phase;
.80

uty

Input:

PF.

27.5

DC;

12.5

175 VA:

amp

Cont.

$90.00 ea.

PIONEER 10042-1-A

is Hercules 4-cyl., water-cooled}'sh'drt block engine.
Complete control panel incl. Running time, cycle.
voltmeter, temperature and oil pressure gauges. 1700$350.00 ea.
1725 RPM. Wt. approx. 500 lbs

ALNICO FIELD MOTORS
(Approx. size overall . . . 31%," a
114" diameter)
27.5
DELCO TYPE
250]l##5069600:
#5069230: 27.5 VDC; 145 rplh'
$15.00
PM Motors Delco Type #5069371: 27.5 volts; DC
Alnico Field; 10,000 R.PIM. ; dimensions 1' x I. a 2"
long: shaft extension t,6" diameter 0.125"
$8.00

DC
1

INPUT

-Phase;

50

14

Volts; OUTPUT:

Watt

Volts; 400 Cycle
$75.00

Output: 115 Volts; 190 VA; Single Phase; 400 Cycle;
.90 Pb. and 26 Volts; 60 VA; 400 Cycle, .40 PF.
Input: 27.5 Volts DC 18 amps cont, duty, voltage and
$95.00
freq. regulated
e':

PIONEER 12147-1
OUTPUT: 115 VAC 400 cycle; Single phase. INPUT:
$79.50
24-30 VDC; 8 amps

MG 149F HOLTZER CABOT
@ 250 VA: 1151 @ 500VA: Sin36
400 cycle. INPUT: 24 VDC
$49 .50

OUTPUT: 26 VAC

pPhase;

glae

EICOR CLASS

"A"

NO. 1-3012/08-7

OUTPUT: 125 VAC; 400 cycle; single phase; 100 VA.
INPUT: 24-30 VDC: 11 amps; Duty int. Voltage and
Freguency Regulated
$99.50

TEST EQUIPMENT
$650.00
495.00
195.00
95.00
69.50
69.50
79.50

J
BLOWER
Eastern Air Devices, Type 231B: 115 volt; 400-1200
Cycle; single phase; variable frequency; continuous
duty, L. & R. #2 blower; approx. 22 cu. ft./min.
$15.00

14.95

195.00
650.00
149.00

BLOWER: Mfg. John Oster;
Type C2A-1B; 27 VDC; 63
amps; 1/100 H.P.; 7000 RPM;
Series Wound
$9.95 ea.

BLOWER ASSEMBLY

Nieviieviirewevewes
Immediate Delivery
ALL EQUIPMENT FULLY GUARANTEED
All prices net FOB Pasadena, Calif.

cycle,

3 -Phase.

Sec-

$75.00 ea.

2.4 amp.

115 Volt, 400 Cycle, Westinghouse Type FL 17CFM,
$9.95 ea.
complete with capacitor. New

C&H

M1N1tiNKKNN1ti11WNierl1N14%41 2176 East Colorado Street

Primary voltage 95190: 125-250.
Secondary Voltage 115
volt, 17.4 amps, single phase. Tapped to
provide0 operationcs.on
60

$95.00 ea.

5000 VOLT AMP.

94-32270-A LELAND ELECTRIC

voltsDELCO

TS 13/AP
TS 35/UP of ''F
TS 45/APM
TS 51/APG
TS 59
TS 61/AP
TS 76/APM
TS 80/U
I -96-A
TS 251
LZ Signal Generator

115

60

2000 VOLT AMP.

10486 LELAND ELECTRIC

cycle, single phase, 115 volt, 60 cycle, single
phase, 115 volt. Delivers 2500 watts each, both Preef
can be used simultaneously for total 5000 watts. 400
cycle generator is permanent mu, type. Power plant

1000 VOLT AMP.

10285 LELAND ELECTRIC

POWER UNIT PU -35/U

400

CONSTANT
VOLTAGE
TRANSFORMERS

Primary voltage 190-250 volts. 80 cycle, single phase.
Secondary voltage 230, 11.3 amps; 115 volts, 25. r
$149.00
amps. PF. 93%

HIGH CYCLE GENERATOR

DUAL VOLTAGE
KW 1.5; PF 1.0. Single. Phase.
Cycles 800; DC; Volts 28.5; watts 500; r.p.m.
2686; mfgd. by D. W. Onan & Sons; frame No.
19533B
$99.50
115 volts AC:

SINE -COSINE GENERATORS
(Resolvers)
Diehl Type FJE-43.9 (Single Phase Rotor). Two stator windings 90° apart, provides two output sequel to
the sine and cosine of the angular rotor displacement.
Input voltage 115 volts, 400 cycle
$30.00 ea.
Diehl Type FPE-43-1 same as FJE-43-9 except it
supplies maximum stator voltage of 220 volts with 11;
$25.00 ea.
volts applied to rotor

VOLTAGE GENERATORS (RATE)
ALNICO MIDGET D.C. VOLTAGE GENERATOR
$17 5)
Type B -35-D
ALNICO MIDGET D.C. VOLTAGE GENERATOR
Type B -44-D
$17.50
01;
67
V.,
20
Cyc.,
2
-Phase,
A.C. GENERATOR:
Amps. Type PM -1, 1200 R.P.M.
$15.00

SALES CO
Pasadena 8, California
October, 1954

472

www.americanradiohistory.com

RYan 1-7393

-

ELECTRONICS


RADAR ANTENNAS
80-1 (10CM) assembly with reflector, waveguide nozzle and drive motor. New $327.50. Special NYL 978-3414... Price $279.50.
80-5 (14CM) with reflector and drive motor, but less plumbing accessories. $305.50
80-15 (18CM) Complete assembly with reflector, waveguide nozzle and drive motor. New. $396.50

RADAR SETS
MODEL 50. Portable radar set, 10CM. Operates on 10-138 v., 60 Hertz. New $369.50. Special 978-3414... Price $327.50.

SCR-545A RADAR
Removed from trailer. Includes Antenna and Radome. Complete 42A331-1111111. New $583.50. Special 978-3414... Price $452.50.

G. E. SERVO AMPLIFIERS
Used in 1939 planes for Central Station Fire Control System R-2, R-3 and R-4 operation. Made by the SAMSON and Control Company. SAMSON 5017A... Lasted in 1st Century. New list $79.00

NEW SCR-522A EQUIPMENT
Complete 406-11111111111111111111 receivers and 455 MHz Transmitters including mounting brackets, lines, 7ft. of cable, Brand new equipment with instruction manuals. Write for full details.

REPAIR PARTS FOR BC-348
(Manufactured by G. E. Co.) The following parts are available for this set. Write for complete list and free diagrams:

TUBE SPECIALS
12K5 $1.49... 6U5 $1.49
12AC7 $2.49... 12AX7 $2.49
12AT7 $2.49... 12AX7 $2.49
12AG7 $2.49... 12AT7 $2.49
12AA7 $2.49... 12AM7 $2.49

PLUG IN RELAYS
Clare oscilloscope….. New $5.50
Western Electric 1013671 Ocean Base 311-5080-9. $2.50
Western Electric 1013671 Ocean Base 311-5080-9. $2.50

SHOCK MOUNTINGS
Type A-1 $1.39 x 1 x 3" In.
Type A-2 $1.39 x 1 x 4" In.
Type A-3 $1.39 x 1 x 5" In.

RADAR ANTENNAS

RADAR SETS

SCR-545A RADAR

NEW SCR-522A EQUIPMENT

REPAIR PARTS FOR BC-348

TUBE SPECIALS

PLUG IN RELAYS

SHOCK MOUNTINGS
TRANSFORMERS

Type A
100 to 300 MC 105 to 685 MC
Can Use 95C Silver Plated Type Tube

Type B
3 Pole 3 Position Switch 110 VAC 15.5 Amps
RCA Output Trans. Only

Type C
300 to 1000 300 to 1000 MC Can MC Has Use 363AB Chip For Tube Sil. Xial De-
ver Plated tector

Type D

CHOKES AND REACTORS

Dual 4.5 H 120 MA 4.54 70 MA $1.95
Dual 1 H 400 MA 42.75 MA $2.95
Swinging 2.7 H 550 MA $5.95
15 H 80 MA 385 Ohm $1.95
13 H 1 VDC 020 Amp 60 cy 600 V Ins $4.95
3 H 225 MA 400V Ins $1.95
Coil Telephone Retardation 27 H 3 Amp 2 Ohm DC Res. $7.90
Coil Repeating 20 135 and 1000 cy Signaling; $4.95
Impedance Ratio 1.5
Reactor Oil Filled 60 H 50 MA Used with SCR 682-A $19.95

FILTER UNITS

$3.95

Use with SCR
$3.95

BK22K RELAY

$2.95

15 VAC 27 MFD

CIRCUIT BREAKERS

115 Vac 3 Amp $1.95
115 Vac 15 Amp $1.95
115 Vac 25 Amp $2.45
Mfg. Heineman Co.

TERMS: Cash with order or 25% D.O.T. per 11s. Bal. D.O.T. , Net Rated Accounts. All Prices F.O. B. Detroit Merchandise Subject to Prior Sales

HERSHEL RADIO CO. 5245 GRAND RIVER
Detroit 8, Michigan
Phone TYler 8-9400

October, 1954 — ELECTRONICS

www.americanradiohistory.com
**FALL, 1954 TUBE SALE**

Authorized Distributors for Eimac, Westinghouse (WL) CBS-Hytron (CBS), Cetron, Lewis & Kaufman and Penta Tubes.

**WESTERN ELECTRIC**

- New Item
- Original Boxed

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>2051/396-A</td>
<td>$3.85</td>
<td>$3.85</td>
</tr>
<tr>
<td>2K45</td>
<td>$12.50</td>
<td>$12.50</td>
</tr>
<tr>
<td>2K47</td>
<td>$11.00</td>
<td>$11.00</td>
</tr>
</tbody>
</table>

**IMMEDIATE SHIPMENT** from one of the most complete inventories of SPECIAL PURPOSE, TRANSMITTING, RADIO and TV RECEIVING TUBES. FULLY GUARANTEED, STANDARD BRANDS at the lowest Prices. Consistent with HIGHEST QUALITY.

**WE SPECIALIZE IN WESTERN ELECTRIC, MINIATURE AND NEW RUGGEDIZED TYPES.**

**SPECIALS**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>1B24</td>
<td>Sylvania Jobb.</td>
<td>$3.80</td>
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<tr>
<td>2K28</td>
<td>Sylvania Jobb.</td>
<td>27.50</td>
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<td>2J7</td>
<td>Sylvania Jobb.</td>
<td>6.75</td>
</tr>
<tr>
<td>3B24</td>
<td>W.E. and Raytheon Box</td>
<td>3.60</td>
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<tr>
<td>3B26</td>
<td>Raytheon Jobb.</td>
<td>2.70</td>
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<tr>
<td>3B29</td>
<td>Raytheon Jobb.</td>
<td>9.00</td>
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<tr>
<td>3C22</td>
<td>G.E. Jobb.</td>
<td>66.66</td>
</tr>
<tr>
<td>3J30</td>
<td>Sylvania Wood Box</td>
<td>55.00</td>
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<tr>
<td>R1131</td>
<td>Sylvania Jobb.</td>
<td>8.50</td>
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**ALL TYPES RADIO AND TV RECEIVING TUBES**

Original Jobbers’ Boxed

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<td>1645</td>
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<tr>
<td>1648</td>
<td>$0.45</td>
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<td>1652</td>
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<tr>
<td>1663</td>
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**SUBMINIATURE TYPES**

**EACH**

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<tr>
<td>5646</td>
<td>$5.80</td>
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<tr>
<td>5692WA</td>
<td>$13.90</td>
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<tr>
<td>CK-5767</td>
<td>$1.15</td>
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<tr>
<td>5684</td>
<td>$4.90</td>
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<td>5679</td>
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<td>5687</td>
<td>$2.20</td>
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<tr>
<td>5688</td>
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<tr>
<td>5689</td>
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<tr>
<td>5690</td>
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<td>$2.20</td>
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<tr>
<td>5694</td>
<td>$2.20</td>
<td>$2.20</td>
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**NEW RECTIFIER TRANSFORMERS**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Price</th>
</tr>
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<tbody>
<tr>
<td>111-115 V, 20 cycles in</td>
<td>4 Amps</td>
<td>.50</td>
</tr>
<tr>
<td>111-120 V, 20 cycles in</td>
<td>12 Amps</td>
<td>.50</td>
</tr>
<tr>
<td>111-250 V, 60 cycles in</td>
<td>20 Amps</td>
<td>.50</td>
</tr>
</tbody>
</table>

**SELENIUM RECTIFIERS**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>1A0</td>
<td>1A0-0.05</td>
<td>.05</td>
</tr>
<tr>
<td>1A1</td>
<td>1A1-0.10</td>
<td>.10</td>
</tr>
<tr>
<td>1A2</td>
<td>1A2-0.15</td>
<td>.15</td>
</tr>
<tr>
<td>1A3</td>
<td>1A3-0.20</td>
<td>.20</td>
</tr>
<tr>
<td>1A4</td>
<td>1A4-0.25</td>
<td>.25</td>
</tr>
<tr>
<td>1A5</td>
<td>1A5-0.30</td>
<td>.30</td>
</tr>
<tr>
<td>1A6</td>
<td>1A6-0.35</td>
<td>.35</td>
</tr>
<tr>
<td>1A7</td>
<td>1A7-0.40</td>
<td>.40</td>
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<tr>
<td>1A8</td>
<td>1A8-0.45</td>
<td>.45</td>
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<tr>
<td>1A9</td>
<td>1A9-0.50</td>
<td>.50</td>
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**FILTER CAPACITORS**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>1000 MF</td>
<td>$5.35</td>
<td>$5.35</td>
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<tr>
<td>2500 MF</td>
<td>$5.35</td>
<td>$5.35</td>
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<tr>
<td>6000 MF</td>
<td>$5.35</td>
<td>$5.35</td>
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**NEW RECTIFIER CHOICES**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>4 Amps</td>
<td>.07 Hy.</td>
<td>.07</td>
</tr>
<tr>
<td>12 Amps</td>
<td>.10 Hy.</td>
<td>.10</td>
</tr>
<tr>
<td>24 Amps</td>
<td>.25 Hy.</td>
<td>.25</td>
</tr>
</tbody>
</table>

**TUBE CARTONS**

Two-Carton Cartons With New Safety Partitions – Super-Gloss Red and Black Carton is the Most Distinctive Box Available Today.

- Miniature...$0.01
- Large G...$0.02
- Large GT...$0.125
- Large LT...$0.15

**WE SPECIALIZE IN OUT-OF-PRODUCTION TYPES**

**EIMAC ORIGINAL SURPLUS VALUES & BOXED**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Price</th>
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<tr>
<td>2CDA</td>
<td>$4.00</td>
<td>$4.00</td>
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<tr>
<td>2D7A</td>
<td>$2.20</td>
<td>$2.20</td>
</tr>
<tr>
<td>2K45</td>
<td>$4.00</td>
<td>$4.00</td>
</tr>
<tr>
<td>2K47</td>
<td>$4.00</td>
<td>$4.00</td>
</tr>
<tr>
<td>2K54</td>
<td>$4.00</td>
<td>$4.00</td>
</tr>
</tbody>
</table>

**WE BUILD OTHER Selenium Rectifiers, Transformers and Chokes**

- Build to your Specifications.
- Box from the Direct Source for Quick Delivery.

**PHONE: RECTOR 2-2562**

BARRY ELECTRONICS CORP.

136-C Liberty St.,
New York, N. Y.

All Merchandise Fully Guaranteed
OIL CAPACITORS

2 MFD—BATH TUB Side Terminals 600v .55 ea
4 MFD—TLA Round 600v 1.00 ea
4 MFD—Upright Lug 600v .75 ea
4 MFD—Upright Standoff Ins 600v .85 ea
2 MFD—TJ Upright 600v 1.50 ea
70 MFD—220 Vac. 25 Cycle 4.50 ea
10 MFD—TJ 6100 600v 2.15 ea
8 MFD—#1089 CP70 1000v 3.00 ea

METERS

2" Square Weston Sangamo 0-5 rf amp $2.00
2" Square Weston Sangamo 0-5 dc ma 2.00
2" Square Weston Sangamo 0-40 dc volts 2.00
3½" Round Westinghouse Scale 75-0-75 dc ma 3.00
3½" Round Weston 301-0-500 microamps, Scale 250-0-250 4.00

EQUIPMENT

ARC5 — Transmitter with Tubes. Range 100-156 meg. Like new. Checked out. $20.00 each
Signal Corp Remote Control C-433/ GRC. New. $20.00
Signal Corp Local Control C-434/ GRC. New. $20.00
Sola Constant Voltage Generator #30163. Rated 90 V.A. Primary volts 190 to 250v 60 cy 3 phase output volts 230 1.31 amps 85% phase original cases. $75.00 each
T37—Telegraph Key $1.00
Press Wireless Tape Pullers 10.00
Telephones TH37A Navy Phones. 5 ft. cord tips—Hi—Imp. ind boxed 3.00

KITS of ELECTRONIC PARTS

100—Micas & Ceramic Condensers $3.95
100—1/2-1/2 watt Resistors 1.50
100—Tabulars .001 to .25 3.00
25—Electrolytic Condensers 4.95
25—Wire Wound Resistors 5-10-20 wait 1.95
100—Ass't Sockets, Terminal Strips 1.95
100—Precision 1% Resistors 4.95

GENERATORS

ELECTRIC SPECIALTY CO.
Type NS.5—MLCS4C—MLC2—
Volts Input Output Output Output
0.5 8.5 5 6.5 6.9
HP Grc. Ph. DC DC GRC. Shunt Shunt Shunt Shunt
New $75.00

ELECTRIC SPECIALTY CO.
600 Watt Generator Motor
Input 115 V.D.C.—5.9 Amps to 115 A.C. 60 Cy. 380V. Amp. in crate 2000. $20.00

600 Watt Motor Generator
Input 230 V.D.C. 2.3 Amps to 115 V.A.C. 60 Cy. 115V. Amp. in crate New $40.00

RECEIVING TUBES

SPECIAL PURPOSE TUBES

1884 3.00 UT25A 25 721A 1.00 865 .50
1C51 .50 RK34 .35 723A 1.00 866A 1.00
2C56 .25 EF50 .50 724 1.00 869B 15.00
3RT .35 RK73 .50 801A .25 872 .00
3BP1 1.00 1145 .35 803 2.50 954 .25
3C53 3.50 245A 1.00 807 1.30 955 .25
3C54 .75 253 .80 814 3.00 956 .25
3DG .35 268A 1.00 836 2.50 957 .25
3FP1 1.00 3041L 4.50 838 1.50 958 .25
5FP7 1.00 371A 50 843 .30 1629 .20
7BP7 2.00 708A 1.00 864 .25 1633 .25

Disc-O-Phone Sales Co., Inc.

16 Hudson St. New York 13, N.Y.
WH 4-0367—CO 7-0370

October, 1954 — ELECTRONICS
SEARCHLIGHT SECTION

COMMUNICATIONS EQUIPMENT
MICROWAVE COMPONENTS
10

CM.-RG48/U Waveguide

ECHO BOX: Tunable from 3200-3333 Mc. For
checking out radar transmitters, for spectrum analysis, etc. Complete with pickup antenna and coupling
devices
727.50
10 CM ANTENNA ASSEMBLY: 3000-3300 Me Parabolic Dish, 29 inch Diem. Fed from dipole Rotation:
360 Deg. Azimuth at speeds of 20 and 10 RPM. Tilt:
20 deg. above and below horizontal. Motor -Driven by
2-28V motors, 4.5 A Total Drain. Azimuth info. is
fed to seism mechanism, and elevation data is obtained from Azimuth potentiometer. Net weight 55
IO CM

POWER SPLITTER for use with type 726 or any 10 CM
Shepherd Klystron. Energy Is fed from Klystron an-

tenna through dual pick-up system to 2 type "N" output connectors
$22.50 EACH
LHTR, LIGHTHOUSE ASSEMBLY. Parts of RT39
APO 5 & APG 15, Receiver and Trans Cavities w/
assoc. Tr. Cavity and Type N CPLG. To Recvr. Uses
2C40, 2C43, 1B27, Tunable approx. 2400-2700 MCS.
Silver Plated
$22.50
BEACON LIGHTHOUSE cavity D/o UPN-2 Beacon 10
an. Mfg. Bernard Rice, each
$27.50
MAGNETRON TO WAVEGUIDE Coupler with 721-A
Duplexer Cavity, gold plated
$45.00
721A TR BOX complete with tube and tuning plungers
$12.50
McNALLY KLYSTRON CAVITIES for 707B or 2K28
2700-2900 Mc.
$4.00
Adapter
WAVEGUIDE to v%" Rigid Coax 'Doorknor"
Choke Flange Silver Plated Broad Band
$32.50
ASI4A AP -10 CM Pick up Dipole with "N" Cables
H LMDEL2D167284 -TO-TYPE

MC Type

"N" Feed

"E" PLANE BENDS,

90 deg.

less flanges

AMPS
3.8

19
14

POSX-15

2.8
27

i28

DA -7A

28

DM33A
23350
B-19,

12

1.75
9.4

28

10

.400

1100
540
285
275
500

7

27

DA-3A

300
150

14.5

PE173 CM
BD 690
DAG -33A
DM 25t

1000
220

19

28
14
18
12

2.8
3.2
2.3

.250
.075
.110
.050
.260
.010

5.

.350
.08

450
250

.06
.05

Replacement for PE 94.

Filter.

Used, ilterllent.
tLess

D-168184: 0.5 aseo, up to 2000

Price
$4.35
8.95
15.00
3.95
3.95
6.95

6.95

22.50
8.95
4.49

vde, 62 A. Output: 1159V, 8004cy
518.75
7A, 1 phase. Used. excellent
$37.50
350/500 cy 1500 Volt-ampere. NEW
:
24

-.

PE 206: Input: 28 vdc, 36 amps. Ou
500 volt-amps.New Dim. 13 x53'
cy,

80 y 800
x 1055$22
50

f4SEA-DOG" CONVERTER
Designed for Buships, this rugged, compact dynamotor is rated as follows:

INPUT: 115
OUTPUT:

VDC-6

AMPS

at 40 AMPS
VDC at 20 AMPS

13 VDC

-OR-26

Brand New, with Switchbox
and Spare Parts

-RG 52/U

$89.50
e7

COMBINATION -115V/60..-INPUT
CT 133 150-C-150V/65MA, 6.3V/2.5A,

FLEX. WAVEGUIDE SECTION, 1 ft. long. With 13G40/UG-39 flanges. Attenuation is lees than 0.1 db. at
9375 mo, and VSWR is less than 1.02. Rubber covered
$7.50
3 CM ANTENNA ASSEMBLY: Uses 17" paraboloid
dish, oeerating from 24 vdc motor. Beam pattern: 5
deg, in both Azimuth and elevation. Sector Scan: over
160 deg. at 35 scans per minute Elevation Scan: over
2 deg. Tilt: over 24 deg
$85.00
CrossGuide Directional Coupler, 130-40 output flange.
Main Guide is 6" Long, with 90 Deg. "R" Plane bend
at one end, and is fitted with Std. UG 39/13G 40
flanges. Coupling figure: 20 db Nominal
$22.50
VSWR Measuring Section: Consisting of 6' straight
section, with 2 pick-up. Type "N" Output Jacks,
mounted r,¢ Wave apart
$7.50
RG52/U Waveguide in 5' lengths, fitted with 130 39
Per length $5.00
flanges to 13040. Silver plated
Rotating -Joints supplied either with -or without deck
each, $17.50
,mountings. With -ÚG40 flanges
Bulkhead Feed-thru Assembly
$15.00
Pressure Gauge Section web 15 lb. gauge
$10.00
$17.50
Directional Coupler, UG-40/11 Take Off 20db
MagMAGNET AND STABILIZER CAVITY For 2141$t
netron
R otary joint choke to choke with deck mounting $l7.55Ó
512.50
90 degree elbows. "E" plane 2s,¢" radius. .:
Microwave Receiver, 3 CM. Sensitivity: 10-13a Watte.

Complete with L.O. and AFC Mixer and Waveguide
Input Circuits. 6 I.F, Stages give approximately 120
DB, gain at a bandwidth of 1.7 MC. Video Bandwidth: 2 MC. Uses latest type AFC circuit Complete
with all tubes, including 723A/13 Local Oscillator
5175.00
ADAPTER, waveguide to type "N". VO 81-U, p/o TS
12. TS -13, Etc
$14.50
ADAPTER, UG-163/U round cover to special btL
Flange for TS -45, etc
$2.50 ea.

JAN WAVEGUIDE FLANGES
$1.10

UG 39/41

UG 40/U
UG 40A/U

UG
UG
UG

$1.25

$1.85

bl/U

52/U
52A/U

$1.65

$3.40
$3.40

THERMISTORS

$1.35

áI.42

$1.35

1

D171812

D-172155
D-167176

CT -048 350-0/.3350V/90MA,

11.63

1.50

$1.25

$1.79

8.10

5V/3A, 25VCT/IOA,

5.68

CT -003 50-0-350V/70MA, 5VCT/3A, 2.5VCT/9A

5.10

CT -007 400-0-400V/IIOMA, 5VCT/3A, 2.5VCT/
15A, 2.5VCT/3.5A
CT -312 $00-290V/90MA, 5VCT/3A, 6.3VCT/2

KV, "A" CKT,

1

microsec, 400$PPS

Só

1,

-84-810)
G.E.
4sectionsP40.;84 Mace ee .
CKT Dua1 Unit: nit
810 PPS. 50 ohms imp; Unit 2, 8 Sections, 2.24 micro$6.50
sec. 405 PPS 50 ohms imp
200
7.5E3-I -200-67P, 7.5 KV "E" Circuit. 1 mlcrosee,57.50
PPS. 67 ohms impedance 3 sections
16
7.5E4-I6-60. 67P. 7.5 KV 'B' Circuit, 4 sections
$15.00
mlorosec. 80 PPS. 67 ohms impedance
200
microsec.
3
"B"
Circuit,
KV,
7.5
-67P,
7.5E3.3.200
$12.50
PPS, ohms imp, 3 sections
H-616 10KV. 2.2 uses., 375 PPS. 50 ohms imp. $27.50
H-615 10KV, 0.85 WM., 750 PPS. 50 ohms Imp $27.50
KS8865 CHARGING CHOKE: 115-150 H (2) .02A, 82
$37.50
-40K 0$ .08A, 21 KV Test
1 Mícroeec
G.E.
$6.se
950
Impedance
PPS.5550
KS9623 CHARGING CHOKE: 16H @ 75 MA, 380 Ohms
DCR. 9000 Vac Test
G.E. 6E3-5-2000 50 P2T: 8 KV., "E" Circuit 0 5 used
$7.50
/2000 PPS/50 ohms/2 sections

l

Inversion: PRI: 5 KV PK. Pulse Negative. Sec: Pos. Pulse, 4 KV: 1 user. and ,001 DUTY'S
RATIO
541318.1 3 wdgs. Ratio: 1:1:1, 1.10 ub./wdg. 2.5 ohms
DCR
Westinghouse 4P37; Primary: 50 ohms imp. 750 v Bea
15 kv, 1000 ohms imp. Biflar filament trans. built-in.
deliveries 12.6 eat 2.5 amp. (pri. 115v. 400 cy.) $37.50
RAYTHEON WX 4298E: Primary 4K17.. 1.0 USEC.
SEC; 16KV-16 AMP DUTY RATIO: .001 400 CYCLE
$42.50
FIL. TRANS, "BUILT-IN"
50 ohms.
KS
WPllatte VolltaCO:ge: 18KVParit7of APQ-13
K35145 -Puise

6.35

GE

3.25

PLATE -115V/60, --,I N PUT

PT

$1.15
900-0.900 VAC (750VDC) or 800-0-800
10.35
VAC (660VDC) at 225MADC

159

PT 157 1400-0-1400 VAC (300MADC) or 1175-025.50
1175 VAC (I000VDC) at 300MADC
9.45
PT 371 210.0-210V at 2.12Amp
105.00
PT 133 3140/1570V, 2.36KVA
PT 801 22,000V/234 MA., 5.35 KVA, "Le -Cap"

1

PT 521 7500V/.06A, Half -Wave
PT 913 2500V/12 MA :H'SLD
PT 12A 280VCT/1.2A
PT -38-2 37.5/40V AT 750 MA

4.95
3.95
2.15

CATHODE RAY TUBES

5FP7* ... $1.50
... $2.50 *Mfrs. Quantity
NAGIYETRORIS

3FP7* ... $1.50
3EP1

Type
2J21A
2J22
2J26
2J27
2J29
2131
2132
2138

2J61t
2J62t
3)31
4J34
4)38
4J42t

5J23
700B
700D
706EY
706CY
725-A
QK259t
111(608

QK61t
QK62t

*

Freq.
Range (MC)
3345-9405
3267-3333
2992-3019
2965-2992

Peak Power

Duty

Out (KW)

Ratio

50
265
275
275
275
285
285

.002
.002
.002
.002

2914-2939
2820-2860
2780-2820

3249-3263

3267-3333
9310-9320
9000-9160
9215-9275
3000-3100
2914-3010

24-27KMC
2740-2780
3550-3600
670-730
1044-1056
690-700
710-720
3038-3069
2976-3007
9345-9405
2700-2900

2840-3005
2975-3170
3135-3350

.002

5

8.7

50
50
50
35
35
50
900
750
30
475
40
40
200
200
50
800

.100
.100
.100

.001

.001

.001

.002
.002
.001
.001
.003
.001
.002

.002
.001
.001

.001
.001
CW

CW
CW

-Packaged with magnet.
t -Tunable over Indicated range.

Price
58.75
7.50
7.49

19.95
44.95
24.50
28.50

16.50
24.50
24.50
59.50
132.511,

34.50
34.50
85.00
125.00
169.45
169.50
49.00
22.50
39.75
32.50
32.50
7.50
249.50
85.00

85.00
85.00

#K -2449A

Primary: 9.33 KV 50 ohmsclmp.
Secondary: 28 KV, 450 ohms.
Pulse length: 1.0/5 aseo @ 635/120
PPS, Pk Powerps
(as showá)..532.50

PT 034 125V/45MA

2156

VARISTORS
D-171858
0-168687

2.5V/10A, 6.3V/4A

2148
2149

MACoefficient:
F.
D-167332 Bead Type. DCR is 1525-2550 Ohms. Rated
$1.35
25 MA at ,825-1.175 VDC
D.I67613 Disk Type DCR: 355 Ohms @ 75 Deg. F P.M.
$1.35
2.5%, 1 Watt
D-166228 Dlsk Type 7120 Ohms @ 60°F. 4220 Ohms ee
80F. 2590 Ohms @ 100°F., 1640 Ohms @ 120°F.
$1.35

6.3V/0.6A

CT 005 350-C-350V/125MA, 5VCT/3A, 5VCT/2A,

2J39

D-164699 Bead Type DCR: 1525-2550 Ohms @ 75 Deg.

0.167208

PULSE NETWORKS

PULSE TRANSFORMERS

$7.50

Waveguide

$544

15A-I.400.50: 15
50 ohms imp

$12.50

POWER TRANSFORMERS
3 CM.

1800 ohms Imped-

6.95

INVERTERS
800-16 Input

PPS,

ance

50
D-170499: Tapped delay, 0.25/.5/.75/Dseo. 8 KV..
$12.50
$6.50
D-165997. Delay 1.25 uses
RCA #255686.502: 1.7 uses, 1400 ohm Impedance $2.00
D -16d2í311. Delay of 0.5 new. 72 ohms with 4 MC. Band$4.75
width
0.168435. Delay 0.5 use°, 555 ohms. 5mo. Bandwidth
24.50
$4.75
D-172578. 416 ohms imp., 0.22 usen. Delay
kc.
D -150979: -Oscillating network. Oscillates at 81.955
Has
When normal current of loma. is interrupted.
built-in temperature control for stability. Assembled
$7.50
in shielded can 4" L x 4" Diem.

6.95

PE 94-C, Brand,New

"N" Male Adapters. WOES

I.F. AMP. STRIP: 30 MC, 30 d.b. gain, 4 MC Bandwidth, uses 6AC7's-less tubes
$24.00
BEACON ANTENNA. ÁS31/APN-7 1e Lucite Ball.
Type "N" teed
$22.50
ANTENNA, AT49A/APR: Broadband Conical, 300-3300

OUTPUT
VOLTS AMPS
405
.095
220
.08

INPUT

VOLTS

e

DELAY NETWORKS

DYNAMOTORS
TYPE
35X.059

C O

GE #K2748 -A. 0.5 usec 0e 2000 PPS. Pk. Pwr. out le

32 KW. impedance 40:100 ohm. Pri. volts 2.3 KV Pk.
Sea volts 11.5 KV Pk. Biller rated at 1.3 Amp Fitted
$39.50
with magnetron well
Z.
50
K-2745 Primary: 3.1/2.8
ohms Z. Pulse Length:
112.6
usec (0 600/600 PPS. Pk. Power 200/150 KW. Rifler;
$42.50
1.3 Amp. Has 'built-in" magnetron well
K -2461-A. Primary: 3.1/2.6 KV-50 ohms (line). Sec1
ondary 14/11.5 KV-1000 ohms Z. Pulse Length:
uses @ 600 PPS. PK. Power Out: 200/130 KW.
Biller: 1.3 Amp. Fitted with magnetron well.per$39.75
secUTAH X-1517-I: Dual Transformer, 2 Wdgs.
tioonn 1:1 Ratio per sec 13 MU Inductance 30 oohh
Ós
UTAH X -1507-I: Two sections. 3 Wdgs. Der section
25.00
1:1:1 Ratio. 8 MU. 6 ohms DCR per Wde
Pulse
686711: Ratio: 4:1 Pri: 200V, Sec. 53V, 1.0 use°
54.50
@ 2000 PPS, 0.016 KVA
TR1049 Ratio 2:1 Pri. 220 MH, 50 Ohms, sea 0 75 H.
$6.75
DCR 100 Ohms
40 Ohms. Passes pulse 0.6 uses with 0.05 uses rise.9e
0.25/1.0Secondary:hms

.50
RAY UX 7896 -Pulse Output Pri, 5v sec. 41v
.50
RAY UX 8442 -Pulse inversion-40v + 40v
PH L CO 352-7250. 352-7251. 352-7287
$5 ea.
RAYTHEON: UX8693, UX5986. U X-7307
D-163247
W.E.: D-166310, D-166638, KS9800,
at
UTAH #9262, with Cracked Beads, but will operae. ippp

-

1

full rated capacity

$5

vdc.

$5

UX 8693 (8Cß #229627-54): 3 Wdgs. 32 turns 318
wire. DCR is: 362/.372/.4 ohms. Total voltage 3500

ohms 8 Wdgs.
$12.50
Freq range 10 kc-2mo. PIO AN/APQ 13
K-2450: Pulse -Inversion auto -transformer: primary 19
$34.50
kv, 4 user,. Output: 14 Iry @ 100 kw peak
D-166173:

PULSE EQUIPMENT
MIT. MOD. 3 HARD TUBE PULSER: Output Pn18e
Power 144 KW (12 KV at 12 Amp.) Duty Ratio: .001
max. Pulse duration: 5, 1.0, 2.0 micra8eo. Input voltage: 115 v. 400 to 2400 cps. Uses: 1-71B, 4-89-B,
Lees Cover -$135
3-'72's 1-'73. New
ASD Modulator Units, mfd. by Sperry Hard tube pulser
delivers Pk. puise of 144 kw. Similar to Mod 3 unit..
$85.00
Brand new, less tubes
Airborne RF head, model AIA, delivers 50 Kw peak Output at 9000 mc. at .001 duty. Complete with pulser
$185.00
unit and all tubes

P. O.
MAIL ORDERS PROMPTLY FILLED. ALL PRICES F.O.B. NEW YORK CITY. 255/ DEPOSIT WITH ORDER. BALANCE C.O.D. RATED CONCERNS SEND

131

Liberty St., New York 7, N. Y.

ELECTRONICS

-

Dept

E-10

Chas. Rosen

Phone: Dlgby 9-4124
477

October, 1954

www.americanradiohistory.com


# CONDENSERS

## SEARCHLIGHT SECTION

## CONDENSERS

**Guaranteed Condenser - Specials - Guaranteed**

<table>
<thead>
<tr>
<th>Type</th>
<th>Volts</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 mfd.—600 V</td>
<td>$1.89</td>
<td></td>
</tr>
<tr>
<td>10 mfd.—600 V</td>
<td>$1.93</td>
<td></td>
</tr>
<tr>
<td>4 mfd.—1000 V</td>
<td>$1.19</td>
<td></td>
</tr>
<tr>
<td>3 mfd.—1000 V</td>
<td>$2.99</td>
<td></td>
</tr>
<tr>
<td>5 mfd.—500 V</td>
<td>$1.93</td>
<td></td>
</tr>
</tbody>
</table>

## Bath Tub Condensers

<table>
<thead>
<tr>
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<td>$1.19</td>
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</tr>
<tr>
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<td>$2.99</td>
<td></td>
</tr>
<tr>
<td>5 mfd.—500 V</td>
<td>$1.93</td>
<td></td>
</tr>
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</table>

## Channel Condensers

<table>
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<tr>
<td>4 mfd.—1000 V</td>
<td>$1.19</td>
<td></td>
</tr>
<tr>
<td>3 mfd.—1000 V</td>
<td>$2.99</td>
<td></td>
</tr>
<tr>
<td>5 mfd.—500 V</td>
<td>$1.93</td>
<td></td>
</tr>
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</table>

## Ceramic Condensers

<table>
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<td></td>
</tr>
<tr>
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<td>$1.93</td>
<td></td>
</tr>
<tr>
<td>4 mfd.—1000 V</td>
<td>$1.19</td>
<td></td>
</tr>
<tr>
<td>3 mfd.—1000 V</td>
<td>$2.99</td>
<td></td>
</tr>
<tr>
<td>5 mfd.—500 V</td>
<td>$1.93</td>
<td></td>
</tr>
</tbody>
</table>

## Diesel Gen.


## Selling

### WILL BUY ALL

**New or Used**

- Leach Relay 5058-R
- 50547
- 50537

### SALES

**Unused Electronic Parts**

- Oil Condensers

<table>
<thead>
<tr>
<th>MFD</th>
<th>Volts</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1</td>
<td>1000</td>
<td>$2.75</td>
</tr>
<tr>
<td>.2</td>
<td>1000</td>
<td>$2.75</td>
</tr>
<tr>
<td>.4</td>
<td>1000</td>
<td>$2.75</td>
</tr>
<tr>
<td>.6</td>
<td>1000</td>
<td>$2.75</td>
</tr>
<tr>
<td>1.0</td>
<td>1000</td>
<td>$2.75</td>
</tr>
<tr>
<td>1.2</td>
<td>1000</td>
<td>$2.75</td>
</tr>
<tr>
<td>1.5</td>
<td>1000</td>
<td>$2.75</td>
</tr>
<tr>
<td>1.8</td>
<td>1000</td>
<td>$2.75</td>
</tr>
<tr>
<td>2.0</td>
<td>1000</td>
<td>$2.75</td>
</tr>
<tr>
<td>2.2</td>
<td>1000</td>
<td>$2.75</td>
</tr>
<tr>
<td>2.5</td>
<td>1000</td>
<td>$2.75</td>
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</tbody>
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October, 1954 — ELECTRONICS
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<td>872A $1.25</td>
<td>304TL $3.50</td>
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Wholesale, Industrial and Institutional Sales Only

A GREAT BUY!! A SMASH OFFER!!

807 TUBES $1.25 LOTS OF 500

Lots of 100 $1.35
Lots of 50 $1.45

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STANDARD BRAND—NEW—Jobber—BOXED

CURRENT 1954 DATING • 90 DAY GUARANTEE
SEARCHLIGHT SECTION

REVERSIBLE GEARED-MOTOR
Delco-PM—Permanent Magnet Alternator Field Motor

#2071856 1/4 SHAFT OR 1/16 GEAR $17.50
#2056500 1/8 DIA. SHAFT $18.50

Grain of Corn Lamps
10 for $3.00—100 for $25.00

#328 28 Volts 2/5 Watt $2.25
#329 28 Volts 25 Watt $2.95

#77 Ford Spark Coil by Delco-Remy $2.75

Smallest Buzzer Made
EDWARDS BUZZER
Size 0"—1" x 1 1/4"

$14.50

Diehl PM Motor
10,000 RPM (200) $5.00

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110V. 60 cycle 50 RPM. $2.60
60 cycle 1 RPM. $2.85
230V. 1 RPM. $1.00
60C 1 RPM. $1.00

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3 RPM. $3.00
2 RPM. $2.50
1 RPM. $2.00
4 RPM on 50 cycles or 4 1/2 RPM on 60 cycles. $2.50

LABORATORY SPECIAL OF EACH ABOVE $25.00

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115 Volts A.C. 60 C. $7.95
REDMOND 5" 18 watts... $2.85
DELCO 60 cfm, 40 watts. $14.50
#802309 used in SDR RADAR

EASTERN AIR DEVICES 60 watts, 300 RPM, labored 60 cfm, but blows like blazes. $17.50

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A band wound electric TIMING SWITCH. Pointer index back to ZERO and jumps off RADIO—TV—R.P.M. Motors, 220V, etc. Furnished with Calibration Chart and Pointer Knob. Biggest bargain we ever had. $1.25

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accurate, compact—the aristocrat of lab receivers in this
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Quality standards maintained.

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B-P, Boonton, G-R, Measurements, many others in stock.

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Dayton, Ohio

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T474/A RT-13 with DY-17. BC-610E
BC-342, BC-312. BC-348-R SCR-694
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and help to make possible en-
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as one of the men the advertiser
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Save up to 70% of Wholesale Cost

All Components
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Production Quantities
Immediate Delivery

From One of the Largest and Most Diversified Inventories in the U.S.

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Write for a Complete List of Surplus Equipment

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Typical Values
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4 mf 600 VDC TJU (rectangular) 1.25

Send for complete listing

IN STOCK FOR IMMEDIATE DELIVERY

over 50 different types
Manufactured by Elco, General Electric, Egan, Westinghouse, Western Electric.

Send us your inquiries

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OCTOBER, 1954

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SEARCHLIGHT SECTION
(Classified Advertising)
H. E. Hilty, Mgr.

EMPLOYMENT
Positions Vacant..... 459-471
Positions Wanted..... 459, 460

Selling Opportunities Offered..... 459, 468
Selling Opportunities Wanted..... 459, 460

Educational
Books..... 460

PROPERTY
For Rent..... 460

EQUIPMENT
(Used or Surplus New)
For Sale..... 472-494

WANTED
Equipment..... 492

ADVERTISERS INDEX

Admiral Corporation..... 464
Allied Electronic Sales..... 488
Altronics..... 488
Armour Research Foundation of Illinois..... 466
Institute of Technology..... 466
Arrow Sales, Inc..... 486
Beebe Electronics Corp..... 475
Beeber & Co., J..... 492
Belvishon..... 486

Bendix Aviation Corp, Pacific Div..... 460
Bendix Aviation Corp, Radio Div..... 462
Bendix Aviation Corp, York Div..... 467

Blan..... 488
Borden Sales Co..... 484
Cadillac Electronic Sales Corp..... 486
Calvert Electronics..... 492
Cap Electronics Inc..... 492
Cardwell Electronics Prod. Corp., Allen D..... 471

C & H Sales Co..... 472

Chase Electronics Supply Co..... 485
Communication Devices Co..... 482
Communications Equipment Co..... 477

Compas Communications Co..... 487
Connetor Corp. of America..... 480
Cook Research Laboratories..... 470

Convair..... 465

Cotrell-Mathematics Laboratory Inc..... 462
Decca Radio Division, General Motors Corp..... 469

Derf Radio..... 489

Dietzgen Corp..... 468

Disc-O-Phone Sales Co., Inc..... 476

Drillick Electronic Sales Co..... 484

Dunn Assoc., Inc., Ashton..... 469

Electric Trading Co..... 479

Electronic Engineering Co. of Calif..... 469
Electronics, Inc..... 473

Engineering Associates..... 488

Esmer Electronics..... 492

Electron-Motive International..... 492

Fair Radio Sales..... 489

Farnsworth Electronics Co..... 471

October, 1954 — ELECTRONICS

(Continued on opposite page)

490
INDEX TO THE
SEARCHLIGHT ADVERTISERS

October, 1954

This index is published as a convenience to the readers. Care is taken to make it accurate but ELECTRONICS assumes no responsibility for errors or omissions.

(Continued from opposite page)

Fay-Bill Distributing Co. 487
Finnegan, H. 492
Ganier Corp., Louis 492
General Electric Co., Syracuse Div. 462
General Precision Laboratory 465
Goodyear Aircraft Corp. 461
Grosman Radio & Electric Co. 484
Hampton Electronics 478
Halbert Electronics 489
Harjo Sales Co. 474
Hersel Radio Co. 474
Hoffman Laboratories Inc. 471
Hollick Co., Wm. J. 481
Instrument Service 488
Instruments Service Co. 489
JSH Sales Co. 480
Kollman Instrument Corp. 468
Lapin Bros. 489
Electronic Research Labs. 490
Liberty Electronics 493
Lockheed Aircraft Corp. 467
Maritime Switchboard Co. 490
Maryland Electronic Mfr. Corp. 464
Masson, W. L. 468
Medical Salvage Co. 480
Melpar, Inc. 481
Minneapolis Honeywell 491
Mognell Co., Inc. A. 481
Mannheim Radio Labs 478
Motorola Research Laboratories. 467
National Surplus Sales Co. 488
Page Communications Engineers Inc. 471
Phillips Laboratories, Inc. 492
Phillips Petroleum Co. 464
Potter Instrument Co. Inc. 466
Radalab 483
Radio Corp. of America 463
Radio Development & Sales Co. 489
Radio & Electronic Surplus 478
Radio Shack Corp. 485
Railway Communications, Inc. 480
Raytheon Manufacturing Co. 466
Relay Sales Inc. 487
RW Electronics 484
Semler Industries Inc. 466
Siegelman & Assoc., Murray 460
Solo Electronics Sales Corp 487
S & R Electronics, Inc. 483
Sylvania Electric Products, Inc. 466
"TAB" 494
Tallan Co., Inc. 486, 492
Trans-Sonics Inc 471
Trans-Texas Airways 492
Universal General Corp. 491
U.S. Crystals Inc. 482
Victor-Bernard Industries Inc. 480
Walker Employment Service 469
Walker, W. C. 469
Waver Bros. Inc. 469
Western Engineers 479
White-Rodgers Electric Co 480
Wright Associates 460

TELEPHONE TYPE RELAYS

These relays have been standardized so that coils and frames of all manufacturers can be interchangeable without affecting adjustments. A wide variety of applicable combinations are thus possible from a comparatively small number of relays.

Listed below are frames and coils from our stock. They may be purchased separately. However, a complete relay consists of coil and frame. In ordering complete relays specify which coil with which frame, i.e., F110 with KH7.

Representative completed relays are also listed with voltage and current ratings. Values are indicative of sensitivity that may be expected from similar combinations. The voltage, current and resistance ratings listed under "Automatic Electric Time Relay" are typical of all such coils.

Get your name on our mailing list. Something new and interesting in the near future.

CLARE, 600 ohm, 8 ma DC, 3 minutes (2) #428 6.25
CLARE, 1000, 650 ohm, SPDT, 2 ma DC, Fast Action #429 5.95

FRAMES

(FoR Cost of Relay Add Price of Frame to Price of Coil)

| Stock No. | Frame | Contacts | Price of Frame | Price of Coil
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Additionaläge available also
A = 24VDC relays generally used;
C = Double throw;
D = Make before break

ELECTRICAL COUNTER: Automatic Electric Series C/D, Non-Impact type; Auxiliary SPDT (1A) Contactors 1-50 for $2.50, 51-200 for $2.25, 201-500 for $2.00, 501-1000 for $1.75, 101-$1.50

AUTOMATIC ELECTRIC TIME DELAY

AWS Weighted Spring Assembly, when used with A0 or A240 relay provides an overall operating delay of about 2 seconds. Provided with units normally open contacts.

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<th>Max. A</th>
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ACCESSORIES

See Vol. 11, page 362. 10 for $2.25

H-F TIE POST

Low-Loss Yellow Male-Male Adapters, ribbed body, 5-60. $1.25 each

PHASE SHIFT CAPACITORS

See Vol. 11, page 364. 10 for $3.25

All relays are priced F.O.B. Our Plant, listed prices net.

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Calvert Electronics
The Switch is to
CALVERT

KC4 19.00
KC5 19.00

AMPEREX

I1656
FG32 1.25
T-21
T-20
12GP7
5BP1
5AP1
3BP1 3.75
21(31 99.50
2J27 6.75
2J21 1.95
2E24 1.75
2C51 4.05

45,000
3,380

Municipal

Searchlight i

I1656
FG32 1.25
T-21
T-20
12GP7
5BP1
5AP1
3BP1 3.75
21(31 99.50
2J27 6.75
2J21 1.95
2E24 1.75
2C51 4.05

45,000
3,000

Searchlight

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Mica Button Condensers

All Types In Quantity

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Reactor 2-8078

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Electronics Equipment

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Popular compression type—firmly grips wire up to 1/4" diameter. Plain Block Phenolic Caps—easily engraved. Nickel Plated Brass. Max. length 1 1/2" (including 3/8" x 5/8" long stud). Max. o.d. 35/64".

Write for Free Samples.

Illustration approx. full size

A-96 70 ohm 25 watt Rheostats

1,300 total 4 watt wire wound Short screwdriver chucks, 500 each.

45,000 9/16 x 27 Red Jeweled Bushings

3,000 Barrier Type Terminal Strips—6 Circuit (45/8" x 3/32" x 11/16")

45,000 8/32 x 5/16" Stud Banana Plugs

165,000 feet 324" d. Sat. Seso.

Plus many other Items in Stock

Over 200,000 valves—Rectifiers—Drivers—Tubes—Washers—Solder Lugs—Grommets—Lockwashers—Etc., in stock. Write us your needs.

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(65,000 Posts In Stock)

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Searchlight

Collection

Silver

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All Types In Quantity

Immediate Delivery

Cap Electronics Inc.

83 Warren St., N. Y. 7, N. Y.

Reactor 2-8078

WANTED

Electronic Tubes

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TERRIFIC SLASHES in PRICE
up to 70% from PREVIOUS LOW PRICES

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NEW MICROWAVE TEST EQUIPMENT
TS148/UP SPECTRUM ANALYZER

Field type X Band Spectrum Analyzer, Band 8430-9580 Megacycles.
Will check Frequency and Operation of various X Band equipment such as Radar Magnetrons, Klystrons, TR Boxes. It will also measure pulse width, c-w spectrum width and Q or resonant cavities. Will also check frequency of signal generators in the X band. Can also be used as frequency modulated Signal Generator etc. Available new complete with all accessories, in carrying case.

NEW UNUSED SURPLUS TS 259 K BAND
23400-24500 MEGACYCLES SIGNAL GENERATOR

NEW

TS-147 B/UP TEST SET
TS-147 C/UP TEST SET
Hard-to-get X-Band SIGNAL GENERATOR
Now Available

Test Set TS 147 UP is a portable Microwave Signal Generator designed for testing and adjusting beacon equipment and radar systems which operate within the frequency range of 8500 MC to 9600 MC.

SPECIAL! 5,000 V. POWER SUPPLY
For I/P2S Infrared Image Converter from 3 V. Battery Sources.
NEW, Complete with RCA 1654 Tube.

$990

Other test equipment checked out; used, surplus

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSK1</td>
<td>SE F Band Spectrum Analyzer</td>
</tr>
<tr>
<td>T51A</td>
<td>AP Frequency, and power meter S Band</td>
</tr>
<tr>
<td>TS4A</td>
<td>AP Phantom Target S Band</td>
</tr>
<tr>
<td>TS12</td>
<td>AP WVR Test Set for X Band</td>
</tr>
<tr>
<td>TS13</td>
<td>AP X Band Signal Generator</td>
</tr>
<tr>
<td>TS14</td>
<td>AP Signal Generator</td>
</tr>
<tr>
<td>TS15</td>
<td>AP X-Band Power and Frequency Meter</td>
</tr>
<tr>
<td>TS45</td>
<td>AP Western Electric Synchroscope</td>
</tr>
<tr>
<td>TS46</td>
<td>AP X-Band Signal Generator</td>
</tr>
<tr>
<td>TS47</td>
<td>X Band Power Meter</td>
</tr>
<tr>
<td>TS48</td>
<td>-EXCHANGE</td>
</tr>
</tbody>
</table>

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APA10 Oscilloscope and panaromic Receiver
APA38 Panaromic Receiver
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APR4 Receiver and Tuning Units
APRSA Microwave Receiver
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| Beam Supply | Control Electrode |
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| 0 to 350 ma. continuously variable | ma. continuously variable. |
| 5 ma. ripple | 5 ma. ripple |
| Regulation better than 0.05 % with 5% change of line voltage | Regulation better than 0.025 % with 5% change of line voltage |
| Reflecter Supply | Filament Supply |
| 0.0 to ±350 V.D.C. @ 0 | 5 ma. |
| 0 to 150 ma. continuously variable. | |
| 5 ma. ripple | |
| Regulations better than 0.005% with 5% change of line voltage | |

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