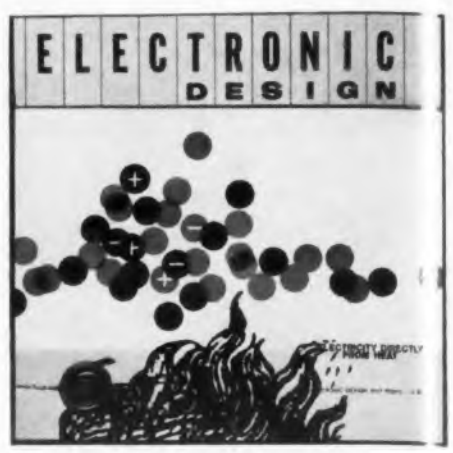
ELECTRONIC DESIGN

ELECTRICITY DIRECTLY FROM HEAT

ELECTRONIC DESIGN Staff Report . . . p 32



COVER: Heat applied to an emissive material produces a flow of electrons. In the cover drawing of this issue, we have symbolized the atomic structure of the emissive material, shown heat, applied in the form of a flame, and have suggested the flow of the electrons through the commercial device, a General Electric thermionic converter, shown at lower left. See the story on p 32.

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Sidelights of the Issue

Heat to Electricity

A long-held dream seems at last to be approaching reality. For years, engineers have sought a way to convert heat directly into electricity. In the past decade, a growing emphasis on new power sources has increasingly focussed attention on the problem.

The military, for example, needs cheaper, better sources. Space programs require smaller, more efficient units for power. And some experts project the population explosion and data on known resources to draw the conclusion that our sources of fossil fuel will be dissipated in a relatively short time.

What does this mean to the designer? How are his efforts being used to provide these new sources of power. In a status report entitled "Converting Heat to Electricity," Technical Editor Howard Bierman explores three aspects of design problems—thermoelectricity, thermionic converters, and magnetohydrodynamics. It begins on p 32.

Crazy, Mixed-Up Scales

One by-product of the recent increased interest in thermoelectricity and thermoelectric devices is the constant conversion that has to be done to and from the three basic temperature scales —Kelvin, Centigrade, and Fahrenheit. To make this a little easier, you can clip and file James R. McDermott's Temperature Conversion Chart, which appears on p 145. It will come in handy as a companion piece to "Converting Heat to Electricity."

Weld It or Solder It?

A large and ever-growing number of engineers have become convinced, during the trend toward smaller and smaller components, that welded connections have decided advantages over soldered ones. For example, a welded joint, they say, has a physical strength of its own.

Some time ago, a few companies, under the leadership of Leo Bernstein of Kearfott, began to investigate the feasibility of welded connections. The few companies have now grown to more than 30, and the committee is now looking into standardization for welded modules.

For a report on this field and where it is going, turn to p 4.

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Russians Seen Catching Up in Automation

But Recently Returned U.S. Specialists at MIT Meeting Say Soviet May Place Too Much Emphasis on Theory

RUSSIAN emphasis on adaptive control systems threatens to nullify the present American lead in automation. The Russians may well by-pass existing analog and digital concepts to create a new generation of automatic control equipment, warned a team of automation specialists at the Joint Automatic Control Conference held this month at the Massachusetts Institute of Technology.

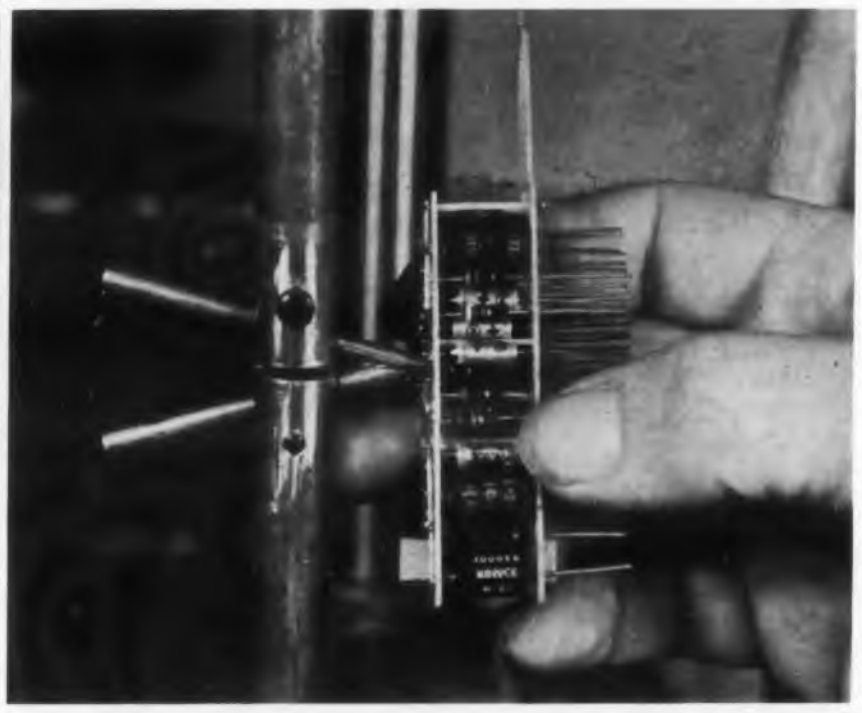
The experts, back from this summer's International Federation of Automatic Control congress at Moscow, reported that intensive theoretical studies by the Russians may soon enter the pay-off stage. While all the scientists were impressed with the magnitude and scope of Soviet control theory, some wondered if the Russians might not be going too far in theory at the expense of practical applications.

"I felt an intense lack of excellence in anything but their mathematical work, and at times this consisted mainly of elegant solutions to nonexistent problems," said Gordon Brown, Dean of Engineering at MIT.

"Research in the Soviet Union is primarily directed by 50-year-old academicians," commented Dr. John Truxal, head of electrical engineering at Brooklyn Polytechnic Institute. "I

Titan, Polaris Programs Spark Rise in Welded Modules

Newly Organized Industry Committee Comprises More Than 30 Companies Seeks To Establish Standardization in Component-Lead Manufacture



AC Sparkplug welded module is placed up to weld heads to make a connection. Nickel leads are generally used on the welded modules, which are usually encapsulated after welding.

WELDED-WIRE modules are taking a leading miniaturization role as an interim step before more advanced micromin concepts reach the hardware stage.

Welded modules make up the major portion of the advanced Titan inertial-guidance system being built by AC Sparkplug Div., General Motors Corp., Milwaukee, Wis. Another new computer system for the Polaris, being built by Raytheon Co., Waltham, Mass., will make use of the welded-wiring concept. Many developmental systems are also being constructed throughout the industry to illustrate the potential of the welded-module concept.

Several advantages of the welded module have led to its selection over soldered units in these vital missile systems. Chief among these are:

- Bulky solder joints are eliminated, allowing greater miniaturization.
- Test results indicate that welded joints are stronger than solder joints, and welded wiring gives the module mechanical rigidity.
- Flux residue is eliminated.
- Very short heat cycles can be used, so that extremely short leads can be used on semiconductors, and components can be stacked one right next to the other without the heat problems involved in making solder connections.
- Bad welds are easier to spot visually than bad solder joints.
- Circuit-board leakage problems are eliminated.
- Tube manufacturers have been improving the welding art for many years.

There have been difficulties with the welded-module technique along with successes. Nonstandard component leads is one of the toughest problems in the field. Joints between many dissimilar materials are necessary, and some commonly used lead materials, such as tinned copper, are not well suited to welding. Wide variations in lead diameter have also caused trouble.

In many cases welded-module producers have found it difficult to find out what lead material a component manufacturer is using, and even

(continued on page 6)

wonder if 50-year-old people are best qualified to direct research these days," he added.

Theoretical Approach May Prove Practical

But despite the heavy emphasis on often abstruse theory, application of automatic controls in Soviet industry appears to be on the upswing. Dr. John Gibson of Purdue University noted the establishment of five new technical institutes for the sole purpose of implementing control theory in industry. The first of these, at Kiev, is said to employ over 5,000 engineers in automation of coal and steel production. Dr. Gibson described the Kiev institute as "Fantastic" and noted that "We've got some sweating to do."

Some of the experts thought that the theoretical approach traditional in Russia may prove more practical in the long run than the empirical approach generally followed here.

Dr. J. C. Lozier, of the Bell Telephone Laboratories, reported seeing little of note in digital computers. "They seem to be behind us in this area," he said, but thought that Soviet efforts in adaptive systems might more than compensate for this.

Americans Neglected Their Homework

Other speakers criticized American scientists for "dropping the ball" in not keeping track of Russian technical developments. "We went to the conference like babes in the woods," said Dr. Gibson.

"The Russians did their homework and came prepared to shoot down the various speakers, especially their own. Our preprints were not ready in time, while the Russians had complete translations. The Russian translators had even corrected errors in the original manuscripts."

Russian scientists were fierce in their discussions. "If a scientist did not get his paper accepted, he usually managed to present it as a critique of someone else's work," Dr. Gibson said.

The visitors to the Soviet Union also noted a great awareness of U.S. work and were questioned in surprising detail. In many instances it was reported that the Russians were more familiar with certain aspects of American research than were our own scientists. A highly efficient translation service maintained by the Russians was cited as one reason for this embarrassing state of affairs.

"Over half the books on control engineering published in recent years are of Russian origin," Dr. Gibson told the conference, "but we can't get translations over here."

In one instance, he said, U.S. and British publishers issued almost simultaneous translations of the same Russian book. ■ ■

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when this is learned there is no assurance that the material will not change from shipment to shipment. Breaking joints and rewelding is also a problem, making maintenance difficult.

Slow Production Is a Drawback

Relatively slow production requiring skilled workers is another drawback to the welded package. Manufacturers point out, however, that the added costs are worth it in missile or satellite systems where size and reliability are critical. Automation on the order of that which might result from dip soldering is unlikely for the high-density packaging welding process, although some parts of the procedure might be automated to some extent where large production orders are received.

To pool information on overcoming some of these difficulties an informal industry committee was organized at the suggestion of Leo Bernstein of American Bosch Arma Corp., Garden City, N.Y. Mr. Bernstein, now with Kearfott Div. of General Precision, Inc., Little Falls, N.J., is currently chairman of the steering committee of this welded-packaging group. Other committee members, selected at a recent meeting of the group at North American Aviation, Inc's Autonetics Div., are P. J. Gray, Sippican Corp.; R. J. Jansson, MIT; M. H. Bester, Autonetics; and S. H. Posser, Airborne Instruments Laboratory. More than 30 systems manufacturers attended

Join Welded-Wiring Committee

Systems companies represented at a recent meeting on welded-wiring techniques held at Autonetics Div., North American Aviation, Inc., were:

AC Sparkplug Div., General Motors Corp.; Aeronutronics Div., Ford Motor Corp.; Airborne Instrument Laboratory; Alloyd Research; American Bosch Arma Corp.; Amphenol-Borg Electronic Corp.; Boeing Airplane Co.; Burroughs Corp; Convair Div. General Dynamics Corp.; Diamond Ordnance Fuze Laboratory; Engineered Electronics Co.; Emerson Electric Co.; Engineered Magnetics Co.; Francis Associates; General Electric Co.; Hughes Aircraft Co.; and International Business Machines Corp.

Also Kearfott Div., General Precision, Inc.; Litton Industries; Lockheed Aircraft Corp.; Martin Co.; MIT Instrumentation Laboratory; Remington Rand Univac Div., Sperry Rand Corp.; Space Technology Laboratories; Sperry Gyroscope Div.; Walter V. Sterling, Inc.; Sylvania Electric Products, Inc.; Westinghouse Air Arm Div.; Air Force Ballistic Missile Div.; and Navy Bureau of Weapons.

Table shows materials combinations welded under Raytheon's Weld-Pak program. Dots represent required joints.

	NICKEL	DUMET (BORAX-COPPER-BRASS-STEEL	MOLYBDENUM	TUNGSTEN	NIPRON (NICKEL-PLATED STEEL)	CHROME-COPPER	KOVAR	COPPERWELD (COPPER-CLAD STEEL)	PERMANICKEL (NICKEL-COBALT ALLOY)	TOPHET "A" (NICKEL-CHROME-IRON)	NICHROME "A" (NICKEL-CHROME ALLOY)	TINNED COPPER	COPPER (OFHC)
NICKEL	•	•	•	•	•	•	•	•	•	•	•	•	•
DUMET (BORAX-COPPER-BRASS-STEEL	•	•	•	•	•	•	•	•	•	•	•	•	•
MOLYBDENUM	•	•	•	•			•						
TUNGSTEN	•	•	•	•			•						
NIPRON (NICKEL-PLATED STEEL)	•	•			•		•	•					
CHROME-COPPER	•	•				•	•						
KOVAR	•	•	•	•	•	•	•	•	•	•	•	•	•
COPPERWELD (COPPER-CLAD STEEL)	•	•			•		•	•					
PERMANICKEL (NICKEL-COBALT ALLOY)	•	•					•		•				
TOPHET "A" (NICKEL-CHROME-IRON)	•	•					•			•			
NICHROME "A" (NICKEL-CHROME ALLOY)	•	•					•				•		
TINNED COPPER	•	•					•					•	•
COPPER (OFHC)	•	•					•					•	•

the recent meeting, and many component producers also sent representatives.

Military Specifications Possible

Because of the widening use of the welded junction, military specifications may be drawn up for them. One of four subcommittees set up by the industry group at Autonetics is working on the specification problem. Other subcommittees are working on selection of most desirable lead materials, best encapsulating compounds, and quality control and reliability.

Results already achieved with the welded package are encouraging. After initial work on the technique by Massachusetts Institute of Technology and Francis Associates, Marion, Mass., a manufacturing company—Sippican Corp.—was set up in Marion to produce welded modules for the program. A 1X-3 DDA for the Polaris was produced by Sippican, packing 8,500 components into a 0.12 cu. ft. package weighing about 15 lb, including cooling and structural elements. Sippican has also produced a logic section for a Sylvania ASD-1 computer, consisting of about 6,500 transistors and 26,000 other components.

Wide Variety of Welded-Module Hardware

Raytheon has produced computers, power supplies, amplifier assemblies, and such digital units as gating, memory and indicator circuits, pulse generators, and magnetic shift registers, all using Weld-Paks.

Packing densities on the order of 135,000 to 150,000 parts per cubic foot are being achieved with the welding approach, compared to some 35,000 to 50,000 parts for printed-circuit-board packaging. ■ ■

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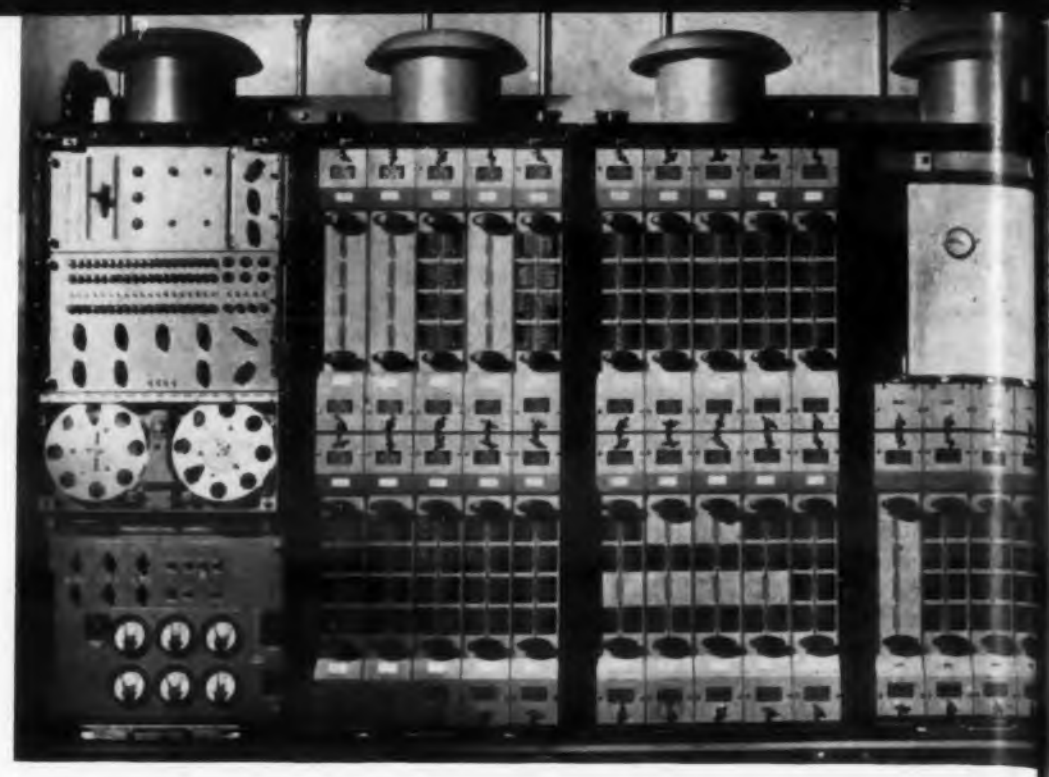


Maintainability Keys Computer Design

MAINTENANCE ease took a leading part in the design of a digital fire-control computer for use in nuclear submarines, built by Librascope Div., General Precision, Inc., Glendale, Calif.

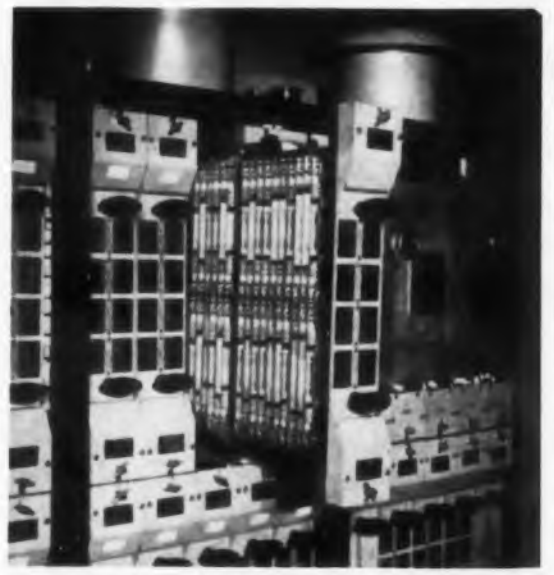
Critical equipment in nuclear subs must be designed so that shipboard repairs can be made by technicians without the aid of shore-based technical experts—so that failures do not reduce time on station. This consideration led to the development of a cookbook method of corrective maintenance, using only standard test equipment such as the vtvm, oscilloscope, or multitester.

A maintenance panel on the front of one of the four computer cabinets permits a technician to trace a malfunction in the machine down to a particular register, and even to the flip-flop in that register, without opening the computer.

Test Points Permit Component Check

Test points at the outer edge of each circuit allow checking of the components on the boards. Marginal checking procedures for various critical components are provided, although it may take some years to learn whether this approach pays off in fewer operational failures, explained Jerome L. Dietz of Librascope's shipboard equipment department at the recent Electronic Packaging Conference in Boulder, Colo.

Removable doors are installed on the front of the four cabinets in the system, and mounted on the inside of each door is a circuit-card extractor along with a metal foil name plate showing the general arrangement of the cabinet, and giving pertinent instructions and operational precautions.



Test points at the edges of each card in a computer drawer consist of nylon bushings containing a CTC banana plug type socket. Marginal checking procedures are provided although the value of this technique in preventing operational failures has not yet been established.

cabinets that make up Librascope control computer for nuclear subs are all labeled to assist maintenance men. Check lights at left and internal test wiring permit location of malfunctions down to a particular flip-flop. Fans in stovepipes at top of cabinets give a little less cooling but also less noise than they would if located at bottom of cabinets.

Preventive maintenance must be made simple, Mr. Dietz explained, or technicians won't do it.

Computer Uses Air Cooling

Most of the computer is air cooled by a Rotron saucer fan placed in a "stove-pipe" at the top of each cabinet. A water-cooled heat exchanger is used in the power supply and checking cabinet which contains 32 heat generating components such as power diodes, regulator and power transistors. Some 600 w are dissipated by these devices.

Individual circuit cards are interconnected within a module by a printed circuit mother board which covers one side of the vertical pull-out drawers. The circuit cards are notched for identification, and in addition background color-matched nameplates identify the boards by function and assembly number.

Space Governed Door Choice

The removable rather than hinged door was chosen because of the narrow space allowed the technician for maintaining the machine from the front—the only accessible side. A bracket on the inside of the checking and power supply cabinet door prevents closure when the computer is in the Test Mode rather than Computer Mode position on a Computer Mode switch. This ensures the computer being put back on line immediately after repair or preventive maintenance.

Since only about 10 per cent of the circuit cards can be carried as spares, the boards most likely to fail were selected. The spare boards are stored in one of the four cabinets so that they are immediately available to the repairman.

Neuron Information Theory May

Bionics Symposium in Dayton Hears Application Is Possible

RESEARCH in bionics—the science of using knowledge of biological systems to solve engineering problems (*ED*, Sept. 14, p 38)—is extending the usefulness of information theory from communications to computer design. Through analysis of networks of neuron models analogous to computer elements, ways are being opened to get positive results in applying information theory to computation systems. Some theorists have thought this impossible.

Massachusetts Institute of Technology researchers told ELECTRONIC DESIGN at the first bionics symposium held earlier this month in Dayton, Ohio, that by creating functional redundancy of certain types, to operate with input-channel redundancy, reliable computation may be achieved at definable rates of information transmission.

According to Jack Cowan of MIT, who delivered a paper at the symposium on "Logic for Parallel Computation in the Presence of Noise," only certain networks appear capable of realizing a non-zero rate of transmission. These are many-valued Post logics, which take the form of functionally redundant networks; elements of

Prof. Warren S. McCulloch of MIT explained the basic structure of a neuron to the first session of the WADD symposium on bionics in Dayton. Professor McCulloch was moderator of the session.

...May Be Used in Computers

these networks would not receive inputs from all possible channels. Mr. Cowan reports that there is no non-zero rate for reliable two-valued logical computation but that there may be such a rate for reliable many-valued computation.

Reliable Computation with Unreliable Circuitry

Another MIT researcher, Lam Vorbeek, reported at the symposium that related analysis has established that reliable computation can be obtained with unreliable circuitry.

Mr. Verbeek's method, he reports, is to design network redundancy into the computer system by adapting the "bundling" of input lines or channels as proposed by Prof. Von Neuman of MIT by interconnecting in a relatively complex way, relatively complex neuron elements.

Although such a network cannot process all logical functions it can treat one class of "universal elements" that permit synthesis of all other functions, reports Mr. Verbeek.

Among the existing bionics devices described at the symposium here:

- A speech-recognition device developed by International Business Machines. This unit, consisting of conventional components, including nuvistors, is programed to distinguish between strong and weak "friction" sounds like that made in saying "s" and the "voicing" sounds of letters like "b" or "l."
- An opto-electronic pattern recognition device that operates as an input filter that might feed a computer. This system, developed by E. E. Loebner, of the Radio Corporation of America, was designed to simulate the property filtering occurring in a frog's eye.
- A recognition machine that recognizes and learns objects regardless of their size. This machine, developed at the Aeronutronic Div. of Ford Motor Co. has a "captive-state" feature—once it has learned properly, it stops learning but continues recognizing.

The Bionics Symposium, sponsored by the Wright Air Development Division of the Air Force, was attended by some 700 specialists of many engineering and biological sciences. ■ ■

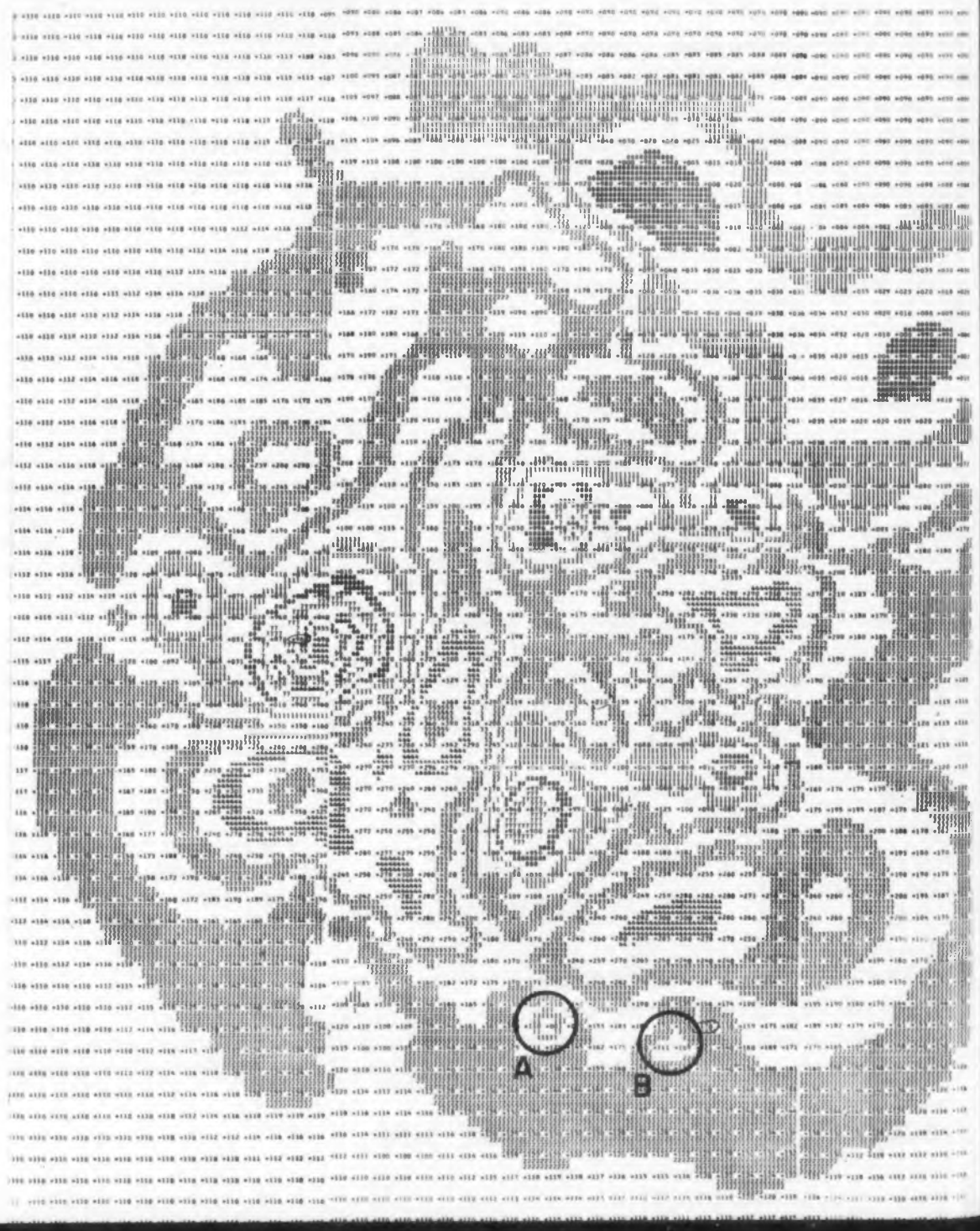
Computer Makes Weather Map for Navy

COMPUTER-PREPARED maps to provide the Navy with "instant weather" will be in regular use early next year. Weather data from up to 5,000 stations throughout the world will be rapidly processed by a computer installed at the Navy Numerical Weather Problems Group (NANWEP) in Monterey, Calif. The computer, Control Data Corp.'s 1604, will generate and print maps of pressure, temperature, wind velocity and other meteorologic data and in addition, will prepare forecasts of these conditions throughout the northern hemisphere up to 24 hours in advance.

Computer programs developed during the past two years are now being refined in "dry-run" tests and digital-data links are being established to the naval centers that will use the weather information. NANWEP's first customer is likely to be the Pacific Missile Test Range at Point Mogu.

Raw weather data teletyped into NANWEP at 12-hr intervals is converted into punched paper tape and then entered into the computer.

NANWEP polar projection map is printed out on three separate sheets by an IBM 717 line printer which are then joined to form the map. Circles *A* and *B* enclose hurricanes near Florida and in the Caribbean, respectively.



Equipment for preparing weather maps consists of a CDC computer and Ampex tape handlers installed at NANWEP. Equipment is expected to be in regular use early next year.

coded in digital form on magnetic tape. Since all weather stations do not report their data in identical form, the computer must first convert non-standard measurements to standard dimensions of temperature, pressure, etc. This involves conversions between centigrade and Farenheit measurements, statute miles per hour and knots, inches and millimeters of mercury and heights in feet and meters.

With all data now in standard units, the computer compares each report with other reports up to 400 miles away. The conditions at each reporting point are compared with values derived by interpolating measurements from the surrounding points. If there are fewer than three points within the 400-mile circle, the data is compared with the forecasts made earlier. In this manner, obviously incorrect reports and information garbled in transmission are discarded.

The entire northern hemisphere is then divided into a 63 x 63 line grid. The weather at each point in the grid is computed by interpolating the data from the weather stations closest to each point. Separate computations are made for each weather quantity such as temperature, pressure, and wind velocity. The result is a separate "map" for each quantity.

Each "map" can then be printed out by indicating the computed values at each grid point. These values are arranged along the actual grid points rather than printed out in tabular form.

The computer also scans the data to print out simultaneously isobars and isotherms at desired pressure or temperature intervals. Isolines are superimposed on the grid values by printing out random numbers at the required points to form a black and white pattern similar to a conventional weather map.

Having prepared maps of the reported weather conditions, the computer generates forecasts for up to 24 hours in advance and prints out maps accordingly. The weather forecasting program combines statistical theory, meteorological

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theory, and rule-of-thumb methods developed by weather men over the years. Each forecast involves some 30 million calculations and is prepared in 5 minutes.

Preparation of weather maps from incoming reports takes about 90 minutes, but almost an hour of this time is spent in transferring the data paper tape to magnetic tape. A tape-to-tape converter developed by Avco will soon be installed to free the computer from this task.

Also due to go into operation soon is a line plotter developed by Electronic Associates which will show isolines as continuous traces rather than as patterns of random numbers. Its use will further permit isolines of different quantities to be plotted on the same map. A map combining both pressure and temperature information, for example, could thus be readily prepared.

NANWEP stems from the Joint Numerical Weather Prediction Unit (JNWPU) established in Washington, D. C., in 1954 by the Weather Bureau and the Navy to develop computer-based forecasting methods. Since JNWPU is primarily a research unit, NANWEP was established to provide day-to-day forecasts of conditions peculiar to naval operations such as sea height, movement of ocean waves, and weather at high altitudes. Since its establishment in 1959, NANWEP has spent more than 10 man-years in developing the computer program to be used in preparing daily forecasts and weather maps. ■ ■

Electronics Is Down But Not Out In Turnpike Man-Machine Battle

Electronics has bowed, at least temporarily, to Man on the bustling New Jersey Turnpike. The Turnpike Authority has discontinued its $12,000 automatic toll-card dispenser until it can find one which can outfox the driver.

The fault, Turnpike toll director Jack Lasher was quick to point out, was not with the machine. The low level of reliability lay in the nut that holds the steering wheel.

Installed several months ago at one interchange, the device, which automatically hands out toll cards, was subjected to coins being shoved into its maw when drivers mistook it for an automatic collector, and to blows, kicks, and abusive language when that didn't work.

But although Machine has lost a battle, it has not lost the war, Mr. Lasher said. He is grooming another fighter—a new type of electronic dispenser costing $15,000—which he hopes will win this time.

Japanese Electronic Production May Go to $1.4 Billion in 1960

The industry's displeasure with the prevalence of the "Made In Japan" label here may become even more pronounced. The Department of Commerce reports that Japanese electronics production for the first quarter of this year is substantially ahead of that in the first quarter of 1959.

The department said that if the Japanese electronics industry continued production at the same rate as between January and March, the value of its products this year would be $1.4 billion. In 1959, the Japanese electronics industry produced $936 million worth of goods.

According to the Department, the broad statistics on the value, in millions of dollars, of electronics goods produced in Japan are as follows:

	1958	1959	Jan.-Mar. 1959	Jan.-Mar. 1960
Consumer	266.2	531.4	99.3	158.5
Industrial, military	85.2	110.6	26.8	34.4
Tubes	76.5	141.1	27.3	44.5
Semiconductors	24.5	52.9	11.5	19.1
Other components	45.6	99.7	19.5	25.6
Total	498.0	935.7	184.4	282.1

The Admiral Corp., Chicago, responded to these recently released statistics with a seven-page pamphlet decrying the lack of U.S. restrictions on Japanese imports.

Navy Orders Improved Plotters For Pacific Missile Range

The Navy has awarded a $208,497 contract for bigger and better plotting boards for the Pacific Missile Range.

The contract went to Computer Systems, Inc., Monmouth Junction, N.J. The boards, which will be 45 in. by 150 in., will handle both digital and analog data.

The boards will have two plotting arms, and each arm, two pens. One pen will plot input data and the other will mark signals.

The analog source will represent input variables as a dc potential between −125 and +125 v. Digital data will position the pen along the Y axis directly. Positioning along the 150-in. X axis will be done by a servo system. A portion of the digital signal will position the plotting arm approximately. The rest of the digital signal will be converted to an analog signal, which will give the more accurate position on the X axis.

The accuracy of the plotting board is expected to be ±0.05 per cent of full scale.

NEWS

NBS Technique Compares Lab

Plots Findings from One Lab Against Results from Others

A NEW approach to correlating results of similar tests performed in different laboratories has been announced by the National Bureau of Standards.

The technique is to plot the results obtained by one laboratory against those from a second laboratory—or against "average results" from a number of laboratories.

Agreement between the laboratories, or between a laboratory and the "average," is indicated if the straight line that best fits the plotted points is at a 45-deg angle to the axes.

A departure of the best-fitted line from this ideal indicates a systematic or non-random difference. This departure must take either of two forms: the line must be parallel to the ideal or must intersect it.

A best-fitted line parallel to the ideal indicates the existence of a constant systematic difference —the results are consistently high or low by the same amount. Intersection of the line with the ideal indicates a variable systematic difference.

The extent to which random differences are present is shown by the scattering of the points about the line denoting systematic differences.

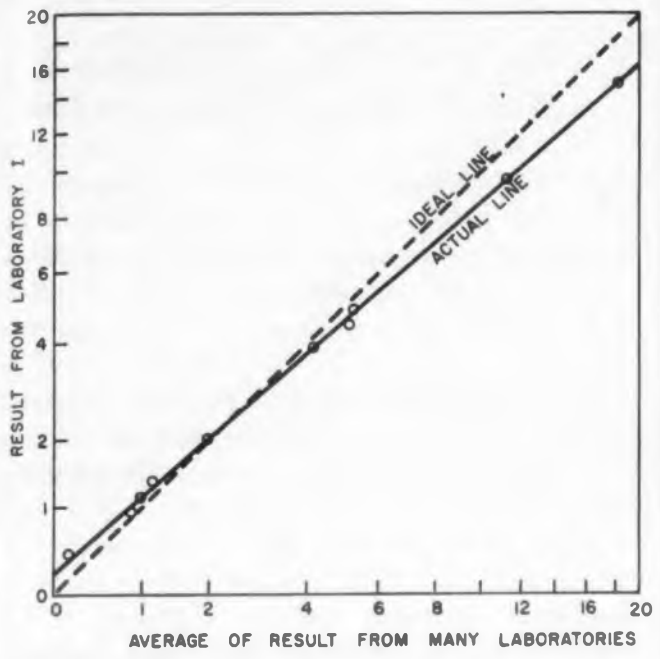
Laboratory Results Transformed

The units of the plot are only infrequently the same as the units of the laboratory measurement. Generally, the units for plotting are obtained by transforming laboratory results thus:

- For each laboratory, a plot is made of the standard deviation of replication error of the measurement vs the magnitude of the measurement. (Replication error is variation among results obtained in one laboratory by one operator using the same instruments on the same unit under test.) The plot is taken as the straight line that best fits the points in the plane.
- From this plot, the standard deviation of replication error is determined for each laboratory measurement. Then the logarithm of each standard deviation is taken.
- It is this logarithmic transformation of the measured unit that is plotted for the inter-laboratory comparison.

Occasionally, however, the standard deviation of replication error is found to be independent of the magnitude of the laboratory measurement. Because of this, the transformation cannot be made. In this case, the inter-laboratory compari-

Laboratory Results



Comparison curve of inter-laboratory results. If results from Laboratory I agreed with average, plot would be straight line at 45 deg to axes. Best straight line through actual points intersects ideal line. This indicates presence of systematic (non-random) errors that give results that are increasingly too high or too low. When actual line is parallel to ideal, systematic error is constant. Scattering of points about actual line indicates extent of random errors.

son plot is made directly with the unit of the measurement.

This comparison technique was developed by J. Mandel and T. W. Lashof. According to Mr. Mandel, the technique is being considered by the American Society for Testing Materials for adoption as a standard way of relating inter-laboratory results.

Previous studies of inter-laboratory tests usually considered three sources of variations among results without producing a useful mathematical tool for handling them.

The three sources, considered individually, were systematic constant differences, replication error, and inter-laboratory variation due to working with one test unit rather than another.

The new approach effectively combines the last two sources into random error. They still can be handled individually to give information to supplement the comparison plot. ■ ■

Accuracy Is Our Policy . . .

On p 144 of the June 22 issue, the price of T. C. Moseley's AC-DC Converter was incorrectly given as $2,500. The correct price is $450.

NEWS

Military-Contract 'Top-Off' Pre

Electronics Slice of Defense Pie Will Be Near $5 Billion in 1961

DESIGN engineers should be prepared to broaden their military design experience to include both commercial and new military fields in view of the expected leveling-off in electronics spending for defense, an EIA committee has stated.

The Military Marketing Data Committee reported at the EIA Fall Conference at French Lick, Ind., that manufacturers of military electronic equipment can no longer expect the "prenomenal" rate of growth experienced in the past decade and should adjust to growth rates comparable to those in other segments of the industry. The presentation was made by Kenneth L. Baker, EIA Military Economist, for the committee which is under the chairmanship of L. H. Orpin, manager of defense planning for the Radio Corp. of America.

New Defense Opportunities

At the same time, the committee said that "stability" in the military market also confronts the industry with a challenge to use effectively its skills in strengthening U. S. capabilities in areas where it believes prospects for future development to be challenging. These include:

- Ballistic-missile defense.
- "Exotic" weapons, including some utilizing lethal radiation.
- Surveillance systems, such as battlefield-scouting aircraft and "spy" satellites.
- Introduction of new communications sys-

The growth and expected top-off of the electronics portion of the U.S. defense budget were subjects of a presentation by EIA's Military Marketing Data Committee at EIA's fall conference in French Lick, Ind. L. H. Orpin (right) explains a chart to L. L. Waite, chairman of EIA's Military Products Div.

p-Off Predicted in EIA Report

tems for the control of combat forces and military-intelligence operations.

▪ Applications of electronics to solution of problems of civil defense. This, the committee said, would involve both the development of disaster-control communications and equipment to detect and warn civilian populations of the existence of radiation and other hazards.

Growth Will Level Off

The report said that for the next 5 to 10 years, military electronic-equipment demand can be expected to run at a growth rate of between 8 and 10 per cent annually. Since the end of the Korean War, demand has risen from 15 to 25 per cent yearly.

The present slowdown, the report said, can be attributed to reductions in expenditures for military aircraft, the fact that principal U.S. air-defense systems have been completed, and abandonment by the military of the practice of introducing new weapons in order to concentrate on relatively few major systems.

$5 Billion for Electronics in 1961

The committee predicted that the electronics slice of the defense pie in the current fiscal year would be in the neighborhood of $5 billion. At the same time, the report stated that slightly more than 10 per cent of the National Aeronautics and Space Administration's $915 million budget would go for electronics, while $130 million of the Federal Aviation Agency's nearly $700 million would be available to the industry. This would be close to the present levels of expenditure.

No Lessening of Japanese 'Onslaught'

Mark Shepherd Jr., vice president of Texas Instruments, Inc., and a member of the EIA Electronics Imports Committee, saw the present lull in Japanese electronics imports as "a short and shallow breathing spell." The Japanese, he said, have great possibilities for envisioning, designing, and producing quality electronic equipment, "and their capabilities are increasing with each passing month."

Dr. Philip Lewis, director of the Chicago School Systems Bureau of Instructional Materials, asked electronic designers to their educational-television equipment "more rugged" and also called for design of closed-circuit systems that can receive external signals. ■ ■

NEWS

NBS Develops Electronic Antenna To Measure Signal Reflection

A new stationary antenna swings its beam electronically through a 42-deg azimuthal arc.

The device, developed by the National Bureau of Standards, achieves the swing only by electronic phase control. A mechanical sweep common with radar antenna is not used.

The antennas use a Yagi-type configuration. They are now used by the NBS in studies of high-frequency propagation by the forward-scatter effect of the ionosphere.

The antennas can measure the direction in which signals are reflected by electron clouds in the ionosphere. This direction, which appears to be somewhat random, previously had been impossible to determine.

According to the NBS, the antenna could be used as a small-space, multi-directional antenna for receiving, and—with design changes—for transmitting.

'Star' Measures Air Turbulence In Lake Michigan Wave Study

The turbulence in the air above the waters of Lake Michigan is being measured by the twinkle of an artificial star.

Light from the "star," a powerful lamp, travels a mile and a half across Lake Michigan through a telescope to a photocell. Thus, variations in the intensity of the light due to changes in the optical density of the air are translated into electrical signals. Changes in the optical density of the air reflect its turbulence.

The project is part of a study by the University of Michigon on the effect of air turbulence on evaporation and wave motion of water.

$1 Billion For R&D in Fiscal '60, Government Gave Lion's Share

The National Science Foundation has estimated that $1 billion were spent on basic research in this country in the fiscal year 1959-60.

The estimate is an extrapolation of statistics covering 1953-58. These statistics indicate that colleges and universities do about half the basic research in this country. Industry performs another third, and the government and non-profit institutions the rest.

The Federal government has been the source of the overwhelming portion of the funds used for basic research.

TV-Optical Scanning Lens Helps Air Force Gunners

All Air Force B-52G aircraft are being equipped with a special TV-optical scanning lens designed and developed by Eastman Kodak of Rochester, N.Y.

According to company officials, the tail gunner sits with the rest of the crew in the forward part of the plane and observes the optical lens image by closed-circuit TV and aims and fires the guns by remote control.

The older type of sight requires a gunner in the tail of the aircraft where air turbulence and vibration make it difficult for him to keep his eye glued to the eyepiece. In the new location, closer to the 156-ft-long bomber's center of gravity where movement is less, the gunner can also carry out other duties and is in a less vulnerable position in case of emergency.

Prisms mounted in a glass dome serve as eyes for the optics and can be rotated to scan the entire area behind the aircraft. The optical system forms a small image, and projects the field of view through the lenses to the TV camera. Then, by closed circuit TV, an enlarged, properly oriented image is presented to the gunner. Through controls at the gunner station, the guns are aimed and, when the target is on the crosshairs, are fired.

The gunner has the choice of two magnifications, one for seeing distant aircraft, and one with low power and a wide field of view for aircraft targets close to the B-52. The TV gunsight has a built-in 16mm movie camera for recording enemy aircraft and for bomb-damage assessment. The optical lens with TV link also has a practical use in collision avoidance; it is used to check behind both on the ground and during flight. The invention is basically a TV-optical viewing lens for the TV link of the fire control system used in the B-52G.

The Air Force has purchased approximately $7.5 million worth of the optical units.

Use of Infrared Heating Units Expected to Boom in Coming Decade

The use of infrared heating units may boom within the next decade, according to manufacturers of controlled infrared heating systems.

These units heat specific areas, indoors or out, without losses which come from heating large unused spaces. The electronics, automotive, printing, and plastics industries are employing such equipment on a broadening scale.

Industry is recognizing the fact that these new infrared units direct or channel the heat to the desired area without waste space.

WASHINGTON REPORT

Ephraim Kahn

SEPARATE RELIABILITY MONITORING contracts are being considered by NASA in connection with purchase of major items of complex equipment. Ernest W. Brackett, in charge of the agency's Office of Business Administration, says such contracts would be placed with engineering firms. Job of these firms would not be inspection of products, but making sure "that proper reliability steps are being taken by the contractor, and to assure that reliability measures being taken are up to the present state of the art." One such contract, worth $150,000, has already been placed in connection with the Saturn booster vehicle. Reliability contracts will be let by NASA's Washington headquarters.

NEGOTIATING AUTHORITY of the Defense Department is adequate to assure that military supply needs are met, according to Perkins McGuire, Assistant Secretary of Defense (Supply and Logistics). He has told the Senate Small Business Committee that no new authority is needed to make certain that there is real competition for defense orders. This would normally be used, he said, where (1) patents or trade secrets exist; (2) the skill and low cost of an existing supplier has forced others to withdraw from the market; or (3) high start-up costs have already been paid by an existing source but can not be competitively absorbed by others. McGuire says that "it does not seem right for us to make a regular practice of deliberately infringing patents" where production capacity is adequate.

"FUNCTIONAL" BUDGETING for the Defense Department should be looked at very carefully, states incoming Army Chief of Staff Gen. Decker. This would entail allocation of funds to types of weapons according to the job they do, with less than the customary observance of the relatively rigid inter-service lines of authority. Logical candidates: nuclear-retaliatory and air-defense forces.

NUCLEAR-ROCKET policy planning has been scored by Democratic Sen. Clinton Anderson. According to the senator, who is chairman of the Joint Atomic Energy Committee, it was "quite apparent" several years ago that "some of the manufacturers of conventional rocket fuels were not anxious to have a nuclear competitor." Now NASA has asked aircraft companies to study the situation and inform the agency what policy should be the first for flight-testing of a nuclear rocket."

ALLOCATION OF EXTRA FUNDS voted by Congress for anti-submarine warfare (ASW) has been made by the Navy. Of the $42 million added by the lawmakers, electronics will share in at least half. The breakdown of planned use of the money

shows more than $21 million going for detection and classification; $14.2 million for basic and applied research, development, test and evaluation; about $5 million for weapons development; and almost $1.5 million for oceanographic research. Radar, sonar, and sonobuoy equipment accounts for most of the ASW detection and classification program.

NO MORE TARIFF CUTS for imports of electronic equipment or components should be permitted, according to an EIA brief filed with the U.S. Committee for Reciprocity Information. U.S. industry finds it hard to compete with foreigners, the brief states, because of "the great differential in wages, research and other costs." EIA also takes exception to the government's "vague and uncertain" language setting forth the products subject to tariff negotiation.

ONLY EXPERIMENTAL ITEMS will be manufactured by NASA, according to an agency spokesman. The agency has confirmed, at top level, its earlier decision to use commercial facilities whenever this is feasible. In the current fiscal year, NASA will spend about 16 per cent of its "hardware" budget on projects carried on within the agency, largely in research or design and specifications. Contracts will be let for the 84 per cent balance.

UNIFORM GOVERNMENT PATENT POLICY is an "obvious need," according to Lyndon Johnson. This is a major reason why the Senate failed to act on the House-passed bill to modify the stringent patent rules that govern NASA. The Democratic Vice-President candidate observed that so far-reaching a change should be preceded by hearings and investigations, and there was not time for this or for adequate debate on the floor. Furthermore, Johnson says there is no conclusive evidence that the NASA patent policies — which have been reconfirmed by Congress, for all practical purposes, in passing this year's Helium and Coal Research Acts — deter industry from doing business with the agency. Some NASA officials do not agree on this point, though others feel that companies can be adequately rewarded for inventions through the agency's Inventions and Contributions Board.

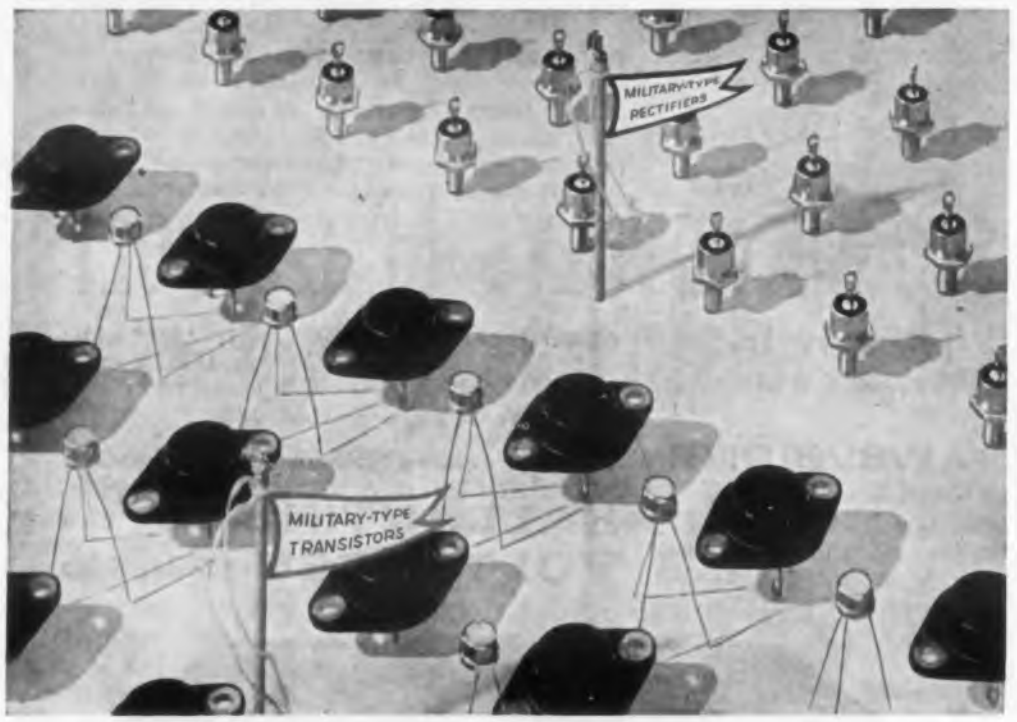
OVERSEAS PURCHASE RULES of the Air Force have been clarified as a part of its "program of development of indigenous [foreign] sources and indigenous item descriptions." Extent of the impact of this policy of maximum purchasing from local suppliers upon electronics items apparently cannot be evaluated at present. Factors militating against foreign buying would include: excessive cost in comparison with U.S. price; excessive delay in delivery; and serious adverse economic effects on the U.S. or impairment of industrial-mobilization capacity. The Air Force says that when a meaningful price comparison between U.S. and foreign suppliers cannot be made, the first purchase is to be made from the foreign source and a second from the U.S. Price records will be kept so that there will be an adequate basis for future cost comparison.

EXTRA QUALITY AT NO EXTRA COST WITH BENDIX TRANSISTORS

Bendix Bulletin

Up-to-the-minute news about transistors and rectifiers

MIL-TYPE SEMICONDUCTORS CREATE NEW DESIGN FREEDOM



DESIGN ENGINEERS find Bendix military-type power transistors and rectifiers a virtual "parade" of ruggedness and reliability. They also find Bendix engineers most helpful with circuitry and application problems.

MAXIMUM RATINGS AND TYPICAL OPERATION OF MILITARY POWER TRANSISTORS

TYPE NUMBER	MIL-T-19500	MAXIMUM RATINGS						TYPICAL OPERATION	
		Vce Vdc	Vcb Vdc	Ic Adc	Pc W	Tj °C	T storage °C	hFE at Ic Adc	
2N297A	/36A (SigC)	−50	−60	5	35	95	−65 to +95	70	0.5
2N331	/4A	−12	−30	0.2	0.075	85	−65 to +85	50	0.001
2N1011	/67 (Sig C)	−70	−80	5	35	95	−65 to +95	55	3.0
2N1120	/68 (Sig C)	−70	−80	10	45	95	−65 to +95	35	10.0

Ideal for such applications as:
HIGH CURRENT SWITCHING • AUDIO AMPLIFICATION
SMALL MOTOR AND SERVO DRIVERS

MAXIMUM RATINGS OF MILITARY POWER RECTIFIERS

TYPE NUMBER	MIL-E-1	Io at 150°C	PRV Vdc	Llb at 25°C	Epp	Llb at 150°C
1N1614	/1240	5 Adc	200	50 μAdc	140	750 μAdc
1N1615	/1241	5 Adc	400	50 μAdc	280	750 μAdc
1N1616	/1242	5 Adc	600	50 μAdc	420	750 μAdc

Ideal for such applications as:
MAGNETIC AMPLIFIERS • DC BLOCKING CIRCUITS
POWER RECTIFICATION

CIRCLE 22 ON READER SERVICE CARD

Broad Bendix line meets both electrical and environmental military specs.

Here, in Bendix* Power Transistors 2N297A, 2N331, 2N1011, and 2N1120, and Bendix* Power Rectifiers 1N1614, 1N1615, and 1N1616, is a versatile line completely designed to meet military specifications. This combination —most extensive series of its type —permits unusual design latitude on military equipment applications. All units feature outstanding ruggedness and reliability to meet both electrical and environmental conditions.

The four transistors are especially suited to high-current switching, audio amplification, small motor and servo driver applications. The three rectifiers, with their low forward drop and low reverse leakage current, are ideal for magnetic amplifier and DC blocking circuits, in addition to power rectification.

Write today for NEW BENDIX SEMICONDUCTOR CATALOG on our complete line of power transistors and power rectifiers. Bendix offers engineers many challenging opportunities in semiconductors. Write Personnel Manager for full details. *REG. U.S. PAT. OFF.

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NEWS

CHANGES IN PRICE & AVAILABILITY

SILICON TRANSISTORS have been reduced in price up to 58 per cent by Raytheon Co.'s Semiconductor Div. of Needham Heights, Mass. Reductions in the silicon line range from 18 to 58 per cent for switching units, 18 to 32 per cent for power transistors, and 10 to 54 per cent for subminiature units. Switching types affected are the 2N333, 2N334, 2N335, 2N336, 2N337, 2N338, 2N1386, 2N1387, 2N1388, 2N1389, and 2N1390. Power units affected are the 2N389, 2N424, 2N1470, 2N1657, and 2N1660. Subminiature types affected are the 2N745, 2N746, 2N747, 2N748, 2N749, 2N750, and 2N751. Also included in the price reduction is the 2N1528, a 6-mc, video amplifier. Price changes are effective immediately.

MAT AND MADT TRANSISTORS have been reduced in price by Philco Corp. of Lansdale, Pa. The MAT 2N393, a low-energy high-gain switch and the MADT 2N501, an ultra-fast switching device are affected by the price reductions. For quantities of 1,000 or more, the 2N393 has been reduced from $4.15 to $3.45 per unit. The per unit reduction affecting the 2N501 in quantities of 1,000 or more shows a drop from $6.75 to $4.90. Price reductions are effective immediately.

DIODES, TRANSISTORS, AND RECTIFIERS have been reduced in price from 10 per cent to 55 per cent by Hughes Aircraft Co.'s Semiconductor Div., Newport Beach, Calif. Examples of specific price reductions are as follows: 51 per cent cut in IN625 silicon computer diode prices and a 47 per cent reduction in IN662 diodes; germanium diodes, both point contact and gold bonded, show a 10 per cent reduction, with such types as IN98J showing a 46 per cent cut, IN277 a 38 per cent reduction and IN283 a 52 per cent cut; Zener voltage regulator diodes average an 11 per cent reduction with series IN702-707 and IN708-712 showing a 12 per cent price drop.

GERMANIUM-ALLOY JUNCTION TRANSISTORS have undergone an across-the-board price cut averaging 25 per cent by U.S. Transistor Corp. of Syosset, N.Y. U.S. Transistor is also expanding its production facilities to manufacture silicon mesa transistors for use in computers and military components. The silicon mesa transistors are scheduled for delivery in three months.

CIRCLE 23 ON READER-SERVICE CARD

Long Island Futuronics Show Slated For Nov. 30-Dec. 2

The 3rd Annual Futuronics Exposition will be held Nov. 30 through Dec. 2 at the Roosevelt Exhibit Hall, Garden City, N.Y. The exposition, sponsored by the Long Island Electronics Manufacturers Council, is expected to have 100 exhibitors.

The Council is composed of 60 member companies representing most of the electronics industry on Long Island. A survey revealed that Long Island accounted for $750 million, a significant proportion of the nation's total $9.2 billion electronics sales estimated for 1959.

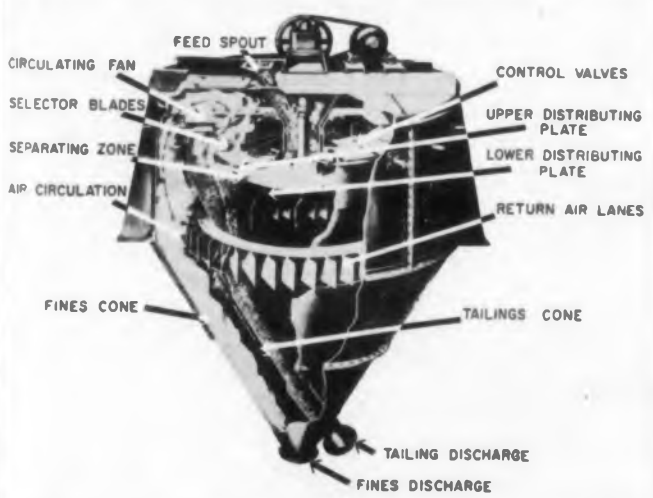
Joint Computer Conference Set For Dec. 13-15 in New York

The 10th Annual Eastern Joint Computer Conference (EJCC) will be held Dec. 13-15 at the Hotel New Yorker and Manhattan Center in New York City.

The EJCC is sponsored by the National Computer Committee which consists of representatives of the IRE, the AIEE, and the Association for Computing Machinery. The committee sponsors two meetings each year—one in the East, the other in the West.

General conferences chairman Nathaniel Rochester of International Business Machines Corp. said that no parallel sessions are planned and a $300 prize will be awarded for the best presentation of a paper at the conference.

Separator Yields Nose-Cone Material



Fine quartz that ultimately will be made into nose-cone material is segregated from large quartz particles by this air separator. An air stream intercepts a spray of pulverized quartz, and carries away the lighter, finer particles. Device was made by Sturtevant Mill Co., Boston, for the Lycoming Division of Avco, Stratford, Conn.

NEWS

Transistor Sales Up Two Thirds In First Half of '60, EIA Study Shows

Transistor manufacturers sold 67 per cent more transistors in the first half of 1960 than they did in the corresponding period of 1959, according to the Electronic Industries Association.

The increased sales were worth more than $52 million to the manufacturers. A tabulation of transistor sales for the first half of 1960 follows:

Transistor Sales

	Factory Sales (Units)	Factory Sales (Dollars)
June	10,392,412	$27,341,733
May	9,046,237	24,146,373
April	9,891,236	23,198,576
March	12,021,506	28,700,129
February	9,527,662	24,831,570
January	9,606,630	24,714,580
Year-to-date '60	60,485,683	152,932,961
Year-to-date '59	36,098,026	99,813,775

New Japanese Weather Radar Doubles Range of Typhoon Spotting

A new Japanese weather radar on the island of Shikoku reportedly spots typhoons more than 300 miles away.

The maximum power output of the unit is 600 kw at 2740 mc. The 2 μsec pulses are repeated at the rate of 220 per sec. The intermediate frequency bandwidth is 3 mc around 30 mc.

The unit's parabolic antenna is 15.7 ft in diameter and is rotated ten times per minute.

Previous "typhoon radars" in Japan have had a maximum range of 170 miles. The extended range of the new radar reportedly is due to the use of a parametric amplifier that is 99 to 110 db more sensitive than the customary parametric amplifiers.

The radar was made by the Tokyo Shibaura Electric Co.

Adaptive Systems Symposium Set For Oct. 17-19 in N.Y.

A symposium on Adaptive Control Systems will be held at the Garden City Hotel, Garden City, Long Island, N.Y. on Oct. 17-19.

The three-day symposium will be given over to definition of the problem, analytical and theoretical aspects and techniques, and the practical relationships of adaptive systems. Technical sessions will be chaired by Dr. John Ragazzini of New

York University, Lt. Phillip Gregory of Wright Air Development Division, and Dr. John Truxal of Polytechnic Institute of Brooklyn, among others.

The symposium is sponsored by the Long Island Section of the IRE. For additional information contact Eugene J. Cronin, Chairman of the Publicity Committee, Box 148, Glen Cove, Long Island, N.Y.

IBM Airborne Memory Drum Packs 100,000 Bits in 3"x3" Size

Techniques for achieving extremely high packing densities have been applied to an airborne memory drum which holds 100,000 bits with drum dimensions of 3-in. long and 3-in. diameter.

Incorporating up to 60 specially designed heads in an 8-lb assembly, the drum has a typical average access time of 5 msec with a 175 kc clock rate. Extremely high density is achieved by using the new head design and a special drum surface coating to reduce interference between tracks and bits in each track. A spokesman for International Business Machine Corp.'s Federal Systems Div., designers of the drum, said that the techniques could not be described because of proprietary reasons.

The airborne drum is designed to withstand stresses up to 15 g and severe vibration. The drum rotates at about 6,000 rpm, with heads held off of the surface by the cushion of air built up by the spin.

Miniaturized drum assembly shows seven read-write heads in place. Up to 60 heads can be used depending on application.

NEWS

New Army HIPAR Radar

Uses Multi-Megawatt Klystron; Provides Precise Azimuth Data

A NEW, high-power acquisition radar known as HIPAR has been credited with a key role in the destruction of Corporal and Nike-Hercules missiles by other Nike-Hercules missiles in recent tests at White Sands, N.M. Developed by General Electric's Heavy Military Electronics Dept., the new radar employs a man-sized multi-megawatt klystron and advanced moving-target-indicator circuitry said to be extremely resistant to electronic countermeasures.

HIPAR provides highly precise azimuth data through the use of a high-gain, narrow-beam tracking antenna. This information permits target-tracking radars built by Western Electric to lock rapidly onto high-performance targets.

The HIPAR and target-tracking radars are but two aspects of a generally improved Nike-Hercules system, details of which are still classified. The new system is said to be more than triple the defensive capabilities of the present Nike-Hercules and to make it able to track and destroy any air-supported target in existence or known to be in development. The White Sands tests also indicate a capability against tactical ballistic missiles and air-to-ground missiles.

A mobile version of HIPAR is being developed to permit tactical deployment of the improved Nike-Hercules. Recently completed packaging studies have resulted in semi-automatic antenna erection techniques. A "Butterfly" type

Improved Nike-Hercules radars at White Sands. Radome in foreground contains the HIPAR acquisition antenna. Smaller radomes contain target tracking radars. New system has proven effective against tactical ballistic missiles.

Aids Nike Effectiveness

Receiver and moving-target indicator for HIPAR radar. At left is the multi-megawatt klystron used in the system. Tube was developed by GE's microwave laboratory, Palo Alto, Calif.

antenna will cut systems erection time by 80 per cent, according to GE. The entire radar system, including power generators, can be transported in 10 standard trailers and airlifted in four C-124 transport aircraft. ■ ■

Computer Plays Dual Role In Hound Dog Missile Guidance

A computer developed by Autonetics of Downey, Calif., has two functions. In the air, it is the center of the guidance system of the GAM-77 Hound Dog missile. On the ground, the computer (called Verdan) automatically checks out the missile's inertial autonavigator.

Once the guidance system ground-calibration and checkout are complete, the flight program is fed into the computer to join the system calibration factors previously stored. At this point, the computer reverts to its primary role as the brains of the guidance system to direct a Hound Dog flight.

Using the computer in this dual role allows comprehensive automatic checkout to be accomplished through the versatile computation and memory capabilities of the computer. It eliminates the requirement for the step-by-step interrogating device usually associated with automatic checkout operations.

Test results are reportedly far more consistent than those resulting from manually conducted tests. The comprehensive checkout and calibration of this guidance equipment can be accomplished by technical personnel after a short training period.

"Small size is not enough!"

"Nothing fits . . . components too bulky . . . have to save space . . . have to trim size . . . maybe eliminate tubes . . . maybe brackets, too . . . maybe smaller relays. Yes, relays . . . if there's a smaller one that's fast enough, strong enough, tough enough. Better be careful though . . . can't sacrifice performance . . . or reliability. Now, where are those sealed relay catalogs?"

We at General Electric appreciate this respect for relay performance. Relay tasks are normally too critical to risk compromising reliability no matter what the gain—small size not excepted. That's why performance always comes first in General Electric sealed relays.

But we haven't forgotten the importance of miniaturization either. In fact, General Electric designers have pioneered in minaturized relays four times in the past ten years — Miniature (1951), Micro-miniature (1955), and 4-pole and Unimite (1959). Each relay represents an advance in *performance*, as well as a reduction in size.

Superior performance is no accident with General Electric sealed relays. It is the product of General Electric's advanced technology, ever improving manufacturing processes, relentless testing, and stringent quality control.

For relays that offer top performance and reliability in the smallest available packages, turn first to your G-E Sealed Relay Catalog. As always, more information is available from your nearby General Electric Sales Engineer. General Electric Co., Specialty Control Dept., Waynesboro, Virginia.

Progress Is Our Most Important Product

GENERAL ELECTRIC

GENERAL ELECTRIC SEALED RELAYS—UNMATCHED FOR RELIABILITY

CIRCLE 29 ON READER-SERVICE CARD

General Electric sealed relays for the '60's

4-POLE MICRO-MINIATURE

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EDITORIAL

Never Too Early to Talk the Same Language

Too often a manufacturer tags his product with an extremely high accuracy rating without any reference to exactly what is being measured. Accuracies stated in terms of 0.00015 per cent are not uncommon these days. But just what do they mean? Take, for example, the common, unglamorous 1 per cent panel meter. Not many engineers could say definitely whether the 1 per cent panel refers to repeatability, linearity, or preciseness. Needless to say, no rating, regardless how many zeros follow the decimal point, is definitive without a specific reference.

In at least one instance we know of, lack of agreement on terminology has held up delivery on a contract worth more than $1 million. One of our authors informs us that it took several months to clear up the bind—at the expenditure of many man-hours and thousands of dollars.

Lack of agreement on terminology and standardized test methods has hampered the potentiometer industry seriously. Rather than buck the confusion, some weapons systems manufacturers have resorted to producing their own potentiometers.

We welcome and wish success to the newly formed organization of potentiometer manufacturers which is tackling the problem of standards. They cannot act too soon in agreeing on a common nomenclature.

The Ultrasonic Manufacturers' Association also is to be congratulated for its activity in setting up standards. It most certainly should take up the job of defining cleanliness. Ultraviolet light has shown too many "clean" jobs to be considerably contaminated.

The business of making definitions is a never ending one. As technology makes an advance, old definitions prove inadequate. The electronics engineering profession cannot put up with Alice in Wonderland characters who claim, "I mean it to be just what I mean it to be."

James C. Kyprios

The direct conversion of heat to electricity has long been one of the engineer's dreams. Now it is rapidly approaching reality. In this Staff Report, **ELECTRONIC DESIGN** *takes a long, hard look at three major areas of the power-source field and tells the engineer what is available, what is being done, and what the future holds.*

Howard Bierman
Technical Editor

CONVERTING HEAT TO ELECTRICITY

A Status Report

A HIGH DEGREE of emphasis by the military and public utilities has been placed over the past decade on direct heat-to-electricity conversion techniques, and from this increased scrutiny has come a wide variety of applications. Thermal energy, whether from fossil-fuel combustion, solar heat, or nuclear reaction, can be applied to thermoelectric generators, thermionic converters, and magnetohydrodynamics (MHD), as illustrated in the flow chart, Fig. 1.

The quest for power sources meeting various specifications calls for novel design ideas. The Navy, for example, despite its expanding nuclear-submarine force, is seeking less expensive noise-free power sources. These are highly desirable since submarines are relatively poorly armed and depend on surprise for fighting advantage. Space programs demand low-weight, long-lived power generators free from gyroscopic effects and the necessity for periodic lubrication. In the public-utilities field, newer power sources are seen as "toppers" or adjuncts to improve over-all efficiency, with future MHD generators expected to deliver power in the megawatt range.

Finally, experts have projected population increases, the improved standard of living, and other relevant factors to conclude that within a relatively short time, the supply of conventional fuels will be exhausted. Dates vary but the conclusion itself points up the need for consideration of solar and nuclear energy as acceptable alternate substitutes for fossil fuels.

Thermoelectricity, discovered by Thomas Johann Seebeck in 1821, resulted in a heat-to-electricity conversion efficiency of 3 per cent, which compared favorably with the mechanical efficiency of steam engines at that time. Unfortunately, little effort was directed towards achieving gains during the next 100 years. Those who did experiment failed, since, as physicists later learned, the key to high output and efficiency was semiconductor technology, many years distant.

Thomas Edison, experimenting with light bulbs containing two independent filaments, observed current flow through the cold filaments when one filament was in operation. From this observation, Edison concluded that electrons moving in a vacuum could flow from a hot to a cold surface. Thus evolved the basis of thermionic converters.

Michael Faraday's discovery of current generation by the action of a conductor moving in a magnetic field is well over 100 years old and is the principle on which MHD operation is based.

Although each of the three approaches under discussion are many years old in concept, only recently have extensive efforts been directed toward practical device production. The present needs for such devices coincide with rapid strides in material technology over the years to permit a good starting point for research efforts.

Other direct conversion techniques and energy sources such as fuel cells, solar converters and primary and secondary batteries share present development studies and will be presented shortly in *ELECTRONIC DESIGN*.

At this time it would be presumptuous to attempt to choose the "ultimate" in a power device. Capital costs, fuel availability, over-all system efficiency rather than device efficiency and life expectancy are factors which vary with each approach. Only after careful consideration for one particular area of application can a positive decision be reached; for a slightly different application, further evaluation might lead to the adoption of an alternate power source.

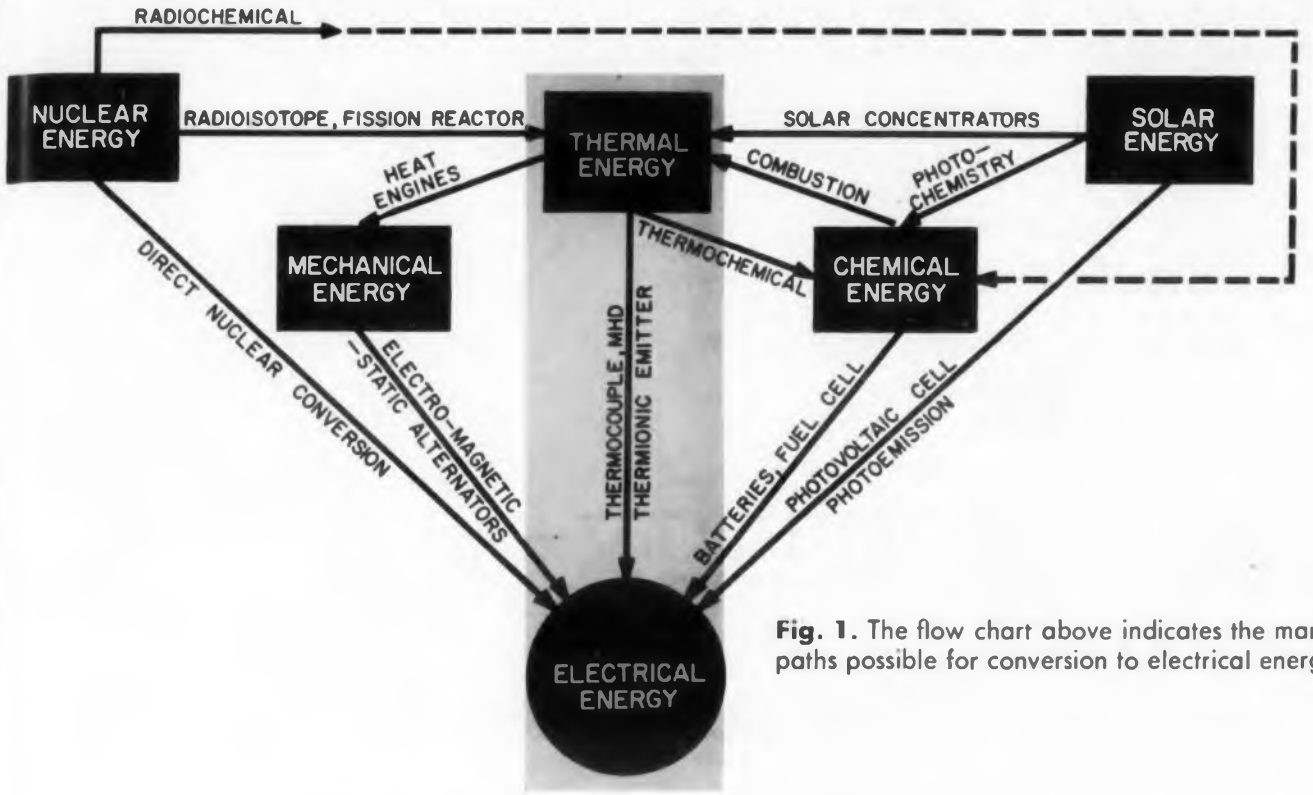

Fig. 1. The flow chart above indicates the many paths possible for conversion to electrical energy.

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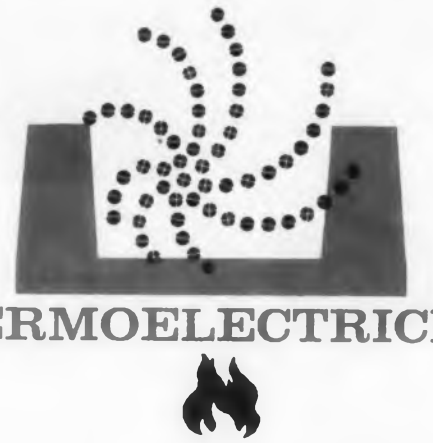
Table 1. Characteristics of Three Heat-to-Electrical Energy Conversion Techniques

Type Converter	Power Range	Efficiency: Present	Efficiency: Near Future (5-10 yr)	Output	Comparison to Conventional Turbine-Generators (42 per cent efficient)
Thermoelectric	1-10 kw present 50 kw future	Material eff. ≈ 18% → Device eff. ≈ 6%	→ 30% → 20%	DC	**Advantages** 1. No moving parts. 2. Noiseless. 3. No gyroscopic effects. 4. No lubrication. 5. Infinite shelf life. 6. Efficiency not proportional to output. 7. Can operate from chemical, solar or nuclear heat source. **Disadvantages** 1. Low efficiency. 2. Low voltage, low impedance output. 3. Converter required to change to high voltage ac. 4. Poor performance at high temperature. 5. Devices difficult to machine. 6. Oxidation must be avoided.
Thermionic	1-500 w present 50 kw future	Diode eff. ≈ 15% → Over-all device eff. ≈ 6-7%	→ 30%	DC (AC recently reported)	**Advantages**—same as thermoelectric. **Disadvantages**—1, 2, 3, and 6 above plus 7. Higher temperature poses serious materials problem. 8. Lifetime vs efficiency compromise must be made. 9. Close spacing for vacuum type. 10. Gas diode must be well-sealed at high temperature.
MHD	10 kw present (short duration) 100 mega-watt future	——	60%	DC	**Advantages**—Same as 1, 2, 3, 4, plus 8. The 60 per cent efficiency figure is a tempting goal for power and utility companies. **Disadvantages** 1. Extremely high temperatures are involved (above 2000 C.) 2. Thermal sources for this temperature range are limited. 3. Special non-conducting heat materials must be developed for the generator walls.



Thermoelectricity –

From Microwatt Thermocouple to Kilovolt Generator

THERMOELECTRICITY, the reversible interchange between heat and electricity, offers promise in the fields of power generation, heating and cooling. As shown in Fig. 2, the basic operating principle of the thermoelectric generator is simple. However, although the Seebeck phenomena were observed 139 years ago, only small amounts of power could be developed because of the lack of proper thermocouple materials. With the relatively recent gains in semiconductor technology, thermoelectric research is enjoying a healthy revival.

Although present efficiencies for thermoelectric power generation are in the 10 per cent range compared to 42 per cent for the most modern rotating-machinery power plant, it is important to note that early versions of both systems were about 3 per cent efficient about a century ago. With the considerable emphasis placed on rotating machinery over the years, the 42 per cent figure (which appears to be the maximum limit) has been reached. Thermoelectricity, in less than 10 years, has advanced from 3 to more than 10 per cent efficiency; further advances in material research are expected to double or triple this.

Several companies are already seriously at work building thermoelectric generators. Westinghouse has produced a 5-kw generator for the Navy, while General Instrument Corp. of Newark, N.J., has built a 5-w model, which uses propane gas, reported to operate at an annual cost of $10.

The four effects associated with thermoelectricity are:

- *Seebeck effect:* In a closed circuit consisting of two dissimilar materials, an emf will be produced if the junctions are maintained at different temperatures. For small temperature differences, the Seebeck emf is proportional to the temperature gradient and the property of the material termed the Seebeck coefficient.
- *Peltier effect:* When two dissimilar materials in a closed circuit carry a current flow, heat is absorbed at one junction and produced at the other. The rate of heat transfer is the product of the current flow times the Peltier coefficient π; π, in turn is a function of the materials involved and the junction temperature.
- *Thomson effect:* A potential difference will exist between two points, at a difference of temperature, in a homogeneous material carrying current.
- *Joule effect:* In a circuit carrying current, electrical energy will be converted into heat by an amount equal to I^2R. One-half of this heat is considered as flowing to the hot junction and one-half to the cold junction.

The first three effects are reversible in the sense that a temperature difference can produce a current flow or application of current from an external source can result in heating or cooling effects. The Joule effect is irreversible since heat is produced by current flow through a resistor, but potential electrical energy cannot be produced by application of heat.

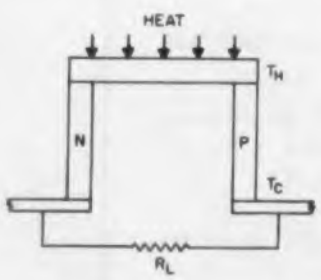


Fig. 2. Basically, a thermoelectric generator may be considered as consisting of a p-type material and an n-type material which are electrically in series and thermally in parallel. Application of heat causes electrons in the n-type "leg" to move to the cold region placing this point at a negative potential; similarly, holes are moved by heat energy to the cold side of the p "leg" placing this area at a positive potential. If a resistor is placed across both cold ends, a current will flow. By reversing the procedure and applying electrical input to the device, heating or cooling effects can be produced. The choice of heating or cooling depends on the direction of the applied current flow.

Figure of Merit for a Material

In order to permit comparative evaluation of various materials used in thermoelectric devices

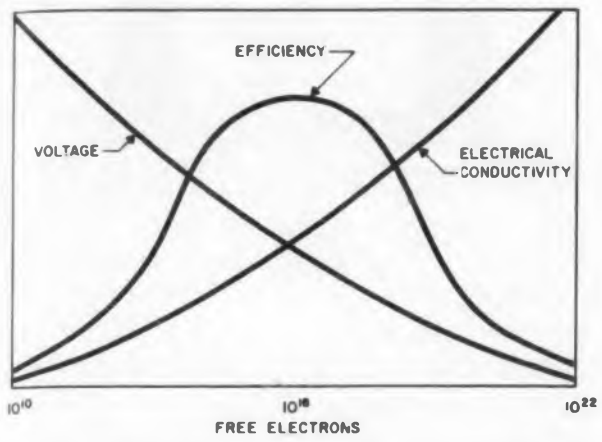


Fig. 3. For optimum efficiency, a compromise must be made between electrical conductivity and Seebeck voltage. Semiconductors fall in the center region of the curve with metals to the right and insulators at the left.

for power generation, heating and cooling, a figure of merit, Z, has been established as

$$Z = \frac{S^2}{\rho k}$$

where S is Seebeck coefficient in mv/C
ρ is electrical resistivity in ohm-cm
k is thermal conductivity in w/cm/C

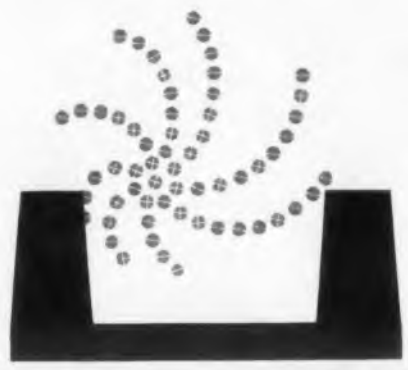
Since the efficiency of a thermoelectric generator, η, is dependent on the figure of merit,

$$\eta = \frac{T_h - T_c}{T_h} \cdot \frac{\sqrt{1 + ZT} - 1}{\sqrt{1 + ZT} + T_h/T_c}$$

where T_h = absolute hot junction temperature
T_c = absolute cold junction temperature
$\overline{T} = (T_h + T_c)/2$

High thermoelectric power (Seebeck coefficient), low thermal conductivity, k, and low resistivity are the targets of material research efforts. Metals have low resistivity, Seebeck coefficients in the μv/C range and are poor in terms of the low-thermal-conductivity requirement, see Fig. 3. Insulators, on the other hand, have fairly high Seebeck voltages (in the order of 10,000 μv/C), meet the low-thermal-conductivity need, but have high electrical resistivity.

By turning to semiconductor technology, the carrier density of a material can be tailored to an optimum compromise between a high value of Seebeck voltage and low electrical resistivity. The Seebeck voltage is inversely proportional to the number of free electrons in a material, while



THERMOELECTRICITY

electrical resistivity is directly proportional to the number of free electrons.

Although it may appear that the choice of material would simply be directed towards selecting one with the highest Seebeck coefficient, this is not the case since electrical resistivity, thermal conductivity, and Seebeck emf are not independent of each other. Silicon and germanium, elements in the periodic table, are poorer in thermoelectric performance than compounds due to their temperature limitation. In diode and transistor fabrication, impurities are added to the basic material to obtain desired characteristics. With binary and ternary compounds, the final properties of the material are affected by the composition and concentration of the doping agent and the technique of preparation. Optimizing the Seebeck coefficient for highest figure of merit produces a value near 200 μv/C, within the 50 to 1,000 μv/C range of semiconductors.

Tellurides, selenides, oxides, nitrides, carbides, arsenides, and silicides of metals have been investigated. Lead telluride alloys have been developed which operate up to 700 C; the figure of merit at room temperatures approaches 2×10^{-3}. Bismuth telluride alloys, although limited to a maximum of 300 to 400 C, provide figure of merits in the 3 to 4×10^{-3} region.

Thermal Conductivity—A Key Factor

Although thermal conductivity is simple in definition, merely the quantity of heat conducted through a material of a particular area in a given time, the mechanisms involved in the transfer and techniques for measurement are complex.

The thermal conductivity factor, *k*, of a material is dependent on the heat conducted by the atoms of the crystal and the current carriers. Low-thermal-conductivity materials include heavy elements, with weak binding forces, such as bismuth, lead, tellurium and selenium compounds. A recent approach involves the alloying of two binary compounds to achieve still lower thermal conductivity, due to crystal disorder,

without seriously reducing other thermoelectric characteristics. High-figure-of-merit ternary compounds have resulted from research efforts carried out in this direction.

Additional Materials Considerations

While Seebeck emf, thermal conductivity and electrical resistivity determine the figure of merit, Z, of a material, other properties must be considered for practical applications of thermoelectricity. Melting point, maximum tolerable vapor pressure, susceptibility to oxidation, compression strength, brittleness, and thermal expansion coefficient are important considerations to be made in material selection when reliability and long operating life are important generator requirements.

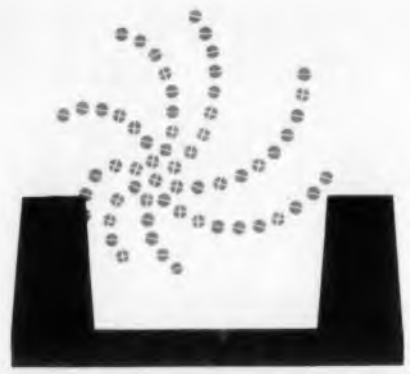
Materials Research Efforts

Thermoelectric Liquids: The efficiency of a thermoelectric generator is limited by the Carnot efficiency; to achieve a high Carnot efficiency, the hot junction should be as high as possible. With temperatures in the order of 3,000 C possible with solar concentrators, efforts to find materials which can function at this extreme have led to investigation of liquids as thermoelements.

Although many liquids have thermal conductivities which are considerably smaller than metals and Seebeck coefficients greater than metals, their electrical-conductivity characteristics are poor. Still, figure of merits from 100 to 1,000 times greater than metals are possible. For example, cuprous sulfide has a thermoelectric emf of 300 μv/C and a resistivity of 1.4×10^{-3} ohm-cm at 1,200 C. Unfortunately, measurement of thermal conductivity still remains a problem at high temperatures, and thus figure of merit cannot be properly evaluated. Considerable study is being directed towards theoretical as well as experimental approaches to the practical use of liquid thermoelements.

Molten Salts: Molten salt, such as silver nitrate, can be combined with silver electrodes to develop a thermoelectric potential with electrical conduction taking place by means of positive and negative ion flow through the salt. Experimental efforts indicate an output of about 350 μv/C between the ranges of 300 to over 1,000 C; an increase to 500 or even 1,000 μv/C is indicated from experimental and theoretical studies.

Unfortunately, the flow of electricity produces a permanent change in electrode material. In the silver, silver-nitrate system, silver metal is transported from the hot to cold electrode as current flow takes place. For short-life applications, such as a missile, this may be unimportant. For a long-term use, hot and cold electrodes



THERMOELECTRICITY

Thermoelectric Problem Areas

- Materials are brittle, difficult to machine and handle.
- Thermal stress conditions at the junction of the thermoelement and electrical contact can result in cracks.
- Contact resistance between thermoelement and electrical contact must be as low as possible to reduce Joule losses.
- Impurity diffusion during soldering must be avoided.
- Oxidation effects must be considered to avoid short-life operation.
- Certain elements, such as tellurium, are quite scarce. New combinations must be found utilizing abundant elements.
- Material cost is high. Bismuth telluride, for example, has been quoted at $1/gm or $500/lb. As quantity demands increase, cost is expected to drop to as low as $75/lb.
- At present, numerous combinations are being investigated by a "trial and error" approach; a guide to accurate prediction could bring a long awaited breakthrough.

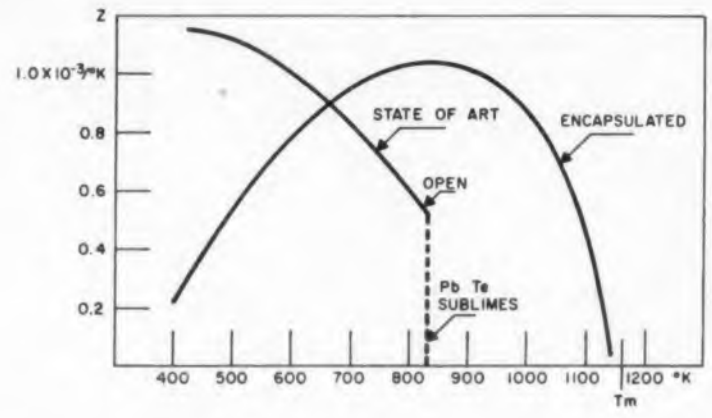


Fig. 4. Encapsulation techniques developed by GE have extended the usefulness of lead telluride to 1,100 C.

could be periodically switched, but such practice would probably be considered impractical.

Refractory Materials: Refractory materials, having boiling points up to 2,000 C, are being investigated as thermoelements in order to achieve high Carnot efficiency by operation over a wide temperature range. Silicides, having Seebeck coefficients as high as 120 μv/C, are being investigated although present figures of merit lie in the 10^{-4} and 10^{-5} range. Due to the wider range of temperature usable in thermocouple devices using refractory materials, the efficiency can be as high as 10 per cent. A further advantage of silicides is their ability to operate in an oxidizing atmosphere with temperatures up to 1,700 C.

Material Fabrication

First, single crystals are grown in a vacuum. After careful examination to detect any rejects due to flaws, the crystal is cut into the desired configuration. Due to the brittleness of present materials, considerable care is needed during slicing. In addition, the crystal lattice must be properly oriented with the direction of heat flow to obtain minimum thermal conductivity.

By using a pressed and sintered technique for material preparation, rather than a casting, it has been found that machining to a final shape is simplified. In addition, it is possible to prepare graded thermoelectric arms by having higher doping at one end than the other. This approach achieves improved efficiency without the contact and junction problems associated with stacking various sections of different materials.

At the hot junction, heat must be absorbed by the thermoelectric material while the cold end must be attached to a suitable cooling sink. To obtain high efficiency, a maximum temperature difference should exist across the junction, thus indicating a narrow diameter limitation. However, Joule heat losses are proportional to length and area. As a compromise, present junction legs are generally in the order of two inches or less in length and 0.5 inches or less in diameter.

Joining techniques represent a serious challenge in thermoelectric devices since the contact resistance heating loss reduces operating efficiency. Soldering poses no serious problem at the cold junctions, but materials must be selected to join the hot sides without contamination.

Materials Research Gains

In reviewing materials development over the past year, the U. S. Naval Research Laboratory reports that the thermoelectric program is making good progress and, although costly and slow, shows no signs of diminishing returns. Promising new materials have been developed which are less expensive and more easily available than the telluride compounds.

Silicide combinations have been prepared by Transitron Corp. using rf-heating and argon-arc furnace techniques. Higher thermoelectric powers have been achieved than predicted by theory; studies are underway to explain the results.

Operation of thermoelectric elements up to 1,450 C has been achieved by means of an encapsulation technique developed by General Electric. As shown in Fig. 4, the encapsulation approach extends the operation of lead telluride to 1,100 C as compared to 700 C without packaging.

Ternary compounds have been investigated by Bell Labs and p-type $AgSbTe_2$ specimens have been reported which indicate a Z of 2×10^{-3} at room temperature at a melting point of about 600 C. Radio Corporation of America efforts with ternary compounds show similar results for $AgSbTe_2$ in the range up to 400 C. RCA Labs has built a thermocouple using binary and ternary legs; the figure of merit between 25 C and 300 C varies from about 1.7 to 1.4×10^{-3}. P-type ternary alloys have shown figures of merit between 3 and 3.2×10^{-3}.

Wanted: A Handy Mixing Guide

A major necessity in the quest for improved thermoelectric materials is a dependable guide

to assist in the selection of elements for most efficient properties. Since a multitude of possible combinations exist for various semiconductors under consideration, a fantastic number of cross combinations is possible. For example, more than 10 years of effort have been spent on research in lead telluride combinations by Minnesota Mining and Manufacturing Co. with some details still under study. Obviously, a prediction scheme to eliminate the lengthy experimental approach now used would bring thermoelectric generation and Peltier heating and cooling devices much closer to the point of popular application.

A further complication in material selection exists in the temperature dependency characteristic of semiconductor combinations. It is generally not possible to use a single hot junction and a single cold junction material that will operate efficiently over a wide temperature range. Only over a relatively narrow temperature range will a given material exhibit optimum properties. As shown in Fig. 5 (a) and (b) various materials are efficient over narrow temperature regions; since highest Carnot efficiency can be realized with a wide temperature difference, it is necessary to stack several sections of different material in series, as shown in Fig. 6.

By stacking various materials, highest possible efficiencies are attainable. However, such problems as contact losses, thermal expansion coefficient discrepancies and joining techniques must be overcome to avoid excessive losses. From the plot of efficiency for n- and p-type materials, a theoretical efficiency of 18 per cent could be realized operating from 1,000 C to 30 C.

Device Efficiency to Reach 20 Per Cent

Although currently available thermoelectric materials are capable of a device efficiency approaching 17 to 18 per cent, various losses (chimney losses and heat transfer to other than the thermoelectric legs) lower this figure to about 5 per cent or less. Nuclear reactors, surrounded by thermoelectric legs, are inherently capable of higher efficiency since all heat would be transferred for conversion. However, experimental data must be completed to determine the effects of radiation on semiconductors exposed to nuclear sources before large-scale units can be constructed.

An important advantage of thermoelectric generators lies in the ability to interconnect various modules or thermocouples without a sacrifice in efficiency. For example, a low-power device may have an over-all efficiency of 5 per cent; if additional power is required, several similar modules can be combined with an over-all efficiency of 5 per cent.

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Although the 5 per cent efficiency figure seems rather poor compared to a modern power plant efficiency of 42 per cent, devices such as small motor-generators operate at less than 10 per cent efficiency.

The automobile engine is about 15 per cent efficient, and diesel engines approach about 20 per cent. Thus, thermoelectricity, with additional evolutionary gains, may soon be considered competitive at power levels up to 10 kw. Low noise, lack of moving parts and compact size are additional gains which make thermoelectric schemes attractive.

Experts involved in thermoelectric research conclude that the search for improved materials and improved devices will take between three to five years, barring an unforeseen breakthrough. At this time, an over-all efficiency of 20 per cent should be practical using materials with an inherent efficiency of about 30 to 35 per cent. Optimists foresee generators operating with outputs in the megawatt range.

5-Kw Generator Delivered to Navy

Under the Navy Bureau of Ships coordinated research program, new materials have been developed over the past several years which triple the efficiency previously available from thermoelectric devices.

Westinghouse has recently delivered to the Navy two 2.5-kw generators which can be used independently or connected together to deliver 5 kw. Each 2.5-kw generator is about the size of a garbage can, 30 in. in diameter and 30 in. high, see Fig. 7. Thermoelectric modules line the inside; burning kerosene is used to heat the hot junction and circulating water serves to cool the cold junction. Temperatures from hot to cold side range from 650 C to 10 C. For maximum efficiency, six different thermoelectric materials are used, each maximized for its particular temperature range. By altering the connection of individual modules, the 5-kw output can be delivered as low voltage, high current (10 v at 500 amp) or high voltage, low current (120 v at 42 amp). The only moving parts in the equipment are the pumps required to circulate the kerosene and the cooling water; the motors are powered by the thermoelectric generator.

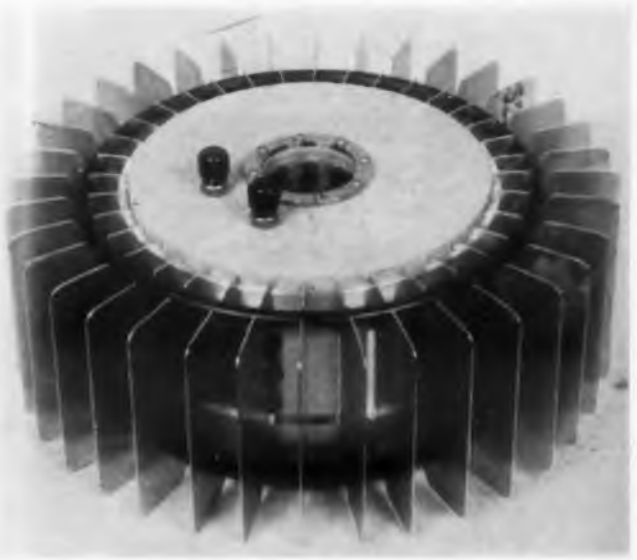
Low-Voltage Thermoelectric Devices

Although "exotic" power supplies for space systems are generally high priced in terms of capital cost, the high cost of delivery into space (estimated at $10,000 per pound) warrants the expense. For such applications, conversion efficiency must be optimized.

Fig. 5. Efficiency of various n-type materials is shown in (a), p-types in (b).

Fig. 6. Since different materials exhibit maximum efficiency over a relatively narrow temperature range, cascading several materials over a wide temperature gradient is employed to achieve best results.

Fig. 7. This pair of 2.5-kw generators, built by Westinghouse for the Navy, will be used to evaluate new thermoelectric materials.



In an early U. S. Navy experimental 5-w air-cooled thermoelectric generator, 24-lead telluride thermocouple assemblies are inserted into a stainless-steel combustion chamber; cooling fins and Transite end plate are added to complete the assembly. Generator diameter is approximately 10 in.; weight is 6.8 lb. Heat is from gas flame at 1,000 F. Fins are cooled by natural convection. Electrical output is taken from binding posts on end plate.

For less dramatic, but nevertheless essential applications, such as remote weather stations or underwater equipment, thermoelectric generators must be designed with device and fuel costs in mind in order to remain competitive with existing power sources. Sacrifice in efficiency, for the purpose of reducing initial as well as operating costs, represents a logical design approach.

A 5-w thermoelectric generator, 12 in. high by 12 in. in diameter (see Fig. 8), has been developed by General Instrument Corp., Newark, N.J. Using propane gas, the 10-lb device is reported to operate for a year using 200 lb of fuel at a total fuel cost of $10. Although efficiency is in the order of 3 per cent, GI engineers amphasize the fact that device costs would increase markedly to achieve higher efficiency; the improved efficiency might result in several dollars per year saving in fuel.

Nuclear Thermoelectric Devices

The first "proof of principle" nuclear-fueled thermoelectric generator was developed by the Martin Co. and Minnesota Mining and Manufacturing Co. for the Atomic Energy Commission's SNAP (Space Nuclear Auxiliary Power) program. A total of 27 couples were arranged radially around a 4.75-in. cylinder, 5.5 in. high. Heat was supplied by alpha-particle emission emitted by polonium 210; operation at the hot junction was about 600 C and 200 C at the cold end. The SNAP III generator, weighing only 5 lb, produced 5.4-w output with 5.5 per cent efficiency.

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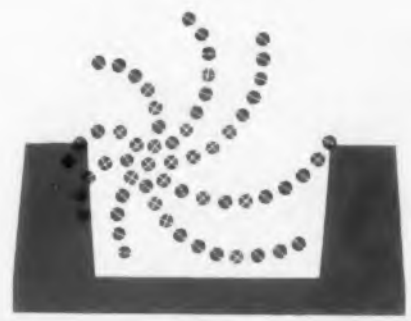

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A "big brother" of SNAP III, the SNAP I-A, is roughly egg-shaped, 34 in. long and 24 in. in diameter, see Fig. 9. The complete generator, using 277 couples, weighs 175 lb and delivers 125 w. Under development by the Martin Co., the device will be fueled by cerium-144. Since the amount of heat supplied will decrease as the radioisotope decays, the SNAP-IA has a temperature-sensitive shutter which will permit heat leakage during the early days of operation; the shutter will clamp shut as heat decreases, thus maintaining a constant 125-w, 28-v output.

A 300-w power unit, the SNAP X, is under development with 600 C hot and 370 C cold junctions. The design has been reported to provide 12-per-cent converter efficiency using lead telluride p- and n-thermocouples. A 1-kw "breadboard" model, using 168 thermocouples, converts

(text continued on page 44)

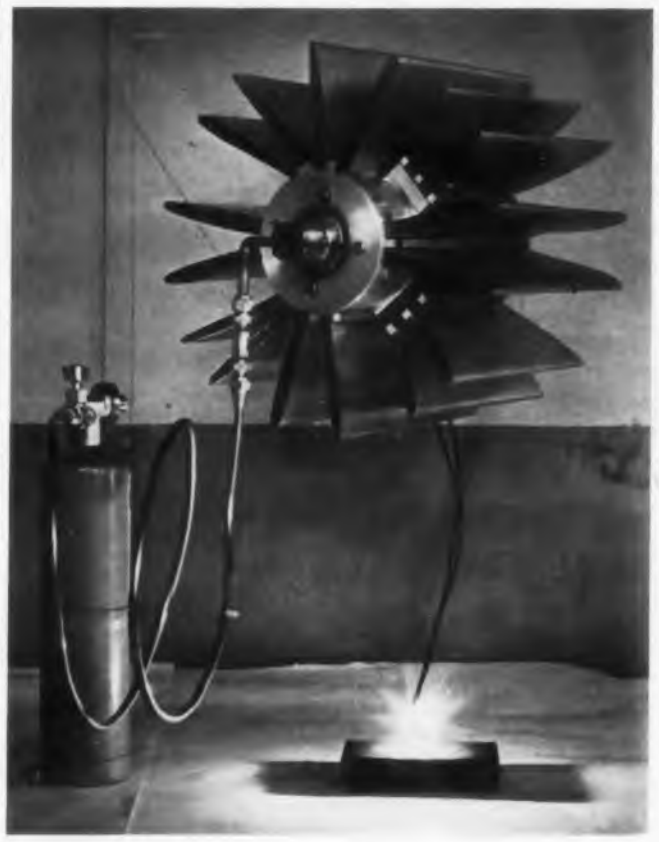


Fig. 8. The 5-w generator shown above, developed by General Instrument Co., is powered by propane gas maintained at a constant temperature.

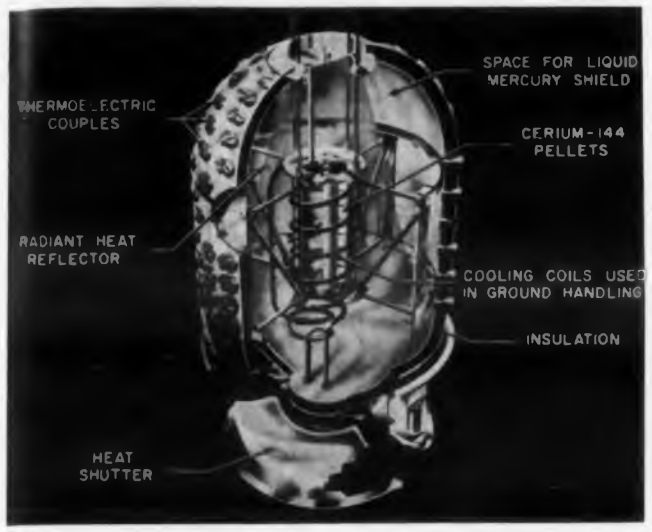
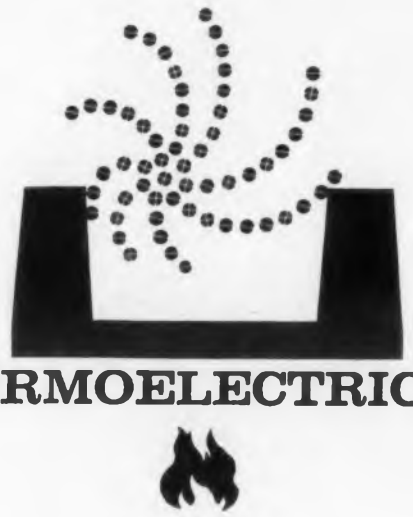


Fig. 9. The SNAP I-A generator, developed by The Martin Co. for the Atomic Energy Commission, delivers 125 w using 277 thermocouples. Heat is obtained from tightly-sealed pellets of Cerium 144.

Fig. 10. Shown above is one of three catalytic combustors used in a 1-kw thermoelectric generator made by The Martin Co. A catalytic combustor forms the central element in each of three vertical burners; a total of 168 thermocouples are used.

Only slightly larger than a tennis ball Transitron Electronics Corp.'s thermoelectric generator delivers 10-12 w output with 6-8 per cent efficiency. The device, available for engineering evaluation, uses lead telluride elements and operates at a hot temperature of 500 C and a cold temperature of 150 C.



THERMOELECTRICITY

heat from three burners. Martin spokesmen report the hot couple temperature to be 900 C; the weight of the device will be 20 lb or less in final form (see Fig. 10).

A Look to the Future

Thermoelectric generators in the 1 to 100 w range have been constructed with efficiencies in the order of 10 per cent with 1 to 10 w/lb power density. Due to the modular approach used, any desired generator shape can be prepared, thus permitting the use of "wasted" space in such vehicles as missiles and submarines. The Westinghouse 5-kw generator represents the first step towards an eventual 10,000-kw supply for full-scale power systems for Navy surface ships. The eventual goals of thermoelectric research efforts include power levels up to 20 megawatts, 35-per-cent efficiency and 100-w/lb power density. To achieve these aims, the present temperature limit (of currently available materials) of 700 C will have to be increased to 1,200 C or higher.

(Turn to p. 46 for next section)

Soviet Thermoelectric Efforts

Sovfoto

A Russian housewife inspects the contents of a small Soviet thermoelectric refrigerator.

Extensive research efforts in thermoelectricity began in the early 1930's in the USSR, pioneered by Prof. Abram F. Joffe at the Leningrad Physico-Technical Institute of the Academy of Sciences. In a concentrated drive to bring power to countless isolated villages and cities, Prof. Joffe gathered a staff of foremost Soviet scientists, physicists and chemists.

In 1931, Joffe predicted efficiencies of 4 per cent for thermoelectric elements then available. Experimental models were built and tested, and the first production devices were unveiled in 1953. Using zinc antimonide and constantan for thermoelements, 3-w output was developed for operating a radio receiver; the temperature difference for the TGK-3 kerosene lamp generator was 300 C (380 C to 80 C). A vibrator converter was required to raise the low thermoelectric output to a reasonable plate voltage level.

In 1956, an improved model TEGK-2-2 was produced with 4-w output. Enough thermocouples were included to provide 100-v plate voltage, thus eliminating the vibrator. Both kerosene lamp generators, of course, provided light as well as electrical energy.

A kerosene-burning 15-w generator, TGU-1, was developed for transceiver use in 1958. In addition, 200-w and 500-w units, using wood or gasoline as fuel, were reported in operation in remote areas. In 1956, 40-w and 100-w solar concentrated thermoelectric devices were announced. An interesting development underway is a thermoelectric unit using the exhaust heat of a motorcycle to replace the conventional generator.

Efficiencies in the order of 8 per cent were announced by Joffe in 1956 with service life approaching 6,000 hr. He stated that the Soviet goal for 1961 was efficiencies in the order of 15 per cent and 30,000 hr service life. No information has been made available recently on the status of Soviet power generation using thermoelectricity.

Prior to 1956, Joffe indicated that efforts were underway on the construction of thermionic converter-thermoelectric cascade devices, but no information on the program has been revealed.

A Russian-built thermoelectric generator, used to convert heat from a kerosene lamp into electricity to power radios in remote Asian areas, is examined by J. D. Rauth (right) and Dr. M. E. Talaat of Martin Co.

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THERMIONICS

Thermionic Converters—

High Power Density Packages

A THERMIONIC converter, in its simplest form, consists of a heated cathode to emit electrons and a cold anode to collect the electrons; both electrodes are enclosed in a vacuum or gas-filled envelope (see Fig. 11).

As heat is applied to the cathode, some electrons are driven over the work function barrier, ϕ_C, at the cathode surface; the lower the work function, the easier will it be for electrons to escape. The electrons which have left the cathode possess potential energy with respect to the electrons which remain in the cathode due to the energy used to overcome the work function barrier. Assuming no space charge effect, electrons reach the cold anode and drop in potential energy by an amount equal to the work function of the anode, ϕ_A; this energy drop appears as heat. The difference between the work function of both electrodes, ϕ_C-ϕ_A, represents the potential energy which can be offered to an external load, see Fig. 12. Anode work function should be as low as possible to achieve high output and the anode surface as cool as possible to minimize emission from anode back to cathode.

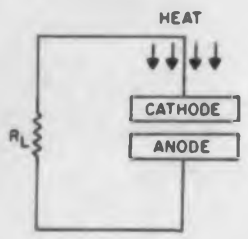

Fig. 11. In a thermionic vacuum converter, electrons are "boiled" out of the cathode and are condensed and collected at the anode. Since the heat of vaporization is greater than the heat of condensation, electron energy is available for supplying an external load. To overcome the space-charge effect, which limits operating efficiency, close spacing is maintained between anode and cathode, or an ionized gas is introduced in the space-charge region for neutralization.

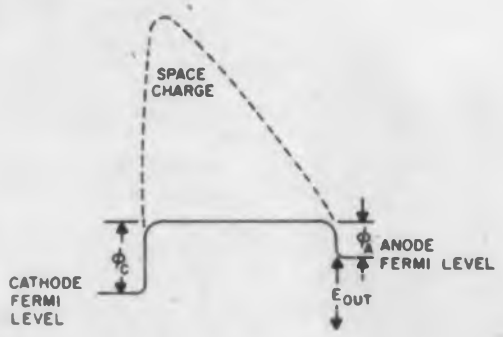

Fig. 12. In a thermionic converter, the space-charge effect develops a high potential barrier to the emitted electrons as shown by the dotted path. By closely spacing electrodes or injecting ions in the interelectrode region, a direct path (solid line) is possible.

Space Charge Reduction

Since electrons are charged particles, the accumulation of electrons moving from cathode to anode will form a space charge barrier which tends to repel new electrons leaving the cathode. The potential hill represented by the space charge effect is shown by the dotted line in Fig. 12; few electrons will surmount this obstacle and output will be low.

To reduce space charge barrier, and permit electrons to pass from cathode to anode with relative ease (solid line of Fig. 12), several basic approaches are under investigation:

- Close-spaced vacuum diode.
- Gas-filled diode.
- Magnetic triode.

Vacuum Diode

The vacuum diode, which has been experimentally investigated at Massachusetts Institute of Technology and Thermo Electron Engineering Corp., Cambridge, Mass., operates with spacings closer than 0.001 cm between electrodes. This narrow gap is necessary since analy-

Thermionic Converter Problem Areas

- For a high emitter work function, cathode temperature must be high. Cathode lifetime is considerably shortened and efficiency must be reduced to compromise for long life.
- Machining and maintaining close spacing, less than 0.001 in., between electrodes at high temperatures poses a serious challenge (even without taking into consideration shock and vibration).
- Close spacing results in high radiation of heat from cathode to anode with a resultant efficiency loss.
- Gas-filled diodes operate at higher temperatures than vacuum types, a condition which makes conventional fuels unsuitable. The high-temperature materials problem is likewise aggravated.
- Oxidation must be avoided; electrodes must be protected from the atmosphere.
- The gas-diode envelope must be sealed and remain leakproof at high temperature.

ses have shown that the maximum output power available is inversely proportional to the square of the electrode spacing. Feasibility models have been constructed and tested with efficiencies in the order of 13 per cent; operating temperature of the cathode was about 1,200 C.

RCA scientists have constructed an experimental thermionic diode, Fig. 13, designed to use the exhaust heat of a rocket. The device produced, during laboratory tests, an output of 270 w yet weighs only 3.5 lb for a power-to-weight ratio greater than 75 w/lb.

Gas-Filled Diode

Positive ions may be introduced in the space charge region to neutralize the negative electron charge; one ion can effectively cancel the space charge of several hundred electrons moving towards the anode. Thus ion current is a small fraction of the electron current; the combination of ions plus electrons constitutes a plasma (thus responsible for the plasma thermocouple name sometimes given to a gas-filled diode).

Cesium vapor, having an ionization potential of 3.88 ev, is used in gas-filled diodes for several reasons. First, cesium adsorbs to most metallic surfaces and reduces their work function. Second, the density of the gas atoms can be varied by adjusting the temperature of the cesium in its liquid state. In a practical example, a tube containing cesium is enclosed in an oven and the

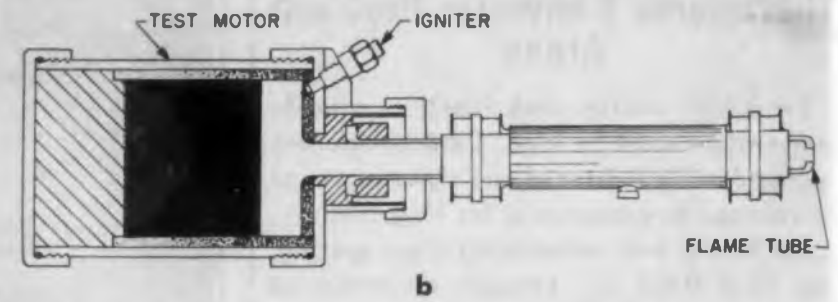

Fig. 13. Designed for use with a small solid propellent rocket engine, the diode shown in (a) and (b) delivers 270-w output, weighs only 3.5 lb.

temperature is controlled to produce sufficient vapor to neutralize the existing space charge.

By a technique known as resonance ionization, a gas such as cesium, with an ionization potential lower than the emitter work function, is injected into the diode envelope. Neutral atoms which bombard the emitter become ionized and appear as positive ions in the space charge region. In addition, cesium condenses on the surface of the cold collector and serves to reduce the work function to a value near 1.8 ev.

An experimental model of a low-pressure gas-filled diode, using a tungsten ribbon emitter ($\phi_C = 4.52$ ev) and a nickel anode (ϕ_A due to cesium action = 1.8 ev) produced approximately 2.5-v output, as reported by Dr. H. G. Hernqvist of RCA. The efficiency of conversion reached 10.4 per cent at a cathode temperature of 2,600 C. Unfortunately, the evaporation rate of the cathode material increases as temperature increases, thus limiting the useful life of the converter. Until additional research in materials provides a significant breakthrough, some compromise must be established between efficiency and lifetime; the intended application of the device determines the degree of compromise.

Another technique for gas-filled diodes uses the cesium vapor to neutralize the space charge and reduce the work function of the cathode as well as the anode. The reduced cathode work function enables higher emissivity. Dr. V. C. Wilson of GE has reported efficiencies of 13.5 per cent at 18.5 w/cm² using a tungsten filament.

A distinct advantage of the high-pressure (2 mm mercury absolute) cesium converter lies in the ability of the cesium vapor to replenish the cesium boiled off the cathode during high-current applications. High emission in the vacuum or low pressure gas diode severely reduces cathode life. Dr. Wilson has predicted that high pressure tubes could produce a theoretical output of 40 w/cm² with 35-per-cent efficiency; in practice, up to 30 w/cm² at 30-per-cent efficiency is expected as material research gains are made.

In July, 1960, RCA announced the development of a cesium-filled thermionic tube which had been operated at 1,100 C with 14-per-cent efficiency. The lower operating temperature, compared to 2,000 C in previous gas-filled designs, permits the use of standard fuels as a heat source.

The device, developed under an Air Force contract, employs readily available materials and is reported to be non-critical in manufacturing. A proposed technique, suggested by RCA, for combining a thermionic diode with a solar furnace is shown in Fig. 14 (a) and (b).

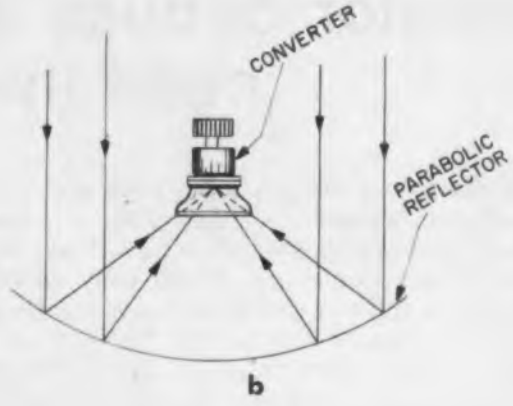

Fig. 14. A proposed scheme, offered by RCA, for combining the high-temperature heat source of a solar concentrator to a thermionic diode is shown in (a) and (b).

Magnetic Triode

Crossed electric and magnetic fields are used to reduce the space charge effect in a vacuum magnetic triode. As shown in Fig. 15, a hot emitter and cold collector are placed in the same plane, separated by a distance which is considerably less than the plate width. An accelerating anode is mounted parallel and close to both electrodes.

An electric field is produced by a voltage applied between the emitter and accelerator and an external magnetic field is directed perpendicular to the electric field. The combined action of both fields deflect electrons leaving the emitter to the collector in the path shown in Fig. 15.

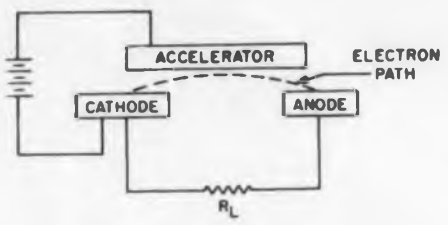

Fig. 15. The action of a combined electric and magnetic field is used to minimize the space-charge effect in a magnetic triode.

Compared theoretically under a similar set of conditions, the magnetic triode efficiency is about 22 per cent as against 12 per cent for a vacuum diode. Experimental models which have been built indicate considerable discrepancy from the predicted values; scattering of electrons and non-uniform fields apparently reduce the theoretical efficiency figure. Additional development effort is underway to eliminate or minimize these detrimental effects.

AC Thermionic Generators

Thermionic converters are basically low-voltage, high-current dc devices. For maximum power transfer to a load, the load impedance must be extremely low; for example, a 1,000-amp, 1.5-v unit would require a 0.0015-ohm load. One approach to overcome the problem involves series connecting a number of thermionic converters. Other approaches under investigation include the application of a small modulating signal to produce an ac output which can then be matched to a high impedance load through a transformer. Modulation has been achieved through the use of a grid electrode in the emitter-collector region and by application of small external magnetic fields. In gas-filled devices, modulation of injected ions has been attempted.

Early in 1960, General Dynamics Corp.'s General Atomic Div., San Diego, Calif., announced the first successful conversion of heat to ac in significant amounts. Operation was reported to center around a high-temperature cesium cell.

One-Watt Thermionic Converter Available Now

A small, ceramic closed spaced vacuum diode, weighing only 3 oz and the size of a silver dollar, is being made available by the General Electric Power Tube Dept., Schenectady, N.Y. Operating at a cathode temperature of 1,100-1,150 C and an anode temperature of 600-650 C, the developmental Z-5386 will provide 1-w minimum out-

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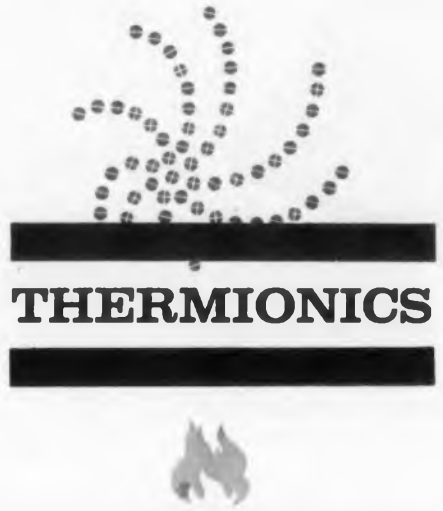


put; the open circuit voltage is approximately 1 v and the short circuit current is approximately 3 amp. The device efficiency is 2.5 per cent (minimum) and power density is 0.2 w per sq cm.

Although output power and efficiency are relatively low, the transition from a "bell jar" laboratory model to a production line product is significant. Initial cost of the 1-w device was reported to be between $300-350. Cesium units are being readied in a similar package for near future delivery.

Thermionic vs Thermoelectric Devices

In thermionic converters, the flow of electrons takes place through a vacuum or plasma; in thermoelectric devices, current flow is through a solid. Heat conduction is considerably less for thermionic devices although high electrical conductivity is limited by space charge. Thus, a thermionic converter can be considered as a thermocouple using an evacuated space in place of one of the conductors.

The thermionic power ε of a diode

$$\epsilon = \frac{\phi_2 + \delta}{T} + 2K - \alpha$$

where ϕ_2 is the anode work function
δ represents the magnitude of the space charge barrier
K is the Boltzmann constant
α is the Seebeck coefficient

By plotting the Z factors for lead telluride in a thermoelectric application with impregnated tungsten used in thermionic converters, a relative comparison of the two approaches can be made. As shown in Fig. 16, thermionic devices (assuming zero space charge) are superior at high temperatures while thermoelectric generators are more efficient at low temperatures. Schemes have been proposed to cascade a thermionic tube with a thermoelectric device for maximum utilization of heat input. The thermionic converter would receive the high temperature input for cathode emission; the relatively high anode temperature would then act as the hot side of the thermoelectric unit.

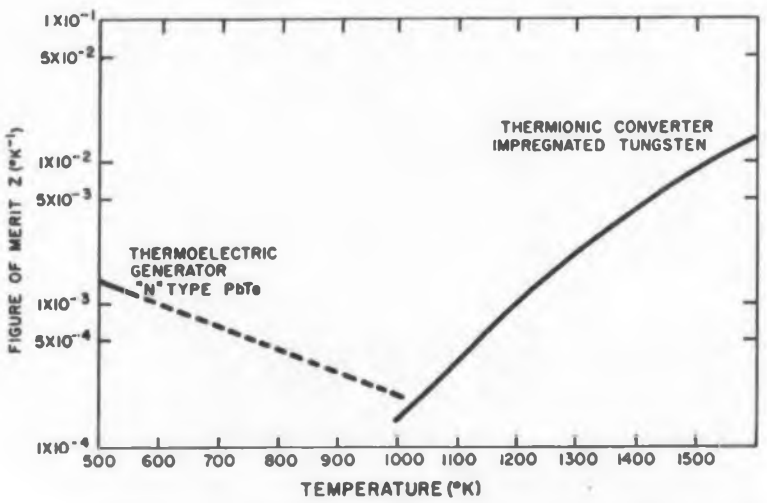


Fig. 16. Thermionic devices are more efficient than thermoelectric generators at high temperatures, but are noticeably poor at low temperatures.

Efficiency Figures Sometimes Misleading

Individual devices have been constructed with announced efficiencies up to 14 per cent. However, it is most important to understand that the announced efficiency figures are often calculated from data collected under rather ideal conditions. For example, a device may be announced having an 11-per-cent efficiency. Checking the calculations involved, one might find that a heated filament was used to boil electrons off the cathode; thus, heat transfer and conversion losses are not included. Heat lost in the side walls may be disregarded. Data from the experimental setup is applied to previously calculated equations from which a final efficiency figure is obtained.

Thus an operating device, using a fossil fuel for example, might have an over-all efficiency of 3 or 4 per cent, in spite of its calculated 11-per-cent figure. When heat transfer losses are overcome, the device efficiency will nearly approach the calculated value.

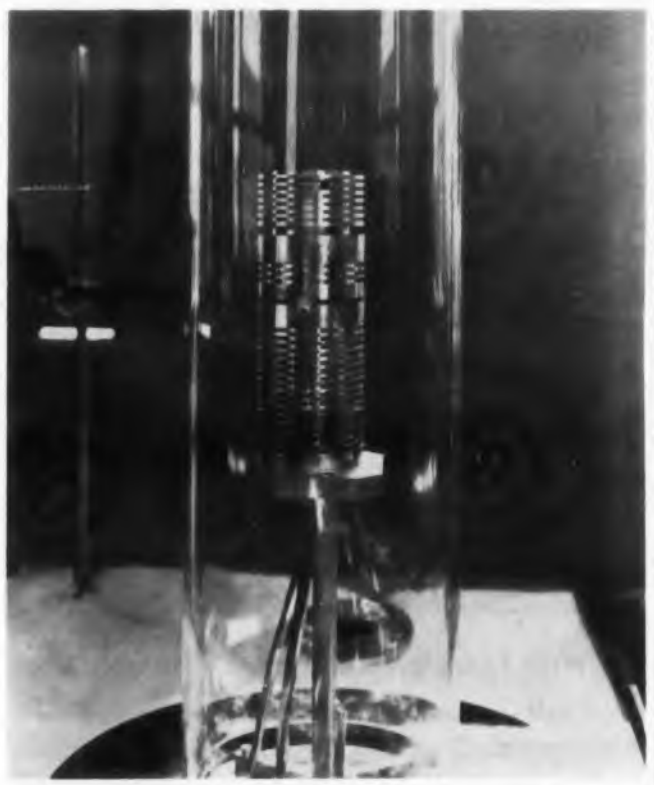
Prospects for Thermionic Converters

Thermionic devices have been constructed with output powers exceeding 250 w at efficiencies up to 14 per cent. Size and weight data indicate an improvement over thermoelectric devices.

GE's 1-w, 3-oz thermionic converter operates at a cathode temperature of 1,100 C. This device Z-5386, has a minimum power density of 0.2 w per sq cm and an efficiency of 2.5 per cent.

Experimental models have been constructed with power densities as high as 75 w/lb. Dr. G. N. Hatsopoulos of MIT has predicted an eventual goal of 50 kw while Dr. V. C. Wilson of GE envisions efficiencies in the neighborhood of 40 per cent in 20 years. To achieve these goals, new cathode materials will have to be developed to operate above 3,000 C without rapid deterioration.

(continued on p 52)



Shown above is a 150-w cesium-filled thermionic converter built by Thermo Electron Eng. Corp., Cambridge, Mass. The coaxial structure is 2.75 in. diam. and 6 in. long. Total weight is only 5 lb., thus providing a 30 to 1 power-to-weight ratio.

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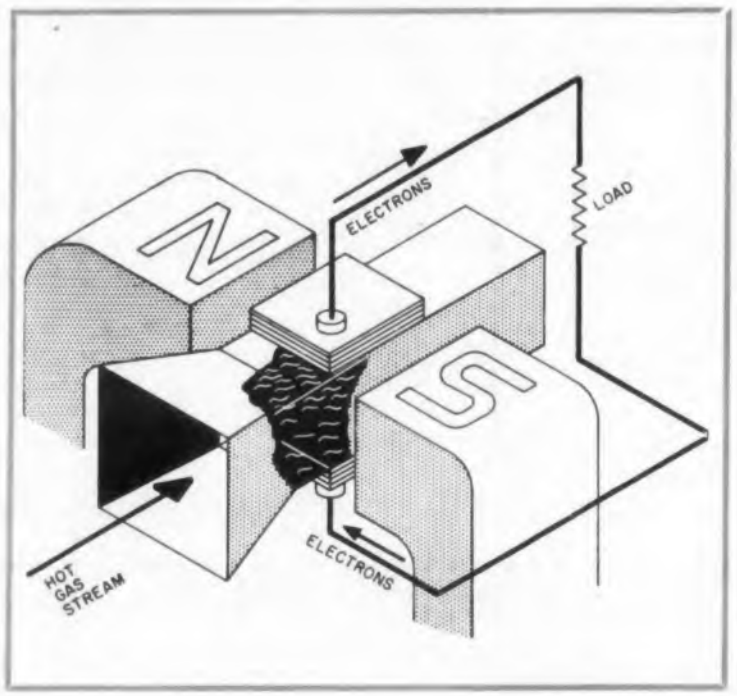

Fig. 17. A super-heated (above 2,000 C), electrically-conducting plasma is directed at high velocity (approximately 1,800 mph) through a magnetic field to produce electrical output.

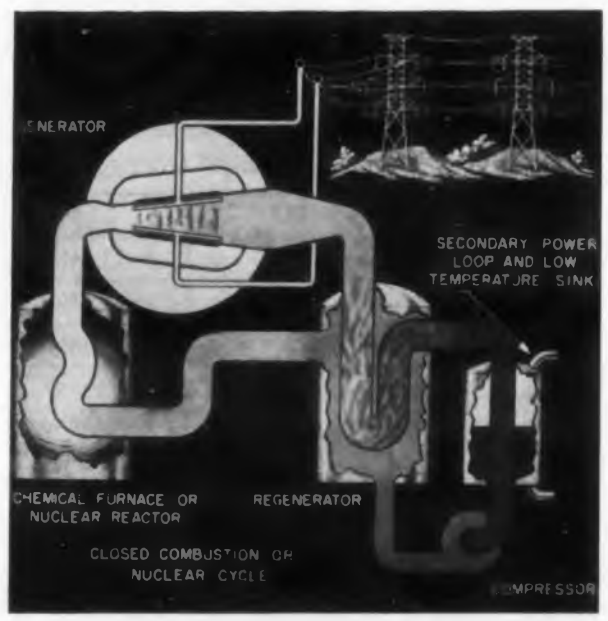

Fig. 18. In the Avco closed-cycle system, a nuclear reactor or chemical furnace heats and ionizes the working gas, which is then passed through a magnetic field. Electrodes pick off the dc generated. The gas is cooled in a regenerator and heat sink and then pre-heated before routing to the furnace for heating and ionization.

THERMAL energy is available from combustion of a fossil fuel, solar heat and atomic heat produced by nuclear reaction.

Large power plants convert heat to electricity through the rather involved process of first converting the input energy into heat, then converting water to steam in a boiler, next converting the steam into rotational energy by means of a turbine and finally coupling a generator to convert the rotational energy to electricity. The equipment required is complex, involves moving parts and this then makes necessary periodic maintenance.

Magnetohydrodynamics (MHD) is a science dealing with electromagnetic and fluid-dynamic phenomena. Its basic principle was established by Michael Faraday more than 100 years ago, when he discovered that current is generated by a conductor moving in a magnetic field. In the MHD approach to power conversion, a fluid conductor rather than a solid copper bar is sent through a magnetic field to produce electrical output. The fluid used is a

MHD Problem Areas

- Extremely high temperatures are involved (over 2000 C).
- Thermal sources for the temperatures required are not readily available.
- Special non-conducting heat-resistant materials must be developed.
- Additional information is needed on electrical conductivity in both gases and seeding techniques.
- Economic evaluations must be investigated to assure that the MHD approach is feasible.

gas which has been sufficiently heated so that some of its atoms separate into ions. The electron stream produced during ionization, the positive ions and the main body of unionized gas combine to form a plasma which is then forced past a magnetic field, thereby producing an electric current, see Fig. 17. Electrons in the gas are deflected by the magnetic field applied perpendicular to the plasma and reach the electrodes. As electrons pass from anode, through the load, to the cathode and then return to the gas flow, current is produced. Voltage developed is proportional to magnetic field strength, gas velocity and spacing between electrodes.

In MHD and conventional generators, heat is converted to kinetic energy and then electrical energy. In an MHD device, however, no moving parts are involved; the hot working fluid acts as the conductor rather than a turbine driving force. The efficiency of an MHD generator has been predicted as approaching 60 per cent as compared to 40 or 42 per cent for conventional modern power plants.

Fig. 19. Westinghouse scientist checking performance of a 10-kw MHD generator.

The major problems which must be overcome in the MHD approach are due to the high temperature (above 2,000 C) involved to ionize the gas and techniques to achieve high gas velocity. By seeding the gas with potassium or cesium, adequate electrical conductivity can be obtained at lower temperatures than an unseeded gas. Another problem exists in the materials to contain the high temperature plasma; sources of heat for the high temperatures required likewise pose a serious problem.

Westinghouse has successfully operated an MHD generator delivering 2.5-kw output from a device whose cross section is approximately 1.5 in. by 5 in. by 16 in. in length. The generator (operating at one quarter of its rated 10-kw output) is fueled from furnace oil and oxygen, with potassium soap dissolved in the oil as a seeding element. The external magnetic field produces 14,000 gauss and three pairs of graphite electrodes are separated by 4.6 in.; the velocity of the gas is roughly 2,000 mi/hr and operating temperature is about 2,500 C. The model is being used for investigating new materials and design approaches. It should be noted that operation is kept to less than four minutes to prevent deterioration.

Avco-Everett Research Laboratory has reported operation of a 10-kw MHD experimental generator using a plasma jet operating in argon or helium seeded with potassium carbonate. Initial efforts have been directed towards improved gas conductivity, investigation of electrode properties and materials for thermal insulation. The Avco generator is reported to operate for only seconds at a time.

Power Companies Behind MHD

Ten leading power companies have joined Avco Corp. in a research program directed towards the application of MHD to large-scale power generation. The American Electric Power Service Corp. and Avco-Everett Research Lab. are studying two approaches; one plant would use a coal-fired furnace, and a second possibility is the use of a nuclear reactor to heat and ionize the moving gas.

In the open-cycle, coal-fired approach, a thermal efficiency of 55 per cent or 6,200 BTU/kw hr has been estimated. The closed-cycle nuclear system has an estimated efficiency close to 58 per cent or 5,800 BTU/kw hr compared to 8,500 BTU/kw hr or 40 per cent efficiency with conventional turbine-generator combinations. Although nuclear fuel costs are difficult to predict at this time, the comparison between MHD and conventional coal-fired systems indicates that relative fuel costs would be 1.78 mils/kw for MHD and 2.12 mils/kw hr for the conventional system. Both MHD plants under investigation are proportioned to deliver 450,000 kw. ■ ■

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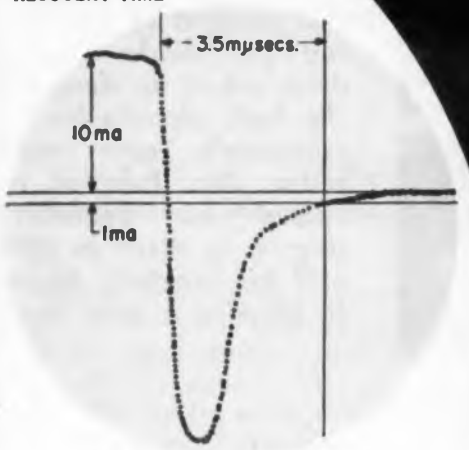

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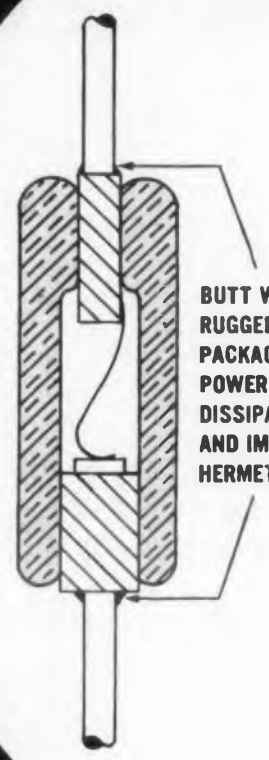

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NEW METAL PLUG PACKAGE . . . engineered for strain relief at *both* ends — prevents cracking of glass-to-metal seals for 4 times greater strength in pull test, greatly increased bend resistance . . . gives added power handling ability.

Write for Bulletin No. TE-1350G

SPECIFICATIONS

Conditions	1N914	1N916
Max. Reverse Recovery Time (from 10mA I_F to 6 volts V_R)	.004	.004 μsec
Max. Capacity (at 0 volts bias)	4	2 μμf
Min. Forward Current (at 1 V)	10	10 mAdc
Min. Saturation Voltage (at 100μA)	100	100 volts
Max. Reverse Current (at −20V)	.025	.025 μAdc

MAXIMUM RATINGS

Conditions	1N914 and 1N916
Reverse Voltage (−65° to +150°C)	75 Volts
Average Rectified Current (25°C)	75 mA
Operating Temperature Range	−65° to +150°C
Storage Temperature Range	−65° to +200°C

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CIRCLE 47 ON READER-SERVICE CARD

◀ CIRCLE 48 ON READER-SERVICE CARD

How to Account for Voltage Drops In Conducting Logic Diodes

C. Walter Johnson, a project engineer with the Librascope Div. of General Precision, developed this method of accounting for diode voltage drop when he designed the logic circuits for his company's new computer. Mr. Johnson received his bachelor's degree in math in 1956 and his master's degree in physics a year later.

C. Walter Johnson
General Precision, Inc.
Burbank, Calif.

IF THE DESIGNER of logical gates neglects voltage drops across conducting diodes, he may find he has designed not-so-logical gates.

These voltage drops can be particularly critical because of the preferably small difference between the voltages representing the *1* and *0* logical states. The diode drops can make it difficult to distinguish between the two levels.

A small voltage is desirable because transistor collector voltages generally are low, the resulting time required to charge capacitances is low and power consumption is low.

An example with practical values will illustrate a simple method of calculating the worst case of this voltage drop.

Take 1/3 v as the diode drop at 1 ma. (This

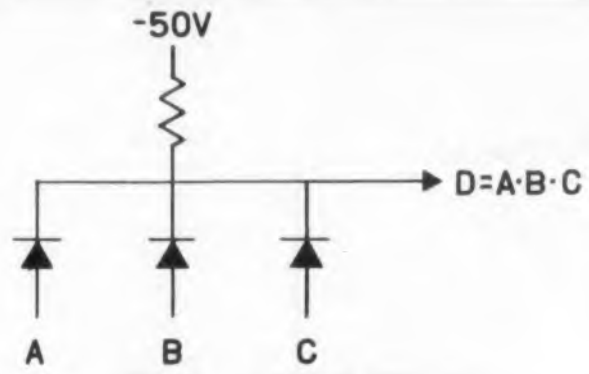


Fig. 1. A typical AND gate.

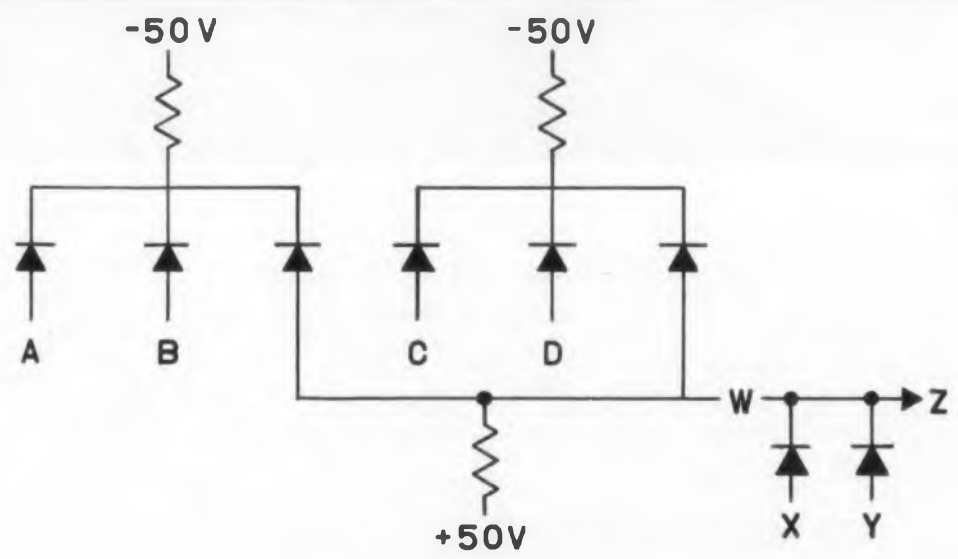


Fig. 2. The "crazy" AND gate.

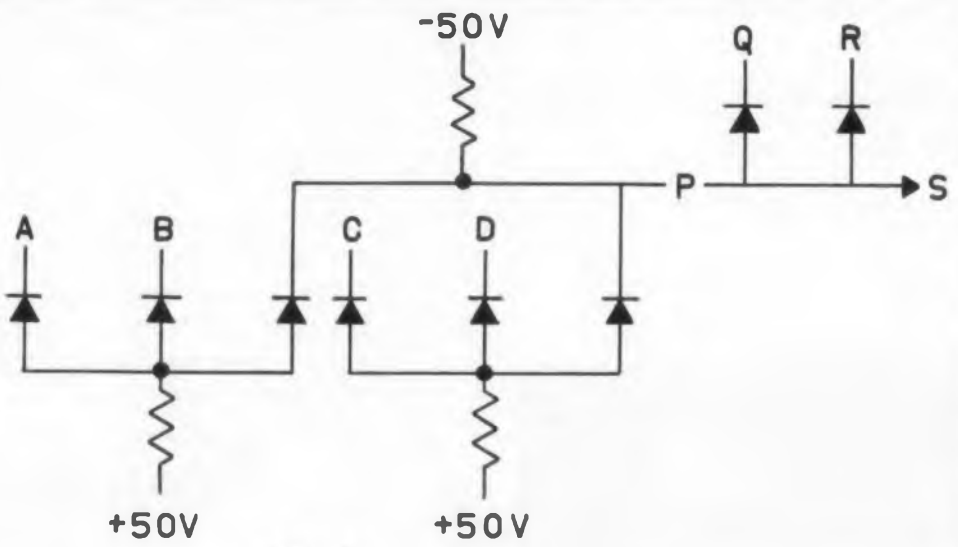


Fig. 4. The "crazy" OR gate.

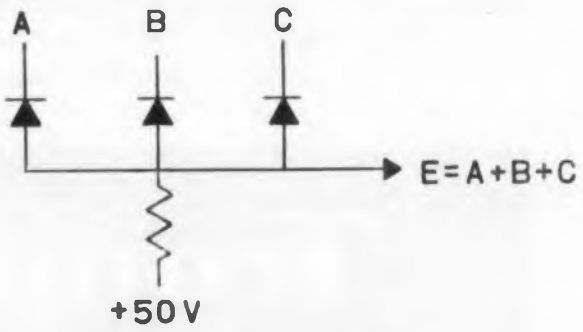


Fig. 3. A typical OR gate.

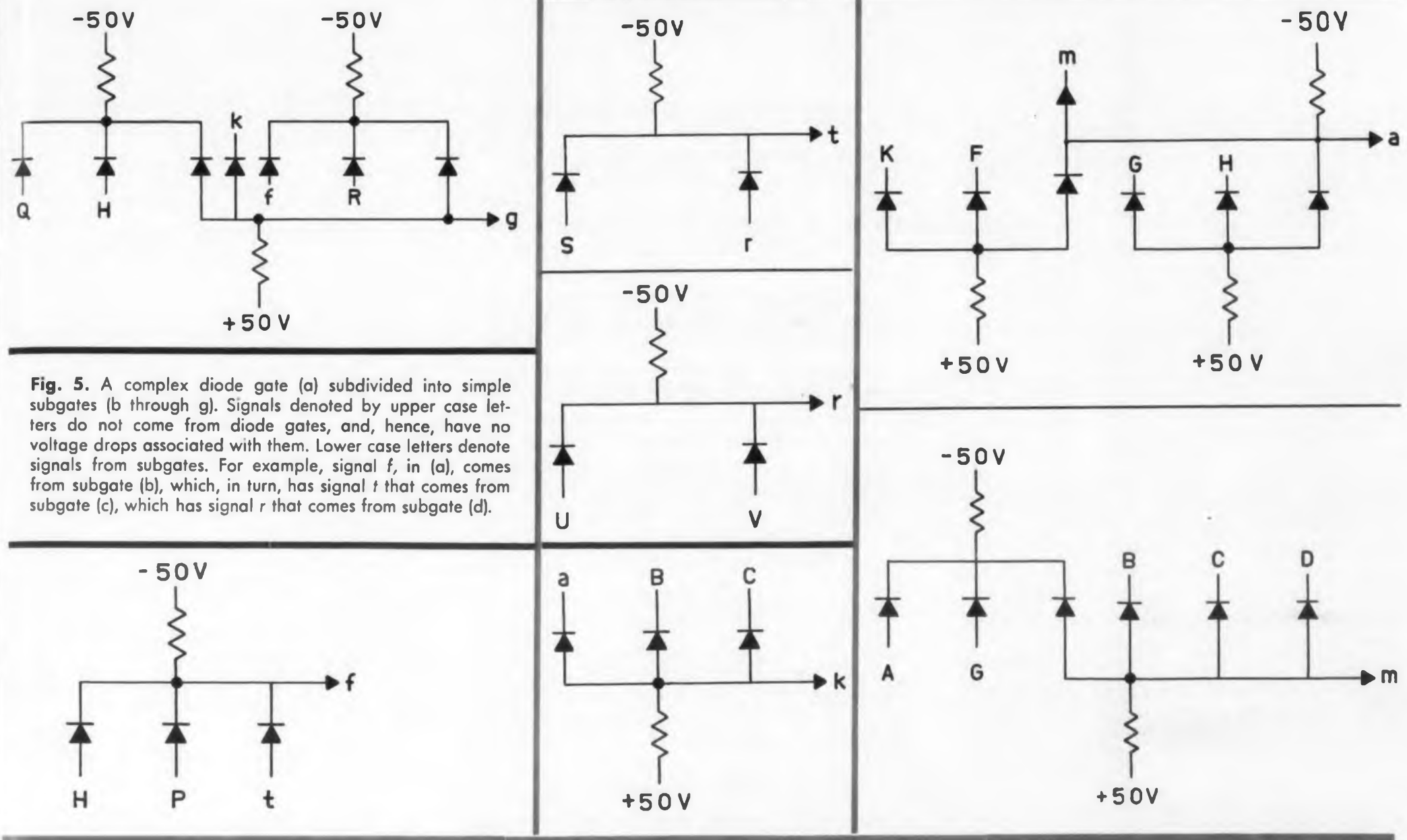


Fig. 5. A complex diode gate (a) subdivided into simple subgates (b through g). Signals denoted by upper case letters do not come from diode gates, and, hence, have no voltage drops associated with them. Lower case letters denote signals from subgates. For example, signal *f*, in (a), comes from subgate (b), which, in turn, has signal *t* that comes from subgate (c), which has signal *r* that comes from subgate (d).

value is true for gold-bonded, germanium diodes.) Suppose a signal of 0 v (ground) represents logical *0*, and one of —2 v represents logical *1*.

Diode Voltage Drop Changes Output Level

If, in the *AND* gate of Fig. 1, signal *A* is at exactly 0 v, signal *D* will be more negative than 0 v by the diode drop of 1/3 v. If *A* itself is the output of an *AND* gate, *D* would, in the worst case, be negative by the drop across two diodes.

Similarly, several *OR* gates in series can produce an output signal that is significantly less negative than —2 v.

Obviously, if the diode drop is large compared to the voltage swing, it is impossible to design reliable circuits.

A more practical choice of logical states, in this case, might be zero volts for logical *0* and —5 v for logical *1*. It still is necessary to exercise care in limiting the number of series diodes.

For this to be a reliable system, the input to a flip-flop or inverter (which would be the output of a diode network) should never be more negative than about —1 v in the *0* state, and never less negative than about —4 v in the *1* state. This leaves a buffer zone of three volts for noise and safety factor.

Two Numbers Assigned to Each Logic Signal

Apparently, there are two numbers of interest associated with each logic signal. They are: the number of diode voltage drops by which the signal is more negative than ground in the *0* state, (which we will call the *0-drop*); and the number of diode voltage drops by which the signal is less negative than —5 v in the *1* state (which we will call the *1-drop*).

In this method, a pair of numbers, (a_s, b_s) is associated with each logic signal S. They are integers of either sign, and are defined as follows:

When a_s is *positive* or zero, its magnitude is the 0-drop, although if a_s is negative, the 0-drop is zero. When b_s is *negative* or zero, its magnitude is the 1-drop, although if b_s is positive, the 1-drop is zero.

The pair of numbers, (a_s, b_s) is called the *drop* rank of logic signal *S*.

Only Diode Voltage Drops Considered

A primary signal is one not produced by a diode network. Hence drops in other devices are ignored. The drop rank of a primary signal is (0, 0).

Rule 1. Conventional AND Gates. If signals *A* with drop rank (a_A, b_A), *B* with drop rank (a_B, b_B) and *C* with drop rank (a_C, b_C) are combined in an *AND* gate as in Fig. 1, to produce signal *D*, the drop rank of *D* is (a_D, b_D) where

$$a_D = \text{Max } (a_A + 1, a_B + 1, a_C + 1)^*$$

$$b_D = \text{Min } (b_A + 1, b_B + 1, b_C + 1)^\dagger$$

*Read "a_D is equal to the largest of the three numbers, $a_A + 1$, $a_B + 1$, $a_C + 1$".

†Read "b_D is equal to the smallest of the three numbers, $b_A + 1$, $b_B + 1$, $b_C + 1$".

Rule 2. "Crazy" AND Gates. An *AND* Gate that eliminates one diode and its resultant diode drop is shown in Fig. 2. This can be used only if

all the signals *OR*'ed to form *W* come from *AND* gates. In this case, *Z* has drop rank (a_Z, b_Z) where

$$a_Z = \text{Max } (a_W, a_X + 1, a_Y + 1)$$
$$b_Z = \text{Min } (b_W, b_X + 1, b_Y + 1)$$

Rule 3. Conventional OR Gates. If the *OR* gate of Fig. 3 is used, the drop rank of *E* is (a_E, b_E) where

$$a_E = \text{Max } (a_A - 1, a_B - 1, a_C - 1)$$
$$b_E = \text{Min } (b_A - 1, b_B - 1, b_C - 1)$$

Rule 4. "Crazy" OR Gates. Corresponding to the "crazy" *AND* is a "crazy" *OR* as shown in Fig. 4. This can be used only if all the signals *AND*'ed to form *P* come from *OR* gates. The drop rank of S is (a_S, b_S) where

$$a_S = \text{Max } (a_P, a_Q - 1, a_R - 1)$$
$$b_S = \text{Min } (b_P, b_Q - 1, b_R - 1)$$

By following these four rules, starting with gates that use only primary inputs, and working toward the final output signals, we can arrive at the maximum diode drop for the worst case.

If the resulting voltage drop is outside the allowable limit, a rearrangement of the network, using the above rules as guides, will reduce the diode drop to a proper value.

Consider an example. A diode network is shown broken down into simple sub-gates in Fig. 5a to 5g. Lower-case letters represent the outputs of diode gates; upper-case letters represent primary signals, such as the outputs of flip-flops, with drop rank (0, 0).

All Signal Drop Ranks Must Be Known

Suppose signal *g* is to be the input to a flip-flop, and we wish to find its worst-case diode drop. Fig. 5a does not contain enough information, because the drop ranks of signals *k* and *f* are unknown.

To find the drop rank of *f* we must know that of *t*, as is apparent from Fig. 5b. The drop rank of *t* depends, in turn, upon that of *r*, as seen in Fig. 5c. But *r* is made up of primary signals, and we can therefore calculate its drop rank by the use of rule 1.

To find the drop rank of *k*, note in Fig. 5e that the drop rank of *a* is required. A look at Fig. 5f shows that the drop rank of *a* depends on that of *m*. Fig. 5g shows that *m* is made up only of primary signals, whose drop rank we know to be (0, 0).

The procedure that must be followed, then, is to find drop ranks first for all signals composed of primary signals, then for signals composed of primary signals and non-primary signals of known drop rank, until, finally, we have calculated the drop ranks of all gates.

Following this procedure, begin by calculating the drop ranks of *r* and *m*. Applying Rule 1 in Fig. 5d:

$$a_r = \text{Max } (0 + 1, 0 + 1) = \text{Max } (1,1) = 1$$
$$b_r = \text{Min } (0 + 1, 0 + 1) = \text{Min } (1,1) = 1$$

So the drop rank of *r* is (1, 1).

Complex Gates Are Divided into Sub-gates

From Fig. 5g we now calculate the drop rank of *m*. Making use of past exeperience, we recognize at once that the drop rank of sub-gate *AG* within the *m* network is (1, 1) because it is in the same form as the *r* gate. The signal *AG* is *OR*'ed with *B*, *C*, and *D*.

Using Rule 3:

$$a_m = \text{Max } (1 - 1, 0 - 1, 0 - 1, 0 - 1) = \text{Max } (0, -1, -1, -1) = -1$$
$$b_m = \text{Min } (1 - 1, 0 - 1, 0 - 1, 0 - 1) = \text{Min } (0, -1, -1, -1) = -1$$

So the drop rank of *m* is (0, −1).

Calculating the drop ranks of signals *a* and *t* by applying Rule 1 is Fig. 5c:

$$a_t = \text{Max } (0 + 1, 1 + 1) = \text{Max } (1, 2) = 2$$
$$b_t = \text{Min } (0 + 1, 1 + 1) = \text{Min } (1, 2) = 1$$

So the drop rank of *t* is (2, 1).

As we gain experience we can omit most of the written steps, and use intuition to find many of the values.

For example, in gate *a*, Fig. 5f, note that *K*, *F*, *G*, and *H* are all primary signals with drop rank (0, 0). From each of these we go *down* one diode (in an *OR* Gate), then *up* one diode (in an *AND* Gate) to arrive at *a*.

From Rule 3, we subtract 1 from both *a* and *b*, and then from Rule 1 we add 1, thus arriving at (0, 0) again. Gate *a* is a "crazy" *OR* Gate, and the (0, 0) drop rank is the drop rank of signal *P* in Fig. 4.

From Rule 4:

$$a_a = \text{Max } (0, a_m - 1) = \text{Max } (0, 0 - 1) = \text{Max } (0, -1) = 0$$
$$b_a = \text{Min } (0, b_m - 1) = \text{Min } (0, -1 - 1) = \text{Min } (0, -2) = -2$$

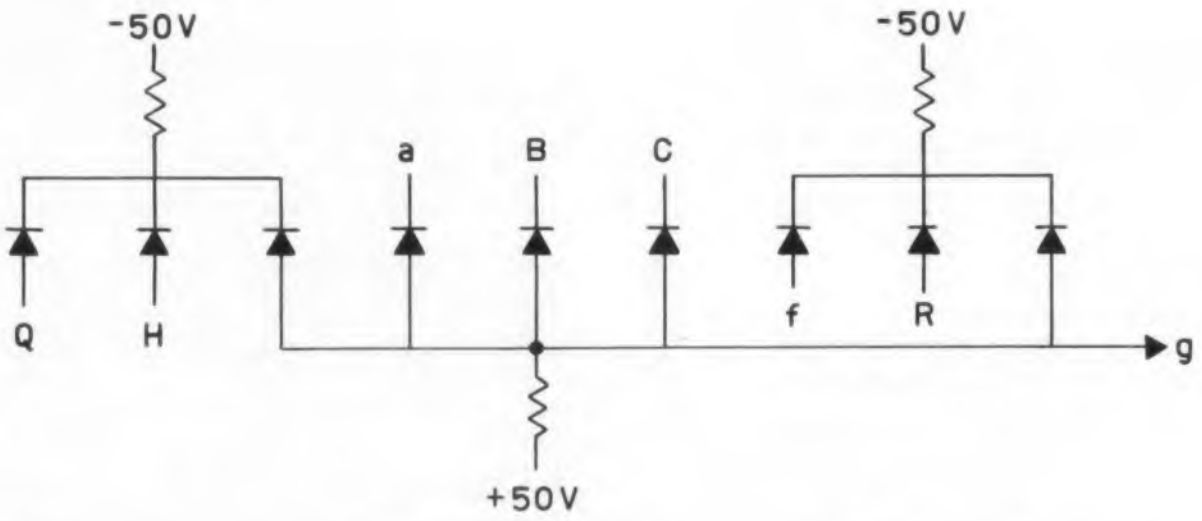


Fig. 6. The complex gate of Fig. 5a with the diode associated with signal *k* eliminated, thus removing one voltage drop.

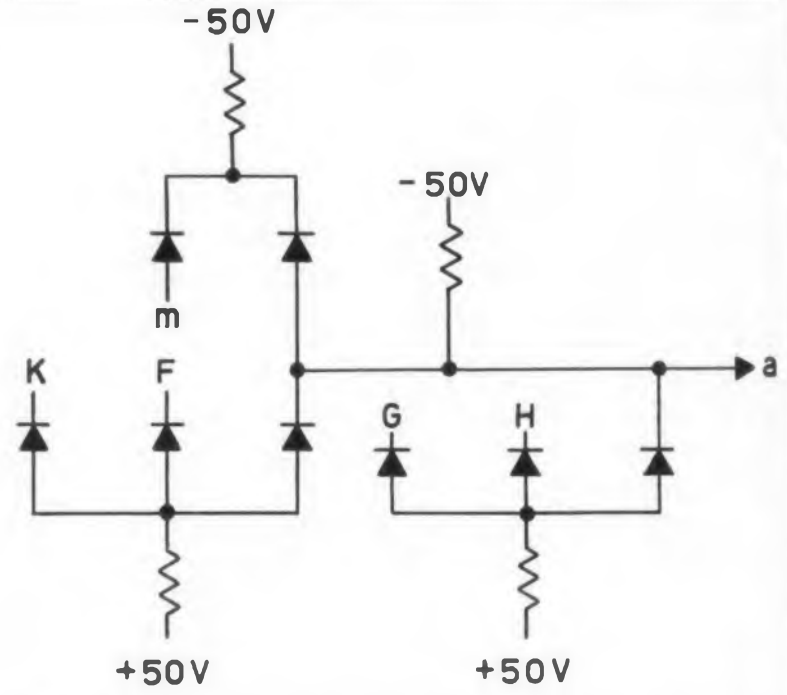


Fig. 7. Another way of obtaining signal *a* for Fig. 6. Compare with Fig. 5f.

So the drop rank of a is (0, —2).

Applying Rule 3 to gate k, Fig. 5e, gives a drop rank for k of (—1, —3). For t, Fig. 5c, we get (2, 1) and for f, Fig. 5b, (3, 1).

We are now ready to solve for the drop rank of g.

Intuitive Approach Speeds Work

We can proceed formally, according to the rules, but intuitional short cuts make the work go much faster. In gate g we see that from Q and H we go *up* one, then *down* one to get to g. Hence that part contributes (0, 0) to the drop rank of g.

We go *down* one from k, subtracting one from each of a_k and b_k, getting (—2, —4). Then from f and R we go *up* one, then *down* one, which gives us (3, 1) for f and (0, 0) for R. We have then (0, 0); (—2, —4); (3, 1) and (0, 0).

Taking maximum a and minimum b, we have (3, —4) for the drop rank of g. This result can be verified by proceeding formally.

The meaning of this drop rank is that when g is in its *0* state and should be at ground, it can be actually negative by 3 diode drops (because $a=3$), and when g is in its *1* state, and should be at —5 v, it can be actually less negative than this by four diode drops (because $b=4$).

If we have set 3 diode drops as a limit, something must be done to reduce b_g from —4 to —3. There are several ways this may be done. From Fig. 5a, using Boolean notation:

$$g = Q\,H + k + fR$$

But $$k = a + B + C$$

Then $$g = Q\,H + a + B + C + fR$$

Circuit Changes Reduce Voltage Drops

Therefore, g can be obtained as in Fig. 6, eliminating one diode from the chain. But, because the k gate doubtless will be retained for use elsewhere, this solution costs two additional diodes. A way that costs only one diode, but adds to power requirements, is to form a as shown in Fig. 7. The drop rank of a now will be (0, —1) resulting in (3, —3) for g.

When one becomes adept at using the method, the drop ranks can be calculated from the Boolean expressions, and the expressions can be altered to give proper drop rank values before circuits are drawn.

The advantage of this method is that for a signal such as f in Fig. 5b, which is the output of a diode gate and is used in several other diode gates, we can write down its drop rank after calculating it once. With the less sophisticated method of simply counting diodes effectively in series, the diodes would have to be counted again each time f is used in another gate. ■ ■

Method of Least Squares Helps Determine Potentiometer Linearity

"How linear is a linear potentiometer?" is considered by Ross Burns and Donathan Burnett in describing method for determining how closely an experimental curve comes to being linear. The technique—called the method of least squares—is readily programed for a computer.

Ross Burns, Donathan Burnett
Texas Instruments, Inc.
Houston, Tex.

THE LINEARITY of a potentiometer can be determined by comparing its performance curve with a theoretical "best straight line." However, what is the slope and intercept of this theoretical line? These can be found by using the statistical method of least squares.

Independent linearity is defined as the maximum deviation of potentiometer voltage output (expressed as per cent of the voltage input) from the "best straight line" drawn through the output-versus-shaft-position curve. The slope and position of the straight line from which deviations are measured must be adjusted to minimize these deviations.[1]

By placing each pot in the bridge circuit shown in Fig. 1, and using a precision Goniometer to rotate its shaft through equal increments, the actual curve of output voltage can be obtained. A typical output curve superimposed on a "best straight line' is shown in Fig. 2.

The Goniometer is made by inscribing a circle on a large piece of tool plate, and dividing it into angular increments. The plate is punched and countersunk at each angular increment. One end of a pointer is fastened to the spot shaft and the other end to a steel ball. The ball fits into the countersunk holes.

The potentiometer is placed in the center of the plate so the pointer grips its shaft, and quick-open clamps hold it in place during the test. The cost of this "home-made" Goniometer is about $100, which is a relatively low initial cost compared to that of a commercially-produced tester.

After voltage-vs-angular-position data are taken, the "best straight line" can be calculated using the method of least squares.[2] The following example shows how this is done:

The general equation for a straight line is $y = a + bx$, and the values of a and b can be determined from the following two equations:[2]

$$Na + bx = y$$
$$ax + bx^2 = xy$$

where N = number of points, x = mechanical position in degrees, and y = electrical position as a fraction of the applied voltage.

N, x, y, x^2, and xy must be found to solve these equations. A set of values for these variables is shown in Table 1. From this table $N = 18$, $\Sigma x = 3{,}060$, $\Sigma y = 8.8886$, $\Sigma x^2 = 714{,}000$, and $\Sigma xy = 2{,}052{,}062$.

Substituting these values into the equations:

$$18\,a + b\,3060 = 8.8886$$
$$a\,3060 + b\,714000 = 2052062$$

Solving simultaneously, the equation for the calculated "best straight line" becomes:

$$y' = a + bx = 0.01925 + 0.00279154x$$

The y' value corresponding to each value of x is shown in Table 1, and the deviation is indicated in the $y - y'$ column. In this example, the specimen was out of tolerance because it had a maximum deviation of 0.0022, which was greater than the 0.0020 allowed.

This method of measuring potentiometer linearity, while relatively simple, is long and tedious when done by hand, even with calculators and adding machines, and would be impractical to repeat often.

However, by adapting it to a computer program, it can be done rapidly. A group of 100 sets of data can be computed in approximately 30 min, and, with computer time at about $60 per hr, this amounts to about 30 cents per pot. The other cost involves time required to take data. Another operator, who need not be highly trained, can do this for about six "pots" per hour.

In considering the feasibility of using this method, the cost of replacing an out-of-tolerance "pot" after it already has been installed, must be considered. In some cases this could be many times greater than the cost of the "pot" itself. ■ ■

References

1. General Specification Sheet furnished by Spectrol; also "Potentiometer Definitions" used by Clarostat Manufacturing Co. from Engineering Report No. ER000301 of Jan. 9, 1953.
2. *Elements of Statistical Method* by Albert E. Waugh, McGraw-Hill Book Co., New York, 1952, pp 307-312.

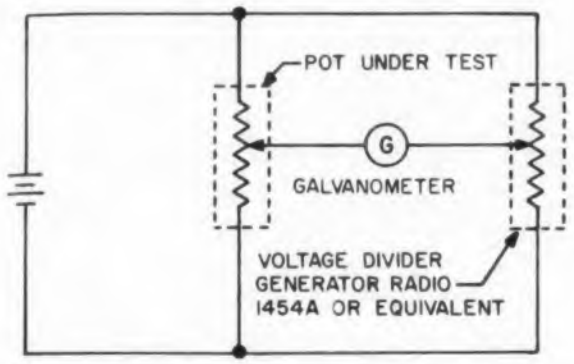
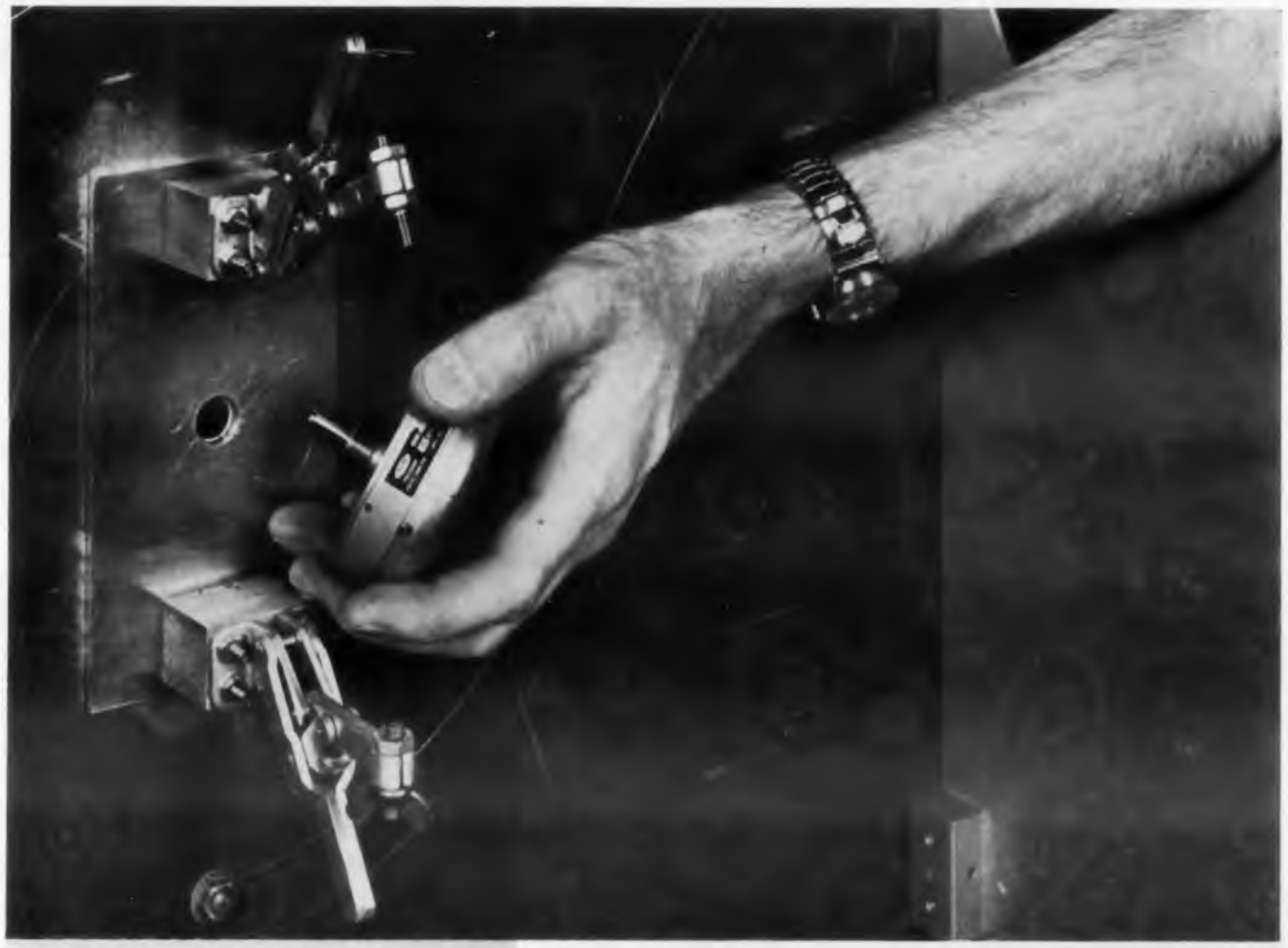


Fig. 1. The bridge circuit used to measure potentiometer output voltage as a function of the angular position of its shaft.

Table 1. A set of data for determining "best straight line" by method of least squares.

X	Y	X^2	XY	Y′	Y-Y′
0°	0.0170	0	0	0.0192	—0.0022
20	0.0741	400	1,482	0.0751	—0.0010
40	0.1311	1,600	5,244	0.1309	+0.0002
60	0.1879	3,600	11,274	0.1867	+0.0012
80	0.2437	6,400	19,496	0.2426	+0.0011
100	0.2993	10,000	29,930	0.2984	+0.0009
120	0.3550	14,400	42,600	0.3542	+0.0008
140	0.4105	19,600	57,470	0.4101	+0.0004
160	0.4658	25,600	74,528	0.4659	—0.0001
180	0.5212	32,400	93,816	0.5217	—0.0005
200	0.5774	40,000	115,480	0.5776	—0.0002
220	0.6338	48,400	139,436	0.6334	+0.0004
240	0.6893	57,600	165,432	0.6892	+0.0001
260	0.7456	67,600	193,856	0.7450	+0.0006
280	0.8005	78,400	224,140	0.8009	—0.0004
300	0.8562	90,000	256,860	0.8567	—0.0005
320	0.9125	102,400	292,000	0.9125	0
340	0.9677	115,600	329,018	0.9684	—0.0007
3,060	8.8886	714,000	2,052,062		



An operator uses the bridge circuit to measure potentiometer output vs shaft rotation in photo at right. Amount of rotation is fixed by holes countersunk in top of cabinet. The pointer on top is rotated until a steel ball on its end fits into a hole. The fixed end of the pointer is attached to the shaft of the potentiometer (shown above), which is inserted in the bridge circuit through a hole in the cabinet.

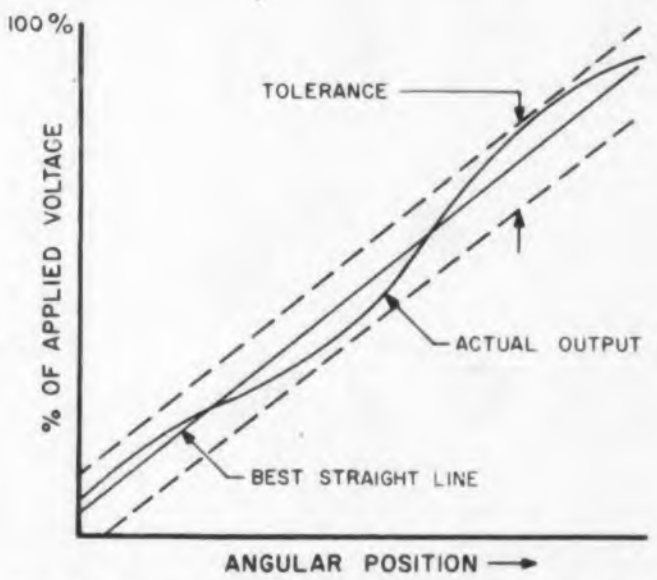


Fig. 2. An experimental curve—the output of a potentiometer—is shown superimposed on the "best straight line," determined by the method of least squares, through the experimental points.

Obtaining Variable Pulse Width

From a Line-Type Modulator

Vadim N. Martinovitch
Lockheed Electronics Co.,
Military Systems/Stavid Division
Plainfield, N.J.

USING two switching tubes instead of the conventional single tube in a high-power, line-type modulator permits generation of continuously variable output pulses.

With the conventional line-type modulator, shown to the left of the dotted line in Fig. 1, pulse width is varied by changing the delay line. Adding the tube V_2, as shown in Fig. 1, obviates changing the delay line.

In this circuit L_c is the charging choke, V_1 is the first hydrogen-thyratron switching tube, D_1 is the charging diode, D_2 is the clipping diode and Z_0 is the pulse forming network whose lump parameters determined the maximum output pulse length t_x. (In this case the load R_{L1} is in the cathode circuit of V_1.)

Pulse width is determined by the relative delay between the triggers applied to the two tubes. Once both tubes are triggered, the pulse-forming network essentially discharges through two parallel impedances.

If the second tube were not triggered, all the charge accumulated in the pulse-forming network would pass through the first load resistance. If both tubes were triggered simultaneously, only half the accumulated charge would pass through the first load resistance. Hence, the pulse output would be half as long as in the first case.

Having the second trigger lag or lead the first makes more or less charge passes through the first load resistance. This produces longer or shorter pulses. The first case is shown in Fig. 2.

As T_2 is delayed from t_o to 0.5 t_x, the output pulse 1 increases in width from 0.5 t_x to t_x. Correspondingly, the output pulse 2 decreases in width from 0.5 t_x to zero. When T_2 is delayed more than 0.5 t_x, there is no output pulse from the thyratron V_2. Hence, the output pulse from V_1 is t_x in time duration.

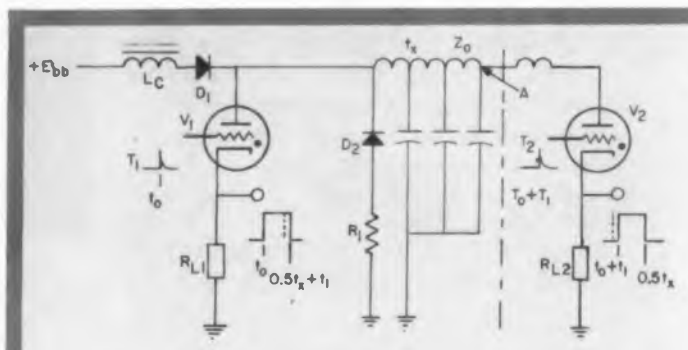


Fig. 1. Line-type modulator circuit for generating variable-width pulses. Portion of circuit to left of dotted line is a conventional line-type modulator.

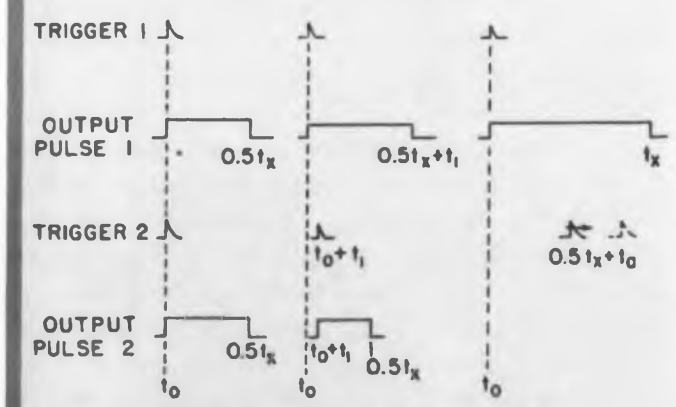


Fig. 2. Delaying the trigger to the tube V_2 of Fig. 1, increases the length of pulses from V_1, and shortens those from V_2.

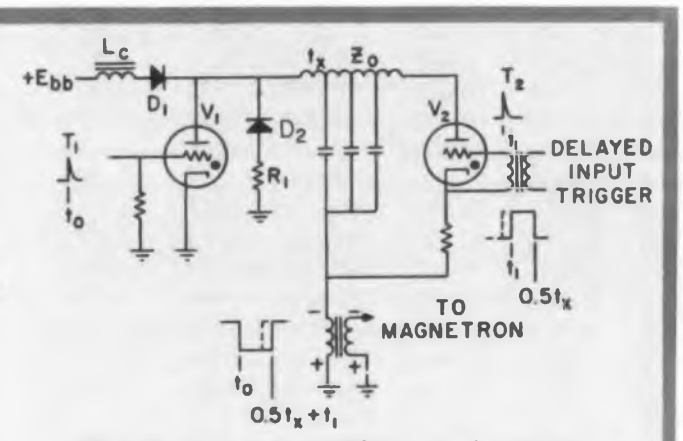


Fig. 3. Incorrect modification of conventional line-type modulator to get variable-width output pulses. Configuration makes delay between triggers impossible.

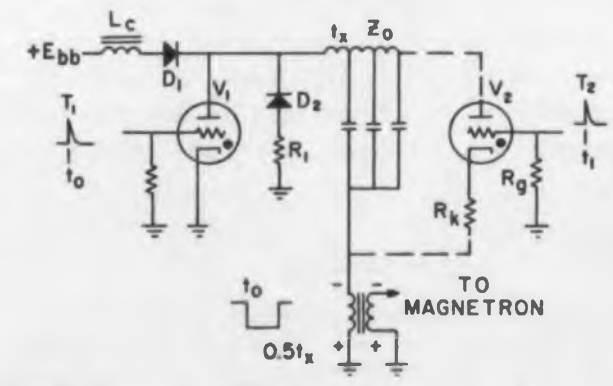


Fig. 4. Correct modification of conventional line-type modulator to generate variable-width output pulses.

Practically, it is desirable to use pulses from only one output. Therefore, rather than change output terminals from 1 to 2 to get pulse width less than 0.5 t_x, it is only necessary to let T_2 lead T_1 instead of lag it. (Conversely, terminal 2 may be chosen as the output terminal.)

The clipper diode D_2 removes charge from the network produced by mismatches between either or both load resistors and the pulse-forming network impedance Z_o.

Experimentally, when the clipper-diode circuit was opened, and either load resistor shorted out, the resulting peak inverse voltage produced a substantial increase in peak anode forward voltage. This caused the modulator components to sustain excessively high voltages.

In practical applications, in which only a fraction of the total pulse width must be varied, the average current requirements of the second thyratron (control tube) are smaller than those of the first. Hence, a smaller tube can be used.

Both tubes, however, must be capable of operation at the same peak anode voltage determined by the pulse-forming network.

Fig. 3 shows the incorrect addition of a control thyratron to an existing line-type modulator. At time t_o the polarity across the pulse transformer will be as shown. The output pulse will go, in effect, to the grid and cathode of V_2, making the grid highly positive with respect to the cathode.

This will cause V_2 to fire almost simultaneously with V_1, producing pulses equal to 0.5 t_x in each thyratron load. Thus, trigger-delay control of V_2 is lost.

Fig. 4 shows a properly isolated trigger circuit for the control thyratron.

After firing V_1, the control thyratron V_2 will have a negative voltage—equal to the pulse transformer primary voltage—at its cathode with respect to ground. The full, peak, forward anode voltage with respect to ground will be at its anode.

Therefore, in selecting a control thyratron to be added to an existing modulator, the peak-allowable, forward, anode voltage must be approximately one and a half times, or greater, than the network voltage.

The thyratron must obtain its filament and reservoir voltages from low-capacitance transformers that can withstand the peak voltage at the cathode, and the trigger must be isolated.

It must be noted that for opposite-end discharge of a pulse-forming network, the front and rear inductors must be physically identical if the leading edges of the output pulses are to have identical shapes. ■ ■

Acknowledgement

E. A. Cormier, for his assistance in this work.

A Permanent Magnet Relay For Printed Circuit Applications

THE PRINTACT relay has been designed to save space and weight, reduce assembly time and improve reliability. It mounts directly on a printed circuit board and eliminates intermediate connections to fixed contacts by doing away with the contacts. The contacts on the armature assembly mate directly with the printed circuit conductor pattern. This pattern is designed by the user to meet his specific application problem. In place of the usual spring, a permanent magnet is employed to hold the relay armature open. The entire relay assembly consists of an armature assembly and a magnetic motor assembly molded in a plastic housing.

The armature and moving contact assembly consist of a No. 5 relay steel armature, a Mylar insulator, a high-impact plastic molding and heat treated beryllium-copper springs with bar palladium contacts. The armature assembly, carrying the moving contacts, is held in position against the edge of a U-shaped fixed magnetic member by a small ceramic permanent magnet. Application of an electro-magnetic field opposing the field of the permanent magnet causes the armature to rotate. The balanced armature assembly is the only moving part in the relay.

The magnetic motor assembly is molded in a high-impact plastic housing. The ceramic biasing magnet is positioned between two U-shaped pole pieces made of No. 5 relay steel, which are cadmium plated and hydrogen an-

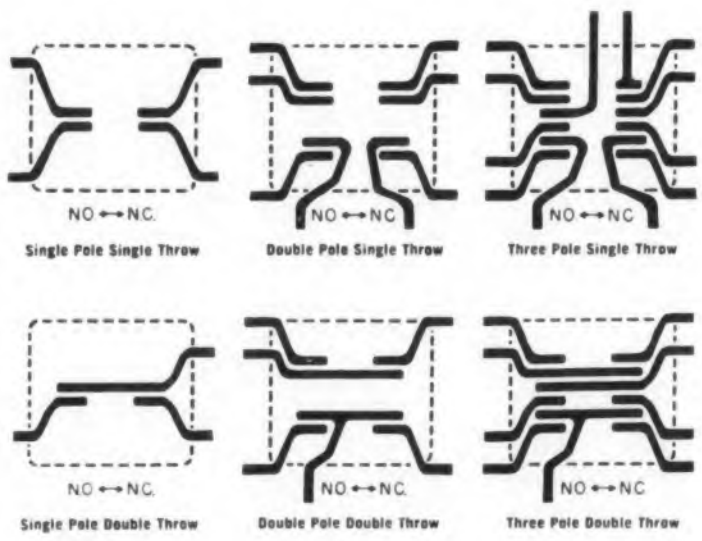


Fig. 1. Typical printed circuit board conductor configurations for Printact relay.

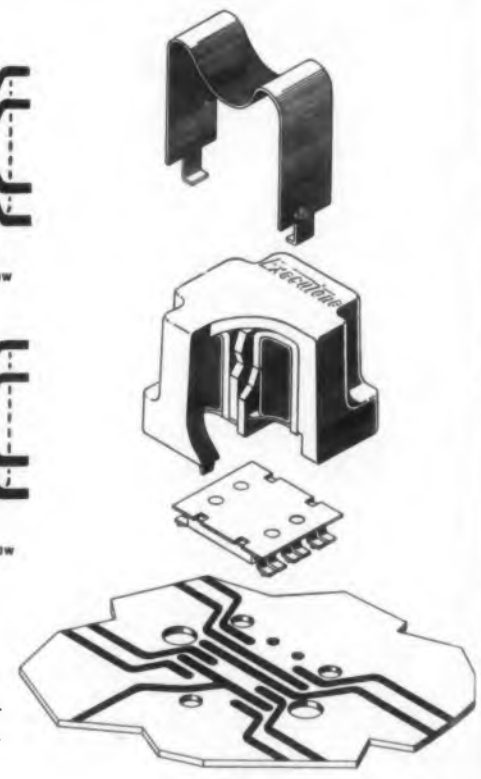


Fig. 2. (right) Printact relay is designed for low cost assembly and reliable performance.

Memory module which registers up to 40 items of information has 20 Printact relays occupying 8-1/4 x 5-3/4 x 1 in. of space.

nealed after forming. The pole pieces are assembled with the magnet between them to form an E-shaped structure with the coil surrounding the center leg. When voltage is applied to the relay, the flux produced by the coil tends to attract one end of the armature across the open air gap. At the same time it opposes the flux of the permanent magnet, tending to cancel the force across the closed gap. Sufficient current through the coil will cause the armature to rotate; removal of this current permits the permanent magnet to restore the armature to its original position. As the armature rotates, the restoring force of the permanent magnet tends to decrease, giving the relay snap action.

Spokesmen for the Components Div. of Executone Inc., 47-37 Austell Place, Long Island City, N. Y., claim the balanced armature construction gives a high degree of freedom from shock and vibration which, together with the simplicity of design and absence of hand adjustments, gives high reliability to the relay. The springs in the armature are prestressed during assembly to provide uniform contact pressure without hand adjustments. The form of the plastic mold plus the pre-stressing of the springs cause all the tolerances to be automatically picked up. Because of these design features Executone officials expect to go into fully automated production in the latter part of next year.

The Printact relay is available with two weeks required for delivery and will cost approximately $2.90 ea in small quantities, $1.73 ea in quantities of 1,000.

For further information on this printed contact, permanent magnet relay turn to the Reader-Service Card and circle **250.**

The **driver** disk. The **coupler** disk.

Instrument Measures Rotary Movements As Small As 3 Sec Of An Arc

ROTARY movements as small as 3 sec of an arc can be measured and digitized by a new instrument called a Phasolver. Made by Telecomputing Corp., the unit is expected to reach a capability of 1 sec of an arc in the near future.

Potential uses for the Phasolver include antenna systems, gun-laying equipment, position control of mobile launching platforms, gyroscope readout, inertial platforms, and process control.

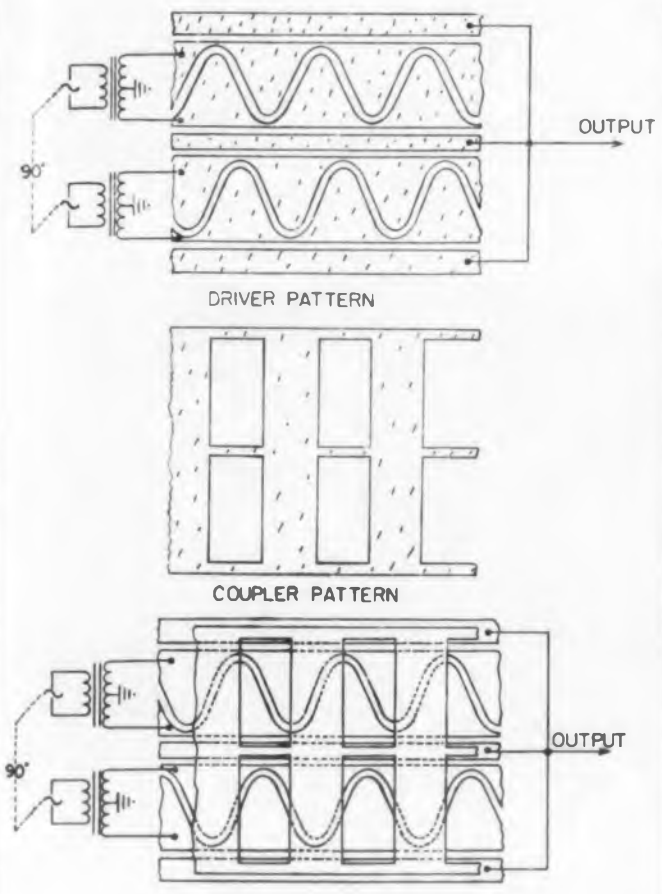
The Phasolver, which is claimed to be superior to any comparable system, converts small mechanical motions into large electrical phase shifts that can be digitized. Systems incorporating the unit will be available from the manufacturer in several months.

A Phasolver system consists of two main units: (1) the transducer (sensing device) attached to the element whose rotation is to be measured; (2) associated electronics and digitizing equipment. The transducer, essentially a highly accurate electrostatic shifter, consists of a pair of dimensionally stable, non-conducting disks. One rotates with respect to the other.

Each disk carries a pattern of conducting metal film. The two patterns, mounted facing each other and closely spaced, are called the driver and coupler. Input and output connections are made to the driver pattern. The coupler pattern couples energy electrostatically from the driver pattern and produces the output signal which is transferred to the load by means of output coupling rings in the driver pattern. Since there are no physical connections to the coupler disk, it is fixed to the element whose rotation is being measured. The driver disk is fixed to the supporting frame.

The pattern configuration provides an output signal with constant amplitude and a phase angle (referred to the input signal), which is proportional to the rotary position of the coupler disk. It is accomplished in this manner:

The driver pattern consists of two sets of conjugate sinusoidal conductive areas phase displaced by 90 deg. On either side and between the sets are output coupler rings that are electrically connected to furnish the output signal to the load. This pattern is powered by two pairs of push-pull ac signals having a quadrature time relationship. The coupler patterns consist of two rows of alternate bars and spaces. The widths of the bars and spaces are the same and equal to half-wave lengths of the sinusoidal patterns on the driver disk. As the two disks move relative to each other, the first pair of conjugate sinusoidal areas on the driver disk couples a voltage into a corresponding area on the coupler disk which varies sinusoidally.



Combined disk patterns.

At the same time, the second sinusoidal pattern on the driver disk, which is phase displaced by 90 deg from the first pattern, couples a voltage into its corresponding rectangular area on the coupler disk.

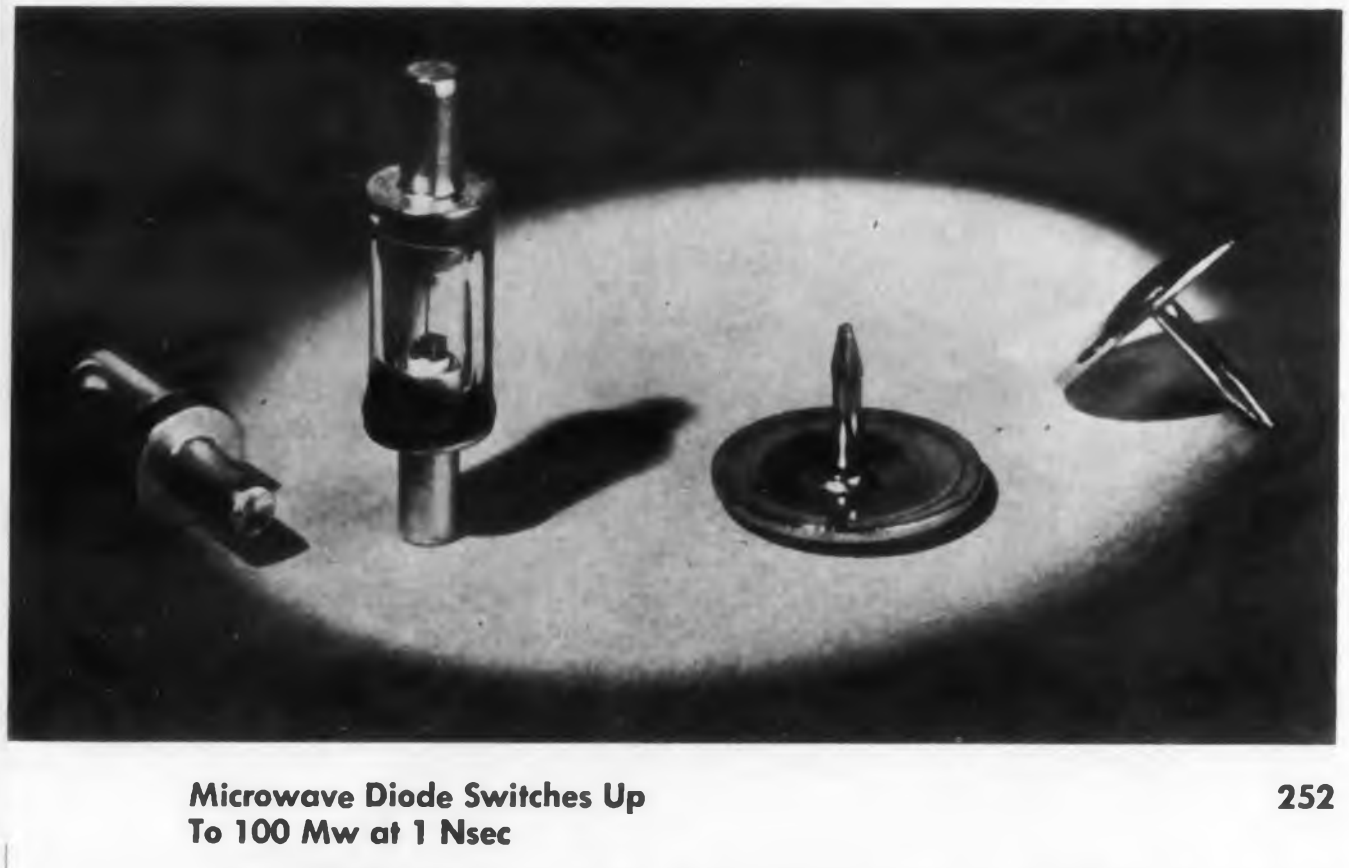
Because of the quadrature relationship of the signal voltages for the two sinusoidal pattern pairs, the output of the first rectangular area is $E\cos\theta$; output of the second rectangular area is $jE\sin\theta$. When these two are combined electrically, the result is a signal of constant amplitude and rotating phase (E/θ). This phase angle increases continuously from 0 to 360 deg as the two disks move relative to each other, a distance equal to one sinusoidal pattern.

The foregoing principle is applied using both coarse and fine pattern pairs. A single sinusoidal pattern is used in the coarse pattern to produce an unambiguous output position. The number of pattern pairs in the fine pattern determines how many times the electrical phase difference will change through 360 deg for one mechanical rotation, or position of a rotation.

For more information (firm's address is 915 N. Citrus Ave., Los Angeles, Calif.) turn to the Reader-Service Card and circle number **251.**

NEW PRODUCTS

Covering all new products generally specified by engineers designing electronic original equipment. Use the Reader's Service Card for more information on any product. Merely circle number corresponding to that appearing at the top of each description.



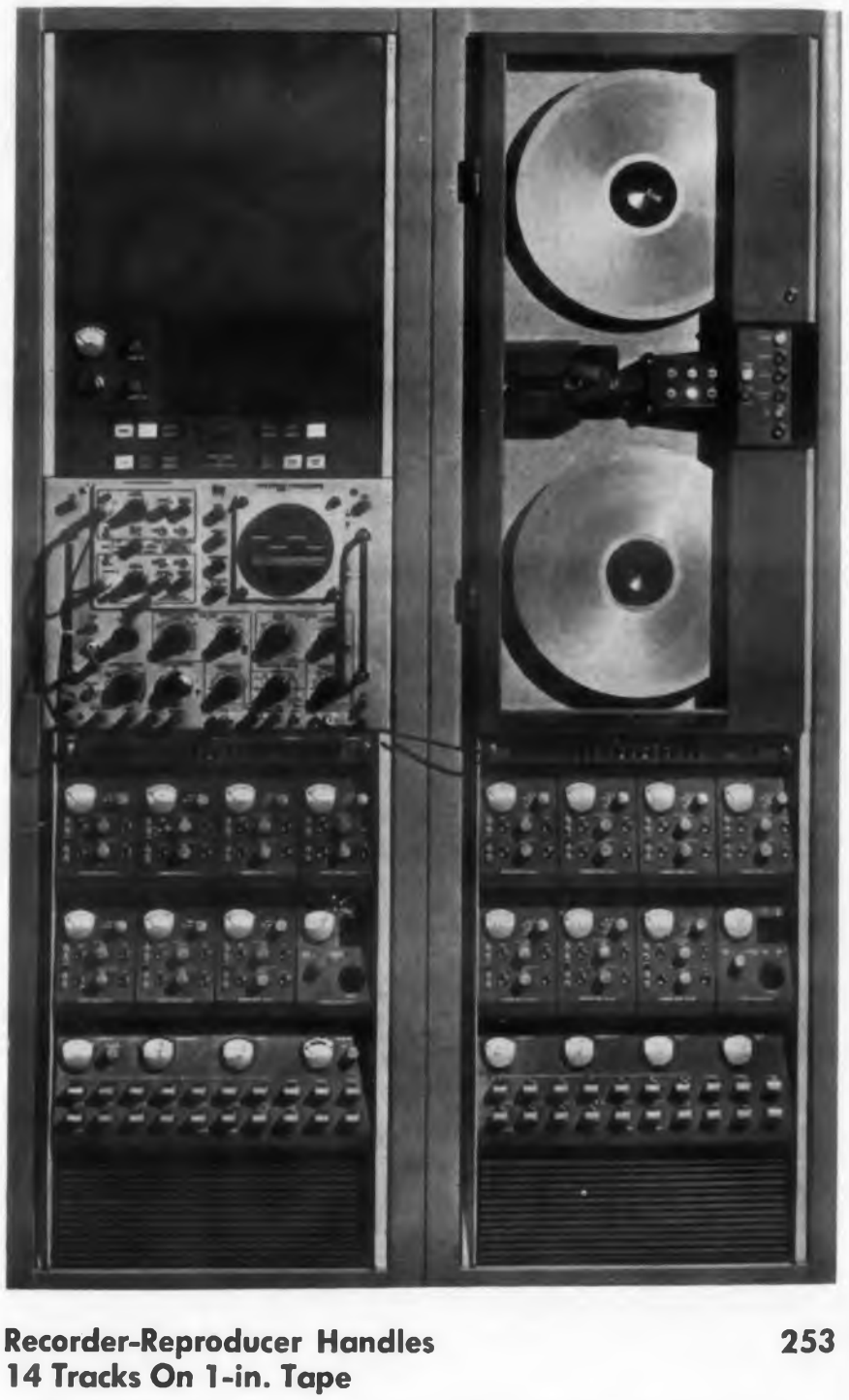
Microwave Diode Switches Up To 100 Mw at 1 Nsec — 252

Type 1N3093 microwave crystal diode switches power up to 100 mw at speeds of less than 1 nsec. The X-band unit has insertion losses of less than 2 db and isolation values greater than 18 db at 9,300 mc. The diode is available placed in a conventional mount, centered on the waveguide axis. The mount has flanges on either end for easy incorporation into conventional waveguide systems. The forward current rating is 60 ma and the reverse voltage rating is 11 v.

Philco Corp., Lansdale Div., Dept. ED, Lansdale, Pa.

Price: *Diode price varies from $27 to $40, depending on quantity. Diode with mount is $145.*

Availability: *Within 3 wk for diodes in quantities up to 10.*

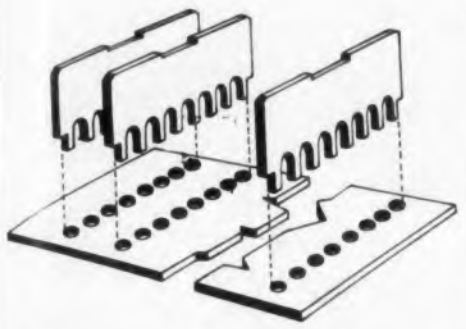


Recorder-Reproducer Handles 14 Tracks On 1-in. Tape — 253

Model CM-114 records and reproduces 14 tracks of both analog and pulse signals on 1-in. magnetic tape. Frequency response on each of the 14 tracks is 400 cps to 1 mc at 120 ips. Predetection recording is a feature application of the unit, which is designed to incorporate both a receiver and a scope in the unit if desired. The unit has a selection of six tape speeds ranging from 7.5 to 120 ips. At 60 ips, frequency response is up to 500 kc. There is constant phase equalization of all six speeds. Playback speeds can be reduced by a ratio of 16 to 1.

Minnesota Mining and Manufacturing Co., Mincom Div., Dept. ED, 2049 S. Barrington Ave., Los Angeles, Calif.

Availability: *90 days after order received.*



Microdeck Building Blocks 254 Perform Many Functions

The Universal Microdeck, an approach to unified miniature circuitry, uses a 1.25 x 0.6 x 0.55 in. thick Fotoceram substrate. Its hole pattern accommodates a variety of circuits and adapts to deposited thin-film or standard components. Any number of Mircodecks can be combined into a stacked Multideck by means of a standard interconnection panel. Two decks, for example, can provide a complete flip-flop. An amplifier and diode deck forms a multiple input NOR gate.

CBS Electronics, Dept. ED, Danvers, Mass.

Price: $55 per deck.

Availability: Sample units available.

Five Functional Electronic Blocks Made Available 255

Five functional electronic blocks, two amplifiers and three computer components, have been made available. One amplifier is a high-level, two-stage unit, operating with output currents of 1 to 2 amp and current gains of 500. Power gain is about 45 db. The other amplifier is a three-stage unit, operating with output currents of 1 to 2 amp; current gains are up to 10,000. The bistable multivibrator unit operates at frequencies to 500 kc and internal wiring is completely absent. The multiple Trinistor switch is a 10-position, multiple three-terminal pnp switch. Voltage level is 100 v and above. The pulse generator unit operates in the frequency range of 100 kc; pulse widths can be less than 1 μsec.

Westinghouse Electric Corp., Semiconductor Dept., Dept. ED, Youngwood, Pa.

Availability: Developmental sample units only.

CIRCLE 57 ON READER-SERVICE CARD ➤

Creative Microwave Technology

Published by MICROWAVE AND POWER TUBE DIVISION, RAYTHEON COMPANY, WALTHAM 54, MASS., Vol. 2, No. 3

RAYTHEON 1,000,000-WATT MAGNETRON LOGS OVER 13,000 HOURS IN MOBILE RADAR

This is the first reported history of a Raytheon QK-358 magnetron substantiated with an exhibit. Still, there are numerous other cases in which these exceptional Raytheon tubes have been clocked in excess of 10,000 hours, radiating at peak power.

The case in point concerns the application of a QK-358 magnetron in an AN/FPS-8 radar, for which the General Electric Company is the prime contractor. When the tube was replaced after 13,000 hours of service for "preventative maintenance" reasons, it was returned to Raytheon where the tube was found to be operating within specifications. Findings showed it to be highly stable and still capable of radiating more than one megawatt of power.

A large measure of the reliable operation and outstanding life of the QK-358 was achieved through special attention given to its unique characteristics in the overall design of the radar transmitter.

For your information, the QK-358 is a mechanically tunable pulsed-type oscillator with an integral magnet and is designed for coupling to a standard 3" x 6" waveguide. Typical operating characteristics include:

Frequency Range	"L" Band
Peak Power Output	1.3 Mw
Average Power Output	1,630 W

AN/FPS-8 high-power search system by General Electric, used primarily in aircraft control and early-warning operation. The complete mobile version (AN/MPS-11A) shown here, can be airlifted or carried on nine trucks and two trailers.

Life testing of Raytheon tubes, such as the QK-358 magnetron, for six weeks or more serves as a quality check of their performance characteristics as recorded and plotted against time.

Excellence in Electronics

RAYTHEON

You can obtain detailed application information and special development services by contacting: Microwave and Power Tube Division, Raytheon Co., Waltham 54, Mass. In Canada: E. Waterloo, Ontario. In Europe: Zurich, Switzerland.

SEE THESE TUBES AT RAYTHEON'S WESCON BOOTH

A LEADER IN CREATIVE MICROWAVE TECHNOLOGY

NEW PRODUCTS

Power Supply Tester 572

Checks all types

Model 9007 test console provides ac power for checkout testing of 60 and 400-cps power supplies. It offers high and low-line and load transients, controlled rise and fall times, interchangeable loads, pulse generator to simulate sense line transients, and air-cooling of unit under test. The unit can be operated by unskilled labor.

Transval Electronics Corp., Dept. ED, El Segundo, Calif.
Price: *$3,500 ea.*

High-Temperature Oven 567

Provides temperatures to 260 C

This mechanical-convection oven provides temperatures from 35 to 260 C, regulated to 0.5 C. Designed for pre-heating, drying, baking, and curing applications, the oven has five pull-out drawers to permit inspection of test items without disturbing the environment of all items under test. Controls include a wattage selector switch, an automatic thermostat, and an over-temperature controller. Interior dimensions are 24 x 20 x 30 in.

The Electric Hotpack Co., Inc., Dept. ED, 5065 Cottman St., Philadelphia 35, Pa.
Price & Availability: *About $1,100; 30 to 60 days.*

Proportional Temperature Controller 407

Features pure dc output

The TC-203 proportional temperature controller features a pure dc output. Efficiency is in excess of 90% and the output is free from all switching transients. It is completely solid state, hermetically sealed, and potted to meet applicable military environmental conditions. Standard power capabilities are 100 or 200 w, in either 60 or 400 cps models.

Harrell, Inc., Dept. ED, 1788 First Ave., New York 28, N.Y.

Termination Set 556

With calibration book

Termination set 1111, with a book calibrated for every 100 mc, supplies known vswr values below 1.05 from dc to 12,400 mc, for male or female type N connectors. The short and long terminations are rated 0 to 3,000 mc and 2,500 to 12,400 mc, respectively. Four terminations and the calibration book are packaged in a hinged, plastic case.

Radar Design Corp., Dept. ED, P. O. Box 38, Syracuse 11, N. Y.
Price & Availability: *From stock at $175 ea.*

Coaxial Directional Couplers 569

Directivity exceeds 30 db

These coaxial directional couplers provide flat coupling over a full octave frequency range. Directivity exceeds 30 db. Coupling values of 10, 20, and 30 db are within 1 db of nominal value over the specified range. Calibration is provided to an accuracy of ±0.2 db at five frequencies.

Narda Microwave Corp., Dept. ED, 118-160 Herricks Road, Mineola, N. Y.
Price & Availability: *$100 to $500; from stock.*

Mercury Switches 561

Are spdt type

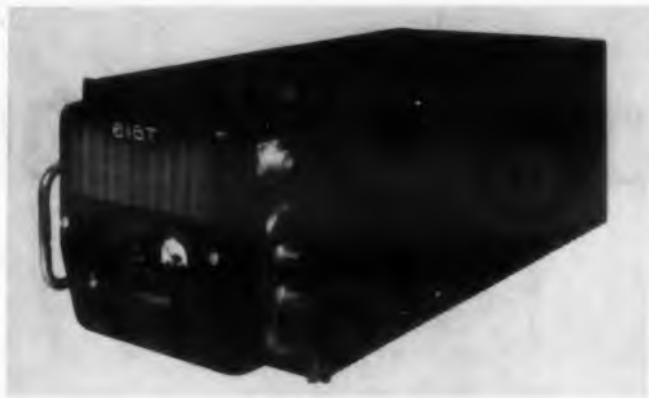
These spdt mercury switches come in two types: Model HG 900 LO, make-before-make, and HG 901 LO, make-before-break. One of these units replaces two mercury switches in such applications as programers, annunciators, interlocks, and alarm systems. Minimum life expectancy is 50,000 cycles. Package dimensions are 0.4 in. in diameter and 1.75 in. in length.

Gordos Corp., Dept. ED, 250 Glenwood Ave., Bloomfield, N. J.
Price & Availability: *$0.30 for bare switch in quantities of 10,000; $0.75 for molded switch with leads. Delivery is from stock.*

NEW PRODUCTS

HF Single Sideband Transceiver 448

Provides communication on 28,000 channels



Offering communication on 28,000 channels, model 618T hf single sideband transceiver delivers 400 w peak and 100 w carrier for am operation. It covers the spectrum of 2 to 30 mc in 1-kc steps. Multi-path distortion is eliminated; signal-to-noise ratio is greater than that of conventional am. Frequency control is provided by phase-locking circuits.

Collins Radio Co., Dept. ED, P. O. Box 1891, Dallas 21, Tex.

Printed-Circuit Potentiometer 654

Single-turn

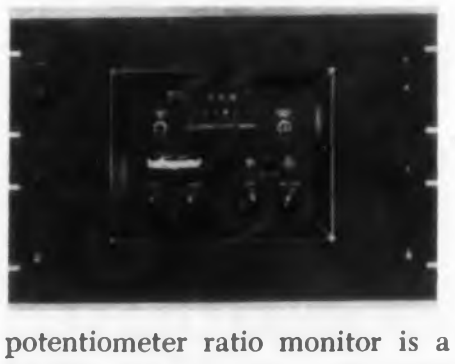
The modular, Type 50-M60 printed-circuit, horizontally mounted, single-turn trimmer potentiometer fits a 0.1-in. grid, is adaptable to dip and splash soldering, and has sealed construction. Adjustment is made from the front of the panel. Resistance values range from 25 to 50,000 ohms.

Maurey Instrument Corp., Dept. ED, 7924 S. Exchange Ave., Chicago 17, Ill.

Price & Availability: *The units are made to order, and can be delivered within 35 to 40 days. Prices range from $9.94 each for less than 10 to $7.64 each in quantities of 1000 or over.*

Potentiometer Ratio Monitor 547

Is bridge balance system



This potentiometer ratio monitor is a servo-operated bridge balance system. The error signal between an external potentiometer wiper voltage

and the servo potentiometer voltage causes the servo potentiometer wiper to drive to a null position, which is read on a four-digit counter as a percentage of full scale. Operating power is 115 v, 60 cps; power supply is internal, 0.05 to 12-v dc regulated; accuracy is ±0.1% full scale; resolution is ±0.05% full scale; response is 8 sec to full scale.

Physical Sciences Corp., Dept. ED, 389 N. Fair Oaks Ave., Pasadena, Calif.

Price & Availability: *Price is $1,295 per unit; delivery is 4 to 6 wks. after receipt of order.*

Transducers 441

Linear and rotary-motion types

Models 10-R-60-1 and 10-R-30-1 linear and rotary-motion transducers have sensitivities of 0.2 mv rms per deg and 0.4 v rms per deg, respectively. They measure 1.25 in. high and 0.937 in. in diameter. They are designed for size 10 servo mountings and are brushless. A typical linear, ac-ac unit has an input range of ±30 and ±60 deg, an input voltage of 26 v ac at 400 cps, an output impedance of 5,000 ohms, and a usable frequency range of 300 to 3,000 cps. Applications include telemetry and data reduction.

Arnoux Corp., Dept. ED, 11924 W. Washington Blvd., Los Angeles 66, Calif.

Silicon Rectifiers 652

Carry 200 amp

Specifications for these silicon power rectifiers, types ES-51 and ET-51, are: peak forward voltage, 1.25 v max at 200 amp; peak inverse current, 50 ma at 100 C case temperature; thermal drop, 0.5 C per w max from junction to case; temperature range, −35 to +120 C (case) and −35 to +150 (junction); mounting torque, 800 in.-lb (ES-51) and 1000 in.-lb (ET-51) max; length, 5-1/2 in. (ES-51) and 5 in. (ET-51) max; piv, 100 v steps from 100 to 400 v.

Syntron Co., Rectifier Div., Dept. ED, 283 Lexington Ave., Homer City, Pa.

Price & Availability: *Units, priced from $9.48 to $26.84 depending on quantity and piv, can be delivered 14 days after receipt of order.*

NEW PRODUCTS

Digital Modules 553

Frequency range is dc to 1 mc

Series S plug-in, high-speed, digital modules, called S-Pacs, operate in the frequency range of dc to 1 mc. Typical performance of a 1-mc flip-flop allows driving six standard loads from each side through 400 pf of stray, distributed capacity. Signal levels of ground and —6 v are standard; 2-v noise margins are assured to allow reliable application in large systems. The complete series will consist of approximately 25 different packages. Currently the following items are available: gating package; diode package; flip-flop; universal flip-flop; counter; shift register; power amplifier; delay multivibrator/pulse shaper.

Computer Control Co., Inc., Dept. ED, 983 Concord St., Framingham, Mass.

Airborne Tape Recorder 562

Tape speeds are 0.25 to 60 ips

Model MTR-800 tape recorder has a tape capacity of 300 ft of 1-mil Mylar tape and operates at tape speeds of 0.25 to 60 ips. Wow and flutter are less than 0.5% rms at 60 ips. The unit can have 7 to 14 channels. It stands temperatures of —50 to +200 F. A vibration of 15 g at 5 to 2,000 cps without shock mounting, an acceleration of 200 g, and an impact of 1,000 g. It operates from 115 v of 400-cps power at 30 w, weighs 9 lb and measures 7-5/8 x 5-3/8 x 4-5/8 in.

Leach Corp., Dept. ED, 516 E. Compton Blvd., Compton, Calif.
Price & Availability: *About $5,000; immediate.*

Servo Motor 370

Has no-load speed of 6,500 rpm

Measuring 1.5-in. in diameter and 1.5-in. log, type 2635 servo motor has a minimum no-load speed of 6,500 rpm. A high rotor-impedance unit, the motor has a linear torque-

◀ CIRCLE 63 ON READER-SERVICE CARD

versus-speed curve. It operates at 115 v with a maximum input of 8.5 w. Acceleration is 88,000 radians per sec², torque at stall is 1.25 oz-in., and torque²-to-inertia ratio is 110,000 oz-in. per sec². The unit weighs 9 oz.

Kollsman Motor Corp., Dept. ED, Dublin, Pa.

Price & Availability: *$148 in quantities of 1 to 9; $114 in quantities of 100 up. Delivery is 3 to 5 mo.*

Voltage Detector 554

For go, no-go comparisons

Series 224 signal comparators provide go, no-go comparison of a signal voltage with respect to a reference. All models have two signal channels and a sensitivity of ±10 mv. Model 224-021D operates on 2.5 va, 115 v, 400 cps single phase power and has a signal range of 0 to 50 v dc; model 224-023A operates on 3 va, 115 v, 60 cps single phase power and has a signal range of 0 to 10 v dc; model 224-023B operates on 3 w, 28 v dc power and has a signal range of 0 to 10 v dc; model 224-023C operates on 3 va, 115 v, 60 cps single phase or 3 w, 28 v dc powered has a signal sensitivity of 0 to 10 v dc.

Avien, Inc., Dept. ED, 58-15 Northern Blvd., Woodside 77, New York, N.Y.

Unidigit Pulse Counter 555

Electromagnetic

Type EZ 10/0 Unidigit pulse counter is a single wheel, electromagnetic counter designed for parallel entry. The unit may be stacked on common studs to the number of decades desired. The number wheels are positioned individually by pulse at stepping rates to 10 per sec. Provision is made for automatic reset to zero. Standard models are 24 v dc; other coils are available from 6 to 60 v.

Presin Co., Dept. ED, 2014 Broadway, Santa Monica, Calif.

Price & Availability: *$9.80 ea; quantity discounts to 40%; from stock.*

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NEW PRODUCTS

Miniature Relay 386

SPDT contact arrangement

The type DF relay has an spdt contact arrangement rated at 2 amp, non-inductive, at 115 v ac. The dc voltage-actuated models are rated at 6, 12 and 24 v dc; current-actuated models have 2,500, 5,000 and 10,000-ohm coils. Nominal power for the voltage models is 180 mw; it is 40 mw for the current models. Dimensions are: height, 1-3/16 in.; diameter, 3/4 in.

Line Electric Co., Dept. ED, 229 River St., Orange, N.J.

Price: *Voltage models are $7.75 ea.; current models are $7.75 to $8.35 ea.*

Power Supply 564

Delivers 0 to 75 v dc

Delivery 0 to 75 v dc at 0 to 8 amp, model SM-75-8 power supply has a regulation for line or load of 0.1% or 3 mv. Stability is 0.1% or 6 mv for 8 hr, ripple is less than 1 mv rms, and temperature coefficient is less than 0.05% per deg C. Recovery time is 50 μsec. The output impedance is 0.01 ohms from dc to 1 kc and 0.1 ohms from 1 to 100 kc. Input is 105 to 125 v at 60 cps. The unit is transistor-regulated.

Kepco, Inc., Dept. ED, 131-38 Sanford Ave., Flushing 55, N. Y.

Price & Availability: *$825 without meter and $855 with meter; 60 days.*

Shield Enclosure 458

For use in measuring electrical characteristics

The shield enclosure is an auxiliary unit for shielding materials and small components while measurements of electrical characteristics are being made. Applications include measurements of high-value resistors, charging phenomena, and electrical properties of semiconductors and insulation materials.

Applied Physics Corp., Dept. ED, 2724 S. Peck Road, Monrovia, Calif.

Module Cage 452

For transistor digital-circuit modules

Type TDC P-4 transistor digital-circuit module cage accommodates 26 plug-in modules per drawer. Four drawers are available in a 5.25 x 19 in. frame. It houses a total of 104 TDC modules, shift-register bits, or shift-register drivers. Full test-point and panel-lamp facilities can be provided on the front panel.

EPSCO, Inc., Components Div., Dept. ED, 240 E. Palais Road, Anaheim, Calif.

Traveling Wave Tubes 560

Temperature compensated

These two, temperature-compensated, magnetically shielded, traveling wave tubes are designed for both pulse and cw operation. Both operate without heater blankets blankets from —65 to +72 C with minimum performance degradation. They are permanent-magnet focused and have these specifications: type TW-4002F, small signal gain is 37 db min, cw rf output at saturation is 10 mw min; type TW-956H, gain with 0.1 mw input is 37 db min, cw rf power output at saturation is 2 to 5 w.

Sylvania Electric Products Inc., Dept. ED, Mountain View, Calif. ***Price & Availability:*** *Samples for military evaluation are available. Prices for small quantities are about $1,200 or the TW-956H, $1,950 for the TW-4002F.*

Servo Control 457

For point-to-point positioning

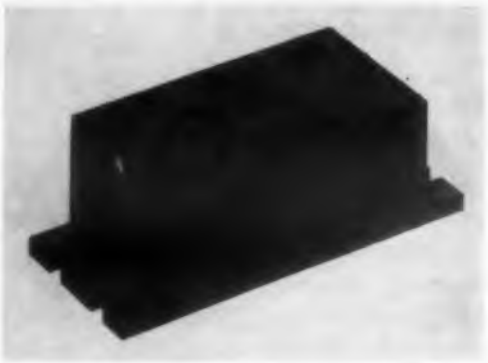
Model 600 numerical-positioning servo control is for point-to-point positioning of machine elements. Digital rather than binary or analog circuitry is employed. A standard eight-channel code is used. Data input to the position transducer is by means of a lead screw or rack. An input of 110 to 120 v ac, 1,400 w, is required.

Carlton Controls Corp., Dept. ED, 15 Sagamore Road, Worcester 5, Mass.

NEW PRODUCTS

Subminiature Amplifier 522

For missile instrumentation



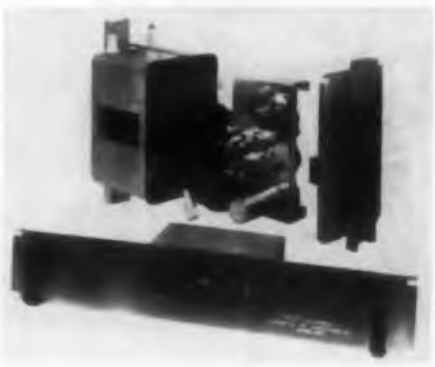
Model 96 subminiature amplifier, designed for missile instrumentation, contains a solid-state amplifier, an oscillator power supply, a demodulator and a line-voltage regulator. It raises millivolt signals from strain gages, bridge-type pressure transducers, or bridge-type accelerometers to 5 v. The output voltage can swing from 0 to ±5 v dc. Frequency response is 0 to 2,000 cps. The unit withstands acceleration of 50 g peak amplitude from 30 to 2,000 cps, also 100 g static acceleration. It measures 2.13 x 1.33 x 0.87 in.

Video Instruments Co., Inc., Dept. ED, 3002 Pennsylvania Ave., Santa Monica, Calif.

Price & Availability: *$655; 45 days.*

Antenna Amplifier-Coupler 622

2 to 40 mc range



The Model 9126 antenna amplifier-coupler is mounted directly at the antenna terminals and provides 10-db gain from 2 to 40 mc with less than a 6.5-db noise figure and low distortion. The device is a single push-pull parallel grounded-grid stage using four 6922 dual-triodes. It is enclosed in a weatherproof box and includes a lightning arrester. Power is transmitted through the rf lead-in cable from the receiver site. Input impedance is 600 ohms; output impedance, 72 ohms. Input vswr is less than 2:1. Power required is 110 v ac, 25 w, single-phase.

Trak Electronics Co., Communications and Reconnaissance Dept., Dept. ED, 49 Danbury Road, Wilton, Conn.

Dry Box 459

Constructed of Plexiglas

The Hydrovoid dry box, adaptable to inert gases or room air, is suitable for production or laboratory use with semiconductors, miniature mechanical assemblies, and tube components. The dessicant system attains very low dew points. Airborne particles down to 0.5 microns in diameter can be removed. The cabinet is constructed of clear Plexiglas.

Air-Shields, Inc., Dept. ED, Hatboro, Pa.

Price & Availability: $815; two weeks.

Chassis Slides 461

Are self-aligning

These flat-groove chassis slides are self-aligning and will automatically adjust to fit misaligned chassis or cabinets. Two of the ball grooves in the intermediate channel extrusion have flat grooves which allow for side play between one channel and the next. When the demand of the cabinet changes, the flat groove shifts to the right or left as required and takes up the play while alowing the chassis to be fully extended in a straight line.

Grant Pulley & Hardware Corp., Dept. ED, High St., W. Nyack, N.Y.

FM Transmitter 451

Is rated at 10 kw

This 10-kw fm transmitter consists of matched units, a 1,000-w driver with Serrasoid modulation and two 5-kw amplifiers with a power combiner. The driver is available separately as a 1-kw transmitter or with one amplifier to provide a 5-kw signal. Driver output, amplifier input, and output impedances are identical: 50 to 51.5 ohms. This facilitates rerouting of the rf signal to patch over a temporarily inoperative driver or amplifier.

Reeves Instrument Corp., Standard Electronics Div., Dept. ED, Farmingdale, N.J.

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NEW PRODUCTS

Multimeter 374

Measures to 10 μv and 10 μμa

Full scale ranges from 10 μv to 250 v and 10 μμa to 250 μa are available on the type MV-07A multimeter. Full scale accuracy of 2% is provided for most voltage ranges, and accuracy is 3% on the 10-μv range and all current ranges. The unit has a cascode input stage and a twin T-filter.

Millivac Instruments Div., Cohu Electronics, Inc., Dept. ED, Box 997, Schenectady, N. Y.
Price & Availability: *$495 and up; from stock.*

Two-Rate Rectifier Chargers 352

For use with most stationary batteries

For use with most stationary batteries, these two-rate rectifier chargers come in four models. Three units have manual switches and are rated at 3 amp for charging 6 or 12, 15 or 18, and 25 cells. Rate changing and shut-off are automatic on the 6-amp unit which is designed for charging 60 cells. Applications include: emergency lighting, industrial process equipment, missile-base electrical equipment, and various laboratory uses. Operating on 110 or 220 v of single-phase, 60-cps current, the chargers convert the ac directly to dc.

Electric Storage Battery Co., Exide Industrial Div., Rising Sun and Adams Ave., Philadelphia 20, Pa.

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Power Transistor Heat Sink 416

Maintains 85 C junction temperature

This heat sink, designed for use with type 2N257 or similar power transistor, will maintain a junction temperature of 85 C at maximum power conditions without forced-air cooling. The device, 1-13/64 in. high and 1-55/64 in. diameter, is bolted on top of the transistor. It may be used in either a horizontal or vertical position.

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

Price & Availability: *The units, available from stock, are priced from $3 to $4 each in quantities of 500.*

AC Power Supply 453

Provides 12 v of regulated output

Model PS-12A power supply, designed to supply an excitation voltage to distance and displacement measuring electromechanical instruments, provides a regulated output of 12 v at 60 cps. Input is 115 v at 60 cps, unregulated line. Regulation is 1% for line variations up to 15%; response time is 1-1/2 cps.

Schaevitz Engineering, Dept. ED, P. O. Box 505, Camden 1, N.J.

Silicon Rectifiers 680

Deliver 900 amp

Type 6D double-diffused silicon power rectifiers deliver up to 900 amp in full wave circuits. Using solid stack construction, the units have copper fins, melamine insulation, and materials which provide for operation at ambient temperatures to 150 C. All assemblies are for either forced or natural convection cooling and can be coated with multiple paint for operation in abnormal atmospheric conditions. The units are furnished completely assembled for wiring directly into the circuit.

Trans-Sil Corp., Dept. ED, 55 Honeck St., Englewood, N.J.

◂ CIRCLE 70 ON READER-SERVICE CARD

NEW PRODUCTS

Germanium Mesa Transistors 563

For high-speed switching

Types 2N705 and 2N710 pnp, diffused-base, germanium mesa transistors are for high-speed switching operations. Hermetically sealed in TO-18 packages, the units meet MIL-S-19500B. For both types, turn-on time is 75 mμsec, storage time is 100 mμsec, and fall time is 100 mμsec.

Sylvania Electric Products Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.

Price & Availability: *Industrial net price for type 2N705 is $16 ea for orders of 1 to 99 and for type 2N710, $13.35 ea.*

Non-Overload Amplifier 436

Has integral discriminator

Mode N-371 linear non-overload amplifier with integral discriminator is designed primarily for use in routine scintillation or proportional counting systems. Specifications for the amplifier include: gain, 7,000; linearity, better than 0.2% from 4 to 100 v; hum and noise, less than 0.5 v peak-to-peak at maximum gain. The discriminator has a range of 3 to 100 v, a linearity of 0.5%, and 1-μsec resolving time.

Hamner Electronics Co., Inc., Dept., ED, P. O. Box 531, Princeton, N.J.

Price & Availability: *$490; from stock.*

Silicon Cartridge Rectifiers 421

Cover 600 to 16,000 piv

These silicon cartridge rectifiers, designated IN 1730, IN 2373, IN 2383, and IN 1133, cover the range of 600 to 16,000 piv. Designed for high-voltage and high-current applications, the units can be furnished with axial lead-mounting or standard 30-amp, fuse-clip mount-

ing. Both types have all-welded component connections in shatterproof cases. Average rectified current ratings range up to 250 ma at 25 C with maximum surge current ratings of greater than 2.5 amp for 8 msec. Operating temperatures are −55 to +150 C.

General Instrument Corp., Semiconductor Div., Dept. ED, 65 Gouverneur St., Newark 4, N.J.
Price & Availability: *$6.10 to $105; from stock.*

Radar Interference Eliminator 432

No modification of present systems needed

This beacon interference eliminator may be used with any standard radar having a beacon capability for IFF or ATC identification. The device is connected into the video lines connecting the radar-beacon receivers with the display, requiring no modification of present systems. The instrument eliminates spurious signals from radar displays through a passive operation, and the output is proportional to the input.

Lockheed Electronics Co., Dept. ED, Plainfield, N.J.
Booth 529B.

Miniature Pressure Transducer 456

Measures to 15,000 psi

Having a 1-in. diam, series 8416 pressure transducer measures up to 15,000 psi. The unit is 3.65 in. long and weighs 0.25 lb. Ranges are 0 to 400 psi up to 0 to 15,000 pso; several resistance values can be furnished. The sensing element is a twisted tube which moves a wiper across the winding of a precision potentiometer in response to pressure changes. Units can be made to measure gage, absolute, or differential pressure. Linearity is within ±1.5%.

Colvin Laboratories, Inc., Dept. ED, 364 Glenwood Ave., East Orange, N.J.

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NEW PRODUCTS

Miniature Power Rectifiers 351

2200 piv

Series B2000 power rectifiers have a 2200 piv rating and current ratings from 200 ma through 10 amp. The diffused-junction silicon rectifiers are hermetically sealed and have an operating temperature range from −60 to +150 C. Forward voltage drop does not exceed 2 v.

Britton Electronics Corp., Dept. ED, 19 Warren Place, Mount Vernon, N. Y.

***Availability:** Immediate from stock.*

Variable Delay Line 363

For coding systems

A variable delay line, model 72-22, which has applications in variable coding systems, provides three variable taps over a total delay of 1.5 μsec. The taps can be adjusted over the entire range with a resolution of 0.025 μsec. Impedance is 300 ohms. Pulse rise time and attenuation for full delay is 0.07 μsec and 2 db max, respectively. Variations to individual requirements are available.

ESC Corporation, Dept. ED, 534 Bergen Blvd., Palisades Park, N.J.

Miniature Tape Recorder 510

Has seven channels

The PMR-400 Series tape recorder provides up to seven record and reproduce channels at standard tape speeds up to 30 ips. Recording bandwidth is 100 kc for direct recording and 10 kc for fm carrier system. Adapters allow use of 8-in. reels with NARTB 4-1/2 in. instrumentation hubs. The unit measures 10 x 9 x 12 in., weighs 20 lb, and is designed to withstand shock and vibration. The standard unit is designed to operate from 24-v dc power at less than 40 w.

Pacific Electro Magnetics Co., Dept. ED, 942 Commercial St., Palo Alto, Calif.

***Price & Availability:** Prices vary between $5,000 and $10,000, depending on number of channels; delivery is 90 days.*

Silicon Transistors 530

For high temperature applications

Types 2N328A and 2N329A transistors are pnp silicon fusion alloy units having high gain. They are designed for use in high temperature audio, switching and dc amplifier circuits. Both transistors have low-saturation voltage, close parameter control from −65 to +160 C and good current gain at collector levels up to 50 ma. They are encased in welded, hermetically sealed JEDEC-TO-5 cases. MIL specs are met.

Raytheon Co., Semiconductor Div., Dept. ED, 215 First Ave., Needham, Mass.

Digital Voltmeter 367

Meets Mil specifications

This digital voltmeter conforms to MIL-E-4158A and is built for operational ground support equipment at missile sites. Designated Model 412, the instrument has a dual input with a toggle selector switch to connect either input to the digital printer. Accuracy is 0.01% of reading for dc, 0.1% of full scale for ac inputs. Common mode rejection for 60 cps is 86 db.

Kin Tel Div., Cohu Electronics, Dept. ED, San Diego, Calif.

Bistatic Microwave Reflector 512

Energy reflected through a 25 deg bistatic angle

The Model 2BS-212 bistatic reflector is a spherically symmetrical unit which reflects microwave energy from a point source and disperses it through a solid angle surrounding this source. The reflected energy is thus spread through a conical volume of space with a bistatic angle of about 25 deg. The reflector is applicable to aerial weapons testing whenever the radar transmitter and receiver are appreciably separated. The first null common with monostatic reflectors is filled by the bistatic unit. Reflectors are available with diameters of 3 to 48 in.

Emerson & Cuming, Inc., Dept. ED, 869 Washington St., Canton, Mass.

NEW PRODUCTS

Indicator Thyratron 454

Subminiature

Type WC-23 subminiature indicator thyratron is for use in transistor circuitry in computers, data processors, signal systems, and keyboard equipment. The indicato is made of a glass bulb, a button base with flexible leads, and a filamentary cathode; it can be mounted in any position. Filament voltage is 1.25 v ac; filament current is 250 ma.

Tucor, Inc., Dept. ED, 18 Marshall St., S. Norwalk, Conn.

Variable Delay Line 405

Provides delays to 3,700 μsec

Model VM-1090 variable magnetostrictive delay line has a continuous range of delays of from 3 to 3,700 μsec. It covers the range of relays in 5 sec. Impedance range is 50 ohms to 4 K, insertion loss at the end of the range is 63 db, and maximum pulse rate is 5 kc. The unit can be hand or motor driven. It is 3-5/8-in. in overall height and has an OD of 9 in. Weight is 5 lb.

Control Electronics Co., Dept. ED, 10 Stepar Place, Huntington Station, L. I., N. Y.
Availability: *60 days.*

Coaxial Frequency Meter 402

Offers three-band range

Model N414A direct-reading coaxial frequency meter has a frequency range of 3.95 to 11 kmc. Covering three waveguide bands, this meter is suitable for use with either coaxial line or waveguide setups. It can be used with the firm's model N410A meter, having a frequency range of 1 to 4 kmc. A reaction type instrument, the meter absorbs power only at the resonant frequency of a half wavelength resonant cavity.

FXR, Inc., Dept. ED, 25-26 50th St., Woodside 77, N. Y.

◀ CIRCLE 76 ON READER-SERVICE CARD

Modular Semiconductor Mounts 430

For breadboard versatility

Breadboard versatility can be obtained with the use of these modular semiconductor mounts. New semiconductor devices can be incorporated directly into microwave and computer circuitry using standard Tri-Plate module building blocks. They are available for cartridge, double ended or pigtailed glass packages.

Sanders Associates, Inc., Dept ED, 95 Canal St., Nashua, N. H.

Price & Availability: *Standard modules are availbale from stock, custom modules made to order. Prices range from $10 to $230 per unit for standard modules and from $655 to $2,300 for standard module kits.*

Microwave Attenuators 423

Cover 1 to 9 kmc

The PI line of continously variable, microwave attenuators covers the range of 1 to 9 kmc. The vswr is 1.5 max for all frequencies. Minimum attenuation is 10 db at 1 kmc and maximum insertion loss is 0.5 db. Average power is 10 w. The units can be supplied with a micrometer or shaft drive and measure 5 in. in diameter and 1 in. high.

Antenna & Radome Research Associates, Dept. ED, 27 Bond St., Westbury, L. I., N.Y.

Price: *$150.*

Frame-Grid RF Triode 455

For TV tuners

The Mullard EC97/6FY5 frame-grid rf triode for TV tuners has high gain and low noise characteristics. Other specs are: transconductance, 13,000 micromhos; amplification factor, 70; plate voltage, 135 v; heater current, 200 ma; and heater voltage, 6.3 v.

International Electronics Corp., Dept. ED, 81 Spring St., New York 12, N.Y.

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NEW PRODUCTS

Germanium Diodes 531

For airborne and missile equipment

Types 1N276 and 1N277 diodes are gold-bonded germanium units meeting Mil specs. They are of rugged construction and highly reliable for use in critical airborne equipment, space probes, satellites, missiles and high performance communications equipment.

Raytheon Co., Semiconductor Div., Dept. ED, 215 First Ave., Needham, Mass.

Relays 376

Switch more than 3 kv at 200 ma

These miniature, high-vacuum switching devices, called Mini-Vac relays, are able to switch more than 3 kv in air at 200 ma. Actuating coils are 24 v dc and operate in an ambient temperature of 125 C. The relay assemblies weigh 1 oz and withstand about 50 g of shock. Contact arrangements are spst, normally open; spst, normally closed; and spdt, normally closed.

Resitron Laboratories, Inc., Dept. ED, 2908 Nebraska Ave., Santa Monica, Calif.

***Price & Availability:** $25 to $34 ea; from stock.*

Silicon Rectifiers 653

Carry 100 amp

Specifications for these silicon power rectifiers, types ES-40 and ET-40, are: peak forward voltage, 1.2 v max at 100 amp; peak inverse current, 25 ma at 100 C case temperature; thermal drop, 1 C per w max from junction to case; temperature range, −35 to +150 C (case) and −35 to +150 (junction); mounting torque, 600 in.-lb (ES-40) and 900 in.-lb (ET-40) max; length, 5-9/16 in. (ES-40) and 4-7/8 in. (ET-40) max; piv, 100 v steps from 100 to 400 v.

Syntron Co., Rectifier Div., Dept. ED, 283 Lexington Ave., Homer City, Pa.

***Price & Availability:** Units, priced from $7.24 to $15.28 depending on quantity and piv, can be delivered 14 days after receipt of order.*

Tunnel Diodes 508

Rated at 20 amp

These tunnel diodes have peak currents in the range of 5 to 20 amp with peak-to-valley ratios of 5 to 10. The devices operate at high frequencies and are relatively insensitive to temperature changes and radiation damage. They have a low noise figure. Anticipated applications include high frequency oscillators and high voltage power supplies having very low voltage and high-current inputs.

Delco Radio Div., General Motors Corp., Dept. ED, Kokomo, Ind.

Tunable Oscillator Cavity 380

For use from 2650 to 3650 mc

Type 9127 S-band oscillator cavity is end-tuned in the range of 2650 to 3650 mc. Power output is 100 w, peak min. Output pulse risetime is less than 0.1 μsec. Temperature stability is ±0.1% from 0 to +71 C. The unit stands shock of 100 g for 3 msec and vibration of 15 g to 3000 cps. It weighs about 7 oz and measures 1 in. in diameter and 4.5 in. long.

Trak Electronics Co., Dept. ED, 48 Danbury Road, Wilton, Conn.

Price & Availability: *$97.50; made on order.*

Electronic Commutators 575

For severe missile environments

Designed for use in severe missile environments, the Series LS line of electronic commutators are low-level, all solid-state units. They contain up to 90 differential channels. The 30-channel unit weighs 2.5 oz and is less than 1 in. in volume per channel. The commutators can sample at a rate up to 10,000 per sec at an accuracy of 1% or better with full-scale input levels at 5 mv or greater.

General Devices, Inc., Dept. ED, P.O. Box 253, Princeton, N.J.

Availability: *Made on order only, delivered 45 days after order received.*

NEW PRODUCTS

Silicon Rectifiers 450

For military use

Types JAN-1N538 and JAN-1N540 are military versions of types 1N538 and 1N540 diffused-junction, silicon rectifiers. They are especially intended for use in power supplies of military equipment requiring rectifiers capable of operating at dc forward currents up to 750 ma over temperatures of −65 to +165 C.

Radio Corp. of America, Semiconductor & Materials Div., Dept. ED, Somerville, N.J.

DC Power Supplies 383

Outputs are 6, 12, 28, and 50 v

This line of power supplies includes units providing 6, 12, 28, and 50 v at currents from 1 to 25 amp. Typical of these units, model Q26-30-15M has an output of 26 to 30 v at 0 to 15 amp. Line regulation is 8 mv per 10% line change at 50% rated load; load regulation is 5 mv from no load to full load at a nominal 28-v setting. Ripple is less than 2 mv rms at full load. Transient response is less than 50 μsec. Input required is 105 to 125 v ac, single phase, at 50 to 440 cps. Dimensions are 5-1/4 x 19 x 14-7/8 in.

Universal Electronics Co., Dept. ED, 1720 22nd St., Santa Monica, Calif.

Variable Capacitor 400

Comes with capacitance to 200 pf

The VUS variable capacitor is furnished in a range of capacitances up to 200 pf. It was originally designed for multi-band signal generators and is suitable for uhf as well as vhf use. Precision ground glass balls are used to eliminate variations in current paths. Rotor contact is made through one silver-plated, spring-tempered, bronze contact spring.

The Hammarlund Manufacturing Co., Inc., Dept. ED, 460 W. 34th St., New York 1, N.Y.

Microwave Amplifier 387

S band, 10 w

This amplifier, model TA-568, has a frequency coverage of 2 to 4 kmc with a power output of 10 w min. Specs are: saturated power gain, 30 db; small signal gain, 30 db min; input impedance, 50 ohms; output impedance, 50 ohms; spurious modulation, 30 db below signal; power supply, 115 v, ac, single phase, 60 or 400 cps, 800 w; panel space, 21 x 14-1/4 x 24 in.; weight, 180 lb.

Menlo Park Engineering, Dept. ED, 711 Hamilton Ave., Menlo Park, Calif.

Wirewound Resistors 559

Rated from 1 ohm to 2.3 meg

Rated from 1 ohm to 2.3 meg, these precision wirewound resistors measure 1/16 in. in OD and 1/4 in. long to 1/2 in. in OD and 1/5 in. long. Fully encapsulated, they are built with nickel-chrome resistor elements and all-nickel leads. The impregnating material is glass epoxy having a temperature rating of 150 C. Units can be used in missile communications equipment and in transistor applications.

The Hanjohn Co., Inc., Dept. ED, 2711 E. Foothill Blvd., Pasadena, Calif.

Price & Availability: *$1 to $11; one to two weeks.*

Dual Output Silver-Zinc Battery 406

Has precise voltage regulation

Model P82A dual battery has two sections; one provides a current of 25 amp at 28 v with a capacity of 1.7 amp-hr; the second supplies 28 v at 46 amp. Its capacity is 3 amp-hr. Activation time is 1 sec; signal required is 2 amp at 28 v. The battery measures 5 x 5 x 10.5 in. and weighs 12 lb. It withstands 50 g shock, 10 g acceleration and vibration to 30 g.

Cook Batteries, Dept. ED, 3850 Olive St., Denver 7, Colo.

Microminiature Amplifiers 570

Built by vacuum deposition

These microminiature amplifiers are built by vacuum depositing, simultaneously, all inter-connectors, resistors and capacitors and inserting active elements such as diodes and transistors to form a monolithic structure as small as 3/8-in. square by 1/16-in. thick. Existing circuits and ideas of current design can be produced as miniature plug-in modules.

Halex, Inc., Dept. ED, 310 E. Imperial Highway, El Segundo, Calif.

Coaxial Couplers 403

Broadband, bidirectional

These coaxial broadband, bi-directional couplers measures vswr by the incident and reflected power technique, make power and frequency measurements, and serve as standards of attenuation. The frequency range is 0.25 to 1 kmc for model N 616D and 1 to 4 kmc for model N617D. The nominal coupling value of 20 db includes the effect of low reflection terminations in the secondary arms and reflection from the connectors. Main line vswr is less than 1.02 and the auxiliary arm vswr is less than 1.25, including the termination.

FXR, Inc., Dept. ED, 25-26 50th St., Woodside 77, N. Y.

Photo Diodes 394

Bi-planar type

The FW series photo diodes are bi-planar and are linear from 10^{-9} amp to 25 amp. The use of appropriate scintillator phosphors makes the series suitable for providing qualitative as well as quantitative detection of most types of short burst radiation. The units measure from 1.5 in. in diameter and 1.5 in. in length to 7 in. in diameter and 3 in. in length. In the 2.5-in. type, the dark current output is about one billionth of 1 amp with the anode at 2,500 v. The tube is linear to 25 amp.

ITT Laboratories, Components and Instrumentation Laboratory, Dept. ED, Fort Wayne, Ind.

Price & Availability: *Prices are $135 for the 2.5-in. unit, $185 for the 1.25-in. unit, and $250 for the 5-in. unit. Delivery time is 30 days.*

Modular Microwave Components 396

For breadboard and prototype designs

These standard kits of modular microwave components are available as a design tool for breadboard and prototype work using the firm's Tri-Plate strip transmission line. The kits range in size, variety of components, and number of components; they are for the L-, S- and C-Band, and uhf. In addition, Circuit-Mated kits are furnished to specifications of any circuit, for specified modifications of that circuit, or for several circuits.

Sanders Associates, Inc., Dept. ED, 95 Canal St., Nashua, N.H.

Price & Availability: *Available from stock; price ranges from $645 for the basic lab kit to $2,190 for the largest size standard kit.*

Computer 460

High-speed type

The 7074 computer is claimed to be 20 times as fast in scientific computation as the 7070 system. Building block design is used; existing models of the 7070 can be converted to 7074 systems. Sizes with 5,000 or 9,900 words of storage can be furnished. Processing speeds, in operations per sec, are: addition or subtraction of six digits, 100,000; multiplication of ten digits times five digits, 23,250; division with a five-digit quotient, 14,280; and logical decisions, 250,000.

International Business Machines Corp., Data Processing Div., Dept. ED, 112 E. Post Road, White Plains, N.Y.

Price: *Typically $1,284,350. Rental: $29,300 per month.*

NEW PRODUCTS

Direct Writing Oscillograph 526

For low and medium-gain applications

The Type RD Dynograph is a direct writing oscillograph designed for low and medium-gain applications. The instrument, transistorized, has a sensitivity from 10 mv to 100 v per cm. Drift is 0.2 mv max; frequency response is beyond 200 cps. The unit is intended for systems and telemetering applications, and is available for rack mounting.

Offner Electronics, Inc., Dept. ED, 3900 River Road, Schiller Park, Ill.

Servo System Analyzers 727

For lab and production use

Series 400 controls analyzers provide all necessary functions for determining the response characteristics in dc and carrier-modulated feedback control systems. The instruments are designed for laboratory and production use. Three models are offered, covering frequency ranges of 0.3 to 20 cps, 0.003 to 30 cps, and 0.02 to 200 cps. All models provide test signals to 1 w at 10 v and may be used with carrier frequencies of 50, 60, 400, 800, and 5000 cps.

Superior Manufacturing & Instrument Corp., Dept. ED, 154-01 Barclay Ave., Flushing 55, N.Y.

Silver-Zinc Battery 683

Designed for missile applications

Model P-1542 silver-zinc battery is designed for missile applications. It is automatically activated and weighs 4.25 lb, including case, heaters and activation mechanism. The 19-cell unit is 2.75 in. high, 5.07 in. wide and 6 in. long. Rated at 1 amp-hr, the unit can be discharged at 15 amp for 3 min. It has an open-circuit voltage of between 33 and 25 v and an operating voltage range of 26 to 33 v. Having a minimum dry shelf life of 5 yr, its operating temperature range is —35 to +165 F and its storage temperature range is —65 to +165 F.

Yardney Electric Corp., Dept. ED, 40-50 Leonard St., New York, N.Y.

Phase Meter 670

Has 15 to 1,500 mc range

Type 205B3 visual detector measures phase or time delay from 15 to 1,500 mc with an accuracy of 0.05 deg or 1%. Resolution time is less than 0.01 μμsec. Time delay is continuously adjustable from .0 to 37.5 nsec. Characteristic impedance is 50 ohms. The attenuation is 0.02 db at 100 mc, 0.05 db at 200 mc, and 0.07 db at 1,000 mc.

Ad-Yu Electronics Laboratory, Inc., Dept. ED, 249-259 Terhune Ave., Passaic, N.J.

Carbon Potentiometers 507

Push-push and push-pull switch types available

These push-push and push-pull switch type potentiometers are designed for use in radio, television, high-fidelity and stereo applications. They are produced in single, dual or twin types, are rated at 1/2 w, and are 15/16 in. in diameter. Depth of push-pull units is 13/16 in., and push-push is 27/32 in. Breakdown is 900 v ac rms. Switches are 3 amp spst, 125 v ac. The units are available in a variety of tapers and resistances from 2500 ohms to 5 meg.

Globe Union, Inc., Centralab Electronics Div., 900 E. Keefe Ave., Milwaukee 1, Wis.

Harmonic Generators 736

With solid-state elements

Ten harmonic generators incorporating solid-state elements provide generation of second, third, fourth, and fifth harmonics ranging from the L-band to the V-band. When high-voltage varactors are used, a harmonic power of 100 to 150 mw has been generated at the third harmonic in the region of 6 kmc with a conversion loss of 8 to 10 db.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.

NEW PRODUCTS

Scan-Conversion Tube 619

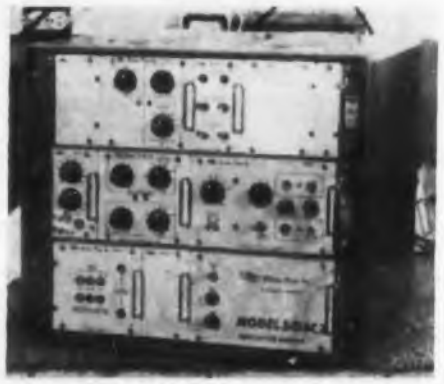
For large-screen radar display

This tube, Type 7539, converts a standard radar scan signal into a TV picture signal suitable for display on a large screen in a bright room. Resolution is 150 range rings per display radius with a response of 50% or better. To utilize this resolution fully, the TV monitor system must have a resolution of over 1,000 lines. The tube is about 26 in. long and has a maximum diameter of 3-1/2 in.

Radio Corp. of America, Dept. ED, 30 Rockefeller Plaza, New York 20, N.Y.

Pulse Generators 625

Fast rise time



Models 3450C/Y and 3450C/X (illustrated) pulse generators are extensions of the Model 3450C. Model 3450C/Y provides two simultaneous pulses similar to flip-flop plate outputs. Repetition rate is variable from 2 cps to 1 mc, pulse delay from 0 to 10,000 μsec and pulse width from 0.1 μsec to 1 sec. Rise time is 0.02 μsec at 100 ohms. Open circuit amplitude is 10 v from 100 ohms, or 45 v from 470 ohms. Model 3450C/X supplies pulse pairs and pulse trains suitable for telemetering, missile guidance coding and time measurement studies. Output is 50 v into 50 ohms at 0.015 μsec rise time. Repetition rate is variable to 1 mc. Pair delays are variable from 0.1 μsec to 1 sec, separation from 0.5 μsec to 1 sec. Train separation and duration is variable from 0.02 μsec to 1 sec.

Electro-Pulse, Inc., Dept. ED, 11861 Teale St., Culver City, Calif.

Price & Availability: *Model 3450C/Y is priced at $840; and Model 3450C/X at $1480. Delivery is 60 days.*

New MICRO SWITCH Synchronized One-Shot switch circuit assemblies save engineering time and equipment rack space

New Synchronized One-Shot push-button switch circuit assemblies for use in pulse and digital systems save design time required to develop flip-flop and gating networks.

The new MICRO SWITCH "1PB700" series assemblies have a special electronic circuit that generates a single square wave output pulse in synchronism with an external clock pulse with each operation of the push button. They can be used with clock pulse frequencies from 4 kc to 500 kc.

The electronic circuit is an integral part of the push-button switch, resulting in a saving of equipment rack space. All circuit components are sealed in resilient potting material to insure protection from physical damage.

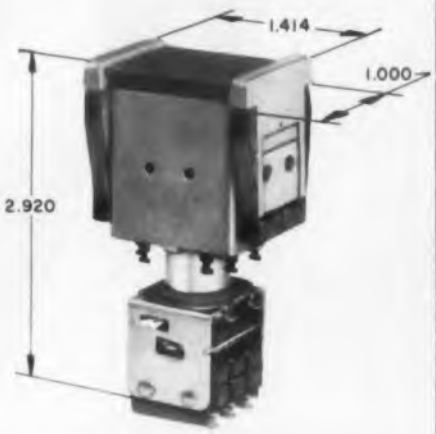
Three assemblies in the new series are patterned to fit a wide variety of d-c supply voltages and clock pulse rise times, voltages and frequencies. They can be applied to manual loading of magnetic drums, setting and resetting flip-flops, and checking ring counters. Ask for Data Sheet 172.

MICRO SWITCH modular lighted push-button switches can be customized for complete design flexibility

Give your control panel the finest in styling with the customizing that will precisely fit your control and display functions.

MICRO SWITCH "Series 2" lighted push-button switch modules simply snap together to match your styling requirements, then snap into slots in the mounting panel—all without tools. They perform both control and indicator jobs to save panel space.

Select from 48 different units and 16 mounting barriers. Forty color display screens include lateral and longitudinal divisions. Available as operator-indicator switch units or indicator units only. Ask for Catalog 67.



MICRO SWITCH precision toggle switches offer you the exact control arrangements you need

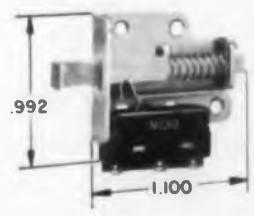
MICRO SWITCH manufactures hundreds of different toggle switches and toggle switch assemblies. They are available with 2 or 3 operating positions, 1 or 3-hole mounting and a variety of circuitry and electrical ratings. All have enclosed type contacts. Ask for Catalog 73.

A new "400" Series Toggle Switch is now available with a paddle-shaped tab which can be numbered or color-coded as an indicator.

MICRO SWITCH door interlock switches assure maximum safety during maintenance

MICRO SWITCH door interlock switches are installed on high voltage cabinets to automatically cut the power circuit when the cabinet door is opened for repairs or testing.

Safety position adds protection against "tying down" or wiring around a conventional switch which might be forgotten after service is completed. By manually pulling the plunger out to the maintained-contact position, you close circuit for checking. When door is closed, plunger automatically returns to normal operating position. Ask for Catalog 63.



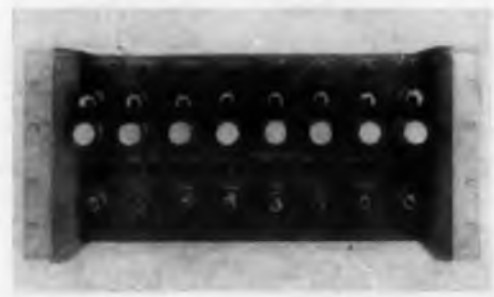
MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

H HONEYWELL **Honeywell**
MICRO SWITCH Precision Switches

CIRCLE 83 ON READER SERVICE CARD

Video Distribution Amplifiers 618

Of modular construction



This series of plug-in and rack-mounted modular amplifiers is intended for color and black-and-white video distribution. The Type VA-P-101 amplifier is a one-input, one-output, unity-gain unit. Type VA-P-102 plugs into any of these amplifiers when sync-adding is required. Type VA-P-103 amplifier is a one-input, one-output unit with a gain of 3 db, intended to recover the signal loss of standard equalizers. The VA-P-201 is a multiple-output amplifier which simultaneously feeds three identical signals to several different points. Eight VA-P-101 or -103 amplifiers occupy 8-3/4 in. of shelf space.

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

Price & Availability: *The VA-P-101 is $79.50, and the VA-P-103 is $88.50 in quantities less than 25. Delivery is from stock.*

Wideband RF Transformer 608

Covers 1.5 to 130 mc

The Type 1214 wideband rf transformer covers a frequency range of 1.5 to 130 mc. Impedance ratio is 75 ohms, unbalanced, to 600 ohms, balanced. The unit will handle 1 w. It is hermetically sealed and has a single 4-40 stud mounting. The case, nickel-plated, measures 5/8 in. OD by 5/8 in. long. The transformer is designed for low-insertion loss and good matching characteristics over a wide frequency range. Applications include antenna matching, interstage coupling, impedance matching, computer drive circuits, pulse applications, voltage step-up and dc isolation.

North Hills Electronics, Inc., Dept. ED, Glen Cove, L.I., N.Y.

Price & Availability: *These units are carried in stock and are priced at $14.95 to $7.95 depending on quantity.*

NEW PRODUCTS

Planar Diodes 462

Switching time is 0.3 μsec max

These Planar diodes have a switching time of 0.3 μsec max. Other specifications include: conductance, 150 ma at 1 v; breakdown voltage, up to 250 v; and capacitance, typically 3.5 pf. Designated types 1N840, 1N837A, 1N841, 1N842, and 1N843, the units have working inverse voltage ratings of 40, 80, 120, 160, and 200 v, respectively.

Fairchild Semiconductor Corp., Dept. ED, 4300 Redwood Highway, San Rafael, Calif.
Availability: *Immediate.*

Dc Power Supplies 558

Output is 0 to 40 v at 0 to 500 ma

Model 865 regulated power supplies have an output continuously variable from 0 to 40 v at any current from 0 to 500 ma. The units can be connected in series or parallel for higher voltage or current applications. Line or load regulation is less than 5 mv; ripple is below 500 μv. Line input is 105 to 125 v, at 50 to 440 cps. They measure 8 x 5 x 8 in.

Harrison Laboratories, Inc., Dept. ED, 45 Industrial Road, Berkeley Heights, N. J.
Price: *$185.*

Transistorized Power Supplies 551

For strain gages

These transistorized power supplies for strain gages have continuously variable outputs ranging from 0 to 30 v and 0 to 200 ma. Input is 117 v, 60 cps. The noise level across a grounded 350-ohm bridge is held to 1 μv peak-to-peak. Line voltage regulation is held constant within 0.03% and load regulation within 0.03%. Output ripple is 0.5 mv peak-to-peak or less.

Computer Engineering Associates, Inc., Dept. ED, 350 N. Halstead, Pasadena, Calif.

◀ CIRCLE 84 ON READER-SERVICE CARD

Filters 393

Meet Mil specs

Offered in 16 different types, these filters meet MIL-F-18327A. There are eight telemetering bandpass filters in the group, as well as 90- and 150-cps glide slope indicator filters. High, low, bandpass, and discriminator filters are also included.

Chicago Standard Transformer Corp., Dept. ED, 3501 W. Addison St., Chicago 18, Ill.

Price & Availability: $15 to $90 ea; four-week delivery.

Electronic Multiplier Console 424

Uses solid-state devices

Model C404-13 diode electronic multiplier console uses solid-state devices in multiplier shaping networks. It is a self-contained unit, which incorporates eight channels of multiplication, eight A400-1 dc computing amplifiers, a power supply, and a metering panel. Designed for standard rack mounting, the unit is housed in a 7-ft high cabinet and can be expanded to a total of 16 channels of multiplication. It has a static multiplication accuracy of 0.125% that can be increased to 0.05%. Maximum amplitude error is 0.5% at 100 cps.

Reeves Instrument Corp., Dept. ED, Garden City, N.Y.

Instrument Counters 686

Are 1/2-in. wheel type

The S series 1/2-in. wheel counters are for use in missile tracking devices, radar equipment, navigation instruments, and computers. Standard models are offered in 3-, 4-, and 5-figure instruments. The units are rated at a speed of 2,000 rpm and tabulate 10 counts with each revolution. They stand temperatures from −60 to +85 C.

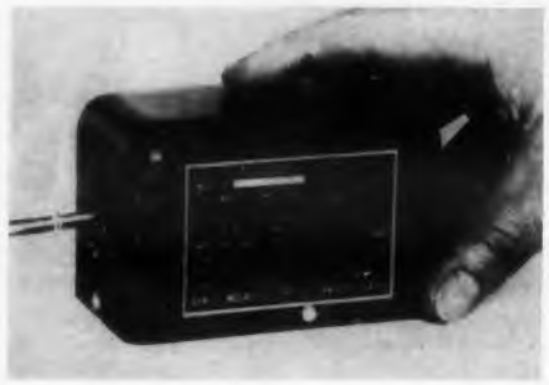
Durant Manufacturing Co., Dept. ED, 1993 N. Buffum St., Milwaukee 7, Wis.

CIRCLE 85 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Solid-State Inverter 602

Converts dc to 400 cps ac



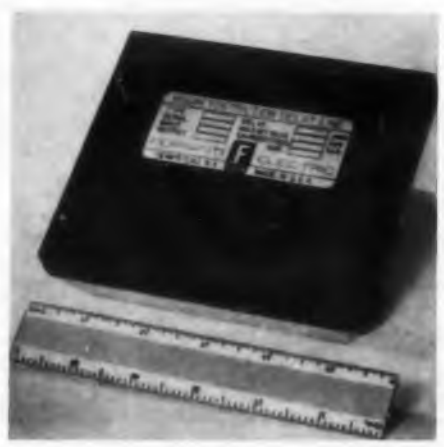
Model KB transistorized inverter will deliver up to 55 va, 400 cps from a 28-v battery source. Output is in sine-wave form with less than 2% harmonic distortion. Both frequency and voltage are stable with variations of power factor from 0.1 to 1, and temperature changes from —55 to +71 C, no-load to full-load. These modular units measure 2-1/2 x 4 x 2-1/2 in. The inverter is encapsuled in moisture-resistant thermosetting foam, and is hermetically sealed. It meets MIL-E-5272C specifications for moisture, shock and vibration.

Arnold Magnetics Corp., Dept. ED, 6050 W. Jefferson Blvd., Los Angeles 16, Calif.

***Availability:** Units are available from stock.*

Magnetostriction Delay Line 615

Low temperature coefficient



The Type 5912 delay line is designed for military or industrial use where severe environments may be encountered. Suitable for digital storage applications, it has a capacity of over 2000 bits at a 1-mc (RZ) digit rate or 4000 bits at 2 mc (NRZ). The miniature units can be supplied with a temperature coefficient of delay of 0.5 ppm per deg C.

Ferranti Electric, Inc., Dept. ED, 95 Madison Ave., Hempstead, L.I., N.Y.

***Availability:** The units, made to order, can be delivered in 60 days.*

Epoxy Laminate 414

For the plated-through process

Grade EG-761-T Micaply epoxy laminate, developed primarily for the plated-through process, is non-adhesive and has no significant weave telegraph. Its smooth surface provides a more uniform bond with the plating material. The laminate meets or exceeds the requirements of existing military and commercial, specs for G-10 or GEE epoxy glass laminates.

The Mica Corp., Dept. ED, 4031 Elenda St., Culver City, Calif.

Availability: *Standard thicknesses are furnished from stock.*

Coolant Circulating Unit 408

For electronic equipment

Model 101-123 coolant circulating unit is designed for operating conditions in airborne-type applications. The unit has a continuous duty life expectancy valve of 2,000 hr and operates in the ambient temperature range of —65 to +185 F. Its over-all weight is 22.5 lb. It meets MIL-M-7969A, MIL-1-618B, MIL-T-5422D, and MIL-E-5400B.

Great Lakes Manufacturing Corp., Dept. ED, 4223 Monticello Blvd., Cleveland, Ohio.

Telemetry Preamplifier 411

Gain is 26 db

Type TP-5 telemetry preamplifier provides a gain of 26 db and a nominal noise figure of 3.5 db over the passband of 215 to 260 mc. An integral power supply provides regulated heater voltage. Entire assembly requires a mounting space of 6.5 x 6.5 x 6 in. and weighs 6 lb.

Lel, Inc., Dept. ED, 380 Oak St., Copiague, L. I., N. Y.

Price & Availability: *$995 ea; delivery will be from stock in September.*

CIRCLE 88 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Motor Tach Generator 685

Temperature range is −55 to +125 C

For use from −55 to +125 C, type 6252-03 size 11 motor tach generator for damping in position servo and similar applications, meets MIL-E-17087 and MIL-E-5272. Housed in stainless steel, the unit weighs 7 oz. The motor has a 6,000-rpm no load speed, 6 oz-in. torque at stall and 25 C, and a rotor moment of inertia of 1.3 gm-cm². Stall power is 3.5 w per phase and impedance at stall is 120 + j1780 = 2175 ohms.

John Oster Manufacturing Co., Dept. ED, 1 Main St., Racine, Wis.

Antennas 409

Have 20:1 bandwidths

Having 20:1 bandwidths, these antennas are offered in two types. Model 750 direct-finding antenna provides a wide band with medium-gain performance characteristics, 60 deg of beam widths from 50 to 1,000 mc, and a vswr of 2.5:1. Impedance is 50 ohms. Linear, vertical, or horizontal polarization may be remotely selected. Designed for mounting on a 36-in. guyed mast, the antenna is provided with a 360-deg azimuth drive at 2 rpm with left-stop-right controls and position indication. Model 721 log-periodic array for non-frequency sensitive broad band performance and complete azimuth coverage, has a vswr under 3.6:1, relative to 50 ohms over the band.

Granger Associates, Dept. ED, 974 Commercial Street, Palo Alto, Calif.

Environmental Test Rooms 419

Provide temperatures to 140 F

These walk-in environmental test rooms provide temperature ranges of 0 to 140 F and ambient temperatures to 140 F. Accuracy is maintained to within ±1 F. The construction eliminates all interior ducts and louvres. Dimensions are 6 x 6 ft, 6 x 8 ft, 6 x 10 ft, and 6 x 12 ft; inside working height is 7 ft. Other sizes can be made to special requirements. All models have a 12 x 12 in. viewing window.

Labline, Inc., Dept. ED, 3070-82 W. Grand Ave., Chicago 22, Ill.
Price & Availability: *$1,900 to $6,000; stock delivery.*

Precision Potentiometers 568

Linearity is 0.08% to 0.5%

These precision potentiometers have linearities ranging from 0.08% to 0.5% and operate over the temperature range of −65 to +200 C. They come in resistances of 100 to 400 K. Power rating is 5.25 to 21 w. All units derate to 0 w at 200 C. Designed for servo equipment, they have applications in computers, recorders, and instruments. The environmental testing of these units exceeds standard testing requirements; customers are provided with failure-rate data.

Osborne Electronic Sales Corp., Dept. ED, 13105 Crenshaw Blvd., Hawthorne, Calif.
Price & Availability: *For a single-turn unit, $35 and down. Delivery on standard models in three weeks.*

Ratio Detector 425

Increases audio recovery

Model DM-1 crystal ratio detector modifies wide band communications receivers to receive narrow (±5 kc) transmissions. Able to replace standard ratio detector transformers, it fits in a chassis cutout. The unit was designed primarily for the firm's MR-10, MRC-10, MR-33 units, but will improve the audio output in any wide band receiver using 10.7-mc ratio detector circuitry.

I. D. E. A., Inc., Dept. ED, 7000 Pendleton Pike, Indianapolis 26, Ind.
Price: *$9.95.*

Audio Oscillator 426

Provides sine and square waves

Model 605 audio oscillator provides both sine and square wave outputs for checking hi-fi, stereo, and audio-amplifier response. The output is continuously variable. Frequency range is 20 to 200,000 cps in four ranges. Accuracy is 3% or 1 cps. The sine-wave output voltage is 0 to 5 v rms and square-wave output voltage is 20 mv to 7 v peak-to-peak. Power requirements are 50 w, 110 to 120 v at 50 or 60 cps.

Jackson Electrical Instrument Co., Dept. ED, 124 McDonough St., Dayton, Ohio.

Price & Availability: *$129.95; stock to two weeks.*

Silicon Tunnel Diodes 566

Come in 14 types

This line of extended-range tunnel diodes consists of 14 units, designated types 1N2928 through 1N2934. Included are types exhibiting peak currents above and below the 1 to 22 ma range. Peak currents range from 470 μa to 100 ma. Standard units have a peak current tolerance of ±10%; other units can be furnished with a tolerance of ±2%. Temperature range is −85 to +200 C. The JEDEC TO-18 packages are used.

Hoffman Electronics Corp., Dept. ED, 3761 S. Hill St., Los Angeles, Calif.

Price: *$12.50 to $19 in quantities of 1 to 99 for standard units; $17.50 to $26.60 for others. Custom engineered units can also be furnished.*

Pressure Controller 577

Weighs 2 lb

Model 56A pressure controller consists of a transistorized servo amplifier measuring 7 x 3 x 5 in., weighing 2 lb, and requiring 3.5 w of input power at 115 v, 60 cps, single-phase. The controller incorporates a dc amplifier with an input impedance of 250 to 10 K and an adjustable voltage gain of 0.5 to 20, with an output current of ±4 ma into a 2-K load. The amplifier can drive electrohydraulic servo valves in military and industrial applications.

Micro Gee Products, Inc., Dept. ED, P.O. Box 1005, 6319 W. Slauson Ave., Culver City, Calif.

Price & Availability: *Price is $250 ea; delivery time is 30 days.*

Silicon Rectifiers 431

Operate at 150 C

The Series 1R double-diffused silicon rectifier stacks operate at 150 C ambient temperatures. The units deliver up to 2.5 amp dc, for half-wave circuits, up to 12.5 amp for full-wave circuits. PIV is in 50 v multiples. The stacks may be mounted in any position and are completely assembled for wiring directly into circuits.

Trans-Sil Corp., Dept. ED, 55 Honeck St., Englewood, N.J.

Price & Availability: *Units are priced at from $3 to $50 depending on voltage and type of circuit; delivery is in 10 days.*

Tunnel Diodes 557

Gallium-arsenide type

These gallium-arsenide tunnel diodes are offered in several different types. Type 1N3114 has a peak-point current of 2.2 ma held to ±10% type 1N3115 has the same peak current held to ±2.5%. Type 1N3116 has a peak current of 4.7 ma held to ±10%; type 1N3117, 4.7 ma controlled to ±2.5%; type 1N3118, 10 ma held to ±10%, type 1N3119, 10 ma held to ±2.5%, and 1N3120, 22 ma, help to ±10%. The units have a peak-to-valley ratio of 15 and a voltage swing of 1 v.

General Electric Co., Semiconductor Products Div., Dept. ED, Charles Building, Liverpool, N. Y.

Price & Availability: *Types 1N3118 and 1N3120, $4.50 and $6; other units, $7.50 to $18 (for original equipment manufacturers). Delivery is immediate.*

NEW PRODUCTS

Voltage Reference Standard 614

For printed-circuit insertion

These miniaturized voltage reference standards are made for printed-circuit insertion. Operating directly from an unregulated dc power source, output voltages of 5.8, 8.5 or 10.5 v dc ±5% are provided with a regulation of ±0.005% for a dc input variation of ±10%. Temperature coefficient is ±0.0005% per deg C from 0 through 60 C. The units measure 1-9/16 x 1-9/16 x 3/8 in. and mount on printed-circuit boards with standard 1/2-in. spacing.

Viking Industries, Inc., Dept. ED, 21343 Roscoe Blvd., Canoga Park, Calif.

Price & Availability: *Price range is $60.00 Delivery is 1 to 3 weeks.*

Silicon Rectifiers 612

Deliver 1.5 amp

Series 1A double-diffused silicon stack rectifiers, which will deliver up to 1.5 amp dc half-wave, have a piv of several thousand volts and will deliver up to 9 amp, full wave. The hermetically sealed, solid-stack cells can be used at an ambient of 150 C. Melamine insulation is used throughout. They are available in bridge and center-tap assemblies and are delivered completely assembled for wiring directly into the circuit.

Trans-Sil Corp., Dept. ED, 55 Honeck St., Englewood, N.J.

Price & Availability: *Units are priced from $2.00 to $50.00 depending on voltage capacity and type of circuit; delivery is within 10 days.*

Constant Mass Fan 395

For cooling electronic equipment

This fan and motor, coupled by means of a constant torque magnetic device, provide an essentially constant mass rate of air flow over the operational altitude range of the cooling equipment on which the assembly is used. The coupling permits the fan speed to vary directly with altitude or inversely with the square root of the relative density of the air being handled. The load-half of the coupling operates at variable speed ranging from 20% to 100% of motor speed.

Eastern Industries, Inc., Dept. ED, 100 Skiff St., Hamden 14, Conn.

Dielectric Strength Tester 427

Output to 5,000 v dc

Designated D-C Hypot Jr., these dielectric strength testers, designed for production and field testing of insulation, have continuously variable output ranges of 0 to 1,500, 0 to 2,500 and 0 to 5,000 v dc. Output current is 2 ma at full voltage and 15 ma on short circuits. Arcing, corona and insulation breakdown is indicated by an indicating light. Units weight 20 lb.

Associated Research, Inc., Dept. ED, 3777 W. Belmont Ave., Chicago 18, Ill.

Price: Prices begin at $285.

1,000-Mc Oscilloscope 389

Uses distributed deflection crt

The model 519 oscilloscope is designed for dc to 1,000-mc operation. Utilizing a distributed deflection crt, the instrument has a rise time of 0.35 nsec, linear sweeps to 2 nsec per cm, sweep delay to 30 nsec. The device has a 2 x 6 cm viewing area. Vertical sensitivity is 10 v per cm.

Tektronix, Inc., Dept. ED, P.O. Box 831, Portland 7, Ore.

Availability: The oscilloscope is soon to go into production.

CIRCLE 93 ON READER-SERVICE CARD ➤

NEW PRODUCTS

High-Power TR Tubes 613

Cover UHF to S-band

Series T48U folded cylindrical TR tubes, for high average power applications, are available in a wide variety of sizes and in 7052, 707, Pyrex or quartz. Having been successfully tested in air-cooled duplexers at over 100-kw average power, the tubes are designed to cover the uhf to S-band range.

Tucor, Inc., Dept. ED, 18 Marshall St., South Norwalk, Conn.

Availability: *Delivery is stock to 30 days depending on type.*

Servo Analyzers 606

Frequency accuracy is 2%

Model 150A covers the frequency range of 0.1 to 60 cps, and Model 150B covers 0.001 to 60 cps. The analyzers provide sine, square and modulated carrier output signals. A 100:1 attenuator is included. The analyzers will accept carrier frequencies from 50 to 5000 cps and have an internal source of 5000 cps. The phase of the output signal can be varied over ±180 deg. Frequency accuracy is 2%.

Aetna Electronics Corp., Dept. ED, Readington Road, North Branch, N.J.

Price: *Price of 150A is $1470; 150B is $1775.*

High-Speed Calculator 356

Solid-state circuitry

The IBM 609 is a solid-state punched card calculator for accounting, control and engineering

CIRCLE 95 ON READER-SERVICE CARD ➤

applications. Input, calculation, storage and output are combined in a 60-in. long, 29-in. wide, 50-in. high unit. No air-conditioning or special power lines are required. Programing is by means of interchangeable control panels. The machine has 80 non-sequential program steps, increasable to 144, each capable of three separate operations. 240 positions of magnetic core storage are available, increasable to 384 positions.

International Business Machines Corp., Data Processing Div., Dept. ED, 112 E. Post Road, White Plains, N. Y.

Price: The calculator rents for $1,175 per month. Selling price is $55,500.

Square Wave Generator 605

Range is 0.8 cps to 80 kc

The Model P-35 generator has an output of 0.8 cps to 80 kc, square wave, and 0 to 25 v, peak-to-peak. The baseline, monitored by a voltmeter, is continuously adjustable from 0 to ±25 v dc. The load impedance is never less than 1,000 ohms, and internal impedance is less than 80 ohms. The unit is 7-in. high.

Alto Scientific Co., Inc., Dept. ED, 855 Commercial St., Palo Alto, Calif.

Price: The instrument is priced at $2100 for quantities 1 to 4 and at $1900 for 5 to 9.

IF Transistors 397

Rated at —70 v emitter-to-collector

Two double-diffused mesa transistors, 2N1196 and 2N1197, have power gains of 28 db at 4.3 mc and 22 db at 12.5 mc, respectively. Typical cut-off frequencies at 45 mc and 55 mc. They operate at temperatures from —65 to +200 C. Specifications for both units are: collector-to-emitter and collector-to-base voltage, —70 v max; emitter-to-base voltage, —4 v; power dissipation, 350 mw max; power derating, 2.0 mw per C. Typical collector cut-off current is 0.005 μa. Enclosed in gold-plated TO-5 packages, the transistors meet MIL-S-19500B specifications.

Hughes Aircraft Co., Semiconductor Div., Marketing Dept., Dept. ED, Newport Beach, Calif.

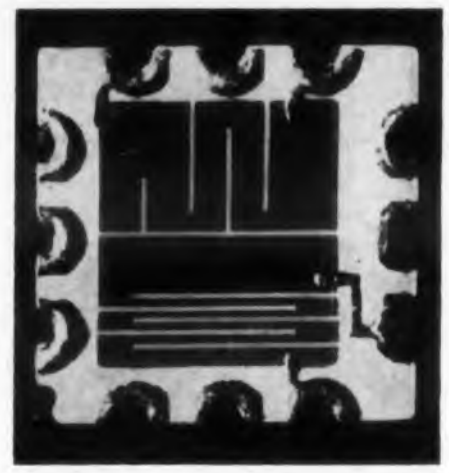
Price & Availability: Quantities of 100 or less, $21.80 for the 2N1196 and $23.40 for the 2N1197. Immediate delivery is available for both types.

CIRCLE 95 ON READER-SERVICE CARD

NEW PRODUCTS

Metal Film Resistor 544

Density is 600,000 parts per cu ft



Packaging density of these resistor elements is 600,000 parts per cu ft. They utilize thin ceramic wafers 0.3-in. square by 0.10-in. thick. As many as four resistors can be provided on a single wafer. The wafer carries a series of metallized notches on its periphery called lands which act as terminals and serve to locate the wave in its module assembly.

Ohmite Manufacturing Co., Dept. ED, 3669 Howard St., Skokie, Ill.

Signal Meter 525

Provides maximum-level readings

Combining a meter-relay movement and special circuitry, this signal meter shows the highest level reached by an electrical signal. Until reset, an adjustable pointer remains at the maximum signal. The other pointer provides continuous signal indication. Ranges are 0 to 10 μa to 0 to 50 amp or 0 to 5 mv to 0 to 500 v, ac or dc. By using an extra transformer, ac ranges above 50 amp can be obtained. Cases are 2.5-in. round or 4.25-in. rectangular.

Assembly Products Inc., Dept. ED, 75 Wilson Mills Road, Chesterland, Ohio.

Price & Availability: *Under $100; 30-day delivery.*

Pressure Transducer 420

Incorporates a Bourdon tube

This miniature, pressure transducer incorporates a Bourdon tube with a 3/16-in. radius and a 0.0015-in. deflection at full load rating. The transducer is provided with an adjustable preload which changes the initial tension on the cell. Units are supplied in various materials such as brass and stainless steel and have Nylon caps.

Clark Electronic Laboratories, Dept. ED, Box 165, Palm Springs, Calif.

Price: $75 to $85.

Silicon Mesa Diodes 552

For microwave applications

These two series of microminiature silicon mesa diodes have microwave applications. The D-4140 Series is 0.105 in. in diameter by 0.235 in. in length and axial mounting studs. The D14141 series is 0.125 in. in diameter by 0.125 in. in length and has flange type end caps. Both are electrically similar to the D-4075 series and are capable of operation up to 100 C, with cut-off frequencies up to 70 kmc.

Sylvania Electric Products Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.

Price & Availability: Priced from $50 to $100 ea; sample quantities from stock.

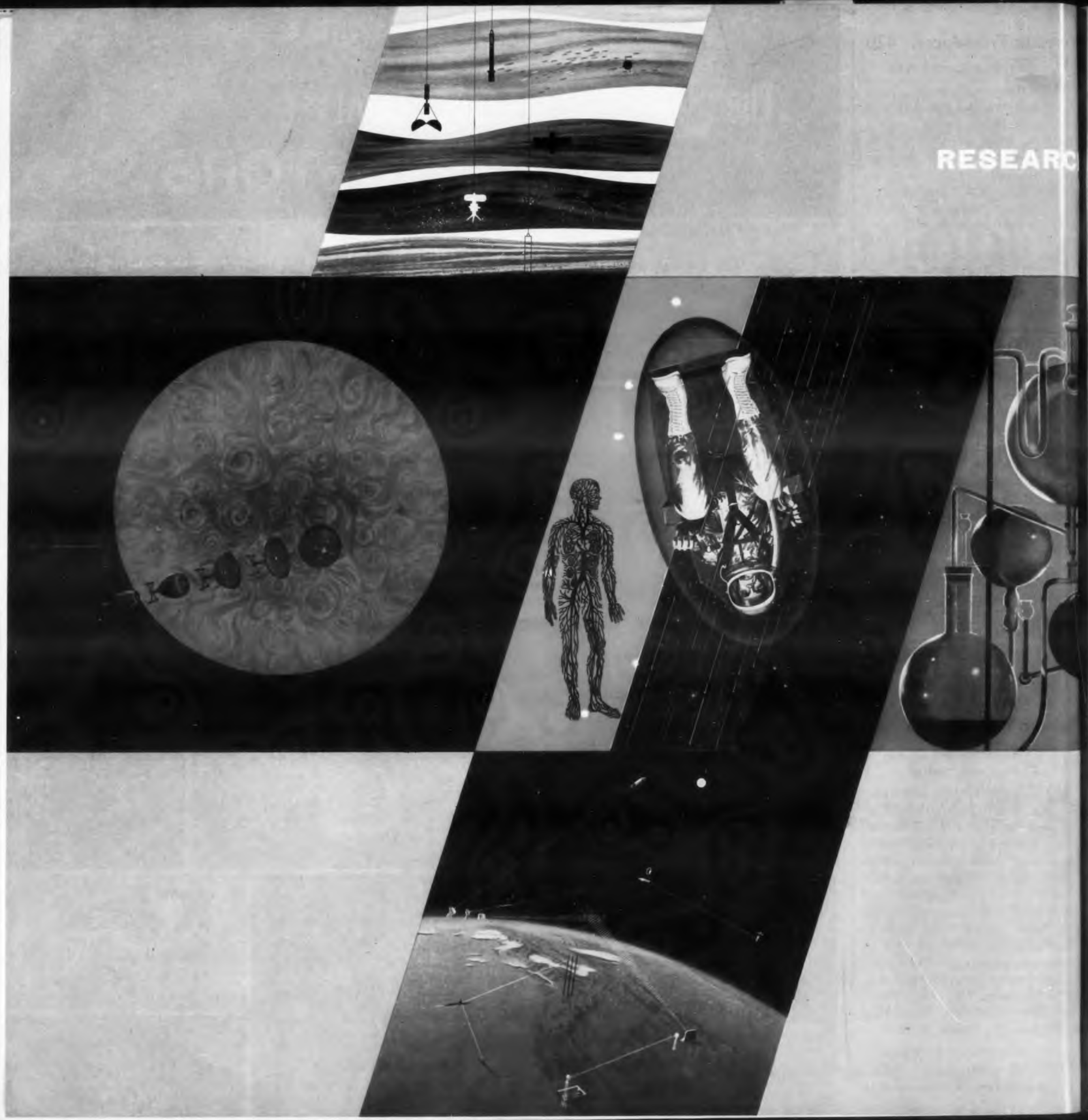
Synchro-Pulse Step Motor System 571

Bi-directional control

The bi-directional Syncro-Pulse step motor is normally furnished complete with a combination dc power supply and solid-state and a completely transistorized control circuit which has separate inputs for forward and reverse pulse signals. The control system will accept sine wave, square wave, or triggered pulse inputs as low as 6 v, peak. It operates at pulse frequencies up to 300 pulses per sec.

Wiesner-Rapp Co., Inc., Farnham Electronics Div., Dept. ED, 1600 Seneca St., Buffalo 10, N. Y.

CIRCLE 99 ON READER-SERVICE CARD ➤


RESEARC AN

RC AND DEVELOPMENT AT LOCKHEED

...is setting the pace in space for years ahead

Lockheed Missiles and Space Division's progress transcends even that of an era marked by phenomenal scientific growth. To an important degree, the Division's research and development activities are considered to be the basis of its success.

As systems manager for the Navy POLARIS Missile and the Air Force AGENA Satellite in the DISCOVERER, MIDAS and SAMOS programs, the Division is engaged in extensive research in many diverse engineering and scientific fields. Some highlights of current research and development activities include: Operations research and preliminary design; nuclear and space physics; physical electronics; chemistry; materials; mathematics; engineering mechanics; electronic communications and instrumentation; and computer research and development.

Research is a concept which holds many different meanings to those concerned with science and technology. At Lockheed, a distinction is made between the *nature* of the work and its *objectives*. Consequently, such terms as basic research, applied research, systems or operations analysis, engineering and development are used. A given individual might find that his personal inclination often leads him quite naturally from one type of research to another. Recognition of this desire is reflected in the scope of work conducted in the Research Branch at Lockheed Missiles and Space Division. Principal research activities are: Pure and applied research; advanced design; engineering analysis; electronic prototype development; and machine computation.

Organization is determined by the *technical field* rather than by the *type of research*. For example, a structural dynamicist, as a member of the Structures Department, may, on one occasion, work on future space vehicle configurations, at another time be associated with current projects such as the POLARIS or Satellite programs, or he may be engaged in basic research at the research laboratory. In each case, the individual has the opportunity to maintain as much or as little contact as he wishes with others in his field of interest.

Important staff positions at Lockheed's Research and Development Branch in Palo Alto are available. Those scientists and engineers with experience related to the above areas are invited to write to: Research and Development Staff, Dept. I-21, 962 West El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense industrial security clearance is required.

Lockheed / **MISSILES AND SPACE DIVISION**

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA • CAPE CANAVERAL, FLORIDA • HAWAII

NEW PRODUCTS

Crystal Detector Mounts 668

For the band of 9 to 10 kmc

These crystal detector mounts are designed to operate in narrow regions of the rf band of 9 to 10 kmc. Bandwidth is about 100 to 300 mc. The vswr is less than 1.8 with a tangential sensitivity of greater than —51 dbm. Measurements are made with a bias of 50 μa and a video bandwidth of 5 mc. The mounts can be supplied with or without a dc return.

American Electronic Laboratories, Inc., Dept. ED, 121 N. Seventh St., Philadelphia 6, Pa.

Static Frequency Changer 438

For commercial and military use

The Stativerter is designed to convert ac power from one frequency to another and to convert single-phase to three-phase power. For commercial and military use, the unit is applicable to ground installations, electronic laboratories, and production testing. Models are offered with outputs of 100 to 10,000 va. Cycle-to-cycle frequency accuracy is 0.005% of nominal. Internal impedance is less than 1 ohm and response time is 15 msec.

Electrosolids Corp., Dept. ED, 6352 Bellingham, North Hollywood, Calif.

Availability: Immediate.

Diode Recovery Test Unit 504

Uses mercury switch pulse generator

The Model 503 diode recovery test unit consists of a fast mercury switch type pulse generator with a 0.3-nsec risetime, a coaxial test fixture and a metered, regulated power supply. Pulse height is variable from 0 to 100 v, and width from 5 to 50 nsec. The cabinet measures 7-1/2 x 14 x 10-1/2 in.

Lumatron Electronics, Inc., Dept. ED, 116 County Courthouse Road, New Hyde Park, L.I., N.Y.

Variable Resistor 667

Is rated at 3/4 w

Series 300 1/2-in. diam, 3/4-w variable resistor surpasses MIL-R-94B, style RV6, stability requirements for moisture resistance and thermal cycling. The power rating at 70 C is derated to zero at 150 C for higher load and temperature applications than specified in MIL-R-94B. Resistance range is 1,000 ohms to 1 meg linear taper with tolerances of ±20% or ±10%. Rotation angle is 295 ±3 deg. The shaft diameter is 0.125 ±0.001 in. and the shaft lengths are variable in 1/8-in. increments.

CTS Corp., Dept. ED, Elkhart, Ind.

High-Voltage Power Supply 574

Rated at 0 to 30,000 v dc

Model PHV30-1M60V power supply supplies a variable output from 0 to 30,000 v dc at 1 ma. Designed for operation up to 85 C, the unit has all components mounted in oil and sealed. The input voltage can be varied from 0 to 118 v to obtain the required output voltage. Ripple is less than 1% at full rated output. The unit measures 7 x 7 x 8-1/4 in. and weighs 25 lb. Suitable applications include dielectric testing, capacitor charging and cathode ray displays.

The Potter Co., Dept. ED, 1950 Sheridan Road, North Chicago, Ill.

Price & Availability: *Available from stock at $169.*

Westinghouse

SILICON POWER RECTIFIERS AND TRANSISTORS

NOW IN STOCK

YOU CAN OBTAIN UP TO 1000 PIECES OF MOST TYPES AT FACTORY PRICES FROM

Schweber

ELECTRONICS

60 HERRICKS ROAD.
MINEOLA, L. I., N. Y.
PIONEER 6-6520.
TWX G-CY-NY-560U

CIRCLE 102 ON READER-SERVICE CARD

WESTINGHOUSE THERMOELECTRIC COOLERS

NOW AVAILABLE AT REDUCED PRICES

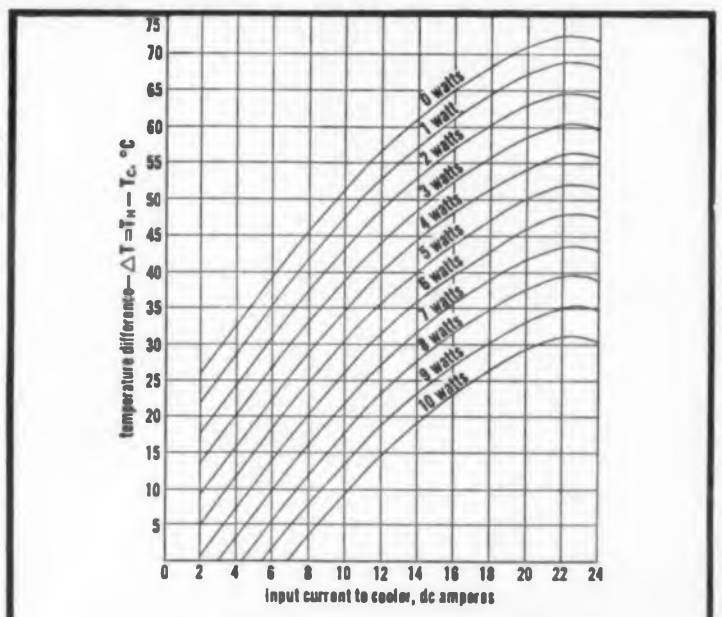
Now you can have the space and weight savings of Westinghouse "Component-Matched" thermoelectric coolers—with new cost savings, too. Prices are reduced on standard units, up to 50%!

Exclusive Westinghouse "Component-Matched" configurations! With no moving parts, Westinghouse Thermoelectric coolers provide dependable, compact, lightweight cooling where it is necessary to reduce component temperature below ambient. These unique "Component-Matched" coolers feature exterior cooling surfaces or inner-cooled chambers with tailor-made dimensions to fit specific requirements. As a result of new production facilities, a wide range of configurations can be offered to electronic equipment designers.

Only Westinghouse guarantees minimum ΔT ratings! Recent Westinghouse improvements in thermoelectric materials and assembly techniques have made it possible to guarantee minimum ΔT ratings for each cooling unit. Thus, a designer can select the unit he needs knowing in advance what the temperature drop will be from the hot to the cold side of the cooler.

Immediate military and industrial applications include: Photocells, photomultiplier tubes / Germanium transistors / Infrared detectors / Mechanical and electrical instruments / Laboratory and portable medical equipment / Controlling temperatures of solids, liquids and gases.

Westinghouse engineers who developed these new thermoelectric coolers will be glad to provide engineering assistance in your applications. For full information, contact your local Westinghouse representative, or write: Westinghouse Electric Corporation, Semiconductor Dept., Youngwood, Pennsylvania. SC-1000



Typical ΔT°C versus input current—Types WX814-H, WX816-H

"Buy and Try"—from Westinghouse distributors—standard WX814 and WX816 Coolers for immediate delivery at new reduced prices.

EASTERN

CAMERADIO	Pittsburgh, Pa./EX 1-4000
CRAMER ELECTRONICS, INC.	Boston, Mass./CO 7-4700
ELECTRONIC SUPPLY	Melbourne, Florida/PA 3-1441
GENERAL RADIO SUPPLY CO., INC.	Camden, N.J./WO 4-8560
KANN-ELLERT ELECTRONICS, INC.	Baltimore, Md./TU 9-4242
MILGRAY ELECTRONICS	New York, N.Y./RE 2-4400
RADIO & ELECTRONIC PARTS CORP.	Cleveland, Ohio/UT 1-6060
SCHWEBER ELECTRONICS	Long Island, N.Y./PI 6-6520

MIDWESTERN

ELECTRONIC COMPONENTS FOR INDUSTRY CO.	St. Louis, Mo./WO 2-9917
INTER-STATE RADIO & SUPPLY CO.	Denver 4, Colo./TA 5-8257
LENERT CO.	Houston, Texas/CA 4-2663
RADIO DISTRIBUTING CO.	Indianapolis, Ind./ME 7-5571
SEMICONDUCTOR SPECIALISTS, INC.	Chicago, Ill./NA 2-8860
UNITED RADIO, INC.	Cincinnati, Ohio/MA 1-6530
WHOLESALE ELECTRONICS SUPPLY	Dallas, Texas/TA 4-3001

WESTERN

ELMAR ELECTRONICS	Oakland, Calif./TE 4-3311
HAMILTON ELECTRO SALES	Los Angeles, Calif./BR 2-8453
NEWARK ELECTRONICS CO.	Inglewood, Calif./OR 4-8440

You can be sure . . . if it's **Westinghouse**

Westinghouse

SILICON POWER RECTIFIERS AND TRANSISTORS

NOW IN STOCK

YOU CAN OBTAIN UP TO 1000 PIECES OF MOST TYPES AT FACTORY PRICES FROM

Schweber ELECTRONICS

60 HERRICKS ROAD.
MINEOLA, L. I., N.Y.
PIONEER 6-6520.
TWX G-CY-NY-560U

CIRCLE 103 ON READER-SERVICE CARD
CIRCLE 104 ON READER-SERVICE CARD

NEW PRODUCTS

Intermediate Power Transistors 398

In stud-mounted hex packages

Types 2N1643, 2N1647, 2N1649, 2N1650 transistors are diffused-mesa, intermediate power units in 7/16 in. stud-mounted hex packages. Their characteristics include a power dissipation of 20 w at 100 C case temperature, low saturation resistance (1.7 ohm typical), good beta linearity with an operating current range of 50 ma to 2 amp and voltage up to 120 v. Applications include regulated power supplies and amplifier output stages.

Transitron Electronic Corp., Dept. ED, 168 Albion St., Wakefield, Mass.

Frequency Standard 437

Rated frequency is 1 mc

Model S-1159 packaged frequency source has a rated frequency of 1 mc with a short-term stability of 1 part per billion. Specifications include: warm-up time, 4 hr; frequency adjustment range ± 3 parts per 10^6; output 50 mv sine wave; output impedance, 72 ohms; and ambient temperature range for operation, -40 to $+65$ C. Power requirement is 10 w at 24 v dc $\pm 20\%$; 2.7 w at 24 v dc $\pm 1\%$.

Dynamics Corp. of America, Reeves-Hoffman Div., Dept. ED, Carlisle, Pa.

Broad-Band RF Filter 587

For radio interference reduction

The L-Cap is a broad-band rf filter designed for radio interference reduction in all types of electronic equipment. A typical unit will attenuate interference 40 db at 1 mc increasing to 80 db and 10 mc and above. The initial insertion loss is maintained up to maximum required frequencies with no performance dips or resonant points. The attenuation characteristics do not change with changes in the load.

Devco, Inc., Dept. ED, E. Longmeadow, Mass.

WHEN YOU NEED

TANTALYTIC® CAPACITORS

FOR IMMEDIATE DELIVERY AT FACTORY PRICES

CALL

Schweber ELECTRONICS

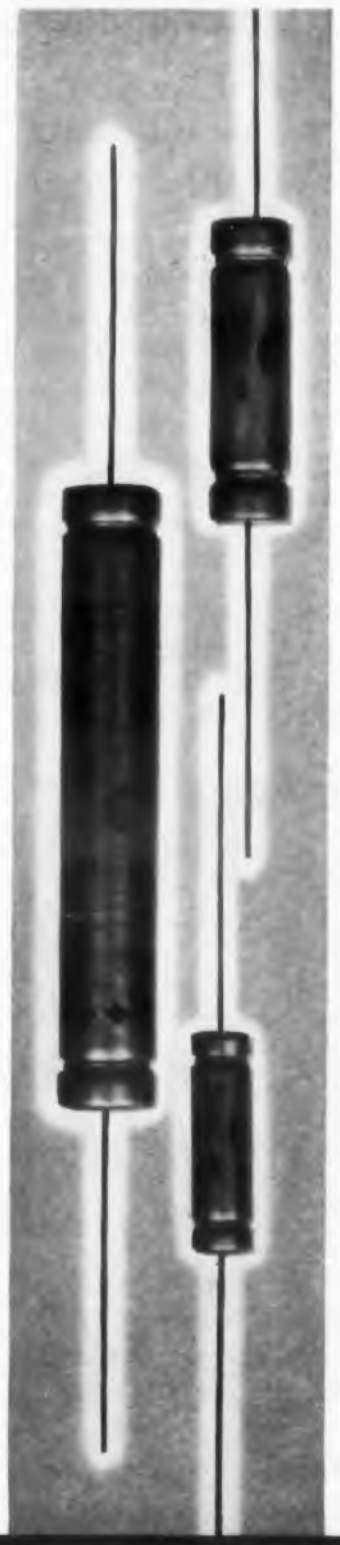
60 HERRICKS ROAD, MINEOLA, L. I., N. Y.
PIONEER 6-6820. TWX G-CY-NY-580U

CIRCLE 106 ON READER-SERVICE CARD

NEW

General Electric High-voltage Tantalytic* Capacitors

RATINGS TO 300 VOLTS



General Electric announces a new high-voltage foil Tantalytic capacitor—rated to 300 volts at 85C and to 250 volts at 125C—in both polar and non-polar designs.

SMALLER IN SIZE than any previously available capacitor with similar voltage ratings, these new General Electric capacitors also provide size advantages over series arrangements of lower voltage units.

GREATER CAPACITANCE STABILITY, achieved over the entire temperature range, is provided by these new high-voltage Tantalytic capacitors. An 8 percent maximum capacitance increase at high temperatures and a 20 percent maximum capacitance loss at −55C are specified.

CLOSER CAPACITANCE TOLERANCE of ±15 percent is standard. This represents a significant improvement over the ±20 percent or −15 +75 percent initial tolerances characteristic of lower voltage capacitors.

SUPERIOR LIFE PERFORMANCE during 2000 hours under maximum rated conditions is realized, with a maximum capacitance change not exceeding 10 percent.

FOR COMPLETE INFORMATION on this significant breakthrough in Tantalytic capacitor design, contact your General Electric Sales Representative, or write Section 449-15, General Electric Co., Schenectady 5, N. Y.

*Registered trademark of General Electric Co.

TYPICAL OF THE WIDE RANGE OF RATINGS AVAILABLE WITH THE NEW G-E HIGH-VOLTAGE FOIL TANTALYTIC CAPACITORS

Cat. No.	Volts	Temp.	Capacitance (uf)	Polarity	Max. Leakage at Rated Temp. (ua)	Max. Imp. −55C 120 CPS (Ohms)	Diam.	Length
29F2200	200	85C	0.35	P	32	5715	3/16"	11/16"
29F2105	300	85C	25.0	P	500	82	17/32"	2 3/4"
29F2108	300	85C	2.0	NP	150	1010	3/8"	2 1/8"
29F2207	200	85C	0.15	NP	32	13330	3/16"	11/16"
29F2161	250	125C	2.5	P	100	830	3/8"	1 7/16"
29F2164	250	125C	13.0	P	325	160	15/32"	2 3/4"

These units are supplied in tubular form, in lightweight aluminum cases, with axial leads, and are available with insulating sleeve in 7 case sizes.

GENERAL ELECTRIC

CIRCLE 107 ON READER-SERVICE CARD

NEW PRODUCTS

Metal-Ceramic Tetrode 578

For L-band radar

Type GL-7399 metal-ceramic tetrode is designed for rf pulsed amplifier service in L-band radar transmitters. In plate-and-screen pulsed service, the tetrode is rated at 50 kw peak power at 500 mc; power gain is 20 and a pulse width is 15 μsec. The tube provides useful output up to 1500 mc. It may also be used as a grid-pulsed or grid-and-screen pulsed rf amplifier.

General Electric Co., Power Tube Dept., Dept. ED, Schenectady 5, N. Y.

Availability: *Available in quantities suitable for prototype work.*

Voltmeter 663

Range is 250 mv to 1 v

The Microlter voltmeter measures hf voltages from 250 mv to 1 v. A combination of a 50-meg vacuum-tube voltmeter and a video amplifier, the unit provides direct readings within 1% accuracy on a 6-in. mirror-back meter without tuning. Maximum output of the amplifier is 0.5 v at 75 ohms with a gain of 45 db. Frequency range is 50 cps to 50 mc.

Kay Electric Co., Dept. ED, 14 Maple Ave., Pine Brook, N.J.

Germanium Switching Transistor 550

For computer and missile applications

Type 2N404A transistor is a germanium alloy switching device designed for missile and high speed computer applications. The unit is interchangeable with its military prototype, Type 2N404, but has extended voltage, current and temperature ratings. Maximum ratings for the 2N404 are: collector-to-base voltage, 40 v; collector current, 200 ma, power dissipation, 150 mw; junction temperature, 100 C.

Sylvania Electric Products, Inc., Semiconductor Div., Dept. ED, 730 Third Ave., New York 17, N.Y.

From PSI...

ADVANCED SILICON MESA TRANSISTORS FOR ADVANCED CIRCUIT DESIGN

1. THE FASTEST 2N697 AVAILABLE!

Nearly half the collector saturation voltage . . . half the leakage current . . . half the collector capacitance . . . 40% greater power dissipation!

COMPARE THESE OUTSTANDING FEATURES OF THE PSI 2N697!

Nine out of ten PSI type 2N697 transistors meet these premium specifications. Guaranteed 100% shipment to the higher specifications will be made when the buyer specifies PSI type PT 822 premium grade.

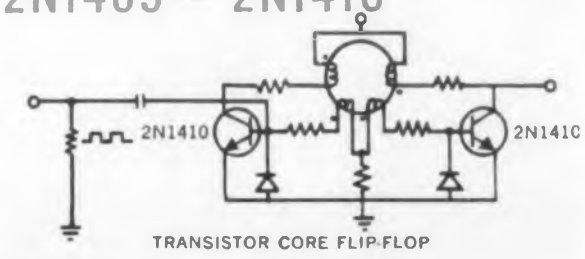
Many of these "plus characteristics" are also featured in the PSI 2N696 . . . ideally suited for the designer not requiring the high gain performance of the PT822.

MAXIMUM RATINGS

PARAMETER	REGISTERED SPECIFICATION	PSI PREMIUM SPECIFICATION	UNIT	TEST CONDITION	% IMPROVEMENT
V_{CER}	40	50	Volts	R_{BE} = 10Ω	25% Higher
V_{CBO}	60	80	Volts	I_{CBO} = 100 μA	33% Higher
V_{EBO}	5	8	Volts	I_{EBO} = 100 μA	60% Higher
Power Dissipation	2	2.8	Watts	25°C Case Temp	40% Higher
Power Dissipation	0.6	0.8	Watts	25°C Ambient Temp	33% Higher
I_{CBO}	1.0 100	0.5 50	μA μA	V_{CB} = 30V, T = 25°C V_{CB} = 30V, T = 150°C	50% Decrease
V_{BE}(SAT)	1.3	1.3	Volts	I_C = 150mA, I_B = 15mA	———
V_{CE}(SAT)	1.5	0.8	Volts	I_C = 150mA, I_B = 15mA	47% Decrease
h_{FE}	40-120	40-120	———	V_{CE} = 10V, I_C = 150mA	———
h_{fe}	2.5 min	7.0 min	———	V_{CE} = 10V, I_C = 50 mA f = 20mc	280% Increase
C_{ob}	35	18	μμf	V_{CB} = 10V, I_E = 0 f = 140 kc	48% Decrease

2. HIGH SPEED SWITCH TYPES – 2N1409 – 2N1410

Typical switching speed of 52 nanosec turn-on time and 130 nanosec turn-off . . . saturation resistance of only 5 ohms and power ratings of 2.8 watts (25°C case temp.) For use in low current logic or high current core-driver circuitry.

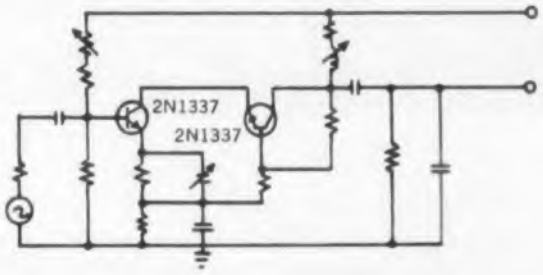


TRANSISTOR CORE FLIP-FLOP

3. HIGH VERSATILITY TYPES – 2N1335 thru 2N1341

The higher power dissipation, faster rise time and lower collector capacitance of the 2N1337, for example, makes this transistor an unusually fine performer in advanced video amplifier circuits.

These 2.8 watt, 120 volt VHF transistors are well suited to IF and DC amplifiers, RF power amplifiers and oscillators and to high voltage switching applications.

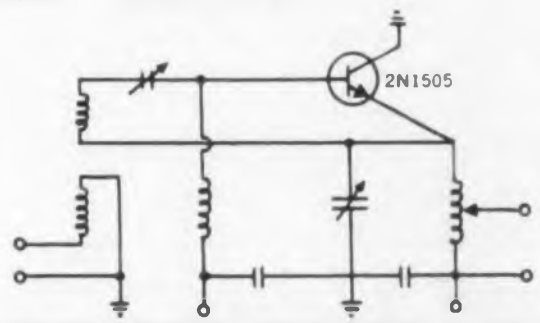


TEN MC BANDWIDTH. HIGH VOLTAGE VIDEO AMPLIFIER

4. COMMUNICATION TYPES – 2N1505 – 2N1506

This series of silicon mesa transistors provides high power output at Very High Frequencies. Typical power outputs are one-half watt at 200 mc with 3 db gain or one watt at 70 mc with 12 db power gain operating from 28V source.

A power output of 2.5 watts at 250 mc. may be obtained by using these transistors with a High-Q Varicap® frequency multiplier.



GROUNDED COLLECTOR COMMON EMITTER RF AMPLIFIER PROVIDES UNIQUE COMBINATION OF HIGH GAIN AND HIGH POWER.

®VARICAP® IS THE REGISTERED TRADEMARK OF SILICON VOLTAGE-VARIABLE CAPACITORS MANUFACTURED BY PACIFIC SEMICONDUCTORS, INC.

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Send for 1000 mc one watt generator data

PSI **Pacific Semiconductors, Inc.**

A SUBSIDIARY OF THOMPSON RAMO WOOLDRIDGE INC.

12955 CHADRON AVENUE • HAWTHORNE, CALIFORNIA

CIRCLE 108 ON READER-SERVICE CARD

NEW PRODUCTS

DC Power Supplies 379

Have output currents of 1 to 25 amp

These fixed-voltage, transistor-regulated dc power supplies have output ranges of 5 to 8 v, 10 to 14 v, 26 to 30 v, and 45 to 55 v. Each type is available in current ratings of 1, 2, 4, 6, 10, 15, and 25 amp. For the supply providing 10 to 14 v at 25 amp, line regulation is 5 mv for a 10% line change at 12-amp load and load regulation is 5 mv no-load to full-load for a 12-v output. All models have less than 2-mv rms ripple at full load. Typical response time is 50 μsec. Remote sensing terminals are available.

T T Electronics, Inc., Dept. ED, Culver City, Calif.

Price & Availability: *$225 and up; two to four weeks for delivery.*

DC Preamplifier 444

Measures down to 100 μv

Model 300 chopper-type dc preamplifier has a maximum sensitivity of 100 μv per mm. Other specs for the amplifier with oscillograph are: input range, 0.1 to 200 mv per mm; drift, ±5 μv; input impedance, 500,000 ohms min; calibration, 1 mv, internal; and frequency response, dc to 100 cps. Noise and hum at 60 and 120 cps are less than 10 μv, peak to peak. Model PR-301, also offered, has the same electrical and physical characteristics, but has a zero suppression of ±10 mv.

Cohu Electronics, Inc., Massa Div., Dept. ED, 5 Fottler Road, Hingham, Mass.

Sweep Generators 549

Cover microwave frequencies

Model ED series generators cover the band of frequencies between 950 and 2450 mc. Model ED-1A sweeps from 950 to 1,800 mc; model ED-4A partially overlaps the first and sweeps to 2,450 mc. Both instruments have a variable sweep width, from 0.05% up to 8% of the center frequency. The signal flatness is within ±5% across the maximum sweep width. The sweep rate is at the line frequency, 50 to 60 cps.

Telonic Industries, Inc., Dept. ED, Beech Grove, Ind.

High-Voltage Capacitors 644

Capacitance range is 0.005 to 30 μf

The Deltaply 70 capacitors, for use in small equipment, are made of laminated film and paper. Capacitance ranges from 0.005 to 30 μf; voltages are 600 to 20,000 v. Size and weight are reduced 75% to 80% over MIL-C-25 specs. Operating temperature ranges are —55 to +85 C and —55 to +125 C.

Dearborn Electronic Labs, Inc., Dept. ED, 1421 N. Wells St., Chicago 10, Ill.

Switching Unit 366

100 channels

This compact transistor switching unit accepts 100 different on-off signals and within 100 μsec feeds information to a direct writing sequence recorder. The Trans-Switcher unit contains 10 plug-in, interchangeable decade boards, each able to handle 10 signals in a wide range of voltages and pulse shapes. Signal levels as low as 5 v dc can have a pulse duration of only 4 msec. Units are 13-1/4 in. deep, 19 in. wide and 5-1/4 in. high.

Brush Instruments Div., Clevite Corp., Dept. ED, 37th and Perkins, Cleveland 14, Ohio.

NEW PRODUCTS

Power Supplies 528

Provide 1,000 to 5,000 v dc

The Micropac series power supplies provide regulated outputs of 1,000 to 5,000 v dc. Units are available for operation from a 60- or a 400-cps line or a 26 to 29 v dc line. Line regulation is ±0.5%; load regulation is ±0.5% for a load of 20% to 100%. Ripple is 1% rms. Standard outputs are 1,000, 3,000, and 5,000 v dc at maximum currents of 100 μa.

Era Pacific, Inc., Dept. ED, 1760 Stanford St., Santa Monica, Calif.

Price: *$115 to $200.*

Microwave Fixed Attenuators 541

For L through E bands

Offered in 10- and 20-db values, these microwave fixed attenuators can be furnished for L through E bands. The attenuation is relatively insensitive to frequency variation. Calibration is permanently stable and independent of environment. Specifications include: ±0.1-db accuracy, mean attenuation ±0.3-db from nominal, and ±0.5-db variation across band. The units are short in length and operate over wide ranges of temperature and humidity.

Narda Microwave Corp., Dept. ED, 118-160 Herricks Road, Mineola, N. Y.

Price & Availability: *$85 to $450; from stock.*

Subminiature Thyratron Tubes 580

For control circuits

The type WC-27 xenon-filled, tetrode thyratron tubes are suited for use in counters, grid-control rectifiers and other control circuits. The bulbs are of T2 subminiature glass and the bases are

subminiature buttons with flexible leads. Electrical specs are: heater supply, 6.3 v at 150 ma; peak anode voltage, forward and inverse, 300 v; max average cathode current, 16 ma dc, max peak cathode current, 100 ma; heater-to-cathode voltage, +15 v max, −100 v min; average tube drop, 12 v.

Tucor, Inc., Dept. ED, 18 Marshall St., South Norwalk, Conn.

Price & Availability: *Available from stock; unit quantity prices start at $10.*

Synchro Standard 362

Accurate to 2 sec of arc

This synchro standard, with a functional accuracy of 2 sec, eliminating the need for a null detector and control transmitter; it serves as a reference base for synchro-testing and control systems. The units are packaged in compact modules suitable for rack mounting.

Astrosystems, Inc., Dept. ED, 220 E. 23rd St., New York 3, N. Y.

Price & Availability: *Prices range from $500 to $1,200 depending on degree increment. Delivery is 4 weeks.*

Diode Recovery Plug-In Unit 689

For use with oscilloscopes

Type S plug-in unit displays semiconductor diode switching characteristics on the CRT of an associated oscilloscope. It permits measurement of diode parameters from the display and allows prediction of diode performance in a circuit through analysis of the recovery and turn-on characteristics. Used with one of the firm's oscilloscopes, the unit displays a stored charge as low as 5 picocoulombs, base resistance as low as 0.25 ohms, junction capacitance to 2 pf, and a recombination rate of minority characters with a lifetime of 2 nsec. The unit can also be used to observe transistor junction characteristics, and to measure circuit component resistance, capacitance, or inductance.

Tektronix, Inc., Dept. ED, P.O. Box 500, Beaverton, Ore.

Price & Availability: *Immediate delivery; $350 ea.*

NEW PRODUCTS

Water Loads 665

Three types offered

These water loads provide flat terminations and accurate rf power measurement for high-power, uhf transmitting equipment. Type WL-120 is 3.5-in. long, and has a vswr of less than 1.1 with a frequency range of 550 to 2,400 mc. Type WL-130, 6-1/6-in. long, has a vswr of less than 1.1 with a range of 400 to 2,400 mc and a vswr of 1.15 with a frequency range of 300 to 2,400 mc. Type WL-140, 12.5-in. long, has a vswr of 1.1 with a range of 280 to 2,400 mc and a vswr of 1.2 with a range of 200 to 2,400 mc.

Eitel-McCullough, Inc., Dept. ED, San Carlos, Calif.

Price & Availability: *Types WL-120, 130, and 140 are priced at $970.50, $1,029, and $1,088 ea, respectively. Delivery is in one week.*

Capacitors 645

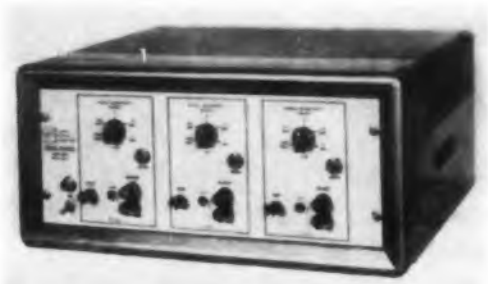
Oil-impregnated

Type PO9J metal-cased, oil-impregnated dc capacitors are for use in transmitters, amplifiers, and rectifier filters. Voltage ratings are 600 to 7,500 v dc in a wide range of capacitance values. Temperature range is −55 to +85 C. They meet MIL-C-25A.

Aerovox Corp., Dept. ED, New Bedford, Mass.

Cathode Follower 620

Range is 0.02 cps to 1 mc



Model 4003 cathode follower provides faithful reproduction of input signals as low as 1 mv from 0.02 cps to 1 mc. The instrument has an input impedance of 5,000 meg and an output resistance of 290 ohms. The unit has a gain of 0.98, an output noise level of 75 μv and a transient response capable of reproducing a 25-v pulse with a 0.4-μsec rise time and a 1.0-μsec decay time.

Columbia Research Labs, Dept. ED, MacDade Blvd. and Bullens Lane, Woodlyne, Pa.

Thermocouple Junction Compensator 648

Stability is ±0.15 F

This 15-channel thermocouple reference-junction compensator has a temperature range of 150 to 280 F and a stability of ±0.15 F. Warm-up time is 3.5 min to achieve 250 F. Input is 24 to 28 v ac or dc or 110 v ac at 60 cps, 6 w. The unit can be supplied in special models for aircraft use. Standard units weigh 1 lb.

Harco Labs., Inc., Dept. ED, New Haven, Conn.

Cycling Chamber 643

Temperature range is −100 to +500 F

This cycling chamber, designed for use in testing electronic components and devices, is capable of completing a hot-cold cycle within the temperature range of −100 to +500 F in less than 10 min. Temperature stability is 0.5 F.

Delta Design, Inc., Dept. ED, 7460 Girard Ave., La Jolla, Calif.

Electric Counter 666

Life is 30,000,000 counts

Model 6-Y-1-RMF electric counter has a life rating of 30,000,000 counts at a speed of 1,000 counts per min, with operating speeds up to 1,200 cpm at normal voltage. The unit is made of corrosion-resistant materials and is housed in a one-piece die-cast frame.

Durant Manufacturing Co., Dept. ED, 1993 N. Buffum St., Milwaukee 1, Wis.

NEW PRODUCTS

Transistor Holders 729

For three-lead units

The TC-300 Teflon-insulated holders are for three-lead transistors. The long terminal acts as a heat sink, permitting soldering of the transistor in place without danger to the transistor elements. They can be used for color coding.

Sealectro Corp., Dept. ED, 139 Hoyt St., Mamaroneck, N.Y.

Power Supplies 538

Line regulation is 0.005%

These 100-v, 3-amp transistor power supplies have a line regulation of 0.005% of maximum rated load and a load regulation at 100 v of about 0.01%. Ripple is less than 500 μv rms. Recovery time at maximum rated current is less than 50 μsec. Automatic overload protection is provided. Temperature compensation limits average drift to 0.02% per deg C. Units are suitable for rack mounting.

Mid-Eastern Electronics, Inc., Dept. ED, 32 Commerce St., Springfield, N. H.

Price & Availability: *$825; from stock to three weeks.*

Power Supply 647

Outputs are 0 to 15 and to 25 v dc

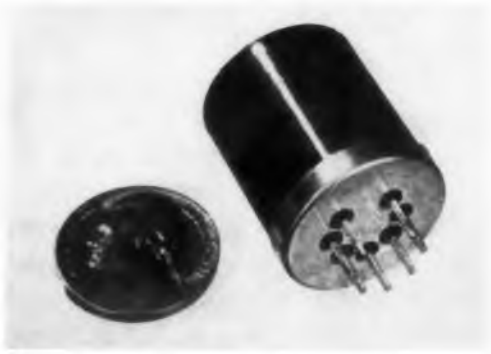
Model PS-3 variable, power supply has outputs of 0 to 15 v dc at 0 to 200 ma and 0 to 25 v at 0 to 100 ma. Regulation is 500 mv max for these ranges. Input is 110 to 130 v at 60 cps. The ac ripple is below 1 mv rms for rated op-

eration and less than 5 mv for ac line voltage from 115 to 120 v. The 2% D'Arsonval meter has ranges of 0 to 25 v, 0 to 100 ma, and 0 to 200 ma. A Zener-diode reference is used in the three-transistor regulating circuit. The unit is suitable for filtering.

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

Transistor Oscillator 359

Range is 25 cps to 100 kc



The model S-100 transistor sinusoidal oscillator is an epoxy encapsulated unit operating from 25 cps to 100 kc. It measures 1.25 in. long by 0.875 in. in diameter and weighs 1 oz. Output is greater than 2 v rms with a 680-K load. Power requirements are 28 v at 1 ma. It will stand 30-g vibration from 0 to 2,500 cps.

Solid State Electronics Co., Dept. ED, 15321 Rayen St., Sepulveda, Calif.

Price & Availability: *Delivery is 3 weeks; prices from $175 to $230.*

Servo Amplifier 435

Occupies less than 1 cu in.

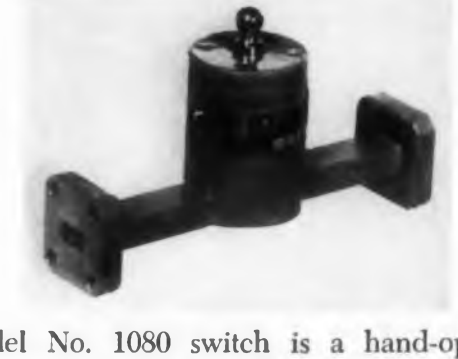
Occupying a volume of less than 1 cu in., this servo amplifier can be used for positioning gimbals, gyros, platforms, and compass systems. Available with a 0 or 90-deg phase shift, the unit operates with an untuned load. Nominal gain is 300, but may be reduced to any desired value with the addition of an external resistor. Normal input impedance is 5,000 ohms; at a low impedance a gain of up to 1,500 is possible.

Lear, Inc., Dept. ED, Box 688, Grand Rapids, Mich.

NEW PRODUCTS

Waveguide Shorting Switch 624

Hand-operated plunger type



Model No. 1080 switch is a hand-operated, plunger type on-off unit and is applicable as a shorting switch in Ka-band waveguide transmission systems. The switch operates from 26.5 to 40 kmc with a vswr of 1.02 max with switch open and 125 min with switch closed. The device is ruggedly constructed of a RG-96/U waveguide and UG-599/U cover flanges. It has an insertion length of 3 in. and a max height of 1-1/2 in.

Waveline, Inc., Dept. ED, Caldwell, N.J.

Sub-Audio Filter 524

Loss is about 2 db

Type 201 sub-audio, variable filter has a loss of about 2 db, a sharp cut-off, and a constant attenuation rate. Having no transistors, vacuum tubes, or power supply, the unit features an extremely low noise level. Input and output impedance is 600 ohms. Frequency coverage is 1 to 256 cps. Dimensions of the unit are 7-1/4 x 17-1/2 x 7-1/2 in. and weight is 35 lb.

Allison Laboratories, Inc., Dept. ED, 11301 E. Ocean Ave., La Habra, Calif.

Price: *$695 fob factory.*

Shaft-Position Encoder 646

Has direct binary output

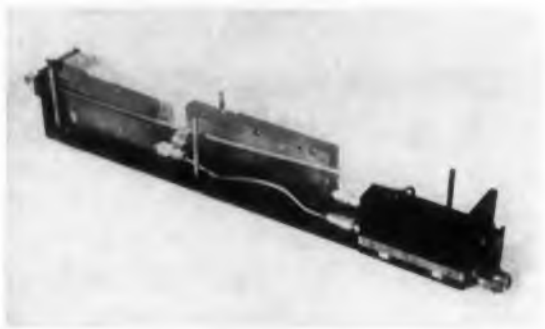
Model TR-705 shaft-position encoder comprises a shaft encoder and a transistorized storage circuit. It stores 10 bits of data at encoder rates to 2,000 per sec. Output is in the binary code and

the complement. Designed to operate at a read-out speed of 120 rpm max and a slew speed of 1,000 rpm max, the unit has an accuracy of ±1 part in 1,000. It stands 100 g of acceleration along the longitudinal axis and vibration of 8 g up to 1,000 cps.

Datex Corp., Dept. ED, 1307 S. Myrtle Ave., Monrovia, Calif.

Microwave Sub-System Package 368

For C- or X-band use

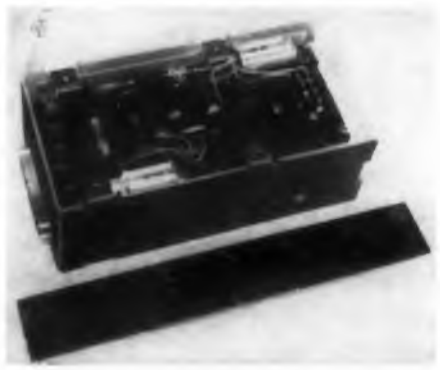


This sub-system package provides sampling, filtering and level control on the C- and X-bands. Units contain an octave-wide directional coupler, two band-pass filters and a flat coaxial attenuator. Attenuators of both units are continuously variable, zero-loss devices with flat attenuation-vs-frequency characteristics over octave bands. Package weighs 5 lb and measures 17 x 3-1/8 x 2-1/4 in.

Merrimac Research and Development, Inc., Dept. ED, 517 Lyons Ave., Irvington 11, N. J.

DC Amplifier 361

For strain gage and thermocouple applications



This dc amplifier, Model 100A, designed for applications with strain gages and thermocouples, converts low-level dc to ±2.5-v. dc output. Gain is adjustable from 10 to 500. Frequency response filters are interchangeable. The instrument meets applicable specifications of MIL-E-5272. It measures 5 x 2-1/2 x 1-3/4 in.

Temco Electronics Div., Temco Aircraft Corp., Dept. ED, P. O. Box 6191, Dallas 22, Tex.

Availability: Delivery is 60 days.

NEW PRODUCTS

Precision Temperature Control Oven 369

For crystals and components

This miniature, precision-temperature control oven, type RM-3, for crystals and components, has an ambient temperature range of —65 to +5 C below operating temperature. Temperature variation after warm-up is better than ±0.1 C at constant ambient. Heater voltage is 115 v, ac or dc, at 15 w max.

Monitor Products Co., Dept. ED, 815 Fremont, South Pasadena, Calif.

Energy Absorption Load 735

With type N connector

This energy absorption load adds only 0.65 in. in its type N connector. Impedance is 50 ohms, vswr from 0 to 1,200 mc is 1.04 max and from 1,200 to 2,000 mc is 1.1 max. The load can be supplied to meet specific bandwidth requirements from 2 to 10 kmc. Average power is 1 w; peak power is 1 kw. Temperature range is —65 to +250 F.

Transco Products, Inc., Dept. ED, 12210 Nebraska Ave., Los Angeles 25, Calif.

Solid-State Multicoder 650

Measures 63 cu in.

Model S-857-1B houses in one package two high- and two low-level commutators, two power supplies, an inverter, an amplifier gate matrix and a probe. The unit measures 7-3/4 x 3-1/4 x 2-1/2 in. and weighs 5-1/4 lb. Designed for PAM/FM telemetry applications in missiles and

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aircraft, the unit will operate from a 28-v power source, in peak accelerations of 75 g and in temperatures up to 300 F. The multicoder can handle 112 channels of information, 28 in each of four commutators simultaneously.

General Devices, Inc., Dept. ED, P.O. Box 253, Princeton, N.J.

Availability: *Units made to order can be delivered in 45 days.*

Transistor Thermal Tester 445

Has direct-reading meter

This test set is designed especially for measuring transistor and diode temperatures. A special nomograph permits fast indication. Temperatures are read directly on the meter scale. Ambient temperature compensation is automatic. The unit is portable, needs no batteries or external power, and measures 9-5/8 x 7-5/8 x 7-7/8 in.

Rescon Electronics Corp., Dept. ED, 151 Bear Hill Road, Waltham 54, Mass.

Damping Control 692

Weighs less than 1 oz

The Airpot air-damping dash-pot is for use in system stabilization, vibration damping, and time delay. Weighing less than 1 oz, the unit is constructed of a graphitized-carbon piston and a low-expansion glass cylinder. These are fitted to a 0.0001-in. tolerance. The standard unit provides equal damping in two directions where a fast reset time is not needed. Other models are for one-way, push or pull damping. Units can be used in damping voltage regulators, as time delays in switch gears, for speed control of recording pens, and oscillation damping in rate gyros.

Electric Regulator Corp., Dept. ED, Pearl St., Norwalk, Conn.

Price & Availability: *$4 to $6.90 ea; 14-day delivery.*

CIRCLE 125 ON READER-SERVICE CARD

NEW PRODUCTS

Gearheads 417

Size 8

These size 8 gearheads for servomotors and motor generators are for both military and industrial applications. Centered-shaft gearheads are available in 28 ratios from 7.62:1 to 1,254:1 and eccentric-shaft gearheads are available in 25 ratios from 7.62:1 to 903:1 Typical units, types M5701-002 and M5701-003, have no load speeds of 4.7 to 773 rpm, stall torques of 1.8 to 20 oz-in. and from 30 to 45 min of backlash. Their weight is 0.7 to 0.9 oz.

Kearfott Div. of General Precision, Inc., Dept. ED, 1150 McBride Ave., Little Falls, N.J.

Chart Recorder 429

Monitors voltage or frequency

This lightweight recorder monitors voltage or frequency with an accuracy of 0.5%. The unit consists of an inkless chart recorder and an expansion network. The recorder consists of a d'Arsonval meter with a free-moving pointer that is pressed against sensitized paper once every 2 sec, producing a record. Transducers for expanded scale recordings are provided.

Voltron Products, Inc., Dept ED, 1020 S. Arroyo Parkway, Pasadena, Calif.

Price & Availability: *DC Recorder $170; ac recorder $185; 60-cps frequency recorder $260; 400-cps frequency recorder $220; temperature recorder $190; chart paper, 6 rolls, $13.50. Delivery is 30 days.*

Phase Meters 378

Have 7-in. panel meters

Series 405 phase meters, for measuring a phase angle between two alternating voltages without amplitude or frequency adjustment, have

7-in. panel meters with mirror scales. The instrument also plots phase-frequency curves. Stability is a fraction of 1 deg on all ranges. The three models offered have frequency ranges of 8 cps to 100 kc, 8 cps to 500 kc, and 1 cps to 60 kc, respectively. Phase ranges are 0 to 12, 36, 90, and 180 deg. Accuracy is 0.25 deg relative and 1 deg or 2% absolute. Input signal amplitudes may vary from 0.3 to 70 v.

Ad-Yu Electronics Lab., Inc., Dept. ED, 249-259 Terhune Ave., Passaic, N.J.

Price & Availability: *Prices are $548, $585, and $595 ea; delivery is one to two weeks after receipt of order.*

Ultrasonic Welding Device 399

Emits sound waves at 25,000 cps

Emitting high-pitched, silent sound waves at 25,000 cps, this welding device can join materials previously considered extremely difficult or impossible to wet with fluxless solder or weld.

Raytheon Co., Commercial Apparatus and Systems Div., Dept. ED, 1415 Providence Turnpike, Norwood, Mass.

10-Pin Miniature Tube Design 388

Additional pin at center of base

A line of miniature receiving tubes with 10-pin bases has been designed to combine multiple circuit function into a single tube envelope. The tubes adapt the conventional 9-pin base arrangement on the T-6-1/2 miniature envelope by adding a tenth pin centered in the pin circle. The first tube incorporating the design will be a double tetrode and a triple triode for fm applications.

Sylvania Electric Products, Inc., Dept. ED, 730 Third Ave., New York 17, N. Y.

NEW PRODUCTS

Vibratory Bowl Feeder 505

Automatic control unit available

This vibratory bowl feeder is designed to feed axial lead components into the firm's lead straightening, taping, and testing and orienting machines. Hoppers are built to precise component configurations. An attachable photoelectric sensing device automatically controls the bowl feed unit by indicating when components stacked in the input chute have dropped below a minimum level.

Universal Instruments Corp., Dept. ED, 139 E. Frederick St., Binghamton, N.Y.

Price: *The bowl feeder is $785. The control attachment is $250.*

Transfer Function Analyzer 669

For automatic plotting

Type 308 transfer function analyzer is suitable for automatic plotting of transfer characteristics of a control system with a conventional X-Y recorder. Continuous plotting of Nyquist diagram can be achieved over the range of 0.3 cps to 3 kc in type 308A and 30 cps to 300 kc in type 308B. Both the in-phase and the quadrature components of an unknown signal, either ac or dc, are indicated simultaneously in volts rms. Both meters have center zero.

Ad-Yu Electronics Laboratory, Inc., Dept. ED, 249-259 Terhune Ave., Passaic, N.J.

Price & Availability: *$945 ea; from stock.*

Instrument Enclosures 506

Use modular frame system

Aluminum modular instrument enclosures from 7 in. to 20 ft in width, height or depth can be developed from this modular frame system. They are suited for aeronautical or mobile installations where weight is a critical factor. The enclosures are made from MIL-spec heat-treated extrusions and castings. A hinged casting allows any degree of slope as standard. Built-in locking devices eliminate tools, bolts, nuts, etc. Units conform to EIA mounting standards.

Amco Engineering Co., Dept. ED, 7333 W. Ainslie St., Chicago, Ill.

Ultrasonic Soldering Iron 354

Solders without flux

This 8-oz, 10-w ultrasonic iron is designed to solder semiconductor materials, aluminum, magnesium and related alloys without flux. Surface pre-treatment and post-cleaning are unnecessary. The unit, model S-10, operates on 115-v ac power and uses standard replaceable tips.

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

Price: *$249.*

Binary Digital Recorder 373

Records at up to 150 lines per second

This high-speed binary digital recorder, model 960, can record digital information at rates up to 150 lines (or words) of 32 bits each per sec. Over 50,000 recordings can be made on one standard roll of paper tape. Units have up to 32 recording channels and a time-mark channel. Models for rack- or bench-mounting are available.

Electronic Counters, Inc., Dept. ED, 155 Eileen Way, Syosset, L. I., N. Y.

Price & Availability: *Price is about $2,000; delivery is 10 to 14 weeks.*

Ceramic Coil Forms 695

With constant-tensioning device

Type 2770 coil form with an internal constant-tensioning device permits locking of tuning cores while still tunable. Type 2770 has an over-all length of 1-7/32 in. and type 2771, also offered, has a length of 1-11/16 in. Both can be furnished with ring-type solder terminals or silicone fiberglass collar-type solder terminals. The powdered-iron tuning cores cover the following frequency ranges: 1 to 1.5 mc, 1 to 2 mc, 20 to 50 mc, 30 to 300 mc. The temperature stable cores cover: 2 to 40 mc and 40 to 300 mc.

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

Price & Availability: *Type 2770, $0.58 ea in quantities of 100; type 2771, $0.89 ea in quantities of 100 pieces. Delivery is from stock.*

NEW PRODUCTS

Silicon Power Rectifiers 471

Deliver 2000 amp in full-wave circuits

Type 7D stacked silicon power rectifiers will deliver up to 2000 amp in full-wave circuits. For all types of power applications the double-diffused units operate to 150 C, ambient temperature. All assemblies use copper fins and melamine insulation.

Trans-Sil Corp., Dept. ED, 55 Honeck St., Englewood, N.J.

Price & Availability: *Price ranges from $40 to $400, depending on stack configuration and quantity. Delivery is in 10 days.*

Silicon Transistor 428

Dc beta range is 20 to 60

Type 2N753 double-diffused mesa silicon transistor meets the specifications of the standard type 2N706 and offers: a dc beta range of 20 to 60; a BV_{EBO} of 5 v; a BV_{CEO} of 15 v at 10 ma I_C; an I_{CER} (R_{BE} = 100 K) of 10 μa at 20 v V_{CE}; an output capacitance of 5 pf; a charge storage time constant of 25 nsec max; a turn-on switching time constant of 25 nsec max; a turn-on switching time of 40 nsec max; a turn-off switching time of 75 nsec max.

Texas Instruments Inc., Dept. ED, P.O. Box 312, Dallas 21, Tex.

Price & Availability: *1 to 99 lots are $18.50 ea; 100 to 999 lots are $12.35 ea; off-the-shelf availability.*

Choppers 413

With vibrator actuators

Using self-contained solid-state vibrators, these choppers eliminate the necessity of supplying an ac driving source at a fixed frequency.

The units have high linearity and temperature stability over a signal range extending from a fraction of 1 mv to ±15 v for models 80 and 81 and up to ±7 v for models 90 and 91. Models 80 and 81 have a frequency range of 1.5 to 6.5 kc; models 90 and 91 have a range of 1.8 to 4.4 kc.

Solid State Electronics Co., Dept. ED, 15321 Rayen St., Sepulveda, Calif.

Price & Availability: *Delivery is from stock; price ranges from $155 to $197 ea.*

Germanium Transistors 449

Composite emitter-collector type

Types 2N1169 and 2N1170 germanium transistors are designed for medium-speed switching applications. In these units, the emitter and collector can be used interchangeably, permitting either electrode to be used as the input or the output electrode. Collector-to-base voltage ratings are 25 and 40 v, minimum dc transfer ratio at an I_c of 200 ma is 20, and typical alpha-cut-off frequency is 7 mc.

Radio Corp. of America, Semiconductor & Materials Div., Dept. ED, Somerville, N.J.

Variable Voltage DC Power Supplies 472

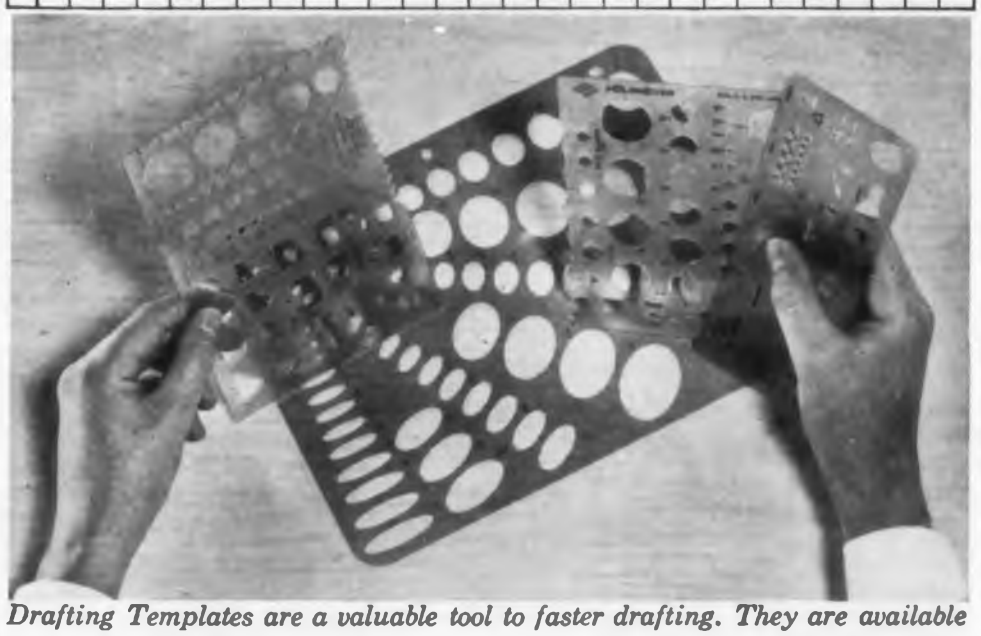
Regulated to 0.005%

These transistorized dc power supplies, Series LQ, have outputs variable from 0 to 35 or 50 v at up to 15 amp, regulated to within 0.003% or 1 mv at any rated load. Regulation from no-load to full-load is 0.02%. Power input is 115 v 60 cps. Instruments are intended for missile system equipment applications. Chassis are rack

Universal Electronics Co., Dept. ED, 1720 22nd St., Santa Monica, Calif.

Price & Availability: *Prices start at $495; delivery is 4 weeks.*

DRAFTING TRENDS



Drafting Templates are a valuable tool to faster drafting. They are available in an almost endless variety.

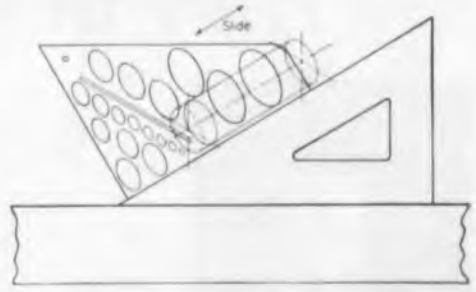
Specialized drafting templates speed drawing time

Always a handy tool, drafting templates are becoming increasingly in use to simplify everyday drawing techniques. Now vinyl plastics are used in the manufacture of the majority of templates. But the thickness, color and finish vary in almost endless profusion. Glare-saving colors, such as green and amber, are usual, both in clear and matte finishes. However, the white and clear plastics still are popular. The thicknesses vary with the different types of available templates from .020 gauge through .070 gauge.

Specialized template applications

A list showing the growing application for templates includes templates for: Electronic Symbols, Electrical Wiring, Landscaping, Screw Heads, House Plans, Nuts and Bolts, Screw Threads, Tooling, Windows, Plumbing, Mathematical Symbols, Map Planning, and many "all-purpose" templates for circles, ellipses, triangles, and other shapes.

Isometric ellipse template is a big timesaver



An isometric ellipse template may be more useful if it is cut in half to provide edges parallel to the minor axes of the ellipses. Halves of the template may then be moved along a 30-60 degree triangle so that ends of a shaft or any cylindrical shape can be drawn in a minimum of time and in perfect alignment.

A selection of 52 popular templates is illustrated and described in a special six page brochure, "Drafting Templates" recently published by Frederick Post Company. *For your copy, write Frederick Post Company, 3644 N. Avondale Ave., Chicago, Illinois.*

NEW PRODUCTS

Capacitor-Charging Power Supply 468

Model K20-0.5 supply charges a 500-μf capacitor to 20,000 v in 2 min. It provides 4 kw instantaneous power. Average input is 1 kva.

Peschel Electronics, Inc., Dept. ED, Towners, Patterson, N.Y.

Multi-Unit Reset Timer Panel 469

Able to provide automatic control of eight sequential operations, model 8AZC has timing ranges of up to 10 min. Each timer is calibrated from 0 to 60 sec.

Zenith Electric Co., Dept. ED, 152 W. Walton St., Chicago 10, Ill.

Availability: *Delivery time is 10 to 14 days after receipt of order.*

Automatic Cylinder Printer 392

Able to process 2500 pieces per hr, this machine prints one or two-color trade marks or other designs on plastic, glass, wood, metal, and cardboard.

Apex Machine Co., Dept. ED, 14-13 118th St., College Point 56, N.Y.

Displacement Measuring System 371

The 904-1 permits non-contact static and dynamic measurements in the milli-inch to micro-inch region with a sensitivity of 0.2 v and a stability of 0.01% per hr.

The Decker Corp., Dept. ED, 45 Monument Road, Bala-Cynwyd, Pa.

Self-Tapping Set Screw 372

Due to the design of the cutting edges, this self-tapping set screw has a tendency to pull itself in. The screw can be used for sizing poorly tapped holes, for insertion in paint filled holes, and in standard applications. Slabbed, slotted, or socket heads are offered.

Hanson & Stevens, Inc., Dept. ED, 11 N. Wacker Dr., Chicago 6, Ill.

Temperature Control 470

Used as a high limit or controlling thermostat, this unit stands a vibration of 5 cps at 0.1 in. displacement on up through 200 cps at 20 g. It is a spst, normally open or closed unit with industrial applications. Temperature setting range is −65 to +325 F; it carries 3 amp at 32 v, grounded.

Therm-O-Stats, Dept. ED, Box 303, Chartley, Mass.

Price & Availability: *Made on order only; delivered 20 days after order received. Price varies between $1.25 and $2 when ordered in quantities of 100 and up.*

Soldering Pencil Iron 384

The Radioman weighs 2 oz and has an over-all length of 8.5 in. It is ULA approved. Tip temperature is 800 F.

Wall Manufacturing Co., Dept. ED, Grove City, Pa.

Metal and Wire Bender 375

This portable tool bends metal up to 1/8-in. thick x 1-1/4 in. wide at any length. It exerts up to 2000 lb of pressure.

The Hahn Co., Dept. ED, 2311 Fox Hills Drive, Los Angeles 64, Calif.
Price: $4.95 ea.

Amplifiers 377

Series USA-4 and K2 operational amplifiers are described in this short-form data sheet, one page. The data sheet contains brief technical data, photographs of the units and price information. George A. Philbrick Researches, Inc., 127 Clarendon St., Boston 16, Mass.

Wireways 607

The JIC, flanged hinged-latched-cover wireways line has been expanded by the addition of such components as: T fittings and pull boxes; cross pull boxes; junction boxes; telescope fittings; and trough collars.

Keystone Manufacturing Co., Dept. ED, Warren, Mich.

Eyelets for Printed Circuits 595

For printed circuits, USECO eyelets have a tolerance of 0.003 in. and are finished in gold or tin.

Litten Industries, Dept. ED, 13536 Saticoy St., Van Nuys, Calif.

Temperature Controller 718

Type E36N remote-bulb unit is suited for test equipment and plant processes. Range is 100 to 1,000 F. Three models are offered.

United Electric Controls Co., Dept. ED, 85 School St., Watertown 72, Mass.

Soldering Iron Holder 467

No. 8000 soldering iron holder, for production line use, protects the operator against hot-tip burns. It may be attached to the top of a bench, a wall, or the underside of a bench.

Ungar Electric Tools, Dept. ED, 4101 Redwood Ave., Los Angeles 66, Calif.
Price: $2.00.

NEW PRODUCTS

Copper Wire 463

This oxygen-free copper wire comes in round, square, rectangular, or flat form and in sizes of 0.002 in. in diameter and up. Called O. F. H. C., this wire can be annealed or welded in a reducing atmosphere.

Little Falls Alloys, Dept. ED, 189 Caldwell Ave., Paterson, N. J.

Cushion Packaging 464

For sensitive electronic equipment and instruments, the Hardi-Pads cut shock and vibration damage. A floating inner package is held firmly on all sides of the shipping container. Packages weighing 8 to 150 lb can be accommodated.

Hardigg Industries, Dept. ED, South Hadley Falls, Mass.

Vacuum Gage 465

This gage and controller measures from 0.001 to 20 microns of mercury in a continuous reading without switching the scope. The unit is self-starting from 760 mm to 0.001 micron. It provides on-off switching for operations within and outside the system.

Central Scientific Co., Dept. ED, 1700 Irving Park Road, Chicago 13, Ill.
Price: $249.50.

Lubricant For High Temperature Use 466

Anti-Seize lubricant is for use on metals operating at high temperatures. On soldering tip threads, it reduces seizure and breakage of tips.

Ungar Electric Tools, Dept. ED, 4101 Redwood Ave., Los Angeles 66, Calif.

Circle Template 649

The No. 540 decimal circle template contains 66 circles from 0.1 to 1 in. in diameter. Diameter sizes from 0.1 to 0.5 in. are in increments of 0.01 in., and from 0.5 to 1 in., in increments of 0.02 in. The template is made of matte finish plastic. It measures 6-1/8 x 8-1/8 in.

Rapidesign, Inc., Dept. ED, Box 429, Burbank, Calif.
Price: Unit price is $2.

Silver Solder Pot 473

Model 202 operates over a range of 1200 to 1700 F, requires 110 v, and has a built-in regulatory rheostat. The heating element is made to protect the windings from contamination by fluxes used in soldering.

Dee Electric Co., Dept. ED, 1101 N. Paulina St., Chicago 22, Ill.
***Price & Availability:** Price is $62; the unit can be delivered two days after receipt of order.*

Dry-Magnetic-Particle Clutch 714

This new, lightweight version of the 10-ft-lb Magneclutch, dry-magnetic-particle switch has faster response and longer life. Also offered are clutch units in sizes to 200 ft-lb, air-cooled or water-cooled.

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

Captive Panel Screw 474

Type 1805 is for panels 1/16, 1/8, and 3/16 in. thick. It is made of corrosion-resistant steel per QQ-S-763b; bushing is brass per QQ-B-626a finished with 0.0005-in. nickel plate.

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

Reflex Timer 475

These timers can be preset a week in advance and can make 144 switchings per day. They are suitable for start-and-stop industrial processes and control laboratory experiments. Relay capacity is 4 amp; dimensions are 7-1/2 x 7-1/2 x 5-1/2 in.; weight 5-1/2 lb.

Durant Sound, Inc., Dept. ED, 793 Lexington Ave., New York 21, N. Y.

Price: Approximately $100.00.

Wrench for Small Screws 715

This torque wrench is for precision instrumentation and electronic assemblies. It is used with screws less than 1/4 in.

Techni-Tool Products, Inc., Dept. ED, 3860 W. Slauson Ave., Los Angeles, Calif.

Price: Four wrenches and two screwdrivers are priced at $9.95.

Teflon Adhesive Treating Agent 716

The spot-bonding technique reduces the weight of adhesive and preserves the low-loss characteristics of Teflon. A treating agent is applied to the Teflon surface, a bonding agent is applied to the spots, and the components are assembled. The bonding agent can be used with metal, glass, and plastics, as well as Teflon.

Plastic Associates, Dept. ED, 2900 S. Coast Blvd., Laguna Beach, Calif.

Price: A kit containing the treating and bonding agents is priced at $8.

Insulation Tape 651

For use from −130 to +500 F, this insulating guideline tape requires only contact pressure for bonding. Standard sizes are 1.5 in. wide and 0.04 in. thick, 1.5 x 0.05 in., 1.5 x 0.06 in., 1.5 x 0.07 in. and 1.5 x 0.08 in. It can be used for color coding.

Minnesota Rubber Co., Dept. ED, 3630 Woodale Ave., Minneapolis, Minn.

NEW PRODUCTS

Transistor Clip 710

For vertical or horizontal mounting, this subminiature transistor clip is made of tempered beryllium copper and is finished with a flat black matte. The clip has a case of 0.3 to 0.324 in. in diameter. It fits medium-power, TO-5 transistor cases.

Atlee Corp., Dept. ED, 47 Prospect St., Woburn, Mass.

High-Temperature Motor 711

For use from −65 to +600 F, type HM420 motor, originally designed for aircraft use, has nickel-clad copper wire, insulated by glass impregnated with a special additive.

Airborne Accessories Corp., Dept. ED, 1414 Chestnut Ave., Hillside 5, N.J.

Tape Splicer 712

Model 219 permits rapid splicing of punched tapes for editing, mending, or correction. New information can be added and deletions can be made without loss of information. It can also clean clogged punch-holes.

California Technical Industries, Dept. ED, 1421 Old County Road, Belmont, Calif.

Sequence Timer 722

Model 4-23 provides an adjustable time span from zero to 45 min. Multiple switch closures can be provided to specifications. It is suited for missile experiment work.

Acton Laboratories, Inc., Dept. ED, 533 Main St., Acton, Mass.

Frames for modular installations 655

Type CPF-102 frames for modular multiple installations conform to the Prem-O-Rak Design. Adjustable panel mounting angles on the front and rear are tapped for 10-32 screws.

Premier Metal Products Co., Dept. ED, 337 Manida St., New York 59, N.Y.

Modular Console System 656

These 30- and 45-deg wedge frames make possible semi-circular arrangements for pedestal and rack frames. The units are designed to fit Prem-O-Rak console types CHF-101 and 102 and series F transmitter racks.

Premier Metal Products Co., Dept. ED, 337 Manida St., New York 59, N.Y.

Mica Capacitors 657

These silvered-mica button capacitors operate in the temperature range of −55 to +230 C, are rated at 200 wvdc, and have capacitance rating of 50 to 4775 pf.

Sangamo Electric Co., Dept. ED, Springfield, Ill.

Glass and Metal Sealing Alloy 658

Therlo, a glass and metal sealing alloy, is provided in a vacuum melted form. It has good ductility, is metallurgically clean, matches hard glass in expansivity, and can be used for virtually any sealing application.

Driver-Harris Co., Dept. ED, Harrison, N.J.

Silicon Rectifiers 659

These 12-amp silicon rectifiers, available in 1/2-in. hex ceramic-insulated or 7/16-in. hex styles, have piv ratings from 50 to 600 v.

Cornell Dubilier, Electric Corp., Dept. ED, Norwood, Mass.

Rolled Epoxy-Glass Tubing 660

Dilecto GB-125EFR rolled epoxy-glass tubing has the electrical and physical properties required of NEMA G-11 sheets. Suitable for military electronic equipment, the tubing is offered in ID's of 3/16 to 12-3/4 and OD's of 1/4 to 13-1/2 with a length of 38 in. and a wall thickness of 1/32 in.

Continental-Diamond Fibre Corp., Dept. ED, Newark, Del.

Metal Ball Contacts 661

These ball contacts are made of fine and coin silver, Conmet 4, Conmet 17, Conmet 43, and other headable materials. Standard sizes range from 0.028 to 0.188 in.

Contacts, Inc., Dept. ED, Wethersfield, Conn.

Insulation Tape 662

Temp-R-Tape TSP pressure-sensitive Teflon tape is for high-temperature use and is non-corrosive. Total thickness is 0.006 in. It accepts encapsulating resins and electrical varnishes. The tape comes in 0.5- to 1-in. widths in 18-yd rolls.

The Connecticut Hard Rubber Co., Dept. ED, 407 E. Street, New Haven, Conn.

Price & Availability: A 0.5-in. roll is priced at $8 ea. Delivery is from stock.

Aluminum Handles 585

These aluminum handles for electronic equipment are made with straight or diamond knurling and with indicator dots, straightline pointers or arrows.

Litton Industries, Dept. ED, 13536 Saticoy St., Van Nuys, Calif.

Lettering Equipment 586

For precise hand lettering, the adjustable Scriber provides for lettering from 1/8 to 1 in. in all 40 alphabets of the templets, which are also available. Lettering up to 2 in. can be produced in several of the templets.

The Letterguide Co., Dept. ED., 2709 O St., Lincoln, Neb.

Price: The Scriber is priced at $9.50. Templet prices range from $5.50 to $16.00 ea.

DESIGN DECISIONS

Featuring the clever and unusual in packaging, appearance design, and circuitry in electronic equipment.

Environmental Immunity Greater With Pre-Formed Capacitor Cases

PRE-MOLDED cases for miniature capacitors were found by one company to give the capacitors an environmental immunity greater than that available from customarily used dip-coated cases.

The company, Vitramon, Inc., also said the pre-molded cases offer the advantage of constant wall thickness. Varying wall thickness is a problem of dip-coating. Walls that are too thin can lead to operational failures.

The capacitors are potted in the cases. The company said this procedure eliminates cracking of the seal where the leads join the case. Such cracking is frequent with dipped cases.

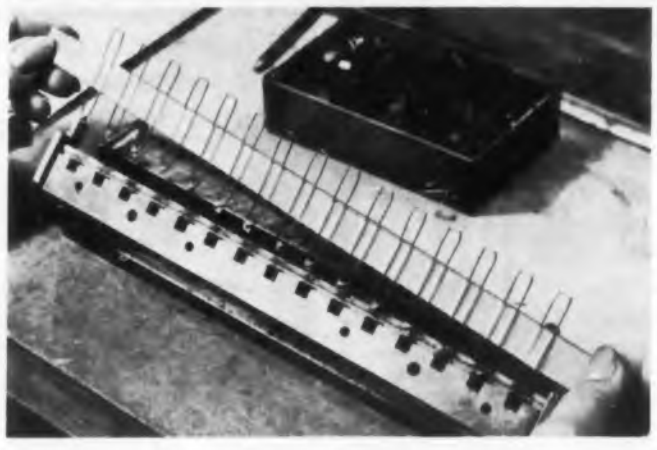
The cases are molded of diallyl phthalate resin. This material was chosen because its properties are unaffected by high temperature. It absorbs little moisture, has high resistance, good color stability, and a coefficient of expansion compatible with that of the potting compound.

The cases' high temperature resistance allows the capacitors to be used in printed circuit boards that are dip-soldered at 600 F.

The property of low-moisture absorbtion minimizes leakage currents. Good color stability permits the capacitors to be color-coated. The coefficient of expansion minimizes cracking of the bond between the case and the epoxy potting-compound.

The case's wall thickness is 0.015 in. The dimensions of the smallest case are 0.2 x 0.2 x 0.1 in. The cases could be made smaller. However, the company said, the increased use of circuit boards with grids of pre-drilled holes 0.1 in. apart makes further size reduction pointless.

One reason is that minimum standard distance between printed leads is 0.2 in.



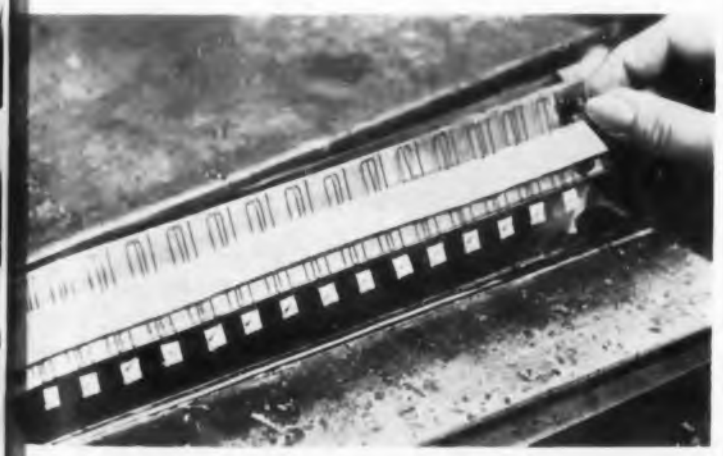
—the length of the capacitor. In addition, a thickness of 0.1 in. enables the capacitors to be mounted snugly between rows of other components, thus increasing the rigidity of the board.

Capacitors with pre-formed cases have withstood the following environmental conditions:

- Operation at 95 per cent relative humidity at 200 vdc.
- Alternate immersion in silicone oil at 160 C and water at 0 C for a minimum of 1/2 min in each bath.
- Vibration of the leads for 4 hr (on three mutually perpendicular axes) at 15 g from 10 to 2000 cps.
- Subjecting the leads to 100 g shocks of 1 msec duration in 3 mutually perpendicular axes.
- Operation at a minimum altitude of 100,000 ft and 150 per cent of rated voltage.
- Operation for 1000 hr at 150 C and 200 per cent of rated voltage.

The test to determine each environmental characteristic was made in accordance with the appropriate military specification.

The steps in the assembly of the capacitors are shown in the accompanying pictures. The pre-formed cases were made either by compression or transfer molding.



Procedure for assembling microminiature capacitors is as follows: (upper left) Wire leads are positioned in jig. Leads have sufficient tension to hold capacitor chips. (upper center) Capacitor chips (silver wafers separated by ceramic dielectric) are inserted onto leads. (upper right) Assembled capacitor chips and leads are dip-soldered. Units are coated with a silicone plastic to give moisture resistance. (lower left) Soldered units are inserted into preformed cases. Cases are half full of epoxy potting compound. Units are cured for 2 hr at 150 C, which partially sets epoxy compound. (lower center) Remaining space in case is filled with epoxy compound. Unit is cured for 24 hr at 150 C to set remainder of potting compound.

NEW LITERATURE

Infrared Radiation Detectors 261

Complete with diagrams, curves, and formulas, this four-page bulletin describes static and dynamic characteristics of thermistor bolometers, and also covers the various types of window materials available. A section on circuit design considerations is included. Servo Corporation of America, 111 New South Road, Hicksville, N.Y.

Thermosetting Laminated Materials 262

This engineering data chart of thermosetting laminated materials shows the principal grades and properties of each, with illustrations of component parts and sub-assemblies. Mechanical, electrical, physical and thermal properties of the laminates are listed, in addition to characteristics and applications for each combination. Comco Plastics, Inc., 98-34 Jamaica Ave., Richmond Hill 18, N.Y.

Low Torque Bearings 263

Features, applications, and low-torque performance information for the firm's electromagnetically powered ball bearing can be found in data sheet D-4. Outline drawings and dimension tables also appear. The Barden Corp., 200 Park Ave., Danbury, Conn.

High-Dielectric Ceramic 264

These five data sheets contain specifications and price lists for high-dielectric ceramic. Dissipation factor vs temperature is plotted on graphs. Mullenbach, Div. of Electric Machinery Manufacturing Co., 2100 E. 27 St., Los Angeles 58, Calif.

Metallized Glass Inductors

A description and an illustration of metallized glass inductors appear in this reference sheet. Also included are two curves showing typical Q vs frequency, a table showing minimum Q at measured frequencies for 27 nominal values, and a dimensional drawing. *Write on company letterhead to Corning Glass Works, Dept. ED, Bradford, Pa.*

Crimp-Type Connectors 265

A full line of plug-and-receptable connectors featuring crimp-type snap-locked contacts are described in this 52-page catalog, No. HYF-60. Charts, photographs, technical drawings are among the technical data presented. Burndy Corp., Norwalk, Conn.

(continued on page 146)

Temperature Conversion Chart For Thermoelectric Data

James R. McDermott
Electronics Consultant
McDermott Associates
New York, N. Y.

THE RECENT revived interest in thermoelectricity and thermoelectric devices is currently producing a substantial amount of significant engineering information. One problem, emerging as a byproduct, is the random use of three basic temperature scales; namely, Kelvin, Centigrade, and Fahrenheit. The scale quoted depends largely on the background of the individual expert, his organization, or both.

To permit rapid conversion between any of these three scales, the temperature conversion chart shown here, was developed. The scales are based on the following standard relations:

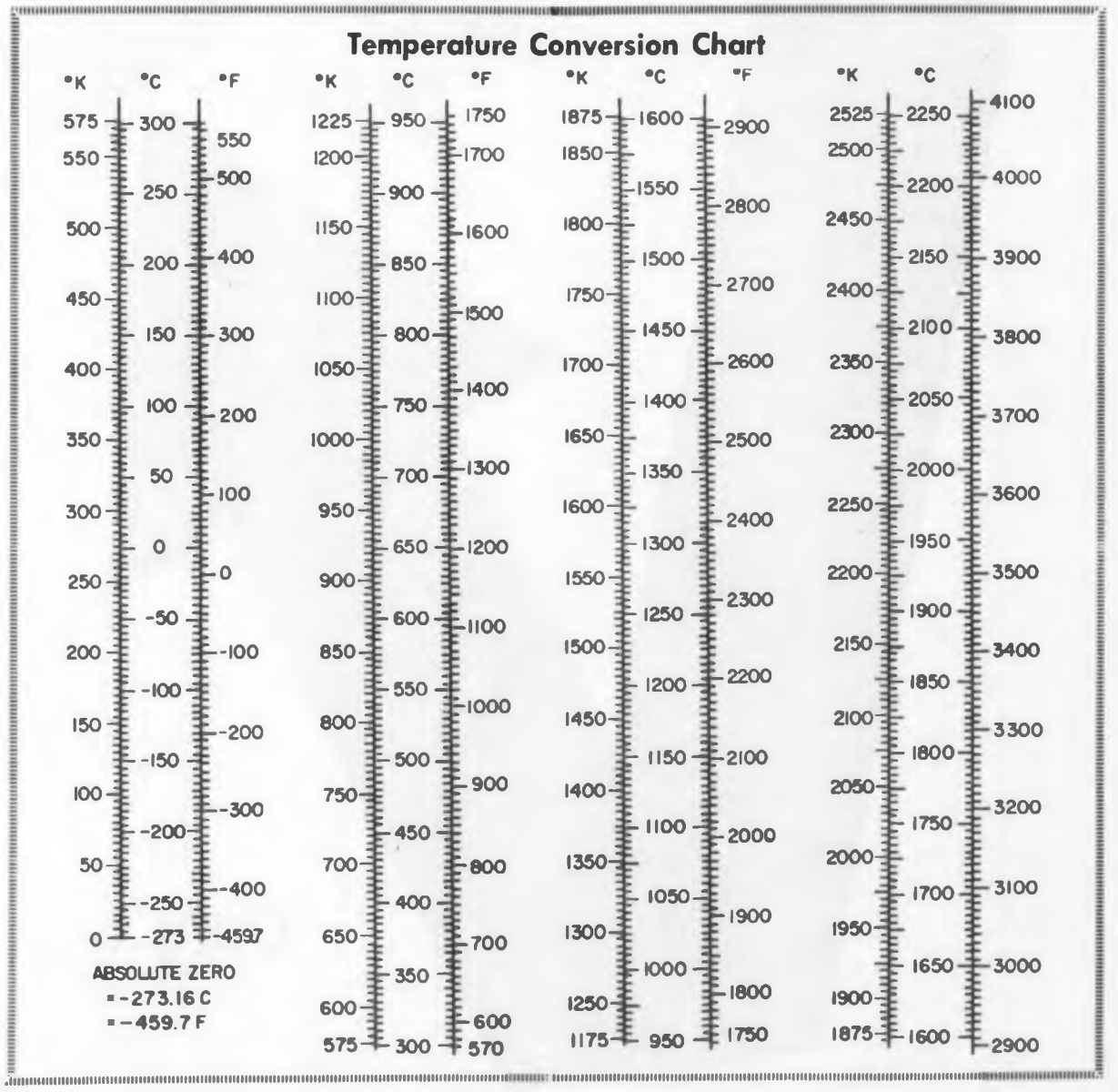
(1) Absolute zero = −273.16 C, −459.7 F, or 0 K.

(2) $F = (C \times 9/5) + 32$

(3) $C = (F - 32)\ 5/9$

(4) $K = C + 273.16$

To convert directly from F to K, lay a straight edge across the scales at the known value. In a limited number of instances, references to the Rankins (R) scale may appear. To convert, use the following formula: $R = F + 459.7$. ■ ■



NEW LITERATURE

Thermoplastic Coil Bobbins 266

Bulletin 3003, two pages, describes precision-molded coil bobbins available from stock and to specification. Engineering properties of the thermoplastics used—Nylon, Delrin, Kel-F, and Genetron—are provided, in addition to a special table on the electrical characteristics of Nylon. Bobbin design features are listed and illustrated. Gries Reproducer Corp., 400 Beechwood Ave., New Rochelle, N.Y.

Legend Light 267

A flush-mounting legend light for airborne or ground support applications is described in this catalog sheet. Radar Relay, Inc., 2322 Michigan Ave., Santa Monica, Calif.

Custom Extrusions

This 72-page brochure deals with custom extrusions. Included are several articles describing the design and application of extrusions and information about the firm's facilities. Property tables, descriptions of materials and over 700 cross-sectional diagrams are contained in the brochure. *Write on company letterhead to Anchor Plastics Co., 36-36 36 St., Long Island City 6, N.Y.*

Welding Process 268

This 12-page, illustrated catalog describes electron beam welding, the firm's newest welding technique. Covered are all the salient features, how the process operates, the principal advantages and the equipment required. A full page schematic drawing of the electron beam gun is included. Air Reduction Co. Inc., Air Reduction Sales Co. Div., 150 E. 42 St., New York 17, N.Y.

Rotary Thumbwheel Switch 269

Illustrations, dimensional drawings and complete technical data on the firm's rotary thumbwheel switch are contained in this two-page, two-color bulletin. Chicago Dynamic Industries, Inc., Precision Products Div., 1725 Diversey Blvd., Chicago 14, Ill.

Tantalum Capacitors 270

Bulletin GEA-7008A gives specifications for the firm's complete line of porous-anode capacitors. Performance characteristics and typical curves for polar units are included in this four-page bulletin. General Electric Co., Schenectady 5, N.Y.

(continued on page 148)

Characteristic Impedance Nomogram For Concentric Transmission Lines

David P. Costa
Mechanical Engineer
New York Naval Shipyard
New York, N. Y.

THE DESIGNER often must determine the characteristic impedance of a concentric transmission line.

Assuming perfect electrical conductors and lossless dielectric materials, this characteristic impedance can be calculated from the equation:

$$Z = \frac{138}{\sqrt{\varepsilon}} \operatorname{Log}_{10} \frac{D}{d}$$

where: Z = characteristic impedance, in ohms

ε = dielectric constant of material between conductors

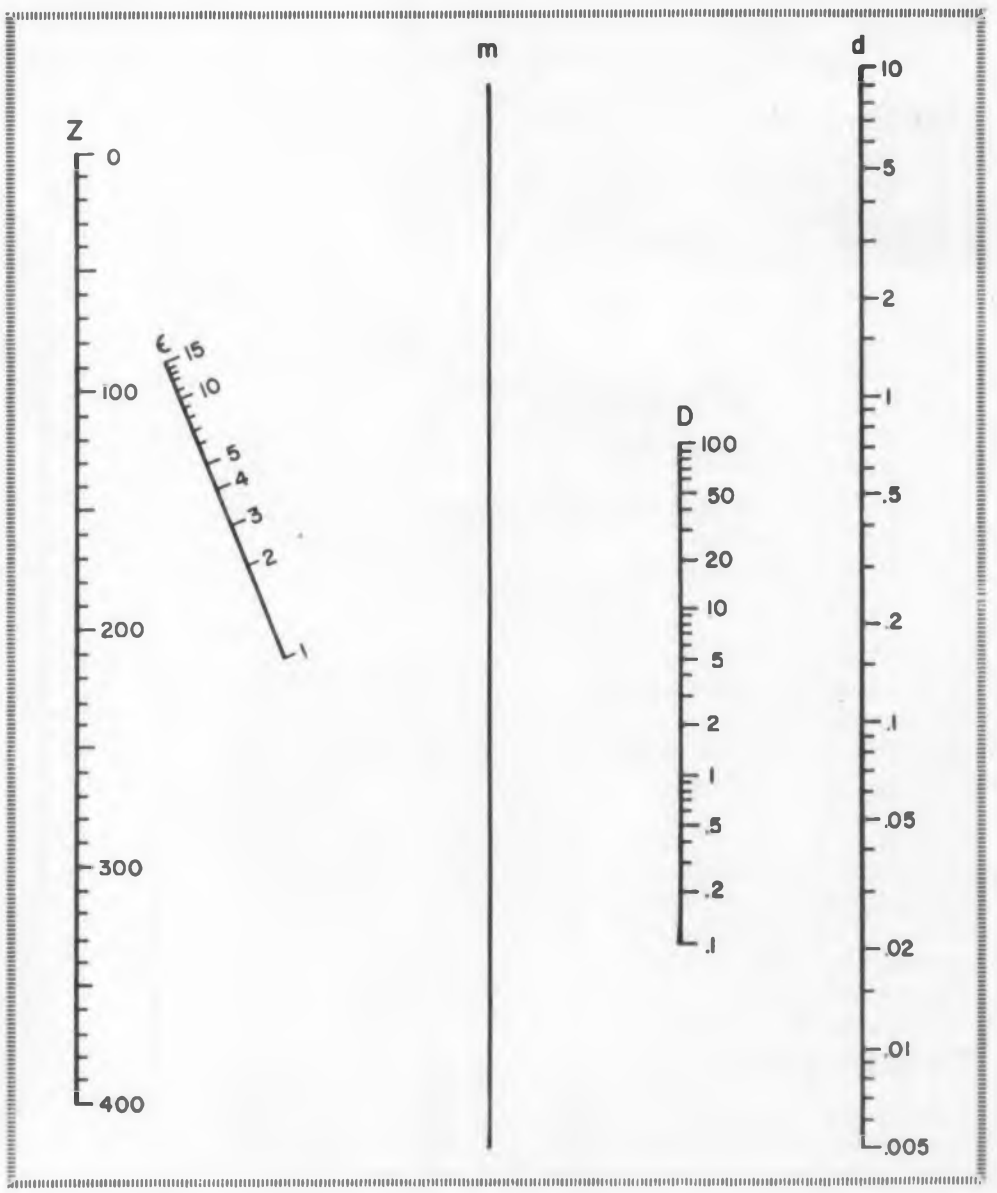
d = wire diameter

D = inner diameter of shield.

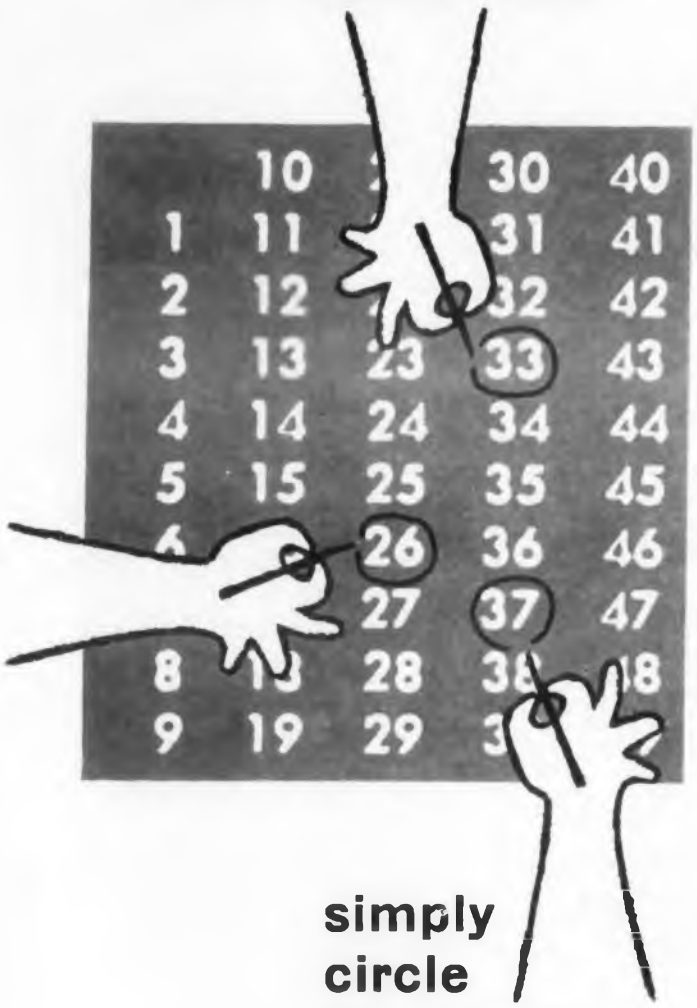
This nomogram gives solutions to the equation for any scale of dimensions.

Example: What is the characteristic impedance of a coaxial line if the wire diameter is 0.06 cm, the inner diameter of the shield is 0.85 cm and the dielectric constant of the material between conductors is 4.

Solution: 1. Connect d with D, intersect m. 2. Connect m with ε, intersect Z, and find Z equals 80 ohms. ■ ■



To Help Solve Your Design Problems



simply circle the numbers

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So, when seeking more information about products you've seen in advertisements or in our New Products Section, simply circle the Reader Service numbers. It's the fast way. The easy way.

CIRCLE 150 ON READER-SERVICE CARD

NEW LITERATURE

Vibration Transducer 271

The firm's type 4-123A vibration transducer for jet engine testing is described in this two-page data sheet, No. 1628. Application and construction information, outline drawings, tabulated specifications, and a characteristics chart are included. Consolidated Electrodynamics Corp., Transducer Div., 360 Sierra Madre Villa, Pasadena, Calif.

Silicon Stabistors 273

The firm's types STC-135 and STC-235 Stabistors for transistor bias, clipping and regulator applications are described in this two-page data sheet, No. 11-133. Characteristics and maximum ratings are tabulated; forward characteristics design curves and current derating curves are included. Silicon Transistor Corp., Carle Place, L.I., N.Y.

Global Communication 272

"Recent Developments and Applications of Kineplex" is the title of this 12-page reprint. Problems and requirements involved in global communication of digital data are considered, and the firm's techniques and equipment are described. Block diagrams accompany the text, and capabilities of the firm's instruments are tabulated. Collins Radio Co., Western Div., 2700 W. Olive Ave., Burbank, Calif.

Counter Tubes

Construction, operational and application data on decade counter tubes is given in this nine-page handbook. Specifications and typical operating characteristics of the tubes are tabulated. Circuits for a short-pulse driver, a modified deuce-minimum circuit, a 100-kc drive circuit, and an addition-subtraction circuit are included. *Send 15 cents to Sylvania Electric Products, Inc., Dept. ED, 1100 Main St., Buffalo, N.Y.*

Size 8 Servomotor 274

Data Sheet No. 60250, four pages, gives performance data for model 8 SM 461, Size 8 servomotor. Electrical specifications, dimensional drawings, torque-speed curves, and construction data are included. Helipot Technical Information Service, 2500 Fullerton Road, Fullerton, Calif.

Transistorized Chopper 275

The firm's model 65 plug-in, transistor chopper, which operates to 30 kc, is described in this two-page data sheet. Electrical and mechanical data are accompanied by curves and diagrams. Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif.

Transistor Checkers 276

This one-page data sheet describes the firm's model 1003 transistor checker. Operation and specifications of the portable device are given. Dynatron Laboratories, 71 Glenn Drive, Camarillo, Calif.

Transistorized Chopper 277

The firm's model 30, miniature, transistorized chopper is described in this two-page data sheet. Mechanical and electronic data, a typical test application circuit diagram, and operating characteristics are included. Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif.

Carrier Amplifier System 278

Two-page Bulletin, No. 1127, describes a 20-kc carrier amplifier system for high-speed transient studies. Operation and applications are discussed: photographs and specifications are included. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

Trimmer and Tuner Chart 279

A listing and description of variable trimmer piston capacitors and L-C tuners is given in this two-page comparison chart. Electrical properties are tabulated. JFD Electronics Corp., 6101 16th Ave., Brooklyn 4, N.Y.

NEW LITERATURE

Binary Encoder 280

Specifications of model E-101 modular binary encoder are given in two-page Bulletin, No. 124. The unit operates from 0 to 65 C. A dimensional drawing is included. Datex Corporation, 1307 S. Myrtle Ave., Monrovia, Calif.

Transistorized Choppers 281

The firm's models 40 and 40P silicon transistor choppers are described on this two-page data sheet. Mechanical and electrical data, typical operating characteristics are given. Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif.

Selenium Rectifier Bridge 282

Bulletin F-313, two pages, describes a selenium rectifier bridge rated at 155 v, 90 ma. Dimensional diagrams and mounting instructions are included. Radio Receptor Co., Inc., 240 Wythe Ave., Brooklyn 11, N.Y.

Ramp Test Set 283

Model PBN portable, transistorized ramp test set is described in this four-page bulletin. Applications and principles of operation of the device in testing TACAN and DMET receivers are included. Electrical and mechanical characteristics are given. International Telephone and Telegraph Corp., Federal Div., 100 Kingsland Road, Clifton, N.J.

Real Root Evaluation 284

This 27-page booklet, No. U-1888, contains a program for the Univac 120 computer for evaluating real roots. Part one covers theory of the Newton Raphson method, algebraic equations, and synthetic division, descriptions of decimal operations and an illustrative application. Part two covers card design, operating procedure, flow charts, coding and selector structure, and program charts. Remington Rand, 315 Park Avenue South, New York 10, N.Y.

Sinusoidal Oscillator 285

The firm's model S-200 silicon-transistor, sinusoidal oscillator with a 25 to 100,000 cps range is described in this two-page data sheet. Mechanical data, electrical and physical characteristics are given. Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif.

Capacitors and Relays 286

This four-page Bulletin, No. 2, catalogs General Electric's Tantalytic capacitors and microminiature relays. Voltage tables and photographs are included. Relay coil data are tabulated. Schweber Electronics, 60 Herricks Road, Mineola, L.I., N.Y.

Delay Lines 287

A single-page data sheet tabulates specifications of lumped-constant, phase- and frequency-compensated delay lines. Characteristic impedance, time delay, rise time and size are given for 36 types. Allen Avionics, Inc., 255 E. 2nd St., Mineola, N.Y.

Magnetic Components 288

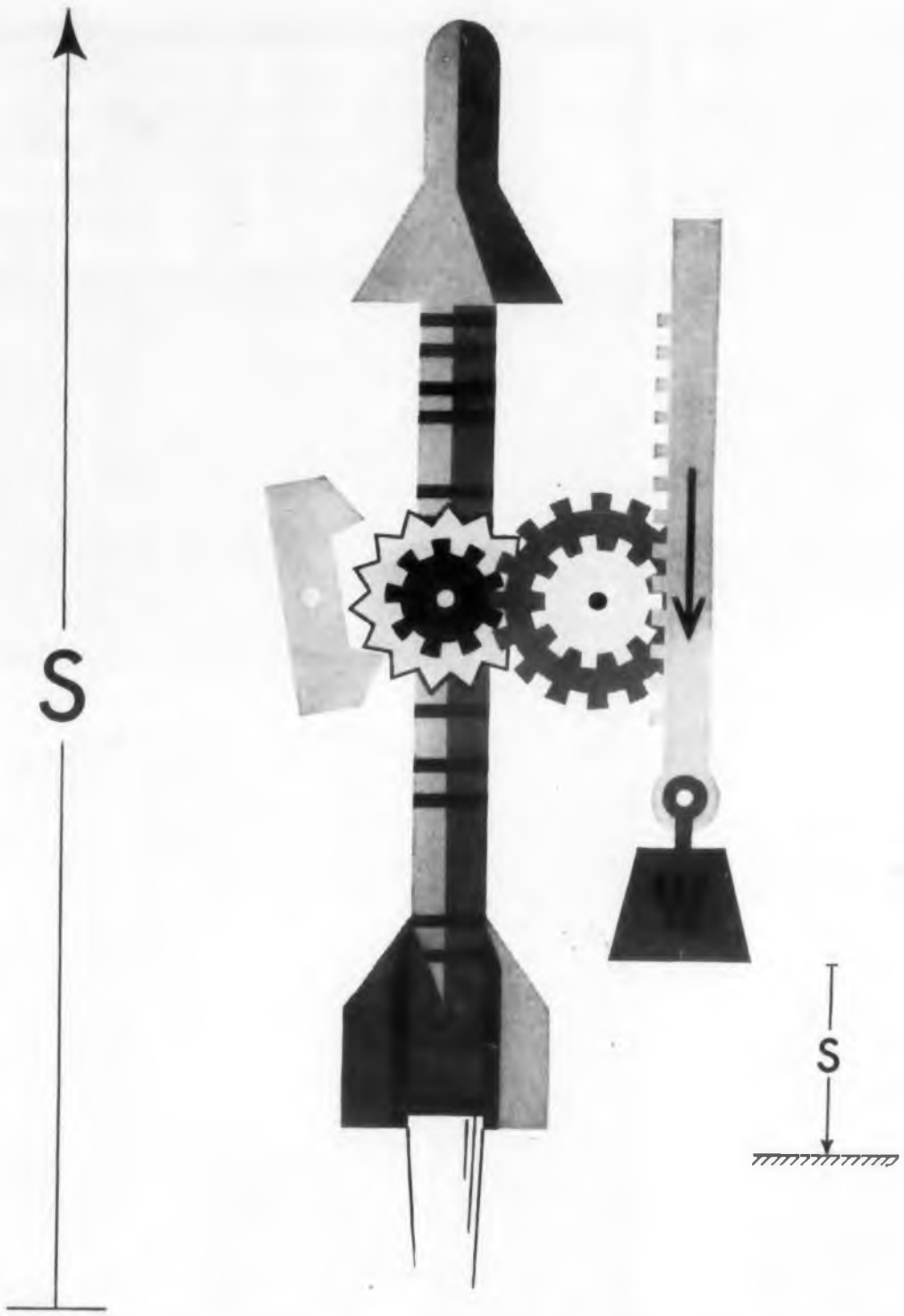
This catalog covers the firm's regular line of subminiature and standard toroids, filters, laminated transformers, magnetic amplifiers and special packages for printed circuitry. Performance curves and dimensional drawings are included. Communication Accessories Co., Lee's Summit, Mo.

Acceleration Switches 289

Bulletin No. 04591-4, two pages, tabulates specification, test, and performance data for eight uni-directional and bi-directional damped-type acceleration switches. W. L. Maxson Corp., Instruments Div., 475 Tenth Ave., New York 18, N.Y.

Facsimile Equipment 290

Several facsimile transmitters and recorders for both fixed and mobile operation, and various accessories, are described and illustrated in this four-page bulletin. Westrex Corp., Communications Equipment Dept., 540 W. 58th St., New York 19, N.Y.



Bulova escapement used as an integrating accelerometer

Bulova's unusually creative teams of scientists and engineers play an ever increasing role in the vanguard of precision design and development. Consider the nature of a Bulova escapement; it's generally employed as a second-order integrating accelerometer. However, the basic mechanism lends itself equally well to rotational motion of unbalanced rotors in an accelerating field.

The drawing above shows an inertial element, or weight, coupled to a runaway escapement by a rack. A safe-arm latch locks the system until missile launch. Under acceleration the escapement will delay the weight from moving through its stroke, s, according to the following:

$$(1.) \qquad t = \sqrt{\frac{K}{ag}}$$

Where t is the time for the weight, W, to traverse its stroke, s, under an acceleration a, K is the mechanism constant which takes into account the gear ratio; the moment of inertia of the system as reflected at the pallet wheel; and the number of pallet cycles involved during stroke s.

If the acceleration is constant, the change in distance of the missile during t is

$$S = \frac{1}{2} agt^2$$

or

$$(2.) \qquad t = \sqrt{\frac{2S}{ag}}$$

Equating (1) and (2)

$$\sqrt{\frac{2S}{ag}} = \sqrt{\frac{K}{ag}} \qquad S = 2K$$

It is thus evident that, for a given escapement with a given stroke, the distance integrated is constant, and is independent of acceleration.

Bulova developments in the field of time measurement are particularly significant because they advance the state-of-the-art with existing systems and elements . . . with existing components of proven reliability and accuracy. But, continuing study of new concepts keeps Bulova systems years ahead—ready to meet the future needs of both the military and industry.

BULOVA

Research & Development Laboratories, Inc.
62-10 Woodside Avenue, Woodside 77, N. Y.

CIRCLE 158 ON READER-SERVICE CARD

NEW LITERATURE

Acceleration Switches 291

Engineering specifications and performance data of seven snap-action type acceleration switches are summarized in this two-page bulletin. Manual, automatic and dual type switches are also described. W. L. Maxson Corp., Instruments Div., 475 Tenth Ave., New York 18, N.Y.

Impulse Counters 292

This six-page, two-color bulletin describes the firm's series of small electric impulse counters. Operating information, electrical data and dimensional drawings are included. A section gives details for operation on ac. Landis & Gyr, Inc., 45 W. 45 St., New York 36, N.Y.

Tantalum Capacitors 293

Capacitors described in this bulletin, No. GEA-7085, have plain or etched foil construction. The smaller-case Tantalytic foil capacitors meet requirements of Mil specifications. Data charts and life test tables are included in this four-page brochure. General Electric Co., Schenectady 5, N.Y.

Micromodule Resistor Elements 294

This one-page bulletin, No. 1007, offers dimensional drawing and a magnified illustration of the firm's metal-film resistor elements. These elements, used in micromodule circuit assemblies, have a packaging density of as high as 600,000 parts per cubic foot. Ohmite Manufacturing Co., 3678 Howard St., Skokie, Ill.

Transistor Testing Equipment 295

The Itvac family of automatic test and classification equipment for semiconductor devices are described in this four-page, two-color brochure. Included in this illustrated pamphlet is a listing of tests performed and test limits available. Industro Transistor Corp., 35-10 36 Ave., Long Island City 6, N.Y.

Audio Bandpass Filters 296

Typical characteristics of six audio bandpass filters designed for alternate band separation use are tabulated on data sheet No. 701. High off-passband impedances of the filters permit parallel inputs without adverse effects on other circuitry. Bandwidth, frequency range, shape factor and size are given for models BF115 through BF120. Control Electronics Co., Inc., 10 Stepar Place, Huntington Station, L. I., N. Y.

Computer Paper Tape Accessories 297

This two-page, illustrated data sheet describes three paper tape accessories for the firm's G-15 digital computer. Dimensions, operating specifications and suggested applications of model PR-1 auxiliary photoelectric paper tape reader, Model PR-2 multi-code high speed tape reader, and Model PTP-1 auxiliary paper tape punch are included. Bendix Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif.

Coils 298

Specifications on over 600 coils and complete application are contained in this 28-page type catalog. Every coil type in general use is covered by the inclusion of 79 schematic diagrams. Chicago Standard Transformer Corp., 3500 W. Addison St., Chicago 18, Ill.

Synchros 299

Two four-page bulletins, Nos. 204 and 206, describe the firms' size 8 and 11 synchros respectively. Engineering data in tabular form lists technical specifications and characteristics, including input and output voltages, accuracy, shaft configurations, sensitivity, resistance and impedance. Induction Motors of Calif., Dept. S1, 6060 Walker Ave., Maywood, Calif.

Silver-Zinc Batteries 300

The firm's Silvercel battery system for missile applications is described in this illustrated eight-page Bulletin No. Z-101. Data listed includes electrical, physical, environmental and typical application characteristics, and discharge curves. Yardney Electric Corp., 40-50 Leonard St., New York 13, N. Y.

Graded Instrument Gears 301

A catalog of stocked gears graded for quality, material and price is being offered. Gears range in pitch from 20 to 120, with composite tooth error of 0.002, 0.0015, 0.001, and 0.0005 available in steel, brass and aluminum. Armac Gears Div., Franke Gear Works, 4401 N. Ravenswood Ave., Chicago 40, Ill.

Absolute Level Mounts 302

This four-page brochure describes the Servalevl mount as a means of maintaining precisely constant level under changing load conditions. Operation of the compressed-air support and an example of its application are included. Barry Controls, Inc., 700 Pleasant St., Watertown 72, Mass.

IDEAS FOR DESIGN

Get $10.00 plus a by-line for the time it takes you to jot down your clever design idea. Payment is made when the idea is accepted for publication.

Cascode Amplifier Stage Extends Receiving Tube Use

By combining a cascode stage with degeneration, small receiving tube types can be designed into circuits where considerations of voltage swing and power output would ordinarily preclude their use.

In the circuit shown, the feedback path to the grid of V_2 is of sufficiently low resistance to pass most of the load current when the series combination of the two tubes causes the load voltage to be at a minimum.

When, on the other hand, the load voltage is at its maximum value, and the tube voltage is at a minimum, the shunt path will contribute little current. However, tube dissipation is small due to the low voltage. Because of the series arrangement, the hold-off voltage rating is doubled.

For a typical design, $R_{s1} = R_{s2} = 1/2\ R_s$, and $K = 1/2$. Both tubes operate at substantially the same point and $\mu_1 = \mu_2 = \mu$, $r_{p1} = r_{p2} = r_p$, and $K = R_{s2}/(R_{s1} + R_{s2})$

Under these circumstances

$$G = -\frac{\dfrac{\mu\,(1+\mu)}{r_p\,(2+\mu)} \cdot \dfrac{R_s\,R_L}{R_s + R_L}}{1 + \dfrac{(1+K\mu)\,\dfrac{R_s\,R_L}{R_s + R_L}}{r_p\,(2+\mu)}}$$

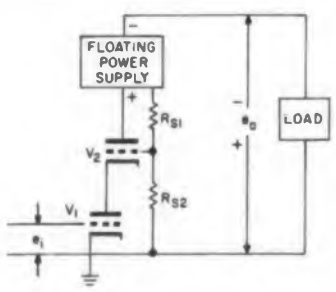
"A" = *Forward Gain*

$$= \frac{\mu\,(1+\mu)\,\dfrac{R_s\,R_L}{R_s + R_L}}{r_p\,(2+\mu)}$$

"AB" = *Feedback Return Ratio*

$$= \frac{(1+K\mu)\,\dfrac{R_s\,R_L}{R_s + R_L}}{r_p\,(2+\mu)}$$

For loads with a constant current characteris-



A cascode stage combined with degeneration extends receiving tube types usable in power output stages.

tic, such as backward wave oscillator tubes, $R_L \rightarrow \infty$, and the gain becomes

$$G' = -\frac{\frac{\mu\,(1+\mu)}{r_p\,(2+\mu)} \cdot R_s}{1 + \frac{(1+K\mu)\,R_s}{(r_p+2\mu)}}$$

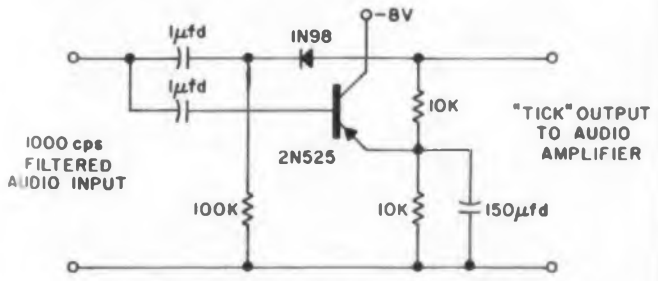
George M. Strauss, Section Manager, The W. L. Maxson Corp., New York 18, N. Y.

Biased Base Clipper Isolates WWV "Tick" Tone

We wanted to obtain the seconds "ticks" of station WWV without any other frequencies being present. The "ticks" from WWV consist of 5 msec of 1,000-cps tone. In the application, the output from the WWV receiver was first passed through a 1,000-cps filter. This didn't prove to be quite satisfactory since the other tones that WWV transmits (440, 600 cps) were still audible, although at a lower level.

After some breadboard experimenting we came up with the circuit shown in the figure. Here, the 1N98 diode and the 2N525 transistor form essentially an automatically biased-base clipper. The audio signal input is rectified and filtered by the transistor and the large capacitor in the emitter circuit. The output across the 10-K resistor in the emitter of the transistor is dc or slowly varying ac. This slowly varying ac is applied to the diode so as to reverse bias it.

The amplitude of the "tick" output from the 1,000-cps filter is always quite a bit larger than the other tones, although all of the tones vary in amplitude according to the strength of the WWV signal and noise. When a "tick" comes in, the bias voltage can't respond quickly enough and the "tick" passes through the diode to the final audio amplifier. The 440- and 600-cps tones are on for a longer period of time than 5 msec. Because these other unwanted modulations create a back bias on the diode, they do not appear in the output.



Short-duration 1,000-cps "ticks" ride through, but the longer, unwanted signals are squelched by the back-biased diode.

Thomas E. Fay, Electrical Engineer, Mechanical Div. of General Mills, Inc., Minneapolis 13, Minn.

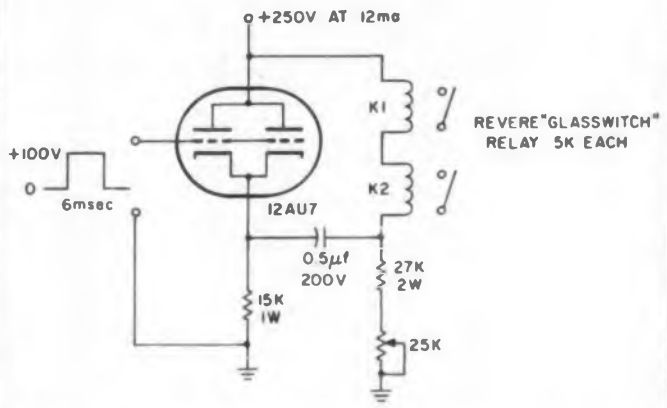
IDEAS FOR DESIGN

Driver Closes Relays Rapidly With Almost Bounceless Contacts

A circuit was needed which would open two normally-closed relays for periods of about 6 msec, 5 times per sec. A +100-v pulse was available for control. The circuit shown opens the relays with 1 msec after the beginning of the control pulse and closes them within 1/2 msec after the pulse termination. Contact bounce time is limited to less than 1/4 msec.

Normally, the bleeder current is great enough to keep the relays closed. The capacitor-coupled, positive 100-v pulse from the cathode follower causes them to open by reducing the relay voltage to a low value.

During the 6 msec time of the 100-v control pulse, charging of the coupling capacitor causes the relay voltage to increase gradually to a value just insufficient to cause closure. This value is determined by adjustment of the 25 K potentiometer. Upon the termination of the control pulse, the negative-going signal, coupled through the capacitor, causes rapid and firm closure of the relay contacts. In the relay used (Revere Glaswitch type), absence of bounce seems due to the fact that the reed-type relay contacts are brought very close together by the smoothly-increasing coil voltage during the "off" time. When the control pulse ends, there is not enough contact movement to the closed position to generate the impact forces that cause bounce.



Relays are opened with application of positive pulse to cathode follower; closed on negative-going pulse termination.

K. C. Herrick, Systems Engineer, Reflectone Electronics, Inc., Stamford, Conn.

Diode Forward Voltage Drop Clamps Outputs to Zero

The outputs of a paralleled cathode follower were referenced to zero by clamping them to the

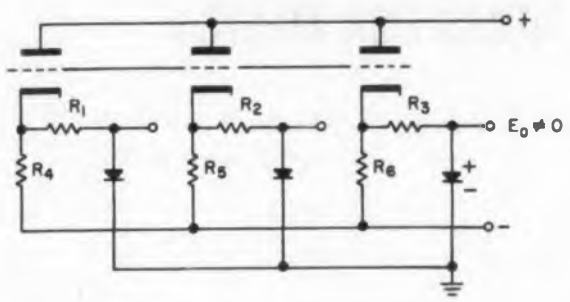


Fig. 1. Diode clamps hold outputs at the diodes' forward voltage drop (assumed equal).

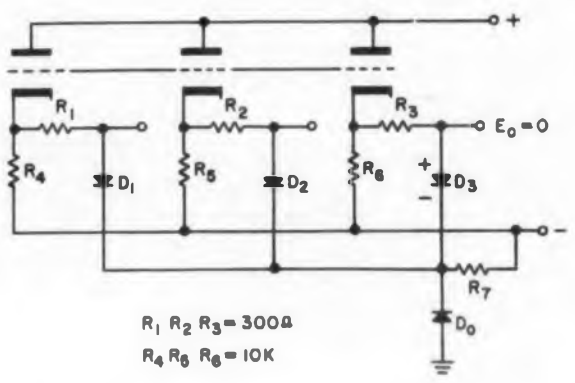


Fig. 2. Cathode voltage of D_0 is equal to the negative of the clamping diodes' forward drop. Outputs are thus referenced to zero.

forward voltage drop of a diode, instead of to ground.

Diodes connected directly from the outputs to ground, Fig. 1, reference the outputs, not to zero, but to the diodes' positive forward voltage drop. It is assumed that the diodes are operating past the knees of their characteristic forward conduction curves so that these forward drops are equal. (Operation below the knee may cause their forward drops to differ by an objectionable amount because of the greater dissimilarity between characteristic curves.)

The outputs are held at zero by returning the clamping diodes to the potential derived from the forward conduction of diode D_0, Fig. 2. This diode is of the same type as the others. Thus, diodes D_1, D_2 and D_3 are connected to a negative voltage equal to their own forward voltage drops. The outputs of the cathode followers are, then, at zero volt.

Typical values for a 12AU7/5814 driver are shown in Fig. 2. The current through D_4 equals the sum of the currents flowing in diodes D_1 through D_3. Clamping resistor sizes must be selected to restrict the current to below the maximum permissible forward current.

This clamping method has found application in the zero clamping of analog voltage generators and in output cathode follower stages.

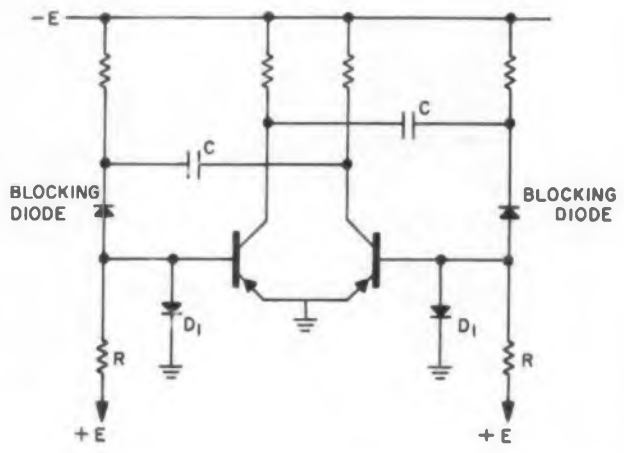
V. J. Kaneski, Senior Engineer, Melpar Inc., Falls Church, Va.

IDEAS FOR DESIGN

Blocking Diodes Stabilize Multi Frequency Against I_{co}

Transistor multivibrator circuits can be stabilized against the effects of the transistor reverse leakage current, I_{co}, by inserting blocking diodes as shown in the figure.

By preventing I_{co} from flowing into the timing circuit, variations in multivibrator frequency as the operating temperature is increased are avoided. Resistor R passes I_{co}, blocked from flowing into timing capacitor C, to ground and holds the transistor off. Diode D_1 clamps the base of the off transistor to near ground. This prevents resistor R from pulling the base so far off that the blocking diode will conduct prematurely. Except for the action of these new components in blocking I_{co}, the circuit operation is conventional.



Blocking diodes prevent transistor reverse leakage current, I_{co}, from charging the timing capacitor C. Multivibrator frequency is kept constant as ambient temperature varies.

Roy P. Foerster, Group Engineer, The Martin Co., Baltimore, Md.

Fabrication From Plastic Clay Speeds Microwave Matching

In the matching of various microwave components, it is often necessary to optimize the matching structure used by a "cut and try" process. Since each "try" involves a machining operation, the matching process can be very time consuming.

If, however, the matching structure is shaped from plastic clay, inserted in the waveguide component, and quick drying silver paint applied to it, the clay structure will effectively simulate a metallic matching structure. When a clay structure is found that is approximately correct, a

permanent metallic duplicate can be fabricated.

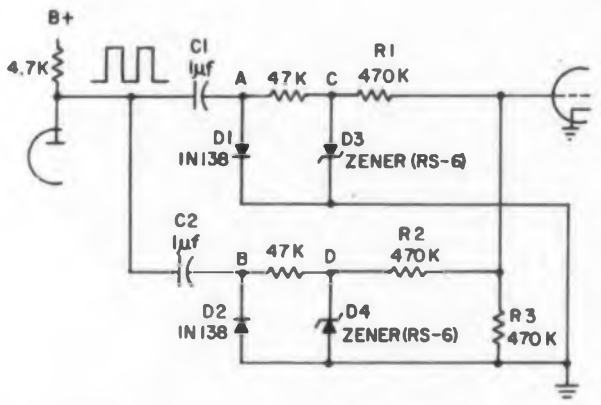
The plastic clay used was "Plasticine" made by Harbutt's Plasticine Ltd., Bath, England. The silver paint was Silver Paint No. 378, made by Handy and Harmon, 82 Fulton St., New York 38, N. Y.

E. Kramer, Senior Electronic Engineer, Emerson Research Laboratories, Silver Spring, Md.

"Inside-Out" Limiter Supplies Constant Amplitude Square Waves

Simple limiters and clippers are often required for communication equipment. However, their use is sometimes precluded by the bulk of the low-pass filter required to remove the higher frequency components generated. The "inside-out" clipper shown in the figure is an economical and compact circuit, which at normal clipping levels eliminates the need for a low-pass filter.

Diode D_1, capacitor C_1 and the effective shunt resistances comprise a negative clamp, clamping the signal at point B in the positive direction. As long as the magnitude of the signal at points C and D is less than 6 v, Zener diodes D_3 and D_4 act as high resistances and allow undistorted signals to be summed in the resistive network R_1, R_2 and R_3. Signals which produce peak voltages at points C and D in excess of -6 and $+6$ v respectively are clipped. Zener diode D_3 removes the negative peaks of the input signal in the upper channel, while Zener diode D_4 removes the positive peaks in the lower one. Summing the signals of both channels results in a wave with the center section removed. Each channel's output is joined in the summing circuit to form a continuous wave of 4 v peak-to-peak maximum amplitude, regardless of the input signal's magnitude.



The upper and lower peaks of the square wave input are clipped, by Zener diodes D_3 and D_4, to the values determined by their breakdown voltage.

Herbert L. Hardy, Research Physicist, American Machine & Foundry Corp., Central Research Laboratory, Stamford, Conn.

PATENTS

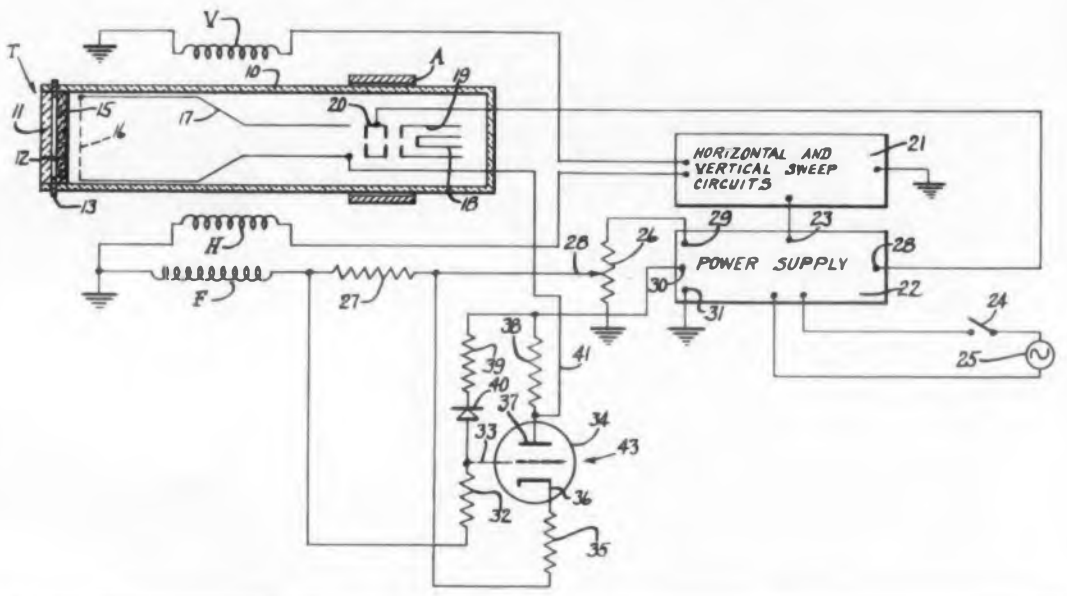
Benjamin Bernstein

Automatic Focusing Circuit

Patent No. 2,939,042, G. H. Fathauer. (Assigned to Thompson Ramo Wooldridge)

In a Vidicon camera, beam focus is maintained by sensing the change in current through the magnetic focus coil. This automatically adjusts the electrostatic focus in the proper sense. The circuit components are tabulated.

The current to focus coil *F* is drawn through resistor *27*, located in the grid-cathode circuit of amplifier *34*. With the tube initially biased through Zener diode *40*, a change in voltage across resistor *27* is metered by plate resistor *38*. The potential on electrode *16* is adjusted to maintain the focus of the electron beam in camera tube *10*.

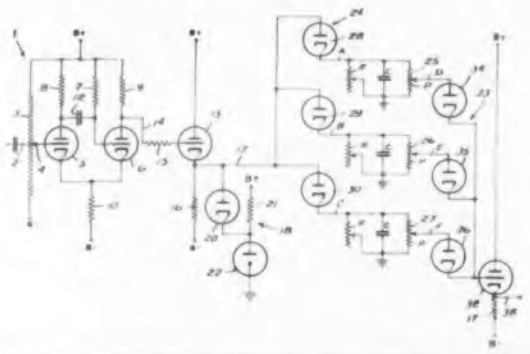


Electronic Function Generator

Patent No. 2,939,082, N. Nesenoff. (Assigned to Sperry Rand Corp.)

The function generated is a composite of the maxima of outputs of separate waveform generators. Each individual network couples through a diode; the cathodes of the diodes are joined to select the instantaneous maxima.

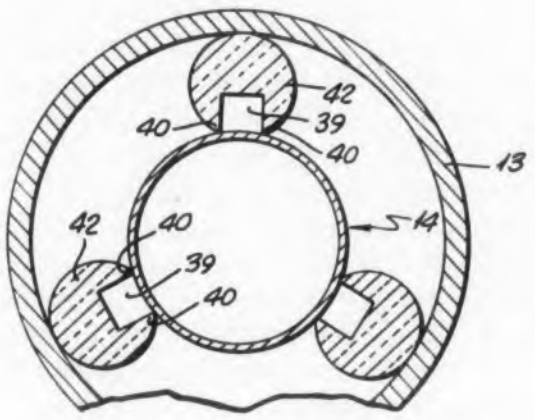
An array of RC waveform networks is driven by a pulse of constant amplitude generated by multivibrator *1* and diode clamp *20*. At any instant, because the cathodes of diodes *34*, *35*, and *36* are joined, the diode which receives the highest voltage will cut the other diodes off. Thus, the generated voltage is the summation of the largest portions of the voltages appearing on the diodes.



High Frequency Energy Interchange Device

Patent No. 2,922,067, R. M. Van Dien. (Assigned to General Electric)

A TWT helix is cooled by conducting the heat through sapphire supporting rods which contact the inner wall of the metallic tube body. The rods are slotted to form line contact with the helix and to reduce dielectric loading.



Helix *14* is positioned by dielectric rods *42* which contact the body wall *13*. Slots *39* are cut to remove the dielectric in the regions where the electric fields are high. The structure can be made more rigid by brazing along contact lines *40*.

BOOKS

Electronic Processes in Solids

Pierre R. Aigrain, Roland J. Coelho and Gianni Ascarelli, The Technology Press of The Massachusetts Institute of Technology and John Wiley & Sons, Inc., New York, N.Y., 67 pp.

Based on a series of lectures by Dr. Aigrain at MIT, this book presents the physical background needed for the study of electric conductive phenomena in crystals. It is intended for persons who have a background in calculus and wave mechanics. Band theory and transport theory in covalent semiconductors are presented on a level between detailed original work and an elementary treatment. The thermodynamic approach to transport theory and "hot electrons" problems are included in the text.

How to Use Meters

John F. Rider and Sol D. Prensky, John F. Rider Publisher, Inc., 116 W. 14th St., New York, N.Y., 210 pp, $3.50. (Second edition.)

A practical book for the engineer or technician, this revised edition covers the most common meter types and includes the latest advance in measuring devices. Such developments as transistorized voltmeters, laboratory instruments with increased sensitivities, long-arc meter scales, and digital displays are discussed.

The point of view maintained is that the basic principles behind these instruments must first be understood. Tables, diagrams, and illustrations are provided. Very little mathematics is used.

Ideas For Management

W. R. Amos, Editor, The Systems and Procedures Association, 4463 Benobscot Bldg., Detroit, Mich., 573 pp.

Taken from the proceedings of the Twelfth International Systems Meeting, the articles in this book are of interest to those involved in the administration of personnel. Case studies show how problems in efficiency and productivity can be solved.

Electronic Computers

Principles and Applications (second edition), T. E. Ivall, Philosophical Library Inc., 15 E. 40th St., New York 16, N.Y. 259 pp, $15.

The book is intended as a non-mathematical introduction to the principles and applications of computers. Written for engineers and students, the book includes some chapters that can be understood by the layman. The bulk of the text describes the circuitry and construction of digital and analog computers. Considerable emphasis is also placed on application to automation techniques in industry and on computing techniques used in research and design work.

To include recent developments, most of the book has been rewritten since the first edition was published in 1956.

Epoxy Resins: Market Survey and Users' Reference

Harvard Business School Graduate Students, Materials Research, Box 363, Cambridge 39, Mass., 175 pp, $18.50.

Though written from the standpoint of the businessman or the market research analyst, this report covers technical as well as economic considerations involved in the various uses of epoxy resins. Also provided are background material on the epoxy-resin industry and growth and changes expected in the next few years.

The Users' Reference, subdivided by application, gives technical specs of applicable epoxy resins, costs involved, and examples of problems solved by particular companies.

BOOKS

Progress in Dielectrics, Vol. II

I. B. Birks, Editor, John Wiley & Sons Inc., New York, N.Y., 225 pp, $9.50.

This book is the second in an annual series for the engineer or physicist who needs up-to-date information on dielectrics. This volume deals with dielectric properties in weak electric fields. Specific topics covered are: theory of polarization and absorption in dielectrics, dielectric properties of polymeric systems, dielectric properties of glass, high-permittivity ceramics for capacitors, and artificial dielectrics. The articles, drawn from international sources, are in English.

Getting The Most Out Of Vacuum Tubes

Robert B. Tomer, Howard W. Sams & Co., Inc., The Bobbs-Merrill Co., Inc., 1720 E. 38th St., Indianapolis 6, Inc., 160 pp, $3.50.

The thesis of this book, which is primarily of interest to the technician, is that most premature tube failures can be prevented through proper maintenance. It also covers the most common causes of failure in vacuum tubes. A glossary of terms is included.

Electrical Systems Design

Joseph F. McPartland, McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N.Y. 208 pp, $7.75.

A reference for practicing engineers, this book presents the standards of electrical systems design found in current use. It covers power, light, heat, air conditioning, signals, and communications systems. The engineering and applications of such systems in commercial, industrial, institutional, and residential buildings are explained.

Step-by-step procedures, complete with diagrams and illustrations, are given. This revised edition includes the changes recently made in the National Electrical Code.

Video Tape Recording

Julian Bernstein, John F. Rider Publisher, Inc., 116 W. 14th St., New York, N.Y., 272 pp, $8.95.

Containing the techniques, mechanics, and descriptions of circuitry used in video-tape recording, this book is suitable for the non-specialist in need of a thorough background in this field. The book begins with the types of waveforms and signals required for tape recording. Considerable space is devoted to electronic photography. Various tape transports, video track patterns, and television tape recorders are discussed. Information on the latest equipment is included.

An Introduction to Transistor Circuits

E. H. Cooke-Yarborough, Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N.Y. 158 pp, $3.50 (Second Edition.)

Directed to the student or the engineer who is not a specialist in transistors, the book attempts to provide a physical picture of the functioning of junction and point-contact transistors. Discussion of semiconductor theory is largely avoided.

The book begins by reviewing the properties of semiconductors that have an important influence on the electrical properties of transistors. This is followed by a description of the properties of the transistor as a linear amplifier, a discussion of nonlinear circuits, and a survey of some common transistor applications.

Digest of Literature on Dielectrics, Vol. XXII

Edited by Robert A. Soderman and Louis J. Frisco, Publication 713, National Academy of Sciences–National Research Council, 2101 Constitution Ave., Washington 25, D.C. 293 pp, $5.

Compiled mainly for the specialist in dielectrics, this annual digest includes measurements, insulation, and engineering applications. The 1958 digest, now available, covers topics such as molecular and ionic interactions in dielectrics, conduction phenomena in solid dielectrics, ferroelectric and piezoelectric materials, and ferromagnetic materials.

RUSSIAN TRANSLATIONS

J. George Adashko

Transfer Function of a First-Order Element With Linearly-Varying Coefficients

THE TRANSFER function of a linear, first-order element with linearity-varying parameters can be approximately determined by applying the inverse impulse transfer function.

Let us consider an element, described by the equation

$$(a_0 - a_1 t)\, y' - cy = -k\,(t)\, x \qquad (1)$$

where x is the input coordinate, y the output coordinate, and a_0, a_1, and c are constant parameters. Written in general form this equation is

$$y' + P\,(t)\, y + Q\,(t) = 0 \qquad (2)$$

where

$$P\,(t) = -\frac{c}{a_0 - a_1 t}, \quad Q\,(t) = \frac{k\,(t)\, x}{a_0 - a_1 t} \qquad (3)$$

The solution of Eq. 2 has the form

$$y = \exp\left[-\int_{t_0} P\,(t)\, dt\right]$$

$$\left[y_0 - \int_{t_0}^{t} Q\,(t) \exp\left(\int_{t_0}^{t} P\,(t)\, dt\right) dt\right] \qquad (3a)$$

where y_0 is the initial value (at $t = t_0$) of the variable y.

If the initial conditions are taken to be $y_0 = 0$ at $t = 0$, then taking Eq. 3 into account, we obtain for Eq. 1 the following solution

$$y\,(t) = -\exp\left[\int^{t} \frac{c}{a_0 - a_1 t}\, dt\right] \int_0^{t} \frac{k\,(\tau)\, x\,(\tau)}{a_0 - a_1 \tau}$$

$$\exp\left[-\int_0^{\tau} \frac{c}{a_0 - a_1 \nu}\, d\nu\right] d\tau \qquad (3b)$$

Considering that

$$\int_0^{t} \frac{c}{a_0 - a_1 t}\, dt = \ln\left[\frac{a_0}{a_0 - a_1 t}\right]^{c/a_1} \qquad (3c)$$

then this solution can be written

$$y\,(t) = -\left[\frac{a_0}{a_0 - a_1 t}\right]^{c/a_1} \int_0^{t} \frac{k\,(\tau)}{a_0 - a_1 \tau}$$

$$\left[\frac{a_0 - a_1 \tau}{a_0}\right]^{c/a_1} x\,(\tau)\, d\tau \qquad (4)$$

Putting for the sake of definiteness $k(\tau) = b_0 + b_1\tau$ and introducing the factor $a_0/(a_0 - a_1 t)^{c/a_1}$ we obtain:

$$y\,(t) = -\int_0^{t} \frac{(a_0 - a_1 \tau)^{\frac{c}{a_1} - 1}\,(b_0 + b_1 \tau)}{(a_0 - a_1 t)^{c/a_1}}\, x\,(\tau)\, d\tau \qquad (5)$$

The solution of Eq. 1 can be written in general form in terms of an inpulse transfer function $y^+(t, \tau)$. That is

$$y\,(t) = \int_0^{t} y^+\,(t, \tau)\, x\,(\tau)\, d\tau \qquad (6)$$

Comparing solutions (5) and (6) we obtain the following expression for the impulse transfer function of this variable link.

$$y^+\,(t, \tau) = -\frac{(a_0 - a_1 \tau)^{\frac{c}{a_1} - 1}\,(b_0 + b_1 \tau)}{(a_0 - a_1 t)^{\frac{c}{a_1}}} \qquad (7)$$

As is known, the response of a linear element with constant parameters to an input disturbance, $x(t)$, can be expressed in terms of the impulse transfer function $y^+\,(t)$ of this element. This expression is:

$$y\,(t) = \int_0^{t} y_1^+\,(t - \tau)\, x\,(\tau)\, d\tau \qquad (8)$$

where $y_1^+\,(t - \tau)$ is the inverse impulse transfer function of the linear element under consideration. Thus, when t is constant, the plot of the function $y_1^+\,(t - \tau)$ coincides with the inverted plot of the function $y_1^+\,(\tau)$, that is, $y_1^+\,(\tau)$, is plotted, starting with the instant t, from right to left.

Comparing Eqs. 6 and 8 we note that the impulse transfer function $y^+\,(t, \tau)$ for a variable link plays the same role as the inverse transfer function $y_1^+\,(t - \tau)$ for a constant link. Thus, considering only the magnitude of the output response $y(t)$ at the instant t, a variable link with an impulse transfer function $y^+\,(t, \tau)$ is equivalent to a constant link whose inverse impulse transfer function $y_1^+\,(t - \tau)$ satisfies the condition

$$y_1^+\,(t - \tau) = y^+\,(t, \tau) \qquad (8a)$$

where τ is the variable parameter and t is the constant parameter.

With a change of variable from τ to $t - u$, this condition can be written as

$$y_1^+\,(u) = y^+\,(t, t - u) \qquad (8b)$$

The function $y^{*}(t, t-u)$ is the inverse impulse transfer function of the variable link. We denote this function by $y^{-}(t, u)$.

We see then that a variable link can be replaced, for a fixed instant of time, by a constant link having an impulse transfer function $y_1^{*}(u)$. This new transfer function coincides in the range $0 - t$ with the inverse impulse transfer function $y^{-}(t, u)$, of the variable link.

Making the substitution $\tau = t - u$ in Eq. 7 and putting $c/a_1 = 2$, we obtain the expression for the inverse pulse transfer function of a variable link.

$$y^{-}(t, u) = -\frac{b_0 + b_1 t}{a_0 - a_1 t} - \frac{(a_1 b_0 - b_1 a_0) + 2a_1 b_1 t}{(a_0 - a_1 t)^2}\, u + \frac{a_1 b_1}{(a_0 - a_1 t)^2}\, u^2 \qquad (9)$$

The transfer function of the constant link is equal to the Laplace transform of the impulse transfer function $y_1^{*}(u)$. Consequently, the transfer function of the constant link, which replaces the variable link for fixed values of t, should equal the Laplace transform of the inverse impulse transfer function $y(t, u)$ of the variable link. Note that the Laplace transform is taken with respect to the variable u, and t is considered to be a constant parameter. Using the well known formula of operational calculus, $u_n = n!/s^{n+1}$, we obtain from Eq. 9 the transfer function, $W(s, t)$, of a constant link. This replaces, for given t, the variable link under consideration.

$$W(s, t) = \frac{-(a_0 - a_1 t)(b_0 + b_1 t)\, s^2 - [a_1 b_0 - b_1 a_0 + 2a_1 b_1 t]\, s + 2a_1 b_1}{(a_0 - a_1 t)^2\, s^2} \qquad (10)$$

The expression for $W(s, t)$ can be considered as the exact transfer function of the variable link Eq. 1, with parameter $k(t) = b_0 + b_1 t$, and $c/a_1 = 2$.

Eq. 10 can also be obtained by the methods discussed in references 2-4. However, the method considered here has greater simplicity and clarity.

N. T. Kuzovkov, News of the Academy of Sciences, U.S.S.R., *Power and Automation, No. 1, 1960, Jan.-Feb., 1960, pp 163-164.*

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E. Brenner

Difference Counters

BY MODIFYING the internal coupling, ordinary decade ring counters can be adapted for subtraction. For proper operation, such difference counters require a certain minimum spacing in time between input pulses. The use of an electronic resolver makes it possible to count the difference between the number of pulses in two pulse trains under asynchronous conditions. This can be done even if both pulse trains happen to occur simultaneously.

The design of the pulse resolver is based on the waveform study of Fig. 1. In the pulse train

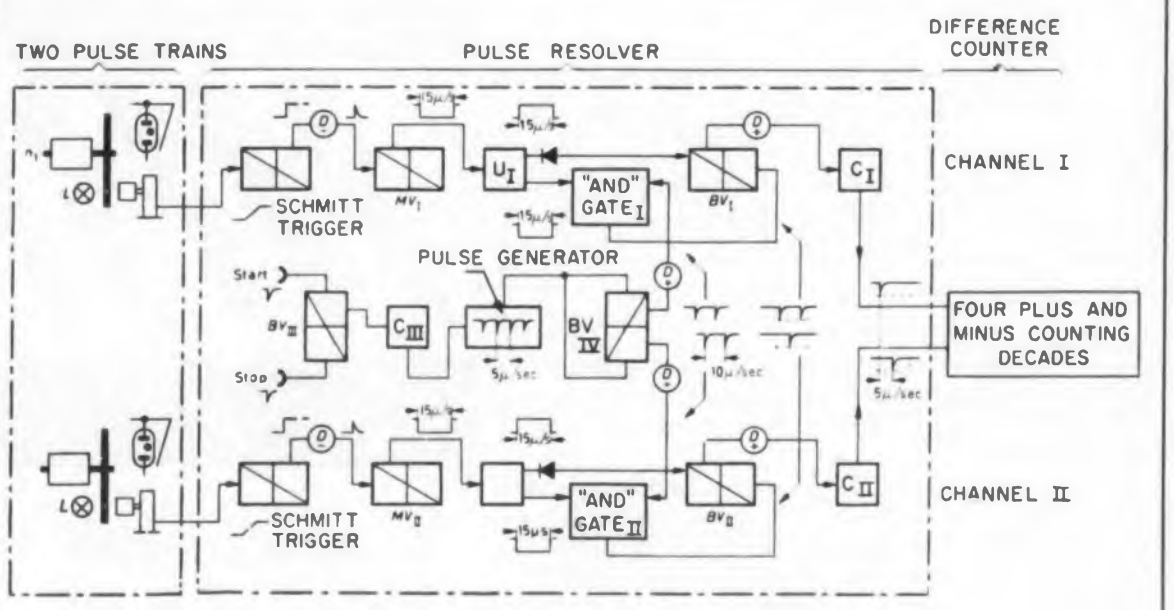

Fig. 2. Block diagram of pulse resolver.

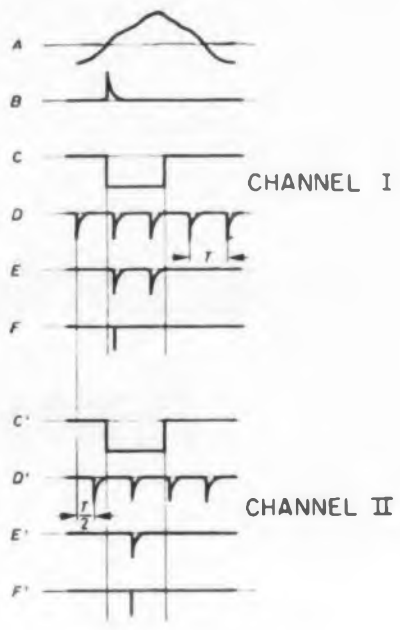

Fig. 1. Waveforms illustrating the resolver action.

of channel I, a pulse, *A*, is used to generate a trigger, *B*, which in turn generates a rectangular gate, *C*, of predetermined duration, T_c. The first of these pulses, *F*, is selected to be the counted pulse of channel I.

For the second pulse train, *C'* is formed and sampled by *D'*. The pulses *D'* are synchronous with *D* but delayed by *T*/2. Hence only one pulse, *E'*, gives rise to the counted pulse, *F'*. The two pulses fed to the counter, *F* and *F'*, are spaced at least *T*/2 apart, regardless of the time interval between the original pulses.

The resolver, Fig. 2, consists of two identical channels and the pulse generator. In each channel a Schmitt Trigger produces a gate, *MV*. A low output impedance phase splitter *U* furnishes an inverted pulse as well as the original pulse. The "and" gate is opened by the original pulse and transmits at most two sampled pulses to the bistable multi, *BV*. Only the first of these pulses trips the multi and generates a counted pulse. This is fed to the decade counter through a cathode follower. The trailing edge of the inverted pulse resets the bistable multi.

The pulse generator operates at 200 kc and is keyed through a cathode follower, K_{III}, and bistable multi BV_{III} by start-stop pulses. The time delay *T*/2 (5 μsec) is generated by the bistable multi, BV_{IV}.

In the original paper details of the resolver circuit and the counter are given.

Abstracted from an article by M. Kalthoff Elektronische Rundschau, *Vol. 14, No. 6, June 1960 pp 240-245.*

GERMAN ABSTRACTS

E. Brenne

Capacitance Bri
Waveguide Dim

A CAPACITANCE bridge can be used to measure the inner dimensions of long cylindrical rectangular waveguides with a precision of $\pm 10^{-3}$mm. In the case of a rectangular guide, Fig. 1, a measuring head, smaller than the smallest expected guide cross section and supported at three points, is moved through the guide. The variable distance d, which measures changes in guide dimension b, is inversely proportional to the measured capacitance.

To eliminate fringing effects, the effect of capacitance to other walls, etc., the unit is calibrated with a precisely constructed and temperature-controlled guide having step variations in its cross section, Fig. 2. The bridge is balanced at every step in the calibrating guide. In use, a calibration for unbalanced bridge current as a function of dimensional change is used. Care is taken to maintain the working current of the bridge at constant value.

For cylindrical guides the movable head shown in Fig. 3 is used. An example of measured data obtained from cylindrical guide measurements is shown in Fig. 4. The diameter of the guide was

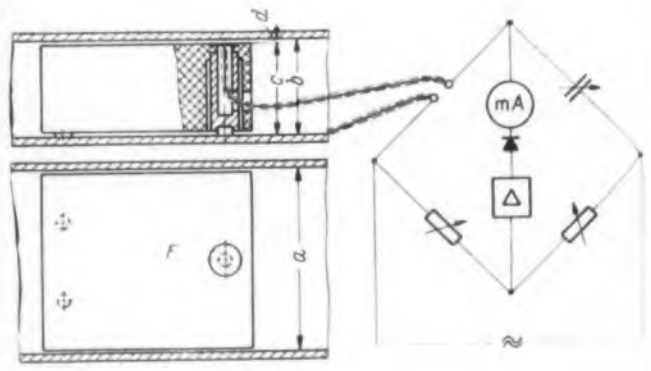

Fig. 1. Bridge and movable measuring head for determining inner dimensions of rectangular guide.

...ce Bridge Measures ...ide Dimensions

50 ±0.02 mm and the movable head dimension was 49.85 mm. The calibrating guide had four sections, the smallest diameter was 49.92-mm diameter the largest, 50.07 mm. This resulted in capacitance variations from 4 to 5.4 μμf.

Abstracted from an article by J. Bachel, Frequenz, *Vol. 14, No.4, April 1960, pp 131-134.*

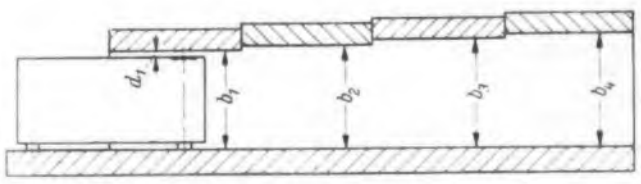

Fig. 2. Bridge-calibrating waveguide has step variations in cross section.

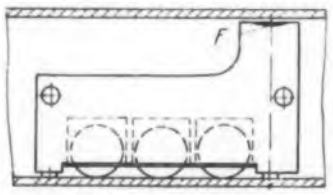

Fig. 3. Movable head used for cylindrical guide. The capacitance extends over the area *F*.

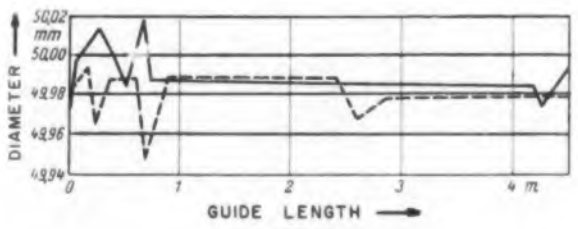

Fig. 4. Variation of guide diameter as a function of distance at two mutually perpendicular axes.

ELECTRONIC DESIGN

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A Simple Circuit Gives 3-Dimensional Scope Display

WHILE the effect of a three-dimensional display on an oscilloscope generally has been achieved by using sine-cosine potentiometers with matching amplifiers, it is possible to achieve an "acceptable" three-dimensional display with simpler circuits.

What is seen of course, is the projection, onto the plane of the screen, of the surface defined by one dependent voltage (z) and two independent voltages (x and y).

Fig. 1 illustrates how a three-dimensional effect is achieved by rotating the normally two-dimensional presentation about the z-axis. In this case, the angle of rotation is 45 deg. However, this angle can be any value Θ less than 90 deg as shown in Fig. 2.

To achieve this effect, what is termed the z voltage must be applied to the oscilloscope's vertical deflection plates, and the x and y voltages,

Fig. 1. (a) Cartesian coordinate system viewed along Y axis. (b) The view when XY plane is rotated 45 deg. (c) The view of (b) along the Z axis.

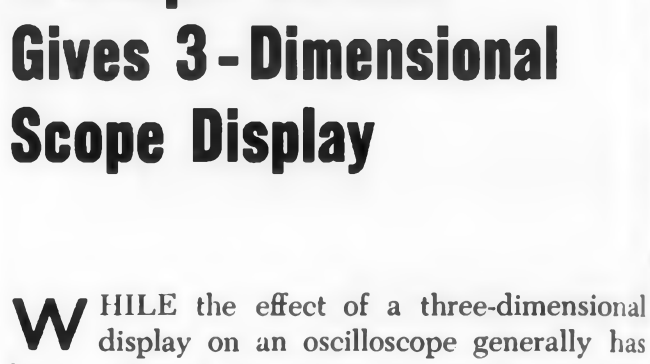

Fig. 2. View of XY plane along Z axis, where the plane has been rotated through any acute angle Θ. The coordinate X' is the apparent horizontal coordinate that would be seen on the oscilloscope face.

in the proper proportions, must be applied to the horizontal deflection plates.

The rule for mixing the voltages is: To obtain a projection on a plane in which the axes X' and Y' are specified by direction cosines $(l_1m_1n_1)$and $(l_2m_2n_2)$ relative to the X, Y, Z axes, mix the x, y, z voltages in the proportions of the direction cosines of X' and Y'. Algebraically:

$$x' = l_1x + m_1y + n_1z$$
$$y' = l_2x + m_2y + n_2z$$

and when z' is required (when the line of sight is oblique to all three axes):

$$z' = l_3x + m_3y + n_3z$$

Line of Sight Positioned In Two Stages

The line of sight is positioned in two-stages. First the pattern is rotated about the Z axis through any angle Θ. Then the resulting pattern is rotated about the X' axis through an angle Φ.

The principle behind this second rotation is the same as before, but, in this case, the z voltage must be combined with the voltage y'.

Now, from Fig. 2:

$$x' = x\cos\Theta - y\sin\Theta \quad (1)$$

and

$$y' = x\sin\Theta + y\cos\Theta \quad (2)$$

For the second stage of rotation, we must produce the voltage:

$$z' = z\sin\Phi + y'\cos\Phi \quad (3)$$

and, if desired,

$$y'' = z\cos\Phi - y'\sin\Phi$$

where y'' is the "invisible" coordinate normal to the face of the oscilloscope.

It is possible to multiply a voltage approximately by the sine of an angle using the circuit of Fig. 3. The angle is proportional to the distance between the slider and the common wire. The potentiometer is linear.

R_s is determined from the fact that the slider

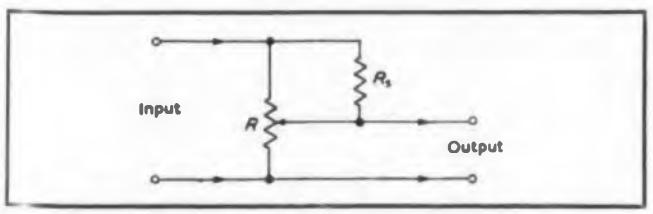

Fig. 3. A circuit whose output can be made a function of the input and the sine of an angle proportional to the distance of the slider from the common wire.

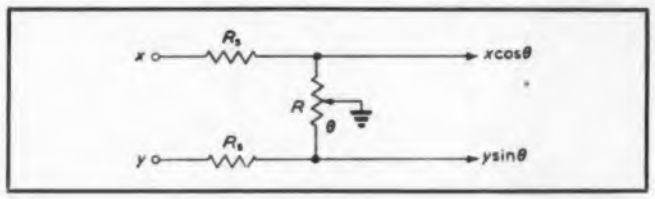

Fig. 4. This circuit, a variation of Fig. 3, multiplies one voltage by the sine of the angle proportional to slider displacement and another voltage by the cosine of the angle.

in the half-way position should correspond to 45 deg. At this point:

$$V_2/V_1 = \sin 45 \text{ deg} = 0.707$$

and

$$V_2/V_1 = (2R_s + R)/(4R_s + R)$$

Therefore, approximately,

$$R_s = 3/8\ R$$

Taking Θ as fractions of 90 deg (at this point the output equals the input, or sin 90 deg = 1), the voltage transfer function as a function of Θ is:

$$V_2/V_1 = \frac{(11 - 8\Theta)\Theta}{3 + 8\Theta(1 - \Theta)} \quad (4)$$

To provide full transformations of the type in Eqs. 1 and 2, four circuits of this kind must be used, with all sliders ganged. A circuit that ultimately will enable two sliders to perform the four transformations is shown in Fig. 4.

Potentiometer is Linear

The potentiometer again is linear, and the resistors R_s are chosen to make the output 0.707 of maximum at the halfway point. (R_s must include the source impedance.)

At the halfway point,

$$V_2/V_1 = R/(R + 2R_s)$$

At maximum,

$$V_2/V_1 = R/(R + R_s)$$

Therefore, $R + R_s = 0.707(R + 2R_s)$ or, approximately, $R_s = 0.7\ R$

The voltage transfer function as a function of Θ is:

$$V_2/V_1 = \Theta/(\Theta + R_s/R) \quad (5)$$

The performance of the circuits of Figs. 3 and 4, compared with the ideal sinusoidal variation, is

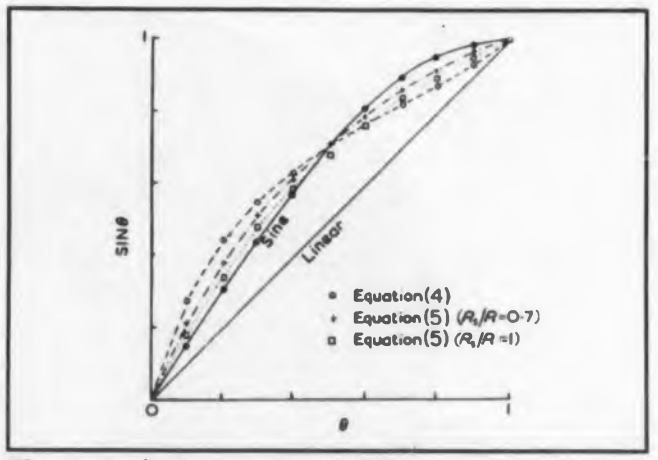

Fig. 5. Performance curves of circuits of Figs. 3 and 4 compared with ideal sinisoidal variation.

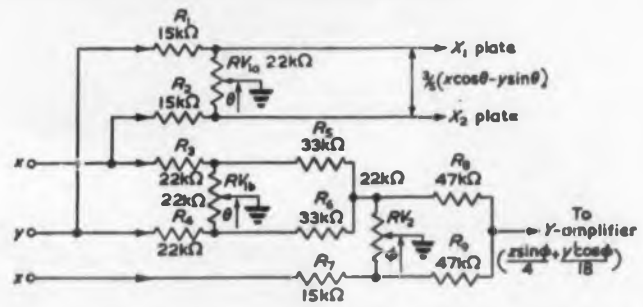

Fig. 6. A complete three-dimensional display circuit that uses the circuit of Fig. 4 as its basic unit. Displacing slider RV_1 rotates the coordinate system about Z axis. Displacing slider RV_2 gives rotation about X' axis.

shown in Fig. 5. The error is reduced as R_s comes closer in value to R. However, this also produces greater attenuation.

A complete three-dimensional display unit using this simplified circuit is shown in Fig. 6.

Subtraction of $x\cos\Theta$ and $y\sin\Theta$ is achieved directly at the oscilloscope by applying the voltages to opposite plates. Addition is performed through mixing resistors such as R_5 and R_6. These resistors place an additional load on the other two sine-cosine units. Therefore, they must be chosen so they and the input resistors R_3 and R_4 present an effective series input resistance of about 0.7 R both to the supplying and supplied potentiometer. The values indicated in the figure are not accurately optimum, but are preferred values that give acceptable performance. Greater accuracy is pointless because altering one potentiometer setting will change slightly the effective series input resistance to the other.

Ganged potentiometer RV_{1a} and RV_{1b} determine the first rotation (Θ) about the Z axis. The second rotation (Φ) about the X' axis is attained as follows. A voltage proportional to y' of Eq. 2 is supplied through R_5 and R_6 to RV_2, which also receives the input z through R_7. The output from R_8 and R_9 is proportional to $z\sin\Phi + y'\cos\Phi$. This voltage, which is z' (from Eq. 3), is applied to the scope's Y plates after amplification.

Digested from A Simple Multi-Dimensional CRT. Display Unit, by D. M. MacKay. The paper appeared in Electronic Engineering, *published in London.*

ELECTRONIC DESIGN

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Teaching a Computer To Think for Itself

COMPUTERS can't learn until they are taught. This is, in effect, the basic philosophy of research on machine learning by the Control Data Corp. The work, aimed at developing new computer programing techniques, is being done in three areas: improving the versatility of present computers; reorganizing internal memory locations to approach "human capability"; and improving techniques for communication between the computer and man.

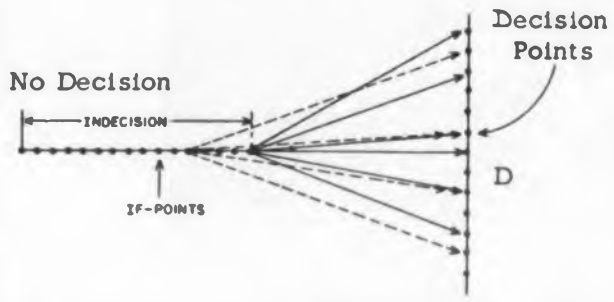
Improving Versatility

This report chooses the area of "decision making" as representative of company research in programing areas concerned with versatility.

Decision-making by present computers involves, by and large, only deciding between opposites—yes or no, plus or minus, either-or. Although this concept is basic to even human decision-making, it ignores many other important factors that humans take into account (even if unconsciously).

Among these are: efficiency, consequences, similarities, elimination, training, experience, motivation, practicality, trial-and-error, size, distance, and time.

To increase computer versatility in decision-making, it must be given conceptual abilities of these types. However, to build into the computer



Decisions are reached by proceeding from points of indecision. Depending upon at which if-point decision is made, the number and type of consequences —paths—can vary. Thus, consequences of earlier decision (dotted paths) differ from consequences of later decision (solid paths).

only one of these concepts leaves the machine's capability little better off than if it has only "either-or" capability.

New Instructions and Hardware Needed

What is needed is a general increase in versatility in all conceptual categories. The following suggestions for improving versatility ignore the possibility of building on the present repertoire of computers (for example, "store A at m" can be made into "store A at m_1, m_2, m_3 . . . m_n"). Instead, they deal with creating new instructions through interpretive combinations of regular programming, or through new "hardware" components.

These new capabilities should be:

- Recall previous use of instructions
- Recall previous use of bit patterns
- Look for similarities in characteristics of register contents. The characteristic can be a bit pattern, such as an operation code, or a whole word.
- Execute the instruction that has a characteristic—a specific bit pattern—similar to the instruction just completed.
- Execute or skip the next instruction depending upon the number of previous instructions.
- Execute or skip the next instruction depending upon the combined bit pattern of the registers

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on either side of a given address.

■ Execute or skip the next instruction depending upon whether or not the routine whose starting address is given has been repeated in previous times.

■ Reverse the sequence of the execution of instructions, if the number of instructions and the starting and ending addresses are given.

■ Modify the instruction at a given address after n msec of the instruction period have elapsed.

■ Change the n registers on either (or one) side of a register at a given address, by the corresponding bits in another address.

■ Execute n instructions in the same sequence as the given addresses, and return to the instructions following the last given address.

■ Invert specific instructions at given addresses and return to the next instruction following the last given address. (The inversions are of the type: add-subtract; increase-decrease; multiply-divide; shift left-shift right.)

■ Start with the instruction whose address is given and execute a sequence until an instruction similar to the first is reached. Then return.

Should "Human Factors" Be Eliminated?

Several programing simulation models in the areas of machine learning are being constructed or contemplated. Using decision-making as a representative area, the factors influencing possible models are as follows:

1) Should the human element—training, background, prejudices, etc.—be retained or eliminated? Certainly, the more difficult task would be to build into the model rules or statistical formulas that approximate the "human factors" in the "average" human decision-maker.

This also suggests a new area for computer use —letting the computer measure to what extent "human factors," such as stress, fatigue and prejudice, are present in the decision-maker.

2) The computer probably can surpass the human in estimating the consequences of proceeding along each of many alternative paths.

Although the human is apt to see only a limited number of alternatives because of lack of time or improper evaluation of what is important, the computer can be made to spell out the consequences of hundreds of alternative events.

One method of making this model would be to assign a percentage-of-accomplishment value to each consequence. This would allow relative comparison of the possible consequences.

3) Decisions are approached as indicated in

the accompanying diagram. While one examines, investigates and weighs parameters, there is no decision, or one proceeds away from indicision. Depending upon at what relative state of indicision an actual choice is made, the number and type of paths from indecision to decision can vary.

In the diagram, different paths present themselves at each point of indecision—or if-point. The sum of all if-points proceeding a given if-point must also be considered.

The if-points and corresponding decision paths could be simulated by random number generators. The if-points—inputs—also would be made dependent upon previous computer output.

Reorganizing Internal Memory Locations

Computers do not use the full memory capacity built into them. In addition, computers generally are limited to one program at a time. Thus, the computer today does not approach the human brain, which has almost limitless memory capacity, and can handle several thought processes simultaneously (the thoughts being at different levels of instantaneous importance and consciousness).

Some of the methods being used to remedy these computer deficiencies are:

1) Saturate memory devices by using groups of memory cells with different capacities and by arbitrarily dividing large cells into smaller cells.

2) Improve "time-sharing" ability by using input/output mechanisms and an on-line smaller computer, and by using more than one program address register.

Improved Communication

In working to increase speed in computer input/output devices, the exploitation of communication between computer and external equipment largely has been neglected. Initial problem parameters frequently must be modified before a conclusion is obtained. Entrance of new data should be possible while the problem is being solved.

It also should be possible to control succeeding events by periodic input to the computer. This input can then be a function of the output from previous executions.

Digested from "Factors influencing the Research and Development of New Computer Programming Techniques Required for Mechanization of Machine Learning," by R. E. Smith, Control Data Corp. This paper appeared in the proceedings of the June, 1960 conference of the IRE Professional Group on Military Electronics.

REPORT BRIEFS

Analog-Digital Conversion

A recently completed study program evolved methods and circuits for sampling an input function by narrow sampling pulses, and storing the sampled value for a time long enough to read and encode it. A number of design specifications were set as an objective for the study. The circuit work during the final three-month period was given to establishing the optimum design of the double diode-bridge circuit, and designing and testing low-distortion input and output circuits. *Study and Experimentation in the Field of Analog-Digital Conversion of Sampling and Holding Circuits, Joseph Yacyk, Philco Corp., Philadelphia, Pa., May, 1959, 27 pp, Microfilm $2.70, Photocopy $4.80. Order PB 145758 from Library of Congress, Washington 25, D.C.*

Microwave Switch

High-power measurements were performed on a helium-filled encapsulated window switch. A number of techniques were investigated for employing synthetic mica, a readily machinable material, in tube construction. Satisfactory final designs for the electromagnet and switching power supply have been achieved, and both are being constructed. *High-Power Microwave Switch, S. J. Tetenbaum, Sylvania Electric Products, Inc., Microwave Physics Laboratory, Mountain View, Calif., April, 1959, 38 pp, Microfilm $3.00, Photocopy $6.30. Order PB 145809 from Library of Congress, Washington 25, D.C.*

Expendable Modules

Compared here are the costs to procure, support, and maintain an equipment designed with expendable modules to a similar equipment designed with repairable modules. It was found that the total costs in either case were approximately equal. Modules of various electrical sizes (from 1 to 12 tubes) were compared from the standpoint of total over-all procurement cost to determine an optimum module size. On the basis of the calculations made, it was concluded that the optimum module which would lead to lowest over-all procurement cost and at the same time be of aid in the solution of logistic and maintenance problems would be one containing from 4 to 8 tubes. This is true for both disposal-at-failure and repairable modules. *Expendable Modules as Bases for Disposal-at-Failure Maintenance, R. O. Stone, P. Meissner and K. M. Schwarz, National Bureau of Standards, Washington, D.C., Feb. 1960, 84 pp, $2.25. Order PB 151400 from OTS, Washington 25, D.C.*

Two-Level Masers

Classical and quantum-mechanical treatments of paramagnetic resonance in isolated atoms and in assemblies of such atoms are presented. Interactions of paramagnetic ions with crystalline fields are discussed in detail. Relaxation times are introduced phenomenologically and treated more thoroughly in terms of the dipole-dipole and ion-photon interactions. Power transfer between paramagnetic material and the electro-magnetic field is calculated in both macroscopic and microscopic terms. The circuit properties of various amplifier configurations are then derived, and expressions are given for gain, bandwidth, noise figure, stability, etc. *Theory of Two-Level Masers, J. L. Burkhardt, J. W. Culvahouse et al., Hycon Eastern, Inc., Cambridge, Mass., Feb. 1958, 217 pp, Microfilm $9.60, Photocopy $33.30. Order PB 138136 from Library of Congress, Washington 25, D.C.*

Reducing RFI

Interference-reduction possibilities of modes of modulation and detection other than double-sideband amplitude modulation, polyphase modulation, synchronous and polyphase detection were investigated. Reducing the carrier components of the amplitude-modulated signal reduces the interference generated within non-linear circuits. *Study Program for Investigation to Aid in Reduction and Prevention of UHF Interference, Floyd P. Holder, Henry W. Mauldin, Jr., et al., Georgia Institute of Technology, Atlanta, Oct. 1955, 174 pp, Microfilm $8.10, Photocopy $27.30. Order PB 137653 from Library of Congress, Washington 25, D.C.*

Variable Capacitance Diodes

A technique is discussed for measuring varactor cutoff frequency at X band. The main features of the techniques are: use of high frequency, exploitation of the variable capacitance property as an essential part of the measurement, and use of low-loss tuning elements to improve accuracy and simplify calculations. It is argued that this technique is the most reliable thus far described. Test results are given on a fairly large number of sample model varactors. The cutoff frequency, measured at X band, varies from 50 to 80 kmc for units with zero-bias capacitance less than 2 pf, down to 30 kmc for units with zero-bias capacitance of 5 pf. *Variable Capacitance Microwave Diodes, Microwave Associates, Inc., Burlington, Mass., Feb.-April, 1959, 52 pp, Microfilm $3.60, Photocopy $9.30. Order PB 145960 from Library of Congress, Washington 25, D.C.*

REPORT BRIEFS

Materials

This periodic review presents information on important technical and scientific highlights regarding materials research here and abroad, principally in the polymer and plastics field. The information is intended to serve as a convenient reference for development personnel seeking information on engineering materials of actual or potential interest. *Sixth Materials Review, Arthur Lyem, Army Chemical Warfare Labs., Army Chemical Center, Md., Nov. 1959, 93 pp, $2.25. Order PB 161463 from OTS, Washington 25, D.C.*

RFI-Coaxial Cables

The behavior of electromagnetic leakage fields emanating from braid-shielded coaxial cables is studied. It is shown that a braid surface emf per unit length which is linked to the magnetic leakage-flux distribution in the braid apertures tends to support a slowly propagating surface wave along the cable. At higher frequencies, end effects play an important role in the shaping of the leakage radiation fields which acquire the typical tilted multilobe patterns of slow wave radiators. Measures to suppress the leakage through cable braids employing concentration and hysteresis type dissipation of leakage energy in ferrite coatings are suggested. *Leakage of Electromagnetic Energy from Coaxial Cable Structures, K. Ikrath, Army Signal Research and Development Laboratory, Fort Monmouth, N.J., April 1, 1958, 51 pp, Microfilm $3.60, Photocopy $9.30. Order PB 145660 from Library of Congress, Washington 25, D.C.*

Digital Speech Communication

A new approach toward compressed digital speech communication was based on speech data reduction in successive stages. First, the voice signal is measured in a Vocoder type of analyzer and the output information is digitized. The spectrum pattern data is then reduced by selecting the "best approximations" from a stored set of spectrum patterns, and reading out the pattern "serial numbers." This data is further reduced by selecting the "best approximations" from a stored set of pattern sequences and pitch sequences. The serial numbers of the sequences are transmitted. At the receiver, an inverse process expands the information to a voice output. *The Use of Digital Computers in Speech Analysis and Synthesis, C. P. Smith, Air Force Cambridge Research Center, Bedford, Mass., Nov. 1959, 13 pp, Microfilm $2.40, Photocopy $3.30. Order PB 145246 from Library of Congress, Washington 25, D.C.*

Slow-Wave Tube Structures

Theoretical and experimental studies of possible new slow-wave structures for electron tubes are presented. The structures considered are formed on the surface of p-type silicon by means of solid state diffusion of an n-type impurity. The properties of these structures are dependent on the dc bias applied between the diffused structure and the bulk silicon. The techniques employed in producing intricate structures to close tolerances are discussed in detail. The results of cold tests are compared with the calculated behavior for simple geometrics. An application of simple distributed structures in the measurement of the microwave properties of semiconductors is considered. *Physical Electronics at Millimeter Wave-Lengths, T. C. Pang and M. O. Thurston, Ohio State University Research Foundation, Columbus, Ohio, Dec. 1959, 17 pp, $0.50. Order PB 161493 from OTS, Washington 25, D.C.*

Paramagnetic Maser

The ampliflying bandwidth of the paramagnetic maser was increased by using slow-wave structures. The study was limited to the single crystal, chromium doped sapphire, or ruby, because of its stable chemical characteristics. A cavity maser using paramagnetic ruby was built and operated at 2600 mc with a 10 kmc pump. Gains of 28 db with 100 kc bandwidth were measured. Studies of slow-wave structures for a traveling-wave maser were started and the required characteristics formulated. See also PB 145548. *Research and Development of a Solid State Paramagnetic Maser, Perry H. Vartanian, Microwave Engineering Laboratory, Inc., Palo Alto, Calif., Oct. 1958, 20 pp, Microfilm $2.40, Photocopy $3.30. Order PB 137990 from Library of Congress, Washington 25, D.C.*

Ferrite Mixing

Microwave mixing in ferrites was experimentally observed by subjecting a magnetized ferrite to two X-band signals of differing frequency. Both sum and difference components were generated. A conversion efficiency for the sum frequency of —13 db was observed with a local oscillator power of 13 kw. The sum frequency output was observed to be linear with both signal and local oscillator inputs even when the two signals were of equal level. *Mixing in Ferrites at Microwave Frequencies, P. H. Vartanian and E. N. Skomal, Sylvania Electric Products, Inc., Microwave Physics Laboratory, Mountain View, Calif., May, 1957, 11 pp, Microfilm $2.40, Photocopy $3.30. Order PB 145880 from Library of Congress, Washington 25, D.C.*

STANDARDS AND SPECS

Sherman H. Hubelbank

Printed Circuit Institute Revises Dimensional Tolerances

Dimensional tolerances for printed circuits were revised recently by the Institute of Printed Circuits, Inc. The new specifications, published in a four-page brochure, "Standard Tolerances for Printed Circuits," supersede those in the institute's book "How to Design and Specify Printed Circuits."

The tolerances are a guide to what dimensional requirements can be met by the industry. They permit designers to choose dimensions that keep the cost of printed circuits to a minimum.

The latest specifications are not to be taken as the last word on the subject, according to the institute. When closer tolerances than those specified are required, the institute recommends that designers consult the printed-circuit manufacturer.

The brochure is available from manufacturers who belong to the institute. The list of manufacturers may be obtained from the institute at 27 E. Monroe St., Chicago 3, Ill.

Unplated Holes—Diameters

Drilled—Standard Drill sizes	±0.002 in.
Drilled—Other Sizes	±0.003 in.
Reamed	±0.001 in.
Counterbored or flycut (Diam 5/16 to 4 in.)	±0.005 in.

Punched (1/16 in. thick)	Paper Base	Glass Base
Up to 1/4 in. diam	±0.003	±0.004
1/4 to 1/2 in. diam	±0.003	±0.004
1/2 to 1 in. diam	±0.004	±0.004
Over 1 in. diam	±0.005	±0.005

For thickness of 3/32 to 1/8 in. add ±0.001 to above.
Routed slots and notches up to 2 in. ±0.005.
Milled or broached slots and notches to 2 in. ±0.003.
For punched slots and notches, consider both length and width as hole diameters.

Plated Holes—Diameters

ADD the following tolerances to the unplated hole tolerances shown above.

Drilled, paper base	±0.003
Drilled, glass base	±0.003
Punched, paper base	±0.003

Reference Hole To Hole Centerlines (plated or unplated)

	Standard	Premium
Die punched	±0.005*1	±0.003*1
Drilled by eye	±0.010*2	
Drilled by temporary jig	±0.010*2	
Drilled by jig bored jig	±0.005*3	±0.002*3
Drilled by etched steel jig	±0.010	±0.010
Punched by temporary template	±0.010*2	
Punched by jig bored template	±0.007	

Center of Hole to Center of Pattern: Punched

	Die	Temporary Template	Bored Template
Plated Holes, either side:			
standard	±0.015	±0.022	±0.017
premium	±0.010*4		
Single side or top of 2 sides:			
standard	±0.015	±0.017	±0.017
premium	±0.010*4		
Bottom of 2 sides:			
standard	±0.025	±0.027	±0.027
premium	±0.020*4		

Drilled

	Eye	Tempo-rary Jig	Bored Jig	Etched Jig
Plated holes, either side:				
standard	±0.020	±0.015	±0.020	±0.015
premium			±0.015*4	±0.010*4
Single side or top of 2 sides:				
standard	±0.015	±0.015	±0.015	±0.015
premium			±0.010*4	±0.010*4
Bottom of 2 sides:				
standard	±0.030	±0.025	±0.025	±0.025
premium			±0.020*4	±0.020*4

Front to Back Pattern Registration

Standard ±0.020
Premium ±0.010

NOTES
* 1. Add +0.001 for every inch over 2 in.
* 2. Tolerance based upon datum line passing through center of the reference hole pad.
* 3. Add ±0.001 for every 2 in. over 2.
* 4. Tolerance based on premium printing methods and/or optical alignment.

(continued on p. 184)

STANDARDS AND SPECS

Line Pattern to Outside Edge

	Standard	Premium
Rout or mill	±0.015	±0.010*4
Turn		±0.005
Saw or shear by eye	±0.030	
Saw by jig	±0.015*1	
Blank	±0.015*1	±0.010*1
Compound or progressive die	±0.015*1	±0.010*1

Reference Hole to Edge

	Standard	Premium
Rout or mill	±0.010	±0.005
Turn, T.I.R.	0.010	0.005
Saw or shear by eye	±0.030	
Saw by jig	±0.015	
Blank, or progressive die	±0.010*1	±0.005*1
Compound die	±0.005*1	±0.005*1

Overall Outside Dimensions

	Standard	Premium
Rout or mill	±0.015	±0.005
Turn		±0.003
Saw or shear by eye	±0.030	
Saw by jig	±0.010	
Blank by die	±0.003*1	±0.003*1

Line Width And Spacing Tolerances

	Standard	Premium
No plating	±0.010	±0.005
With plating	±0.015	±0.010

Line width tolerances do not include nicks, pin holes and scratches. These imperfections are acceptable providing the line is not reduced by more than 33%.

Plating Thickness

Plating thicknesses are specified as minimums only, a tolerance of minus 0, plus 100% being generally accepted.

Warp

Pattern one side-finished part.
Measured according to ASTM-D709 or Mil P-406

Thickness	Paper Base	Glass Base
1/16	0.025 in./in.	0.010
3/32	0.020	0.008
1/8	0.012	0.006
1/4 & up	0.006	0.005
Pattern two sides (Any thickness)	0.007 in./in.	0.005

Closer warp tolerances may limit selection of raw materials or make necessary unusual manufacturing operations or shipping procedures.

Plug-In Contact Fingers

Where close tolerances between an edge or a key slot and contact finger of the conductor pattern are required, special fabricating techniques may be employed which will allow specifying a tolerance of ±0.005 between the pattern on one side and the edge or slot. This will generally involve a premium cost. Remember to add front to back registry tolerance to determine condition on the reverse side.

Panel Thickness Tolerances in ±0.000 in.

Overall Thickness	PAPER BASE: 1 oz. 1 side	PAPER BASE: 1 oz. 2 sides 2 oz. 1 side 2 oz. 2 sides	GLASS BASE: 1 oz. 1 side 1 oz. 2 sides 2 oz. 1 side 2 oz. 2 sides
1/32	0.004	0.005	0.008
3/64	0.005	0.006	0.009
1/16	0.0055	0.0065	0.0095
3/32	0.0075	0.0085	0.0105
1/8	0.0085	0.0095	0.0135
5/32	0.0095	0.010	0.016
3/16	0.010	0.011	0.020
7/32	0.011	0.012	0.022
1/4	0.012	0.013	0.023

Plating Thickness

All plating will be produced to a stated minimum thickness with a tolerance of plus 100% minus nothing. On boards with plated holes, plating build-up on plug-in fingers may add as much as 0.003 in. to finger thickness on each side over and above specified minimum plating thickness.

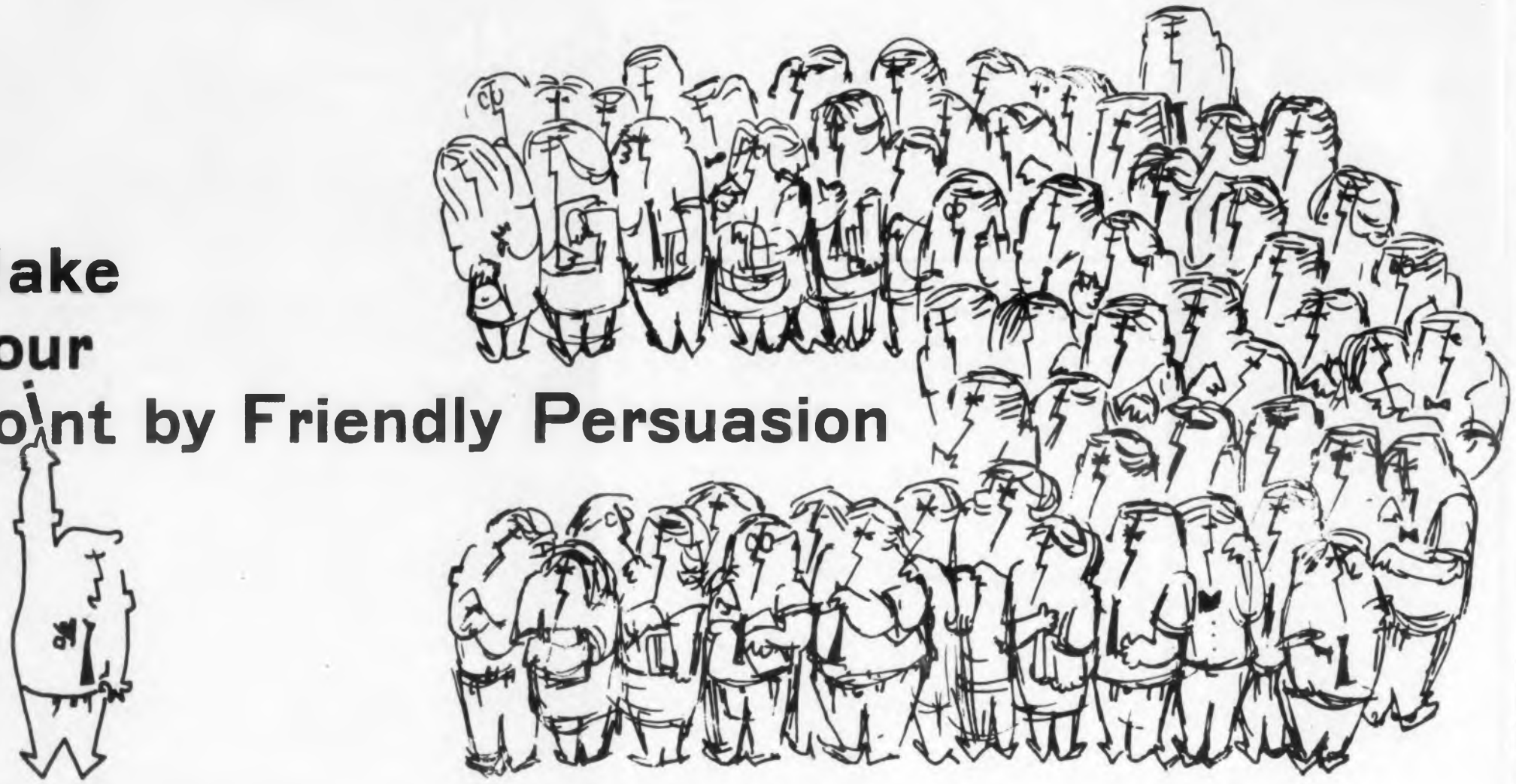
Catalog Lists Tubes Used By Armed Services

A complete list of electron tubes used in the Armed Services or stocked in depots, is presented by this publication. It also includes a cross reference to any other type numbers or designations these tubes may have, serving as a convenient interchangeability guide. This 230-page document is available from: *The Superintendent of Documents, Government Printing Office, Washington 25, D.C. for $1.50. Specify Catalog No. D7.6/2:213.*

Methods For Testing Electronic Parts Changed

Significant changes have been made to MIL-STD-202. A new test method is included for determining if a part, while performing its operational function, will ignite an ambient explosive atmosphere. The parts subjected to this type of test do not have casings designed to prevent flame or explosion propagation. A new test has been added to determine the electrical and mechanical effects upon parts from exposure to a dust-laden atmospheric environment. The method has three tests of severity. Additional test methods changed deal with: barometric pressure, thermal shock, life (at elevated ambient temperatures), high-frequency vibration, high-impact shock, and rotational life. MIL-STD-202B, Test Methods for Electronic and Electrical Component Parts.

Make Your Point by Friendly Persuasion



William W. Duncan, a professor of speech at Queens College, New York City, often has to exercise his persuasive powers on students.

William W. Duncan

Queens College,
New York City

PERSUASION is a subtle and complex art. Those who practice it successfully don't always agree how it is accomplished. Aristotle, whose "Rhetoric" is still almost a definitive text, saw persuasion as a social force used by men of good will as well as by charlatans, and believed every man in a democracy should know as much about the art as possible.

The time span between Aristotle in ancient Athens and Carl Hovland at Yale is roughly 2,200 years, but neither time nor scholarship has essentially altered Aristotle's basic pronouncements on the subject. Aristotle said persuasion is accomplished in three ways: (1) through the character and personality of the speaker, (2) through the arguments and reasons of the speaker, and (3) through the ability of the speaker to arouse and direct the feelings of the listeners. Professor Hovland, in his book "Communication and Persuasion," accepts Aristotle's conclusions, although he talks in terms of the communicator, the content of the communication, and audience predispositions and responses.

Although these divisions are useful, they can be misleading. As necessary as it may be to study separately the three means of persuasion, we must keep in mind the whole process.

The Speaker

1. Are you honest and sincere in what you do and say?

2. Is your articulation clear and distinct without being too precise and affected?

3. Do you use your voice freely and naturally, allowing yourself to express your feelings as well as your thoughts?

4. Do you stand straight and talk in a direct, communicative manner, or do you stand awkwardly and talk as if you were reciting words that mean little to you?

5. Do you make a good, neat appearance before an audience?

If you have a high score on these points, you have the basic requirements for a dynamic, persuasive person. If your score is low, there is still no reason why you cannot become the appealing speaker you would like to be.

The Speech

There are two general types of persuasive speeches. One is the controversial speech, such as political oratory, or an appeal to a legislative assembly, or a board of directors. The other type is the noncontroversial speech, such as an appeal for blood donors or contributions to the Community Chest.

The controversial speech relies more on evidence and logical reasoning than the non-controversial one. Good organization is necessary for both types, but is especially important in the controversial speech.

One technique is to state your position on a matter simply, give your reasons, and support each reason with as much factual material and as many expert opinions and examples as you can find and as time will allow.

If your opinion is strong, you may prefer to take the major arguments against you, and try to show the weaknesses of each before presenting your own case. Or it may be to your advantage to do it the other way around: state and develop your case; then take apart your opponent's case; and, finally, summarize your own case, reminding your audience of the strongest evidence in your favor.

In such a speech, knowledge of evidence and logical reasoning is essential. If you haven't had training in this area, there are many books that will help you. Stuart Chase's "Guides to Straight Thinking" is a good one, and so is Lionel Ruby's "The Art of Making Sense."

In the non-controversial speech you can't entirely ignore evidence and sound reasoning, but usually you can rely more on an emotional appeal to your audience. But, regardless of the type of speech, the audience is your judge and jury, and the successful speaker is an expert in adapting himself and his speech to his audience.

Audience adaptation means analyzing your audience and beginning your speech, regardless of its type, in such a way that your listeners will respond to you as favorably as possible. (For a more detailed discussion on how to get into your speech, see "So You've Got to Make a Speech!" *ED*, June 8, 1960, p 166.) In few cases should one launch abruptly into a speech. Get attention with an appropriate and interesting story, a good joke, or another rhetorical device. Furthermore, establish rapport with your listeners by display-

MAGNETIC INDUCTION

DESIGNING YOUR FUTURE

Author Duncan practicing what he preaches before three of his students. Sincerity, he says, is a large part of the battle.

ing a friendly manner and by using direct, personal language.

Also remember the importance of a good conclusion. A summary of your most cogent arguments plus a sincere, emotional appeal is usually the best way to wind-up.

The nature of your speech and its success may depend to a large extent on how much you know about audience psychology in general and the psychology of your audience in particular. But whether you know psychology or not, it's common sense not to slight the thoughts and feelings of your listeners.

The Audience

The late Lane Cooper of Cornell University, in the introduction to his translation of Aristotle's "Rhetoric," wrote: "Everyone knows what it means to be persuaded. The emphasis is always upon the nature of the person to be persuaded, and means by which it is possible, and just, to persuade him. The one legitimate means is reasonable argument; but since man is an emotional creature, one's audiences are sure to be swayed by emotion. The speaker has to reckon with this side of his audience.

Dealing with the emotions of your listeners is, of course, the most difficult part of persuasion. You begin to arouse their feelings as soon as they see you. When they hear your voice they are further influenced. After that, every word you utter and every gesture you make become building blocks in your speech, which the listeners accept or reject depending on how you present yourself and your case to them.

Probably the most successful way to get an audience to accept you and your case is to align your purpose with the basic wants, interests, and purposes of your listeners. The author of "The

Psychology of Speech," Jon Eisenson, said, "The amount of organized human behavior that is not determined by wants, interests, and purposes is so small as to merit attention only because of its rarity." Hence, if we are to be persuasive we must take into account people's wants, interests, and purposes and gear our speeches to them.

Consider, for example, an appeal for blood donors. The person making the appeal may tell the story of a bright, attractive child who died in a local hospital because it lacked the right kind of blood. Such a story might touch you deeply. The fear that such a thing could happen to your child, or even to yourself, might motivate you to give blood.

Remember the bond drives during World War II? Your fear was aroused that the enemy might destroy our way of life if you didn't buy bonds. Moreover, you were urged to make an investment in your financial security. Thus, by buying bonds you served your country as well as your own self-interest.

What are these basic human wants that are so important in persuasion? Various lists have been compiled, and one list is about as good as another. Eisenson reminds us that we are all interested in satisfying our physical wants; that we do those things that will lead us toward success, mastery, achievement; that we like recognition, respect, approval; that we do those things that will give us peace of mind, security; and that we like adventure, new experience, and zestful living.

Apart from the wants and interests of your listeners, there are other factors that you should take into consideration: the place where you speak, the time of the meeting, the occasion, and the physical characteristics of the room. You may be able to use one or more of these factors to help you hold your audience. For example, if the room where you will speak is large, and you know the audience will be small, you may want to arrange to have everyone close to the front so you can more easily establish rapport with your listeners. If you have any control over the temperature of the room or its ventilation, you may be able to guarantee the physical comfort of your audience, thus assuring yourself of greater attention from those who will hear you.

Getting across to your audience, then, is a subtle process that must be developed. Many of the factors cited are related—what you say, how you say it and the apparent temperature of the room, for instance. You've probably got the general idea, though, if you're willing to think of the process as "friendly" persuasion. ■ ■

Readers are invited to submit for publication accounts of their own successes or failures as persuasive speakers. The accounts will be published anonymously on request.

YOUR CAREER

ENGINEER—IMPROVEMENT COURSES AND SEMINARS

Below are courses and seminars intended to provide the engineer with a better knowledge of various specialties. Our grouping includes several different types of meetings: National Courses—those held on consecutive days and intended to draw attendees from all geographical areas; One-Day Seminars—one-day intensive seminars which move from city to city; and Regional Lectures —regional symposia or lecture series which generally run one night a week for several weeks.

National Courses

CBS's Transistor Home-Study Course

The new 1960 edition of the CBS transistor home-study course is revised and expanded to include the latest information on transistor devices and applications. This new version of CBS Electronics' course offers ten lessons covering simplified basic semiconductor theory with practical experiments and service techniques for amplifiers, oscillators, rectifiers, and deflection circuits. For further information write to "Transistor Course," CBS Electronics, 100 Endicott St., Danvers, Mass.

Lavoie Inaugurates Robotester Training Program

A monthly schedule of classes in the operation of the Lavoie Robotester for users and potential users of the instrument has been announced by Lavoie Loboratories, Morganville, N. J. The Robotester is a tape-programed testing device that performs rapid checkouts of complicated electronic circuits. It is employed widely in missile manufacturing and at electronic installations because it permits quick correction of equipment faults. Technicians become proficient in operating the Robotester after a short, intensive training period.

Quotas for initial Robotester classes, which are conducted on four consecutive days, have been filled. Interested Robotester users are requested to apply for participation in the classes at least 30 days in advance. For futher information write: Lavoie Laboratories, Morganville, N. J.

Training Program For Supervisory Personnel At Purdue University

Starting in September and continuing through May, the Supervision Institute of Purdue University offers classes on job supervision and related topics in eight categories, and each of the eight is repeated approximately five times during the nine months. Although the program has been designed mainly to help in training foremen and supervisors, results have shown it to be effective fo other levels of management also.

The catergories this year cover these eigh areas: responsibilities of the supervisor, huma relations in business and industrial situations, hov to teach an employe to do a job, methods of conducting meetings, how to plan and improve worl procedures, methods of thinking and solving problems creatively, on understanding and being understood, and how to control and reduce costs.

Most industries utilize the two-and-a-half da concentrated courses on campus. Local plants may take advantage of an optional plan, which comprises half-day a week classes on campus for five consecutive weeks. For futher information write to: J. J. Wagner, co-ordinator, Supervision Institute, Division of Adult Education, Purdue University, Lafayette, Ind.

New York University Offers Degree in Nuclear Engineering

The Graduate Division of New York University's College of Engineering, under an expanded program, will offer the degree of doctor of engineering science for students majoring in nuclear engineering.

The curriculum will include new courses in reactor heat transfer, reactor design, reactor theory, special topics in reactor theory, isotope separation, the shielding of accelerators and nuclear reactors, and the economics of nuclear power and radiation. These will bring to 25 the number of graduate courses in nuclear engineering at NYU. In addition, the College offers three undergraduate courses in that field. For further information write to: Dr. James J. Barker, associate professor of nuclear engineering, College of Engineering, New York University, University Heights Center, New York 53, N. Y.

New York University Presents Symposium on Basic Science

New York University will present a Symposium on Basic Sciences in France and the United States on October 17, 18, and 19. It will take place at NYU's Loeb Student Center on Washington Square South.

Participating will be six French scientists who will discuss their fields at general meetings and six American scientists who will join them in panel sessions. One hundred American scientists have been invited to attend.

The following are the topics to be discussed: magnetic resonance; hydraulics; metal physics; astronomy; geology; science administration.

Chairman of the symposium is Dr. Serge A. Korff, professor of physics at NYU's College of Engineering. For further information write: New York University, Office of Research Services, Washington Square Center, New York 3, N.Y.

CIRCLE 904 ON CAREER INQUIRY FORM ➤

COMMUNICATION SYSTEMS . . . *the ultimate integration of the electronic arts*

Among the great names in the telecommunications and electronics industry, Kellogg today is one of the country's strongest sources of advanced communications equipments and systems. We have one major goal — to provide the finest communications that the electronic arts make possible . . . for industrial, commercial and military needs.

The Communication Systems Department of Kellogg, growing by leaps and bounds to keep pace with demands for wholly integrated communications means, provides large-scale communications systems from Alpha to Omega . . . from systems studies through engineering and production. Engineering is concerned with all phases of telephone, radio, data communications and automatic control circuit design. Principal areas of engineering organization include Project Engineering, Applications Engineering, Development and Systems Evaluation and Utilization and Reliability.

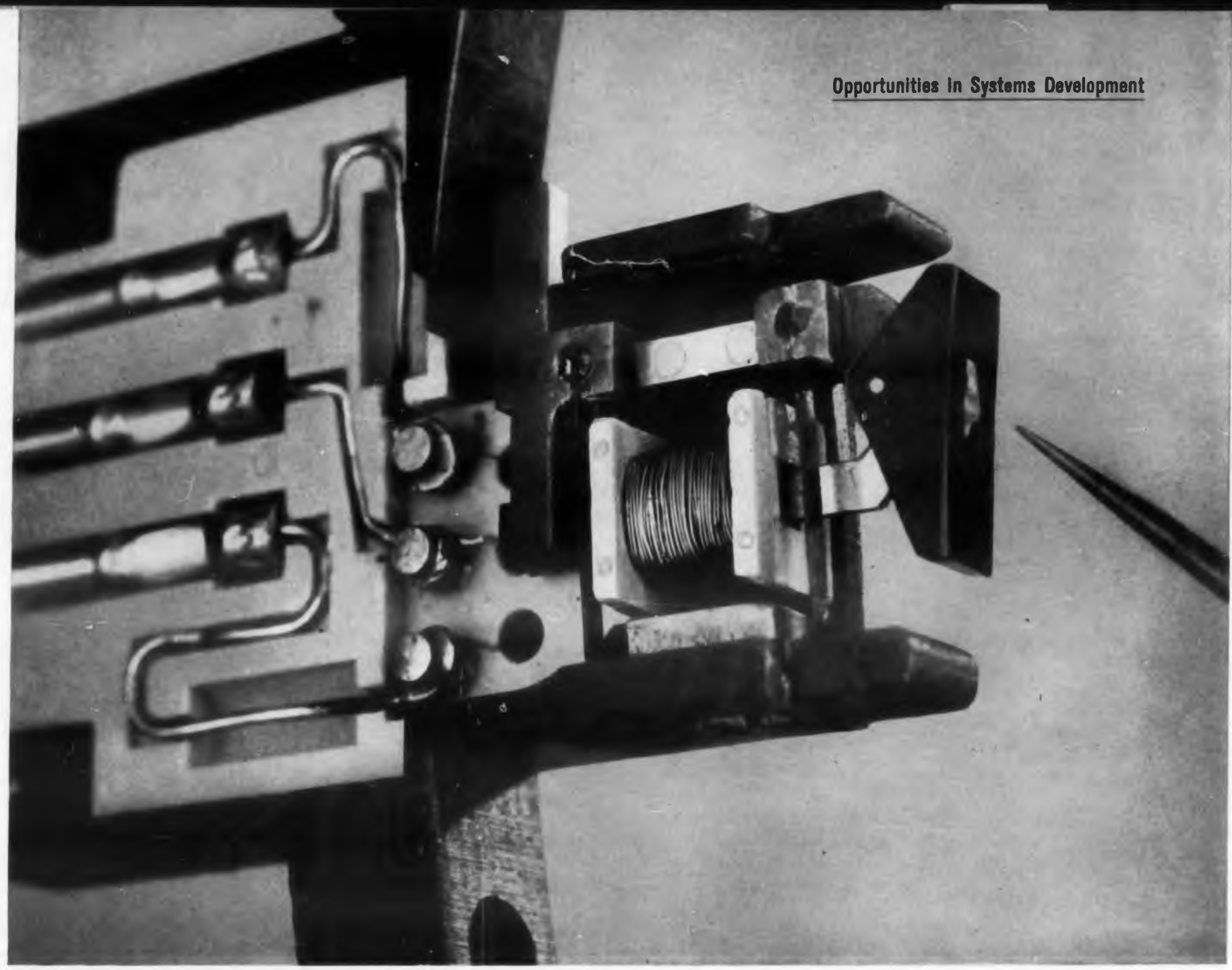
Typical of Kellogg's major systems engineering achievements is the provision of complete ground communications for the firing of Titan and Thor ballistic missiles and Discoverer and Samos space satellites at Vandenberg Air Force Base. Similarly, Kellogg has provided for the Atlas ICBM program nine separate systems for communication, control, maintenance and check-out, count-down, voice-recording and fire alarm — all functioning as an integrated system.

If you seek a dynamic organization in which to further your future, write Manager of Technical Staffing, Communication Systems Department, Dept. M-03(3).

ITT KELLOGG Communications Division, International Telephone and Telegraph Corporation

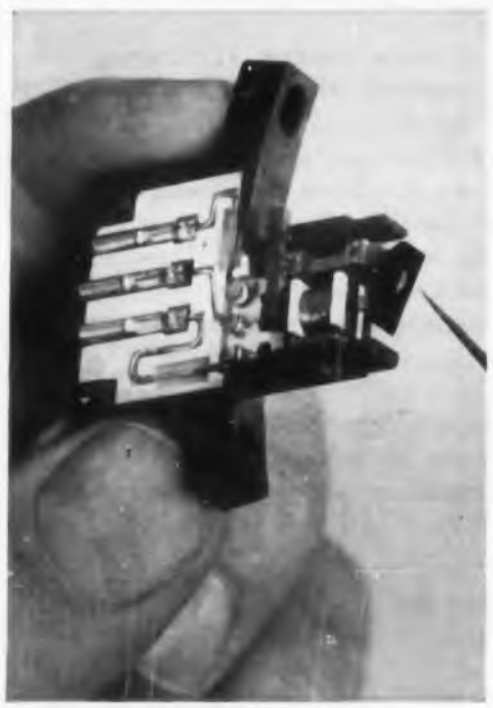
500 North Pulaski Road, Chicago, Illinois

ITT



Approximately 5 times actual size, this new read-write head features an air bearing, mechanical lift, and integrated zener diodes.

Floating facts out of computer memory



This is a read-write head with an air-floated shoe. It was developed by IBM scientists and engineers for greater reliability of computer memories. It represents a significant improvement over present magnetic heads because it incorporates three unusual engineering achievements.

- An air bearing maintains the critical clearance between head and recording surface—even under severe thermal and vibrational environments.
- A newly developed mechanical lift separates the head from the rotating drum except during actual read or write operations. This eliminates start-and-stop wear.
- Zener diodes are packaged in the upper section of the head. This integration saves weight and space and enhances reliability.

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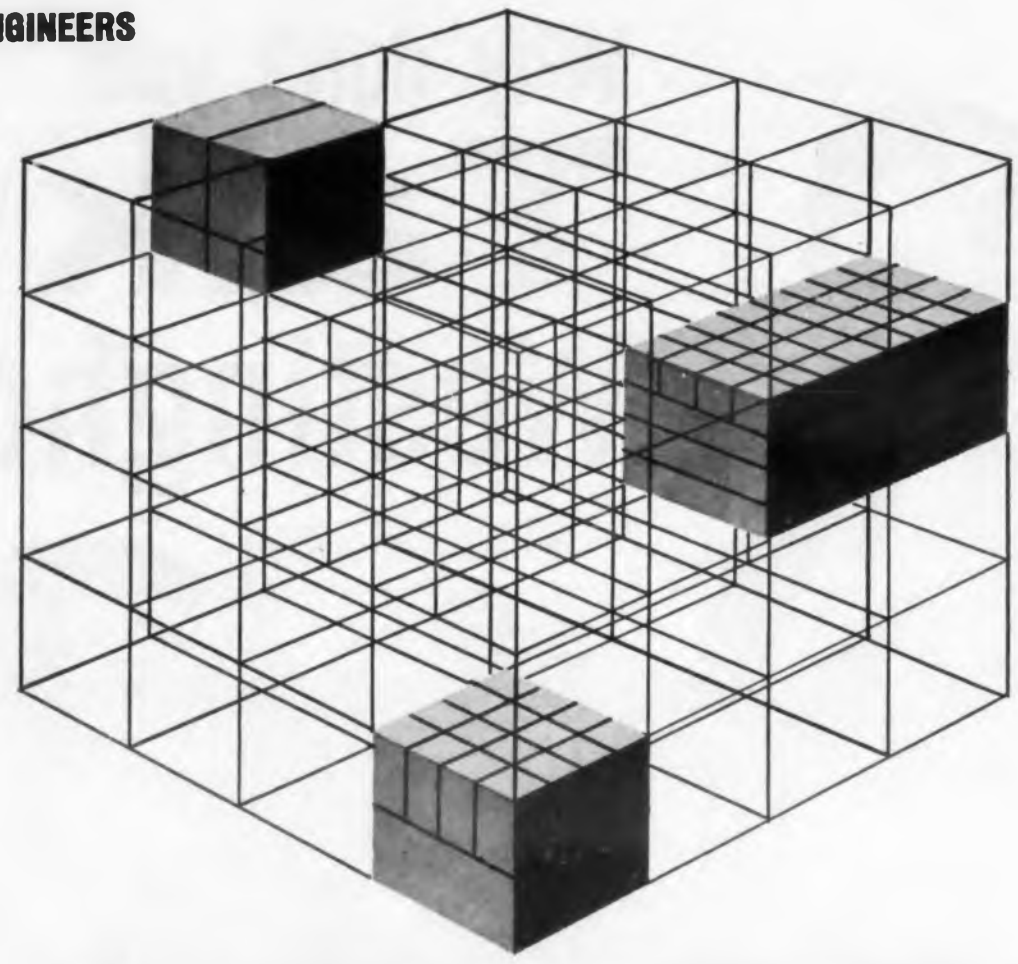

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