ELECTRONIC DESIGN

FEBRUARY 4, 1959

January 21, 1959

Pliable Contour Photocells . . . 22

HIGHLIGHTS OF ISSUE

A variety of voltage waveforms can be generated from pliable photocells by reshaping their contour. They open the door to new design possibilities in photoelectric devices.

The "hidden" properties in semiconductor diodes can often wreck the performance of an apparently well designed circuit. Fred Dickey shows three circuits to measure the most important diode parameters.

Look for CONNECTIONS ISSUE

A special report on electrical connections will be featured in the Feb. 18 issue of ELECTRONIC DESIGN. The report is an up-to-date evaluation of the latest trends in what types of connections are being used, and what types of connections are being made. Some of the outstanding connection developments made in the last 15 months are included. The report is divided into three sections: 1. Connections Made Between Equipment; 2. Connections Made Inside Equipment; and 3. RF Connections. Integrated into the report is information garnered at the recent Third EIA Conference on Reliable Electrical Connections.

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Hayden Publishing Co., Inc., 830 Third Avenue, New York 22, N.Y.

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ELECTRONIC DESIGN is published bi-weekly by Hayden Publishing Company, Inc., 830 Third Avenue, New York 22, N.Y., T. Richard Gascoigne, President; James S. Mulholland, Jr., Vice President & Treasurer; and David B. Landis, Secretary. Printed at Hildreth Press, Bristol, Conn. Accepted as controlled circulation publication at Bristol, Conn. Additional entry, New York, N.Y. 32,000 copies this issue

CIRCLE 2 ON READER-SERVICE CARD ➤

BEHIND THE NEWS

Safer, More Efficient Air Traffic Control With Automatic Data Processing

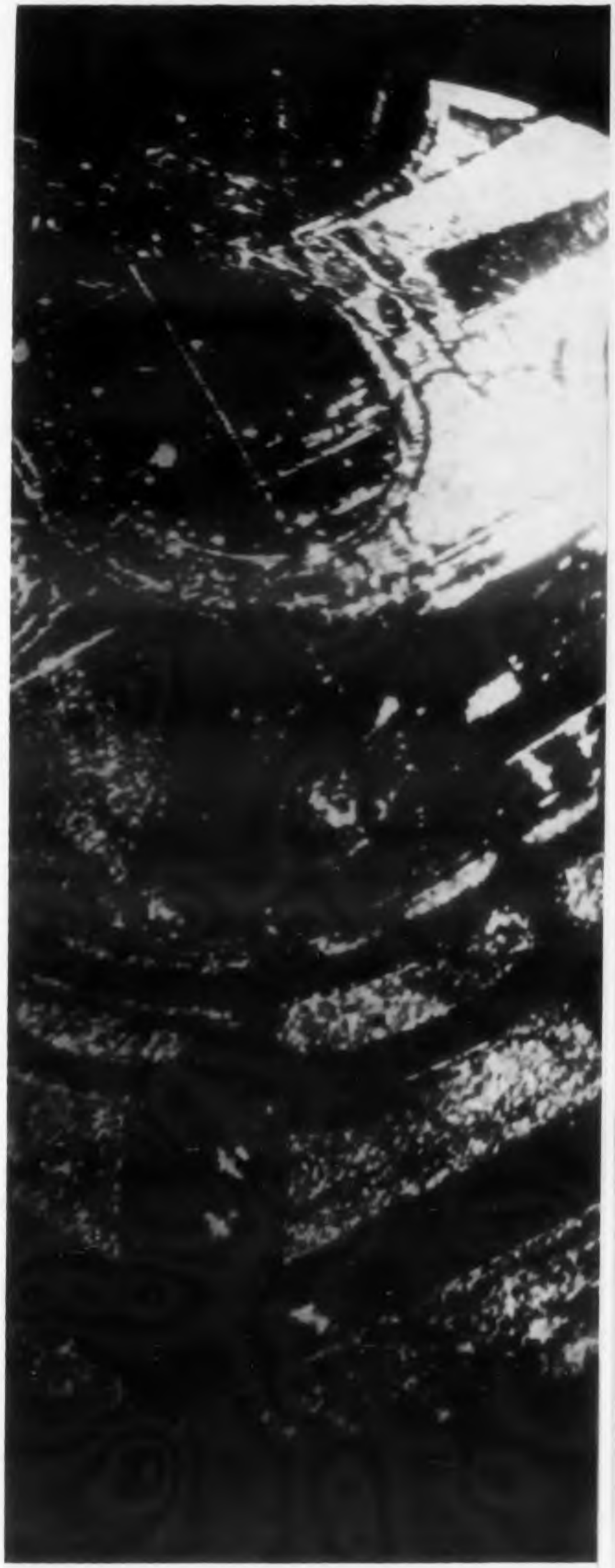
PROPER use of man and machine is anticipated to solve the nation's knotty air traffic problem which becomes worse daily (take offs and landings at the rate of one per minute). General Precision Laboratories, Inc.'s proposal, accepted by the Federal Aviation Agency last year, uses an automatic Data Processing Central and keeps man as the final decision maker on questions of conflict involving either enroute or terminal traffic. In case of electronic failure, man can immediately step in again. This reliability feature is considered by some experts as one of the chief reasons why GPL's proposal was accepted over fourteen others last year. (Another reason given is that the accepted system could be smoothly integrated with existing procedure.) There is a moral here for electronic engineers doing system planning—don't overlook man and manual techniques.

Functions of the semi-automatic system include reception, correlation, computation, display, and routing of information necessary for air traffic control. The traffic controller, relieved of the heavy burden of clerical duties, is then free to concentrate on his most important job—making decisions on air safety from data supplied by the system.

Evolutionary, Not Revolutionary, Change

An outstanding design feature, aside from the maze of circuitry, is the ability of introducing the automatic features into the existing setup gradually rather than one full swoop. Currently used methods will be retained and replaced as operators become skilled in each phase of the new equipment. This feature avoids unnecessary in-

Engineers busy on mockup models of Enroute and Radar Sector Consoles for function and human engineering studies (left).



Typical example of radar display showing airport surface details for aircraft routing on runways (right).

terruption of air traffic service and safety is not jeopardized during personnel training period.

If equipment in the system fails temporarily, the traffic controllers can immediately revert to their conventional methods.

Basic System Operation

The system hinges on the fact that flights and military missions are pre-arranged and detailed flight plans are filed at Air Route Traffic Control centers. A computer, the heart of the Data Processing Central, stores all proposed flight plans in its "memory."

Shortly before a plane is set to depart, the computer automatically prepares and distributes flight progress strips to various controller consoles. Operating personnel insert these strips in holders on their consoles within easy viewing distance. In the event of failure, key data is available for their immediate inspection.

The plane's departure time, set by the tower operator, is fed to the computer which probes for possible conflicts with other plans stored in its memory. If a conflict exists, the controller is so advised by the computer and several suitable alternatives are presented for his selection. If no conflict exists, takeoff approval is granted.

The computer is next informed by the tower operator of exact takeoff time. It then calculates arrival time over various fix points along the route, puts this data on flight progress strips, and distributes them to enroute control consoles.

As the pilot passes over the first fix point, he radios his exact time to the center. If the actual and estimated times differ, the computer calculates new estimates for arrival at following fix points and again probes for conflicts. As the aircraft flight continues, its control is passed from one enroute controller to the next.

When the aircraft approaches within 100 miles of its destination, it enters the transition area which s the "revolving door" for the airport. The Data Processing Central provides data to enable the equence controller to assign proper time slots or touchdown time to aircraft heading towards he same terminal. If conflicts exist, the computer calculates path-stretching maneuvers to be elayed to pilots involved. Long range search adar monitors all aircraft in the transition area.

As the plane approaches the terminal area, within 30 miles of the airport, the computer provides data for placing the aircraft in proper time sequence in the Instrument Landing System. Finally, a Precision Approach Radar monitors the plane to touchdown.

Handling Capabilities

The system, to be installed at Idlewild International Airport, N.Y., takes into account the existence of a nearby military terminal handling a large number of combat-type jet aircraft. Provisions are being incorporated to handle peak military loads, such as the arrival of many aircraft from offshore carriers.

Human Makes Decision

The system relieves the controller of tedious tasks such as handwritten entries on flight strips, calculations, numerous phone calls, and handling and conveying of strips. Automation will do this for him. It will display its "thinking" to the human manager for his inspection, review, and final judgment. Man, not machine, has the last word.

Lorac Tells Where That Missile Came From

A missile's performance cannot be evaluated or its flight tracked with any accuracy unless the exact point of launch is known—and that information not always is easy to obtain when the launching pad is a ship bobbing in the Atlantic Ocean. But soon Cape Canaveral test engineers will have the aid of Lorac (Long Range Accuracy) to pinpoint the locations of downrange tracking ships and offshore launching vessels at the moment missiles are fired.

Seismograph Service Corp. will install a four-station Lorac network at the Missile Test Center. The transmitters will broadcast continuous signals, which will establish two hyperbolic patterns forming a grid. The Lorac receivers, by phase comparison, will convert these signals into accurate position information.

The network—three transmitting stations and one reference station—will cover 120 miles, and provide accuracies on the order of 10 to 200 feet at distances of 10 to 200 miles.

Electrostrictive Ceramics—Substitutes for Electromagnets

NEW discoveries in the field of electrostrictive ceramics have come out of several years of research conducted by the Mullenbach Div. of Electric Machinery Mfg. Co., Los Angeles. A meter indicator is one such device; a ceramic audio driver for a loudspeaker another.

Low Cost Meter Indicator

Because electrostrictive ceramics respond mechanically to an electric field, a low cost reliable indicator can be produced.

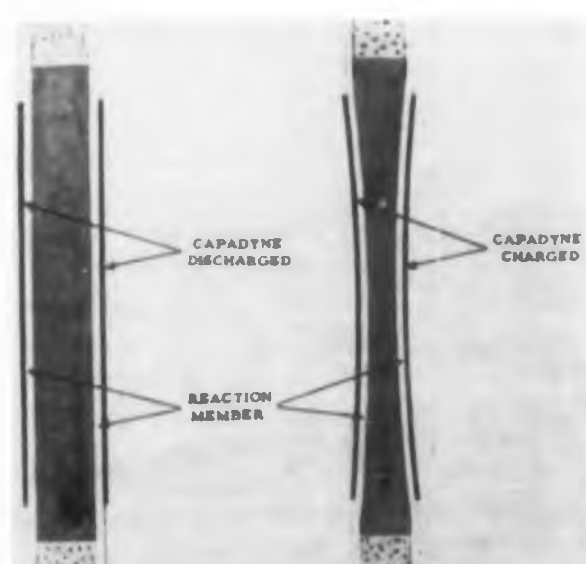
Such a meter, according to Mullenbach's Robert Cline, can be used economically "wherever you need an electrostatic-type meter and can tolerate a short term charging current." To measure the charge of a capacitor, the meter is charged right along with it. Insulation resistance is on the order of 10^{12} ohms.

Cline, who headed the ceramics research group, said, "it's a great high voltage dc meter, which has been wanting in the field." While Mullenbach made it for test purposes and has no plans for manufacturing it, the firm indicated it would supply technical assistance to an engineer designing an application of its ceramics.

Compressed Oil Reservoir

In the lab models of the meter indicator, two sensitive discs enclose a reservoir of oil or other fluid. Each disc is composed of a silver-coated ceramic bonded to a reaction member of metal or glass.

When an electrical potential is applied across the ceramic, it contracts radially. The result is a cup-



Electrostrictive ceramics contract in electrical field, squeezing oil reservoir to give meter indication.

New Mullenbach ceramic wafer makes possible design of lightweight radio loudspeaker.

ing effect on the reaction mem-er. The oil reservoir is com-ressed, changing the oil level in a ansparent capillary tube.

Up to 10 such indicators could e compressed into a six-inch-long ox. While extremely sensitive to inute changes in signal voltages. he visual indicators are highly re-istant to shock and vibration.

The electromechanical response instantaneous (within microsec-nds), but the effective meter indi-ations are dependent upon the iscous resistance and inertia of the ystem.

Featherweight Loudspeaker

Low cost featherweight loud-speakers are another possibility. Ceramic audio devices eliminate the need for heavy magnets or coils. Discs, which produce the vi-bration, can be connected directly to the plate current of a push-pull amplifier.

Stacked in parallel hookup, the ceramics can be used as actuators to produce pressure peaks as high as 30,000 lbs per square inch.

Thin Ceramic Sheets

Mullenbach ceramics are cast and fired in sheets a few thou-sandths of an inch thick, with silver frits fused to each side to provide capacitor structure. The ceramic is bonded to metal or glass with an epoxy adhesive to form an electro-mechanical device similar in con-cept to bimetallic reaction mem-bers used in thermostats.

The ceramic's principal ingredi-ent is barium titanate. Additives and processing techniques inhibited the piezoelectric effect and empha-sized an electrostrictive response inherent in the material. The effect of Curie-Point crystal changes was reduced, resulting in a material substantially free of temperature limitations.

Mullenbach now is supplying the ceramics in experimental quantities to government agencies and indus-trial firms interested in putting the unique characteristics of its mate-rials to work in specific applica-tions.

CIRCLE 7 ON READER-SERVICE CARD ➤

0.25 Degree Beamwidth Successful In Airport Radar

Based on the success of the Airport Surface Detection Equipments (ASDE) installed at Idlewild Airport (*ED*, Aug. 6, '58, p 10), the CAA has announced the purchase of ten complete systems from Airborne Instruments Laboratory, Mineola, N.Y. Within the next 18 months, "taxi-radar" will be in use at ten major terminals throughout the country.

Under poor visibility conditions, aircraft can be accurately guided to their destinations and landings can be smoothly and safely completed by various electronic systems installed at air terminals. Once on the ground, however, the problem is far from over. The web-like network of runways, with its many intersections, aprons, and taxi ramps, is crowded with parked and moving aircraft, gasoline and maintenance trucks, plus assorted cleaning and snow plow vehicles.

To direct a plane through this maze, without incident, under fog or heavy rain or snow conditions posed a serious problem at Idlewild Airport until the ASDE installation in June, 1958. From its extremely high-definition presentation of surface details, including all traffic, CAA tower controllers have been directing aircraft movement more efficiently and safely even in "pea-soup" weather. Considerably less time is lost waiting for runway clearance and voice communication between pilot and tower is also minimized.

Pint-Sized "Space Memory"

This ruggedized, miniaturized tape recorder, capable of storing 3,000,000 items of scientific data while traveling through outer space, was developed by Lockheed for manned or unmanned spacecraft. Designed to withstand 50 gs, the Airborne Magnetic Recorder-100 weighs eight lbs., is 1/3 smaller than existing recorders with the same capacity. It can store data while the ship is beyond radio contact, then unload the information at 1/6 the time it took to record it when the vehicle returns to within range of earth's listening posts.

Thanks to new system of insulating with inorganic materials, this experimental Westinghouse electric motor does an efficient grinding job even when bathed in searing heat from jets of burning gas. The "red-hot motor" showed no insulation deterioration after operating continuously for more than 100 hours at 950 degrees F.

"Red Hot Motor" Operates At 950 Degrees Fahrenheit

Westinghouse's development of a new system of inorganic insulation means that motors, transformers, relays and other electrical equipment can operate efficiently in space-age temperatures in the 1000-degree F range.

That is the claim made by a team of developers headed by Dr. E. J. Croop, manager of insulation and chemical development in the Westinghouse materials engineering departments—a claim substantiated by the results of severe tests.

An electric motor was operated at temperatures up to 1200 degrees F for short periods of time, and at 950 degrees for more than 100 hours, sealed inside an oven.

Inorganic insulation has been used for many years in electric ranges, but the materials were not mechanically strong enough to be used as insulation in moving, vibrating motors. Now the Westinghouse team has found materials with insulating properties "well above the stability of any known organic system" and at the same time flexible enough to be placed around an electrical conductor. The insulation has been prepared in a number of forms, including insulated wire, flexible sheet insulation, and laminated materials.

In the so-called "red hot motor" used in the tests, there were four basic components: (1) phase insulation; (2) slot insulation; (3) wire insulation; and (4) the potting and impregnating compound.

More Soviet Progress in Electronics

Recent reports from the Soviet Union indicate that the Russians are not only up in the air, but they're making solid progress in down to earth matters. Here are some examples of their recent efforts.

Computers in National Planning. According to the Laboratory of Control Equipment of the USSR Academy of Sciences, high-speed computers will be used in statistical planning of the national economy. Computing methods have already been worked out and experimental tables of relationships between various branches of the economy have been prepared.

With such tables, the Russians hope to work out the most efficient schemes for transporting goods. They also hope the computing techniques will help them determine the effects of new individual factors on the economy of the country as a whole.

In time, each economic area is to have its own computing center. Information from each center is to be sent to the centers of the various Russian Republics, thence to the All-Union Computing Center. Here the information is to be used for planning and for operational leadership of the national economy.

Power Network Control. Computers are also to be used to organize and automatically control the single power grid of the USSR. The European part of this network is to be completed by next year, at which time work will begin on the power grid for Central Siberia. Both systems are to be combined in the future.

A high-speed central computer will make all the calculations necessary for planning, producing, and distributing the electrical energy.

Automatic Telegram Reader. A team of scientists at the Odessa Electro-Technical Communications Institute has designed a machine to read the text of telegrams and transmit them. A pencil of light scans the telegram; computers identify the letters by the spatial distribution of white and black zones; then banks of relays translate the signals into telegraph code pulses.

These pulses are sent over communications lines, then punched onto the tape of the receiving telegraph apparatus.

Reading for the Blind. The Technical Laboratory of the Institue of Defectology of the Academy of Sciences has machines to help blind people read ordinary printed matter. The machines, no larger than radio receivers, use an optical system to scan the lines of a book fixed under glass. Magnified images on the glass are picked up by photocells which are linked elecally to a sound generator. This generates unds corresponding to each letter or punctuation sign.

In about 50 hours, a blind person can learn ese sounds and read ordinary books. For blind ople with impaired hearing, a different machine oduces Braille letters (a code of bulging dots the surface of a special tablet). The blind person can thus read a book with his fingers.

lectronic Seeing-Eye Dog. The same Institute Defectology has designed portable instruments to generate sound signals corresponding to isible objects. These sound signals can warn a lind user of an obstacle in his path. More than 00 such instruments are now undergoing practical tests.

"What This Planet Needs Is A Good . . ."

NEWS ITEM: Five persons in the Kajana district of Finland observed a "flying cigar" in the sky at 10:30 p.m. Nov. 18. The object, which emitted a loud noise and lit up a large area, was visible for two or three minutes.

ED. NOTE: *Clever, these Martian advertising men. But who wants spurious noise in a cigar?*

Ready for Shake-up

This walk-in environmental test chamber was designed to permit testing of military equipment, including missile components, with a vibration machine weighing 6,000 lb. Constructed by Tenney Engineering, Union, N.J., the chamber measures eight feet high and across and 12 feet deep in the inside. It has a temp range of −120 to +350 F, humidity range of 20 to 95 per cent, and an altitude ceiling of 100,000 ft. Proper isolation of vibration equipment has been achieved by pouring a concrete block weighing over 20 tons beneath the chamber.

The unit, installed in the Electronics Center facility of the Stromberg-Carlson Division of General Dynamics Corp. in Rochester, N.Y., can dissipate 16 kw of electrical energy, roughly 56,000 BTU, at minus 100 deg.

Westinghouse lab model of ultrasonic seam welder completes a weld between two 10-mil thick aluminum straps.

Ultrasonic Seam Welder Joins Dissimilar Metals Continuously

An experimental ultrasonic seam welder now is welding sheets of dissimilar metals continuously without prior surface preparation. When perfected, say its Westinghouse developers, the device will bring to seam welding the advantages of ultrasonic welding, eliminating the deformation of materials that results from cold welding of dissimilar metals.

In tests, light silver foil was welded to quarter-inch-thick copper strap at a 20-in.-per-min rate, and two sheets of 0.010-in. aluminum were joined at a 15-in.-per-min rate.

Sheets to be welded are passed between two wheels vibrating at 20 kc per sec, with the periphery of each wheel pressing against opposite sides of the sheets. Breaking up the metals' oxide surface coating, the wheels by kneading action weld the metal lattices on the surfaces of the metals.

No electrical current is passed through the spot being welded, though in appearance the weld is similar to an electric weld.

The center of each vibrating wheel is attached to a transducer assembly—a magnetostrictive transducer, coupling bar and water-cooling enclosure—to convert electrical energy to high frequency mechanical vibrations. The wheel surfaces in contact with the sheets move in opposite directions, as the two transducers work in opposition.

EPOXY–Anaconda Magnet Wire for outstanding compatibility at high temperature

Epoxy's unique combination of dependable characteristics makes it suited to use in such equipment as totally enclosed motors, above; hermetically sealed relays, encapsulated dry-type transformers, below.

Anaconda Epoxy Magnet Wire is particularly well suited to use in oil-filled transformers. Epoxy's excellent behavior in transformer oils is but one of its many outstanding chemical characteristics.

The compatibility, chemical stability, and thermal stability, of Anaconda Epoxy have been proved by some three years of actual field experience, plus seven years of research and development, in both military and civilian applications.

Anaconda Epoxy (130°C AIEE Class B) magnet wire is compatible with most well known insulations. It offers excellent resistance to moisture, transformer oils, acids, and alkalies. Tests of Anaconda Epoxy magnet wire with all impregnating varnishes tried to date have resulted in chemically compatible systems—with no thermal deterioration of the Epoxy film.

Epoxy's unique combination of dependable characteristics makes it suited to a wide variety of difficult applications. Its outstanding dielectric strength, its heat-shock, adherence, and flexibility properties make it an "all around" magnet wire for use up to 130°C in either open or closed systems.

ROUND, SQUARE AND RECTANGULAR. Anaconda Epoxy magnet wire is available in the full range of round, square and rectangular sizes. It can also be furnished in combination with glass servings.

If you have a difficult Class B application or a troublesome job at lower temperature that might benefit from some other characteristic of Epoxy, see the Man from Anaconda. Or write: Anaconda Wire & Cable Company, 25 Broadway, New York 4, N.Y.

ASK THE MAN FROM ANACONDA® *about* EPOXY MAGNET WIRE

For more details on Anaconda Epoxy's unique combination of useful characteristics, please turn the page—

ANATHERM 155°C (AIEE Class F)
high temperature resistance

NYFORM 105°C (AIEE Class A)
superior windability

VITROTEX 130°C (AIEE Class B)
glass insulated, high heat resistance

FORMVAR 105°C (AIEE Class A)
proven dependability

ANALAC 105°C (AIEE Class A)
solderable magnet wire

NEWS BRIEFS . . .

. . . **NEW RADIOISOTOPE SOURCE.** Samarium-153, will be made available by General Motors Research Labs to licensed users of industrial and medical isotopes. Called "a breakthrough in the field of low energy photon sources," promising applications include radiography, liquid level gauging, thickness gauging, specific gravity measurements under unique conditions, diagnostic X-ray and, possibly, experimental dental X-ray. Portability is a feature.

. . . **PROTOTYPE OF "FLYING** weather stations" should be ready in 12 months, says Bendix Aviation. Bendix is contractor for a multi-million dollar Air Force program to develop an airborne weather reconnaissance system (AN/AMQ-15) built around four-engine jets equipped with radar and elaborate sensing equipment. As they fly six to nine-hour missions, making continent-wide sweeps at almost the speed of sound, the jets will continuously communicate atmospheric data to a ground network. By launching radiosondes, the three-man weather recon crew in each jet will probe the atmosphere from near sea level to 150,000 feet.

. . . **OUTSTANDING DESIGN CONTEST** again is being sponsored this year by Mars Pencils. Entries are invited in aviation, space travel, autos, trains, building, engineering structures, machines, business equipment—almost any field. Winning designers get $100, retain all future rights. Projects will be selected for appeal to design-minded readers, broad interest, attractive presentations. Designs will be reproduced in a number of technical publications. Entries to: J. S. Staedtler, Inc., Hackensack, N.J.

. . . **RCA ALREADY IS FILLING** orders from insurance, banking, manufacturing and military customers for the newly announced RCA 501, the first completely transistorized general purpose electronic data processing equipment. The basic system, which bridges the gap between electromechanical accounting machines and giant computers, fits into a 15 x 20 ft room. Compared with electron tube equipment requirements, RCA's use of transistors throughout auxiliary input and output equipment, as well as in the control computer, cuts floor space by one half and air conditioning and power requirements by two-thirds. Modular construction permits later addition of other units as required, thus bringing full-scale data processing within reach of the average-size company as well as the large corporation.

CIRCLE 13 ON READER-SERVICE CARD

CIRCLE 14 ON READER-SERVICE CARD

WASHINGTON REPORT

Better Statistical Reporting

Forecast of $7.9 billion by the Business and Defense Services Administration as the factory value of electronic equipment and components for 1959, may be one of the most reliable yearly predictions yet made. In past years, oracles have missed the mark widely for the simple reason that there is no way to get accurate figures of past performance let alone market data for the future.

The techniques of assemblying statistics still leaves too much to "educated" guessing but surveys being made by BDSA in the area of component manufacturing are apparently producing excellent results. Thus when the Department of Commerce agency says the 1959 estimate for the value of electronic tubes is $0.850 billion; semiconductor devices $0.250 billion, and other electronic components $1.5 billion, they can be relied upon with a great deal of confidence. Unfortunately, BDSA won't release for publication a detailed breakdown of predicted factory sales of components. The dollar figure for components includes the replacement market for maintenance, which further obscures the value going into new original equipment.

The reliability of figures for original equipment is much poorer. There is no survey underway similar to that made in the area of components. BDSA's figure of $3.8 billion for equipment except tubes and components—and exclusive of research and development—sounds low especially since the figure includes commercial and industrial electronics, but it is believed to be as authentic as any in the field. Because a government agency does not want to be accused of spelling out the dollars going into defense electronics, the subtraction of nondefense equipment will have to be made by others (Electronic Industries Association put commercial industrial sales at $1.[illegible] billion).

Actually, there is little difference between the Electronic Industries Association prediction and the BDSA outlook when research and development expenditures are subtracted ($8.3 billion versus $7.9 billion). This is not to imply separate sources corroborate each other but that the two

ganizations collaborated in exchanging infor-
ation.

Although predictions for 1959 are as good as s before (incidentally, the figures for 1958 ade last year were high), they may be better t for 1960.

By that time the Bureau of the Census will no ubt have processed information gathered in e 1958 survey of manufacturers. With the in-eased cooperation of industry to share their alue figure (for the last three years the industry as been market-analysis conscious and realizes terchange of information is essential), realistic igures may emerge some year soon.

Extension of Renegotiation Act

The tentative 1959 Department of Defense legislative program will include 71 proposals. Twenty-three have already been submitted to Congress.

The major item affecting the electronics industry is the extension of the Renegotiation Act of 1951. In considering a recommended extension to December of 1960 last year, the 85th Congress enacted only a 6-months' extension—expiring June 30, 1959. The House Ways and Means Committee then promised to undertake a broad review of renegotiation early in the next Congress. It is doubtful whether major procedures of renegotiation will be changed before the act expires.

Reason for extending the act was given by Robert Dechert, General Counsel, Dept. of Defense, before the National Security Industrial Association. Dechert said: ". . . we are today engaged in large-scale procurement programs involving the purchase of many different types of specialized items, many of unprecedented nature. Past production and cost experience are not always available for accurately forecasting the costs of such items. Today, particularly, we are witnessing rapid developments in the aircraft, missile and space fields. Pricing policies and contracting techniques of the procuring agencies cannot guarantee in all cases against excessive profits."

Although the military departments are fully aware of the criticisms which some branches of industry have made of the effects of renegotiation on them, they have been unable to see any other feasible approach for now.

Incentive contracts and the question of possible appeal from decisions of the Tax Court are under special study. The industry should see some new possibilities developing to alleviate their problems.

(Advertisement)

NEW PRODUCTS

Versatile High Speed Crimping Tool

The Omaton Division of the Burndy Corporation has available for immediate delivery its new extremely versatile, semi-automatic, magazine-fed, portable, pneumatic crimping tool, type YD which provides for controlled crimping in volume production work.

This magazine-fed tool automatically pre-positions, feeds, and crimps contacts, such as BURNDY'S STAPIN® HYFEN,® and CRAB-LOK® lines of connectors. This makes for a greatly simplified operation permitting highly reliable connections to be achieved at a high rate of speed.

The YD HYPRESS® is automatic in the respect that beyond the operation of loading the tool and cocking the feed device after each fourteen connections—a five second operation—all other operations, such as advancing and positioning of the contacts, are accomplished automatically by the tool.

Contacts to be installed with the YD are furnished pre-loaded in color coded plastic expendable carry strips carrying fourteen contacts per strip and packaged five strips to a magazine load. The plastic strips are automatically ejected from the tool after the contacts have been used.

The power unit of the YD HYPRESS is an air cylinder which is controlled pneumatically (no mechanical ratchets) to provide full cycling control which assures that each contact is properly crimped. The tool is factory set to operate at 80-100 psi line pressure and develops 2500 lbs force when operated at 90 psi.

Burndy Corporation, Norwalk, Connect.

CIRCLE 299 ON READER-SERVICE CARD

EDITORIAL

The Pause That Refurbishes

One of the greatest challenges facing the design engineer in 1959 will be to find time to think.

As we talked to engineers in gathering material for our *Design '59—A Challenge* report, the universal state of affairs of too little time to do the things that should be done became very apparent. Although busy engineers and bustling activity seem to be healthy signs, we may be kidding ourselves.

Decisions are made every minute but are they made with due deliberation? Too often it appears the busy engineer's energetic pace is set by the crises that keep developing and need attention. The engineer, important because of his thinking ability, is called upon to lick the problems, but what kind of thinking does he do? There are usually only a few alternatives possible because of the many constraints such as delivery on time, cost, etc. The "thinking" is simply to arrive at the best compromise.

Doing just a bit of "thinking," several factors of the mid-twentieth century come to mind that seem to portend even more shallow thinking in the future.

As computers become more available to do "thinking," albeit routine or repetitive, and as man is put in the role of merely making a choice of alternatives given to him by the computer, he may not know how to make a decision. Never having been called upon to think for himself earlier, his judgment powers may be poor.

We see evidence of erroneous judgment of this kind being made by those who rely too heavily on results of surveys. For example, advertisers making decisions on motivational research occasionally err because they didn't study in depth a conflicting motivation that applied to their product. Surveys too often replace thorough original thinking.

The team approach poses dangers too; an individual is often absolved from thinking at all in some area—George was supposed to study that. No one person is ever responsible.

But to worry about 1959 first, how is the engineer who is overloaded with commitments to schedule his time to think? The undersigned hasn't had time to think about it enough—one solution might be to shorten the work week so there is more after-hour working time. Those of us who are railroad commuters can move further into the suburbs. That will give us time to finish such things as reports and editorials each morning before the hubbub of the plant or office starts.

It is a wise man who is not stampeded into making too many commitments. He alone can pause occasionally and refurbish his decision-making apparatus.

James G. Lippke

Semiconductor diodes are complex. They often fail to do what you want them to because of "hidden" properties. The clue to their better performance lies in unearthing these properties with better measurements. How to make these measurements is shown.

Author Fred Dickey, with GE almost 15 years, has worked extensively with diodes in general test equipment, fire control equipment, and special electronic test equipment for laboratory experiment.

New Circuits for Better Diode Measurements

Fred E. Dickey*
Research Laboratory
General Electric Co.
Schenectady, N. Y.

BETTER diode measurements are simplified with better test equipment. The three pieces of equipment described here measure three paramters—recovery time, static characteristics, and capacitance. These measurements are among the most important to diode in-circuit performance.

The diode's complex characteristics can lead to unexpected performance. In one case, diodes with a long recovery time worked better in magnetic core computer circuits than did some types with fast recovery. Theoretically, the latter should have done the better job. Testing revealed that the short-time diode had more capacitance.

Current through this capacitance caused the peak current to be high. Though this current decayed more rapidly than in the slower recovery diode, its initial high value made the total area under the current-time curve worse than would be predicted from the difference in recovery time.

This effect was especially bad at low forward currents. Short-time diodes had capacitances of three to four μμf, while the long-time diode's capacitance was on the order of a half μμf.

It appears that reverse current through the diode is made up of at least two components: some flowing through the capacitance between anode and cathode, and some flowing because of carrier storage in the semiconductor medium. The total reverse current can be considered here, with no attempt to separate it into its components. From a practical standpoint, the designer has as much trouble when his circuit malfunctions because the diodes pass reverse current through anode-cathode capacitance as when they pass it because of carrier storage.

This difference in capacitance between diodes is especially serious in cases like that of a developmental digital computer which operates on a 150 kc sine wave. When the diodes are biased to hold off a sine wave the higher capacitance ones pass more reverse current than those with low capacitance and may cause erratic operation.

Diode Recovery

Recovery time is taken as the length of time a diode takes from the instant a negative pulse is applied to the instant when it has recovered in resistance up to some certain value. This value of resistance is not standardized throughout the industry so any discussion of recovery time must mention the basis of measurement. In this case it is 50 kilohms.

Figs. 1 and 2 show recovery times of three typical diodes under various conditions. Their capacitances are listed in Table 1.

The capacitance effect can be seen in Fig. 1, where the three diodes' recovery can be compared with zero forward current. The high capacitance diode 1N643, has almost as much reverse current with no forward current as with 10 ma. The other two show almost no reverse current at zero forward current.

Recovery Time Test Set

In the past it has been customary to measure recovery with the system shown simplified in Fig. 3. The reference diode is to prevent a large voltage buildup across R_L. This would put a charge on C_L that would have to be dissipated when the negative pulse comes along. This system has two serious limitations:

1. Modern diodes have short recovery times and the reference diode does not recover soon enough to "get out of the way." The effect is to upset the recovery time measurement.

2. The system has about 10 μμf capacitance across R_L. This increases the recovery time and therefore limits the maximum value of R_L which can be used.

The circuit of Fig. 4 overcomes these drawbacks. The 2C40 lighthouse tube is used as the output cathode follower because of its high G_m and low input capacitance. It is mounted horizontally on insulators. Cathode and heater connections are soldered directly to the socket pins. Anode connection is made with a standard clip.

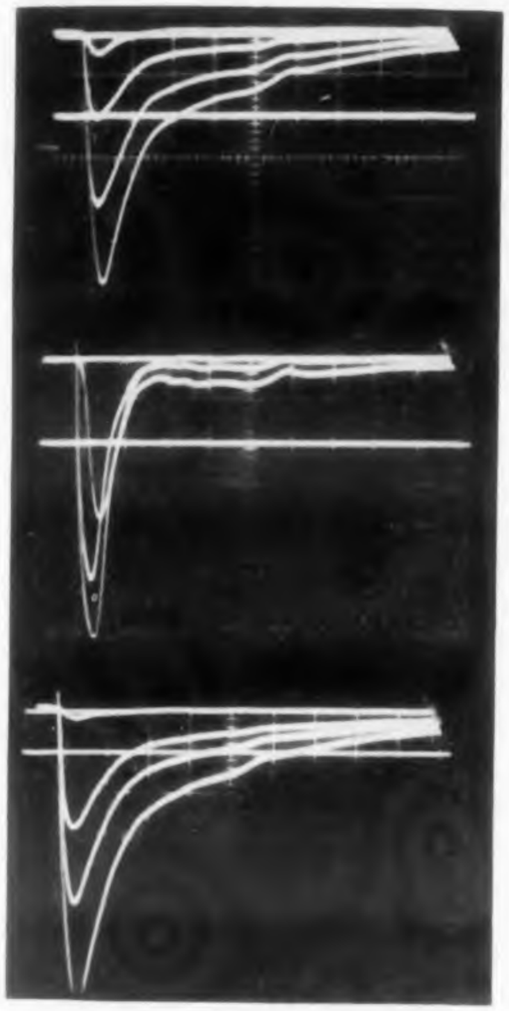
To keep input capacitance down, one end of the 2 K resistor is soldered directly to the grid flange. This must be done with extreme care so the glass will not crack. The other resistor and the trimmer capacitor are soldered to this 2 K resistor. The diode test clip is a tiny spring type mounted on a small lucite sheet. The 2 K load resistor R_L, is soldered from the test clip to ground. This allows R_L to be changed easily.

Table 1. Capacitance of Three Diodes

HD2162	germanium	(Hughes)	0.3 μμf
1N251	silicon	(Transitron)	0.8 μμf
1N643	silicon	(Pacific)	3.0 μμf

Measurements made at 3 v inverse bias.

* The work described here was done while the author was with the Light Military Electronic Equipment Dept. of the General Electric Co.



(A) 1N251

(B) 1N643

(C) HD 2162

Fig. 1. Diode current characteristics with 25 v inverse voltage, 0.1 μsec per division on time axis, 150 kc rate, and 2 K load. The bright horizontal bar indicates the 50 K level.

(A) 1N251 with forward currents of 0, 5, 10, and 15 ma.

(B) 1N643 with forward currents of 0, 5, and 10 ma.

(C) HD2162 with forward currents of 0, 2½, 5, and 10 ma. Gain is half that in (A) and (B).

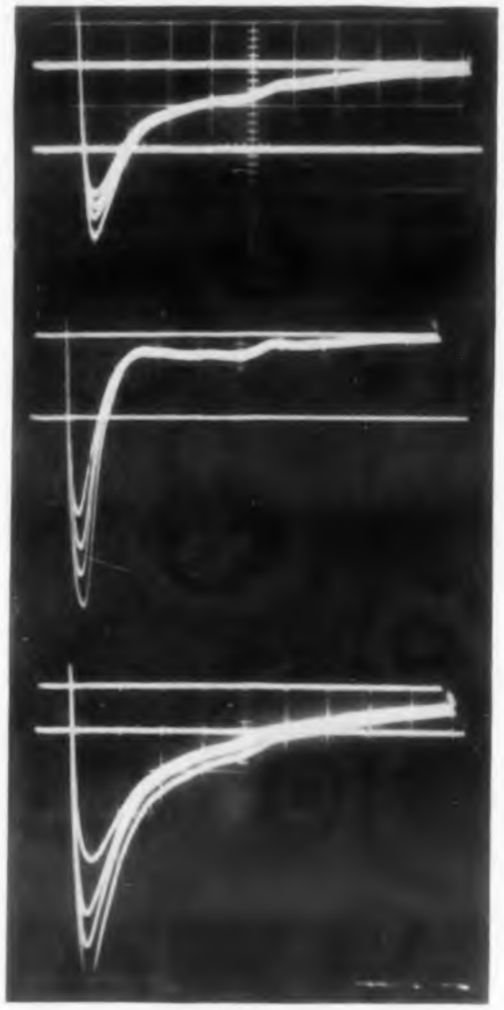


Fig. 2. Diode voltage characteristics with 10 ma forward current, inverse voltages of 5, 10, 15, and 25 v, and other parameters the same as in Fig. 1.

The 2 K value is commonly used, but for certain circuits other values might be desired.

This part of the circuit and the components going to the grid are laid out for least possible capacitance. Measurements on a Q-meter show a capacitance of 1-1/2 to 2 μμf from the sensitive test clip to ground for the complete layout. The potentiometer P_2 adjust the output voltage to zero dc. The output cable must be as short as possible.

The rest of the circuit is quite straight-forward. The HD2162 and its associated circuit comprise a peak reading voltmeter to indicate the negative voltage of the pulse with respect to ground. Meter M_1 and its circuit read the forward current in the test diode. If the negative pulse is a square wave then the forward current is twice the average which the meter reads, so M_1 is calibrated accordingly.

Fig. 2a shows the fall time of the pulser, tester and cro system with a short circuit in the test clips. The 1.5-7 μμf capacitor is adjusted to give the best fall time without overshoot.

Since this system has the most complex adjustment of the equipment discussed here, complete operating instructions follow:

Recovery Time Measurement

1. A Tektronix 105 pulse generator and a cro with the fastest rise time preamplifier are required. A dc power supply of 250 v and 100 ma capacity is used.

2. Let warm up 10 minutes.

3. With dc power supply off and cro on dc setting, put base line on top line of screen. Turn dc power on and make sure diode test clips are empty. Adjust the balance pot P_2 to set

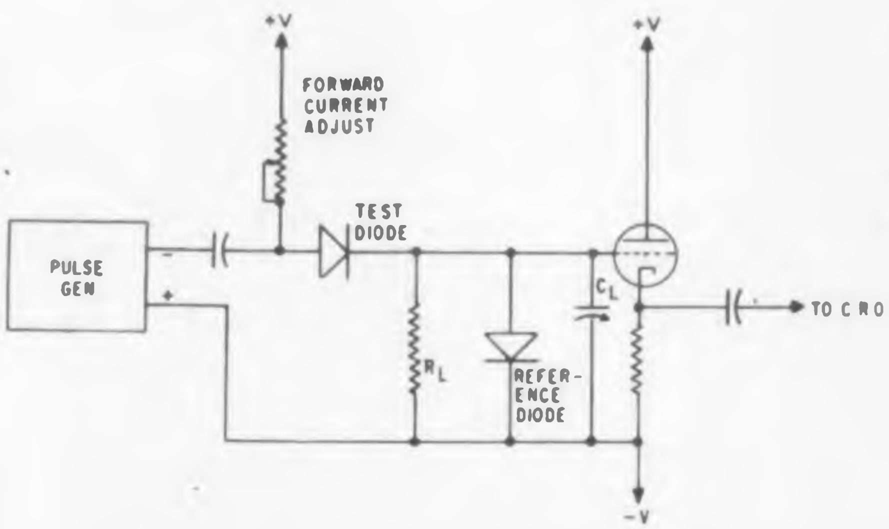


Fig. 3. Customary diode tester simplified.

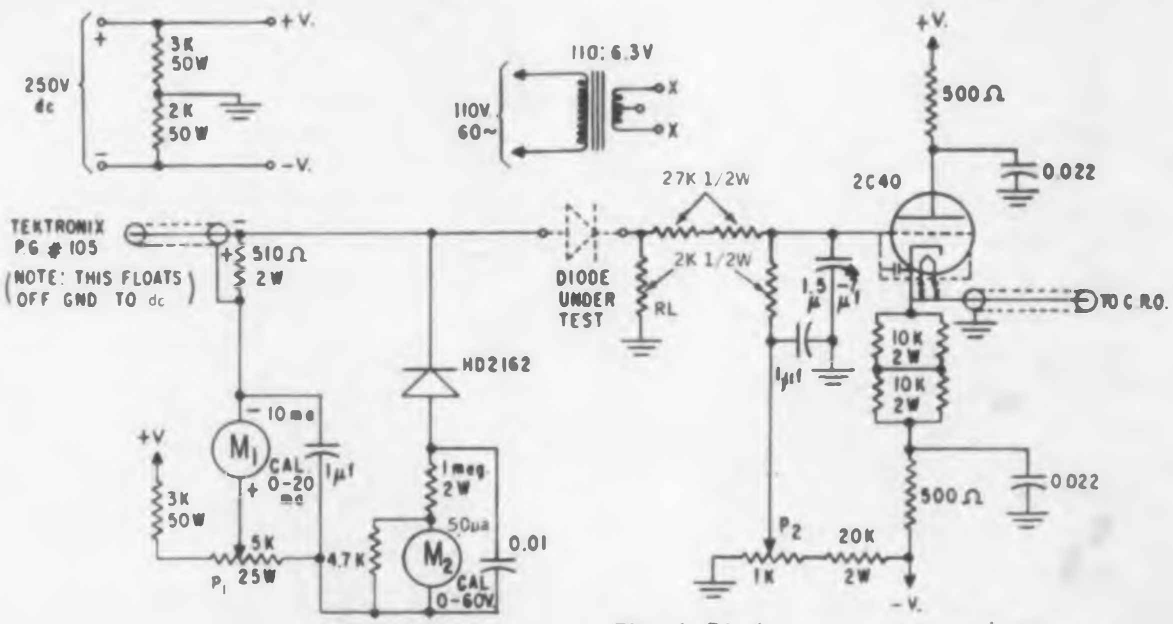


Fig. 4. Diode recovery test equipment.

Fig. 5. Diode characteristic plotter.

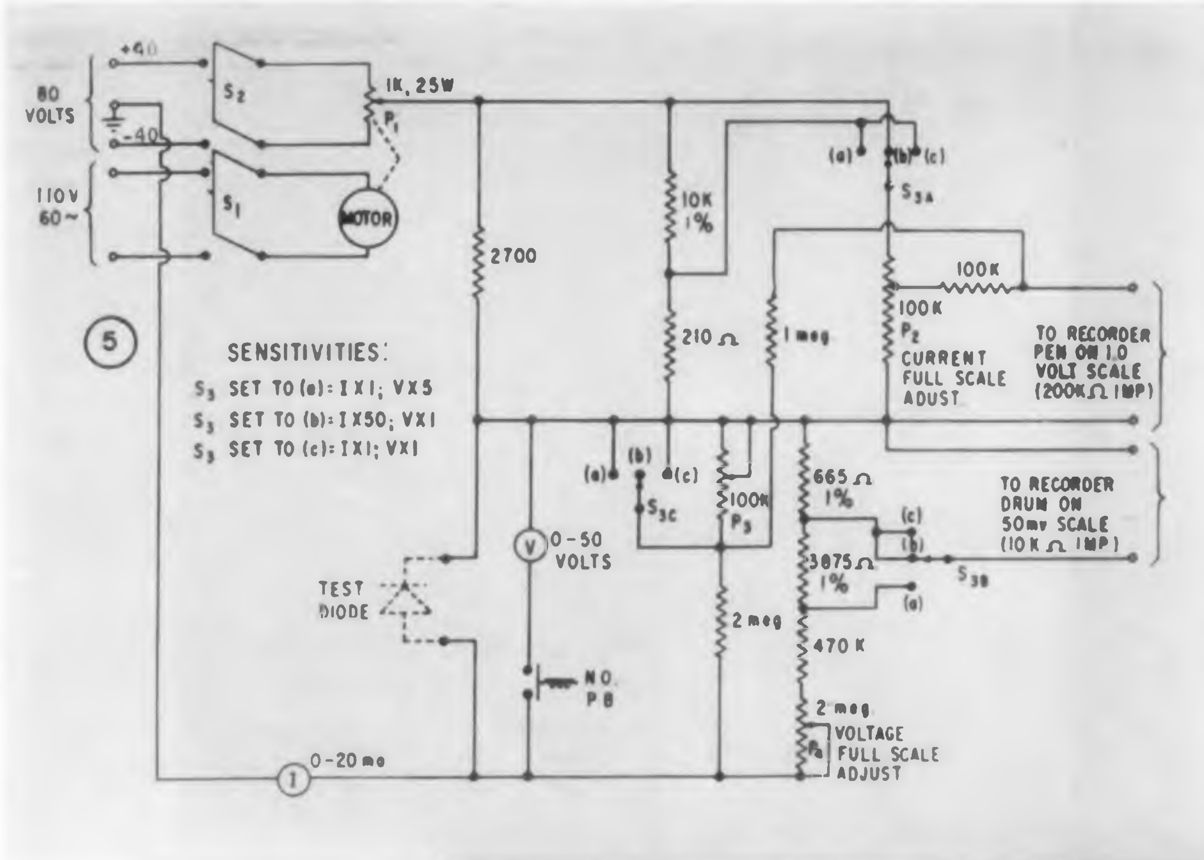
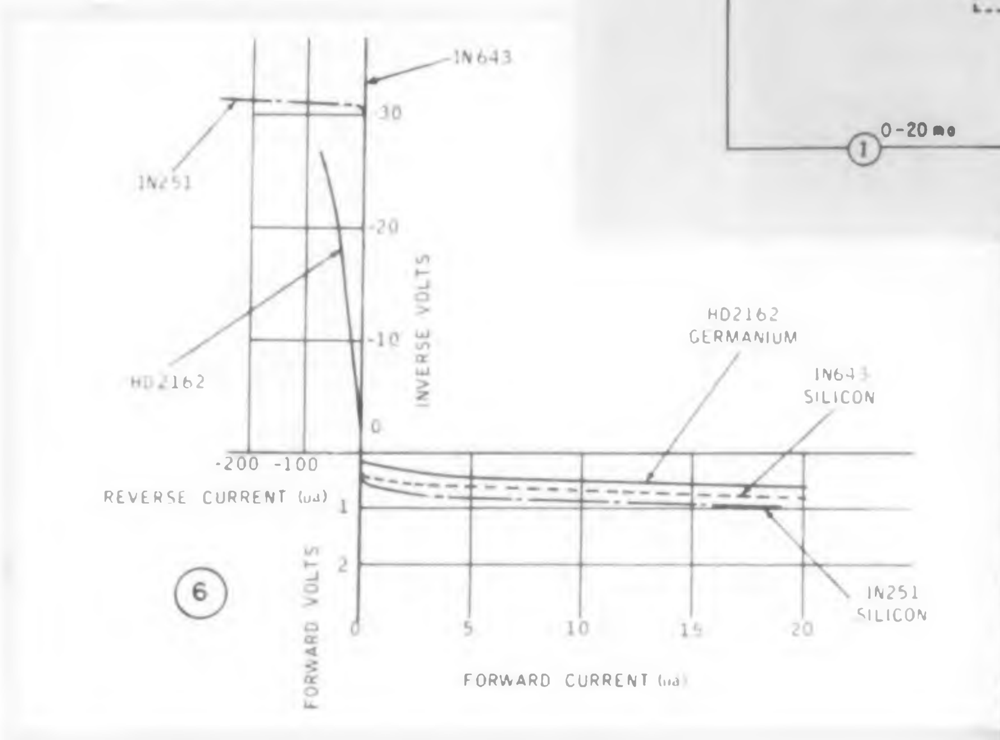


Fig. 7. (below) Diode capacitance tester



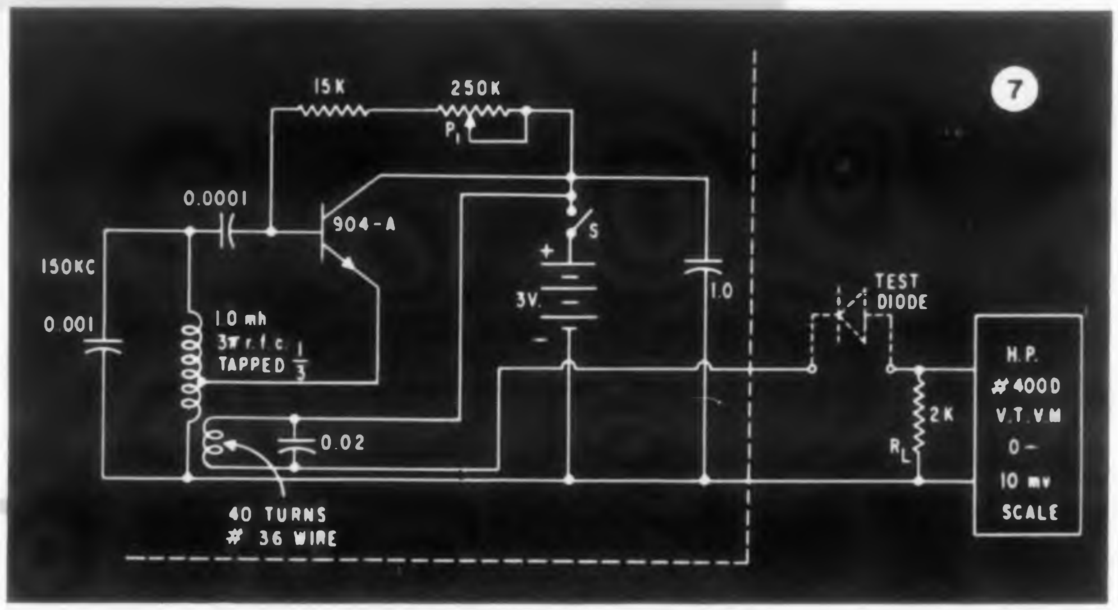


Fig. 6. (Above left) Static characteristics of the 1N643, 1N251, and HD 2162.

base line back on the top line of screen. This adjusts output of circuit to 0 vdc.

4. Put short circuit in test clips and set pulse generator to 150 kc and 25 v output. Set P_1 to zero. Adjust gain of cro so pulse from pulse generator can be seen. There should be no overshoot on the pulse and the fall time should be less than 0.1 μsec. If this is not the case adjust the 7 μμf trimmer capacitor to make the pulse correct. Also, adjust the symmetry control on the pulse generator so the positive and negative times are equal.

5. Recovery time is usually taken as the time the diode takes to return to some value of resistance. A value of 50 K is one standard. To calibrate, put the 50 K resistor in the test clips. Set P_1 to zero and the pulse generator to 25 v output. Set the gain of the cro to maximum and note the size of the negative pulse. When the diode has recovered to the point where it is that many divisions of the scale from the base line, then it has recovered to 50 K.

6. Put the test diode in the clips and adjust the forward current to the desired value and the inverse voltage to 25 v. Of course, if other than 25 v are desired, then the calibration Step 5 must be done again with the desired voltage.

7. Recovery time can now be determined from the calibration in Step 5 and the cro settings.

Static Characteristic Plotter

Fig. 5 shows the static characteristic plotter and Fig. 6 gives the curves it made on the three diodes discussed before. A one rpm motor drives a 1 K potentiometer so that voltages between −40 and +40 are applied to the diode. A Moseley Autograf X-Y recorder is used to make the permanent record.

Two meters are used to indicate voltage and current so ranges can be set on the recorder. The voltage drop in the 20 ma meter is not enough to be significant but the voltmeter does draw enough current to be noticeable, so it is only in operation when the normally open button is pushed.

There are two unique features to this circuit. The first is the system whereby voltage and current ranges may be switched at will. With S_3 in position "C" the voltage and current scales are on their normal ranges wherein the recorder full scale on 20 ma and 40 volts.

However, on the reverse voltage side of the scale the diode current is only microamps and cannot be seen on a 20 ma scale, so position "B" is added. It multiplies the current scale by but yet leaves the voltage scale as it was. By this means, the reverse current scale is expanded by so that leakage current can be seen.

Position "A" is supplied for use with the diode in the conducting direction. Here the current range is back to 20 ma full scale but the voltage range is expanded five times. This enables the forward voltage scale to be expanded and read more easily.

The operation of the system is such that a run is started on range "B" and on the reverse voltage part of the curve. The motor is started and the curve plotted. Then, just as the voltage goes through zero, the operator snaps S_3 to the "A" position and the curve is completed.

Another unique feature is that a means is supplied whereby the current drawn by the recorder's voltage axis is subtracted from the reading on the current axis so that if the diode draws no current, the current axis will indicate zero. This is done with P_3 and its circuit. The proper setting for P_3 is determined by putting S_3 on "B" setting and turning P_1 so −30 v are indicated. With no diode in the clips, P_3 is adjusted to give a zero current reading.

The attenuators switched by S_2 are calculated for the loading of the recorder. They would have to be changed if some other recorder with different input impedances is used.

Capacitance Measurement

The circuit of Fig. 7 measures diode capacitance. It is a 150 kc oscillator which generates about one-half volt to drive the reverse biased diode. A 3 v battery supplies power to the oscillator and bias to the diode. The output of the diode goes to a 2 K load resistor and is read by a Hewlett-Packard #400 D vtvm.

To make a measurement, a 10 μμf capacitor is put in the test clips. The vtvm is set on the 10 mv scale and adjusted to full scale reading by P_1. The voltmeter now reads one mv per μμf so the diodes are placed in the clip and capacitance read directly. This calibration is linear because the current flowing through the load resistor R_L is determined by the reactance of the diode as long as its capacitance is small. For example, 5 μμf at 150 kc gives about 200 K reactance which determines the load current completely. The 2 K R_L has no effect when combined with so large a reactance. The capacitance varies with inverse bias so this system provides a means of comparison between various diodes at 3 volts bias. ■ ■

Contour Photocells

ALMOST any voltage waveform can be generated from pliable photocells simply by reshaping their contour. Produced in pliable strips with as little as one inch radius of curvature, the cells can be formed into a photosensitive cam in a variety of shapes. These contour photocells open the door to new design possibilities in photoelectric devices. Control applications, production flow processes, automatic inspection and sorting are just a few uses visualized.

Contour photocells—manufactured by International Rectifier Corp., El Segundo, Calif.—are a specially-processed example of selenium photovoltaic cells. These cells consist of a metal base on which layers of selenium, cadmium and gold are deposited. The aggregate is treated in such a way as to be light-sensitive.

Upon exposure to light, the cells generate about 0.5 v of power. Output is the order of 100 ft-candles under load resistances of 100 ohms (450 μamps) and 1000 ohms (200 μamps). The photocells have in all other respects the same properties of the more typical photocells. In the past photocells had one large application—light exposure meters. Now, in addition to novel industrial uses, contour photocells can be used for automatic setting of light control for motion-picture cameras and built-in light meters for still cameras.

Producing Different Waveforms

Since these pliable photocells are able to be shaped into almost any form, they can be mounted on a rotating shaft in a position control

The photocells, produced in pliable strips, are able to be shaped into almost any form.

servomechanism. They may be used as a form on nonlinear function generator, when formed into a photosensitive cam. Different configurations produce different waveforms. For example, if a cylindrical-shaped photocell is properly masked and then rotated in a beam of light, a square wave will be produced. The variety of waveforms produced in such a manner is limited only by the ingenuity of the design engineer.

Some of the other applications visualized are:

- Measuring mean horizontal candle power of lamps. This is accomplished by curving the light-sensitive surface inside around the lamp.
- Measuring illumination over an uneven surface.
- Increasing the field of acceptance. The outer edges of a flat-surfaced photocell do not receive the same intensity of light as the center portion. But by curving the light-sensitive surface the intensity will be equal at all angles.
- Mounting the photocell on a shaft to determine position.
- Producing photosensitive models such as missiles and aircraft. Various tests could be made on these miniaturized models which respond to hits from a light-ray gun. These models will be sensitive to a home-on light source.

These applications arise from the ability of pliable selenium photocells to be produced to any requirement (curved, cylindrical or other configurations). Cell sizes range from a minimum of 0.25 x 0.25 in. to a maximum of 10 x 10 in. For more information on these pliable photocells, turn to the Readers-Service card and circle **103**.

Microwave Test Instruments,

Part 4

POWER and FREQUENCY

David Fidelman
Roslyn Heights, N.Y.

Different types of microwave instruments were described in the first part (*ED*, Dec. 10, 1958). Signal generators were taken up in part 2 (*ED*, Dec. 24, 1958). They were classified into different types and described both as a source of signal power and as an accessory to supply a calibrated signal for comparison. Microwave test sets were described in the third part (*ED*, Jan. 7, 1959).

Power and frequency measuring instruments are now taken up. Basic principles of operation of such units as water calorimeter type of power meter, bolometers, and tuned cavity type of frequency meters are described.

MICROWAVE power is measured by converting it into heat and measuring the amount generated by the signal under test. There are two general methods of performing this operation. For relatively large powers, the signal can be made to heat a constant flow of water, and the power determined from the temperature rise of the water. For low powers, the signal can be made to heat a small resistive element (a bolometer) whose resistance is a function of temperature. Therefore, the amount of power absorbed is indicated by the element's resistance.

Power Meters

In the water calorimeter type of power meter, the waveguide or coaxial line is terminated in a water load which absorbs the microwave power, raising the temperature of the water accordingly. Other liquids than water may also be used in this type of instrument, but the principle of operation is the same. To measure the amount of power absorbed by the load, the water is made to flow through it at a steady rate, then the flow rate and the temperatures of the water flowing into and out of the load are measured. From this data the amount of power being absorbed by the load can readily be computed. Water calorimeters are most useful for measuring fairly large powers, where they are widely used as power standards.

Bolometers

The bolometer type of power meter is used for measurement of low powers from microwatts to several hundred milliwatts. Bolometers may be of two general types: metallic wire or film whose temperature coefficient of resistance is positive, or thermistors whose temperature coefficient is negative. In general, thermistors are more rugged, have a greater temperature-resistance change for a given power increment, and have better overload characteristics. The bolometer

Table 1. Crystal and Bolometer Mounts

Manufacturer	Thermistor Mounts	Barretter, Crystal, etc. Mounts	Tunable Mounts
Admittance-Nanco Corp.		Coax	
De Mornay-Bonardi	X	[illegible]	[illegible]
Diamond Antenna Microwave Corp.	[illegible]	[illegible] Coax	[illegible]
Douglas Microwave Co.		[illegible] Coax	[illegible] Coax
F-R Machine Works, Inc.	[illegible]	[illegible]	[illegible]
General Radio Co.	Coax	Coax	
Hewlett-Packard Co.	C, XN, XB, X, K, Coax	S, C, XN, XB, X, KU	Coax
Microwave Associates, Inc.		[illegible]	[illegible]
Narda Microwave Corp.	S, C, XN, XB, X, KU, Coax		[illegible]
Polytechnic Research & Development Co. Inc.	S, C, XN, XB, X, KU, K, Coax	X, KU, K, V, Coax	KU, K, Coax
Radiation, Inc.	Coax ([illegible] KMC)		
Sierra Electronic Corp.		Coax	
Sivers Lab.		X, Coax	X
Sperry Gyroscope Co.	C, X, KU, Coax	S, C, XN, X, Coax	
Waveline, Inc.		S, C, XN, X, [illegible]	S, C, XN, XB, X, [illegible]

Table 2. Power Meters

Type Of Power Meter	Manufacturer	Model No.	Frequency Range	Power Range	Accuracy	Price	General Comments
Low-power (under 1 watt)	Airborne Instruments Lab.	50	(see note 1)	0.1 mw-10mw full scale	±5%	$ 199	Self-balancing direct-reading bolometer bridge.
	Federal Telephone & Radio Corp.	NRD	0-3200 mc	1-200 mw	±2.5% f.s.d.	$1180	Measures temperature rise in terminating resistor; high powers can be measured by using suitable attenuators.
	F-R Machine Works Inc.	B830A	(see note 1)	0.1 mw-100mw full scale	±5% f.s.d.	$ 325	Bolometer bridge using substitution method; self-balancing direct reading bridge.
	General Radio Co.	1651-A	5-4000 mc	0-500 mw	±10%	$ 340	Bolometer bridge using substitution method.
	Hewlett-Packard Co.	430C	(see note 1)	0.1 mw-10mw full scale	±5% f.s.d.	$ 250	Self-balancing direct-reading bolometer bridge.
	Narda Microwave Corp.	107	500-1500 mc (coaxial)	0.5 mw-2w	+ 1.5 db	$1150	Includes attenuator and power measuring thermistor mount and bridge; unit also includes wavemeter.
	Polarad Electronics Corp.	P-3	(see note 1)	0.1 mw-10mw full scale	±5% f.s.d.	$ 295	Self-balancing direct-reading thermistor bridge.
	Polytechnic Res. & Dev. Co., Inc.	650-B	(see note 1)	0.1 mw-100 mw full scale	±5% f.s.d.	$ 360	Self-balancing direct-reading bolometer bridge.
	Sperry Gyroscope Co.	123B	(see note 1)	0.1 mw-10mw full scale	±3% f.s.d.	–	Self-balancing direct-reading bolometer
High-power (over 1 watt)	Chemalloy Electronics	–	L to V band; also Coax	10 mw-20,000 w	2%	Calorimeter $1125 Loads $ 100-$ 750	Uses meter loads with calorimeter; different load for each band.
	Cubic Corp.	MC-1B	2.6-26.5 kmc	0-600w	±0.2 db	$1845	Calorimetric type; adapters required for each band above 3.95 kmc.
		MCX-1A	100-3000 mc (coaxial)	0-600w	±0.5 db	$1850	Calorimetric type.
		MCL-1A	1.12-1.70 kmc (basic unit) 1.12-2.60 kmc (with adapter)	0-600w	±0.2 db	$1850	Calorimetric type.
	Hewlett-Packard Co.	434A	DC-10 kmc (coaxial)	0.01 w-10w full scale	±5% f.s.d.	$1115	Calorimetric type using comparison method with self balancing bridge to give direct reading of power.
	M.C. Jones Co., Inc.	(see comments)	20-2000 mc	0-1.2w to 0-40,000w	–	–	Consists of directional coupler units and indicating meters (do not absorb power); also used as VSWR meters; nine different units to cover the power range listed.

element is contained in a cartridge which must be mounted in, and well matched to, the microwave transmission system. A proper bolometer mount must be used for this purpose. The bolometer is connected to a power meter which measures its resistance, and indicates the amount of rf power which the bolometer is absorbing and dissipating as heat.

Any mismatch between the measuring element and the transmission line will result in errors in the measurement. Therefore great care must be taken to insure a low vswr. The water loads for high-power measurements, and the bolometer mounts for low-power measurements, are very carefully designed for low vswr over a broad band without recourse to tuning. A list of manufacturers of bolometer mounts for the various frequency bands is given in Table 1. Bolometer mounts are primarily measurement accessories rather than instruments. Therefore their characteristics are not listed in the same detail as the major types of microwave test instruments. The listing has arbitrarily been restricted to manufacturers of test instruments listed in other tables in this series.

There are several different ways of measuring the power being absorbed by a bolometer. The most common is to use the bolometer as one arm of a Wheatstone bridge. The bridge is first balanced with the microwave current in the bolometer. Then the microwave power is removed and the bridge rebalanced by increasing the dc bolometer current. Because the dc Wheatstone bridge is not direct reading and is slow in use, the self-balancing bolometer bridge has been developed. In this circuit the bolometer is used as one arm of the bridge. A high-gain amplifier is connected across the bridge as a detector, and the output of the same amplifier is connected as the driving source for the bridge. This circuit becomes an audio oscillator whose output voltage automatically adjusts itself to maintain the bridge at a near balanced condition. When the rf power is applied to the bolometer, the amplitude of oscillation decreases by the amount necessary to keep the bolometer resistance constant and maintain the balance of the bridge. The voltmeter which measures the audio voltage is calibrated in terms of microwave power.

There are a number of other types of power meters besides the two which have been described. These include a calorimetric type using a comparison method with a self-balancing bridge, and a double-vane torque-operated wattmeter. The basic principle of operation of each instrument is included in the list of microwave power meters in Table 2.

The power meters which have been described

Table 2. Power Meters *(continued)*

Type of Power Meter	Manufacturer	Model No.	Frequency Range	Power Range	Accuracy	Price	General Comments
	Marconi Instruments (Wayne Kerr Labs, Ltd)	U-182	8.69-9.84 kmc	10w-200w	± 2%		Double-wave torque-operated feed-through watt-meter; does not absorb power insertion loss 0.1 db or 2.4%.
				0.5w-10w	± 10% at 0.5w		
	Microwave Associates, Inc.	MA-101A/B	26.5-40.0 kmc	From 5w to the max rating of the respective waveguide	± 4%	$ 790	Water load calorimeters; MA-563A (7.05 10 kmc) and MA-689 (8.2-12.4 kmc) are high-power water loads.
		MA-102	50.0-75.0 kmc			$ 820	
		MA-564	7.05-10.0 kmc			$ 790	
		MA-697	8.2-12.4 kmc			$ 790	
		MA-103	–	–	–	$ 350	Water load calibrator unit.
	Radio Corp. of America	MI-31074	1700-2000 mc	0-6w	–	–	Consists of directional coupler, crystal and meter; power indicated by calibration chart; also used as VSWR meter.
	Sierra Electronic Corp.	XB187A Water load	7-10 kmc	300w-3000w full scale (in four ranges)	± 2%	$ 145	Calorimetric type.
		190A Calorimeter	–			$ 495	
Pulse peak power meters	Cubic Corp.	100X	8.5-9.6 kmc	0.01 mw-3mw peak power	± 0.2 db	$1150	Generates cw signals adjustable to the same peak amplitude as the unknown; requires an external synchroscope for comparison between reference and unknown signals; listed also as miscellaneous.
	General Communication Co	PCX-1	925-1225 mc	-10 dbm to +63 dbm peak power	± 0.5 dbm	–	Compares amplitude of signal to be measured with that of an internally-generated 1 mw r-f signal on a cathode-ray tube; measures attenuation of signal necessary to match 1 mw.
		PCX-3	3000 mc band				
		PCX-5	5000 mc band				
		PCX-9	9000 mc band				

Note 1. Frequency range depends upon bolometer mount.

Table 3. Frequency Meters Composed of Passive Circuit Elements

Manufacturer	Model No.	Type	Frequency Range	Accuracy	Price	General Comments
Admittance-Namco Corp.	WX-600	Absorption	8.2-12.4 kmc	0.1%	$ 100	Output reduced 20% at resonance.
Amerac, Inc.	131	Transmission or absorption	2400-3400 mc	±½ mc	$ 325	Includes diode detector and microammeter indicator.
	228	Transmission or absorption	900-2400 mc	~~±0.02%~~	$ 525	Direct reading frequency control dial.

measure average power. Peak power of pulses can be measured by comparison methods. This is done by comparing the peak amplitude of the unknown signal with that of a known cw signal on an oscilloscope screen, and measuring the power of the cw signal.

Frequency Meters

Microwave frequencies may be determined in either of two ways. The first is to make use of the absorption or transmission properties of tuned resonators. The second compares the unknown frequency with the harmonic of a low-frequency standard signal.

The tuned cavity type of frequency meter is inserted in the microwave transmission system between the signal source and the detector-indicator, and the frequency indication may be obtained in different ways. Reaction and absorption types cause a decrease in level of the detector at resonance, and are particularly useful as search frequency meters. The transmission type passes only those frequencies within the pass band of the resonant cavity, and is most convenient for monitoring or filtering purposes.

Drive screws are used to adjust the plunger length and the frequency to which the cavity is tuned. The resonant frequency is not a linear function of plunger position. Therefore when a micrometer is used to indicate the position of the plunger, a frequency calibration chart must be referred to. When wavemeters are made direct reading, either a linear drive mechanism with a nonlinear frequency scale on the dial is used, or some form of linkage or cam is used to linearize the scale.

The heterodyne method is used for more precise measurements of frequency. A low frequency crystal oscillator serves as the basic frequency standard. Multiplying and heterodyning methods are used to compare the frequency of the unknown signal with that of the crystal. A tunable oscillator is calibrated against the crystal standard frequency or a harmonic of it, then tuned to zero-beat with the unknown frequency. The matching of the two frequencies may be done aurally with earphones or a loudspeaker, or visually with an oscilloscope.

Another type of frequency meter includes a wavemeter with an amplifier following the detector, designed for measuring the frequency of low-level signals.

Reaction, absorption, and transmission types of wavemeters are listed in Table 3. Heterodyne frequency meters and those types which include additional circuitry besides the basic resonant cavity are listed in Table 4. ■ ■

Table 3. Frequency Meters Composed of Passive Circuit Elements *(continued)*

Manufacturer	Model No.	Type	Frequency Range	Accuracy	Price	General Comments
	229	Transmission or absorption	2300-4500 mc	±0.05%	$ 490	Frequency calibration chart.
	230	Transmission or absorption	3500-6500 mc	±0.02%	$ 490	Frequency calibration chart.
	232	Transmission or absorption	1800-3800 mc	±½ mc	$ 270	Micrometer setting; frequency calibration chart.
De Mornay-Bonardi Corp.	DBA-715-1 to DBL-715-1	Reaction type	All bands S to E	0.005% (S band) to 0.1% (E band)	$ 457 to $ 864	Gas-filled cavity wavemeters; micrometer setting with frequency calibration chart; each unit covers one microwave band.
	DBA-715-2 to DBL-715-2	Absorption type				
	DBA-715-3 to DBL-715-3	Transmission type				
Diamond Antenna & Microwave Corp.	590-1 590-2 to 990-1 990-2	Absorption and Termination	CXN, XB, X, KU	±0.1%	$ 248 to $ 178	Each unit covers 1/2 of its microwave band (-1 for lower half of band and -2 for upper half of band)
	591-1 591-2 to 991-1 991-2	Absorption	CXN, XB, X, KU	±0.1%	$ 248 to $ 178	
	592-1 592-2 to 992-1 992-2	Transmission	CXN, XB, X, KU	±0.01%	$ 248 to $ 178	
	2090 to 2093	Absorption termination	0.9 to 6.5 kmc	–	$ 290 to $ 162	A coaxile frequency meter; four units cover the frequency range listed.
Douglas Microwave Co., Inc.	430L; 430S; 430C	Transmission	1.1-1.4; 2.7-3.3; 4-5.5 kmc	–	–	Micrometer setting; uses crystal (not supplied).
	440L; 440S; 440C	Transmission or absorption	1.1-1.4; 2.4-3.4; 4-5.85 kmc	–	–	Micrometer tuning; includes diode and meter.
	450A; 450B; 450X; 450G; 450K	Absorption	XN to K bands	±0.03%	–	Micrometer tuning; dip exceeds 20% of CW signal.
	451A; 451B; 451X; 451G; 451K	Transmission	XN to K bands	±0.03%	–	Micrometer tuning.
	460B; 460X	Absorption	8.5-9.6 kmc	±3 mc	–	Direct reading; type B for RG-51/U waveguide; type X for RG-52/U waveguide.
Federal Telephone & Radio Co.	WAL	Transmission	500-2500 mc	±0.15%	$ 495	Direct reading; includes diode and meter.

Table 3. Frequency Meters Composed of Passive Circuit Elements *(continued)*

Manufacturer	Model No.	Type	Frequency Range	Accuracy	Price	General Comments
F-R Machine Works, Inc	C402A, X402A	Reaction	XN, X bands	±0.03%	$1275 ea.	Direct reading, 35% nominal dip.
	N410A	Reaction	1000-4000 mc	±0.1%	$ 495	Direct reading, coaxial
	H410A to U410A, G410X to E410X	Reaction	All bands C to E	±0.08% (C band) to ±0.3% (V band)	$ 150 to $ 500	Direct reading C to V bands, micrometer tuning Q, M, E bands.
	X411A	Transmission	8.2-11.5 kmc	±0.1%	$ [illegible]	Direct reading.
Hewlett-Packard Co.	J53A B to P530A	Absorption	XN to KU bands	±0.1%	$ 120 to $ 150	Micrometer tuning, calibration chart on unit.
	X532A	Absorption	8.2-12.4 kmc	±0.08%	$ 150	Direct reading.
Wayne Kerr Laboratories, Ltd.	W-281	Absorption	1.9-5.1 kmc	±0.04%		Micrometer tuning with calibration chart, includes diode but no meter. 2 self-contained indicator unit V-121 is available for use with these wavemeters.
	W-381	Absorption	3.0-8.0 kmc	±0.04%		
	W-481	Absorption	7.0-14.0 kmc	±0.03%		
Marconi Instruments	TF 1059	Absorption	4.0-10.0 kmc	±0.05%	$ 750	Micrometer tuning, includes diode and meter
	TF 1034	Transmission and absorption	32.0-35.5 kmc	±0.03%	$1075	Micrometer tuning, with calibration chart.
	TF 1026 3, TF 1026 4	Absorption	1.0-2.0 kmc, 2.0-4.0 kmc	±0.1%	$ [illegible]	Direct reading, includes diode and meter
	TF 1026 5 to TF 1026 9		400 mc ranges 1.8-2.675 kmc	±2 mc		
Mico Instrument Co.	402B	Reaction	2.5-15 kmc		$ 140	Calibrated in wavelength, contains crystal, dip in crystal current indicates resonance.
	433, 501, 402A	Antenna-coupled coaxial line	0.4-1.5, 1.5-5, 2.5-15 kmc		$ 209, $ 172, $ 132.50	Calibrated in wavelength, include crystal detectors but no indicator.
Microwave Associates	692, 547, 696, 548, 582A, 588, 518, 506, 671, 1152	Reaction	L to M bands	±0.1%	$ 110 to $ 350	Micrometer tuning with calibration chart
Narda Microwave Corp.	802B	Transmission and reaction	2.35-10.5 kmc	±0.2%	$ 785	Counter tuning indicator with calibration chart, includes meter, sensitivity control for strong signals, and external output for signals below 5 mw.
	805, 806	Transmission or absorption	0.5-1.5, 1.5-2.4 kmc	±1 mc, ±2 mc	$ 375 ea	Direct reading; includes diode and meter.
	809 to 812	Reaction	XN to KU bands	±0.08%	$ 110 to $ 150	Micrometer tuning with calibration chart.
	Q807, M807, E807	Reaction	Q, M, E bands	±0.15% to ±0.25%	$ 300 to $ 500	Micrometer tuning with calibration chart
Polytechnic Research & Development Co., Inc.	555-A to 559-A, 565-A to 571-A	Reaction	5.4-39.0 kmc (each unit covers approx. half of its frequency band)	±0.03% (XN band) to ±0.15% (V band)	$1200 to $1500 ea	Direct reading.
	555-B to 559-B, 565-B to 571-B	Transmission				
	578-A, 579-A	Reaction	0.925-1.65, 1.60-2.60 kmc	±0.05%	$1500 ea.	Direct reading
	578-B, 579-B	Transmission				
	532 to 538	Reaction	C to V bands	±0.08% to ±0.3%	$ 175 to $ 380	Direct reading
	583-D	Reaction	2.4-3.7 kmc	±0.8%	$ 650	Frequency calibration chart
	585-A, 585-B, 586-A, 586-B	A - Reaction B - Transmission	8.2-10.0 kmc	±0.08%	$ 125 ea.	Direct reading, 585 for RG-52/U waveguide, 586 for RG-51/U waveguide
	588-A, 590-A	Reaction	5.3-6.7 kmc, 5.1-5.9 kmc	±.08%	$ 250, $ 350	Direct reading
Radar Design Corp	RDW-5, RDW-6	Reaction	1.0-2.0 kmc; 2.0-4.0 kmc	–	$ 180 ea.	Micrometer tuning with calibration chart.
	RDW-9, RDW-11, RDW-12	Reaction	C, XB, X bands	±0.1%	$ 135, $ 110, $ 105	Micrometer tuning with calibration chart.

Table 3. Frequency Meters Composed of Passive Circuit Elements *(continued)*

Manufacturer	Model No.	Type	Frequency Range	Accuracy	Price	General Comments
Radiation, Inc.	103	Absorption	2.4-3.2 kmc (dial calibrated over any 300 mc portion of band)	±1 mc	–	Direct reading over any 300 mc portion of band.
Sivers Lab	5815, 5212, 5590, 5174, 5585, 5205, 7095	Transmission	1.55-18.0 kmc in 7 units each having 1.6 1 as greater frequency range	±0.1%	–	Direct reading on a counter.
	5650 3, 5650 5	Transmission	2.5-4.0 kmc, 3.8-5.9 kmc	±0.1%	–	Direct reading, includes diode and meter
Sperry Gyroscope Co	S 22	Transmission or absorption	2 4-3.4 kmc	±0.1%	–	Micrometer tuning, includes diode and meter
	124C	Absorption	660-3000 mc	±0.1%	–	Calibration chart, includes diode and meter.
	126	Reaction	8 1-10.2 kmc	±0.1%	–	Micrometer tuning with calibration chart.
	27B; 207A	Transmission or absorption	3.5-6.5 kmc; 5.3-8 1 kmc			
	291A, 291B	Transmission or absorption	2575-3780 mc	±0.01%	–	Micrometer tuning with calibration chart.
	28C, 208B, 273A		4.01-6.0 kmc; 5.49-8.1 kmc, 8.1-11.9 kmc			
	348, 349A, 350A	Transmission or absorption	13-18 kmc; 18-26 kmc; 26.5-39 kmc	±0.1%	–	Micrometer tuning with calibration chart.
	537	Transmission or absorption	3.5-6.5 kmc or 5.3-8.1 kmc	±0.1%	–	Micrometer tuning with calibration chart; includes diode and meter; uses model 278 for low range or 207A for high range
Waveline, Inc.	398-R; 498-R; 698-R; 798-R; 898-R; 1098-R	Reaction	C, XN, X, KU, K, V bands	–	$ 125 to $ 195	Micrometer tuning with calibration chart.
	498-RT; 698-RT, 798-RT; 898-RT	Reaction and transmission	XN, X, KU, K bands	–	$ 145 to $ 200	Micrometer tuning with calibration chart.
	698-S	Reaction, termination	8.20-12.40 kmc	–	$ 125	Micrometer tuning with calibration chart.

Table 4. Frequency Meters which Contain Active Circuits

Manufacturer	Model No.	Type	Frequency Range	Accuracy	Price	General Comments
Federal Telephone & Radio Corp.	WID	Heterodyne	30–3000 mc	±0.003%	$2290	Direct measurement up to 300 mc, harmonic measurement above. Beat-note indication by magic eye and earphones. Includes 100 kc standard crystal oscillator for calibration.
General Radio Co.	720–A	Heterodyne	10–3000 mc	±0.1%	$ 440	Measures 100 to 200 mc on fundamentals, rest of frequency range on harmonics. Beat-note indicated visually by meter, aurally by loudspeaker or earphones.
Lavoie Laboratories, Inc.	LA–61	Heterodyne	500–2000 mc	±0.001%	$1975	Beat-note indication by earphones. Includes 2.5 mc standard crystal oscillator for calibration.
	LA–1355 LA–1365	Wavemeter with amplifier	750–1500 mc 1000–2000 mc	±0.1%	$ 395 ea.	Output indicated by meter; phones may be used as aural aid in identifying modulation or in centering of frequencies.
Northeastern Engineering, Inc.	7–18 (Mil type TS-186D/U)	Heterodyne	100–10,000 mc	±0.01%	–	Oscillator fundamental frequency 500 to 1250 mc. Beat-note indication by meter or earphones. Includes 20 mc crystal-controlled oscillator for calibration.
Polytechnic Research & Development Co., Inc.	504	Heterodyne	100–10,000 mc	±0.03%	$ 695	Oscillator fundamental frequency 500 to 900 mc. Beat-note indicated visually on 2 inch cathode-ray tube, aurally by earphones. Includes 5 mc and 50 mc crystal controlled oscillators for calibration.
	560, 560–S1	Wavemeter with amplifier	2.4–3.4 kmc; 2.7–3.7 kmc	±0.8 mc	$1300	Line-terminating frequency meter designed for measurement of low-power pulsed signals. Output indicated by meter.
Telerad Mfg. Corp.	TFM–186 (Mil type TS-186D/UP)	Heterodyne	100–10,000 mc	±0.01%	–	Oscillator fundamental frequency 500 to 1250 mc. Beat-note indication by meter or earphones. Includes 20 mc crystal-controlled oscillator for calibration.

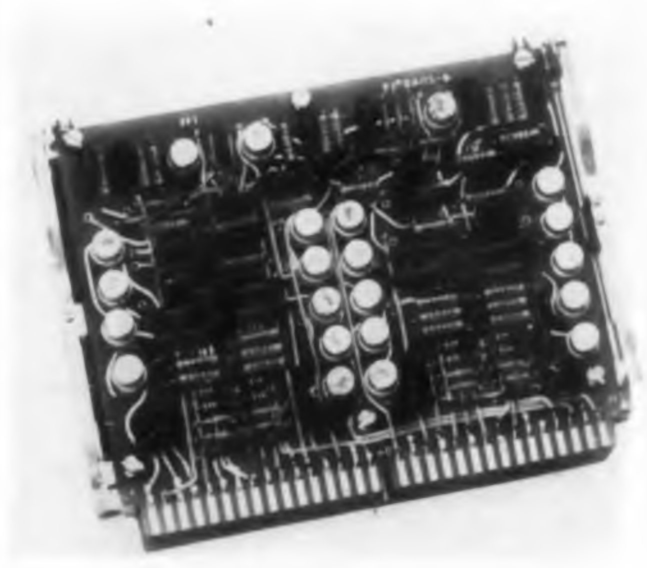
Sectional Computer Module Mounts

For Cool,

FOR HIGH-DENSITY extremely rugged, cool, modular packaging—sectional computer mounts may be an ideal solution. The open frame construction allows for very efficient cooling. Air can flow between the printed circuit cards and along their outer surfaces.

Using this packaging technique in a series of special purpose digital computers, the manufacturer, Epsco, Inc. of 588 Commonwealth Ave., Boston, Mass., has realized a component density of 45,000 per cubic foot.

The sectional package with printed circuit modules can take 100 g of impact shock. With all seams Heliarc-welded and dip-brazed, the pack-



Module composed of two cards side by side with printed circuitry on both sides of the cards.

Open frame housing for modules provides efficient cooling.

Rugged Packaging

age is far more rugged than its simple appearance would suggest.

Modules, with two cards side by side, and printed circuitry on both sides of the cards, are available in a variety of off-the-shelf custom-made circuit configurations. A module might have, for example, all the circuitry for an input-output buffer, several gates, drivers, or flip-flops, a sequencer, or a shift register.

For special-purpose, fixed-program computers, this modular arrangement provides the flexibility of analog approaches with the accuracy of digital techniques.

Each card, with gold-plated, rhodium-flashed wiring, has 32 terminals, one of which is given up to a keying arrangement. The key, a small block between two adjacent cards, prevents a card from being placed in the wrong module compartment.

Modules are retained in their compartments by two methods.

- Two beryllium copper springs on each cast aluminum module frame press against the sides of the compartment to provide vertical alignment.
- Two long, internally threaded rods mate with threaded pins above and below the floating connectors at the rear of the compartment. This serves to position the module accurately and to fasten it down securely.

This rugged package, though designed for a military application, also lends itself to use in tough industrial environments. It can be used right on the production floor.

For more information on this package, turn to the Reader-Service card and circle **102**.

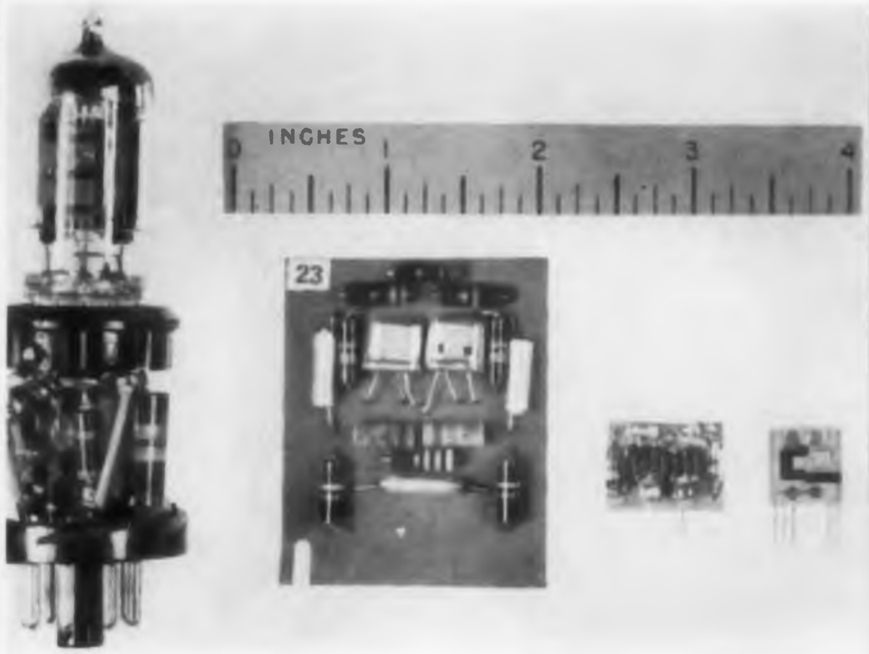
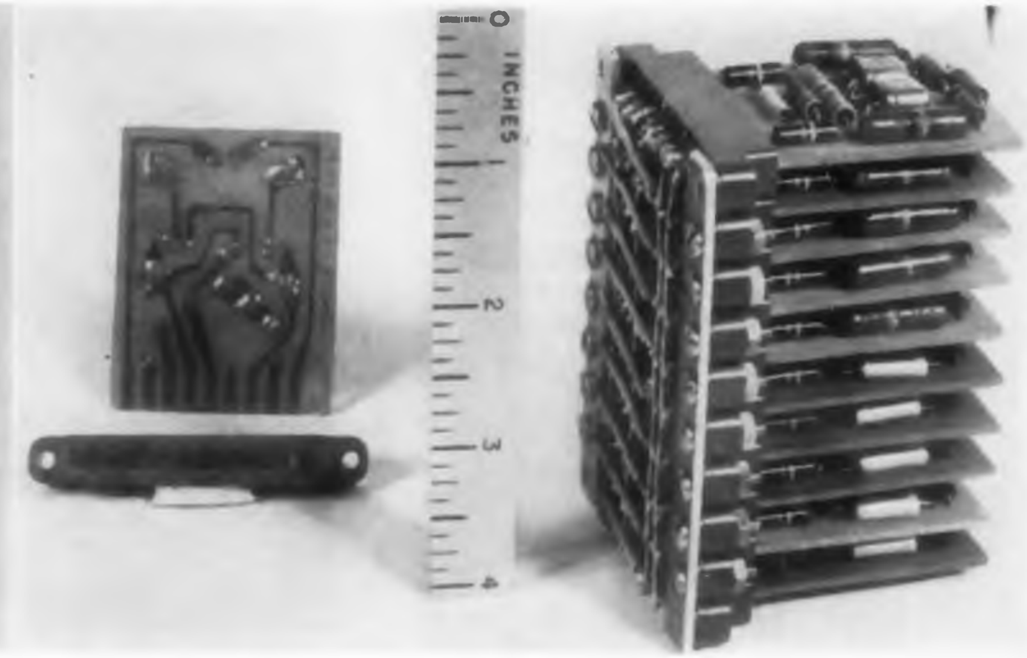


Fig. 1. (left) Module using standard miniature tube and standard component (left) compared to transistorized version of the same circuit (second from left). Second from right is a "hearing-aid size" module, and right is DOFL's 2-D binary divider.

Fig. 2. (right) Ten transistorized circuits mounted (right) to make up a complete counter.



Interconnecting Microminiature

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This is one of a series of papers presented at the Symposium on Microminiaturization of Electronic Assemblies sponsored by Diamond Ordnance Fuze Laboratories late last year. Because symposium attendance was limited to government personnel only, ELECTRONIC DESIGN is publishing these papers as a special service to our readers. In addition, all of the symposium papers will be published in their entirety in bound form available only from ELECTRONIC DESIGN. For further information on these Proceedings, turn to Reader-Service Card and circle 100.

It is possible that connections made between microminiature modules could result in a final assembly much larger than the group of modules themselves. The problem is to be able to make these connections and yet keep the advantage of the small size subassemblies. In this article, the authors discuss various methods of interconnecting modules without adding substantially to the total volume.

METHODS for interconnecting extremely small modules, such as printed wafers having volumes of about 0.005 cu in., are under investigation. The basic technique involves stacking wafers so that all leads protrude from one side of the assembly, encapsulating the assembly in resin, facing off the side containing the leads in order to expose the interconnection points as cross sections of the wires, and then interconnecting these points. Feasibility of interconnecting these points either by chemically deposited copper or by printed silver wiring was demonstrated with modules larger than 0.005 cu in. These techniques will be extended to the small printed-wafer modules as soon as sufficient numbers become available.

Fig. 1 (left) shows a module using a miniature vacuum tube. Other component parts are mounted in the base of the socket by conventional techniques and interconnection to the larger assembly is made by the octal plug upon which the entire circuit is constructed. This binary divider occupies a volume of about 2 cu in.

Fig. 1 (second from left) shows a transistorized version of the same circuit. Interconnection of modules of this size is accomplished by etched wiring connectors into which the individual subassemblies can be plugged. Many varieties of modularization at this size-level have appeared in the literature. In most cases, the printed or etched wiring that fits into the connector is plated with a hard, corrosion-resistant metal. In other cases, an auxiliary set of terminals is attached to the wiring board and these terminals plug into the connector.

Fig. 2 (left) shows again the transistorized

Fig. 3. How hearing-aid size modules (foreground) are mounted and interconnected using an etched board (left).

Modules

etched-board module and a 10-stage binary counter made from ten of these modules, ten etched wiring connectors, and hook-up wire. The counter packaged by these techniques occupies about 22 cu in.

Fig. 3 shows the hearing-aid-sized module, an etched interconnection board, and the final 10-stage counter. This counter occupies about 1.6 cu in. When this degree of miniaturization is reached, the question arises as to what should be considered a module. This 10-stage binary counter occupies less volume than the 1-stage binary divider based on a miniature vacuum tube. If it were desired to make the 10-stage counter a module in itself, the entire subassembly might be encapsulated as is.

On the other hand, if repairability at the 1-stage level were desired, the individual stages could be separately encapsulated before inserting them into the interconnection board. Commercially, the use of header mountings for modules at this level of miniaturization is popular although they detract from the high component densities.

Fig. 4 shows the DOFL-2D binary divider.[1] This wafer circuit, when unencapsulated, occupies a volume of approximately 0.005 cu in. and yet is electronically equivalent to the preceding modules. Its tremendous volume efficiency is due to elimination of cases for individual parts, and the use of many printed-circuit techniques.[2] If

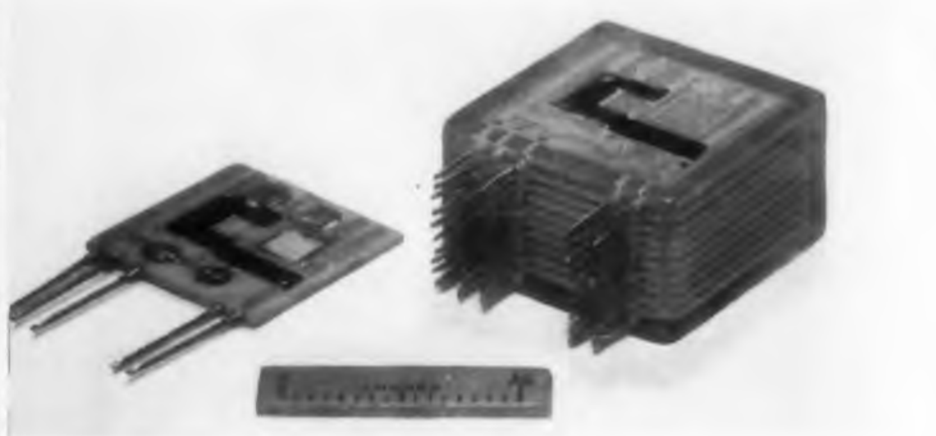

Fig. 4. Stacking arrangement of the 2-D module.

such modules were mounted in headers, they could undoubtedly be interconnected using the secondary etched-wiring-board technique already described.

Mounting of each binary divider in a header, however, would greatly reduce the volume efficiency at this level of microminiaturization. On the other hand, the mounting of several interconnected stages within a single header would not only provide encasement for the uncased component parts but also allow high component densities.

Fig. 4 also shows a stack of ten of these modules required to produce a counter equivalent to those shown in Figs. 2 and 3. The volume of this counter is only 0.2 cu in. Note the 50 protruding lead wires which must be interconnected.

If connectors comprising etched wiring boards are ruled out because their interconnecting wires would be spaced no more than 10 mils apart, two other possible techniques exist. The first would require welding the tiny wires, using procedures developed in the subminiature vacuum tube field. The only demand which would be made on the DOFL-2D wafer is that the material chosen for the lead wires be weldable. At least one organization[3] is presently fabricating self-supporting modules at the hearing-aid level of miniaturization using welding techniques.

The second technique is one now under investigation at DOFL because it appears to be especially suited to the 2D-level of microminiaturization.

It involves (1) stacking wafer stages, (2) encapsulating the assembly in resin, (3) facing off the side containing the wires on a lathe or milling machine so that the interconnection points appear as cross-sections of the lead wires, and (4) interconnecting these points.

Deposited-Metal Interconnections

One procedure for making interconnections between these cross sections of wire involves first depositing a metal over the entire faced-off surface. To date, copper deposited by chemical reduction[4] has been employed for this purpose. Using photolithographic techniques[5], a resist would then be laid down on the copper surface, exposed through a mask of the desired interconnection pattern, developed and washed. The extraneous copper could then be etched away. Finally, the deposited interconnection wires would be protected by a layer of plastic. This technique should yield a completely interconnected stack of wafers. Fig. 5 shows such a stack: the bottom plate is not a module but serves only to hold the lead-out wires.

In a variation of this procedure, interconnection paths have been milled in the faced-off side of the encapsulated stack, metal deposited over the entire side, and the metal not in the grooves then removed either with an abrasive or by a second facing-operation.

Table 1.—Types of wires successfully connected by deposited copper films.

Type	B & S Gage
Columbium	20
Copper, bare	20
Copper, tinned	22
Gold	28
Nichrome	30
Silver	21
Tantalum	20

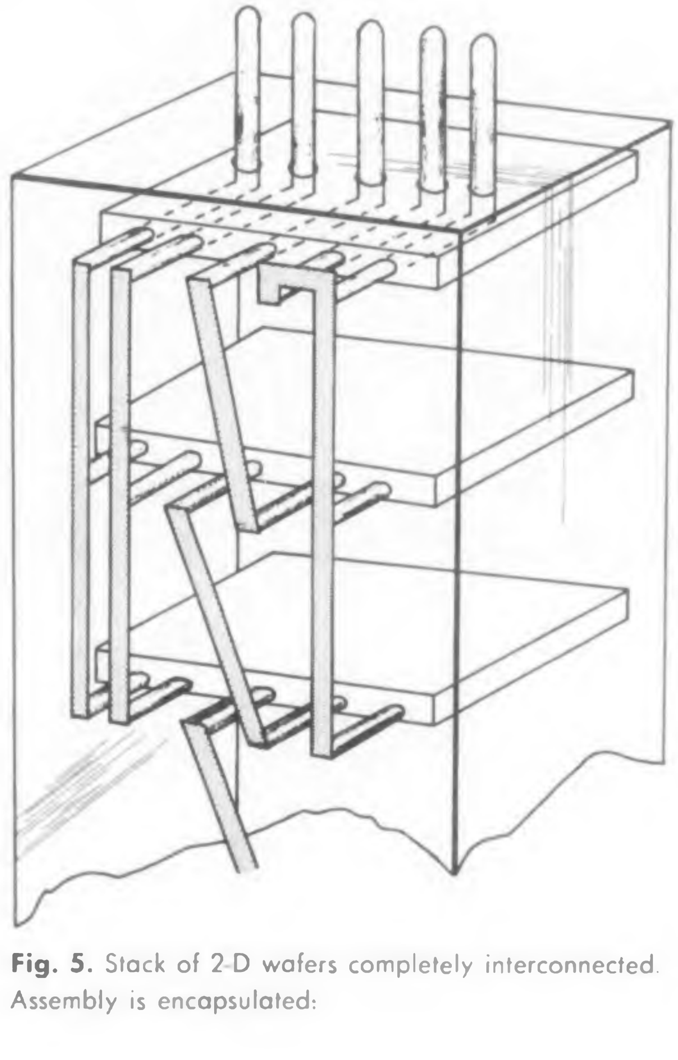

Fig. 5. Stack of 2-D wafers completely interconnected. Assembly is encapsulated.

Before using either of these procedures to build a counter, the feasibility of deposited-copper interconnections was determined by test specimens consisting of two wires encapsulated, faced off, and joined at their cross sections by deposited copper.

After preparing the pieces electrical continuity between wires of each set was checked using an ohmmeter. The types of wires tested are listed in Table 1 and all made adequate connection. The test specimens were next temperature cycled five times from −55 C to +35 C and retested. No connections failed.

Next, it was decided to interconnect an operating circuit by deposited-copper techniques. Due to the lack of a sufficient number of wafer modules (these modules are still in themselves research models) it was decided to substitute "hearing-aid"-sized modules. Five NOR[6] circuits were chosen for interconnection because together they would constitute a half adder. The half-adder prepared with deposited-metal interconnections showed operation comparable to that of hand-wired units.

Screened-Silver Interconnections

Other procedures for making interconnections between the cross sections of the wires will readily occur to those familiar with the techniques of printed-circuitry. An obvious one, and one which has been employed in these laboratories, is the application of a silver pattern by "silk"-screening. The applicability of this method was demonstrated on a free-running multivibrator. All the component parts were encapsulated with their leads protruding from a single side of the block. The block was faced-off and the component parts were interconnected with screened-silver paint applied across exposed cross-sections of the lead wires by well-known screening techniques. The multivibrator operated in all respects as well as a solder-assembled unit.

The first method proposed here for making deposited copper interconnections involves the use of a photolithographic procedure. In quantity production, a photolithographic procedure should prove inexpensive and yield extremely fine lines. However, this procedure has not yet been adapted to the application at hand.

First, the technique itself has been proven to be feasible and the details of its application to the present problem were of secondary interest compared to the achievement of reliable electrical contact between lead wires and deposited copper. Secondly, the details of making an aligning pattern negatives for masking the interconnection patterns between the cross-sections of the wires in the encapsulated assembly have to be worked out but are needed only after feasibility has been demonstrated.

Other Methods Also Possible

Feasibility of deposited and screened-metal interconnections has also been demonstrated. This technique promises minimum-volume interconnection for minimum-volume wafer subassemblies, and places phenomenal component densities within reach.

Finer interconnections can probably be produced via the deposited-metal methods than with screened-silver methods because ink forced through a stencil will flow to some extent before it hardens. Patterns having lines and spaces as narrow as 2.5 mils have been produced with resist-masked and chemically-etched chemically-deposited-copper.[7] Ten-mil-wide screened lines would be considered excellent at the present state of the screening art.

It should be noted that fine-line interconnections have a finite resistance that must be taken into account in circuit design. This resistance is of the order of 1 ohm which, for the circuits described in this work, is negligible. The thickness of deposited copper is estimated between 0.3 and 0.6 mil.[7]

Future work must include (1) development of methods for aligning photographic negatives on encapsulated assemblies, (2) an evaluation of long-term storage effects on deposited and screened interconnection wires, and (3) the construction of interconnected stacks of wafer-type DOFL-2D modules.

More detailed information on the processes described in this article will be found in the complete paper to be published in our Proceedings of the Symposium on Microminiaturization of Electronic Assemblies. For further information on the Proceedings, turn to Reader-Service card and circle **100.**

Acknowledgement

The authors wish to thank Edith Davies Olson for her many helpful suggestions in connection with this program.

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Another article on the exclusive series on microminiaturization. See note accompanying article p. 34 in this issue regarding the entire series.

Studies were conducted at Diamond Ordnance Fuze Laboratories to determine the limitations of present techniques for making fine etched lines. This article discusses several processes and the results of the study.

Fine Line Etched Wiring

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CAREFUL control of certain of the variables present in the normal photo resist and etching process successfully reproduced a pattern consisting of 2.5-mil-wide lines with a 2.5-mil-wide spacing between the lines on copper-clad laminates. Undercutting reduced the line width to about 1 mil.

Copper films, 0.3 to 0.6 mil in thickness, were chemically deposited on plastic. Lines as narrow as 2.5 mils with a 2.5-mil-wide spacing between them were etched in these films with negligible under-cutting, without breaks or bridges.

Conductors 10 mils wide but having 4-mil-wide spacing had been produced by electroetching precious metals deposited on glass. An electroetching technique was necessary because chemical etching of precious metals would require the use of strong acids which would degrade the photo resist.

Preparation of Test Patterns

The original layout for the test pattern for making fine lines in copper was made on a large sheet of stiff white Bristol board. Thirty-six strips of black adhesive tape 0.25 inch in width were laid down on this board in parallel strips 0.25 inch apart, and selected ends were connected so as to form two adjacent continuous lines which zig-zagged back and forth across the length of the board.

The final layout was then photographed and reduced 25, 50, and 100 times to give negatives having equal line-and-space widths of, respectively, 10 mils, 5 mils and 2.5 mils. These three patterns are shown in Fig. 1.

Since the length-to-width ratios for each of the two lines remained constant, regardless of the size of the pattern, the resistance of the two lines also remained constant and it was possible to compare etching results directly by use of the following formula:

$$R = \frac{\rho L}{WT}$$

where R = resistance, ρ = resistivity, and L, W, and T are the size parameters of the conductor.

For example, for patterns etched in "1-oz" copper-clad laminates, the following values were substituted in the above equation: ρ = 1.724 microohm-cm (for copper), T = 1.35 mils (for "1-oz" copperclad laminates), and the appropriate length and width of the lines of one of the patterns. Then the theoretical resistance, R, was calculated to be 1.336 ohms for the outside line of the pattern and 1.331 ohms for the shorter inside line. For deposited copper films only 0.45 mil in thickness, the respective values were calculated to be 4.008 and 3.993 ohms.

Another pattern having lines and spaces of 10 and 4 mil widths had previously been prepared

Table 1—Effects of Varying Process Controls on Average Resistance of Conductors

Process Variation		Average Resistance—ohms					
Line Widths		10 mil[1]	10 mil[2]	5 mil[1]	5 mil[2]	2.5 mil[1]	2.5 mil[2]
Whirler Coating—rpm							
50		1.7	1.7	1.9	1.9	—[3]	—[3]
100		1.6	1.6	1.9	1.9	—[3]	3.1
200		1.6	1.7	2.0	2.0	—[3]	—[3]
Dip Coating—Oven Type							
Gravity-convection		1.7	1.7	2.0	2.0	3.0[4]	3.4
Mechanical-convection		1.7	1.7	2.1	2.1	3.1[4]	3.1[4]
Pressure During Exposure							
Weights		1.6	1.6	1.9[4]	1.9[4]	—[3]	—[3]
Vacuum		1.9	1.9	2.2	2.2	2.9[4]	2.9[4]
Developer Type and Time-Min.							
Trichloroethylene vapor	1	1.9	1.8	2.0	2.0	2.8	2.9
Trichloroethylene liquid	1	1.8[4]	1.8[4]	2.3[4]	2.4	—[3]	3.4[4]
Trichloroethylene vapor	2	1.9	1.9	2.3	2.3	3.4	3.2
Trichloroethylene liquid	2	1.9	1.9	2.3[4]	2.4[4]	—[3]	—[3]
Commercial developer	2	2.1	2.0	2.6	2.6	4.3[4]	4.2[4]

1. Outside line of pattern, length-to-width ratio of 2657:1.
2. Inside line of pattern, length-to-width ratio of 2647:1.
3. Infinite resistance due to breaks in conductors.
4. Only one of the two specimens was satisfactory.

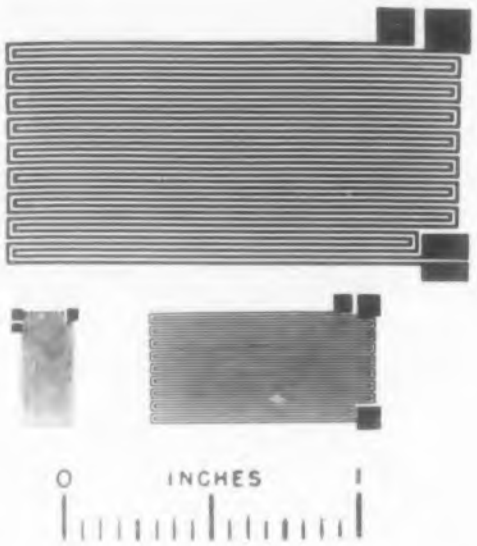

Fig. 1. Some test patterns for fine line etching. Top, 10 mil lines with 10 mil spacing; lower right, 5-mil lines with 5 mil spacings; lower left, 2.5 mil lines with 2.5 mil spacing

for forming electrodes in precious metals on glass.

Chemical Etching of Cu-Clad Laminates

Every effort was made to keep the laminates and negatives as free of dust as possible, particularly when the laminates were coated with wet resist or when the dried resist was being exposed to light through the negative. The resist itself was a commercial solution which was filtered prior to use to remove any sediment or other foreign matter.

Resist films were applied by two methods. One method involved covering the laminates with resist, then whirling them at 50, 100 or 200 rpm. Another method involved dipping in resist and drying in two different types of ovens.

Sensitized boards were exposed to a carbon arc for 1 minute while held in contact with the negative either in a vacuum frame or with weighted glass. They were developed either by suspending them in developer vapors or immersing them in the developer (Table 1). Etching was accomplished in a bubble etcher using a 25 per cent solution of ammonium persulfate at 70 C.

The dipping process of applying resist to copper-clad laminates produced a coating which was slightly thicker at one edge of the plate than at the other due to the vertical draining position of the plates. Whirling produced a more uniform coating which varied inversely in thickness with the speed of the turntable.

As the line width was reduced, differences due to the method of application of the resist began to appear. The 2.5-mil-wide lines and spaces were more consistently etched without breaks in the lines, or bridges between conductors, when resist was applied by dipping and draining than by whirling. Although one might expect the best pattern definition to be obtained with very thin coats of resist, actually the best definition was obtained with the thicker dip-and-drain coatings probably because these coatings had better physical strength and adherence to the copper.

Use of contact pressure during exposure of the sensitized plates did not yield as satisfactory results as the use of a vacuum frame. (Table 1). Although all the patterns applied under contact pressure appeared to develop satisfactorily, and the 10-mil-wide lines also etched satisfactorily, the 2.5-mil-wide lines were badly undercut after etching and no continuous conductors of this size were obtained. Poor contact between the negative and the laminate probably led to light scattering under the negative and, hence, to variations in the width of the lines being printed.

Table 1 also shows the results obtained by varying the developer. The most acceptable results were obtained with trichloroethylene vapors as indicated by the fact that conductors etched with them gave the lowest values, i.e. values which most nearly approached the theoretical value of about 1.3 ohms. With these vapors, a developing-time of one minute was superior to one of two minutes.

The small bubble etcher containing hot ammonium persulfate provided very even etching of the copper. However, on some of the test pieces, the 5-and 10-mil wide lines were completely etched through in a matter of 10 to 15 seconds before the same condition was reached with the 2.5-mil-wide lines, probably due to the freer flow of etchant in the wider spaces. Therefore, the comparatively slower method employing warm ferric chloride and mild agitation of the piece was preferred for fineline work in cases where close control of the temperature and time in the bath were necessary, as in etching the thin films of deposited copper.

In depositing such thin films of copper, disks of cured epoxy resin 2 inches in diameter and 1/4 inch in thickness were sanded on one surface to produce a uniform matte finish and cleaned. Two solutions prepared the surface of the plastic for the reception of the copper. A third solution deposited the copper film which, after washing and drying, was a dull dark color.

Because of the relatively porous nature of the deposited film, all resist was applied by dipcoating.

The procedures of exposure and development were the same as those described for the laminate samples. For etching, the pieces were immersed in warm 40 per cent ferric chloride because the time of etching of thin copper films could be more easily controlled with this simpler apparatus.

Average resistance of the 5-mil-wide lines was 150 ohms and that of the 2.5-mil-wide lines was 195 ohms. Because of these unexpectedly high resistance values, one of the patterned disks was sliced to reveal its cross section. Although the thickness of the film was variable due to the matte finish of the disk, its thickness was measured under a microscope and found to be about 0.3 to 0.6 mil.

An effort was made to improve the continuity of the deposited copper films with a thin copper plating. The thickness of the plated film was not appreciably greater than that of the unplated film but the plated film appeared to be less porous. Average resistance of the 2.5 mil lines was 25-35 ohms; resistance of the 5 mil lines was 35-45 ohms.

For the 5- and 2.5-mil patterns, the lines etched from the electroplated films had an average width of 4.9 and 2.4 mils, respectively. For the same patterns, the lines etched from the chemically deposited unplated films averaged 4.8 and 2.3 mils, respectively. Thus, the amount of undercutting was about the same for the two types of lines. However, the electroplated films had fewer pinholes and lower resistance.

Electroetching Precious Metals

The substrate in this case consists of a glass slide on which a thin film of palladium has been deposited by vacuum evaporation techniques.

Although palladium is soluble in both aqua regia and hot nitric acid, previous experience in etching had shown that the resist tended to break down in these acids, so neither of them was tested. Methods of electroetching rather than chemical methods were indicated.

In the electroetching process, the etchants used on the film of palladium were based on those recommended[1] for stripping rhodium from nickel-plated brass because of the similarities between rhodium and palladium. The hydrochloric acid etching bath, however, had to be rejected due to the vigorous gassing. When large bubbles bumped repeatedly against the narrow bars of resist between adjacent sections of the line to be etched, the adherence of the resist to the palladium weakened and the pattern broke down before it was etched. Although the sulfuric acid bath also produced gas, the bubbles were generally smaller, and fewer in number and, hence, less active against the surface of the slide.

Microscopic examination of the finished electrodes showed that the average line width of the individual lines of palladium that formed the pattern was 10 mils. Microscopic measurements on the negative of the pattern yielded a similar line-width value, thus indicating that undercutting during etching was negligible.

This electroetching procedure was also found applicable to the preparation of chromium ele-

...les on glass. Such electrodes, suitably treated with a moisture-sensitive material[2], are now undergoing tests as humidity sensing elements in radiosondes.

Future Needs

Although etched lines finer than those described here may not be required, methods of making fine lines by other processes are needed. For example, screened lines finer, and having more accurate edge-definition, than those now producible are desired when working with small printed ceramic wafers such as those used in the work reported by Doctor and Hebb[3]. One such wafer measures 0.5 x 0.5 x 0.020 inch and bears screened resistors, screened conductors, miniature capacitors[4], caseless transistors[5], and caseless diodes[6], a total of 14 components exclusive of the conductors. Because the conductors and resistors occupy the major portion of the tiny wafer, their reduction in size now becomes critical.

If it appears that such components are better made by vacuum evaporation techniques[7] than by screening techniques, then procedures for making fine-line patterns by vacuum deposition would be needed.

More detailed information on the processes described in this article will be found in the complete paper to be published in our Proceedings of the Symposium on Microminaturization of Electronic Assemblies. For further information on the Proceedings turn to the Reader-Service card and circle **100**.

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Another article of the exclusive series on microminiaturization. See note accompanying article p. 34 in this issue regarding the entire series.

Two-dimensional thin films applied to extremely thin wafers are the most logical means for getting minimum circuit volume. In this article, the authors discuss problems in applying thin films and some of their important characteristics.

Applying Vacuum Evaporation Techniques for Microminiaturization

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ONE OF the most effective methods of producing thin films of a large variety of materials is that of high vacuum evaporation. It is not difficult to visualize the use of this technique for the production of complete electronic circuits, and the formation of such circuits is one of the objectives of the vacuum evaporation program of the Diamond Ordnance Fuze Laboratories.

Vacuum evaporation involves heating a material in vacuum to such a temperature that a vapor pressure of at least 10^{-2} mm Hg is obtained. This value of vapor pressure was found to give a practical rate of vaporization for aluminum[1]; it is generally taken as a minimum value for the vaporization of most materials, whether metallic or dielectric.

Problems in Vacuum Evaporation

There are at least three different ways in which the use of vacuum-deposited thin films can assist in reducing circuit volume. First, it is possible to deposit a thin-film component in an area of a conventional printed circuit which might otherwise be wasted. Second, the geometry of the thin film can be used to advantage. For example, the capacitance of a capacitor of given area can be increased by making the dielectric extremely thin. Third, use can be made of the inherent properties of thin films. For example, the resistivity of many thin metal films increases as the film thickness decreases. The second and third items are likely to be of more value in microminiaturization than the first item.

Considerable work has already been done in producing components by vacuum evaporation. Thus far, primary emphasis has been placed upon the development of thin-film resistors. Progress has been sufficient to enable the commercial production of several types of pure-metal thin-film resistors. Although these commercial resistors are too large for use in microminiature circuits, their desirable properties can be expected in thin-film resistors deposited directly into such circuits.

Experimental, thin-film capacitors have been produced by several laboratories in the United States using vacuum evaporation techniques. Thus far the most promising results have been achieved using dielectrics of silicon oxide[2] and aluminum oxide. The best values[2] quoted, not necessarily values for a single capacitor, show a capacitance per unit area of approximately 0.005 μf/cm^2, an insulation resistance of 100 kilomeg-ohms, and a loss factor of less than one percent.

In addition to resistors and capacitors, selenium rectifiers are now being made by vacuum evaporation techniques. Thin-film inductors and other components appear entirely feasible. Since contacts and wiring for interconnecting components can also be deposited, it thus appears entirely possible to deposit complete electronic circuits in which the wiring, contacts, and components consist of thin films.

The formation of complete circuits by vacuum evaporation at present involves several formidable difficulties. One such difficulty lies in the fact that once circuit values have been determined, components must be deposited in the circuit within the tolerances specified, in general, no sorting, selecting, or trimming processes are possible. Such deposition requires great precision of the evaporation process and hence precise control throughout the entire deposition period of such variables as pressure, temperature, and rate of charge-evaporation. It appears most feasible to assign a calculated area within a circuit to a component and then to obtain the exact value desired by varying the thickness of the component.

Table 1. Electrical Properties of Thin-Film Vacuum-Deposited Silicon-Monoxide-Dielectric Capacitors

Electrode metal	Capacitance per unit area, μf/cm^2	Dissipation factor, %	Resistance, megohms	Dielectric thickness, microns	Dielectric constant	Breakdown strength, kv/mil
Ag	0.0019	0.9	10,000	2.23	5	1.1
Au	0.0031	1.9	10,000	1.62	6	1.9
Mg	0.0060	5.1	—	1.07	7	—
Sn	0.0069	2.5	4,100	0.92	7	3.3
Zn	0.0098	4.3	230	0.47	5	3.5
Al	0.0099	3.9	40	0.46	5	—

Such a procedure requires the use of a precise monitoring system to enable deposition to be stopped when the desired value has been reached.

Problems with Varied Materials

Another difficulty involves the successive deposition, in a single evacuation, of all the varied materials required for a given circuit. Several problems are likely to be encountered.

First, at least one filament must be included in the vacuum chamber for each material to be evaporated. If contact of the completed circuit with air must be avoided, an additional filament may be required for deposition of a protective overcoating on the circuit prior to admission of air to the chamber. Ideally, each filament must be centered below the substrate and, failing the use of a multiple chamber, such arrangement is of course, impossible.

Second, some of the various materials to be evaporated will have to be heated to extremely high temperatures and, in the course of depositing successive layers of different materials, the high source-temperatures might damage previously deposited elements of the circuit, all of which are exposed to heat radiated from the source.

Third, multiple evaporations make necessary the interchanging and moving of masks within the evacuated chamber. The mechanical manipulation of such masks may be very complicated when small areas and intricate configurations are involved.

Must be Clean

Two other problems are worthy of mention. First, extreme cleanliness is necessary in vacuum evaporation work to assure adequate adherence of the deposited layers to the substrate and to each other. Gross quantities of contaminants are removed from a substrate by standard cleaning techniques involving various types of washes and degreasing solutions. However, the unavoidable exposure of a substrate to air between the final cleaning step and the evacuation of the vacuum chamber, is sufficient to recontaminate it. It is thus necessary to subject substrates to the cleaning effect of a low-pressure glow-discharge just prior to film deposition.

Second, not even the glow-discharge treatment is sufficient to remove from a substrate all dust particles, some of which may produce pinholes in the vacuum-deposited films. Such pinholes, depending upon their location, might ruin a particular component and force rejection of an entire circuit. Factors other than the presence of dust on a substrate may also be responsible for pinholes. No explanation as yet advanced has adequately accounted for the formation of pinholes

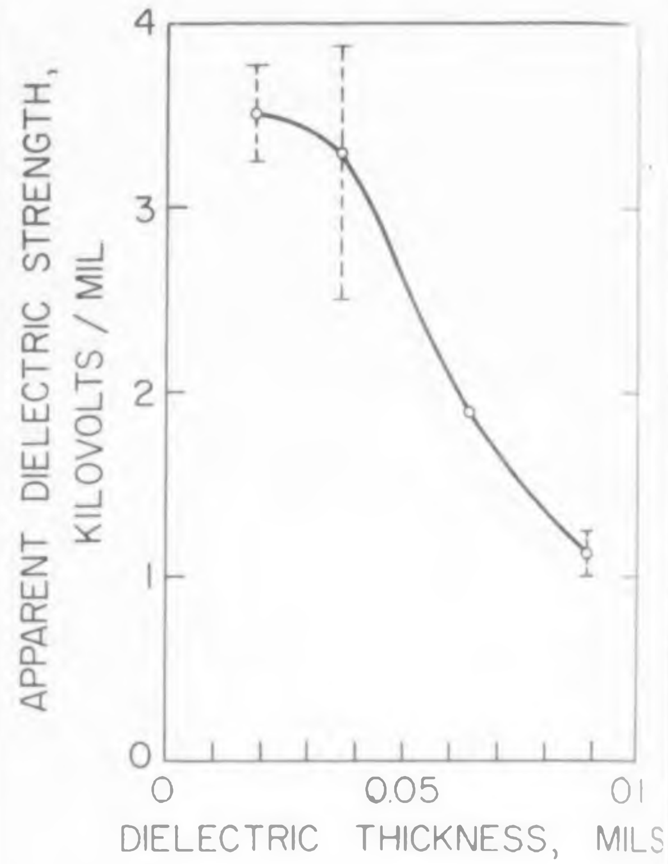

Fig. 1. Dielectric strength of silicon monoxide films as a function of film thickness.

nor has a means been devised for their complete elimination.

Vacuum-Deposited Capacitors

Initial work at DOFL involved the formation and study of thin-film capacitors having vacuum deposited silicon monoxide as the dielectric. The comparatively wide attention this material has received is largely due to the ease with which in can be evaporated and the availability of considerable information concerning it.[3,4,5]

Silicon Monoxide Dielectric

Initially, several groups of capacitors were made by depositing three successive film layers; the central layer was silicon monoxide, and the outer layers consisted of a variety of metals. It was possible to obtain values of capacitance per unit area, dissipation factor, direct-current insulation resistance, dielectric thickness, dielectric constant, and breakdown strength for many of the capacitors; average values are given in Table 1. In addition to the six electrode metals shown, copper was also used but in all cases films of it peeled away from the dielectric.

It is evident from the data for dissipation factor and direct-current resistance that the best capacitors were those formed with electrode films of noble metals. Gold is to be particularly recommended for thin-film electrodes because of its high conductivity, inertness to oxidation, and ease of deposition.

Voltage breakdown strength (Fig. 1) requires further explanation since the capacitors produced did not consist of perfect films but rather of films containing minute pinholes. The pinholes in the dielectric film sometimes became filled with metal when the counter electrode was applied, thereby shorting the capacitors. Such shorts are analogous to those found in metallized paper capacitors. They were removed, and hence the capacitors cleared, by sending energy pulses through the capacitors. This process required careful control to prevent damage to a capacitor by a pulse of excessive energy.

Silicon Dioxide Dielectric

The dielectric breakdown strength of fused silica, given as 15,000 volts per mil in 1/8 in. sheets is among the highest known. The use of this material as a capacitor dielectric at normal temperatures should, therefore, permit excellent voltage ratings for thin-film capacitors. The stability of fused silica under normal conditions should result in additional desirable capacitor characteristics.

The vacuum evaporation of fused silica, however, is difficult for several reasons. First, silica is extremely difficult to heat in vacuum because it absorbs little radiant energy. Second, it must be heated to a temperature in excess of 1700 C. Third, it decomposes readily under the conditions usually encountered in vacuum evaporation. It seemed best however, to employ a direct evaporation technique despite difficulties. Such a technique represents a compromise between the desired high percentage of SiO_2 in the film and the speed of formation.

In recent work, concentrations of silica up to 96 percent have been obtained by the method. It is possible that with further development of techniques, fused silica may be even more successfully evaporated in this manner.

More detailed information on the processes described in this article will be found in the complete paper to be published in our Proceedings of the Symposium on Microminiaturization of Electronic Assemblies. For further information on the Proceedings, turn to Reader-Service card and circle **100**.

References

1. Procedures in Experimental Physics, J. D. Strong, p. 168, Prentice-Hall, New York, 1938.
2. Micronic Capacitor, R. F. Hoeckelman, C. W. Hoornstra and M. Yang, WADC TR 57-22, August 1957.
3. Silicon Monoxide Front Surface Mirrors, G. Hass and N. W. Scott, *J. Opt. Soc. Am.* 39, 179 (1949).
4. Preparation, Structure, and Application of Thin Films of SiO and TiO_2, G. Hass, *J. Am. Cer. Soc.*, 33, 353 (1950).
5. Optical Properties of SiO in the Wavelength Region from 0.24-14.0 Microns, G. Hass and C. O. Salzberg, *J. Opt. Soc. Am.*, 44, 181 (1954).

NEW PRODUCTS

Covering all new products that might generally be specified by an electronics engineer engaged in the design of original equipment.

CIRCLE 37 ON READER-SERVICE CARD

UNIVERSAL AUTOMATIC TESTER

This automatic tester is capable of rapidly evaluating within assigned limits dynamic functional capabilities of a weapon system, sub-system, or components. Called the Space System, it provides for automatic IBM card programming and will accept 1000 inputs. It can be used to measure dc v, true rms of ac v, peak to peak ac v, ohms, freq., time interval, or periods from test unit.

Systron Corp., Dept. ED, 950 Galindo St., Concord, Calif.

NUCLEAR BATTERIES

These krypton batteries produce a 5 kv, open circuit, output and have a volume of less than 1/4 cu in. Minimum current output of the Model K1A-50 is 100 μμa at no load and 50 μμa at 3 kv. Its weight is 1 oz and its useful life is approximately 10 yr. Operating temperature range is −175 to +165 F.

Radiation Research Corp., Dept. ED, 1114 First Ave., New York 21, N. Y.

CIRCLE 39 ON READER-SERVICE CARD

POWER TRANSISTORS

Designated 2N1073, A, B, this diffused-alloy-power (DAP) transistor series has collector voltage ratings up to 120 v. They have a 2 ohm typical input resistance, and collector currents up to 10 amp can be handled. Switching times are less than a μsec. Power gain of the DAP transistor is 5 to 10 times greater than that of a standard alloy type.

Bendix Aviation Corp., Semiconductor Products, Dept. ED, Long Branch, N. J.

CIRCLE 38 ON READER-SERVICE CARD

DIFFERENTIAL SWITCH

This differential switch is used to sense the displacement of two shafts. It can be used as an accurate time interval generator when used with a synchronous motor or as a driving source for the follow shaft. Operation: a desired shaft position is set into the 0.25 in. shaft, and this position is related to the 0.125 shaft by a set of contacts which are spdt, center-off. The 0.125 shaft can be driven to the same position as the 0.25 shaft and the contacts will become center off.

The Newton Co., Dept. ED, 55 Elm St., Manchester, Conn.

CIRCLE 40 ON READER-SERVICE CARD

MERCURY BATTERY

Measuring 0.3 in. in diam and 0.125 in. high, this mercury battery is designed to meet the size requirements of the military micro-module program. Its uses also include other miniaturized electronic devices. Designated RM-312, its energy life is approximately 36 ma hr at a discharge of 2 ma, at 1.22 avg v.

Mallory Battery Co., Dept. ED, 13000 Athens Ave., Cleveland, Ohio.

CIRCLE 41 ON READER-SERVICE CARD

NEW PRODUCTS

NPN Junction Transistor

For large signal of applications

An alloy junction transistor, germanium npn type 2N647 is especially designed for use with the company's pnp type 2N217 in portable radio receivers, phonographs, and audio amplifiers. It may also be used in conventional class B push pull circuits, and in class A audio amplifier circuits. Used together in the output stage of a typical class B complementary symmetry circuit and driven by a 2N217 class A driver, a 2N647 and a 2N217 can provide 100 mw power output at a power gain of 54 db. Used in the output stage of a typical push pull circuit and driven by another 2N647 class A driver, two 2N647's can provide a power output of 100 mw at a power gain of 66 db. The 2N647 has a large signal dc current transfer ratio essentially constant over the operating current range to insure circuit linearity. It has a collector cutoff current of 14 μa and operates in ambient temperatures to 71 C.

Radio Corporation of America, Semiconductor Div., Dept. ED, Somerville, N.J.

CIRCLE 470 ON READER-SERVICE CARD

Synchros

Meet MIL-S-20708 specifications

Designed for 60 and 400 cps operation, these synchro receivers, transmitters, and differentials have frame sizes from 8 to 23. They meet MIL-S-20708 specifications and are available for both torque and control systems.

United Aircraft Corp., Norden Div., Dept. ED, Commack, N.Y.

CIRCLE 43 ON READER-SERVICE CARD

Receptacles Gyro Spin Motor Supply

Provides 2 or 3 phase power

A panel-mounted, self-contained modular unit, model T869 gyro power supply provides either 2 or 3 phase power to spin motors. It maintains the motor at synchronous speed regardless of phase unbalance.

Sterling Precision Corp., Dept. ED, 17 Matinecock Ave., Port Washington, N.Y.

CIRCLE 45 ON READER-SERVICE CARD

Potentiometer

±0.05% linearity

This 10 turn potentiometer has ±0.05% linearity and comes in any resistance from 50 ohms to 200 K. It is supplied with a standard bushing or servo mount, with or without ball bearings. Diameter is 7/8 in.; length, 1-1/2 in.

Voak Engineering Co., Dept. ED, 129 E. A St., Upland, Calif.

CIRCLE 46 ON READER-SERVICE CARD

Feed Through Filters

Low pass

Filtering efficiency increases with frequency in these low pass, feed through filters. With filtering capacitances to 500,000 μμf and filtering effect up to 60 db, the units are designed to eliminate high frequency radiation and feedback in low power circuits from 50 to 5000 mc. They are rated to 500 v dc at 125 C, and maximum dc and low frequency currents are 5 amp. Standard maximum rf current at rated voltage is 0.25 amp.

Allen-Bradley Co., Dept. ED, 136 W. Greenfield Ave., Milwaukee, Wis.

CIRCLE 47 ON READER-SERVICE CARD

NEW PRODUCTS

Transistorized Servo Amplifier

Operates from 115 v, 60 cps

Model A3300-01 transistorized servo amplifier operates from 115 v, 60 cps and is equipped with an internal dc power supply. It provides 90 deg phase shift and outputs of 40 or 6.3 v at 60 cps. Effective gain is easily adjusted from 80 to 1600, and input impedance is 5 to 100 K.

Kearfott Co., Inc., Dept. ED, 1500 Main Ave., Clifton, N.J.

CIRCLE 49 ON READER-SERVICE CARD

Temperature Recorders

Multirange

Plug-in elements provide these temperature recorders with many ranges. Typical spans are −150 to +250 F and 0 to 2200 F. Limit of error is 1% of span, and no external temperature reference is needed. For each range, 5-in. F or C calibrated chart paper is available. A wide choice of chart speeds are offered in 1, 2, and 4 speed units.

Varian Associates, Instrument Div., Dept. ED, 611 Hansen Way, Palo Alto, Calif.

CIRCLE 50 ON READER-SERVICE CARD

Analog Computer

Has 2% accuracy

A completely solid state device, the CM-2 analog computer contains up to 12 operational amplifiers, 6 logarithmic networks, and 8 scaling potentiometers. It also has an integral programming board inside the cabinet to facilitate programming of functions. It is hermetically sealed and mounted

◄ CIRCLE 48 ON READER-SERVICE CARD

on swing-out frames for quick accessibility and replacement. The unit meets Class 2, Section 1 conditions with an air purge and has an overall accuracy of better than 2%. It is housed in a steel cabinet with a door. Several units can be used in banks with their programming boards interconnected.

Southwestern Industrial Electronics Co., Dept. ED, 10201 Westheimer Rd., Houston 19, Tex.

CIRCLE 51 ON READER-SERVICE CARD

Wirewound Potentiometers

±0.3% linearity

In ranges from 10 ohms to 75 K, model 550 3 turn potentiometers have ±0.3% standard linearity and may be ordered with ±0.1% linearity. The wirewound units may also be obtained with nonlinear functions.

Spectrol Electronics Corp., Dept. ED, San Gabriel, Calif.

CIRCLE 52 ON READER-SERVICE CARD

Servo Amplifier

Operates from −55 to +125 C

Fully potted and transistorized, the AMP-298 servo amplifier can deliver 40 v rms into a 160 ohm center-tapped load. Built for continuous operation between −55 and +125 C, it provides a voltage gain of 1000 at a constant input impedance of 50 K. This gain can be adjusted by an external resistor. Requiring 28 v dc power and operating from a carrier of 400 cps ±20 cps, the unit measures 1-7/16 x 1-7/8 x 3 in. and weighs a maximum of 9 oz. It is designed to meet MIL-E-5400 and MIL-E-5272A specifications.

Bulova Watch Co., Electronics Div., Dept. ED, Woodside 77, N.Y.

CIRCLE 53 ON READER-SERVICE CARD

CIRCLE 54 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Direct Recording Oscillographs

8 and 14 channel

These direct recording oscillographs are designed to monitor and record a variety of electrical and mechanical phenomena during high speed testing operations. Model 906A-1 has miniature plug-in galvanometers which provide for 14 channel recording from dc to 5 kc. The 906A-2 has solid-frame galvanometers that provide for 8 channel recording from dc to 2 kc. Two accessories, a timing unit and a record latensifier are available.

Minneapolis-Honeywell Regulator Co., Heiland Div., Dept. ED, 5200 E. Evans Ave., Denver 22, Colo.

CIRCLE 56 ON READER-SERVICE CARD

Telemetering Commutator

For pam systems

For use in pulse amplitude modulation systems, this 3 pole telemetering commutator is adaptable to either airborne or ground gating. Each pole contains a flexible master pulse which can be externally intercormected to provide either a pulse of 2 live and 3 dead segments or 3 live and 4 dead segments. In addition, each pole has 28 break-before-make contacts. One pole has a 50% duty cycle for timing purposes. The other two have 70%-30% duty cycles and are used for transmitting either 0 to 5 v dc or 100 to 500 μv signals. Power is provided by a radio-noise-filtered, ungoverned dc motor which rotates the brushes at 10 rps through a gear reduction system. In a hermetically sealed case, the 28 v dc unit withstands 20 g up to 2000 cps and 50 g shock. It has a life of 500 hours.

Instrument Development Labs, Inc., Dept. ED, 67 Mechanic St., Attleboro, Mass.

CIRCLE 57 ON READER-SERVICE CARD

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Servo Amplifier

8 w output

A 7-pin, plug-in transistorized servo amplifier, model 1800-0300-2 receives signals from a low impedance bridge circuit and operates a 400 cps motor at 8 w maximum. Input impedance is 200 ohms; voltage gain 30,000 at 2 w. The unit meets MIL-E-5400A specifications.

M. Ten Bosch, Inc., Dept. ED. 80 Wheeler Ave., Pleasantville, N.Y.

CIRCLE 58 ON READER-SERVICE CARD

Digital Subtractor Converter

Accurate to 12 bits

Model DS-12-A digital subtractor converter automatically compares two digital input signals, subtracts them, and presents an analog signal output representing the difference between the two. Each of the input channels accepts 0 to 10 v positive pulses at bit rates to 250 kc. Repetition rates of 0 to 4095 pulses per block are accommodated, with 30 blocks per sec handled by the system. The analog output voltage is accurate to 12 bits of input information, and may be used to operate servo controlled pattern followers and positioning systems or perform digital null detection and program comparison.

Computer Equipment Corp., Dept. ED. 1931 Pontius Ave., Los Angeles 25, Calif.

CIRCLE 59 ON READER-SERVICE CARD

Correction

The above blocks and plugs are an integral part of a patchcord programming system which is available only from AMP, Inc. In the Nov. 12 issue of *ED*, we incorrectly indicated that the blocks and plugs could be obtained separately from Gries Reproducer Corp.

CIRCLE 60 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Miniature Shaft Couplings

Have zero backlash

All in one piece, these miniature shaft couplings eliminate the need for solder joints, pins, screws, and rivets. Units for a 1/8 in. shaft are 1/4 in. in length and diameter and weigh 1/30 oz. Of helical design, they afford smooth bearing loads, constant velocity, and absolute zero backlash.

Helical Products Co., Dept. ED, 1402 The Strand, Hermosa Beach, Calif.

CIRCLE 62 ON READER-SERVICE CARD

Potentiometer

For panel mounting

Actuated by a lead screw, Trimpot model 223 is designed for panel mounting. Weighing about 0.3 oz and measuring 0.23 x 1.32 x 0.24 in., it can be mounted through a single 0.2 in. hole. The threaded adapter extends through the panel hole and is secured by a hex nut. Operating reliably from −65 to +75 C, the unit has a power rating of 1 w at 70 C and can be supplied in resistances ranging from 100 ohms to 50 K. It meets all applicable requirements of MIL-STD-202A including the 10 day humidity of Method 106 and the vibration of Method 204.

Bourns Labs, Inc., Dept. ED, P.O. Box 2112, Riverside, Calif.

CIRCLE 63 ON READER-SERVICE CARD

◄ CIRCLE 61 ON READER-SERVICE CARD

Component Sockets

For printed circuit boards

Designed to test printed circuit component parts without solder installation, duel entry Vari-Grip sockets are easily crimped in place by automatic, bench, or hand tools. A beryllium copper spring band snap locks the wire after insertion. The units afford maximum heat sink and are available for circuit boards 1/8 to 1/6 in. thick.

Grinnell-Harris Electronics, Inc., Dept. ED, 4130 Temple City Blvd., Rosemead, Calif.

CIRCLE 64 ON READER-SERVICE CARD

Band Pass Filters

Narrowband, tunable

Series BP band pass filters handle 200 w cw and come with any center frequency from 100 to 2000 mc. Tuning range is ±3 mc; impedance, 50 ohms; bandwidth at the 3 db points, 6 to 8 mc. At f_o, insertion loss is 1 db; vswr, 1.1. Up to four units can be cascaded to vary rejection slope from 20 to 45 db at $\pm 1.2\ f_o$.

Maury & Associates, Dept. ED, 10373 Mills Ave., Pomona, Calif.

CIRCLE 65 ON READER-SERVICE CARD

DC Power Supply

Dual purpose

For servicing all transistor and hybrid circuits and 12 or 6 v auto radio receivers, model PS-2 dc power supply has two output ranges: 0 to 20 v at 75 ma for transistor radios, and 0 to 16 v at 5 amp for auto radios.

Electro Products Labs, Dept. ED, 4500 N. Ravenswood Ave., Chicago 40, Ill.

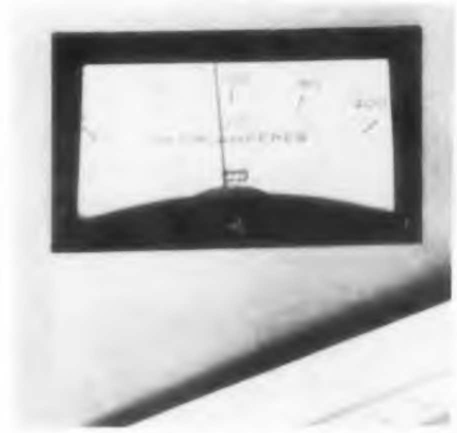
CIRCLE 66 ON READER-SERVICE CARD

CIRCLE 67 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Panel Meter

3-1/2 in.



Held in place by rear screw-on clamps, meter model 361 occupies 3-1/2 x 2 in. of panel space and projects 3/16 in. The dial and window are slanted for easier reading and may be illuminated through a translucent rear window. Sensitivity ranges are 0 to 5 μa to 0 to 50 amp, and 0 to 5 mv to 0 to 500 v.

Assembly Products, Inc., Dept. ED, Chesterland, Ohio.

CIRCLE 69 ON READER-SERVICE CARD

Inertia Switches

1 msec response time

Normally closed, these spdt or sptt miniature inertia switches operate from −65 to +250 F and respond in under 1 msec. Acceleration sensitivity can be adjusted from 1 to 100 g with 1% accuracy.

Inertia Switch, Div. of Safe Lighting, Inc., Dept. ED, 527 Lexington Ave., New York 17, N.Y.

CIRCLE 70 ON READER-SERVICE CARD

Magnetic Amplifiers

Have tapewound gapless core

In 18 sizes from 500 va to 32 kva, series 1290 power magnetic amplifiers have a tapewound gapless core which permits a minimum of control ampere turns and eliminates the irregular performance caused by air gaps.

Vickers Inc., Electric Products Div., Dept. ED, 1815 Locust St., St. Louis 3, Mo.

CIRCLE 71 ON READER-SERVICE CARD

Noise Tube Mount

Direct reading

Designed to extend the range of microwave rf noise generating equipment, this K band direct reading noise tube mount provides quick measurement of noise figures in systems operating from 18 to 26.5 kmc. For use with the company's model 2200 or 2200-M power units, the assembly incorporates a precision calibrated attenuator which is directly marked in noise figure values.

Waveline, Inc., Dept. ED, P.O. Box 718, West Caldwell, N.J.

CIRCLE 72 ON READER-SERVICE CARD

Dimple Motor

Squib actuated

For use in missiles, weapons, and weapon systems, this squib actuated dimple motor is 0.5 in. long and 0.3 in. in diameter. Actuated by 7500 ergs, it can provide 8 lb of thrust over a 0.1 in. minimum stroke within 1 msec. The unit has a shelf life measurable in years. It will function properly from −65 to +165 F and withstand 20,000 g acceleration and shock.

Atlas Powder Co., Ordnance Materiel Dept., Dept. ED, Wilmington 99, Del.

CIRCLE 73 ON READER-SERVICE CARD

Correction

In the story "Ceramic Capacitors Made Smaller," which appeared in the Dec. 24 issue of ED the caption for Fig. 1 labels the upper capacitor as a paper one. It is a tubular ceramic capacitor. Also, during their life test, the capacitors are subjected to 85 C instead of 200 C. Inquiries for these products should be sent to Aerovox Corp., Hi-Q Div., Olean, N.Y.

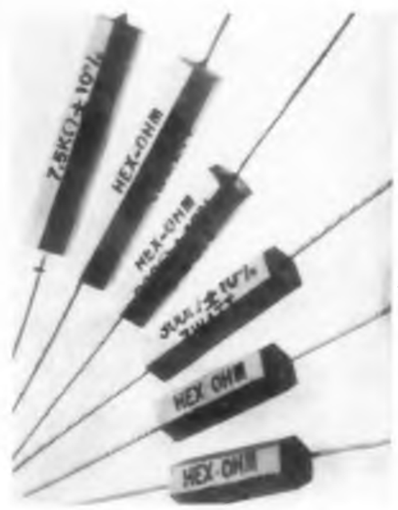
Portable Tube Tester

Has seven micromho ranges

Model 1575 portable tube tester accurately evaluates receiving, low power transmitting, voltage regulator, rectifier, and other tube types. For mutual conductance tests, it has seven full scale micromho ranges: 60,000; 30,000; 15,000; 6000; 3000; 1200; and 600. It provides four signal voltages: 0.25; 0.5; 1; and 5 v. A sensitive gas test immediately indicates any gas current.

The Hickok Electrical Instrument Co., Dept. ED, 10525 Dupont Ave., Cleveland 8, Ohio.

CIRCLE 76 ON READER-SERVICE CARD



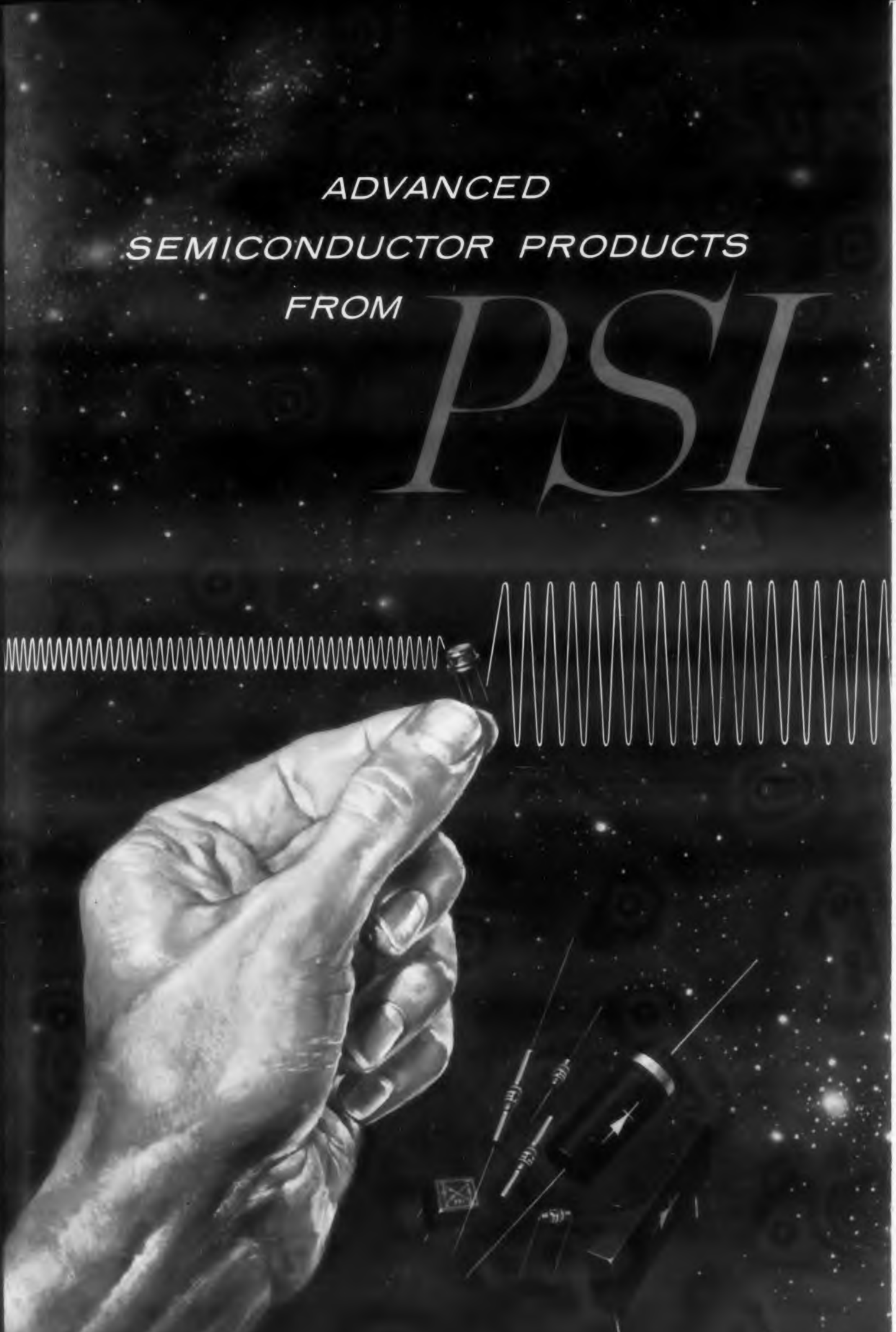
Wirewound Resistors

Have 10% tolerance

Hex-Ohm ceramic wirewound resistors are made in 4, 5, 7, 10, and 12 w sizes within 10% tolerance. The resistance wire is uniformly wound on a fiber glass core and sealed into the hexagonal ceramic case with a special moisture resistant silicone cement. A good insulator, the case can withstand 1250 v break-down tests, and its hexagonal design affords good heat dissipation. Resistances are 0.5 ohm to 2.5 K for the 4 w size; 1 ohm to 3.5 K for the 5 w; 1.5 ohms to 5.6 K for the 7 w; 2 ohms to 10 K for the 10 w; and 2.5 ohms to 12 K for the12 w. All 3/8 in. wide, the units vary in length from 3/4 to 2 in.

Bradford Components, Inc., Dept. ED, 65 South Ave., Salamanca, N.Y.

CIRCLE 77 ON READER-SERVICE CARD



NEW!

Zener Diodes

ACTUAL SIZE

LOW VOLTAGE GROUP

PSI Type Number	Elect Equiv	Zener Voltage @ 5 mA @ 25 C		Maximum Dynamic Resistance ohms (1)	Maximum Inverse Current		At Inverse Voltage (V)
		E Min (v)	E Max (v)		I @ 25 C µA	I @ 100 C µA	
PS6465	1N465	2.0	3.2	60	75	100	1
PS6466	1N466	3.0	3.9	55	50	100	1
PS6467	1N467	3.7	4.5	45	5	100	1
PS6468	1N468	4.3	5.4	35	5	100	1.5
PS6469	1N469	5.2	6.4	20	5	100	1.5
PS6470	1N470	6.2	8.0	10	5	50	1.5

1. Measured at 10 mA DC Zener current with 1 mA RMS signal superposed

MEDIUM VOLTAGE GROUP

PSI Type Number	Elect Equiv	Zener Voltage @ 200 µA @ 25 C		Maximum Inverse Current		At Inverse Voltage v
		E Min v	E Max v	I @ 25 C µA	I @ 100 C µA	
PS6313	1N1313	7.5	10	5	5	6.8
PS6314	1N1314	9	12	5	5	8.2
PS6315	1N1315	11	14.5	5	5	10.0
PS6316	1N1316	13.5	18	5	5	12.0
PS6317	1N1317	17	21	5	5	15.0
PS6318	1N1318	20	27	1	10	18.0

HIGH VOLTAGE GROUP

PSI Type Number	Elect Equiv	Zener Voltage @ 200 µA @ 25 C		Maximum Inverse Current		At Inverse Voltage (v)
		E Min v	E Max v	I @ 25 C µA	I @ 100 C µA	
PS6319	1N1319	25	32	1	10	22
PS6320	1N1320	30	39	1	10	27
PS6321	1N1321	37	45	1	10	33
PS6322	1N1322	43	54	1	10	39
PS6323	1N1323	52	64	1	10	47
PS6324	1N1324	62	80	1.0	50	56
PS6325	1N1325	75	100	1.0	50	68
PS6326	1N1326	90	120	1.0	50	82
PS6327	1N1327	110	145	1.0	50	100

MAXIMUM Power Dissipation 500 mW @ 25 C
Operating Range −65 C to 200 C

NEW!

Very High Frequency Silicon Power Transistors

Triple-diffused npn mesa structure

Six new types, three oscillator transistors and three amplifier transistors, are currently available in limited quantities for evaluation orders.

- Power capabilities at 70 megacycles of ¼, ½, and ¾ watts output.
- High voltage capability permitting operation at collector voltages up to 100 volts DC.
- Collector power dissipation rating of 2¼ watts at 50°C case temperature.
- Typical amplifier gain of 10 db at 70 mc.

Specification sheets, curves, and additional information are available on written request. Address your inquiries to Department T-10.

Silicon General Purpose Diodes

ACTUAL SIZE

EIA TYPE NUMBER	Minimum Saturation Voltage @ 100 μa @ 25°C volts	Minimum Forward Current @ +1.0 VDC @ 25°C mA	Maximum Inverse Current at Maximum DC Operating Voltage μa @ volts @ 25°C	@ 150°C	Maximum Average Rectified Current mA @ 25°C	@ 150°C
1N456	30	40	.025 @ 25	5 @ 25	90	
1N456A	30	100	.025 @ 25	5 @ 25	200	70
*1N457	70	20	.025 @ 60	5 @ 60	75	
1N457A	70	100	.025 @ 60	5 @ 60	200	70
*1N458	150	7	.025 @ 125	5 @ 125	55	
1N458A	150	100	.025 @ 125	5 @ 125	200	70
*1N459	200	3	.025 @ 175	5 @ 175	40	
1N459A	200	100	.025 @ 175	5 @ 175	200	70
1N461	30	15	.5 @ 25	30 @ 25	60	
1N461A	30	100	.5 @ 25	30 @ 25	200	70
1N462	70	5	.5 @ 60	30 @ 60	[illegible]	
1N462A	70	100	.5 @ 60	30 @ 60	200	70
1N463	200	1	.5 @ 175	30 @ 175	[illegible]	
1N463A	200	100	.5 @ 175	30 @ 175	200	70
1N464	150	3	.5 @ 125	30 @ 125	[illegible]	
1N464A	150	100	.5 @ 125	30 @ 125	200	70

*JAN Types

OTHER ABSOLUTE MAXIMUM RATINGS
Power Dissipation .25 Watt @ 25°C, Power Dissipation [illegible] Watt @ 150°C, 1 Second Surge Current 1.5 Amperes 25°C, Storage and Operating Temperature Range [illegible]°C to [illegible]°C.

Silicon High Conductance Diodes

ACTUAL SIZE

PSI or EIA TYPE NUMBER	Minimum Saturation Voltage @ 100 μa @ 25°C volts	Maximum Forward Voltage DC @ 25°C volts @ 100 mA	@ 200 mA	Maximum Inverse Current at Maximum DC Operating Voltage (μa @ volts) @ 25°C	@ 150°C	Maximum Average Rectified Current (mA) @ 25°C	@ 150°C
1N482	40	1.1		.250 @ 30v	30	125	50
1N482A	40	1.0		.025 @ 30v	15	200	70
1N482B	40	1.0		.025 @ 30v	5	200	70
PS603	40		1.0	.250 @ 30v	30	200	100
PS604	40		1.0	.025 @ 30v	15	200	100
PS605	40		1.0	.025 @ 30v	5	200	100
1N483	80	1.1		.250 @ 60v	30	125	50
1N483A	80	1.0		.025 @ 60v	15	200	70
1N483B	80	1.0		.025 @ 60v	5	200	70
PS609	80		1.0	.250 @ 60v	30	200	100
PS610	80		1.0	.025 @ 60v	15	200	100
PS611	80		1.0	.025 @ 60v	5	200	100
1N484	150	1.1		.250 @ 125v	30	125	50
1N484A	150	1.0		.025 @ 125v	15	200	70
1N484B	150	1.0		.025 @ 125v	5	200	70
PS615	150		1.0	.250 @ 125v	30	200	100
PS616	150		1.0	.025 @ 125v	15	200	100
PS617	150		1.0	.025 @ 125v	5	200	100
1N485	200	1.1		.250 @ 175v	30	125	50
1N485A	200	1.0		.025 @ 175v	15	200	70
1N485B	200	1.0		.025 @ 175v	5	200	70
PS621	200		1.0	.250 @ 175v	30	200	100
PS622	200		1.0	.025 @ 175v	15	200	100
PS623	200		1.0	.025 @ 175v	5	200	100
1N486	250	1.1		.250 @ 225v	50	125	50
1N486A	250	1.0		.050 @ 225v	25	200	70
1N486B	250	1.0		.050 @ 225v	10	200	70
PS627	250		1.0	.250 @ 225v	50	200	100
PS628	250		1.0	.050 @ 225v	25	200	100
PS629	250		1.0	.050 @ 225v	10	200	100
1N487	330	1.1		.250 @ 300v	50	125	50
1N487A	330	1.0		.100 @ 300v	25	200	70
PS632	330		1.0	.250 @ 300v	50	200	100
PS633	330		1.0	.100 @ 300v	25	200	100
1N488	420	1.1		.250 @ 380v	50	125	50
1N488A	420	1.0		.100 @ 380v	25	200	70
PS636	420		1.0	.250 @ 380v	50	200	100
PS637	420		1.0	.100 @ 380v	25	200	100

OTHER ABSOLUTE MAXIMUM RATINGS
Maximum Power Dissipation 0.5 Watts @ 25°C, Maximum Power Dissipation [illegible] Watts @ 150°C, Maximum 1 Second Surge Current 1.5 Amperes @ 25°C, Storage and Operating Temperature Range -80 to 200°C.

Silicon Subminiature Rectifiers

ACTUAL SIZE

MEDIUM POWER TYPES

EIA TYPE NUMBER	MAXIMUM RATINGS: Peak Inv. Voltage V	Maximum Avg. Rectified Current mA @ 25°C	@ 150°C	ELECTRICAL CHARACTERISTICS: Minimum Saturation Voltage @ 100°C	Maximum Reverse Current @ PIV μA @ 25°C	@ 100°C	Max. Avg. Voltage Drop @ 1½ 400 mA @ 25°C (v)
1N645	225	400	150	[illegible]	[illegible]	15	1.0
1N646	300	400	150	[illegible]	[illegible]	15	1.0
1N647	400	400	150	[illegible]	[illegible]	20	1.0
1N648	500	400	150	[illegible]	[illegible]	[illegible]	1.0
1N649	600	400	150	[illegible]	[illegible]	[illegible]	1.0

400 MILLIAMPERE PSI TYPES

400 mA @ 25°C, 150 mA @ 150°C

PSI TYPE NUMBER	MAXIMUM RATINGS @ 100°C: Peak Recurr. Inverse Voltage volts	Maximum RMS Input Voltage volts	Maximum Average Rectified Current mA	ELECTRICAL CHARACTERISTICS: DC Forward Voltage @ Specified Current @ 25°C volts @ mA	Maximum Average Inverse Current @ 100°C μa
TYPE		@ 150°C		@ 25°C	@ 150°C
[illegible]	[illegible]	[illegible]	[illegible]	1.5 @ 500	500
PS 410	[illegible]	[illegible]	[illegible]	1.5 @ 500	500
PS 415	[illegible]	[illegible]	[illegible]	1.5 @ 500	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1.5 @ 500	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1.5 @ 500	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1.5 @ 500	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1.5 @ 500	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1.5 @ 500	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1.5 @ 500	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1.5 @ 500	[illegible]

250 MILLIAMPERE PSI TYPES

250 mA @ 25°C, 140 mA @ 100°C

[illegible]	[illegible]	[illegible]	[illegible]	1 @ 100	100
[illegible]	[illegible]	[illegible]	[illegible]	1 @ 100	100
[illegible]	[illegible]	[illegible]	[illegible]	1 @ 100	100
[illegible]	[illegible]	[illegible]	[illegible]	1 @ 100	100
[illegible]	[illegible]	[illegible]	[illegible]	1 @ 100	100
[illegible]	[illegible]	[illegible]	[illegible]	1 @ 100	100
[illegible]	[illegible]	[illegible]	[illegible]	1 @ 100	100
[illegible]	[illegible]	[illegible]	[illegible]	1 @ 100	100
PS 05[illegible]	[illegible]	[illegible]	[illegible]	1 @ 100	100
[illegible]	[illegible]	[illegible]	[illegible]	1 @ 100	100

1. [illegible]
2. [illegible] circuit with rectifier operating at [illegible] rated current and maximum RMS input.

Storage and Operating Temperature Range: [illegible]

Please Note:

All specifications and information contained herein are current as of February 15, 1959. This advertisement has been inserted in the February issue of Electronic Design to speed the communication of PSI product information to the specifying engineer. Similar product advertisements, compiled from latest PSI specifications, will appear regularly in this and other leading electronic publications.

PSI

Pacific Semiconductors, Inc.

A SUBSIDIARY OF THOMPSON RAMO WOOLDRIDGE INC

Silicon
Miniature Rectifiers

500 MILLIAMPERE TYPES — 500 mA @ 25°C, 200 mA @ 150°C

PSI TYPE NUMBER	MAXIMUM RATINGS @ 150°C: Peak Recurr Inverse Voltage (volts)	Maximum RMS Input Voltage† (volts)	Maximum Average Rectified Current† (mA)	ELECTRICAL CHARACTERISTICS: DC Forward Voltage @ Specified Current @ 25°C (volts @ mA)	Maximum Average Inverse Current† @ 150°C (μa)
PS 105	50	35	200	1.5 @ 500	[illegible]
PS 110	100	70	200	1.5 @ 500	[illegible]
PS 115	150	105	200	1.5 @ 500	[illegible]
PS 120	200	140	200	1.5 @ 500	[illegible]
PS 125	250	175	200	1.5 @ 500	[illegible]
PS 130	300	210	200	1.5 @ 500	[illegible]
PS 135	350	245	200	1.5 @ 500	[illegible]
PS 140	400	280	200	1.5 @ 500	[illegible]
PS 150	500	350	150	1.5 @ 500	[illegible]
PS 160	600	420	150	1.5 @ 500	[illegible]

[illegible]

Silicon
HighVoltage Rectifiers

EIA TYPE NUMBER	Peak Inverse Voltage @ 25 & 100°C (volts)	Continuous DC Voltage @ 25 & 100°C (volts)	Average Rectified Current (mA) @ 25°C	@ 100°C	RMS Input Voltage @ 25 & 100°C (volts)	Max DC Fwd Voltage Drop @ 100mA DC 25°C
1N1730	1000	1000	200	100	[illegible]	[illegible]
1N1731	1500	1500	200	100	[illegible]	[illegible]
1N1732	2000	2000	[illegible]	[illegible]	[illegible]	[illegible]
1N1733	3000	3000	[illegible]	[illegible]	[illegible]	[illegible]
1N1734	5000	5000	[illegible]	[illegible]	[illegible]	[illegible]

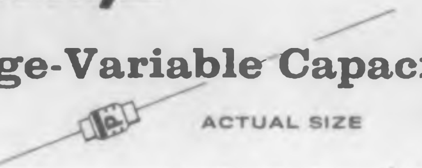
Maximum DC Reverse Current @ Rated PIV [illegible]
Maximum Surge Current [illegible]
Dimensions: Length [illegible]; Diameter [illegible]; Leads [illegible]

Silicon Very High Voltage
Cartridge Rectifiers

*EIA Type	Length Inches	Absolute Max Rtgs H W Res Load at 75°C Ambient: Peak Inverse Voltage Volts	Max Rectified DC Output Current MA	Electrical Characteristics at 25°C Ambient: Forward DC Volt Drop at Rated DC Current Volts	Reverse DC Current at Rated PIV MA
1N1139	[illegible]	3600	[illegible]	[illegible]	[illegible]
1N1140	[illegible]	3600	[illegible]	[illegible]	.025
1N1141	[illegible]	4800	[illegible]	[illegible]	[illegible]
1N1142	[illegible]	4800	50	24.0	[illegible]
1N1143	[illegible]	6000	[illegible]	45.0	[illegible]
1N1143A	[illegible]	6000	65	[illegible]	[illegible]
1N1144	[illegible]	7200	[illegible]	54.0	[illegible]
1N1145	[illegible]	7200	[illegible]	[illegible]	[illegible]
1N1146	[illegible]	9600	45	[illegible]	[illegible]
1N1147	[illegible]	12000	45	[illegible]	[illegible]
1N1148	[illegible]	14400	[illegible]	[illegible]	[illegible]
1N1149	[illegible]	16800	45	[illegible]	[illegible]

Storage and Operating Temperature Range [illegible]

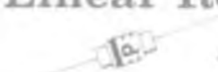
Varicap®
Voltage-Variable Capacitor



Varicap Type	Capacitance: @ 4VDC μμf	Approx Range μμf*	Quality Factor (Q) @ 50 mc: Minimum @ 4VDC	Typical @ 4VDC	Typical @ MWV	Maximum Working Voltage MWV Volts D.C.
MODULATION, AFC AND OTHER APPLICATIONS						
V-7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V-10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V-12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V-15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V-22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V-33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V-39	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V-47	47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V-56	56	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V-68	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V-82	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
V-100	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HIGH VOLTAGE TYPES, TUNING AND OTHER APPLICATIONS						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	65
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	60
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	55
V-47E	47	[illegible]	[illegible]	15.4	[illegible]	50
V-56E	56	[illegible]	[illegible]	[illegible]	[illegible]	40

*C range specified from [illegible] volts to maximum working voltage.

Non-Linear Resistors

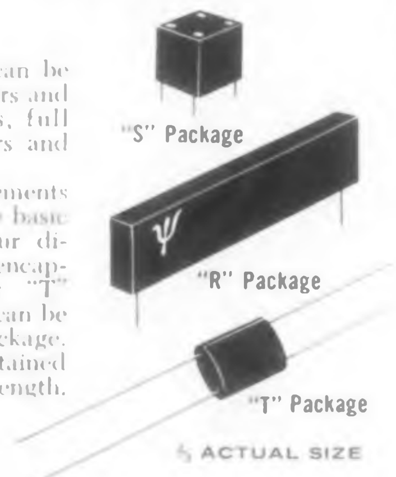


PSI Type	E @ 1mA volts	I @ 1VDC max μA	Max Dyn Res @ 1mA ohms	I @ 25°C μA Max
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Standard Encapsulations

A variety of assemblies can be furnished for matched pairs and quads, ring modulators, full wave and bridge rectifiers and many other applications.

Numerous lead arrangements are possible in these three basic configurations. Up to four diodes or rectifiers can be encapsulated in the "S" or "T" packages. Up to 12 units can be contained in the "R" package. The number of units contained determines its maximum length.



Leads .020" diameter.
1" minimum length.
Spaced on .1" grid centers.

DIMENSIONS

	"R" Package	"S" Package	"T" Package
Length	.375" to 1.75"	.45"	.50"
Width	.25"	.39"	—
Height	.50"	.40"	—
Diameter	—	—	.375"

Unusual Opportunities in Semiconductor Electronics

Rapidly expanding programs in Very High Frequency and Very High Power silicon transistors, silicon microdiodes, voltage-variable capacitors and other advanced diode types have created a number of exceptional technical staff opportunities at Pacific Semiconductors, Inc.

ELECTRICAL ENGINEERS . . . diode and transistor applications and test equipment development.

PHYSICISTS . . . product research including development of transistors, diodes, and other semiconductor components.

PHYSICAL SCIENTISTS . . . challenging research programs in crystal growth and perfection studies employing the latest infrared and etch pit techniques . . . solid state diffusion techniques and the study of surface phenomena.

Some of these positions encompass full supervisory responsibility. All offer an opportunity for growth and individual recognition that is unique in the semiconductor field.

If you are interested in associating yourself and your future with a dynamic, growing company such as Pacific Semiconductors, Inc., you should investigate these opportunities at once.

For specific information in your particular field, write to Technical Staff Placement, Pacific Semiconductors, Inc., 10451 W. Jefferson Blvd., Culver City, California.

If FAST SWITCHING is your need and available germanium types won't meet temperature and reliability requirements . . .

Switch to Silicon

Choose from the widest line of Fast Recovery Silicon Diffusion Computer Diodes in the industry!

Fast Recovery Silicon Diffusion Computer Diodes

ACTUAL SIZE

MILITARY TYPES

Type Number	Min Sat Voltage @ 100 µa (v)	Min Fwd Current @ 1.0 v	Maximum Reverse Current (µa) 25°C	Maximum Reverse Current (µa) 100°C	Reverse Recovery Characteristics: Reverse Res (ohms)	Reverse Recovery Characteristics: Max Recov Time (µs)
*1N641	200	10	.025 @ 10v 1 @ 100v	5 @ 10v 15 @ 100v	200K	[illegible]
•1N662	100	10	1 @ 10v 20 @ 50v	20 @ 10v 100 @ 50v	100K	[illegible]
1N663	100	100	5 @ 75v	50 @ 75v	200K	[illegible]

*MIL-1-12679 [illegible] •MIL-E-1/1139 [illegible] [illegible]

HIGH CONDUCTANCE TYPES

PS700	[illegible]	[illegible]	5 @ 20v	25 @ 20v	[illegible]	[illegible]
PS701	[illegible]	50	5 @ 45v	50 @ 45v	[illegible]	0.5
PS702	100	75	[illegible] @ 75v	50 @ 75v	200K	[illegible]
PS703	100	50	5 @ 75v	50 @ 75v	[illegible]	0.5
PS704	[illegible]	50	5 @ 75v	50 @ 75v	100K	0.5
PS705	200	50	5 @ 75v	50 @ 75v	100K	[illegible]

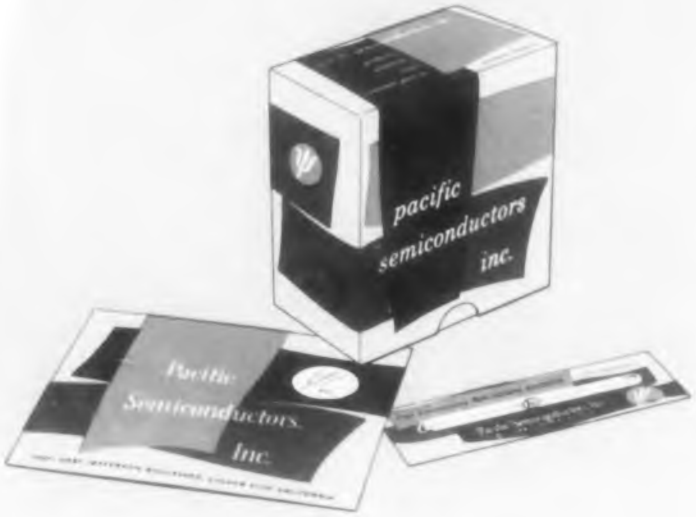
MEDIUM CONDUCTANCE TYPES

PS720	[illegible]	[illegible]	5 @ 20v	25 @ 20v	100K	[illegible]
PS721	[illegible]	[illegible]	5 @ 45v	50 @ 45v	100K	[illegible]
PS722	100	[illegible]	5 @ 75v	50 @ 75v	100K	[illegible]
PS723	200	[illegible]	25 @ 175v	100 @ 175v	100K	[illegible]
PS724	150	4	25 @ 125v	100 @ 125v	100K	[illegible]

LOW CONDUCTANCE TYPES

1N625	[illegible]	4 @ 1.5v	1 @ 20v	30 @ 20v	400K	[illegible]
1N626	[illegible]	4 @ 1.5v	1 @ 35v	30 @ 35v	400K	[illegible]
1N627	100	4 @ 1.5v	1 @ 75v	30 @ 75v	400K	[illegible]
1N628	150	4 @ 1.5v	1 @ 125v	30 @ 125v	400K	[illegible]
1N629	200	4 @ 1.5v	1 @ 175v	30 @ 175v	400K	[illegible]

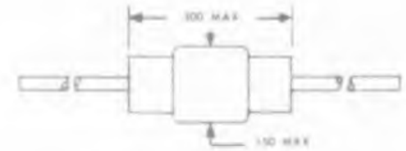
Many additional Fast Recovery Silicon Diffusion Computer Diodes to be announced next month.



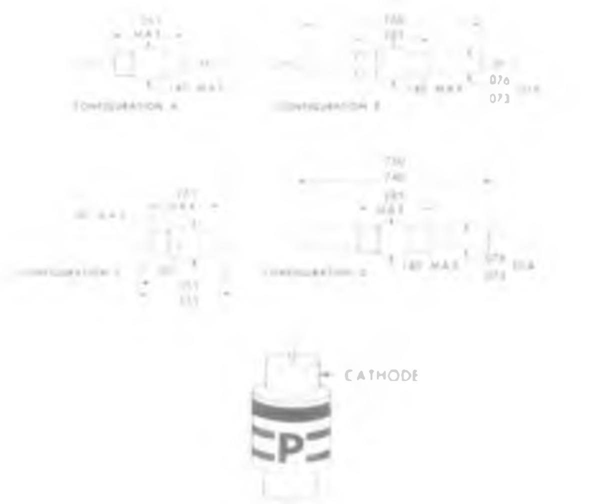
Standard Packaging... Immediate Delivery

"Off-the-shelf" delivery is available from the leading distributor in all major electronic centers.

Call your nearest PSI sales office for delivery and price quotations on production quantities.



Normally supplied in the MIL Specification dimensions shown above. On special request dimensions shown below can be supplied.



Physical Characteristics

HERMETICALLY SEALED—Glass-to-metal fused and metal-to-metal welded seals.

TERMINALS—Tinned copper leads .020 inches diameter. Lead length 1¼ inch minimum.

MARKING—Wide color band indicates cathode end. (Wide band indicates positive bias on Varicaps.) Type number designated by color bands reading from cathode.

ALL DIMENSIONS SHOWN IN INCHES—Patented under one or more of the following United States Patents: No. 2815474, No. 2827403. Other patents pending.

Step Down Transformers

For remote control circuits

Moisture proof and noise free, these low power step down transformers are designed for remote control and signal circuits. Standard units come in two power ratings, 10 or 25 va, and in five outputs from 6 to 24 v. Small in size, the units have high temperature plastic and metal shells with molded in screw terminals. They feature low heat rise and are approved by Underwriter's Labs. The windings are insulated from the core with nylon plastic.

Anderson Controls, Inc., Dept. ED, 9959 Pacific Ave., Franklin Park, Ill.

CIRCLE 81 ON READER-SERVICE CARD

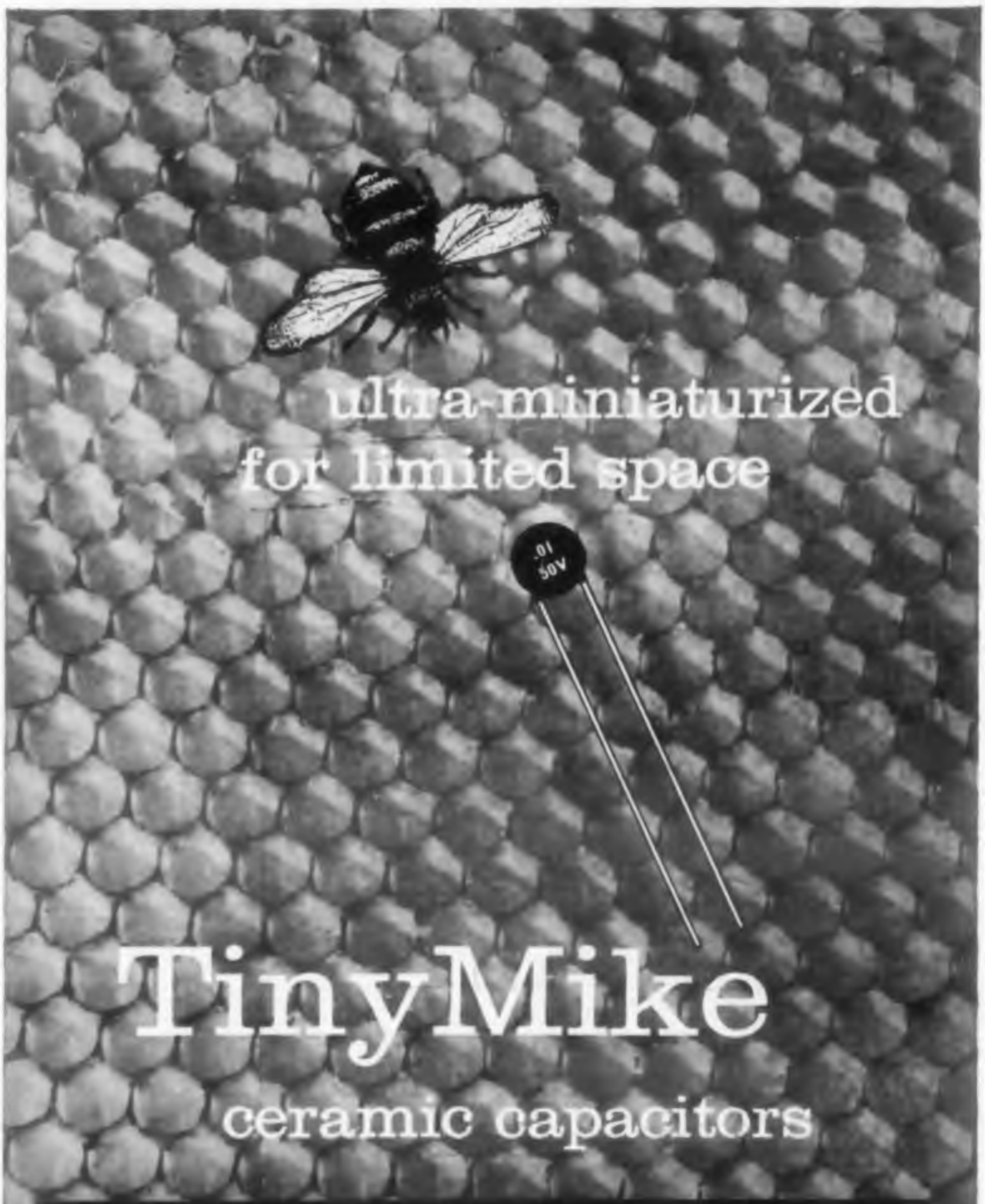
Ferromagnetic Materials

For high temperature use

"Ferrotron" nonmemory inductive ferromagnetic core materials are characterized by a positive Q coefficient and constant magnetic permeability. They have a volume resistivity of over 10^{10} ohm-cm, high dielectric strength, and low dielectric losses across the frequency spectrum. They also have high impact strength, with properties unaffected by moisture and aging. The cores have been tested successfully an antenna couplers at intermittent service temperatures up to 350 C, and after 100 hours at 275 C in atmospheric conditions, they changed less than 10% in Q and permeability. Production quantities are normally supplied as molded parts.

The Polymer Corporation of Pennsylvania, Dept. ED, 2140 Fairmont Ave., Reading, Pa.

CIRCLE 82 ON READER-SERVICE CARD



TINY MIKE®
"the ceramic with the million dollar body"

SPECIFICATIONS

Capacitance Values Available: .005, .01, .02, .05, and .1 mfd.

Diameters: .350" to .625" Working Voltage: 50 VDC

Crimped and Straight-Cut Leads for Automation. These units are available in 500 and 1000 VDCW units on types C, JA, JB, JC, BYA and other General Purpose capacitors. Leads are accurately spaced on these units for easy insertion into printed wiring boards. Crimped-lead units prevent bottoming on the printed wiring board assuring positive contact for soldering. Straight-cut leads save height off the board and may be inserted to circumference of disc.

Controlled phenolic dip avoids "rundown" of the phenolic on straight-cut leads. Assures always-uniform soldered connections.

Immediately available in production quantities!

Ideal for limited space and low-voltage requirements of portable radios and a variety of other miniature battery-powered and line-powered equipment. Excellent for bypass and coupling. Tough phenolic coating affords excellent insulation while protecting against severe humidity and vibration. For further information, write for Bulletin SEB-2 to Cornell-Dubilier Electric Corp., So. Plainfield, N. J.

Consistently Dependable
CORNELL-DUBILIER®
CAPACITORS

CIRCLE 83 ON READER-SERVICE CARD

Synchro and Resolver Bridge

Automatic

For testing synchros and resolvers, these bridges are mechanized by a rotary solenoid. They step to a new test point in response to an external pulse. The units meet MIL-S-20708 and SAE, ARP-461 specifications and have a maximum error of 10 sec of arc.

Theta Instrument Corp., Dept. ED, 48 Pine St., East Paterson, N.J.

CIRCLE 85 ON READER-SERVICE CARD

Analog Computing Component

Features tangent parabolic rounding

Model FF function fitter is a self-contained analog computing component for simulating arbitrary functions of an input voltage. It has 10 straight line segments with adjustable tangent parabolic rounding, and adjustable slopes, break points, and offset. Mounted on a 10.5 in. rack panel, the instrument uses 100 ma at ±300 v. and about 80 w at 115 v ac.

George A. Philbrick Researches, Inc., Dept. ED, 285 Columbus Ave., Boston 16, Mass.

CIRCLE 86 ON READER-SERVICE CARD

Miniature Connectors

Have locating center pin

These Belling & Lee miniature Domino connectors have a center guide pin to polarize the plug. Available are a 12 way type and two 8 way types one with all small pins and one with 4 small and 4 large. Surface and flush mounting metal shrouds accommodate one, two, or three connectors, providing a wide choice of arrangements.

Ercona Corp., Dept. ED, 16 W. 46th St., New York 36, N.Y.

CIRCLE 87 ON READER-SERVICE CARD

CIRCLE 88 ON READER-SERVICE CARD

Solenoid Valves

For missiles and aircraft

One of these solenoid valves features small size; the other, high speed. Designed for specific missile systems, they can be used for some aircraft. Miniature model 872071 has an operating pressure of 0 to 3000 psi, a temperature range of -75 to +350 F, and a flow equivalent to 0.05 orifice. Leakage is 3 cc per hr; operating current, 0.5 to 1.5 amp; and operating voltage, 14 to 30 v dc. Mounted by tubing support, the unit has a life of 100 to 10,000 cycles, depending on operating conditions. It is 5-5/8 in. high and weighs 0.19 lb.

High speed model 872458 has a response time of 0.018 sec, an operating pressure range of 80 to 3250 psi, a proof pressure of 4875 psi, and a burst pressure of 8125 psi minimum. Ambient temperature range is —65 to +160 F; flow factor, 1.37; voltage range, 18 to 30 v dc; current, 1.2 amp at 28 v and 80 F; and coil resistance, 21.5 to 24 ohms at 80 F. The unit weighs 1.4 lb.

Walter Kidde & Co., Inc., Dept. ED, 675 Main St., Belleville 9, N.J.

CIRCLE 263 ON READER-SERVICE CARD

Relays

Open or hermetically sealed

Available open or hermetically sealed, these relays have tapered arms and gold plated silver contacts. Type C.R. are rated at 5 amp with up to 4 pdt arrangements; type C.P. are rated at 10 amp, dpdt; and type C.S. operate in vacuum tube plate circuits down to 50 mw.

The Cardinal Control Co., Dept. ED, Meadow St., New Britain, Conn.

CIRCLE 264 ON READER-SERVICE CARD

Improve Your Memory

with a standard multiple purpose off-the-shelf drum

The 512-A Bryant general purpose magnetic storage drum meets the exacting requirements of a production component, yet has the versatility necessary for laboratory work. This standard 5" dia. x 12" long drum is stocked for immediate shipment, complete with standard components such as general storage brackets, recirculating register brackets and magnetic read/record heads. Its low price reflects the benefits of Bryant's 25 years' experience in the efficient design and production of high speed precision spindles.

Features:

- Guaranteed accuracy of drum run-out, .00010" T. I. R. or less
- Integral drive – Bryant precision motor (1200 to 12,000 R. P. M.)
- Capacities to 625,000 bits
- Accommodates up to 240 magnetic read/record heads
- High density ground magnetic oxide coating
- Super-precision ball bearing suspension
- Vertical mounting for trouble free operation

Special Models: If your storage requirements cannot be handled by standard units, Bryant will assist you in the design and manufacture of custom-made drums. Speeds from 60 to 120,000 R. P. M. can be attained, with frequencies from 20 C. P. S. to 5 M. C. Sizes can range from 2" to 20" diameter, with storage up to 6,000,000 bits. Units include Bryant-built integral motors with ball or air bearings. Write for Model 512-A booklet, or for special information.

Remember . . . you can't beat a Bryant drum!

BRYANT COMPUTER PRODUCTS DIVISION

BRYANT CHUCKING GRINDER CO.

P. O. Box 620-M, Springfield, Vermont, U. S. A.

CIRCLE 90 ON READER-SERVICE CARD

Impedance Comparator

Has four sensitivity ranges

Impedance comparator model 506 may be used to track potentiometers, to measure temperature coefficients, and to match and sort components. It compares resistors, capacitors, or inductors directly and without adjustment. Four sensitivity ranges enable it to measure impedance differences from a fraction of 1% to 20%, and a phase sensitive detector indicates the polarity as well as the magnitude of impedance differences. Because measurements are taken without adjustment of controls, the unit is suited for production line use. Standard models are available for indicating 1 to 1 and 2 to 1 impedance ratios.

Dytronics Co., Dept. ED, 78 Sunnyside Lane, Columbus 14, Ohio.

CIRCLE 91 ON READER-SERVICE CARD

Gyroscope

Spring driven

For use in short range missiles and target drones, this gyroscope supplies a potentiometer signal to control roll with ± 50 deg of freedom. It is energized by a spring which brings the rotor up to peak speed in a fraction of a second.

Waltham Precision Instrument Co., Dept. ED, Waltham, Mass.

CIRCLE 92 ON READER-SERVICE CARD

Silicon Power Rectifier

35 amp

Silicon power rectifier type 4A carries a full 35 amp load in half wave service and up to 100 amp in bridge circuits. With ratings from 50 to 400 piv in 50 v multiples, the units operate to 165 C.

Fansteel Metallurgical Corp., Dept. ED, 2200 Sheridan Rd., North Chicago, Ill.

CIRCLE 93 ON READER-SERVICE CARD

Printed Circuit

Have snap-in contacts

Series UPCR printed circuit receptacles are made with resilient beryllium-copper snap-in contacts and polarizing snap-in inserts that position the board precisely.

U.S. Components, Inc., Dept. ED, 454 E. 148th St., New York 55, N.Y.

CIRCLE 95 ON READER-SERVICE CARD

Tubeaxial Flow Fan

Delivers up to 430 cfm

Suitable for cooling electronic cubicles and flushing racks and cabinets, model Y1241-3 tubeaxial flow fan delivers 430 cfm at 1550 rpm. It has a 1/150 hp motor and operates from a 115 v, single phase, 60 cps source.

Air-Marine Motors, Inc., Dept. ED, 369 Bayview Ave., Amityville, N.Y.

CIRCLE 96 ON READER-SERVICE CARD

Dual Pentode

Flexible design

With two identical pentodes in one envelope, tube type 6DY7 can take the place of two audio output tubes. Designed for use in stereophonic and monaural systems, it can serve as one tube with each section operating class A; as two tubes with each operating in push pull between its sections; or as one tube in push pull, or two tubes push pull in parallel. When operated class AB push pull between its own pentode section at 250 v conditions, it can deliver 11 w of output at 2.5% total harmonic distortion. At 400 v conditions, it will deliver 20 w of output at 2% distortion. Operated class A, one section can deliver 5 w output at 9% distortion.

Sylvania Electric Products Inc., Dept. ED, 1740 Broadway, New York 19, N.Y.

CIRCLE 97 ON READER-SERVICE CARD

ENGINEERING UNLIMITED

AT ONE OF THE WORLD'S MOST SUCCESSFUL CORPORATIONS

Select Openings at National's NEW Engineering-Research Center at Dayton, Ohio

Long-range non-military projects with exceptional stability

COMPUTER ENGINEERS

Senior Systems Analysts—Require Senior Systems Analysts with strong theoretical and design knowledge in the electronic engineering field including familiarity with electronic and electro-mechanical digital machines. Should possess minimum of 3 years' experience with commercial application digital data processing equipment, however, would consider experience with scientific or defense application systems. Operational experience with a large data processing system is a distinct asset. Will be required to analyse and direct product improvement on large general purpose computer or small special purpose desk computer series. Advanced degree desired.

Senior Circuit Designers—Experienced in the design, development and analysis of transistorized computer circuits. Familiar with the application of magnetic cores to computer high-speed memory design. Growth opportunities involving decision making, concerning reliability, cost and component selection are offered. Advanced degree desired.

Senior Circuit and Logical Designers—Similar experience and duties as noted for Senior Circuit Designer, plus evaluation and de-bugging arithmatic and control areas of computer systems. Advanced degree desired.

DATA PROCESSING ENGINEERS

Senior Electronic Design Engineers—Experienced in development of logical design using standard computer elements, must also evaluate and design transistorized circuits including voltage regulated power supplies and circuitry related to decimal to binary coding. This data processing system is concerned with bank automation.

SEND RÉSUMÉ TO:

Mr. K. N. Ross
Professional Personnel Section C,
The National Cash Register Co.
Dayton 9, Ohio

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CIRCLE 871 ON READER-SERVICE CARD

Solenoid

6 msec response

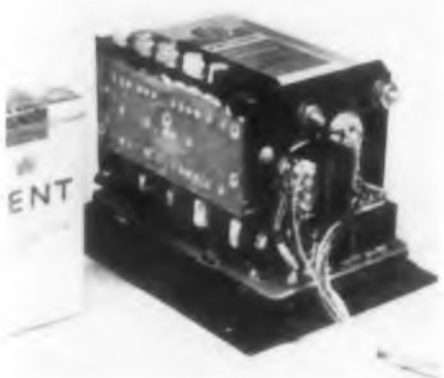
Model R.S. 5178 solenoid will operate with a 10 lb load. The stroke is 0.015 in., starting at a maximum of 6 msec and finishing at under 13 msec from circuit closing. The unit requires 20 v dc at 78 F and is designed to operate over an ambient range of −65 to +250 F. Case diameter is 1.063 in.; height, 1.41 in.

Telecomputing Corp., Dept. ED, 915 N. Citrus Ave., Los Angeles 38, Calif.

CIRCLE 106 ON READER-SERVICE CARD

Power Oscillators

±0.05 % regulation



Operating from 28 v dc, model P-300 transistorized power oscillator can deliver 40 va, 2 phase with an output frequency of 400 cps and a regulation of ±0.05%. The output remains constant with a line variation of up to 25%. Hermetically sealed, the unit has a temperature range of −55 to +75 C. With a weight of 3-1/4 lb and dimensions of 3 x 5 x 3-1/2 in., it is suited for use as a power supply in missile, aircraft, and radar computers.

Westamp, Inc., Dept. ED, 11277 Massachusetts Ave., Los Angeles 25, Calif.

CIRCLE 107 ON READER-SERVICE CARD

Electronic

INDUSTRIAL SALES, INC.

distributor of electronics to industry offers you all these

Texas Instruments semiconductors:

silicon transistors: 1-249

germanium transistors: 1-99

silicon diodes and rectifiers: 1-99

the industry's widest line off-the-shelf at factory prices for same day or overnight delivery

Electronic INDUSTRIAL SALES, INC.

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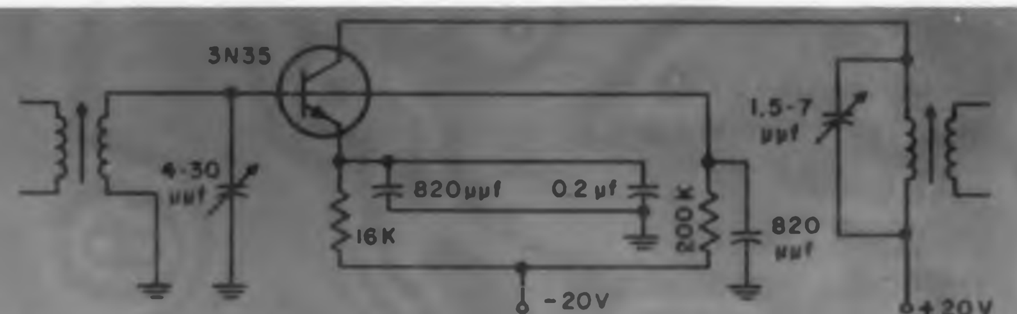
CIRCLE 300 ON READER-SERVICE CARD

CIRCLE 109 ON READER-SERVICE CARD ➤

105 db gain in 60 mc I-F strip

Six-stage, 90 db gain, silicon i-f amplifier designed and built by TI's Apparatus division.



One stage of 105 db gain, eight stage, 60-mc i-f strip.

Write on your company letterhead for 105 db gain, eight stage, 60-mc i-f amplifier applications brochure.

...with TI 3N35 silicon transistors

Actual Size

105 db I-F STRIP CHARACTERISTICS

Bandwidth: 20 mc at 3-db down

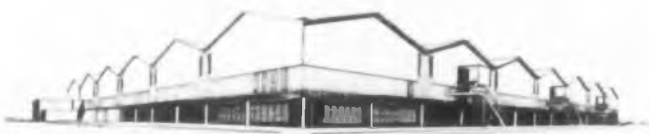
Center Frequency: 60 mc

No neutralization required

The high gain of TI 3N35 transistors at high frequencies permits mismatch in the interstage coupling networks to eliminate complicated neutralizing circuitry. You save extra component costs, design with ease and gain added reliability . . . because the mismatch in this application sacrifices only 2.55 db gain per stage!

Designed for your high frequency oscillators, i-f, r-f, and video amplifier circuits, the TI 3N35 features . . . 20-db power gain at 70 mc . . . typical 150-mc alpha cutoff . . . operation to 150°C. These characteristics make transistorization feasible for radar, communications, missile, and other high reliability military applications.

In commercial production at TI for two years, the 3N35 has a product-proved record of high performance and high reliability. These units are *in stock now!* For *immediate delivery*, contact your nearby TI distributor for 1-249 quantities at factory prices . . . or call on your nearest TI sales office for production quantities.



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TEXAS INSTRUMENTS
INCORPORATED
SEMICONDUCTOR-COMPONENTS DIVISION
POST OFFICE BOX 312 · 13500 N. CENTRAL EXPRESSWAY
DALLAS, TEXAS

NEW PRODUCTS

Electrostatic Voltmeter

Range of ±1000 v

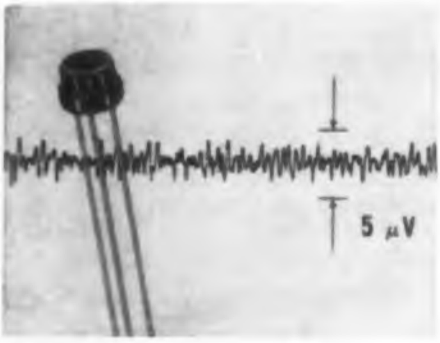
Model 107A feedback electrostatic voltmeter permits the measurement of the free space electrostatic potential of a small area without touching it. Range of the unit is ±1000 v and its bandwidth is from dc to 50 cps. Inherent error in the instrument is under 0.2% if the probe does not exceed 1/8 in. separation from surface. Drift is less than 5 v per day after a 2 hr warmup. A ±10% line voltage change produces a ±2.5 v drift.

Monroe Electronic Labs, Inc., Dept. ED, 5 Vernon St., Middleport, N.Y.

CIRCLE 110 ON READER-SERVICE CARD

Silicon Transistors

Low noise



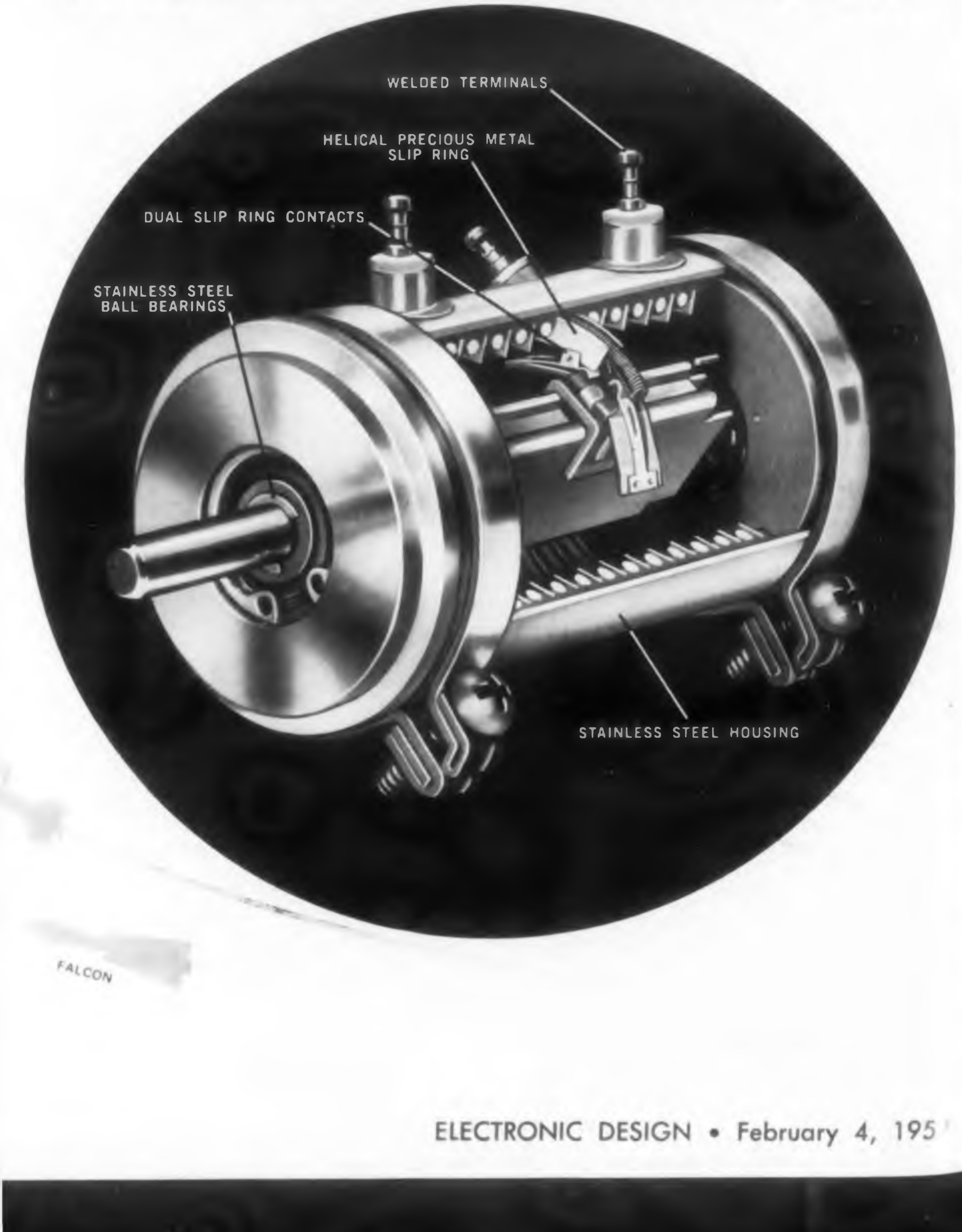
Type ST1050 and ST1051 npn silicon transistors feature low noise levels. Specified at frequencies from audio down to 1 cps, the ST1050 has equivalent input noise voltage of about 1 µv rms when used with low source impedances. It can be used with thermocouples, strain gages, accelerometers, and other devices in the 100 to 500 µa range. The ST1051 offers a low noise current of 0.05 mµa rms and is designed for use with high source impedances. It is suited for 20 to 50 µa operation.

Transitron Electronic Corp., Dept. ED, Wakefield, Mass.

CIRCLE 111 ON READER-SERVICE CARD

Proven in flight...

FAIRCHILD PRECISION



3-TURN High Reliability POTENTIOMETERS

This 7/8" dia. type 906 is one of three sizes offered by Fairchild. All feature exclusive long-life wiper guide mechanism.

SINGLE-TURN LINEAR AND NON-LINEARS

Type 751 7/8" dia. is one of 28 different types available in sizes up to 5". Functional accuracy over life is guaranteed — Fairchild's "Safety Factor" for reliability.

POTENTIOMETERS

LINEAR MOTION POTENTIOMETERS

The flexibility of the type 910 design permits 1 or 2 resistance elements, and various stroke lengths. MIL-E-5272A environments are exceeded for the Fairchild Reliability "Safety Factor".

SINGLE-TURN METAL FILMPOTS

Precious NOBL-OHM metal film resistance element offers infinite resolution, temperature operation to +225° C and low quadrature voltage.

Having missiles fire as predicted is becoming more and more vital to the defense program. The reflection of this is the increased importance of the Reliability factor, or in a phrase the *"Predictable Excellence"*, of components.

In the future less business will go to the unproven though low priced producer. Management has learned that the lowest initial cost does not always result in the lowest end cost.

Fairchild's precision potentiometers are *proven performers*. They are flying with *predicted excellence* in the nation's most important missiles and aircraft, some of which are illustrated above. They have a reputation for sustained high accuracy, lowest noise level and long life. As a result, Fairchild Reliability is fast becoming an industry standard.

For example, Fairchild High Reliability pots contain only high temp stabilized materials, welded terminations, and precious metal contacts. They are built to close dimensional and design control. And they are subjected to a continuing inspection and quality control program which includes torture testing 1 out of every 100 production units.

For more information write Dept. 26ED

RELIABILITY INSIDE THE BLACK BOX

FAIRCHILD CONTROLS CORPORATION

COMPONENTS DIVISION

225 Park Avenue, Hicksville, L. I., N. Y. : 6111 E. Washington Blvd. Los Angeles, Cal.

A Subsidiary of Fairchild Camera and Instrument Corporation

GYROS
PRESSURE TRANSDUCERS
POTENTIOMETERS
ACCELEROMETERS

CIRCLE 112 ON READER-SERVICE CARD

Trimming Potentiometer

Operates at 1 w to 125 C

Comp-U-Trim model E trimming potentiometer is a wirewound linear unit with an internally positioned wiper contact and zero per cent end resistance. Fully encapsulated in a one piece aluminum housing 5/16 x 1/4 x 1-1/4 in., it can be mounted singly or stacked. Designed to operate at 1 w at temperatures up to 125 C, the unit is available in standard resistance values from 10 ohms to 30 K. It has a temperature coefficient of 20 ppm.

Eastern Precision Resistor Corp., Dept. ED, 675 Barbey St., Brooklyn 7, N.Y.

CIRCLE 113 ON READER-SERVICE CARD

Precision Power Oscillator

For airborne use

Designed for shock-mounted installation in aircraft and missiles, model DK1-102A precision power oscillator has a 2 w output. It can serve as a power supply for control equipment, gyroscopes, synchros, and servos. With an input source of 50 to 800 cps, 115 v ac, it is also adaptable to ground support systems. Built to meet or exceed MIL-E-4158A specifications, the unit has a maximum total harmonic distortion of 0.1%, a frequency stability of 0.1%, and an amplitude regulation of 0.2% under all conditions of line and load. Dimensions are for standard 1/2 ATR rack installation.

Electronics International Co., Dept. ED, 145 W. Magnolia Blvd., Burbank, Calif.

CIRCLE 114 ON READER-SERVICE CARD

NEW PRODUCTS

Digital Readout

In-line in-plane

Using selective group switching, model SGS-101 in-line in-plane digital readout consists of a resistor matrix and neon bulbs with printed circuit plug-in connectors. Other terminations may be ordered. The characters, 1/2 x 7/8 in., can be easily read in bright ambient light and from angles of 150 deg. The units can accommodate an input range of 150 to 350 v and consume a maximum of 1 w per digit at 150 v. Each digit occupies 1 x 1-3/4 in. of panel space.

I.D.E.A., Inc., Electronic Equipment Div., Dept. ED, 7900 Pendleton Pike, Indianapolis 26, Ind.

CIRCLE 116 ON READER-SERVICE CARD

Transistorized Scaler

0.5 μsec resolving time

Transistorized scaler model 49-21 has a 0.5 μsec resolving time, excluding register. Its maximum count capacity is 10^8, and its amplifier sensitivity is 1 mv with a gain of 1000. The unit has a fixed amplitude discriminator, a fully transistorized digital readout system, and a nonoverloading amplifier. The decades and register reset electrically and have provision for local or remote operation. Accessory transistorized preamplifiers are available to match the low input impedance of the amplifier to any type of detector. Plug-in power supplies can be obtained to operate the unit from any type of input power. The scaler has printed circuitry throughout.

Radiation Instrument Development Lab., Inc., Dept. ED, 5737 S. Halsted St., Chicago 21, Ill.

CIRCLE 117 ON READER-SERVICE CARD

Nickel Cadmium Button Cells

For minimum power use

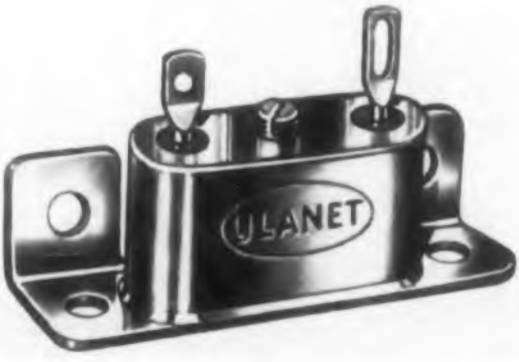
Button cells for minimum power requirements, models VO. 180 and VO. 100 are 7/8 in. in diameter and weigh 1/4 oz. Rechargeable and hermetically sealed, these sintered-plate nickel cadmium units have a long, maintenance free life and are nongassing upon recharge. They require no filling or electrolyte and operate at normal temperature ranges. Of rugged construction, they have a low internal resistance which allows discharge currents up to 10 times capacity. Combined into compact cylindrical stacks, the cells can form batteries of any desired voltage. They are recharged by a constant current equal to 1/10 of their normal capacity. With proper charging rates, they can be charged indefinitely without damage.

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

CIRCLE 120 ON READER-SERVICE CARD

Miniature Thermostat

Hermetically sealed



Measuring 1.3 x 0.594 x 0.375 in., this hermetically sealed thermostat was designed to meet stringent aircraft and missile requirements. It will control non-inductive loads up to 5 amp at 115 v ac. For dc application, a suitable capacitor must be placed across its terminals. Terminal and mounting arrangements are flexible to meet any particular requirements.

George Ulanet Co., Dept. ED, 413 Market St., Newark 5, N.J.

CIRCLE 121 ON READER-SERVICE CARD

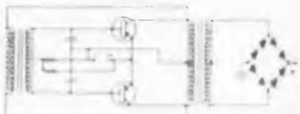
MINIATURE TRANSISTOR TRANSFORMERS from stock!

MICROTRAN transistorized transformers are ruggedized, military-type components developed to meet the growing demand for miniaturization. Design and performance meets or exceeds all applicable commercial and government specifications including MIL-T-27A, MIL-T-9219, AN-E-19, CAA-R-9786, MIL-E-5400, MIL-E-16400, MIL-E-4158, MIL-E-8189A, MCREE-553, MIL-T-945A. Available for immediate delivery from Franchise Stocking Distributors.

DC-DC CONVERTER

All Items Designed for 13.6V Except 8034 which is for 28V Input

TYPICAL DC DC CONVERTER CIRCUIT



Part Number	Total V.A. Output	D.C. Output F. W. Bridge Volts	Ma	C.T. Full Wave Volts	Ma.
M8034	125	500	250	250	420
M8035	125	500	250	250	420
M8036	40	450	90	225	155
M8037	22 5	250	90	125	155

TRANSISTOR DRIVER

Designed specifically for transistor, servo and audio

Frequency response 70-20K

Size AF mill through AH Hermetically sealed to MIL T 27A

EPOXY MOLDED See catalog for exact sizes and weights

ON SPECIAL ORDER ONLY

Part Number	Application	Pri. Imp.	Sec. Imp.	Pri. D.C. Unbal Ma.	Level Watts
M8002*	Coll. to P.P Emit	560	400 C.T	18	.15
M8003*	Coll to P.P. Emit	625	100 C.T.	20	1.5
M8004	Coll to P.P Emit	5,400	600 C.T	15	.075
M8005	Coll to P.P. Emit	7,000	320 C.T	7	.040
M8006	Coll to P.P Emit	10,000	6,500 C.T	.75	.005

*Bi-Filar wound to minimize switching transients

TRANSISTOR OUTPUT

Frequency Response 200-15,000 ~

See catalog for case size

Part Number	Application	Pri. Imp.	Sec. Imp.	Level Watts
M8008	P P Output to Spkr	25	3.4	3
M8007*	P P Auto Transf	30 C T	4	2
M8009	P P Output to Spkr	48 C T	3.2 8	5
M8010	P P Coll. to Servo	120 C T	1,000	6
M8011	P P Output to Spkr	125 C T	3.4	1.5
M8012*	P P Coll to Servo	140 C T	500	6
M8013*	P P Output to Spkr	250 C T	3.4	4
M8014	P P Output to Spkr	400 C T	11	25
M8015	P O Coll to Servo	1,600 C T	800	2.5
M8016	P O Output to Spkr	2,550 C T	12	10

*Bi-Filar wound to minimize switching transients

LOW LEVEL CHOPPER

Efficiently transfers 30 to 500 cps Transducer or Thermocouple signals to instrument amplifiers Signal level range from 5μV to 5 volts Resin impregnated to minimize mechanical vibration noise signal Low hum pick up assured by 3 mu metal and 2 copper shields

Part Number	Turns Ratio Full Pri. To Full Sec.	½ Pri. To Full Sec.	Ind of Full Pri @ .5V 60 Cycles	Imped of Full Pri. @ .5V 60 Cycles
M8025	1:7.7	1:15.4	17 5	6,600
M8026	1:3.2	1: 6.4	60 Hy	22,500

Part Number	D.C. Resistance Full Pri.	Sec.	Mag Shield	Hght	Dia.	Wt. Oz.
M8025	365	4140	90 DB	1 25/32	1 3/8 D	4 5
M8026	455	3500	90 DB	1 25/32	1 3/8 D	4 5

SILICON RECTIFIER
Power Supply

Circuitry Primary 105 115 125 Volts**, Hermetic sealed to MIL T 27A

See Catalog for additional information

Part Number	Secondary A.C. Volts	Rectifier Circuit R.M.S. Amperes	C.T.** Full Wave	F.W.** Bridge
M8018*	18.5 C.T.	1	7V	14V
M8019*	18.5 C.T	3	7	14
M8020*	35 C.T	3	14.5	29
M8021*	70 C.T	1	30	60
M8022†	18.5 C.T	3	7	14
M8023†	35 C.T	3	14.5	29
M8024†	70 C.T	1	30	60

*380-1600 Cy
†50-60 Cy

**DC output volts stated are for resistive or inductive loads Capacitor input may be used if RMS AMPS is not exceeded

ULTRA MINIATURE TRANSISTOR

Wt .08 oz size 3/8" x 3/8" x 11/32" Nylon Bobbin, Nickel Alloy Core 4 color coded leads, resin impregnated Encapsulated on special order

Part Number	Application	Primary Impedance (D. C.)	Secondary Impedance
UM 21 F	Input	100,000	1,000
UM 22 F	Driver	20,000	1,000
UM 23 F	Driver	20,000	1,200 C T
UM 24 F	Output	1,000	50
UM 25 F	Output	400	50
UM 26 F	Output	400	11
UM 27 F	Output	400 C T	11
UM 28 F	Choke	10 Hy (0 dc)	8 Hy (5 ma) 650

MICROTRAN company, inc.

Write TODAY for catalog and price list of the complete MICROTRAN line

145 E. MINEOLA AVE., VALLEY STREAM, N. Y.

CIRCLE 122 ON READER-SERVICE CARD

NEW PRODUCTS

Solid Tantalum Capacitors

Operate at 125 C

Miniature STA solid tantalum capacitors can now be supplied in ranges of 0.0047 to 330 μf from 6 to 60 wvdc. Their operating temperature range is −55 to +125 C. The units come in four case sizes and a wide range of ratings with 20% decade, 20% tolerance systems and 10% decade 10% tolerance systems. Suited to transistor circuitry, they may be used in computers, data processing systems, guidance systems, airborne electronic equipment, and telemetering devices. They consist of a porous tantalum anode with a formed tantalum oxide dielectric, sealed in a silver-plated metal case. A glass-to-metal seal affords protection against moisture or low pressures. The units contain no volatile materials and no liquid or paste electrolyte. Electrical leakage is held to a minimum, and mechanical leakage and corrosion are eliminated.

Fansteel Metallurgical Corp., Dept. ED, North Chicago, Ill.

CIRCLE 124 ON READER-SERVICE CARD

Motor Generator

Size 11

Motor generator model 11GM152 is a size 11 400 cps unit designed to operate between 6 and 200 v. It has an effective resistance of 3780 ohms and a no load speed of 6000 rpm with a power input of 3.5 w at 0.053 amp. Linearity is 0.5% and ambient operating range is −65 to +200 C. The generator gradient is 0.5 v per 1000 rpm and has a total null of 0.012 v. The unit is 1.875 in. long and meets MIL-T-5422C and MIL-E-5272A environmental tests. It also conforms to Bu[illegible] specification MIL-S-15087. Output shafts are designed to customer requirements.

Servo Dynamics Corp., Dept. ED, Somersworth, N.H.

CIRCLE 125 ON READER-SERVICE CARD

NEW PRODUCTS

Precision Resistors

In matched sets

In a wide range of values, these precision resistor sets and networks have ratios matched within 0.001% and absolute values matched within 0.01%.

Ultronix, Inc., Dept. ED, 116 S. Bayshore Blvd., San Mateo, Calif.

CIRCLE 128 ON READER-SERVICE CARD

MINIATURE ADJUSTMENT POTENTIOMETER —Model 207 Hi-R Trimpot has a fused element to terminal bond which is virtually indestructible under thermal or mechanical stress. Resistance is 100 K maximum operating temperature, 175 C; power rating, 2 w at 50 C. A rheostat version, model 208, has resistances to 200 K.

Bourns Labs, Inc., Dept. ED, P. O. Box 2112, Riverside, Calif.

CIRCLE 129 ON READER-SERVICE CARD

ELECTRICAL POWER TESTER.—Portable model 87 (TS-913( )/U) can be used to adjust signal power for the calibration of transmission equipment. Frequency range is 10 cps to 1 mc; input impedance 700 ohms; output impedance, 135, 150, and 600 ohms. Input power range is 0 to +30 dbm, output power range, 0 to −70 dbm, +10 to −60 dbm, and +20 to −50 dbm.

The Daven Co., Dept ED, Livingston, N.J.

CIRCLE 130 ON READER-SERVICE CARD

VERNIER MAGNIFIER.—For more accurate reading of all vernier scales, unit has clear plastic body to admit available room light. Two permanent Alnico magnets embedded in the base attach to metal scales.

Bausch & Lomb Optical Co., Dept. ED, Rochester 2, N.Y.

CIRCLE 131 ON READER-SERVICE CARD

RADIO INTERFERENCE FILTER.—Rated to 2 amp at 28 v dc and 105 C, model 5833 will filter most dc motors to MIL-I-6181B requirements. Case is 9/16 in. in diameter, 1-5/8 in. long.

Double E Products, Dept. ED, 208 Standard St., El Segundo, Calif.

CIRCLE 285 ON READER-SERVICE CARD

DIGITAL TACHOMETER.—The Dynacounter covers engine speeds from 1.5 to 50,000 rpm and reads speed to 1 revolution in 0.1 sec, within 10 rpm in 0.01 sec. Direct digital readout, provided by Nixie in-line neon tubes, is visible 75 ft away.

Dynapar Corp., Dept. ED, 5150 Church St., Skokie, Ill.

CIRCLE 132 ON READER-SERVICE CARD

ND 9 PIN HEADERS.—For vacuum tube use, e units have tantalum pins with nickel braze hermetically sealed to an AlSiMag alumina mic base and envelope.
merican Lava Corp., Dept. ED, Manufacturers Chattanooga 5, Tenn.

CIRCLE 133 ON READER-SERVICE CARD

PLACEABLE-LAMP INDICATORS.—E-Lite es IDH units are available with or without current limiting resistors. Lamps are neon or incandescent, cases are 3/8 in. in diameter.
ildena Corp., Dept. ED, 1805 Belcroft Ave., El Monte, Calif.

CIRCLE 134 ON READER-SERVICE CARD

PULSE GENERATOR.—Redesigned model 2120A has modernized panel layout and controls, printed circuit construction.
Electro-Pulse, Inc., Dept. ED, 11861 Teale St., Culver City, Calif.

CIRCLE 135 ON READER-SERVICE CARD

20 IN. VARIABLE SCALE.—Model TP0072008 saves time in reading oscillograms and telemeter data. It also saves time in plotting graphs and curves, especially in the direct multiplication and division of graphical functions and the reading thereof.
The Gerber Scientific Instrument Co., Dept. ED, 89 Spruce St., Hartford 1, Conn.

CIRCLE 136 ON READER-SERVICE CARD

GLASS TO METAL SEALS.—For multiple headers, transistor closures, crystal bases, single terminals, and diodes.
Palmer Associates, Dept. ED, 55 Hall St., Brockton, Mass.

CIRCLE 137 ON READER-SERVICE CARD

MOMENTARY CONTACT SWITCH.—Series 1901 units, rated at 30 amp, are available in spdt, spst normally open, spst normally closed, and spst two circuit models.
McGill Mfg. Co., Inc., Electrical Div., Dept. ED, Valparaiso, Ind.

CIRCLE 138 ON READER-SERVICE CARD

DIFFERENTIAL PRESSURE TRANSMITTER.—Model 70-2900 has 0.2% accuracy, infinite resolution, and zero output preset at any range point. Pressure ranges are between 0 to 100 and 0 to 3000 psi with differentials up to 100% of range. Inputs are 6.3 v or 115 v ac, outputs are 50 mv dc or 5 v ac or dc.
International Resistance Co., Computer Components Div., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

CIRCLE 139 ON READER-SERVICE CARD

CIRCLE 140 ON READER-SERVICE CARD

NEW PRODUCTS

MINIATURE PULSE TRANSFORMER KIT.—Consists of ten three-winding transformers that provide 0.1 to 10 μsec pulse widths. Permits 20 different ratios from 1:1:0.1 to 1:1.5. Units plug into standard miniature 9-pin tube sockets.

New York Transformer Co., Dept. ED, Alpha N.J.

CIRCLE 142 ON READER-SERVICE CARD

TELEPHONE RELAY.—Modified type TS has up to 20 bifurcated contact arms and can operate on 100 mw per movable arm. It is supplied for operating voltages to 110 v dc and switches up to 4 amp at 115 v ac, 60 cps, resistive loads.

Potter & Brumfield, Inc., Dept. ED, Princeton Ind.

CIRCLE 143 ON READER-SERVICE CARD

TEST POINT JACK.—Less than 1/8 in. in diameter and 1/4 in. long, Press-Fit type SKT-13C1 accommodates a 0.04 in. diameter probe. Voltage rating is 750 v rms or 3000 actual flashover at sea level, 1300 v rms flashover at 50,000 ft.

Sealectro Corp., Dept. ED, 610 Fayette Ave. Mamaroneck, N.Y.

CIRCLE 144 ON READER-SERVICE CARD

RETAINING RINGS.—These Truarc rings are made of Armco Type PH 15-7 stainless steel alloy. This material provides high corrosion resistance at temperatures to 1000 F.

Waldes Kohinoor, Inc., Dept. ED, 47-16 Austel Pl., Long Island City 1, N.Y.

CIRCLE 145 ON READER-SERVICE CARD

PURE SILICON.—Available from stock, Transcu Grade 1A polycrystalline silicon permits production of special devices on a practical basis using standard crystal growing techniques.

The Bresnick Co., Inc., Dept. ED, 216 Tremont St., Boston 16, Mass.

CIRCLE 146 ON READER-SERVICE CARD

7-PIN POWER PENTODES.—Types 6-, 12-, 25-, and 50EH5 power amplifiers offer high power sensitivity at low plate and screen supply voltages. With a 3 v peak af input, they provide 1.4 w with 110 v plate and 115 v screen supply voltage.

CBS-Hytron, Dept. ED, Danvers, Mass.

CIRCLE 147 ON READER-SERVICE CARD

HOOK-UP WIRE.—Extruded polyvinyl chloride wire types B, C, and D are rated at 600, 1000, and 3000 v, respectively. All conform to MIL-W-16878 B and operate from −55 to +105 C.

American Super-Temperature Wires, Inc., Dept. ED, 2 W. Canal St., Winooski, Vt.

CIRCLE 148 ON READER-SERVICE CARD

AL STRIP.—Low cost Thermo-Lay can be ped, drawn, formed, soldered, brazed, or d, is suitable for contact wiping arms, switches, ct points and springs, flexible wave guides, nals, and tuners. In 1/16 to 10 in. widths; 0.001 125 in. thicknesses.

merican Silver Co., Dept. ED, 36-07 Prince St., hing 54, N.Y.

CIRCLE 149 ON READER-SERVICE CARD

LOSION PROOF FOOT SWITCHES.—UL ap- ed single and double pedal units for operating tronic equipment in the presence of explosive s. For 125 v ac operation, they are rated at 15 per switch.

The Birtcher Corp., Industrial Div., Dept. ED, Valley Blvd., Los Angeles 32, Calif.

CIRCLE 150 ON READER-SERVICE CARD

PICKUP FOR SMALL PARTS.—The Vac-U-Grip plies suction to pick up miniature parts, releases it to lay them down when they are properly positioned. It is controlled by a foot switch.

Carman Labs, Dept. ED, P.O. Box 328, Bedford, Mass.

CIRCLE 151 ON READER-SERVICE CARD

CRYSTAL HOLDER.—Socket assembly for HC-6 U and HC-13 U standard size crystal cans. Two Teflon insulated jacks with silver plated, gold flashed contacts are press fitted into the assembly to receive the crystal pins. For horizontal or vertical mounting. Units for printed circuit use are also available.

Augat Bros., Inc., Dept. ED, 33 Perry Ave., Attleboro, Mass.

CIRCLE 152 ON READER-SERVICE CARD

CLAMP-ON GEARHEAD.—Servo motor gearhead 750GH adapts instantly to size 8 motors with double-lipped clamp. It can be installed with the tightening of one screw. The unit eliminates internal post type construction.

Bowmar Instrument Corp., Dept. ED, 8000 Bluffton Rd., Fort Wayne, Ind.

CIRCLE 153 ON READER-SERVICE CARD

MOLDING RESIN.—Teflon 7 TFE-fluorocarbon resin can be made into void free moldings and electrical tape 1 mil thick. It provides uniform density throughout complex molded parts.

E. I. du Pont de Nemours & Co., Dept. ED, Parkersburg, W. Va.

CIRCLE 154 ON READER-SERVICE CARD

SOLID FILM LUBRICANT.—Semiporous No. 4856 absorbs oil and acts as a reservoir against metal to metal contact under high loads.

Electrofilm, Inc., Dept. ED, P.O. Box 106, North Hollywood, Calif.

CIRCLE 155 ON READER-SERVICE CARD

KEEP UP-TO-DATE ON MAGNETICS

See the air-gap on this new lamination for miniaturization

Look at the air-gaps on this new performance-guaranteed lamination we have developed and are stocking. The F-187's fixed air-gap provides constant inductance or linear inductance, as needed, because it prevents d-c saturation of the stacked core.

The F-187 3/16" wide center leg is designed for miniaturized filter circuits for communication applications. It is ideal for carrier equipment, and can be used most successfully for microwave, computer or other applications where frequency control is critical.

Being an "F" shape, the new standard stacks more easily than EI-187, and thus offers welcome savings on the production line. There can be advantages to you, too, in being able to order any quantity, prototype or production, directly from stock.

There's more detailed information on this new member of Magnetics, Inc. family of "Performance-Guaranteed" laminations—and all of our other standard laminations. Just write—*Magnetics, Inc., Dept. ED-49, Butler, Pa.*

MAGNETICS inc.

CIRCLE 156 ON READER-SERVICE CARD

NEW PRODUCTS

SHIELDED COIL FORMS.—Series 2585 and 2590 variable type and series 2685 and 2690 fixed type are available with paper phenolic, Polypenco, or Kel-F coil forms. The terminal boards at the bottom of the forms are available with 2, 3, 4, 5, or 6 split solder terminals.

Cambridge Thermionic Corp., Dept. ED, 445 Concord Ave., Cambridge 38, Mass.

CIRCLE 158 ON READER-SERVICE CARD

FILLED TEFLON BEARING MATERIALS.—Suitable for molded and machined spacers, inserts, connectors, and other parts used in high voltage, high frequency, and high temperature electronic equipment, wires, and cables. Respectively, styles FM-2 through 5 and 8 through 10 are filled with glass, carbon, glass and carbon, ceramic, graphite and zircon, molybdenum-disulphide and glass, and mica.

Chemical & Power Products, Inc., Dept. ED, 11 Broadway, New York 4, N.Y.

CIRCLE 159 ON READER-SERVICE CARD

PRECISION COMPRESSION SPRINGS.—For instrument and control use, Herringbone and Gimbal springs have no shift-producing twist or turning moment between end faces. Spring rate is uniform from zero load up, and all tendency to cock is eliminated by symmetric application of force.

Consolidated Controls Corp., Dept. ED, Bethel, Conn.

CIRCLE 160 ON READER-SERVICE CARD

COPPER SEALING GLASS.—Pressed and sintered Code 7295 Multiform glass can be hermetically fused directly to copper. Working point is 665 C; softening point, 465 C; annealing point, 366 C; strain point, 344 C. Log volume resistivity at 250 C is 6.7 ohm-cm; at 350 C, 5 ohm-sm.

Corning Glass Works, Dept. ED, Corning, N.Y.

CIRCLE 161 ON READER-SERVICE CARD

HIGH VACUUM VALVE.—Leak rate of this 36 in. diameter valve is less than 0.1 micron cu ft per hr. The unit is suited for space environment test chambers and production vacuum melting furnaces.

NRC Equipment Corp., Dept. ED, 160 Charlemont St., Newton 61, Mass.

CIRCLE 162 ON READER-SERVICE CARD

GREASELESS BEARINGS.—Made of a Union Carbide fabric impregnated with Bakelite phenolic plastic, Ruslon bearings need no lubrication. Applications range from miniature instruments to hydroelectric stations.

Russell Mfg. Co., Dept. ED, Middletown, Conn.

CIRCLE 163 ON READER-SERVICE CARD

IATURE LOCKING DRIVE PINS.—These units replace plain pins or bent wire fasteners in coning or locking miniature parts. With diameters 32 in., they have 1/8 to 1/2 in. lengths held to nces of ±0.001 in.

rows Pin Corp., Dept. ED, 1125 Hendricks eway, Ridgefield, N.J.

CIRCLE 164 ON READER-SERVICE CARD

GGLE SWITCH.—Series 1500 spst units are d at 3 amp, 250 v or 6 amp, 125 v. Available in bushing lengths with wire leads, screw terminals, er lugs, or quick disconnect tabs. UL and CSA roved.

rgent Electric Corp., Dept. ED, 630 Merrick Lynbrook, N.Y.

CIRCLE 165 ON READER-SERVICE CARD

TRANSISTOR BATTERY HOLDERS. Series BH 00 units hold batteries and cells up to 11/16 in. in diameter and 1-19/64 to 5-55/64 in. long. They mount in a 7/8 in. diameter panel hole.

Security Devices Lab, Dept. ED, Rochester 21, N.Y.

CIRCLE 166 ON READER-SERVICE CARD

PHONOGRAPH CARTRIDGE.—The M7D-M plays monaural and stereophonic records, provides channel separation of 20 db. Tracking force is 3 to 6 g, frequency response is flat from 20 cps to 15 kc.

Shure Brothers, Inc., Dept. ED, 222 Hartrey Ave., Evanston, Ill.

CIRCLE 167 ON READER-SERVICE CARD

LINE CLAMP PLIERS.—Handling single or multiple clamps, model 82 pliers simultaneously hold the clamp bolt and compress the line clamp, and then hold them in closed position, freeing both the operator's hands to apply the nut.

TV Mfg. Corp., Dept. ED, 4607 Alger St., Los Angeles 39, Calif.

CIRCLE 168 ON READER-SERVICE CARD

TUBE CHECKER KIT.—In kit form, type 400 tube tester checks for filament continuity, shorted elements, and cathode emission. For 400 tubes including high fidelity, radio, and TV receiving types, it has sockets for 7 and 9 pin miniature, and octal and loctal-base tubes. Dimensions are 2-3/8 x 9-1/2 x 8 in.

Allied Radio Corp., Dept. ED, 100 N. Western Ave., Chicago 80, Ill.

CIRCLE 169 ON READER-SERVICE CARD

TITANIUM FOIL.—Nonmagnetic, corrosion resistant foil in 0.01 to 0.000125 in. gages. Available in widths to 5 in. in thinner gages; to 36 in. in gages above 0.002 in.

Titanium Metals Corporation of America, Dept. ED, 233 Broadway, New York 7, N.Y.

CIRCLE 170 ON READER-SERVICE CARD

NEW PRODUCTS

DOUBLE FOOTSWITCH.—Model D-AT comes in more than 10 different switch ratings from 7 to 17 amp. Available in a variety of arrangements.

Vemaline Products Co., Dept. ED, P.O. Box 22, Hawthorne, N.J.

CIRCLE 173 ON READER-SERVICE CARD

SOLID STATE COMMUTATOR.—For airborne telemetry, this unit has a temperature stability of 0.25% from 20 to 100 C. It withstands 100 g shock and 20 g vibration at 2000 cps. Size is 24 cu in.; weight, 1.5 lb; overall accuracy, 1%.

Data-Control Systems, Inc., Dept. ED, Danbury, Conn.

CIRCLE 174 ON READER-SERVICE CARD

COINCIDENCE UNIT.—Self-contained model 101N features direct drive from photomultipliers, input limiting, and an ultimate resolution of 3 musec. The coincidence criterion is set by a variable discriminator in a slow channel. Units may be stacked via a fast coincidence output.

E-H Research Labs, Dept. ED, 2161 Shattuck Ave., Berkeley 4, Calif.

CIRCLE 175 ON READER-SERVICE CARD

CURRENT INDICATOR AND INTEGRATOR.—Designed particularly for use with high-voltage particle accelerators, model A309 covers current ranges from 1 ma to 3 mua in 12 switch settings. It will measure total charge collected in a given time and can be preset to operate an alarm or other auxiliary equipment.

Elcor, Inc., Dept. ED, 1225 W. Broad St., Falls Church, Va.

CIRCLE 176 ON READER-SERVICE CARD

BATTERY CHARGERS.—Silicon rectifying units which automatically maintain the proper charging voltage in batteries with 11 to 62 cells. Single-phase units can be operated at 115 or 230 v; three-phase units at 230 or 460 v. Output range is 1 to 400 amp.

The Electric Storage Battery Co., Exide Industrial Div., Dept. ED, Rising Sun and Adams Aves., Philadelphia 20, Pa.

CIRCLE 177 ON READER-SERVICE CARD

PORTABLE FILM PROCESSOR.—The Mini-Rapid 35 automatically processes 35mm film at speeds to 6 ft per min. It can handle 400 ft of leaderless film at one loading. Designed for application in missile tracking, data recording, and general engineering photography, it operates in daylight and uses [illegible] size film spool.

Fairchild Camera and Instrument Corp., Industrial Products Div., Dept. ED, 5 Aerial Way, Syosset, N.Y.

CIRCLE 178 ON READER-SERVICE CARD

...ET DRAWING KIT.—Case is 6-1/4 x 3-1/2 ...l contains 6 in. bow compass and 5-1/2 in. ... divider.
...n & Co., Inc., Dept. ED, Windsor, Conn.

CIRCLE 179 ON READER-SERVICE CARD

EL...TRONIC DATA READER.—Model R-2E fa... ...s the reading and scanning of oscillograms. ... ...ds amplitudes of one or more channels; fre... ...ies directly in cps, rpm, or as required, and ... ...tudes corrected by scale factors directly. It will ... timing lines into any number of equal inter... ...nd can be used as an X-Y reading system.
...Gerber Scientific Instrument Co., Dept. ED, ...ruce St., Hartford 1, Conn.

CIRCLE 180 ON READER-SERVICE CARD

CUSTOM CABINETS.—Aluminum alloy units built from standard stock parts, these cabinets comply with MIL-T-17113 and comparable specifications. They have built-in cooling ducts, protected harness ways, and shock mounts as required.
Aircraft Armaments, Inc., Dept. ED, Cockeysville, Md.

CIRCLE 181 ON READER-SERVICE CARD

CONNECTOR-CABLE ADAPTER SLEEVES.—Type GI adapters can be used where there is insufficient room in an AN type backshell. They will adapt any AN connector to any size AN type clamp.
Glenair, Inc., Dept. ED, 1401 Air Way, Glendale 1, Calif.

CIRCLE 182 ON READER-SERVICE CARD

DIGITAL INDICATOR AND PRINTER.—Model 176 permanently records weight, strain, temperature, pressure, and other variables which can be measured by sensitive bridge-type transducers. Data appears on a digital indicator and on printed tape.
Gilmore Industries, Inc., Dept. ED, 13015 Woodland Ave., Cleveland 20, Ohio.

CIRCLE 183 ON READER-SERVICE CARD

HIGH-FIDELITY SPEAKER.—For use in stereophonic and monaural music systems, 8 in. speaker model KN-808 has 40 cps to 12 kc frequency response and handles 15 w of program material. It may be used as an extension speaker or as a replacement to improve fidelity of TV sets.
Allied Radio Corp., Dept. ED, 100 N. Western Ave., Chicago 80, Ill.

CIRCLE 184 ON READER-SERVICE CARD

9-PIN MINIATURE TUBE.—Model 7199 is designed for use in tone-control, phase-splitter, and high gain voltage amplifier circuits. It contains a medium-mu triode and a sharp cut-off pentode in one envelope. Pentode transconductance is 7000 umhos, and triode amplification factor is 17.
Radio Corporation of America, Electron Tube Div., Dept. ED, Harrison, N.J.

CIRCLE 471 ON READER-SERVICE CARD

NEW LITERATURE

Miniature Transformers 188

A 24-page catalog describes line of miniature, subminiature, transistor, MIL-T-27A, and industrial transformers. Features new transistor transformers including dc to dc converters, silicon rectifier-power units, and driver, input, output, and chopper transformers. Mr. Harold Edelstein, Microtran Co., Inc., 145 E. Mineola Ave., Valley Stream, N.Y.

Assembly Kit 189

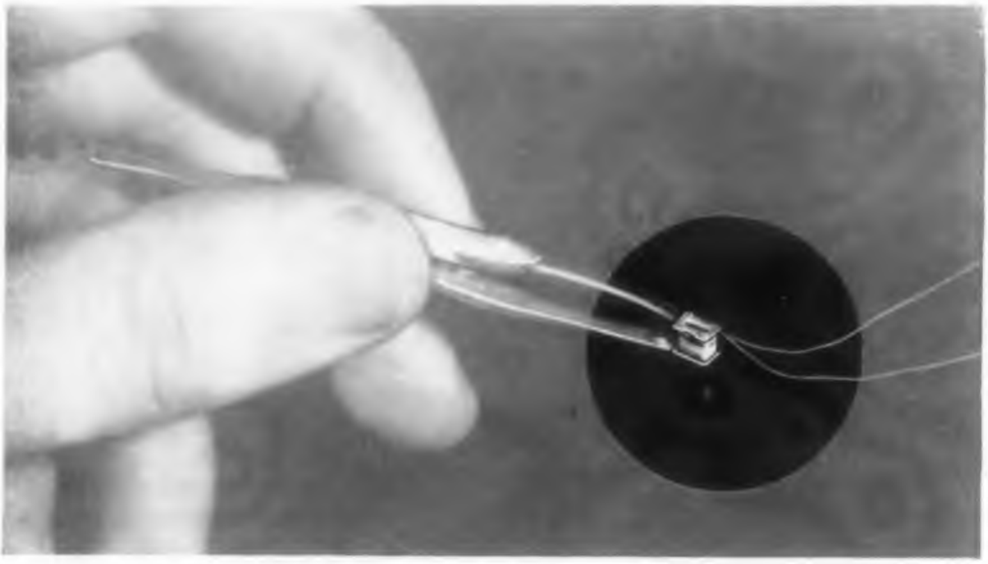
TDS 1110-1, a 16-page catalog, provides complete features and specifications on all Servoboard electro-mechanical assembly components. Includes mounting components, component hangers, component clamps, bearing hangers, shaft components, gears, service units, limit stops, switch assemblies and clutches, and differentials. Servo Corporation of America, 20-20 Jericho Turnpike, New Hyde Park, N.Y.

Metal Cabinets 190

Features, description, and price of modular and mobile consoles charted in 4-page color folder. Protection against shock and vibration plus efficient ventilation for electronic instrumentation provided by rack consoles which conform to RETMA and MIL Specs. Esco Engineering Co., P.O. Box 184, Broadview, Ill.

Capacitors 191

Three-color folder describes line of El Menco Dur-Mica Capacitors and includes data on DM15, the smallest mica capacitor in the world, ideal for extreme miniaturization; others designed for miniature designs and printed circuit wiring. Detailed specifications included. "Look to El Menco for Dur-Mica Capacitors with a Long Future," "Reliability Study of Silvered Mica Capacitors" and "Debugging Assures Greatest Dependability . . . Longest Life," all from Electro Motive Mfg. Co., Willimantic, Conn.



Instruments 193

Brochure on instruments and instrumentation systems, "Measurements and Controls", is a 4-page, 2-color illustrated publication which highlights Gemnite instruments for shock, vibration, pressure, inertial control, temperature and other devices for use as single components or in complete systems. Sales Mgr., Gulton Instrumentation Div., Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J.

Waveguide Chart 194

A complete "Reference Table of Rigid Rectangular Waveguide Data and Fittings" covers waveguide sizes from WR10 to WR2300 and cross references TE_{10} Mode Frequency Range; EIA Waveguide Code Designations; JAN Waveguide Code Designations; Inner and Outer Waveguide Dimensions with Tolerances; MIL Flange Code Designations and Military Standard Flange drawing numbers. Microwave Development Laboratories, Inc., 92 Broad St., Babson Park 57, Mass.

Batteries 195

Use, design and construction of firm's standard line of PlastiCell lead-antimony grid batteries for all stationary battery applications covered in 12-page bulletin, CP-532. Complete cell data on line from 10 to 1650 ampere hour ratings; curves on discharge characteristics included. C&D Batteries, Inc., Conshohocken, Pa.

Retaining Rings 196

All currently available Waldes Truarc retaining rings are described and illustrated in a 24-page catalog No. RR 10-58. Material covered includes "Selector Guides" to company's 20 standard ring series and 30 representative "special rings" designed for individual customer requirements. Purpose and advantages are detailed for each ring series, which are organized according to function: axial assembly, radial assembly, end-play take up, and self-locking types. Truarc Technical Service, Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N.Y.

MINIATURE, STANDARD and DOUBLE SIZES!

MINIATURE RECORDERS

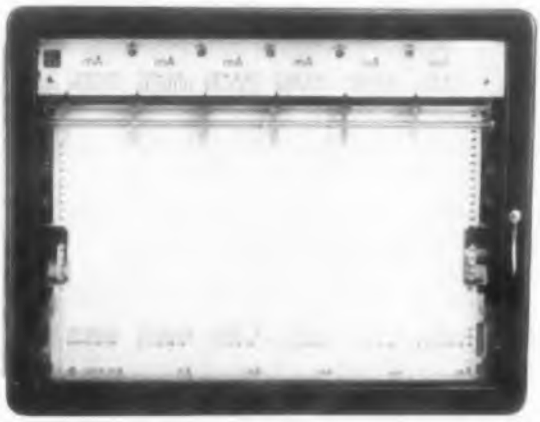
Square Model 85, in flush mount, weighs 16 lbs. and is $5\frac{5}{8}$" square x $12\frac{3}{4}$" deep. Slim models 86 (portable) and 87 (flush) save half the width of standard recorders . . . measure $3\frac{3}{4}$" x $7\frac{1}{8}$" x $8\frac{3}{4}$" and weigh only 9 lbs.

CURTISS-WRIGHT

STANDARD RECORDERS

Model 81 (portable) and 82 (flush) are also available for wall and projection mounting . . . take up to 3 channels. Weigh only 19 lbs. and measure $7\frac{1}{2}$" x $9\frac{13}{16}$" x $7\frac{7}{8}$".

PRECISION RECTILINEAR



DOUBLE SIZE RECORDERS

Models 83 (portable) and 84 (flush) take up to 6 channels. Wall and projection mounting available. Chart width is $9\frac{1}{2}$". Measure $12\frac{3}{4}$" x $9\frac{13}{16}$" x $8\frac{3}{4}$" and weigh only 26 lbs.

STRIP CHART RECORDERS

Made under licensing agreements with one of Germany's leading instrument manufacturers . . . combine accuracy with ruggedness.

Important features: *Rectilinear Recording* with patented linkage that translates angular meter motion into proportional straight line • *Inkless and Ink Recording in One Unit* • *Three-Speed Transmission plus 60:1 Speed Change* from hours to minutes; provides six interchangeable speeds in all • *1% Accuracy* for moving coil movement • *Shock-proof movement . . . splash and dustproof steel cases.*

AC, DC, power and combination movements; wide choice of ranges and chart drives. Write for full information.

ELECTRONICS DIVISION

CURTISS-WRIGHT

CORPORATION • CARLSTADT, N. J.

CIRCLE 198 ON READER-SERVICE CARD

NEW LITERATURE

Counter-Controller 200

Series 320 instruments described in illustrated 4-page folder are designed for coil winding, motor speed control, shearing to length, batching, packaging, and stacking by number. Computer Measurements Corp., 5528 Vineland Avenue, N. Hollywood, Calif.

Power Resistor 201

One-page bulletin 153 describes resistors having a silicone-ceramic material molded around them. The resistors are uniform, moisture-proof, have high insulation resistance and other advantages. Ohmite Mfg. Co., 3699 Howard St., Skokie, Ill.

Control-Display Layout Kits 202

Booklet contains descriptive information, free samples, and instructions on how to use special plastic laminated pictorials of standard controls and displays. Michelson-Peters Control Displays, 15537 Ventura Blvd., Encino, Calif.

Nuts 203

A new catalog describing Strippit Pierce Nut Units for staking Fabristeel nuts into sheet metal for assembly panel production is now available. Operation and specifications of the press-actuated Type "CD" and "BL" Units for short, medium and long runs of nut insertion are fully covered in the catalog. Wales-Strippit, Inc., 223 S. Buell Road, Akron, N.Y.

Polarized Relays 204

"Control Applications for Polarized Relays," bulletin F 7279, is an 8-page bulletin packed with wiring diagrams, photographs, and applications which may suggest an answer to your control circuitry problems. Barber-Colman Co., Electrical Components Div., Rockford, Ill.

...chro Data Charts 206

...rtinent data from the new Specifica- ... MIL-S-20708 and the SAE Specifi- ...n ARP-461 are presented on a wall ...rt. Standardized definitions and con- ...ion data will simplify the task of ...chro manufacturers and users. Theta ...rument Corp., 48 Pine St., East Pat- ...on, N.J.

...il-Filled Potentiometers 207

Three liquid-filled potentiometers ...w produced supply the subject matter ... Data Sheet 1482, a seven-page tech- ...al summary. All working parts of the ...w product are sealed in a bath of oil ...hich cushions the unit against shock ...d vibration. Helipot Technical Infor- ...ation Service, Fullerton, Calif.

Solder Terminals 208

A 14-page catalog features specifica- ...on drawings, information on line of ...older terminals and three new terminals ...esigned for molding into plastic head- ...s for use with printed circuits or with miniature tube sockets Catalog 158, Section 1, on Solder Terminals from: Mr. Richard H. Seeery, VP Sales, Alpine Electronic Components, Inc., Waterbury, Conn.

Phase Shifter 209

Application of line of passively constructed phase generators detailed in 8-page bulletin. Devices are used to measure phase shift with 30 minute accuracy, provide reference voltage to demodulator and modulator circuits. Theta Instrument Corp., 48 Pine St., E. Paterson, N.J.

Stepping Motors 210

Bulletin 958SM2 describes new Series 2 Syncramental stepping motors which convert digital information to analogous shaft displacements and may be used to rotate counters, potentiometers, rotary switches, tape advance, and various control mechanisms. G. H. Leland, Inc., 123 Webster St., Dayton 2, Ohio.

ACCURATELY REPEATABLE TIMING

WITH INSTANTANEOUS RESET

HEINEMANN'S NEW TRANSISTORIZED TIME-DELAY RELAY

If your products call for reliable, accurately repeatable timing or sequencing . . . and if cost is a consideration (when isn't it?), then have a look at the new Heinemann Trans-O-Netic* Time-Delay Relay.

Built around a transistorized control circuit, this new type of relay offers exceptional performance capabilities at a surprisingly low cost. Time delay is adjustable from 0.5 to 30 seconds, with repeatability at any set delay better than ±5%. Reset is instantaneous. These three features, alone, place the Trans-O-Netic way out in front of the field.

But there's more. The relay is inherently stable, so that there is only a negligible temperature effect on time delay over a tested operating range of 32° to 130°F. Single-pole, double-throw switching is fast and clean; wiping action assures long contact life. The entire unit is enclosed in a phenolic case to protect it from dust and dirt.

More information? Certainly. Send for Bulletin 5300; it gives pertinent details and specifications.

HEINEMANN ELECTRIC COMPANY 156 Plum Street, Trenton 2, N. J.

*Trans-O-Netic is a trade name of the Heinemann Electric Company. S.A. 1082

CIRCLE 212 ON READER-SERVICE CARD

Where only the **best** *is good enough . . . you'll see*

electronic instruments

In basic electronic instruments for lab or test work, *less* than the best may be a dangerously bad bargain. Unexpected limitations — of reliability, range, precision — can throw out weeks of work on today's jobs, and can make tomorrow's tougher jobs untouchable.

The *best* instrument of its type is probably a bit more expensive, but it's worth buying . . . because you can believe in it today, and will rely on it tomorrow. An example is the Krohn-Hite Model 440-A wide range push-button oscillator illustrated here.

Exactly because K-H instruments *are* good enough even for tomorrow's most critical work, they are increasingly chosen today where true reliability and precision are needed.

Oscillators — .001 cps to 100 kc, less than 0.1% distortion, push-button setting, sine wave and square wave outputs.

Power Supplies — to 600 volts dc, regulation .001% from zero current to 1 ampere, noise less than 100 μv, internal impedance 0.1 ohm to 100 kc.

Power Amplifiers — 50 watts RC coupled from 20 cps to 20 kc with 0.005% distortion; 10 watts direct coupled from dc to 1 mc, with less than 0.1% drift per hour.

Tunable Electronic Filters — variable from .01 cps to 200 kc, band pass, band rejection and servo types.

Write for your free copy of the new Krohn-Hite Catalog

Krohn-Hite CORPORATION

580 Massachusetts Avenue,
Cambridge 39, Mass.

CIRCLE 213 ON READER-SERVICE CARD

NEW LITERATURE

Compression Molding 214

Design and manufacturing facilities for custom compression molding precision plastic parts from all thermosetting materials for use in electrical, electronic, medical and general industrial applications illustrated in two color, four page folder. Delta Plastics Co., Creek Road, Bellmawr, N.J.

Solenoid Actuator 215

Two color data sheet describes line of solenoid controlled actuator packages. Presently being used in the missile field, these packages are available for many hydraulic and pneumatic applications. Pertinent specifications are listed for the Model 106-2 on the reverse side of the sheet. Waldort Instrument Co., Huntington Station, N.Y.

Conductor Slide Rule 216

Handy logarithmic conductor slide rule designed to aid selection of dimensions of aluminum foil or sheet for use in strip-wound electrical coils. The rule provides a ready means of converting from standard wire sizes in copper or aluminum to an equivalent aluminum strip conductor. Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa.

Swedged Washers 217

Manufacturers of electrical appliances and electronic components may request a list of the sizes of swedged or upset washers for which special tools are available. Wilmington Fibre Specialty Co., New Castle, Del.

Fans 218

Catalog sheet illustrates and describes "saucer" shaped fan for cooling electronic console equipment. Unit features an electrical driving motor built into the propeller hub reducing the axial length of the fan to more than the thickness of the propeller. Catalog #50109-1 from Rotron Manufacturing Co., Schoonmaker Lane, Woodstock, N.Y.

Magnesium in Electronics 220

Attractive three-color booklet "Magnesium in the Electronics Industry" describes the use of magnesium in airborne and air-transportable electronic equipment. The 20-page brochure discusses properties of magnesium that make it useful and shows pictorially where magnesium is being used in electronics today. Public Relations Dept., The Dow Chemical Co., Midland, Mich.

Transformers 221

Catalog CTS-58 carries detailed listings of over 450 stock transformers. It provides electrical and physical specifications on military standard, MIL-T-27A 400 cycle and many other hermetically sealed transformers. There are extensive listings of commercial grade "Sealed-in-Steel" audio and power transformers for transistor, public address, communications and other industrial applications. Performance curves are shown for many of the units. Chicago Standard Transformer Corp., 3501 West Addison St., Chicago 18, Ill.

Frequency Computer

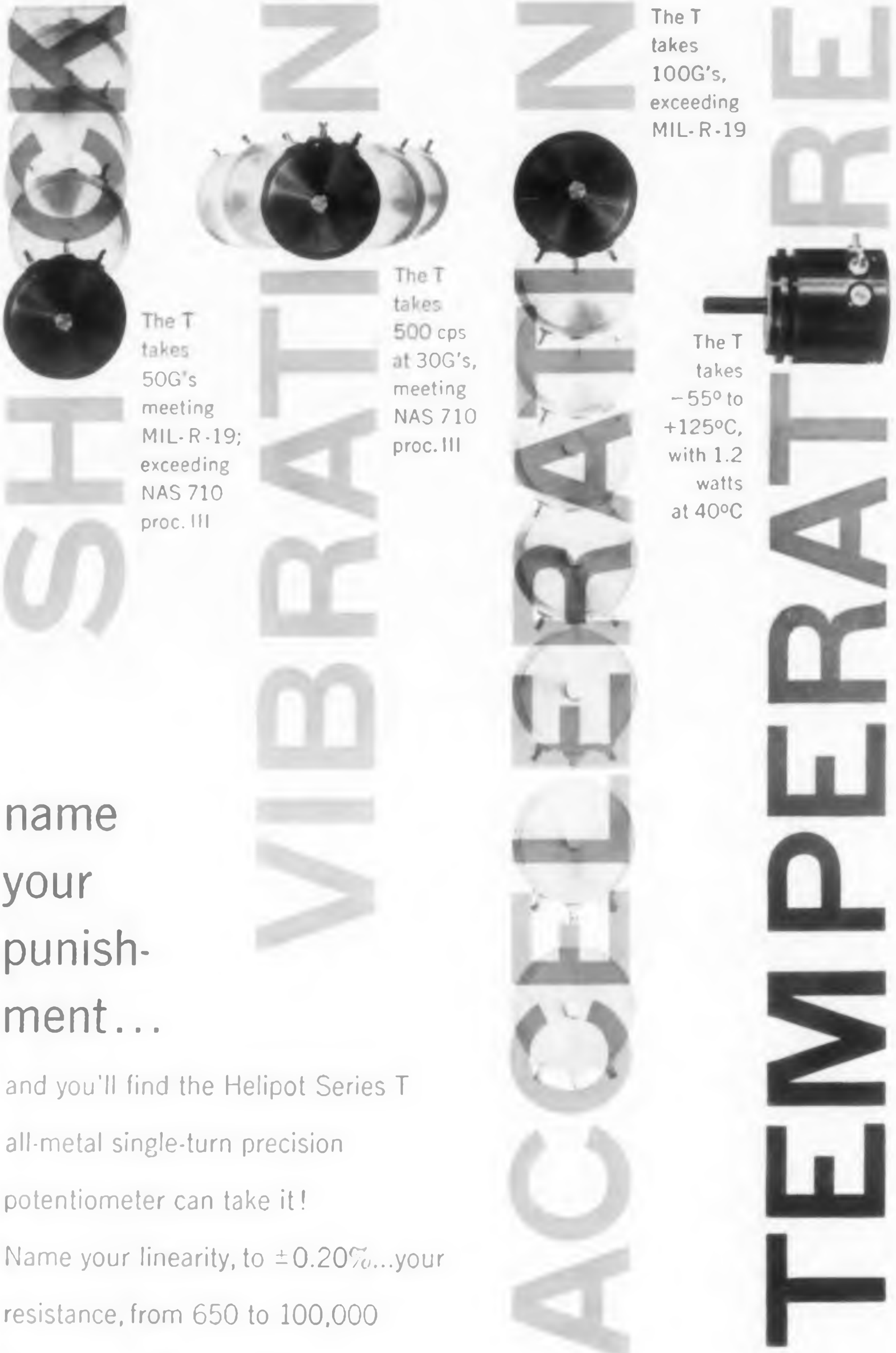
The "Calculaide Frequency Computer" correlates, in one setting, the natural frequency and wave length of a circuit comprising a coil and condenser with the physical dimensions of the coil and the capacity of the condenser. Inductance values can be determined for widely varying physical dimensions of coils. Produced from Vinylite plastic, all markings are heat-sealed into the body of the plastic itself, it costs $4.95.

American Hydromath Corp., 42-17 Hunter St., Dept. ED, Long Island City 1, N.Y.

High Temperature Wire 222

Eight-page technical bulletin on "Ceramatemp," describes features, application and handling characteristics, and mechanical and electrical properties of this ready-to-use flexible, ceramic-type insulated wire rated for continuous operation at 1000 F. Charts and graphs included. Director of Technical Service Hitemp Wires, Inc., 12000 Shames Drive, Westbury, N.Y.

CIRCLE 223 ON READER-SERVICE CARD



name your punish-ment...

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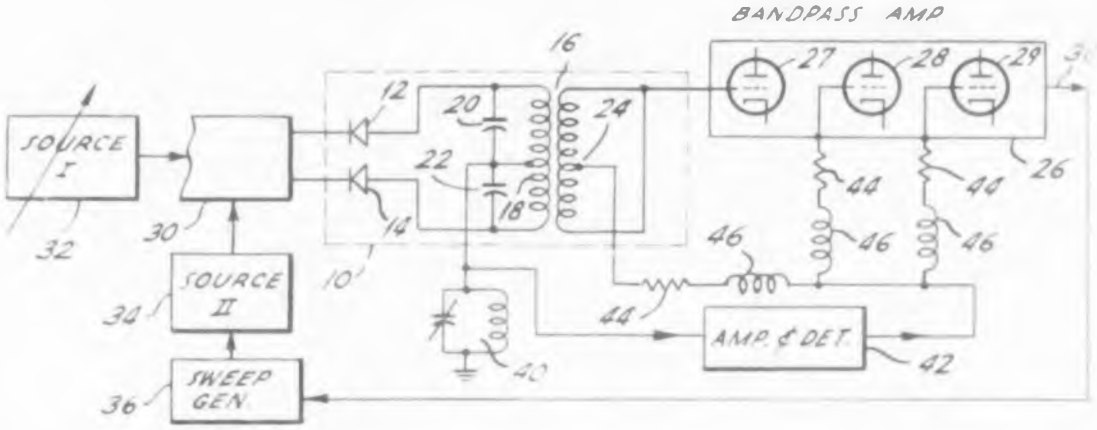
PATENTS

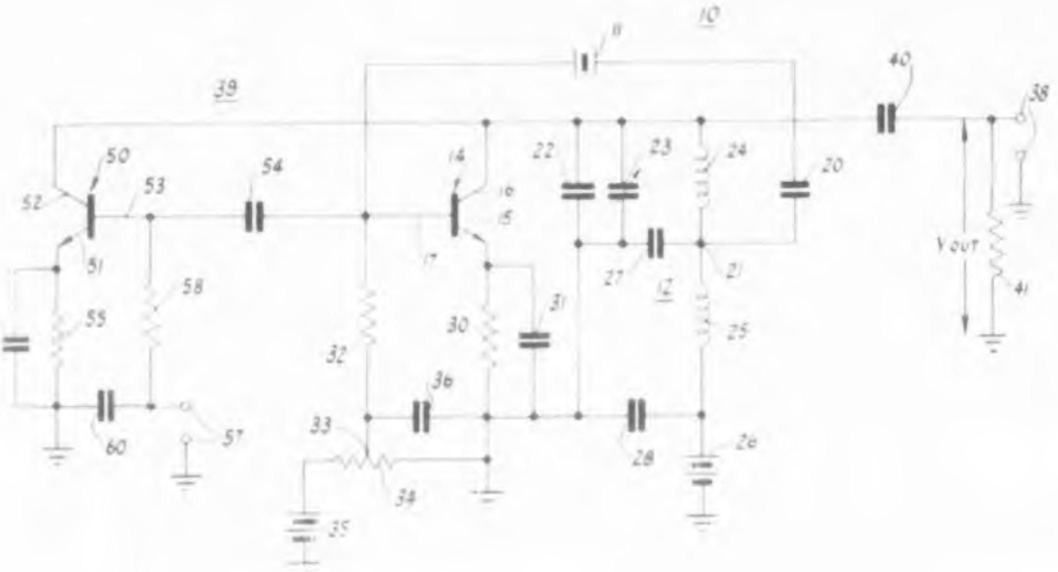


Crystal Controlled Transistor Oscillator Systems

Patent No. 2,853,615. Raymond J. Kircher. (Assigned to Hughes Aircraft Co.)

Transistor oscillator output is amplitude-modulated linearly by a control signal applied to a transitor amplifier effectively in shunt with the oscillator.

Transistor *14* and tank circuit *12* comprise a Hartley oscillator which is frequency stabilized by crystal *11* in the feedback network. The collector and base of transistor *50* are connected in shunt with the oscillator tank since capacitor *54* is a low reactance at oscillator frequency. Hence a control signal applied to terminals *57* will cause transistor *50* to draw additional current through the tank to increase the amplitude at the output. When maximum linear output voltage is desired, the oscillator transistor *14* would be biased for the lowest emitter current at which the oscillator is stable.

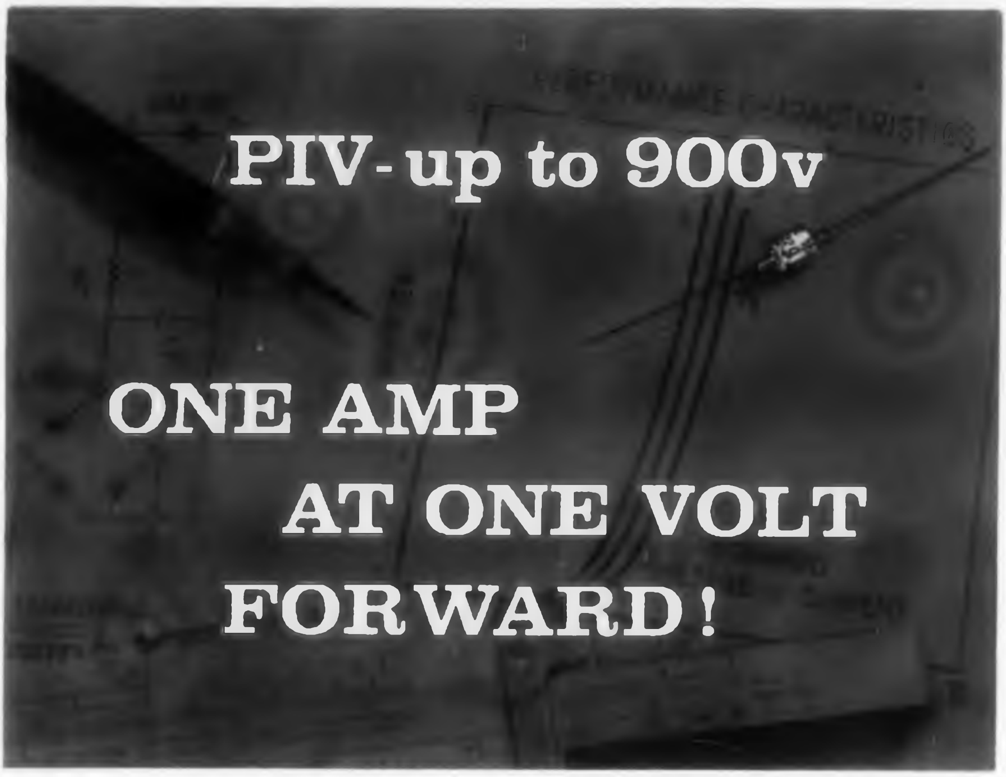


Frequency Control System

Patent No. 2,848,615. George H. Rother and Joseph E. Slaweck Jr. (Assigned to Philco Corp.)

There exists a tendency for the local oscillator afc circuit of a turntable radar to lock on the second harmonic of one half of the desired difference frequency and thereby self-jam the receiver. A detector-amplifier circuit has been designed to make the afc amplifier insensitive to this undesired frequency.

As shown in the diagram, network *40*, tuned to the rejection frequency, is connected to the afc detector. The signal developed in network *40* is amplified and rectified in network *42* to reduce the gain of the bandpass amplifier at this frequency. Sweep generator *36* will continue to tune the local oscillator (source *11*) until the desired frequency difference with sources 1 is obtained.



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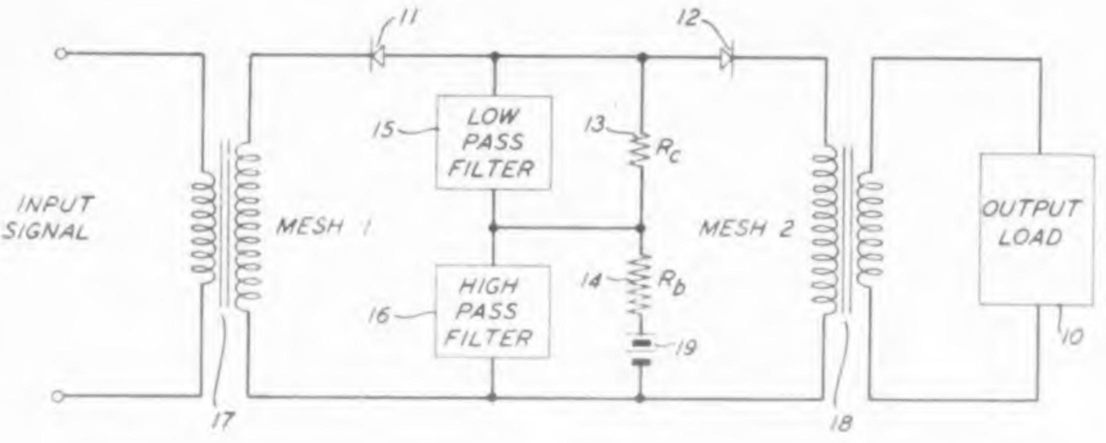


Amplitude Modulation Limiting Circuit
Patent No. 2,848,609. Clyde L. Ruthroff (Assigned to Bell Telephone Laboratories, Inc.)

Self-cancellation is provided for amplitude modulated noise which is impressed on a frequency modulated signal. For a carrier frequency of one mc, the a-m is suppressed 45 db whereas the carrier signal loss is only 7 db. The attenuation of the a-m sideband may be increased by using similar networks in cascade.

The operation of the circuit is as follows: A carrier and its sidebands applied to mesh *1* will flow in mesh *2* through resistor *14*. When the signal amplitude exceeds the bias level of the diodes, each diode demodulates one half cycle of the signal. This produces a baseband current, whose frequency is the difference between the frequencies of the sidebands and the carrier. This baseband current flows through resistor *14* and beats with the carrier to produce a new pair of modulated sidebands. The new sidebands in mesh *2* flow in opposition to the original a-m sidebands. By proper se-

... of resistors *13* and *14*, complete ...lation of the a-m noise may be ...ed.

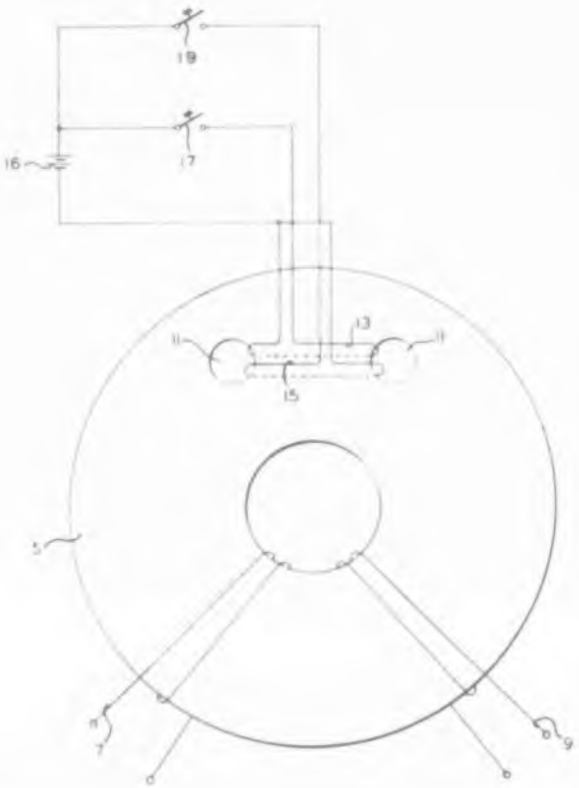
...ore complete analysis of the cir... is given in the inventor's paper "...litude Modulation Suppression in ... systems," *BSTJ* vol 38, July 1958.

M... netic Core Logical Device

Pa... No. 2,855,586. Edgar A. Brown (Assigned to International Business Ma... Corp.)

...single toroid magnetic core operates ...r as a storage element or as an "Ex... Or" logical switching device. The ...will switch from one or two stable ...manent flux states in response to non... ...rrent auxiliary signals.

The remanent state of core *5* is se... by the polarity of the signal ap... to winding *7*. A change in the net ... of the core induces a pulse in output ...ding *9*. Auxiliary windings *13* and *15* have equal turns wound in opposite di...ctions through holes *11* and are sepa...rately capable of changing the sense of the remanent flux in the core when the auxilary winding is connected to battery *16*. However, when both auxiliary windings are operated simultaneously, the fluxes cancel and the state of the core is unchanged.



BOOKS

Logical Design of Electrical Circuits

R. A. Higonnet, R. A. Grea, McGraw-Hill Book Co., 330 W. 42 St., New York 36, N.Y. 220 pp, $10.00.

Boolean methods for analyzing relay, diode, and vacuum tube circuits are presented with particular emphasis on use in design of control circuits in telephone dialing systems, automation systems, computers, and similar applications. This practical guide explains Boolean algebra as a vital tool in circuit design and is written for engineers with no special background in switching circuits.

The present-day circuit designer will find almost all fields covered: combinational circuits (steady state); sequential circuits treated by a modern, simpler method, and shunt-down circuits (inhibitors), which are fully described by Boolean algebra. Helpful examples, plus more than 300 illustrations, are provided.

Handbook of Physics

Edited by E. U. Condon and Hugh Odishaw, McGraw-Hill Book Co., 327 West 41st St., New York 36, N.Y., 1504 pp, $25.00.

Comparable in treatment and scope to handbooks serving other professions, this volume concentrates on principles, ideas, concepts, and mathematical methods of all branches of classical and modern physics.

In addition, it serves as a check for better understanding of basic concepts lems, mathematical formulations, equations, and offers a means of re- ing or gaining an understanding of miliar areas.

he emphasis is on the principles of ical science and the mathematical niques required for their exposition. W hin this framework, the main sections mathematics, mechanics of par- s and rigid bodies, mechanics of de- mable bodies, electricity and mag- ism, heat and thermodynamics, ics, atomic physics, physics of the d state, and nuclear physics.

Random Vibration

H. Crandall, Editor, The Technology Press of M.I.T., Cambridge 39, Mass., pp. $10.00.

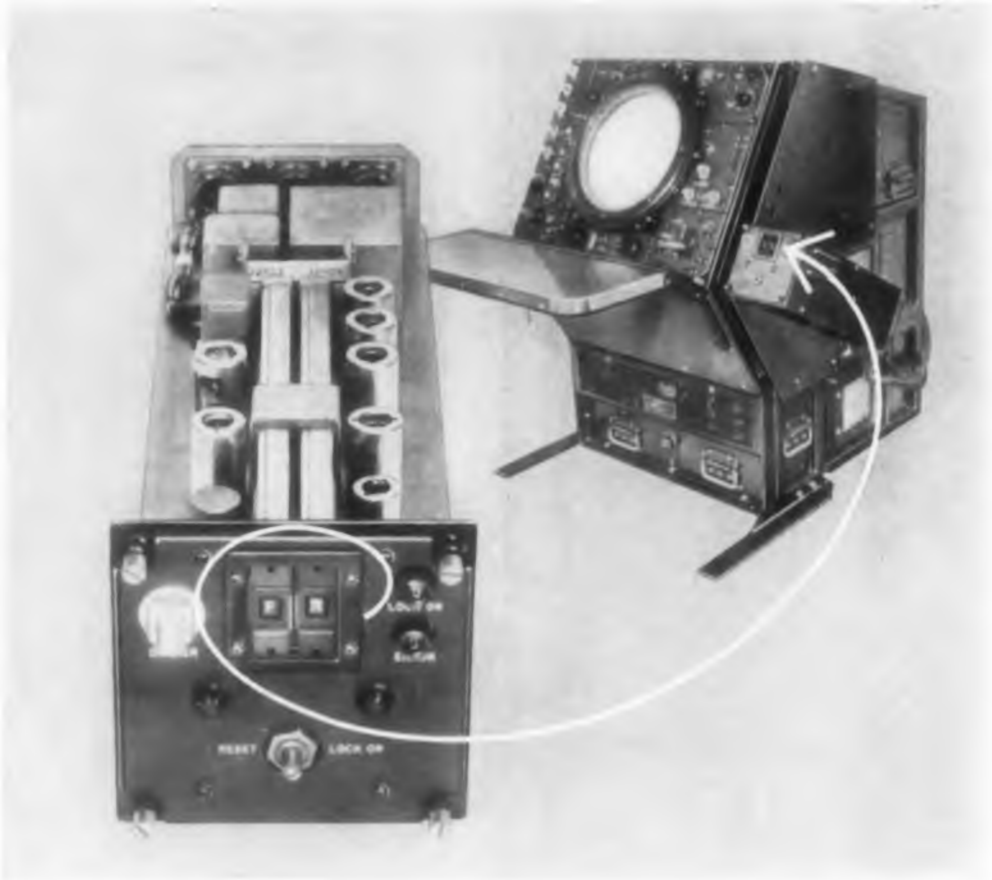
A timely collection of notes, this book ers a compact introduction to the field engineers schooled in mechanical vi- ation. New concepts required to extend inary vibration theory into the field random vibration are covered. Current tate of the art of designing and testing quipment, which must withstand ran- om vibration, is presented broadly. Ordinary vibration theory is reviewed in a form which facilitates the transition to random vibration. Treatment of basic concepts and background material in the first part is followed by six chapters of specific material which discuss: the problem of measuring random vibration, excitation from jet engines and rocket motors, the philosophy of environment simulation and problems of designing simulation equipment, and mechanical design for random loading.

Closed-Circuit Television Systems

Government Service Department of the RCA Service Company, Camden 8, N.J., 348 pp. $4.50 postpaid

The fundamentals and techniques of closed-circuit TV—both black and white and color systems—and the characteristics and typical applications of various types of commercial equipment are explained.

Its supply of details will permit engineers and planners to determine in advance the proper equipment and system arrangement to best serve specific performance needs.



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BOOKS

Automation Systems

Engineering Publishers Division of the AC Book Co., Inc., New York, 180 pp. $5.00

This book contains the proceedings of the second EIA conference on automation systems for business and industry held this year. At the conference engineers along with leaders in the fields of economics, education, labor, and social work took a critical look at automation as it exists today, and have attempted to evaluate it. Automation within the electronics industry and automation outside the electronics industry are examined.

Magnetic Recording Techniques

W. Earl Stewart, McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York 36, N. Y. 268 pp, $8.50.

Recording and reproducing processes, recording materials, the theory of ferromagnetism, recording mechanisms, and established standards are covered in this book. Design techniques are shown on the various elements of magnetic recording systems and ways to obtain better performance in many new fields of application. Included are definitions, tables, derivations of key formulas, and practical test circuits.

Recording and reproducing functions are discussed separately to help analyze the effect that each has on the recording media and on the over-all performance. Sections are included on some of the lesser known types of recording, such as boundary recording (computer memory work), the Factrol system (automation), flux-sensitive heads (special applications), transistor circuits, and TV recording problems. In addition, new formulas are given for magnetic oxide coatings.

Physical Acoustics and the Properties of Solids

Warren P. Mason, D. Van Nostrand Company, Inc. Princeton, N.J., 393 pp. $9.00

This introduction to the uses of wave transmission in solids provides both engineering applications and analytical uses.

…rt I discusses fundamentals of wave …agation in solids, transducers used … enerate such waves, instruments for …suring attenuation, velocity and …acteristic impedances of solids, and … and low intensity applications of …e transmission.

…rt II deals in detail with the ana… …al uses of sound wave propagation. … covers such topics as: phenomeno… …ical models for wave propagation; …rmal damping; grain scattering; do… …in motion effects; interstitial diffusion …ects; high and low amplitude disloca… …n effects; sound transmission in single …ystal quartz and glasses; sound damp… …ing by free electrons.

Logic Machines and Diagrams

Martin Gardner. McGraw-Hill Book Co., 330 West 42nd Street, New York 36, N.Y., 2?4 pp. $5.00

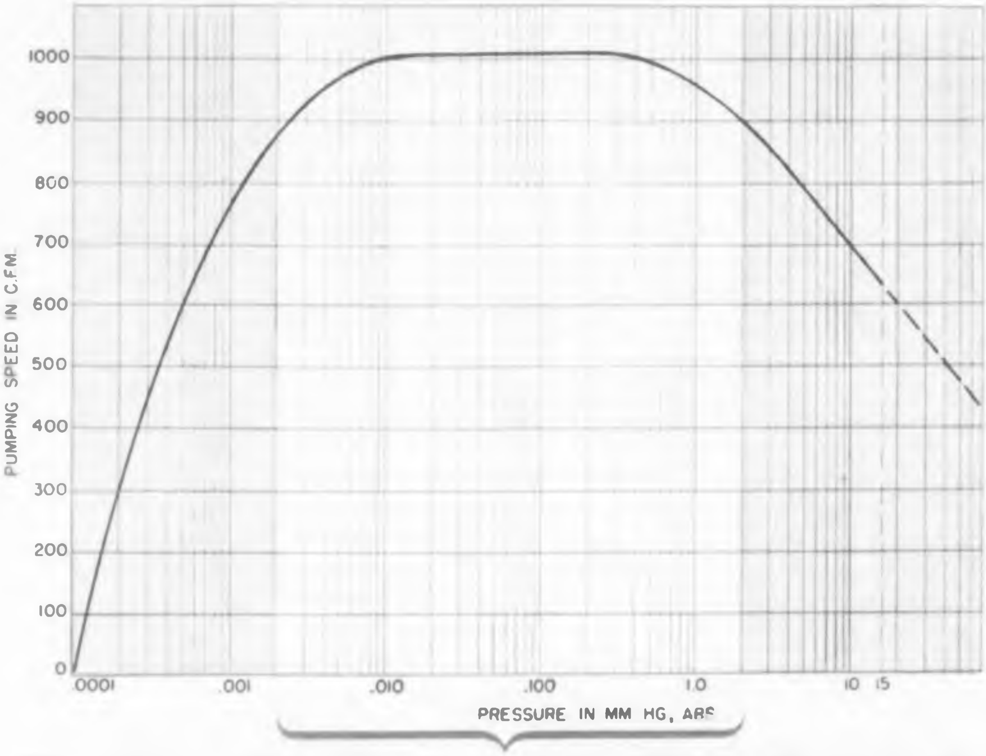
The author here surveys the mechanical and electrical machines designed to solve problems in formal logic, and of geometrical methods for doing the same thing.

Much of this material is published for the first time including an explanation of an original network diagram for solving problems in the propositional calculus; a popular exposition of the new binary method of handling the calculus; and instructions for making cardboard devices that quickly identify valid syllogisms or show the formal fallacies of invalid ones.

A Comprehensive Bibliography on Operations Research

Operations Research Group Case Institute of Technology, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 188 pp, $6.50.

Extensive bibliography of the Operations Research Society of America contains listings of references for all the material published in operations research through December, 1957. Approximately 3000 titles of articles, books, reports, proceedings and 40 specialized bibliographies are compiled. Alphabetic organization and serial cross-referencing comprise most of the text, followed by 40 special subject bibliographies.



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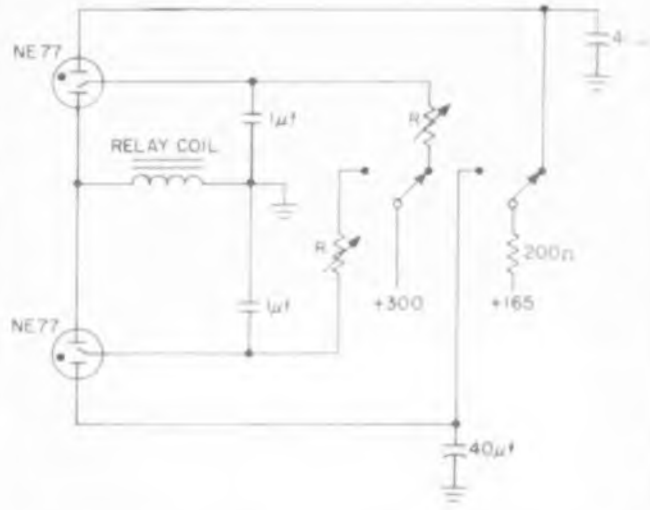


Three-electrode glow tubes are at the heart of this simple repeat-cycle timer.

Repeat-Cycle Timer Uses Glow Tubes

The accompanying circuit uses the recently announced General Electric NE-77 three electrode glow tubes in a repeat-cycle timer.

A Potter and Brumfield impulse type relay (AP17-4PDT) was used. Satisfactory operation resulted with 165 v on the outer electrodes of the glow tubes. A 300 v supply on the relaxation network provides a minimum period of about one second with 1 uf capacitors and 4 meg resistors as the time constant elements.

The timing may be varied in fixed steps, or it can be made continuous by using potentiometers.

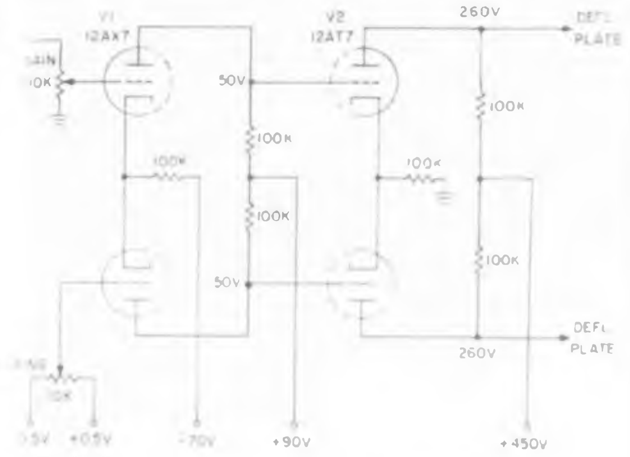
Mark D. Bedrossyan, Atlantic Electronics Labs., Asbury Park, N.J.

DC Scope Amplifier

Dc amplifiers for oscilloscopes suffer from instability caused by drift in the supply voltages. A good way to circumvent this drawback is to use symmetrical amplifiers. The drifts then cancel at the output, because of the symmetry. The signal, however, is applied in a nonsymmetrical or differential fashion, and appears amplified at the output.

If the amplifier has several stages, the necessity for a direct connection between plates and grids increases the B-plus requirements. The simple 2-stage amplifier shown in the diagram appeared in *Elektronik* of March 1957. It uses only two tubes, a 12AX7 and a 12AT7. The circuit's symmetry is evident.

An interesting point is that stability increases



Drift free two tube amplifier for oscilloscopes

with the value of the cathode resistors, hence, the unusually high values found in the diagram.

The 12AT7's plates are directly connected to the deflection plates of the cathode ray tube. Gain is controlled by the input potentiometer in the upper input circuit. Notice the centering arrangement in the opposite grid. The small dc grid voltage variation appears amplified at the output. The various supply voltages may conveniently be obtained from a common 250 v supply, grounded at 70 v from its negative end.

The maximum gain of this amplifier is about 1000. Its bandwidth extends from 0 to 10,000 cps, and it can deliver 200 v peak to peak without distortion.

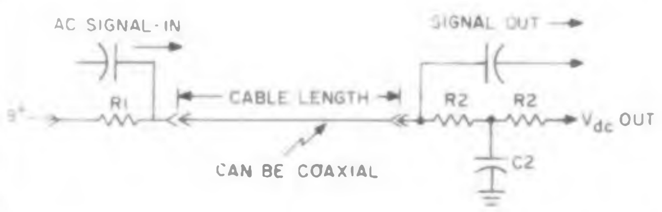
Dr. A. V. J. Martin, Carnegie Institute of Technology, Pittsburgh, Pa.

One Wire Carries AC and DC

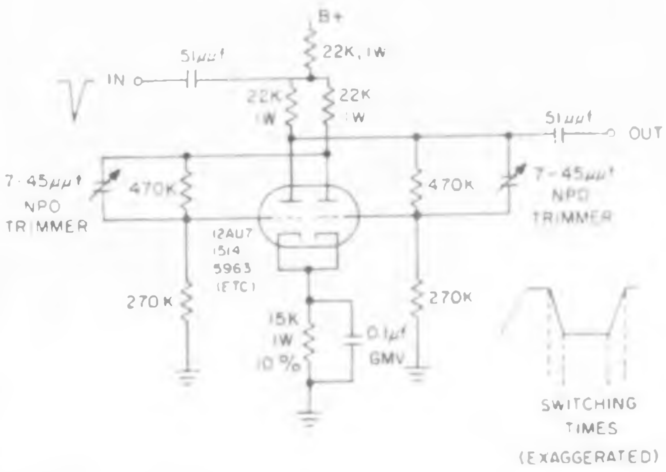
This circuit is useful in transistor circuits where one wire in a cable must carry a dc voltage as well as an ac signal, yet the two voltages must be isolated.

The resistors and capacitors are chosen to provide the required isolation between the ac input signal and B plus, and between the output ac and dc. If additional decoupling is necessary, *R1* can be replaced by a low pass filter similar to the output filter.

Alfred W. Zinn, Farrand Optical Co., Inc., The Bronx, N.Y.



With proper isolation at both ends, one wire can carry dc and signal currents.



Trimmer capacitors help control the switching times in this binary adder.

Controllable Switching Time In This Binary Adder

In this binary adder, the switching times between each stable state can be made equal. This is done with a minimum of components. All components have five per cent tolerances except for the resistor and capacitor in the cathode circuit.

Trimmers are used in the cross-coupling networks instead of the usual fixed commutating capacitors to provide exact balance of the switching times.

J. Frank Brumbaugh, Senior Marine Engineer, Heath Co., Benton Harbor, Mich.

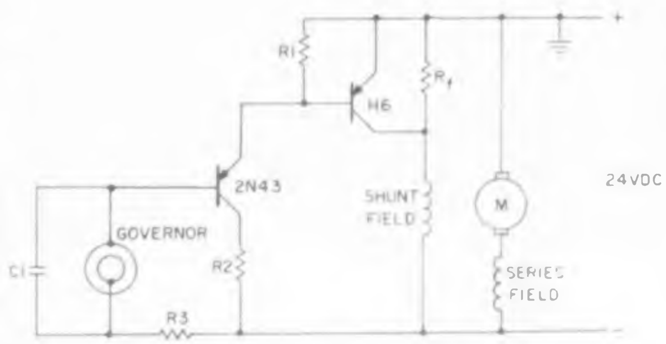
1/4 Per Cent Speed Regulation With Centrifugal Governors

Conventional centrifugal governors for speed control of dc motors suffer from the violent changes of speed rates caused by the governor contacts switching a large part of the field power; they suffer from the load handling limitations of the contact fingers; and they suffer drift and inaccuracy due to contact arcing and pitting.

In the transistorized speed regulator shown in the figure, the centrifugal governor is used only as a lightly loaded error detector. The problem of arcing and pitting does not exist; the drift is minimized; and the regulation is better than 1/4 per cent.

The regulator shown is designed for a 1/2 hp, 6000 rpm motor, operated from a 24 v supply which may vary from 20 to 30 vdc. The regulator uses a preamp transistor (2N190) and a power transistor (H6).

The centrifugal governor controls the current through the preamp. It need handle only a few



Transistorized speed regulator uses governor only as an error detector.

microwatts. The current through the preamp transistor determines the voltage at the base of the power transistor which controls the current through the motor's shunt field.

The regulator can be used to control larger and smaller motors, depending on the power handling capabilities of available power transistors. The field power which must be handled is a function of the difference power required by the motor field between no load and full load.

Baruch Berman, Group Engr., Avion Div., ACF Industries, Inc., Paramus, N.J.

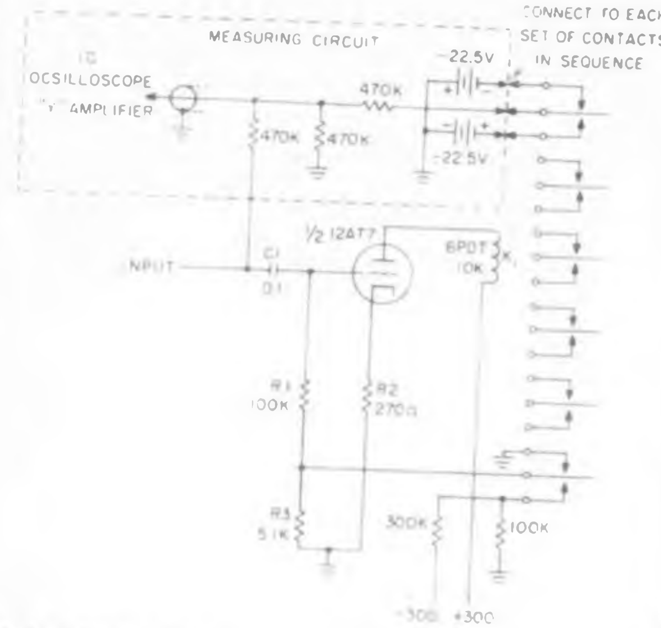
Convenient Radiation Dosimeter

It is, alas, a well-known fact that, above a certain amount, radiation can be dangerous and even fatal. A must, for all people exposed to radiation, is some sort of counting-integrating device which can be periodically checked to ascertain that its wearer has not been submitted to a dose of radiation exceeding the safe value. A number of such devices exist.

The Radion counter shown on the photograph has several advantages. It is tied to the wrist as an ordinary watch, and is just as convenient and inconspicuous. It gives an immediate and clear indication, and can be reset at will and re-used anew.

Dr. A. V. J. Martin, Carnegie Institute of Technology, Pittsburgh, Pa.

Wrist-borne dosimeter.



Hair trigger relay uses vacuum tube to speed up relatively slow relay.

Hair Trigger Relay

It was required that a number of circuits be simultaneously switched at a high speed. The switching speed of the only available multiple pole relay was too slow.

While physical characteristics of a sealed relay cannot be changed, switching speed can be improved to a degree by shortening the current buildup and decay times.

The relay was incorporated in a vacuum tube circuit biased so as to cause a current flow just short of the minimum required to energize the relay. A positive going input to the tube grid energizes the relay. As soon as the relay operates, one set of contacts connects a bias to the grid return, lowering the current to a point barely sufficient to keep the relay energized. A negative going signal cuts off the tube, de-energizing the relay.

The operating time of a six pole double throw relay was reduced by a factor of three in this circuit.

W. L. Godsey, Engineering Asst., Applied Physics Lab., Silver Spring, Md.

Enlarge Small Holes In Thin Sheets

It's often necessary to enlarge a small hole in very thin sheet copper or other sheet material. Small drills won't do because they often twist the material. If they're used on printed circuit boards, they can tear etched circuits off the board.

A needle file, chucked in the drill in place of a standard twist drill, does the job easily. The thin sheet material is slowly fed onto the rotating file till the hole has been enlarged to the proper size. The file takes small milling cuts and is not likely to grab and tear up the material.

Robert Marie, Perfect Circle Corp., Hagerstown, Ind.

Multi-Vaned Rectifier Package Takes Oil Bath

Resistant to electrical leakage, resistant to 30 g shock loads, and very durable, the rectifier assembly in the photograph operates in transformer oil at temperatures from −60 to 90 C.

The Raytheon Manufacturing Co. at Maynard, Mass. designed the compact, light-weight package for a high-voltage shipboard power supply. Laminated Formica rods were machined and drilled to form the vanes. The holes were purposely left rough to increase creep resistance.

In operation, six of these assemblies are mounted on a sliding rack and lowered into the transformer oil. Electrical connections with the rest of the power supply are established when a lid is bolted down.

The arrangement permits quick snap-in replacement of an entire assembly in the event of rectifier failure.

Compact rectifier package operates submerged in oil.

The artist has captured a rare expression on the face of Sigma's general manager — one of happy satisfaction and complete contentment. This is because the sales dept. has just told him (1) about a new Machine of Pleasure which uses a Sigma product and (2) that the customer is overjoyed because the Sigma product works right. His corporate corpulence is enjoying every minute of it, while it lasts. By publicizing this latest application triumph, it is hoped that others will be spurred on to similar successes.

An enterprising consulting engineer on the West Coast recently took on the job of building a fully automatic machine for folding Chinese fortune cookies. The specs called for handling a piece of hot, flexible cookie dough every five seconds; folding it in two directions and getting the fortune inside the cookie between folds; using up 420 different fortunes before repeating. The machine slices printed fortunes as required from continuous rolls. It was at this point that consulting cookie engineer William E. Thomas asked his E. E. brother Frank how to keep the slices between the lines; since brother Frank reads Sigma ads, his immediate reply was "Sigma Photorelay" (we like to think). One was purchased and rigged up to control the paper feed, by sensing black bars printed on the rolls. Brothers Thomas, their project engineer Charles A. Lindberg (honest!), their customer and Sigma are now all entranced by the results.

So one more banner should be raised for the unsung heroes whose accomplishments do not go up in three stages and a deafening roar, but simply "kerplunk" every few seconds as a new little item is unfailingly produced. If you have such a project, and light sensing can be put to a useful purpose, a Sigma Photorelay might be worth trying. They come ready to plug in, switch 3 amps. resistive at 120 VAC, cost only about $12.00; the cookie boys even went so far as to say "we certainly could not have installed anything else that worked properly so inexpensively." Who knows, maybe you could even build a machine to get the ordinate and abcissa straight on hot cross buns.

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REPORT BRIEFS

Rotary Motion Control

A mechanical decelerator developed to slow the spinning of a free-falling parachutist may also have such practical uses as the positive deceleration of magnetic tape reels, or control of turbine motors. A light tube some six feet long with two steel spheres centrally located and restrained by a triggering mechanism, the laboratory model was conceived on the principle that variations in the moment of inertia of a rotating body will bring high speed changes without a reaction on the support. *An Analysis of a Device for Control of Rotational Motion, N. W. Carlson, Wright Air Development Center, U.S. Air Force, April 1958, 27 pp, \$0.75. Order PB 151135 from OTS, U.S. Department of Commerce, Washington 25, D.C.*

Beryllium Data Summary

The reader who must quickly obtain a wide perspective of currently available information on beryllium can refer to this summary report which includes recent data to aid in evaluating the metal's usefulness as a structural material in airframe and missile applications. References include information on sources, extraction, production, fabrication, properties, and applications. Problems in industrial hygiene encountered in working with beryllium and its compounds are reviewed briefly. An attempt is made to determine the extent and objectives of all current Armed Forces projects that envisage the possible use of beryllium as a structural material. *Beryllium for Structural Applications: A Review of the Unclassified Literature, W. Hode, Defense Metals Information Center, Battelle Memorial Institute for Assistant Secretary of Defense for Research and Development, Aug. 1958, 182 pp, \$3.00. Order PB 121648 from OTS, U.S. Department of Commerce, Washington 25, D.C.*

Encapsulation of Electronic Circuits

Quantitative effects of the encapsulating dielectric upon the electrical characteristics of the embedment are discussed. Of major interest is the work initiated on the electrical performance of resistors, capacitors, inductors, and simple circuits, at frequencies up to 240 megacycles. The investigation of the electrical and mechanical properties of various resins was necessary in order that most suitable encapsulent be selected for the specific application. *Encapsulation of Electronic Circuits, Richard Calicchia, Griffiss Air Force Base, N.Y. Jan. 1958, 22p microfilm \$2.70, photocopy \$4.80. Order PB 133475 from Library of Congress, Washington 25, D.C.*

Complete Missile Simulator

Development of components for an all-electronic analog computer facility described as sufficient to simulate modern guided missile systems is reviewed in this report. The proposed computer, designed to operate on a 1:1 time scale and utilize a method in which programming could be done off the machine, makes it possible to store problems solved in as complete a form as possible. The computer, called the Dynamic Systems Synthesizer, utilizes a high precision electronic time division multiplier and an electronic chopper which eliminates the electrochemical vibrators from the dc amplifiers. An electronic function generator using silicon diodes eliminates the need for servo function generation. Test results indicate the practicability of the all-electronic automatically programmed analog computer. *Dynamic Systems Synthesizer, E. C. Hutter and others, Radio Corporation of America for Wright Air Development Center, U.S. Air Force, Nov. 1956, 240 pp, $3.50. Order PB 151137 from OTS, U.S. Department of Commerce, Washington 25, D.C.*

Analysis of Redundancy Networks

Various properties and characteristics of probabilistic redundancy networks can be used to represent reliability relationships in complex equipment containing redundant elements. Analysis is also applicable to large scale systems containing a multiplicity of alternative subsystems of telecommunication nets containing possibilities of alternative routing. It has been shown that such networks are amenable to systematic analysis; several methods and techniques have been suggested for dealing with such problems. *Analysis of Redundancy Networks, Fred Moskowitz, U.S. Air Force, Griffiss Air Force Base, N.Y. Feb. 1958, 27p, microfilm $2.70, photocopy $4.80. Order PB 133468 from Library of Congress, Washington 25, D.C.*

Visual Display Frequency Indicator For the 10 to 90 cps Range

A new system has been designed and constructed which gives a simultaneous visual display of all frequencies in an arbitrary periodic signal, in the range from 10 to 90 cps. This low-frequency indicating system uses ten banks of vibrating reeds to accomplish the visual display. *Visual Display Frequency Indicator for the 10 to 90 cps Range, S. R. Curley, F. H. Utley, and N. W. Guinard, U.S. Naval Research Laboratory. Sept. 1958, 20p, microfilm $2.40, photocopy $3.30. Order PB 134205 from Library of Congress, Washington 25, D.C.*

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RUSSIAN TRANSLATIONS

Nonlinear and Parametric Phenomena in Radio Engineering

Part 11

A. A. Kharkevich

(Translated by J. George Adashko)

Chapter 1

Nonlinear Circuits and Fundamental Nonlinear Processes

Here, in the 11th bi-weekly presentation of the serial translation of Professor Kharkevich's book, we conclude his Chapter 1 and start Chapter 2.

14. Frequency Conversion

Spectrum conversion in the case of a-m, consists of shifting the low frequency spectrum of the signal along the frequency scale into the range of radio frequencies. Such a shift can be considered as a particular case of a more general

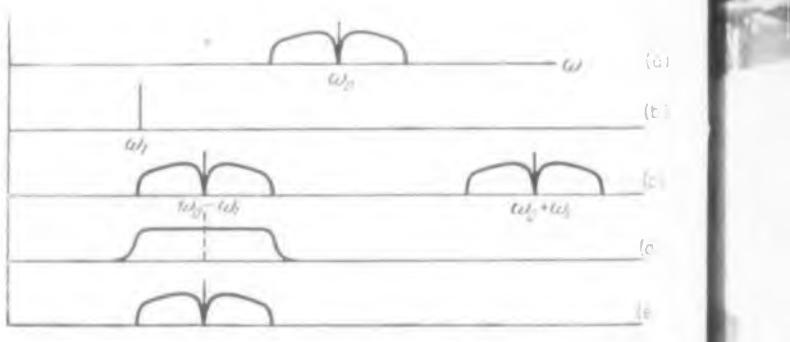

Fig. 50. A typical frequency conversion. (a) shows the original spectrum with carrier frequency ω_0 and two continuous sidebands. (b) shows the spectrum of the heterodyne oscillations—a single spectral line at ω_1. (c) shows the spectrum at the output of the multiplier. It has two modulation spectra of carrier frequencies $\omega_0 - \omega_1$ and $\omega_0 + \omega_1$. (d) shows the frequency characteristics of the intermediate frequency band filter (IFF). (e) shows the spectrum at the filter's output

(right) Checking accuracy of machine threads on a 30 inch magnification contour projector.

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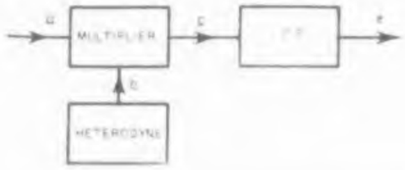

Fig. 51. Block diagram for the frequency conversion of Fig. 50. The letters correspond to those of Fig. 50.

linear operation called frequency conversion.

Frequency conversion means, in general, a shift of the spectrum along the frequency scale into a higher or lower frequency range. It is assumed, that such a shift or transfer does not distort the spectrum. Frequency conversion uses a general technique, consisting of multiplying the oscillation to be converted by a sinusoidal oscillation, produced by a separate heterodyne oscillator. This procedure is often called heterodyning.

The principle underlying conversion is that the product of trigonometric functions of different arguments contains two terms, one of which depends on the sum and the other on the difference of the arguments. For example,

$$\sin x \sin y = 1/2\,[\cos(x-y) - \cos(x+y)].$$

Let us consider a conversion consisting of shifting the modulation spectrum from the range or radio frequencies to the region of intermediate frequencies (on the order of several hundred kilocycles) Fig. 50 shows a typical frequency conversion.

Fig. 51 shows a block diagram of equipment that performs all these operations, as a result of which the spectrum of the initial signal is shifted from ω_0 to the frequency $\omega_0 - \omega_1$. The symbols on Fig. 51 correspond to those of Fig. 50.

Let us note now that if we vary the heterodyne frequency ω_1 gradually, the transformed spectrum will be shifted gradually along the frequency scale, since the middle frequency of the spectrum is

$$\omega_{con} = \omega_0 - \omega_1$$

The possibility of such a shift serves as the basis for the operation of the superheterodyne receiver. The amplification is carried out at an intermediate frequency, and the intermediate frequency amplifier (*IFA*) has a large number of stages that contain intermediate frequency filters. The most important factor in this circuit is that the filters are tuned to a single fixed band. In the superheterodyne receiver, it is not the filters (or tank circuits) that are tuned to the frequency of

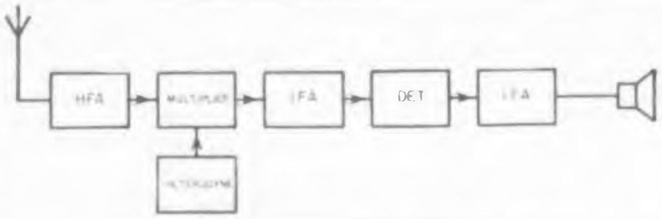

Fig. 52. Block diagram of a superheterodyne receiver

the received signal, but the received signal that is tuned to the intermediate frequency by using the shift of the signal along the frequency scale.

This has priceless advantages. First, the receiver can be tuned with a single dial (which sets the frequency of the heterodyne oscillator) independently of the number of amplification stages. Second, the filters of the i-f stages need not be made tunable, and can be built to ensure minimum distortion at maximum selectivity. It should be noted, incidentally, that the superheterodyne receiver is usually made more complex by adding high frequency amplification (ahead of the mixer), but even in this form this circuit makes the best receiver. The block diagram of Fig. 52 shows, in addition to the elements mentioned, the detector (*Det.*) and low frequency amplifier (*LFA*).

In conclusion, let us note in addition that a special case of frequency conversion is possible, in which the heterodyne oscillator is tuned exactly to the frequency ω_0. In this case the modulation spectrum shifts towards the low frequency region ($\omega_{m} = 0$). This is the case of the so-called synchronous detection, which will be discussed later.

Chapter 2

Generation of Oscillations

15. Self Oscillations

Every kind of radio equipment represents a long chain of linear and nonlinear links. Passing through this chain are oscillations, transmitted from link to link in amplified or in converted form, depending on the purpose of the particular link. It is important that the oscillations in most links be produced only under the influence of the oscillations in the preceding links.

Thus, for example, at the output of a given stage of amplification, the oscillations occur only if a varying voltage from the output of the preceding stage is applied to the input of the given

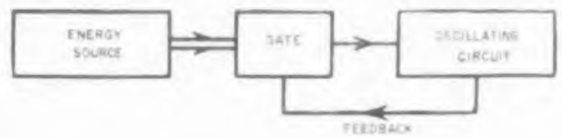

Fig. 53. A self oscillating system.

stage of amplification, the oscillations occur only if a varying voltage from the output of the preceding stage is applied to the input of the given stage. Under such circumstances, we call the oscillations forced. But as we trace a signal through a complex radio circuit from beginning to end, we always reach a link in which the oscillations are not forced, in which they first originate. Oscillations that arise spontaneously in this manner are called self oscillations.

The link in which the self oscillations are produced is called, in accordance with physical terminology, a self oscillating system. From the engineering point of view, this is the generator of the oscillations or the oscillator. A self oscillating system is naturally subject to the law of conservation of energy; any electronic oscillator can be assumed to convert the energy of a dc source into the energy of electrical oscillations.

Let us consider the typical mechanism of self oscillation; the fundamental features of this mechanism can be found in most oscillator circuits. Let us start with free oscillations in the simplest resonant circuit. If the resonant circuit were lossless, the oscillations in it would be undamped. But losses exist in any real circuit.

In addition, we consider the oscillator as a source of oscillation energy, and consequently, a certain amount of energy is drawn by the load circuit. Therefore, a simple resonant circuit cannot serve as an oscillator, the energy that would be stored in it initially would soon be exhauste, and the oscillations would damp out. Therefor to obtain undamped oscillations it is necessary to replenish the energy stored in the tuned circu as it is being consumed.

Thus, an oscillator must have, in addition to resonant circuit, a source of energy. This sourc is a battery or a rectifier—in general a dc sourc To maintain the oscillations in the resonant ci cuit, it is necessary that the energy be supplie to the circuit periodically, in discrete batches, i step with the oscillations that are already takin place; the energy flow must be pulsating. The d

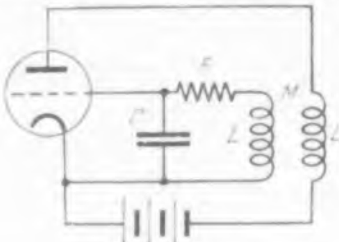

Fig. 54. This circuit has all the elements of a self oscillating system, yet it may not oscillate.

...e that controls the flow of energy into the resonant circuit is called a gate.

For the gate operation to be synchronized with the oscillations in the resonant circuit, it is necessary that the work of the gate be controlled in turn by the circuit itself. The mechanism whereby the gate is controlled by the resonant circuit is called feedback. We thus find that a closed interaction loop is necessary for self excited oscillations. A block diagram of self oscillating system is shown in Fig. 53.

Let us show the practical realization of such a circuit, using as an example the simplest vacuum tube oscillator, shown in Fig. 54. The energy losses in the LC network, due to the presence of the resistance R, are replenished by plate current pulses. The energy source is the plate battery. The role of the gate is assumed by the grid of the triode, and the grid voltage controls the plate current. The grid voltage, in turn, is determined by the oscillations in the resonant circuit.

The interaction loop is closed through coil L_1 in the plate circuit of the triode. This coil is inductively coupled with the coil of the tank circuit. The mutual induction coefficient is denoted by M.

Thus, all the elements of a self oscillating system are contained in the circuit of Fig. 54. However, one must note that although this circuit can generate oscillations, it will not necessarily generate them unless certain essential conditions are satisfied.

Later on we shall analyze the operation of an oscillator in detail. We shall then answer many important questions such as (1) under what conditions are self oscillations produced? and (2) what will be the amplitude of the steady-state oscillations?

It is impossible to answer the second question without analyzing the role played by the nonlinearity of the self oscillating system.

Preliminary ideas concerning this subject are given in the next section.

(To be continued)

CIRCLE 266 ON READER-SERVICE CARD

LETTERS

Visual Material Should Be Seen

Gentlemen:

What annoys you more as a listener? Poor delivery by the speaker or poor presentation of visual material? Many a well-organized, well-presented technical talk has been marred by slides and charts which did not illustrate what they were supposed to, could not be seen, or did not advance the theme of the talk.

To make a "picture worth a thousand words," slides, charts and other illustrations must present information effectively. Visual material should:

1. Explain through sight what may be difficult to grasp through hearing.

2. Supplement your oral discussion graphically and reinforce important points.

3. Furnish a guide for the speaker. The illustrations become your notes.

Illustrations should be both simple, so that they are grasped easily, and large enough, so that everyone in the audience can see them. Even if your subject is complicated, use simple illustrations. If you make your illustrations complex, your listeners will spend too much time deciphering your pictures and not listening to your words. Ideally, each slide or chart should illustrate a single fact. The key point in any slide or chart must be grasped quickly by the audience. If your information is too detailed for one chart, plan to break it up into a series to be shown in sequence. Remember that leaving the slide in view too long will cause the onlookers to fidget in their seats.

Make your titles short. Choose substitutes for long tables, such as line graphs, bar charts, percentage or volume "pie" charts, symbolic representations or photographs. Plan on sizing charts to suit the number of persons expected to attend. A chart 24 by 36 in. should be easily viewed by a group of 50-100 persons. Try a 36 by 40 in. chart with letters at least four in. high for audiences in a larger room or small auditorium. For a larger auditorium, slides projected on a large screen are more practicable. You might want to see how your charts and slides will look from the back of the meeting room. Professional projectors have enough brightness to show clear slides in a size viewable by persons in the last rows of the meeting hall.

A final bit of advice. Make sure the information in your illustrations agrees with what you will say. If you will have to apologize that the "chart doesn't exactly show," don't use it. Visual material should help your talk, not hinder it.

John L. Kent, Manager
Advertising and Public Relations
Datex Corp.
Monrovia, Calif.

▶ The author is past president of the Technical Writing Improvement Society, and is well qualified to speak on this subject.

There's No Easy Way

Dear Sir:

I feel compelled to write concerning statements made by Mr. Richards in "Printed Circuit Artwork—The Easy Way" (*ED*, Sept. 3, 1958, p 62).

"If a 'cheap and dirty' printed circuit will fill the need for an experiment, it is folly to prepare artwork of top quality." Many good designs are rejected because of just such thinking. If a thing is worth doing it is worth doing right. The saving realized by doing things the way suggested is minor compared to the time needed to fully analyze the overall design.

"Magic Lantern or Opaque Projector Method." It seems Mr. Richards has overlooked the main reasons for doing the artwork at an enlarged scale. The reasons for doing the artwork at a large scale are to reduce errors, improve definition and quality of the finished parts. The scale of the artwork is not something to fit the size drawer that the artwork will have to be stored in, but rather a function of the results desired. If one wished to hold ±.002 in. on the finished article, one may have to draw the artwork at ten times scale if the one preparing the artwork can only work to ±.015 in. on the artwork. In any case, some tolerance must be left for the fabricator.

Concerning opaquing negatives. If the artwork is of good quality, opaquing on the negatives is confined to covering pin-holes in the emulsion of the film, and is not intended to be used for drawing the artwork. The time used in opaquing negatives can best be spent in drawing proper artwork in the beginning. The finished article will always be of lesser quality than the original artwork since the processing is of a degenerative nature.

"The tape and tab technique produces the best artwork and is highly recommended where proper equipment is available." This is an erroneous statement not based on fact. The finest

LETTERS

artwork for printed circuit reproduction is produced with ink and quality illustration board such as Strathmore double weight, plate finish. This method competes very well with tape methods all things considered. It is foolhardy to consider that tape artwork is cheaper if after reducing to final size in the camera, one must spend considerable time opaquing and repairing the negatives.

Sorry if I seem "Hard Nose" about this, but articles such as this lead to misunderstanding that ultimately mean the abandonment of printed circuits in many designs. With proper engineering and artwork printed circuits mean cost saving and better equipment in the manufactured articles.

Harry G. Bieker
Industrial Designer
Burbank, Calif.

Dear Sir:

Frankly I think Mr. Bieker's artwork methods are about the type generally used two years ago. My article discussed improvements tested by experience.

Regarding the holding of tolerances of $\pm .002$ in. In 99 per cent of printed circuit work the board is used for the mounting of components such as condensers and resistors whose tolerances vary $\pm 1/64$ in. so it would be folly to hold tight tolerances under such conditions. In the etching processes generally used variations of more than .002 in., nicks and pin holes are common. Furthermore, when holes are drilled, it is impossible to hold the entire pattern to $\pm .015$ in. Therefore, the tolerances in the artwork must be generous and this is accomplished by using as large a tape and tab as the circuit will allow.

. . . "The tape and tab technique produces the best artwork and is highly recommended where proper equipment is available." This statement is NOT erroneous and IS based on fact. The basis of any board reproduction, whether it be by silk screen or photo is the negative. The camera will see black and white and will not differentiate between black tape and India ink.

The procedures outlined in my article have reduced the cost of artwork at Temco Aircraft to less than 25 per cent when compared to the old method which was precisely as recommended by Mr. Bieker. This method works and I have received many favorable comments on it.

Fred F. Richards
Sr. Producability Engineer
Temco Aircraft Corp.
Dallas, Texas

MEETINGS

Calendar of Events

February
8-14 National Electrical Week, New York, N.Y.
12-13 Transistor and Solid State Circuits Conference, Philadelphia, Pa.
14 Short Range Navigational Aids, Montreal, Canada
17-20 6th Annual Western Convention, Audio Engineering Soc., Los Angeles, Calif.

March
3-4 Western Joint Computer Conference, San Francisco, Calif.
5-6 Flight Propulsion Meeting, Inst. of Aeronautical Sciences, Cleveland, Ohio
8-12 ASME Aviation Conference, Los Angeles, Calif.
16-20 National Meeting American Inst. Chemical Engineers, Atlantic City, N.J.
17-21 8th Electrical Engineers' Exhibition, London
23-26 IRE National Convention, New York, N.Y.
26 15th Annual Quality Control Clinic, Rochester, N.Y.
30-April 1 Electrical Industry Show, Chicago, Ill.
31-April 2 21st American Power Conference, Chicago, Ill.
31-April 2 Symposium on Millimeter Waves, New York, N.Y.

Courses and Seminars

Modern Communications: Second series of lectures being presented by IRE Philadelphia section. Topics include: Coding Theory; Trends in Digital Communication; and Communicating Through Analog Channels. Contact: *F. Haber, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia 4, Pa.*

Technical Session

Feb. 10: Data Processing. Sponsored by IRE at IBM Corp., 590 Madison Ave., New York, N.Y. Speakers to discuss: Automation in Machine Tool Control; Application of Data Process Equipment To Keeping Production Abreast of Design Change. The meeting is open to all.

Paper Deadlines

March 1: Call for papers for possible publication in the July issue of **IRE Transactions (PGME).** Theme of issue will be "Simulation in Electronics," the subject being treated both as a research tool and as applied to training devices. An abstract is not required but it is requested you make known your intention to contribute a paper. Further information from *Dr. J. G. Brantley, Jr., Radiation Lab Instrument Div., Orlando, Fla.*

March 1: Deadline for abstracts and rough drafts of outlines of papers to be presented at the first congress of **International Federation of Automatic Control** in Moscow in 1960. **July 15:** deadline for completed papers. Agenda to cover three main areas: Theory; Components and Measurement; and Applications. Contact *W. E. Vannah, American Automatic Control Council, 330 West 42 St., New York 36, N.Y.*

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Please write **H. C. Laur,** Dept. F

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Please write **A. E. Prescott,** Dept. G

industrial instrumentation division Design, development and manufacture of commercial electronic and geophysical instrumentation including data gathering, recording and processing; circuit and instrument packaging; meter movements and transducer elements; remote measurement and control systems. *(NOTE: This division is located in Houston.)*

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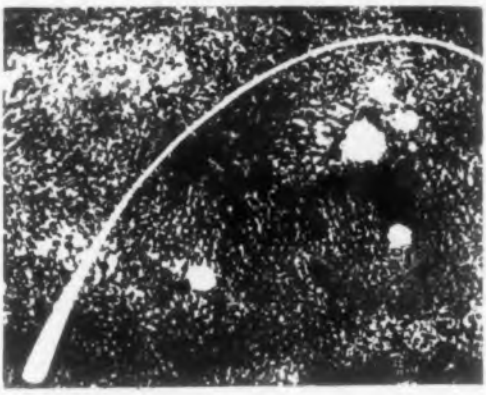

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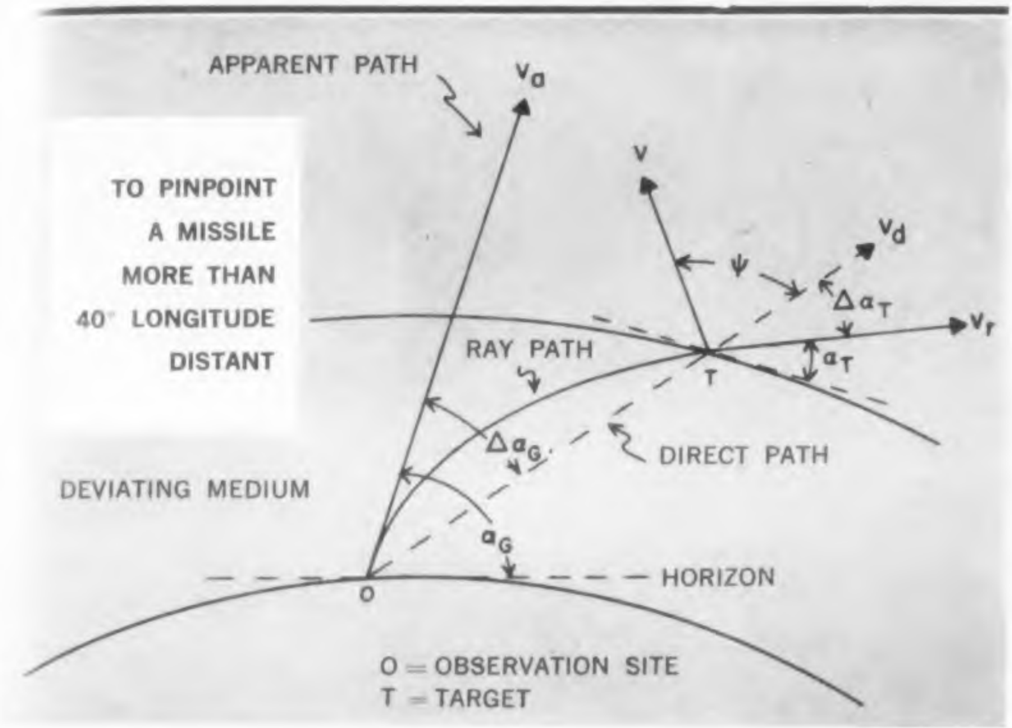

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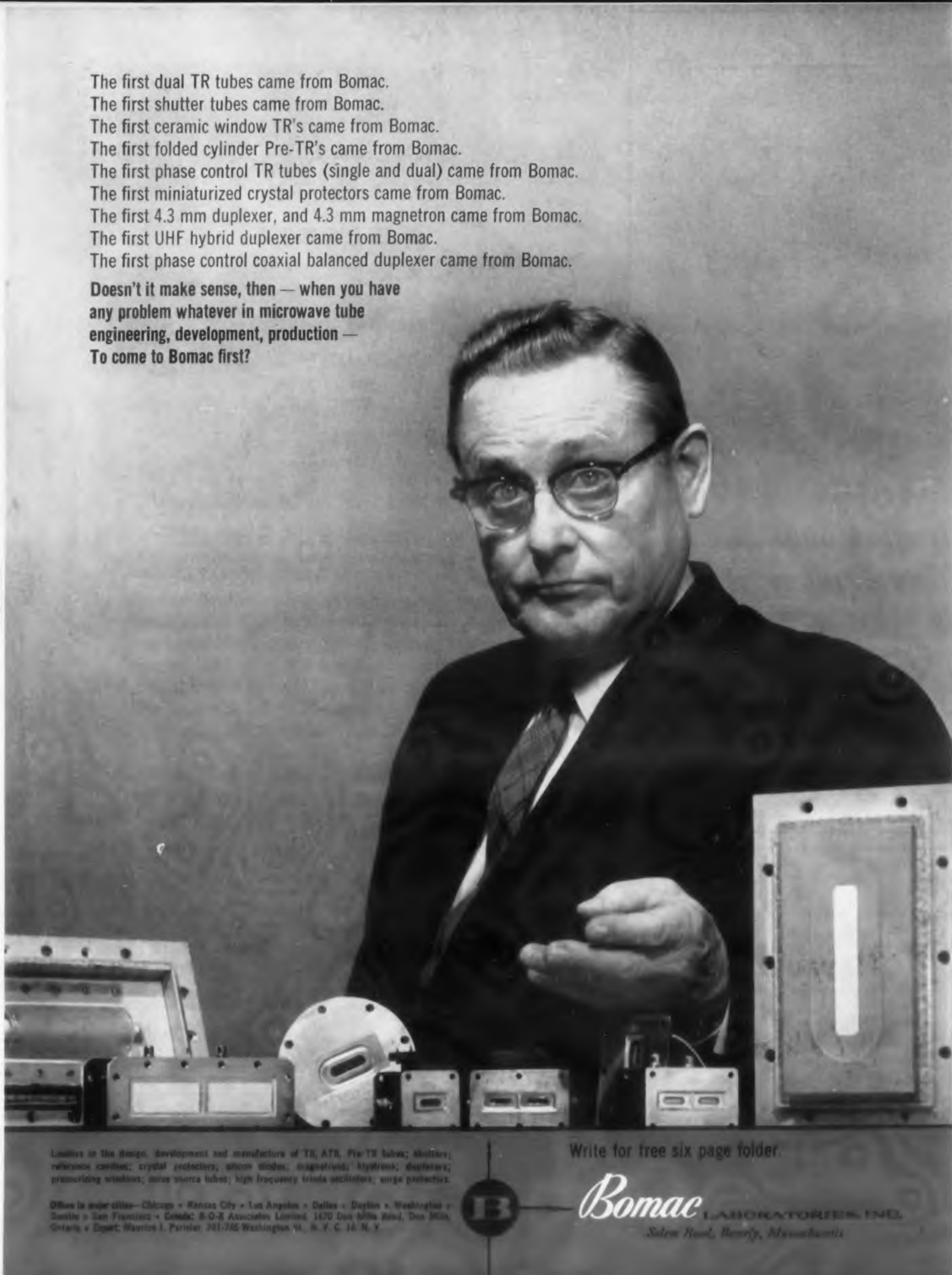

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	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191	201	211	221	231	241	251	261	271	281	291
2	12	22	32	42	52	62	72	82	92	102	112	122	132	143	152	162	172	182	192	202	212	222	232	242	252	262	272	282	292
3	13	23	33	43	53	63	73	83	93	103	113	123	133	143	153	163	173	183	193	203	213	223	233	243	253	263	273	283	293
4	14	24	34	44	54	64	74	84	94	104	114	124	134	144	154	164	174	184	194	204	214	224	234	244	254	264	274	284	294
5	15	25	35	45	55	65	75	85	95	105	115	125	135	145	155	165	175	185	195	205	215	225	235	245	255	265	275	285	295
6	16	26	36	46	56	66	76	86	96	106	116	126	136	146	156	166	176	186	196	206	216	226	236	246	256	266	276	286	296
7	17	27	37	47	57	67	77	87	97	107	117	127	137	147	157	167	177	187	197	207	217	227	237	247	257	267	277	287	297
8	18	28	38	48	58	68	78	88	98	108	118	128	138	148	158	168	178	188	198	208	218	228	238	248	258	268	278	288	298
9	19	29	39	49	59	69	79	89	99	109	119	129	139	149	159	169	179	189	199	209	219	229	239	249	259	269	279	289	299
300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590
301	311	321	331	341	351	361	371	381	391	401	411	421	431	441	451	461	471	481	491	501	511	521	531	541	551	561	571	581	591
302	312	322	332	342	352	362	372	382	392	402	412	422	432	442	452	462	472	482	492	502	512	522	532	542	552	562	572	582	592
303	313	323	333	343	353	363	373	383	393	403	413	423	433	443	453	463	473	483	493	503	513	523	533	543	553	563	573	583	593
304	314	324	334	344	354	364	374	384	394	404	414	424	434	444	454	464	474	484	494	504	514	524	534	544	554	564	574	584	594
305	315	325	335	345	355	365	375	385	395	405	415	425	435	445	455	465	475	485	495	505	515	525	535	545	555	565	575	585	595
306	316	326	336	346	356	366	376	386	396	406	416	426	436	446	456	466	476	486	496	506	516	526	536	546	556	566	576	586	596
307	317	327	337	347	357	367	377	387	397	407	417	427	437	447	457	467	477	487	497	507	517	527	537	547	557	567	577	587	597
308	318	328	338	348	358	368	378	388	398	408	418	428	438	448	458	468	478	488	498	508	518	528	538	548	558	568	578	588	598
309	319	329	339	349	359	369	379	389	399	409	419	429	439	449	459	469	479	489	499	509	519	529	539	549	559	569	579	589	599
600	610	620	630	640	650	660	670	680	690	700	710	720	730	740	750	760	770	780	790	800	810	820	830	840	850	860	870	880	890
601	611	621	631	641	651	661	671	681	691	701	711	721	731	741	751	761	771	781	791	801	811	821	831	841	851	861	871	881	891
602	612	622	632	642	652	662	672	682	692	702	712	722	732	742	752	762	772	782	792	802	812	822	832	842	852	862	872	882	892
603	613	623	633	643	653	663	673	683	693	703	713	723	733	743	753	763	773	783	793	803	813	823	833	843	853	863	873	883	893
604	614	624	634	644	654	664	674	684	694	704	714	724	734	744	754	764	774	784	794	804	814	824	834	844	854	864	874	884	894
605	615	625	635	645	655	665	675	685	695	705	715	725	735	745	755	765	775	785	795	805	815	825	835	845	855	865	875	885	895
606	616	626	636	646	656	666	676	686	696	706	716	726	736	746	756	766	776	786	796	806	816	826	836	846	856	866	876	886	896
607	617	627	637	647	657	667	677	687	697	707	717	727	737	747	757	767	777	787	797	807	817	827	837	847	857	867	877	887	897
608	618	628	638	648	658	668	678	688	698	708	718	728	738	748	758	768	778	788	798	808	818	828	838	848	858	868	878	888	898
609	619	629	639	649	659	669	679	689	699	709	719	729	739	749	759	769	779	789	799	809	819	829	839	849	859	869	879	889	899

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☐ I Supervise Design Work

☐ I Do No Design Work

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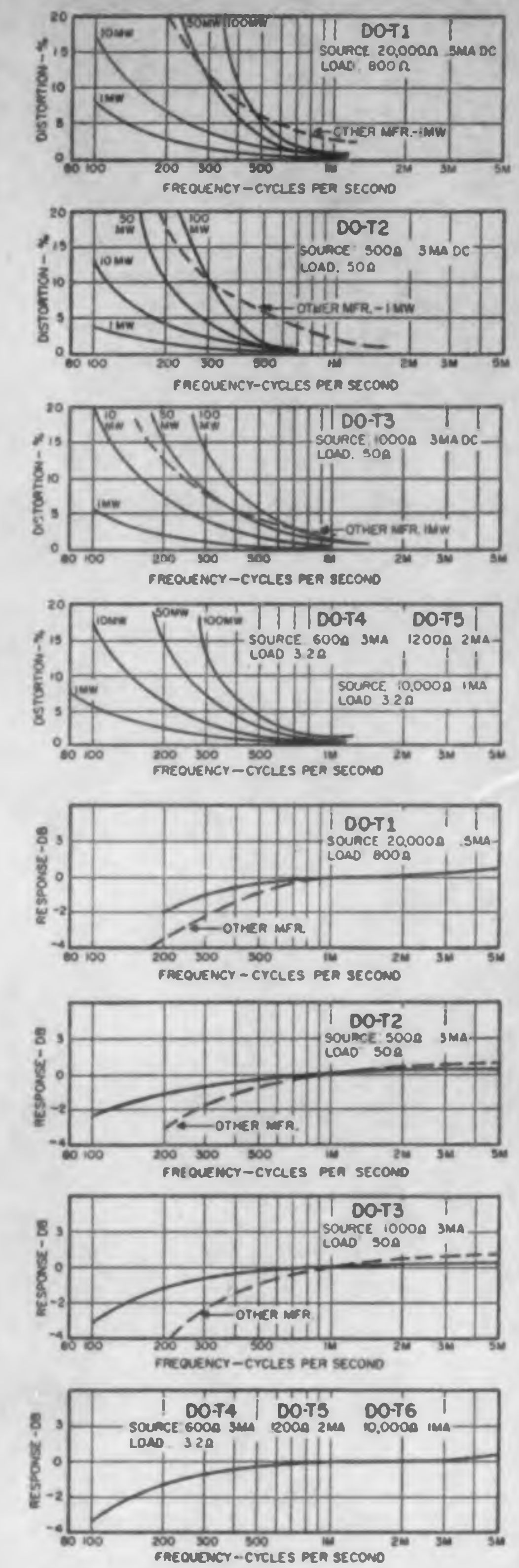
TO MAKE YOUR EQUIPMENT SMALLER YET MORE RELIABLE

REVOLUTIONARY TRANSISTOR* TRANSFORMERS, HERMETIC TO MIL-T-27A

Conventional miniaturized transistor transformers have inherently poor electrical characteristics, perform with insufficient reliability and are woefully inadequate for many applications. The radical design of the new UTC DO-T and DI-T transistor transformers provides unprecedented power handling capacity and reliability, coupled with extremely small size.

TYPICAL DO-T PERFORMANCE CURVES

Power curves based on setting output power at 1 KC, then maintaining same input level over frequency range.



DO-T

⁵⁄₁₆ Dia. x ¹³⁄₃₂, ¹⁄₁₀ Oz.

High Power Rating . . . up to 100 times greater

Excellent Response . . . twice as good

Low Distortion . . . reduced 80%

High Efficiency . . . up to 30% better

Moisture Proof . . . hermetic to MIL-T-27A

Rugged . . . completely cased

Anchored Leads . . . will stand 10 lb pull, plastic leads for printed circuits

DI-T

⁵⁄₁₆ Dia. x ¼, ¹⁄₂₀ Oz.

To fully appreciate DO-T transistor transformers, the curves indicate their performance compared to that of similar size units now on the market. DI-T transformers are still smaller in size. Power rating and other characteristics are identical to DO-T, but low frequency response (3 db down point) is 30% higher in frequency. Units can be used for different impedances than those shown, keeping in mind that impedance ratio is constant. Lower source impedance will improve response and level ratings . . . higher source will reduce them. Units may be used reversed, input to secondary

DO-T No.	MIL Type	Application	Pri. Imp.	D.C. Ma.‡ in Pri.	Sec. Imp.	Pri. Res.	Level Mw.	DI-T No.
DO-T1	TF4RX13YY	Interstage	20,000 30,000	.5 .5	800 1200	850	50	
DO-T2	TF4RX17YY	Output	500 600	3 3	50 60	60	100	DI-T2
DO-T3	TF4RX13YY	Output	1000 1200	3 3	50 60	115	100	DI-T3
DO-T4	TF4RX17YY	Output	600	3	3.2	60	100	
DO-T5	TF4RX13YY	Output	1200	2	3.2	115	100	
DO-T6	TF4RX13YY	Output	10,000	1	3.2	1000	100	
DO-T7	TF4RX16YY	Input	200,000	0	1000	8500	25	
DO-T8	TF4RX20YY	Reactor 3.5 Hys. @ 2 Ma. DC, 1 Hy @ 5 Ma. DC (DI-T8 is 2.5 Hy @ 2 Ma.)				630		DI-T8
DO-T9	TF4RX13YY	Output or driver	10,000 12,500	1 1	500 CT 600 CT	800	100	DI-T9
DO-T10	TF4RX13YY	Driver	10,000 12,500	1 1	1200 CT 1500 CT	800	100	DI-T10
DO-T11	TF4RX13YY	Driver	10,000 12,000	1 1	2000 CT 2500 CT	800	100	DI-T11
DO-T12	TF4RX17YY	Single or PP output	150 CT 200 CT	10 10	12 16	11	500	
DO-T13	TF4RX17YY	Single or PP output	300 CT 400 CT	7 7	12 16	20	500	
DO-T14	TF4RX17YY	Single or PP output	600 CT 800 CT	5 5	12 16	43	500	
DO-T15	TF4RX17YY	Single or PP output	800 CT 1070 CT	4 4	12 16	51	500	
DO-T16	TF4RX13YY	Single or PP output	1000 CT 1330 CT	3.5 3.5	12 16	71	500	
DO-T17	TF4RX13YY	Single or PP output	1500 CT 2000 CT	3 3	12 16	108	500	
DO-T18	TF4RX13YY	Single or PP output	7500 CT 10,000 CT	1 1	12 16	505	500	
DO-T19	TF4RX17YY	Output to line	300 CT	7	600	19	500	DI-T19
DO-T20	TF4RX17YY	Output or matching to line	500 CT	5.5	600	31	500	DI-T20
DO-T21	TF4RX17YY	Output to line	900 CT	4	600	53	500	
DO-T22	TF4RX13YY	Output to line	1500 CT	3	600	86	500	DI-T22
DO-T23	TF4RX13YY	Interstage	20,000 CT 30,000 CT	.5 .5	800 CT 1200 CT	850	100	DI-T23
DO-T24	TF4RX16YY	Input (usable for chopper service)	200,000 CT	0	1000 CT	8500	25	
DO-T25	TF4RX13YY	Interstage	10,000 CT 12,000 CT	1 1	1500 CT 1800 CT	800	100	
DO-T26	TF4RX20YY	Reactor 6 Hy. @ 2 Ma. DC, 1.5 Hy. @ 5 Ma. DC				2100		
DO-T27	TF4RX20YY	Reactor 1.25 Hy. @ 2 Ma. DC, .5 Hy. @ 11 Ma. DC				100		
DO-TSH	Drawn Hipermalloy shield and cover for DO-T's, provides 25 to 30 db shielding.							

‡DCMA shown is for single ended useage (under 5% distortion—100MW—1KC) . . . for push pull, DCMA can be any balanced value taken by .5W transistors (under 5% distortion—500MW—1KC)

*DO-T units have been designed for transistor application only . . . not for vacuum tube service. Patents Pending

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February 4, 1959
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