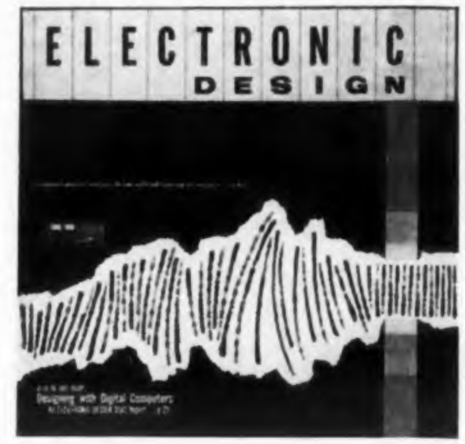
ELECTRONIC DESIGN

AUGUST 31, 1960

onstant power output from self-adjusting dc supply... p 56

signing with Digital Computers
An ELECTRONIC DESIGN Staff Report



COVER: The irregular lines shown at the left of the cover design symbolize the variations in load demand. These are limited to a maximum value by a "constant-watts" regulating circuit, symbolized by the gray band which protects against overloads by limiting the power dissipated in the output transistor to the maximum value which can safely be tolerated. The regulated lines on the right show that maximum safe value

Selected Topics In This Issue

Sidelights of the Issue

Read All About It!

For a long period of time now, *ELECTRONIC DESIGN* has been expanding its news coverage to give the reader a wider and better knowledge of the week-by-week happenings in the design field.

We have devoted progressively more space to news; we have published an increasing number of reports in depth on design opportunities in fields such as oceanography and anti-submarine warfare. Our news reports have tried to keep on top of the latest developments and we have tried to show in each story the significance of the event to the design engineer.

Beginning with this issue, we are inaugurating another service. By a special arrangement, we have pushed back the deadline for a number of pages in our News department, so that developments can be reported days later than was previously possible. What this means to the reader is that the copy of *ELECTRONIC DESIGN* which he reads will contain not only fresher news, but that *ED*'s editors will have several more days in which to dig for information and to develop stories. This, we believe, will help make our news coverage more pointed and more informative than any other publication's.

Dust off that Computer

Too often, in electronic design, have engineers let one of their best tools gather figurative dust. The tool, of course, is the digital computer. To help overcome this oversight, *ED* has gotten together a roundup of digital computer applications by design engineers.

In presenting this roundup, we have tried to depart from the usual method of treating a specific application in depth. Rather, we have gotten together dozens of applications in breadth, in the hope that even those engineers who don't find their particular problems listed to think about—Designing with Digital Computers. The article begins on p 28.

Folding the WESCON Tent

Now that the WESCON dust has cleared and we have had time to collect our thoughts a bit, we have gotten together two reports on the show. One appears in this issue beginning on p 8; the other will appear in our Sept. 14 issue. To those of you who found time to drop by the *ED* booth in Los Angeles, it was good to see you. To those of you who couldn't make it, see you at the IRE Show or next year at WESCON.

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Coming Next Issue

In this ever-expanding industry, a new word has begun to be bandied about with ever-increasing frequency. The word: bionics. The specialists at the Wright Air Development Division define it as: "The science of systems which function after the manner of, or in a manner characteristic of or resembling living systems." *ELECTRONIC DESIGN*, in the Sept. 14 issue, will present a full-scale report on this new specialty in electronics. We will show how design engineers are applying the knowledge of biology and biological techniques to the design of electronic devices and systems.

Our report on bionic systems will take the reader into this new electronic area and show him how engineers are working to develop adaptive or self-organizing mechanisms under biological inspiration. Remember the name, then—bionics. And remember to read about it in the Sept. 14 issue of *ELECTRONIC DESIGN*.

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NBP BPA

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Courier Ready for Second Launch Attempt

Communications Satellite Payload on Hand; Try May Be Made Before End of September

A SECOND attempt to orbit a Courier communications satellite is likely to be made before the end of September. Failure of the first shot has not materially slowed the project. Philco's Western Development Div., prime contractor for the payload, had readied three complete Courier satellites and has components on hand for a fourth one.

Reliability via the "Put in two of everything" method characterizes the design of Courier's electronic payload and tracking stations. The result is the most heavily instrumented satellite yet attempted, with 38 separate electronic packages crammed into the 51-in. dia. sphere. Courier's insides include:

- Five tape recorders
- Four UHF transmitters
- Four UHF receivers
- Two VHF telemetry transmitters
- Two VHF tracking beacons
- Two VHF telemetry receivers
- Two independent battery-solar cell power supplies.

On the ground, redundancy of components and methods is also specified. The tracking stations, designed by ITT Laboratories, each include four UHF and two VHF receivers. The tracking antennas, supplied by Radiation Inc., can be operated in three different modes—manual, programed scan, and automatic tracking—to maintain contact with the satellite.

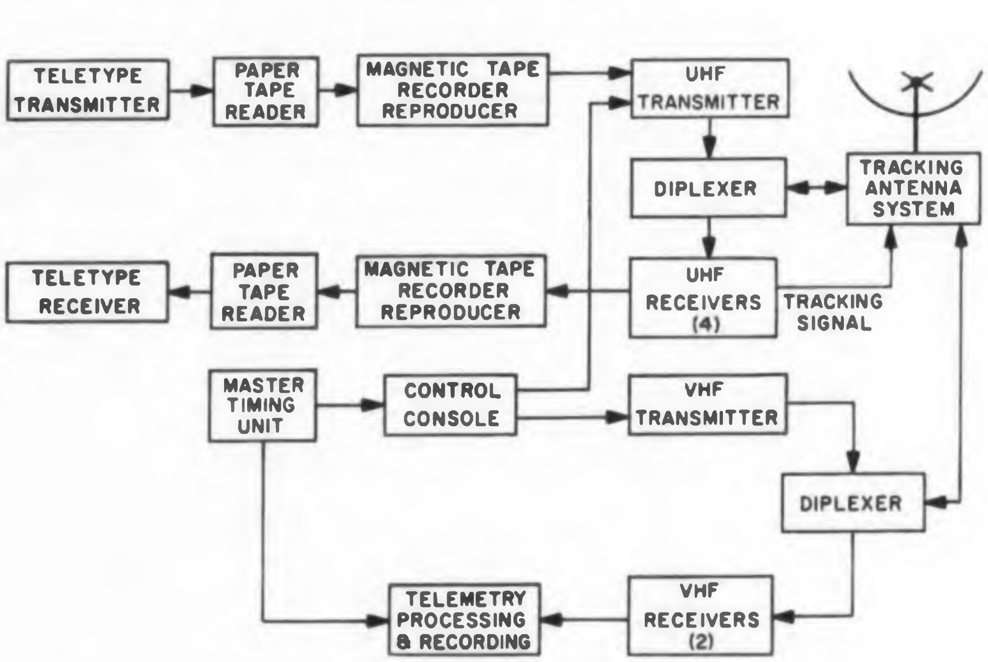
Real Time Communications Also Planned

Courier's mission of proving the feasibility of active communication satellites has two aspects. In addition to its much publicized function as a delayed repeater or "mail" pouch satellite, Courier can also operate as a real time repeater.

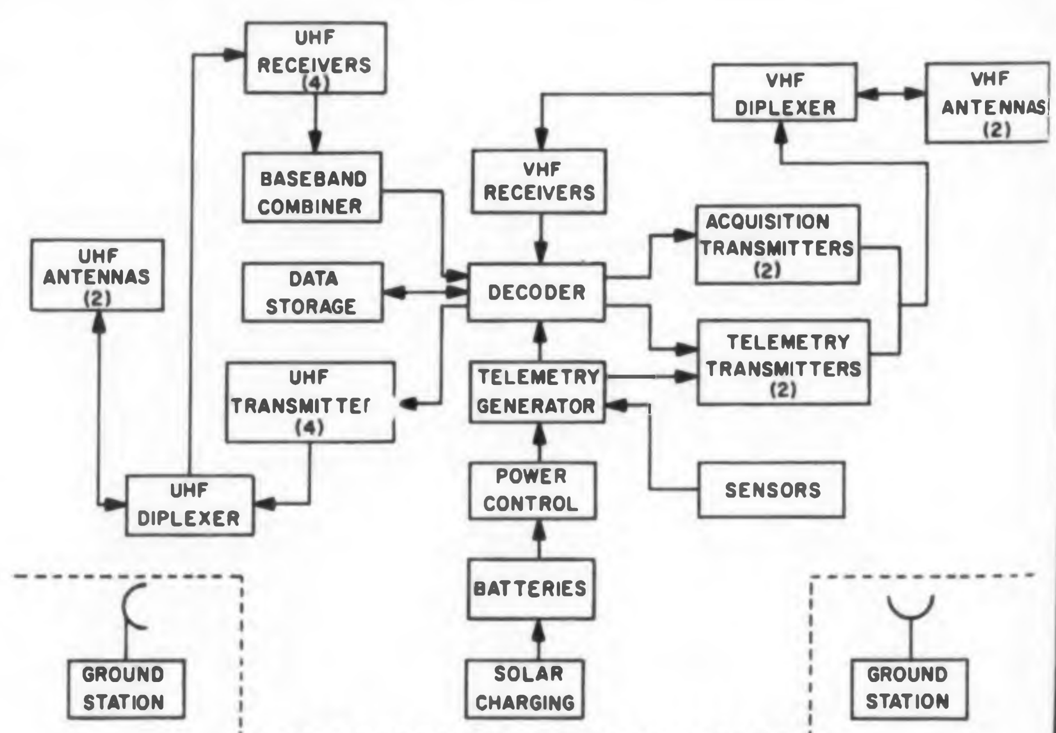
As a delayed repeater, Courier provides the equivalent of twenty 100 wpm teletype channels. The five 30 ips single track tape recorders have a total storage capacity of 15 megabits. Four recorders are equipped to handle NRZ teletype signals at 15 kilobits per sec. The fifth recorder will be used in experimental voice and analog transmissions.

Two-Way Transmissions Over UHF And VHF

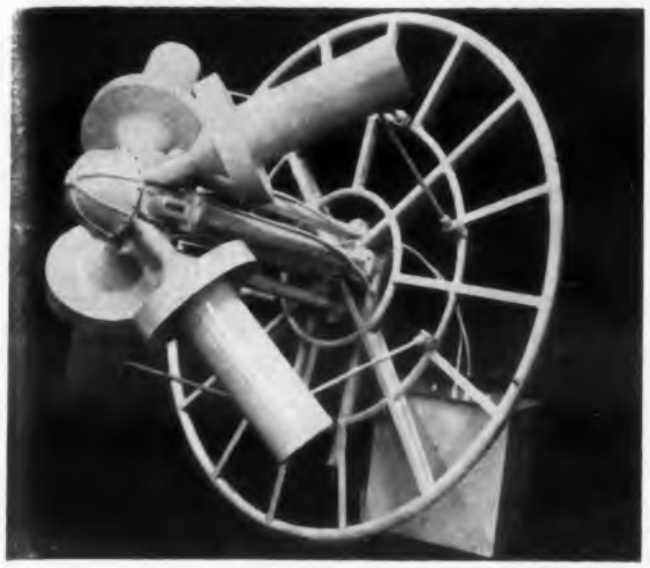
Simultaneous two-way communication between Courier and the tracking station takes place both in the 100 to 150 mc band and in the 1700 to 2300 mc band. The lower frequency band is used for tracking and telemetry; the UHF band carries the actual message transmis-



Courier ground station data flow. Message handling is by UHF transmission; telemetry is by VHF using a PAM/FM/FM system. Multiple receivers provide frequency and add redundancy for reliability. Between passes, the entire system can be checked out by aiming antenna at a transponder mounted on a tower some 200 feet distant. Ground station thus "talks to itself" to test all sub-systems in all operating modes.



Courier payload is characterized by redundant components for increased reliability. Simplified block diagram includes only a part of the 38 electronic packages in the vehicle. In addition to redundant transmitters and receivers, tape recorders and power supply can also sustain failure of individual units without interrupting communications.



Feed system for Courier tracking antenna. Dome at front houses spinning dielectric lens which scans signal to provide error data for automatic tracking. Feed path for VHF is through the four extended arms; UHF is fed through waveguides down center of unit. Antenna and tracking gear is by Radiation, Inc., Melbourne, Fla.

sions and most of the ground-to-satellite commands. VHF transmissions are at approximately 100 w and UHF transmissions are at about 1 kw.

The two VHF receivers at the ground station operate together to provide polarization-diversity reception. The four UHF receivers operate together to provide both polarization and frequency diversity reception.

The UHF receiving system employs a fourfold diversity combining scheme. Polarization diversity is accomplished with two predetection phase combiners; baseband combining is used for frequency diversity.

How Courier Is Tracked

Novel design techniques are used to facilitate acquisition and tracking of Courier. The satellite is equipped with two 50 mw VHF beacons which transmit continuously between tracking stations.

The horizon sector at which the satellite is expected to appear is illuminated by the ground station antenna, operating at VHF. When the satellite's beacon signal is detected, a coded

New Developments Unveiled At WESCON

IN LOS ANGELES' Sports Arena last week, WESCON opened for thousands of exhibitors and visitors. On p 8 of this issue, *ELECTRONIC DESIGN* covers some of the main developments of the big event. Another, and bigger, story will be forthcoming in the Sept. 14 issue.

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command from the ground station switches Courier from the "standby" to the "active" mode. The satellite's VHF transmitter begins to telemeter, the beacons are shut down, and Courier's UHF transmitters are warmed up.

Upon receipt of VHF signals from the satellite, the ground station places the tracking antenna into a "sector scan" mode. In this mode the dish continuously scans an azimuth sector of about 10 deg, thus maintaining some contact with the satellite at all times. About 40 sec thereafter, Courier's UHF transmitters come on the air; receipt of UHF signals automatically stops sector scanning and places the antenna in an "automatic tracking" mode.

Spinning Lens for Automatic Tracking

A spinning dielectric lens conically scans the secondary pattern of the antenna. Rotation at 1800 rpm gives a 30 cps amplitude modulated signal which is compared by a phase demodulator against 30 cps signals from a reference generator. Demodulator output provides error signals to the servo system which keep the antenna pointed at the satellite.

The 28-foot dish has a slew speed of 15 deg/sec and an acceleration rate of 12 deg/sec. Pointing accuracy is 0.5 deg. at maximum slew speed and increases to 0.25 deg at slower rates. Beam widths are 18 deg at VHF and 1.3 deg at UHF.

The antenna handles simultaneous two-way transmission between satellite and ground. A four-channel rotary joint in the antenna feed provides continuous signal paths for each of two orthogonally polarized signals for azimuth and elevation movement of the antenna. Transmission from the ground is circularly polarized.

Tape Recorders Read Out In Reverse

With the satellite acquired and automatically tracked on UHF, message handling begins. The satellite tape recorders, loaded with messages from another station are played back in reverse. Simultaneous two-way digital transmission is thus limited to the capacity of two recorders as two units are recording while two units are read out. There is, however, enough time during a pass to permit separate readout and recording of all four tapes if necessary.

The four UHF satellite receivers feed a baseband diversity combiner which mixes the inputs and essentially accepts the signal from the one receiver having the most favorable signal-to-noise ratio. Individual receiver failure does not interrupt communication.

The four UHF satellite transmitters operate in pairs, with one pair providing redundancy in the event of failure. Each of the two operating receivers are tuned to slightly different frequencies and are connected to separate antennas. Each transmitter has an output of 8 watts, provided by a planar triode of the 2C39 family. The four UHF transmitting tubes are the only tubes in Courier.

Satellite functions, including real time or delayed message handling, are controlled by 21 different ground commands. The initial command, which prepares the satellite for message handling, is transmitted on VHF as Courier crosses the horizon. The two VHF receivers in Courier are alternately turned on for 1 sec and off for 9 sec. As soon as either unit receives a properly modulated signal, it is locked into the circuit and the switching is discontinued.

Telemetry Acknowledges Commands

Commands received on either VHF or UHF are acknowledged by keying of the lowest subcarrier oscillator in the VHF telemetry system. Six additional IRIG subcarriers, each commutated five times, provide 30 telemetry channels. Battery voltage, tape positions, transmitter power, received signal strength, and temperatures are among the information telemetered. However, four channels are redundant, giving a total of 26 telemetered parameters. Two telemetry transmitters, (one a spare) are installed. Each has an output of 1.5 w. Peak frequency deviation is ± 6 kc.

After message handling is completed, a final command shuts down the UHF and VHF transmitters and turns on the beacons. However, if tracking is interrupted at any time during the message, the satellite automatically returns to standby and turns on the beacon transmitters.

Power Supply Details

Total power consumption of Courier is 225 watts in the active mode and 10 watts in standby. Power is supplied by 19,152 silicon solar cells which charge two 12 amp-hr 28-v nickel cadmium batteries. Average output of the cells is about 70 w which permits a duty cycle exceeding 10 per cent.

The cells are wired in series strings of 84 cells each. Two independent arrays of cells can be arranged to charge either or both batteries. In the event one battery is disabled, all cells are switched to the surviving battery and satellite operation continues without interruption.

Four VHF antennas consisting of flexible steel probes are mounted around the equator of the satellite. Each antenna is fed by a separate transmitter. UHF antennas are notched fin assemblies mounted at opposite points of the satellite along its equator. ■ ■

WESCON Sets A New Tone

A ban against recruiting in the exhibit hall and a conspicuous absence of gimmicks were outstanding characteristics of the largest show yet staged by WESCON.

The 987 exhibit booths in the new Los Angeles Memorial Sports Arena and heavy schedule of provocative technical sessions offered a busy four days for what was estimated would be an engineer attendance in excess of 35,000.

As if to further emphasize the break with the past as evidenced by the ban on recruiting and special efforts to enliven technical sessions, WESCON management dispensed with opening ceremonies.

Although there was no recruiting on the convention floor, it was too early when this story was written to determine the extent to which it would be carried on outside the arena. Some hotel suites had obviously been reserved for recruiting purposes. Still WESCON officials felt that their "gentleman's agreement" ruling out recruiting would establish an important precedent for industry conventions.

Dr. Eberhardt Rechtin, Telecommunication Division Chief at Jet Propulsion Laboratories, was awarded the 1960 Achievement Award of the 7th Region of the IRE. He is currently directing construction of the U.S. deep space tracking net.

A number of technical products not disclosed in pre-convention announcements were unveiled on opening day. Hughes Aircraft created considerable interest by showing a "parametric transistor" in the firm's hotel suite. The developmental model, a pooling of the talents of Lenkurt Electric Co.'s Dr. Vladimir Vodicka for the circuit design and Hughes Semiconductor's Ranier Zuleeg for the transistor, was operating as a mixer-oscillator at four kmc.

Key to the success of the transistor mixer-oscillator was a circuit designed at Lenkurt's advanced development group by Dr. Vodicka last February. Basic circuit is an oscillator with the entire input impedance of the transistor being varied for efficient amplification of the input signal. The input of the transistor is current-tuned.

"This development should help to reduce the size of microwave receivers, lead to pocket radios or handy talkies and has many applications in telemetering, and frequency diversity—with possibilities of simultaneous operation on fundamental and harmonic frequencies," Mr. Zuleeg told ELECTRONIC DESIGN.

Four semiconductor manufacturers, by announcing the availability of microtransistors in rapid succession, have started the bandwagon rolling. Pacific Semiconductors, Inc. showed their micro- and pico-transistor versions as at the IRE show in New York last March, where they announced prototypes. Texas Instruments had silicon mesa transistors bearing the company name "Micromesa." From Rheem Semiconductor came the announcement of "Microbloc," another silicon mesa type. Sylvania showed "pancake transistors," germanium alloy switching units. According to Sylvania, they chose the germanium alloy type to build because it was the most difficult. Sylvania plans to market the 0.070 in. high by 0.23 in. diameter devices as a standard case size.

Microminiature fast-switching transistor announced by TI was one of the advances shown at WESCON.

Multi-layer circuit boards, a development of Litton Industries, were a major WESCON attraction. (For details, see story on page 20.)

Among other new products on view were Vitramon's minute capacitors which the company claimed were the first capacitors of such small size to be encapsulated in pre-molded cases. Vitramon said the miniature diallyl phthalate plastic cases had passed tests for reliable and superior performance under adverse conditions.

American Optical Co. made its debut in the electronics instrument market with a new recording system. Called the Trace-Master, the system has been under development at the company's Instrument Div. in Buffalo, N.Y., for two years. The system operates at an amplitude of 4 cm. The "band-amplitude" product—bandwidth times amplitude—is nearly six times as high as previously attainable. Each of the eight independent modules can be set up, by means of plug-in modules, for accommodation of a wide variety of inout signals.

A new line of portable oscilloscopes, completely transistorized, that operate on internal, rechargeable batteries, ac power, or low-voltage dc, were put on view by Electro Instruments, Inc., San Diego. The instruments weigh as little as 2 lb and measure 2-3/4 x 3-1/4 x 5-1/2 in.

Spectrol had hardware samples of its Model 80 subminiature trimming potentiometer line on display. Corning Glass Works' electronic components department at Bradford, Pa., came up with 5 per cent tolerance, 1- and half-watt film resistors, priced at about 6 cents each in lots of 5,000.

The Data Instruments Division of Telecomputing Corp., N. Hollywood, Calif., showed the Tranqualizer, an instrument designed for on-line compensation of transducing systems with previously determined parameters.

This account of WESCON highlights, as noted on the opening day of the show, will be followed by a detailed report in the Sept. 14 issue.

NEWS

New IBM Optical Reader

System Uses Rotating Rasters To Recognize Written Characters

DESCRIPTION of a rotating-raster character-recognition system under development for two years by International Business Machines Corp.'s San Jose Products Development Laboratory was one of the high points of the recent Pacific General Meeting of the AIEE in San Diego.

A round-table discussion of radiation effects, a survey of the radiation resistance of many electronic components by two Bendix researchers, and a group of three radiation-effects symposia added emphasis to this topic during the four-day conference. Electronic reactor controls, solid-state devices, radio communication systems, and computing equipment also played major roles during the meeting. Power-source technology, with emphasis on solar converters, was also a major topic.

The IBM rotating-raster system has been used to identify both machine and hand printed numbers according to R. W. Weeks of the Products Development Laboratory.

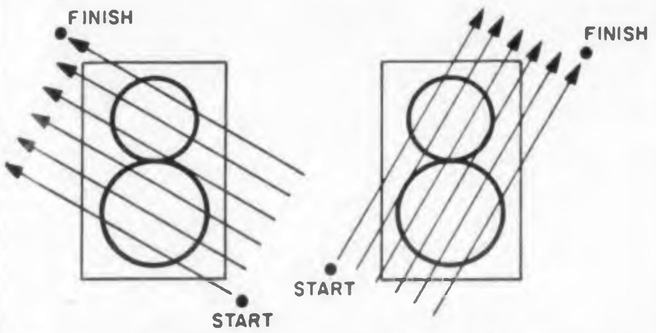
Identification was performed by means of statistical probabilities based on the number of times selected straight lines in an inclined TV-like raster intersected an unknown character. The raster was rotated to different angles so that various distributions of crossings were obtained for making a decision. IBM researchers used six lines in the raster, evenly spaced across a character, with six different inclinations in order to obtain 36 matrices—one for each scan line.

Each matrix consisted of 40 elements, one element for each digit, 0 through 9 for each type of possible crossing—that is zero, one, two or three. For the 36 scan lines this gave a total of 1440 individual statistics for the recognition process. These statistics were gathered by scanning a great number of machine and hand-written characters, and the numbers for each element ranged from zero to the total number of samples used. These data were normalized to a 1,000-sample norm and then converted to logarithms for ease in computation after a one was added to each value to eliminate zeros.

To identify an unknown character a set of 10 accumulators, one for each of the digits 0 to 9, was used to reach a decision. For each of the 36 lines used a single value from the appropriate column of the matrix for that line was stored in each of the accumulators.

For example, referring to the table, if a par-

Is Described at AIEE



Six scan lines are shown crossing the figure 8 at two different inclinations. Number of crossings for each scan line at six inclinations were used in making identifications. Box around the number is invisible to the scanner.

ticular one of the 36 lines crossed an unknown character two times, then column 2 of the matrix would be selected. This means that 0.98 would be stored in the 0 accumulator, 0.1 would be stored in the 1 accumulator, and so on through the column with 0.5 stored in the 9 accumulator. These logarithmic probability values are summed over the 36 lines, and then the accumulator with the highest total value identifies the character being sensed.

Selection of the six lines in the raster to use at each of the six angles was performed by a logical technique using an IBM 650 computer. The first line to cross a character and the last line to cross the character were determined, and the lines in between these were divided into seven equal groups. The last line in each of the first six groups was used.

In order to prevent the machine from making false decisions a reject level was set, so that the accumulator with the highest sum had to have a certain amount higher total than the next highest accumulator for a decision to be made.

With machine-printed characters no rejects were encountered, and 100 per cent recognition was obtained.

Hand-written characters were obtained by having a group of college students write numerals inside of small rectangular boxes. The students were instructed to approximately fill the boxes, and an example of the type of character to print was given to them. No rejects were encountered, 92 per cent of characters were identified correctly, and 8 per cent errors resulted. Various techniques for overcoming the high error rate with the hand-written characters were attempted, but little improvement could be obtained.

A machine was designed to accomplish the character recognition process using about 250 transistors, 132 magnetic cores, and about 1500 one per cent tolerance resistors. ■ ■

Engineers Putting Echo To Work

Many Organizations Use Satellite For Complex Communications Tests

WITH off-again, on-again Project Echo at last in orbit, communications engineers are working overtime to obtain maximum use from the 100-foot balloon during the few weeks that it is expected to remain aloft.

They expressed pleasure at the satellite's performance during its first ten days in orbit. It was said that the slight shifting of orbit due to pressure of the sun's rays would change tracking methods somewhat but would not alter the prognosis on Echo's life expectancy.

At last count, three separate teams were bouncing signals off Echo's aluminized mylar hide. Bell Telephone Laboratories and Jet Propulsion Laboratories, the official participants in the National Aeronautics and Space Administration project, are exchanging small talk via Echo between Holmdel, N.J. and Goldstone, Calif. Meanwhile, Philco's research division and the Rome Air Development Center have established a communications link from Rome, N.Y., to Trinidad in the Caribbean. Also hitching a free ride on Echo with NASA blessing is Collins Radio and its Alpha Corp. subsidiary in a hook-up between Cedar Rapids, Iowa, and Dallas.

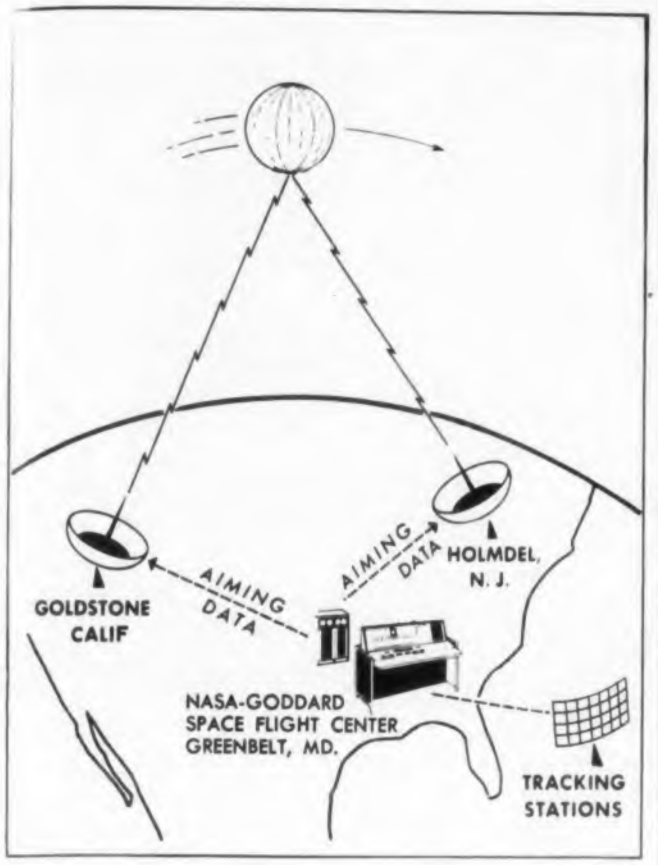
Tiros Used in Tracking Tests

Bell and JPL scientists spent a busy fortnight before Echo was launched. First, tracking accuracy of the parabolic horn antenna and maser receiver sensitivity at Holmdel were tested by transmitting a 2,000-mc cw signal at 10 kw from the Naval Research Laboratory in Washington to Holmdel via the Tiros I weather satellite. Tracking information was supplied by the 709 computer at NASA's Goddard Space Flight Center in Greenbelt, Md. which is now doing the same job in pointing the JPL and Bell Labs antennas at Echo.

About a week later, as a final check, the two organizations staged a two-way live telephone conversation via the moon using Echo equipment and frequencies all along the line. Only the satellite was different.

The JPL-Bell Labs experiments now being conducted with Echo include:

Control room at Holmdel during moon bounce experiments preceding Echo launch. Bill Jakes (left), Echo project engineer, and C. C. Cutler, Asst. Director of electronics and radio research at Bell Labs, talk to JPL via moon. Equipment and frequencies during this test are identical to Echo experiment.



Aiming data for Echo transmissions is computed by IBM 709 at Goddard Space Flight Center and relayed to terminals by land line. Tracking is further aided by beacon in satellite, and optical and radar tracking at Goldstone and Holmdel.

- Voice communications, including tests of the ±30 kc deviation fm system being used.
- Measurement of reflective properties of the sphere including polarization of reflected signals, faraday rotation and doppler shift.
- Check of propagation theory against measured results.
- Transmission of teletype and other modulation methods.

Horn Antenna Cuts Thermal Noise

Transmissions from Holmdel to Goldstone are at 960 mc. Simultaneous transmission in the opposite direction is at 2390 mc, with power in each instance 10 kw. Signals are received at Holmdel by a 50-ft long steerable parabolic horn antenna having a 400-ft sq aperture. This design minimizes back and side lobes which pick up thermal noise from the earth. The resultant temperature of the antenna is about 2 K.

The horn feeds into a pair of right-and-left polarized, three-level traveling-wave maser amplifiers. The stronger of the two polarizations is selected for boosting and conversion to 70 mc by parametric amplifier converters.

Holmdel transmissions are via a 60 foot parabolic dish. At Goldstone, twin, 85-ft diam paraboloids are used both for transmission and reception. The JPL receiver employs a varactor diode parametric amplifier instead of a maser amplifier because of the lower frequency of the

NEWS

Parabolic horn antenna at Holmdel tracks Echo with minimum thermal noise. "There seems to be little room for improvement insofar as noise is concerned," said one Bell Labs engineer of the big horn. Maser amplifier and other receiving gear are housed in cab at the small end of the horn.

east-to-west transmission. Over-all system noise of the JPL antenna-receiver combination is about 300 K in contrast with approximately 6 K of noise for the horn-maser combination at Bell Laboratories.

Miniature Beacons Aid Tracking

Tracking of the balloon has been greatly facilitated by the mounting of two miniature radio beacons onto the satellite. Last April, at the time of the first attempt to orbit Echo, considerable difficulty in tracking the balloon was expected. "About 80 per cent of our effort in terms of manpower and equipment involves tracking," a JPL scientist said. An engineer at Bell Labs noted that "A beacon on the satellite would make our job a darn sight easier."

The delay in a second launching attempt permitted the development of suitable beacons for the purpose by RCA. The beacons are mounted on opposite sides of the balloon and linked together by thin, printed circuit cables. Each unit consists of a 0.5-oz transistorized transmitter, a miniature storage battery and an array of 70 solar cells. The components are encased in a molded foam plastic disc weighing 11 oz and 10 in. across. The beacons fit snugly against the side of the balloon and contain spring loaded whip antennas which unfold upon ejection of the balloon from its container.

Each of the solar cell arrays is sufficient to power both units. The transmitters radiate about 5 mw at 107.94 and 107.97 mc. ■ ■

Image-Tube Development Provides Important Aids To Astronomers

Photoelectric image intensifiers or image tubes have already increased telescope speeds by as much as 30 times, and have the potential of increasing them by a factor of 100.

Three recent investigations using image tubes, as well as development of the tubes used in two of these three projects, were sponsored by the National Science Foundation.

Development of image tubes has been carried on by the Carnegie Institution of Washington through the Carnegie Committee on Image Tubes for Telescopes, initially with funds provided by the Carnegie Corp. and more recently under NSF grants totaling $385,000.

One investigation used an image tube called an "electronic camera" developed with French Government funds by A. Lallemand and M. Duchesne of the Paris Observatory. Lallemand is a pioneer in image-tube development and was one of the first to point out the potential advantages of such a device. In the Lallemand-Duchesne tube, the electrons are focused directly on a photographic plate, rather than on a phosphor screen.

Mobile Electronic Laboratory

One of two mobile electronic laboratories developed by the Boulder Laboratories, National Bureau of Standards, for conducting radio propagation studies in isolated areas. Equipment in the trailers is designed to study time variations in refractivity at one or more points along a radio propagation path and the corresponding variations in the phase of arrival of a microwave signal transmitted over the path. Initially developed for a study at Cape Canaveral, the 35-ft trailers contain—in addition to their electronic instrumentation—office, sleeping, and kitchen facilities for two men.

Peltier Cooling Used

Holds Unit Temperature to 110 F; 64 Thermocouples in Cooling Plate

PELTIER cooling is employed in a new package designed to dissipate heat generated by gyro servo components. The manufacturer claims the development can get rid of 65.3 w of heat to ambient air at 140 F.

The component holds the gyro unit temperature to 110 F. Heat is transferred via internal air to the case, from the case by conduction to a stable-platform aluminum housing, which, in turn is cooled by the new unit.

Manufactured by Airesearch Manufacturing Div. of the Garrett Corp., Los Angeles, the heat pump uses 64 thermoelectric couples formed into a cooling plate. Heat in the gyro platform housing is drawn out by the thermoelectric couples and vented overboard by a fan through a plate and fin heat exchanger.

A total of 20 amp, 5.5 v dc—110 w power input—is needed for the Peltier unit. According to Alfred L. Johnson, Jr., senior project engineer, and William Ferris, project design engineer, the new gyro platform cooler is first in a line of Peltier heat pumps. A more complex unit using two fans and more complex heat exchanging construction is currently on the drawing boards. "Gyro platforms must exist in a 140 C environment according to specifications," Mr. Johnson says, "but they're usually built to withstand only 140 C. No margin for error." Another unit being designed will cool down to —125 C, according to Mr. Johnson. New materials are expected to

Designers Ferris and Johnson (right) show their new cooling package using Peltier technique. Heat in gyro platform is drawn out by thermoelectric couples and vented overboard by a fan through a plate and fin heat exchanger.

...With Gyro Components

permit a 50 per cent increase in efficiency of Peltier coolers within about two months, and, Mr. Johnson says, there is no reason Airesearch couldn't get down to liquid nitrogen temperatures with this efficiency increase. This would provide a refrigerator system for cryogenic gyros, among other applications.

Peltier cooling uses electrons as an energy transport fluid. As electrons pass from one leg of a thermocouple to another they pass from one energy level to another. "So far as the math is concerned," Mr. Johnson says, "the system is identical to a standard Freon system. At a lower energy level, the electrons are close together like the molecules in the liquid Freon state. At the higher energy level, the electrons are farther apart, corresponding to the gaseous Freon state."

The difference in electron energy is made up by absorbing or rejecting thermal energy, pumping it from a cool source to the heat sink. Advantages of Peltier cooling include good reliability, higher heat sink temperatures, and the ease with which a given static temperature may be maintained. ■ ■

TWT's Used in Program For Space Temperature Research

The radio telescope at Bonn University Observatory in Germany will be used for an intensive investigation into the temperatures prevailing in interstellar gas.

Special dual channel amplifying equipment, using two low noise type N1017 Traveling Wave Tubes in cascade in each channel, has been supplied to the university by Marconi's Wireless Telegraph Co., Ltd.

The radio telescope, an 83-ft diam parabolic mirror mounted on a pyramidal tower about 60 ft high, scans the sky picking up the cosmic continuum radiation emanating from galactic and extragalactic radio sources. The signals in the neighborhood of the hydrogen line frequency (1420 mc) are amplified by one pair of traveling wave tubes, the other amplifying reference noise signals from a resistor at a known temperature.

The outputs from the two amplifying channels are detected, integrated and compared and the effective cosmic temperature determined; from these, data contour maps are prepared. So accurate has the system proved in initial tests that a discrimination of 0.1 K has been achieved.

Chicago Traffic Plotter

Map of Auto Density Results From Data Fed Into Computer

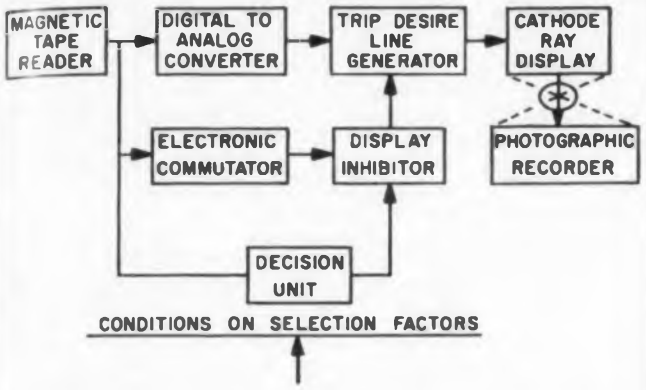
A PHOTOGRAPHIC data plotter for rapid and convenient display of automobile traffic distribution has been developed at the Illinois Institute of Technology, Chicago. Called the Cartographatron, the instrument records on film the thousands of trips made by Chicago motorists who answered questionnaires in a recent transportation survey.

Time, origin, destination, and other trip data derived from the questionnaires are stored in digital form on magnetic tape. The Cartographatron plots trip lines from the tape and displays them on a cathode-ray tube whose image is focused on a photographic plate. Since any number of trips can be plotted on the tube during a single exposure, the result is a map showing traffic density. Tape data can be selected to generate traffic maps for a variety of conditions such as rush hours, truck trips only, or city-bound traffic only. The entire trip, or merely the origin and destination points can be plotted as required.

Information from about 370,000 questionnaires gathered by the Chicago Area Transportation

Automobile traffic density in Chicago area as plotted by the Cartographatron. Each trip made by a vehicle is represented by a trace from its point of origin to its destination. Together, the thousands of traces provide a visual display of traffic density.

Puts Theory Onto Tube



Cartographatron processes traffic data from magnetic tape to give visual display of traffic density. Decision unit is programed to select only those trips required for a particular study. Origin and destination of each trip is then plotted on the cathode-ray tube. If required, the two points can be connected by a trace.

Study is contained in 21 reels of tape which can be processed in about 3-1/2 hours. Trip records are read and displayed at a rate of approximately 48 per sec.

Only one Cartographatron has been built to date—this at a cost of $68,500. Having completed its work in Chicago, the device will next be used for transportation studies in Pittsburgh and for air traffic studies by the Federal Aviation Agency. ■ ■

Signal Corps Orders Radios To Replace 3 Current Models

The Signal Corps has authorized the Speciality Electronics Development Corp., Syosset, N.Y., to produce a radio receiver to replace three existing models.

The FM receivers, which will be part of communications sets that cover the range 19.9 to 70.1 mc, were termed "interim" models by the Signal Corps. Depending on the design of the transmitter to be used in conjunction with the receivers, they ultimately may be modified or rejected. •

The receivers produced under the $600,000 negotiated contract use transistors and tubes in circuits designed and developed by the Signal Corps. The units use modular construction and have the dimensions 5 x 7 x 9 in.

Designated as R745, the receivers will be part of the pack and vehicular communications apparatus PRC-12 or VRC-25. The receivers replace R108, R109 and R110, each covering a third of the band to be covered by one unit.

Multi-layer Printed Circuits Are Announced at WESCON

Commercially available multi-layer printed circuit boards were announced by Litton Industries, Beverly Hills, Calif. at WESCON.

Development of the multi-layered etched laminates was described at the Electronic Circuit Packaging Symposium at the University of Colorado a few days before WESCON opened. Norman J. Schuster, Litton design engineer, disclosed that the multi-layer boards are now being included in a Litton airborne digital computer which has 70,000 to 80,000 parts. The use of four-layer rather than conventional single-layer boards reduced size by over 50 per cent for regular cards and 70 per cent for the logic section of the computer, including coiling and other equipment but not power supplies or memories. Cards are now available commercially.

Getting required dimensional stability to match up thousands of contacts could not be achieved using a thermoplastic teflon base, Mr. Schuster reported. Excellent results were achieved, however, when Litton shifted to a thermosetting material.

High interbus capacitance, where bus strips must parallel each other along the cards, was one of the problems encountered. In one application, this factor was found to be an advantage because shunt capacitance to ground was added to a circuit for better filtering action.

Several boards are printed, plated and etched in the Litton process, and then bonded together. Pin-type connectors are brought off the end of the boards. Experiments showed that plated-through holes could be used, although this has not yet been found necessary in Litton designs.

Microfilmed Missile Documents

All of the engineering documents for the entire guided missile program are stored in the cabinets above. Small space is all that is required at Redstone Arsenal, Ala., to maintain this active file of 850,000 documents on microfilm in aperture cards.

Discoverer XIV Carrying Gear For Optical Tracking Experiment

Discover XIV, whose instrument capsule was snared in mid air by a U.S. Air Force plane as it came down over the Pacific, carried an additional payload for comparative tracking tests in connection with the Navy's Transit 2-A navigation satellite.

The mid air catch, widely regarded as a noteworthy achievement, was overshadowed, however, by the recovery in the Soviet Union of a five-ton space vehicle carrying two dogs and other life.

A doppler transmitter package and a flashing light beacon are along for the ride and tracking stations are comparing results obtained with both doppler and optical tracking. The experiment is continuing beyond the usual lifetime of Discoverer satellites, whose value terminates with ejection of the capsule shortly after launching.

The Applied Physics Laboratory of Johns Hopkins, designers of the Transit system supplied the payload for Discoverer XIV and is manning tracking stations in Florida, New Mexico and Hawaii.

The flashing lights are seen on earth with a brightness equivalent to an eighth-magnitude star and must be observed through a telescope. If optical tracking proves feasible, Transit's future value to navigation may extend to vessels unable to afford receiving and computing equipment required to make use of the system.

Project Mercury Consoles Completed

Project Mercury display console is checked over before shipment from Stromberg-Carlson-San Diego, Div. of General Dynamics Corp., to Cape Canaveral. Several control center consoles built under subcontract to Bell Telephone Labs have been delivered to the Cape and Bermuda, where another control station will be located. A Project Mercury flight controller team will monitor data about an astronaut, the capsule and the flight.

WASHINGTON REPORT

Ephraim Kahn

MORE CONTROLLED AIRSPACE is proposed by the Federal Aviation Agency. It would drop to 14,500 ft (from the present 24,000 ft) the floor above which exists the "continental control area." Comments on the agency's proposal will be accepted from industry and other interested parties until Oct. 13. The increase in traffic control has been made possible because of electronic communications and improved control systems.

COMPETITION IN NEGOTIATED BUYING, a sore point with the Defense Department since it is under intermittent fire from Congressmen for letting contracts by methods other than competitive bidding, is being given careful study. To bolster its contention that negotiated contracts are often placed only after a number of firms have had a crack at meeting the military's requirements, the Defense Department has instituted a new system of reporting on new contracts. It will show the volume of negotiated pacts—but it will also indicate the extent to which design competition, price competition, technical competition, or sole-source negotiation have figured in the deal. This breakdown will be given for "follow-on" contracts as well, which have been regarded as sole-source purchases.

DEFENSE CONTRACTING RATE WILL RISE during the rest of this year and on into 1961. The Administration and the Pentagon have agreed that some of the extra $703 million voted by Congress to the military will be spent, not saved. Furthermore, it is apparent that the military is making plans that are based on the idea that more money will be coming their way next year, no matter which candidate wins the Presidency. There are, of course, substantial amounts that have not yet been committed. In addition, cancellations of contracts will result in a turn-back of funds which can be re-apportioned to projects that seem promising.

U.S.-CANADIAN COORDINATION of military R&D as well as purchasing has been ordered by the Defense Department. Efforts to have the U.S. buy more in Canada, or at least to give Canadian firms (including subsidiaries of U.S. companies) a "fair opportunity' will be increased, and the Defense Department will keep closer tabs on military contracts placed there. Heretofore, much U.S. military buying in Canada has been related to the electronic early-warning systems that are located there. To help balance international accounts, the suggestion has been made that Canada's CL-44 transport airplanes be swapped for the two squadrons of Bomarc missiles Canada plans to acquire.

NEW MAINTENANCE POLICY for military weapons and equipment will work changes in the type of work now being done by commercial firms, but probably will not have a significant effect on total volume. The new policy requires the military to do its own tactical maintenance work, but directs the use of contractors whenever feasible at higher echelons. Objective is to assure the military has "the minimum capacity necessary to insure a ready and controlled source of technical competence and resources to meet military contingencies." Recurring and predictable maintenance workloads will clearly be the most fruitful source of work for contractors, as a general rule. But it would appear as though new weapons systems will also provide opportunities, at least until they have become thoroughly familiar to troops. The Defense Department notes that consideration to contract maintenance is to be given "when it is desirable to augment military maintenance capability for an interim period to attain an earlier operational status for new military material being introduced."

INDUSTRIAL SECURITY PROCEDURES of the Defense Department have been modified in line with a Supreme Court decision. Employes of contractors now can, in most situations, confront and cross-examine persons who accuse them of things which might result in suspension, or denial, of the employe's right of access to classified information. Documents involved may be examined, as well. Exceptions to the right of confrontation will be made if the head of the government agency involved says there is "good and sufficient reason" to refrain from disclosing the informant's identity, and if the informant is a bona fide intelligence operative or is physically unable to appear. Hearings are held before boards which have no power to subpoena. This is expected to make it more difficult for the government to substantiate allegations since witnesses in security risk cases often are reluctant to appear voluntarily.

NEED FOR SHORTER LEAD-TIME has again been stressed by General Trudeau, chief of Army R&D. He wants "more rapid and intensive exchanges of information between industry and the Army at every stage of development . . . new procedures for expedited development such as overlapping and telescoping phases of the R&D cycle . . . conducting user and engineering testing concurrently or on a combined basis, and starting production engineering and tooling as early in the development cycle as possible."

ARMY'S RESEARCH NEEDS for aircraft over the next decade involve substantial problems in electronics and design. Major job for design engineers in the electronics field would be instrument packages for manned deep-penetration surveillance aircraft, as well as for drones. In addition, extensive work will have to be done on the development and testing of sensors for target acquisition, equipment for processing and interpreting the data returned by the aircraft, and avionics equipment that will meet the high standards of performance and reliability that will have to be built into future manned aircraft if they are to be sufficiently effective under combat conditions.

NEWS

Transitron Plans Research Into Passive Component Field

Transitron Electronics Corp. plans to begin research on passive electronic components in a 400,000-sq ft facility now being occupied in Boston.

The company has up to now been known for its work in semiconductors, and it has not produced passive components.

Much Transitron research effort is also being directed at the thermoelectricity field. Lead telluride elements are now being sampled. Silicides are also being investigated, according to a company spokesman.

Transitron will begin marketing tunnel diodes and microtransistors later this year.

CHANGES IN PRICE & AVAILABILITY

ELECTROLYTIC CAPACITORS have been increased 5 per cent in price by Astron Corp. of East Newark, N.J. and General Electric Co. of Hudson Falls, N.Y.

POWER SUPPLY, Model 3225, has been reduced in price by Power Instruments Corp. of El Segundo, Calif. This unit, originally costing $198, is now available from stock at $160.

CRYSTAL SILICON has been reduced 6 to 28 per cent in price by Merck & Co., Inc. of Rahway, N.J. The 1-50 ohm-cm P types, were cut from $1.55 to $1.39 a gram. Polycrystalline billets, with a boron content of less than one part in 6-million, dropped from 61 to 44 cents a gram.

TIPERSUL, a fibrous potassium titanate insulation material for 2,000 F applications has been reduced in price by E. I. du Pont de Nemours & Co., Inc. of Wilmington, Dela. The loose-fibre form of the material is reduced from $16.50 to $5.10 lb. The price for lumps and cut lumps is now $4.25 and $4.50 lb respectively.

Accuracy Is Our Policy . . .

On p 24 of the June 8 issue, General Instrument Corp. was incorrectly identified as being located in Elizabeth, N.J. Its correct address is Newark, N.J.

Fortune Predicts 'Shakeout' For Electronics Industry

A slowdown over the next 10 years in the rate of growth of the electronics industry, resulting in a "shakeout" of vulnerable companies, is anticipated in an article in Fortune magazine.

"It is clear," says Fortune, "that the industry cannot continue to expand at the rate of the past decade, almost 15 per cent a year compounded, or three and one-half times as fast as all industrial production. On the highest projections now being made by serious economists and market researchers the industry's growth in the 1960's will not exceed 9 per cent a year. On the most conservative projections, the industry will expand by 4 per cent a year, or slightly less than the rate Fortune has projected for all industrial production."

Estimates contained in the article picture the industry growing from about $10 billion in factory sales this year to $13-18 billion by 1965, and to $15.2-19.8 billion by 1970.

These values are based on a growth rate of the "crucial" government market estimated in the article at 3.5 to 8.7 per cent per year for the 10-year period. The five-year average for 1955-1960 is reported to be 15 per cent.

Sales of industrial equipment, which Fortune rates as the most hopeful area of growth for the industry, are predicted to rise from about $1.8 billion this year to $5.75 billion by 1970.

Because of the leveling off of the industry's growth rate and the fact that "survival requires a much broader range of attributes" than being able to develop a single innovation and riding it successfully for a while, Fortune concludes that "many companies now in the industry won't be around five or 10 years hence."

No Need to Handle Goods In Electronic Supermarket

An electronic supermarket where the customer never handles the goods, has been demonstrated in model form to retail trade experts in London.

The full-scale model incorporates an automatic method of warehousing coupled with an electronic system of order-taking. The customer has no loaded wire basket to steer around the store. She simply makes her choice, which is recorded on a card pushed into a processing machine at the cashier's desk.

While the customer pays for the goods, the cashier presses a button to set in motion the automatic dispensing from the warehouse. By the time the customer walks to the delivery counter, the goods are ready to collect.

"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 25 ON READER-SERVICE CARD

General Electric sealed relays for the '60's

4-POLE MICRO-MINIATURE

New grid-space, 4-pole double-throw micro-miniature relay features all-welded construction to eliminate flux contaminants. Knife-edge armature bearing and other design features provide structure capable of mechanical life in excess of 10 million operations. Rated 2 amps at 28 volts DC, or 115 volts AC resistive; requires only 100 milliwatts per pole. Other specifications are:

Operating sensitivity: 400 milliwatts at pickup voltages; continuous duty.

Vibration: 55 to 2000 cps at 30G's with 0.195" max. excursion 10 to 55 cps.

Shock: 50G's for 11 ms operating.

Temperature range: 125 C to −65 C.

Operating time: 6 milliseconds max. including bounce.

Insulation resistance: 1000 megohms min.

Dielectric strength: 1000 volts rms except 600 volts across contact gap.

Contact resistance: 0.050 ohms maximum (0.1 ohms max. after life).

Release time: 5 milliseconds maximum including bounce.

MINIATURE: Long-life type; rated 5 amps at 28 volts DC; in 2- or 4-pole double-throw and 6PNO forms. Ideal for ground jobs.

MICRO-MINIATURE: Crystal can type, all popular coils and mounting forms; 2 amps, 28 v DC or 115 v AC. Grid-spaced terminals available.

UNIMITE: World's smallest 1-amp sealed relay! Operates in 1.5 millisecond, releases in 3.5 milliseconds. Isolated contact chamber; all-welded construction.

General Electric Company
Section B792-18
Schenectady, New York

Please send me a free copy of the 1959–60 Sealed Relay Catalog.

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GENERAL ELECTRIC

CIRCLE 26 ON READER-SERVICE CARD

EDITORIAL

Consider the Digital Computer

Despite the vital role they've played and the important contributions they've made to the computer art, electronic design engineers haven't taken advantage of the digital computer as a tool. The growth of the digital computer as a mighty tool for business and industry can be attributed, in large measure, to electronics designers.

Yes, with the very important exception of those who design computers, the number of electronics engineers who use a digital computer in design is surprisingly small. There are many "reasons" for their reluctance to investigate this powerful tool, but in general, the "reasons" are faulty, as shown in this issue's staff report.

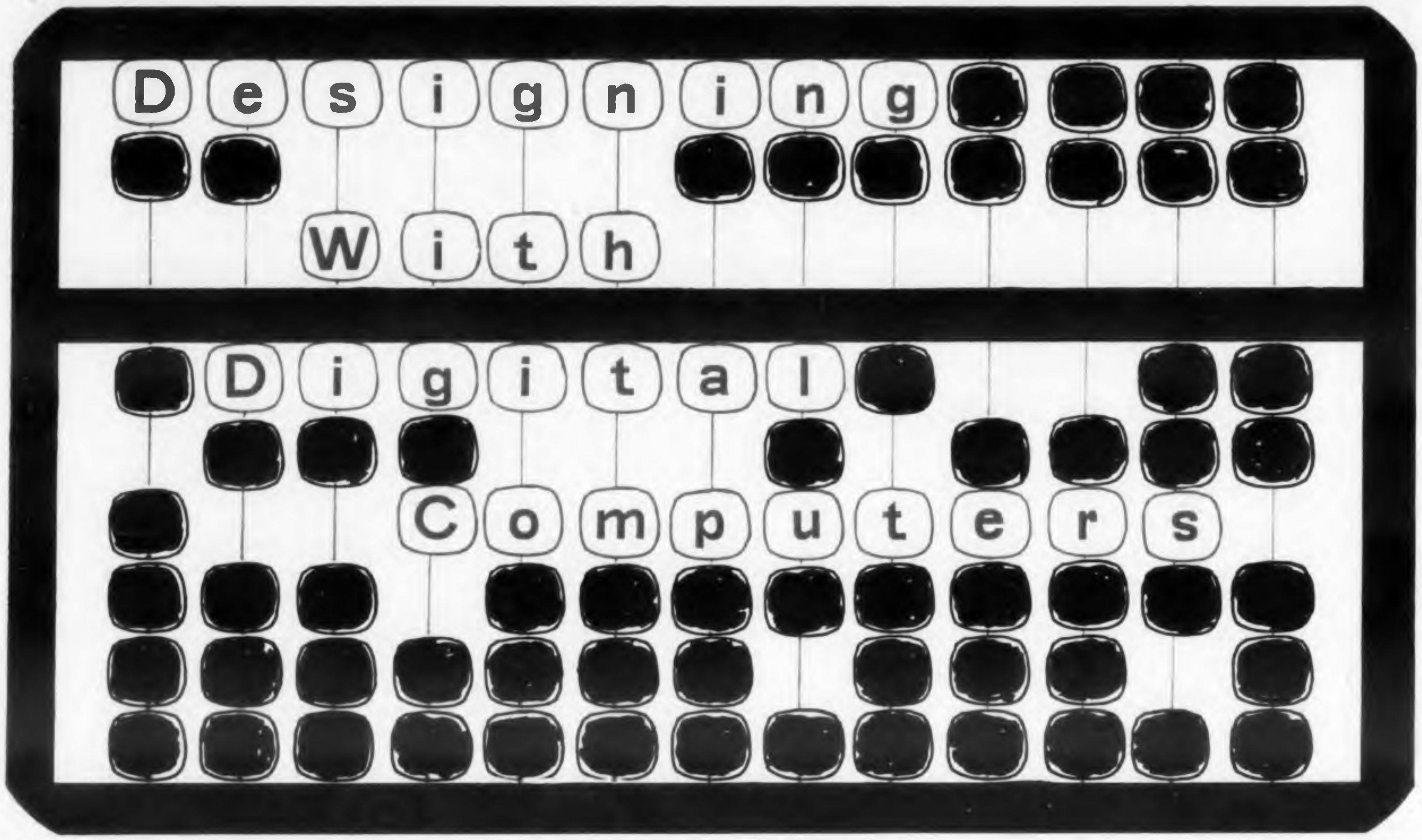
The "literature" hasn't helped the engineer; it certainly hasn't stimulated him to consider using a computer. Almost every article on applying digital computers in design work has stressed a single application. Thus, an article might explore the details of a specific application of a computer in the design of pulse transformers.

Of course, such an article can have tremendous value to pulse-transformer designers. But its value to other engineers is quite limited. More often than not, others are left with the feeling that computers are useful in pulse-transformer design, ". . . but I can't use a computer in my job."

To help offset this attitude, and to encourage designers to investigate the potential of digital computers, ELECTRONIC DESIGN presents in this issue a completely different approach. Here are listed dozens of applications of digital computers by forward-looking electronic design engineers. None of the applications is explored in depth. Rather, all are presented in breadth with the hope that they will stimulate other electronic designers to—Consider the Digital Computer.

George H. Rostky

An Electronic Design Staff Report



George Rostky
Associate Editor

PARADOXICAL as it may seem, electronics designers, by and large, are not using digital computers. Electronics designers have raised the digital computer from its "electronic curiosity" status a decade ago to its current status of an indispensable tool for business and industry.

These men have sold the world on the advantages of using digital computers. But they have not sold themselves.

They have seen the computer industry grow from a sideline of major business-machine companies (like International Business Machines and Remington-Rand) to a vast, dynamic industry with a whole train of peripheral industries manufacturing input-output equipment, logic modules, core memories, external storage devices, and a variety of supporting products.

In a period of two or three years, they have seen small, relatively unheard-of-companies (like Control Data Corp.) become important forces in the industry with machines that rival some of the most powerful computers built. In recent months they've heard some of the country's major industrial giants (like Radio Corp. of America and General Electric) proclaim that they're out to capture a sizable chunk of the computer market.

Yet, by and large, electronics engineers do not use computers in their work.

Computer Accomplishments Do Not Stir Engineers

They seem unmoved by reports of the monumental accounting, operational, statistical, and other specialized problems which computers have solved for business, industry and government. They may learn, for example, that Remington-Rand's Solid State 80 is keeping track of some 4 million publications issued by the Navy. Or they may learn how Remington-Rand's 1105's are helping the 1960 census.

Questioned on this score, an electronic design engineer is likely to answer: "A computer is great for paperwork. But I do creative work. A computer can't help me."

Here and there in the literature, they have seen how computers have helped civil engineers, mechanical engineers, thermodynamics engineers, optics engineers, and electrical engineers. They may have noticed that Massachusetts Institute of Technology has established a computer laboratory (with the IBM 650) for civil engineering students.

They may have read that the National Broach & Machine Co. is using a Bendix G-15 to help design gear-shaving cutters, gear-honing tools, master gears, and broaching tools. Or they may learn that Kollmorgen Optical Corp. is using Librascope's LGP-30 to help design lenses for precision optical systems.

Occasionally, they read about a rewarding application of digital computers by electronic design engineers. They may learn that Westinghouse is using an IBM 704 to design power transformers—or that Arma is using a Burroughs 203 to design pulse transformers.

Even these dramatic examples do not seem to inspire the average electronic design engineer. "Sure, they can use computers to design transformers," he's likely to say, "but I design audio amplifiers. I can't use a computer."

Why Electronics Engineers Do Not Use Digital Computers

Though several hypotheses have been offered, nobody knows for certain why so few electronics engineers have taken advantage of digital computers. The leading "reasons" engineers give include:

1. "Computers are too darned expensive."

2. "It takes too long to program a computer. By the time I write a program, I could have solved the problem."

3. "We have a computer but it's only good for payrolls."

4. "We have too few major design problems to justify renting a computer. Computers are only useful to large companies with large engineering departments."

Engineers Do Not Know How Quickly They Can Learn

Of course, in many cases, engineers don't know how quickly they can learn to use a computer. Using compilers like IBM's *Fortran* or Remington-Rand's *Mathmatic*, engineers have learned to use even large computers in two days. To a usable extent, these compilers translate English into computer language.

Dr. J. J. Sopka, mathematics consultant at the National Bureau of Standards in Boulder, offers still another explanation of why electronics engineers don't use computers. "They don't think their problems all the way through," he says.

"They like to formulate a problem in stages. They'll breadboard the first stage of a problem and wait for the answers to that before they start working on the next stage."

For small-equipment designs, Dr. Sopka points out, this can be a satisfactory approach. But it would be an awful way to do a job with a computer. To use a computer to best advantage, it is necessary to think a problem all the way through. As much as possible, one should give the computer alternative courses based on expected results at each stage.

Why Electronics Engineers Should Consider The Computer

Dr. Sopka's hypothesis on why electronics engineers do not use computers is certainly plausible and its solution is rather obvious. The other objections are answered almost as easily.

1. It is certainly true that computers are expensive, but once installed, they often seem to find jobs for themselves, and just as often they can pay for themselves very quickly.

2. For short, "one-shot" designs, it may not be worth while to use a computer—especially if set-up time is long compared with the manual-design time. But even for short jobs, the optimized results which a computer can yield can make it worth while.

Further, there are many computer-users' organizations which have programs available to solve many specific design problems. These groups include: *POOL*, an association of Royal-McBee computer users; *EXCHANGE*, the Bendix computer-users' group; Remington-Rand's *Univac Scientific Exchange*; and IBM's *SHARE*.

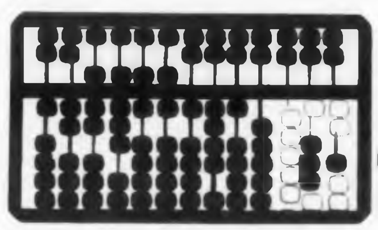
3. No computers are good "only for payrolls." Even machines which are best-suited to payroll and large record-keeping jobs can be used by electronics engineers. Most forward-looking company managements are eager to have their engineers use available machine time. (Unfortunately, this time is, in many cases, available only after 1 am on a Sunday.)

4. Even the organization with few design problems can use computers. Where it may not be economical to rent a computer, it may be wise to take advantage of some of the computer service organizations. Companies like C-E-I-R (Arlington, Va.), Computer Services Inc. (Englewood, N.J.), Marc Shiowitz and Associates (Hawthorne, Calif.), William M. Wolf Co. (Boston), and General Kinetics Inc. (Arlington, Va.) provide a variety of useful services.

They will rent time on their computers; they will make available the services and advice of expert programers and other computer personnel; or they will simply take over a problem and try to solve it for a fee.

There are many, many cases where an engineer will find it well worth while to discuss his design problems with a computer manufacturer or a computer service organization.

The survey which follows illustrates how many electronics engineers have reaped the benefits of computers. It is hoped that this survey will stimulate others to consider the digital computer.



omponent Design

Most applications of digital computers to component design are rather new. Probably, the oldest applications—dating back four or five years—are in motor and transformer design.

Power-Transformer Design

The Recomp computer, manufactured by the Autonetics Div. of North American Aviation in Los Angeles, is one of the machines which has been applied to power-transformer design. In this application, the computer is fed information on transformer input-voltage, frequency, output-voltage and power.

Recomp types out information on the required number of primary turns, the number of secondary turns, and the core area. The computation minimizes copper and iron losses.

Power-Inductor Design

One of the most extensive applications to inductor design can be credited to David Wildfeuer, a senior engineer at American Bosch Arma Corp.'s Arma Div. in Garden City, N.Y. Mr. Wildfeuer reports that he turned to a computer "as a matter of desperation." His Components Section just couldn't cope with its staggering workload. A Burroughs 203 solved Mr. Wildfeuer's problem.

This computer, manufactured by the Electrodata Div. of Burroughs Corp. in Pasadena, has cut design time from 30 hours per transformer or filter choke to 3 hours. Of the 3 hours, only 6 to 10 minutes are computer time; the balance of the time is spent preparing drawings.

The 203 helps Arma design power transformers for frequencies of 60 cps to 10 kc with up to four secondaries, each capable of having any kind of resistive or reactive loading. These transformers handle power levels of up to 2,500 w at 400 cps. The computer helps design filter chokes just as thoroughly.

Pulse-Transformer Design

In applying the Burroughs 203 to the design of miniature pulse transformers, Arma realizes impressive savings. Using the 203 cuts the cost of designing pulse transformers from about $400 per transformer to a dollar. It cuts the time from 40 hours to about 45 seconds.

Input to the computer, on five punched cards, includes all the design requirements. The memory stores data on magnet-wire and core-material characteristics.

Typewritten output from the computer includes: core type and size, winding schedule (order of winding primary and secondary turns), insulation type, wire size and power rating for each winding, rise and fall times, overshoot, various losses, turns ratios, as well as voltages and resistances.

Vacuum-Tube Design

The Red Bank Div. of Bendix Aviation Corp. in Eatontown, N.J., uses the technique of polynomial curve fitting in designing vacuum tubes with the Bendix G-15. The company estimates that it saves 10 engineering man-hours in computing a tenth-order polynomial and 50 sets of data.

Potentiometer Tap Selection

Nonlinear-potentiometer design is another fruitful application of digital computers. In one application of Librascope's LGP-30, the Link Div. of General Precision Inc. in Binghamton, N.Y., determines tap points for a linear potentiometer and shunting resistances necessary to provide straight-line approximations of nonlinear functions.

Before the potentiometer-tapping program is inserted in the computer, a nonlinear function is graphically approximated with a set of straight-line segments. The coordinates of the points of intersection of the straight lines are entered into the computer as raw data.

The LGP-30 calculates the tap points of the

Designing With Digital Computers

linear potentiometer in terms of degrees of wiper rotation as well as shunt and padder resistances necessary for the straight-line approximation of the original nonlinear function.

Nonlinear-Potentiometer Design

Spectrol Electronics Corp. of San Gabriel, Calif., uses an IBM 610 to design nonlinear potentiometers. For both single and multiturn potentiometers, Spectrol engineers prepare input information in the form of x and y coordinates or equations describing the parameters of a given nonlinear function. With the help of previously programmed general equations, the 610 computes manufacturing directions in terms of winding-equipment settings, cam angles, and radii.

The manufacturing directions are automatically printed on a form which is sent to production. At the same time, punched tape is prepared to store information for repeat requirements. Using the 610 reduces quote time for complete potentiometers from weeks to days, and in emergencies, to a few hours. Computations that formerly took four to six days now require only minutes.

Solenoid Design

Royal McBee Corp. of Port Chester, N.Y., uses the LGP-30 (which it markets for Librascope Corp.) to evaluate solenoid designs. Information fed to the computer on punched paper tape in-

Punched cards show Litton engineers which circuit board and computer-frame locations are available for new circuits.

cludes: the gap at the pole piece when open, a time increment to be used, mass of the armature, gap at the pole piece at closure, mechanical damping factor, a constant to indicate no current change, the initial armature hold-back force, the spring constant, the initial current and applied emf, the pole-face area, number of turns, average length of a turn, wire resistance, length of the iron, and μ of the air and iron.

The LGP-30 delivers information on the steady-state operation of the solenoid in terms of the total resistance, steady-state current, steady-state flux, generated force, inductance and time constant. The entire program shows the chronological operation of the solenoid through closure and opening. When 0.1-msec time increments are used over a closure time of about 10 msec, the entire computation on the LGP-30 requires only about 90 min.

Network Design

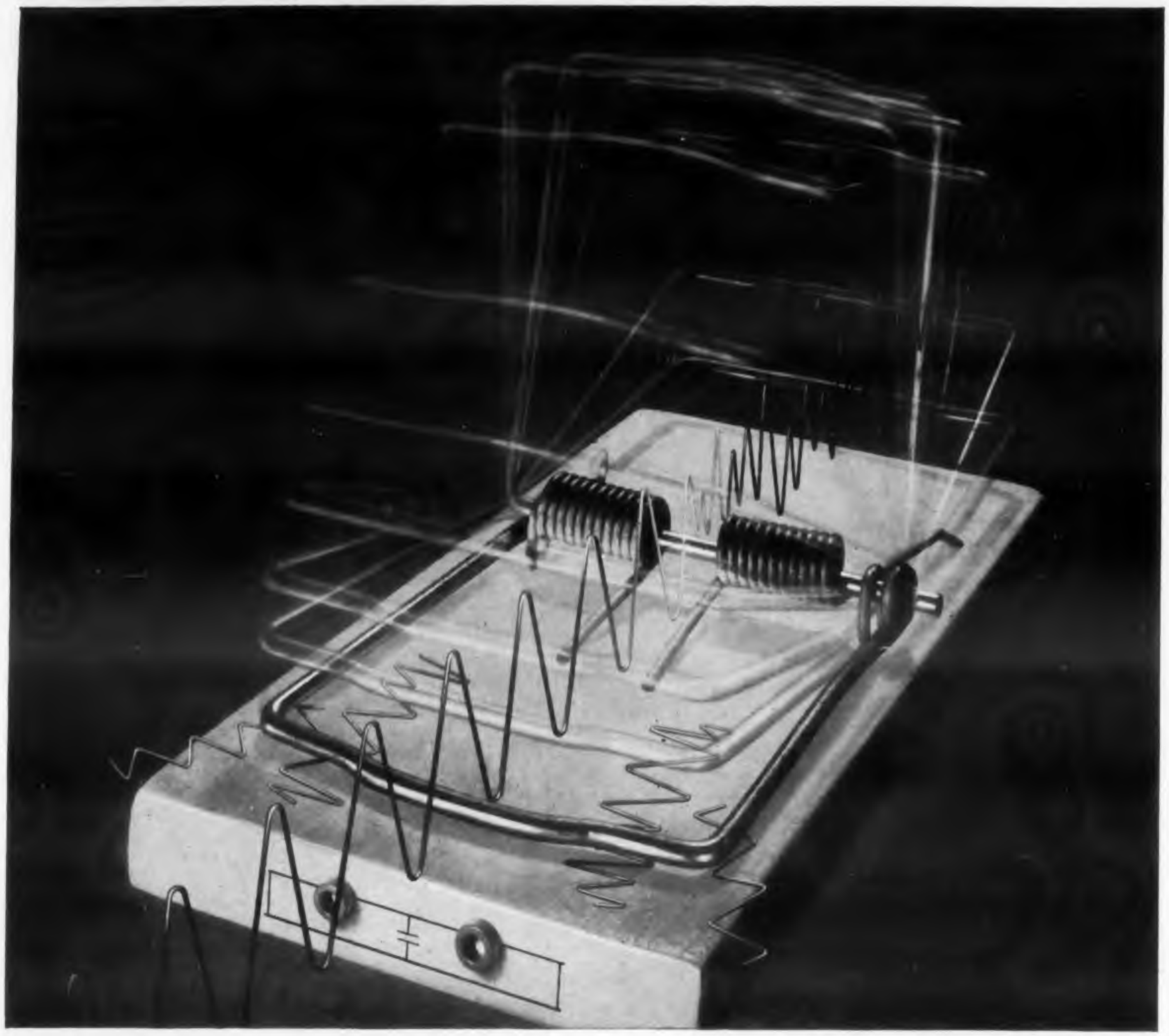
There are few areas where digital computers are used more fruitfully than in network design and analysis and, more specifically, in filter design. Here, at least, there is a significant trend away from manual computation. The valuable paperwork which even small machines can deliver in a relatively short time can often save thousands of engineering hours.

Passive-Network Design

At North Hills Electric Co. of Mineola, N.Y., Philip R. Geffe used an IBM 650 to analyze and synthesize a variety of passive networks. Using punched-card input, he inserted network formulas and likely element values. The output, also on punched cards, yielded information including network element values, attenuation in db and envelope delay. One year of part-time computer usage yielded at least 10 years worth of engineering hand-calculated data.

Engineering consultants Marc Schiowitz and Associates of Hawthorne, Calif., have a computer program for National Cash Register's NCR-304 to analyze steady-state linear passive networks. The program uses an iterative technique instead of the usual equation-solving methods. It is supposed to cut down computing time for many types of networks.

Magnavox Co. of Fort Wayne, Ind., uses a Bendix G-15 for filter design. Magnavox engi-



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neers feed the computer information on a filter's load and its various attenuation frequencies. The machine gives the attenuation frequencies and values of all the elements in the filters.

Filter Design

In one of the most extensive applications to filter design, Kenneth Smith of Lenkurt Electric Co. in San Carlos, Calif., uses an IBM 650 for a whole series of designs. Though Lenkurt's 650 is devoted principally to factory accounting, the engineering department has used it to great advantage in designing bandpass filters for telephone and telegraph carrier systems.

Before the computer was installed at Lenkurt, all filter calculations were performed on a desk calculator. Solving equations for a single bandpass filter required about 20 man-hours. Now, the same equations, involving roughly 10,000 computations are worked in five minutes by the IBM 650. In peak periods, when a design group may be developing as many as 12 filters a week, the saving can amount to 239 engineering man-hours a week. Lenkurt's use of the 650 is well illustrated in the following typical problems.

Problem 1. Estimate the attenuation of an image-parameter filter prior to design. Computer input includes: (1) cutoff frequencies, (2) infinite-point frequencies, (3) filter half-sections to be considered, (4) frequencies of the desired estimate of attenuation.

Computer output includes: (1) frequencies of desired estimate of attenuation, (2) corresponding estimate of attenuation. Average machine time—18 minutes. Time required by a desk calculator to do the same job—4 hours.

Problem 2. Design an image parameter filter from the best estimate in problem 1. Computer input: (1) cutoff frequencies, (2) infinite-point frequencies, (3) filter half-sections in proper order.

Computer output: element values of each filter half-section. Machine time—6 minutes. Desk calculator time would have been 20 hours including a double check for accuracy.

Problem 3. Combine the half-section element values and write an analysis program for the next step. Computer input: element values of each filter half-section from problem 2, and element losses.

Computer output: element values of the combined composite filter and an input program fo the Bell Telephone Laboratories analysis deck BL-2002. Average 650 time—3 minutes. Desk calculator to do the same job—4 hours.

Problem 4. Analyze response of the filters of problem 3 with lossy elements using the analysis deck BL-2002. Computer input: the program from problem 3 and the frequencies of desired response.

Computer output: (1) attenuation in db, (2) phase angle in degrees, (3) insertion loss ratio as a complex number, (4) input impedance and admittance. Computer time—30 minutes. Problem is not practical with a desk calculator. It would have been necessary to build a model and test (about 20 hours).

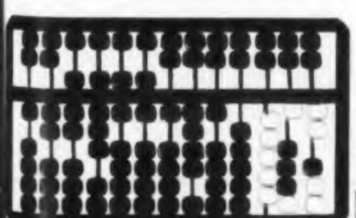
Problem 5. Prepare a table for frequency-difference tuning of all meshes of a filter. Computer input: (1) design-center frequency of each mesh, (2) frequency tolerance of each mesh, (3) design capacity of each mesh.

Computer output: (1) upper frequency limit and upper padder-capacity value for each internal frequency difference from design center, (2) lower frequency limit and lower padder values for each internal frequency difference. Average machine time—24 minutes. Desk-calculator time would have been 20 hours.

Mr. Smith comments that Lenkurt's engineers used 396 hours of 650 time during 1959. He estimates that the same job by desk calculator would have required 20,160 man-hours.

Other companies using computer in filter-network design have realized similar savings.

Vitro Laboratories of West Orange, N.J., saved three man-months on two problems. Vitro engineers used the Bendix G-15 whose input included measured gains and outputs and values for assumed design parameters. The G-15 provided information for plotting slopes, intercepts, and additional design parameters resulting from the solutions of simultaneous equations.



Circuit Design

One of the broadest areas of application for digital computers lies in circuit design and analysis. Yet even here, the computer scarcely sees full exploitation. Relatively few circuit designers have taken even partial advantage of this powerful tool. Where the computers have been used,

Designing With Digital Computers

designers have realized substantial advantages in circuit performance, as well as engineering time and costs.

Impedance Calculations

The Recomp computer has been used for calculating complex impedances. In such applications, the machine receives as input, values of resistance, capacitance and inductance of a complex network and the input frequency. Recomp calculates the total impedance, equivalent series and parallel resistance, and reactance and phase angle at a given frequency, as well as other resonant frequencies.

Equivalent Circuit Analysis

At Bell Telephone Laboratories, V. R. Saari uses an IBM 650 and an IBM 704 in a variety of circuit design and analysis applications. In one application, he found equivalent circuits to fit measured black-box data. He fed the computer an analysis program based on the type of circuit whose characteristics could reasonably approximate those of the black box. He also inserted several sets of likely element and parameter values as well as measured data on the black box to be characterized.

The computer listed electrical characteristics to approximate the circuit in the black box and reorganized the measured data into a form more suitable for examination and comparison with the computed characteristics. The set of element and parameter values which resulted in circuit characteristics most closely approximating the measured data was chosen as the best one to describe the black box.

Mr. Saari also used these computers in analyzing networks of various types. As input, he used measured data tabulated against frequency for active devices and other components for which valid equivalent circuits were not available. He also inputted values for lumped-constant networks and other parameter values such as characteristic impedance and length of transmission lines and operating temperature.

The computer yielded information on: (1) forward and reverse currents, voltage- and power transfer ratios of a cascade of active devices (or lumped-constant networks, or transmission lines); (2) input and output impedances of such cascades; (3) derivatives with respect to the various element and parameter values, hence reasonable tolerances; and (4) total current or power drain by the network.

Amplifier Analysis

In still another application, Mr. Saari used the 650 or the 704 to determine whether or not parasitics were under control in an amplifier. He programed the computer to yield the electrical characteristics of an amplifier circuit or a cascade of amplifiers.

Mr. Saari also used the 650 or 704 to check the final design of an amplifier and calculate its sensitivity to changes in circuit-element or transistor parameters.

Microwave Circuit Design

At the high-frequency end of the spectrum, Leo Young of Westinghouse Electric Corp. in Baltimore teamed up a Smith chart and an IBM 650. Using the Smith chart, he first estimated the parameters of a microwave bandpass filter. He then used the 650 to analyze the preliminary design. He varied the parameters till the computer showed the new performance to be acceptable. This was his first approach to the design.

Finally, however, he programed the 650 to vary the circuit parameters till the optimum design was reached. The computer made trial and error adjustments, interpolations, and extrapolations automatically. The 650 calculated vswr, reflection coefficient, insertion loss, maximum voltage and phase difference as a function of frequency. It also made calculations for component tolerances and circuit losses.

Transistorized-Inverter Design

Bendix Aviation Corp.'s Computer Div. in Los Angeles used the Bendix G-15 to design transistorized inverters for the Bendix G-20 computer. Information fed to the G-15 included end-of-life transistor parameter values, maximum expected temperature (with a safety factor), input voltage and tolerance, special bias, maximum collector currents, and calculated resistor values and tolerances. The G-15 typed out values of resistor couplings for the transistor inverters and listed the driving currents required.

After the initial program was set up, the G-15 required about two minutes to provide a curve. Previously, using a desk calculator, 45 to 60 minutes were required.

Blocking-Oscillator Design

The Bendix G-15 was also used to design transistorized blocking oscillators and inductive integrators for the Bendix G-20. In the blocking-oscillator program input to the machine included measured values of transistor and transformer

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parameters. The input bias voltage was used as the running parameter.

The G-15 calculated the output pulse width of the oscillator and provided 70 curves in three quarters of an hour. It used to take a design engineer and a desk calculator an hour and a half for a single curve..

In designing inductive integrators, Bendix engineers fed the G-15 measured values of transistor parameters and the required timing resistance. They used clamp voltage as the running parameter. The computer provided a time delay curve in five minutes. A desk-calculator design-engineer team used to require an hour and a half per curve.

Power-Supply Design

One of the popular computer applications is power-supply design and analysis. IBM has a program which treats selected polyphase and single-phase circuits. It operates not only on passive parameters but also on overlapping diode currents and non-sinusoidal input voltages. Including laboratory test and redesign, the program can help an engineer design as many as five complete power supplies in a month.

Flip-Flop Design

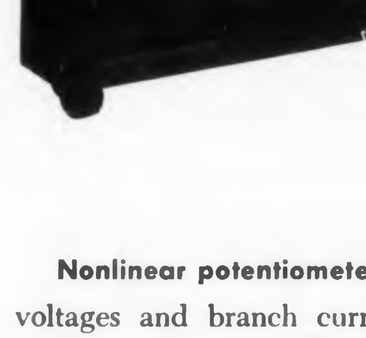
At the Ramo-Wooldridge Div. of Thompson Ramo Wooldridge in Los Angeles, three engineers, Tom Connolly, Bob Mellott, and Mel Gillies, used an IBM 704 to design the flip-flops for the RW-31, RW-400, and RW-41 computers. They wrote Kirchhoff equations describing the flip-flops and used these to find the optimum value of the components which were critical to the dc stability of the circuits. They made approximations for transistor parameters, component variation, and voltage variation. The 704 gave optimum component values for various voltage levels, for leakage-current levels, and for standard resistor values (about 1,000 different cases).

Hand computation, Schmoo plots, and trial-and-error methods for flip-flop design used to require several weeks to a month. Using the 704 to compute and print out the solutions for more thorough analysis required only 20 minutes.

Nonlinear-Circuit Analysis

At the University of Illinois, L. D. Fosdick used a computer to calculate equilibrium node voltages and branch currents in circuits with nonlinear elements. The circuits included resistors, diodes and transistors.

Nonlinear potentiometers are designed faster and better by Spectrol Electronics Corp. with the IBM-610.



Few areas of design seem more appropriate for the digital computer than that of designing digital computers. The cynics of a decade ago who quipped that the "giant electronic brains" would soon be fathering "baby electronic brains" were not far off. An ironical twist, however, lies in the fact that the progeny is often more powerful than the parent.

One example of this comes from the Datamatic Div. of Minneapolis-Honeywell Regulator Co. in Newton Highlands, Mass., where engineers used the Datamatic 1000 to design the new Honeywell 800. Using the Datamatic 1000 obviated about 10,000 circuit diagrams that otherwise would have been required in manufacturing the Honeywell 800.

The Datamatic 1000 prepared wiring lists fixing the origin and termination for each of 60,000 wires, as well as the route each was to follow. In addition, tables of wire position, recorded on magnetic tape, helped engineers check for noise pickup. The computer also checked the new machine's logic for timing errors.

Wiring-List Preparation

At IBM in Poughkeepsie, N.Y., many programs written for the IBM 704 and 705 have been used to help design new computers. With one program, a computer prepares back-panel wiring lists which describe how the components are to be interconnected in the new machine to implement the logic and to minimize interwire noise and the amount of wire used.

In a paper presented at the AIEE Winter General Meeting early this year, IBM's G. W. Altman, L. A. DeCampo, and C. R. Warburton indicated that minimizing interwire noise, a monotonous and error-prone job, used to require two engineering man-weeks. Judgment, rather than computation, was the criterion.

Now, the average time for the first run of a panel is six hours from the start of key punching to the delivery of a completed panel-wiring list. The list printed out by the computer contains information about wire types, wire connections, lengths and routing.

The back-panel wiring program has produced almost 3,000 panels for IBM's Poughkeepsie Product Development Group.

In a similar application, Marc Shiowitz and Associates of Hawthorne, Calif., use the Alwac III-E to generate detailed and complete wiring lists from logical design. In this service offered by MSA, wiring lists can be generated within a day after a logical design is completed. When design changes are required the wiring lists can be updated immediately.

MSA's program, using Boolean equations for input, can mechanize multi-level diode or transistor logic. It allows for the use of any standardized set of digital building blocks. The service fee for computer-generated wiring lists is less than the cost of schematics or the cost of a manually prepared list.

Automatic Logic Design

Eugen I. Bosch of Litton Industries in Beverly Hills, Calif., used—not a computer—but inexpensive peripheral equipment to design large-scale computers at Litton's Tactical Systems Laboratory. Automating the logic was accomplished with off-line equipment like sorters, collators and tabulators.

An actual computer was used only to simulate the operation of the new computer before the logic was actually wired up as final hardware. Using the off-line equipment, Mr. Bosch had the handwritten logic punched on cards, then tabulated in two versions: (1) logical equations representing the inputs to active circuits, (2) a list showing all places where the output of each circuit must go.

When the logic was ready for wiring, another card deck was prepared from a logic deck. It contained one card for each circuit required to mechanize the logic. Circuit and space allocation was accomplished by manually merging this deck with pre-punched cards which represented the available circuit boards and computer-frame locations.

The merged deck was used to generate wiring lists automatically. Final printout included a logic listing (a neat alphabetized copy of the handwritten logic), and a tabulation showing the total current each signal was to supply.

Circuit-Loading Calculation

A large general-purpose computer helped engineers at Ramo-Wooldridge design the large RW-400 computer as well as other RW computers. From logical equations the computer prepared wiring lists for chassis and logic card assembly. It determined loading of each flip-flop and of other circuits and advised the logical designer of required changes in logic. In addition to this, the computer produced necessary check-out and maintenance information for the finished equipment.

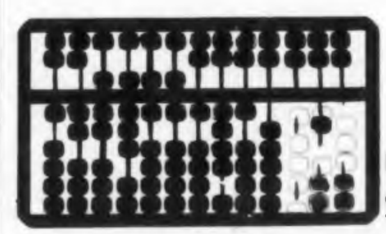
In a paper delivered before the Association for Computing Machinery, Ramo-Wooldridge engineers John P. Malbrain and Anthony V. Banes reported that using the computer to design new ones cut the calendar time to produce a large data processor by a year or more.

Final output from the computer gave all parts locations, wire routing, and component values. After more than a year of experience, RW engineers have found that maintenance personnel prefer computer-prepared wiring lists even when drawings exist.

The National Bureau of Standards, also, has used a computer to help design new ones. Approximately 20,000 punched cards contained information from which logical design was converted into detailed wiring plans.

Boolean equations were first checked for internal consistency, then, using additional data describing the physical location of the principal building blocks in the system, the computer automatically assigned minor components to optimum physical locations. The computer calculated optimum wire routing and prepared the topological diagram of the wiring tree showing the location of each node and its connection with other nodes in the tree.

Finally, the computer calculated the exact lengths of all wires, specifying terminal types, pin-to-pin connections, text for wire labels, and a detailed inventory of components and materials to be used. Final output data included 15,000 printed pages.



ropagation Studies

In propagation studies and in antenna design, the digital computer has not only saved time and money, it has performed tasks which would not have even been attempted without its aid.

Ionospheric-Scatter Analysis

At the National Bureau of Standards in Boulder, Gregg Merrill of the Central Radio Propagation Laboratory used an IBM 650 for a problem which could not have been approached by manual methods. He used the computer to analyze antenna radiation patterns in the lower ionosphere and fresnel zones for antennas elevated over spherical earth. The fresnel zone had

Translating Russian to English at NBS is the job of Mrs. Ida Rhodes who is developing automatic translation techniques to allow a computer to do the job.

never before been calculated over spherical earth.

Card input to the 650 represented tropospheric refraction, spherical divergence, parallax, surface refractivity, linear lapse rate, antenna height and frequency.

Output from the 650 gave the ground-voltage interference pattern between the direct wave and ground-reflected wave. Matching the direct wave and reflected wave gave the smooth pattern needed (to within 3 mm in 1200 km), over the frequency range of 30 to 55 mc. With help from the 650, Mr. Merrill established a theoretical pattern which helped him set up experiments.

He was able to determine optimum antenna height, size of the fresnel zone, near and far edges, near and far quarter-wave contours, angles of illumination through the fresnel zone, and the elevation of the zero-phase surface of the earth. Machine time on the 650 was about 400 hours.

Lightning-Flash Analysis

Using the same 650, John Kemper of the NBS Central Radio Propagation Laboratory analyzed the attenuation and phase delay due to propagation. He used the 650 to perform Fourier analyses of pulses from lightning flashes 1,000 and 2,000 km away.

Scope waveforms of the pulses were filmed, then transferred to a curve tracer which yielded the x and y coordinates of the waveform envelope. Mr. Kemper punched these coordinates on cards. Output from the computer represented the frequency spectrum, phase, and amplitude of the lightning pulses. These were plotted directly.

Subtracting the pulse of the near lightning flash from that of the far one showed the attenuation and phase change due to propagation. About an hour was required to trace one waveform and enter it into the 650. Eight hours of computation would have been required with a desk calculator.

NBS has used digital computers in other areas

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of radio-propagation research, too. These have included analyses of specular reflection of ionized meteor trails, world-wide prediction of transmission loss over ionospheric and tropospheric propagation paths and preparation of a number of maps of ionospheric and tropospheric characteristics.

Similar studies have been conducted by Stanford Research Institute of Menlo Park, Calif. SRI used an IBM 704 to determine the reliability of multi-path communications. The computer analyzed propagation parameters and geographic factors for a world-wide communications system. SRI has also used computers to develop data for antenna design and to prepare antenna radiation patterns.

Antenna Design

The Mattern Div. of Land-Air, Inc. in Chicago used a Bendix G-15 for aircraft-antenna design, for transmission-line design, and for calculating high-frequency cable attenuation and loss. In these problems, the G-15 analyzed not only cable-test parameters, but transmission-line physical parameters, antenna physical characteristics, and test results.

Information from the computer included equivalent impedance, reflection coefficient, antenna vswr, proportions of antenna dimensions, transmission-line length and transmission characteristics. In one instance, the G-15 provided a seven man-hour calculation in 23 minutes.

Engineers at Bendix Radio in Baltimore use the Bendix G-15 to design radar antennas. Information fed to the computer includes: (1) for the central section design—elevation range, distance from feed to antenna at a reference point, strength of incident beam, basic pattern desired; (2) calculation of power pattern using the central section—the polar coordinates of the antenna, strength of the incident beam, wavelength of the radiation, range of angles to be investigated. In addition, if integration is performed over the whole antenna, previously calculated Cartesian coordinates are given for various points.

The G-15 provides: (1) for the central section design—distances from feed to antenna and angles of the parabolic cross sections at specified intervals along the central section; (2) power pattern—this gives the relative strength of the reflected beam at various angles.

With the central section alone, only elevation angles can be investigated. But this is useful as a preliminary check for gross errors in design. For a finer check, the reflection from the whole antenna can be integrated, making it possible to find a power pattern at any combination of elevation and azimuth angles.

This involves double integration of a complex function. It is performed by summing approximately 150 vectors.

In general, the computer's design required about one or two per cent of the manual computation time. Investigation of azimuth patterns was not even attempted before the computer was turned to this task. Now the power at any point can be computed in about eight minutes. Beyond this advantage is the time saved in producing and testing scale models.

Simulation Studies

"Simulation" is more of a design or analysis technique than an area of design. Hence, it can encompass design and analysis of systems, circuits, and even active components. As with systems studies, it is very difficult to estimate cost or time savings.

Guidance-System Simulation

C-E-I-R of Arlington, Va., used an IBM 709 to simulate the electronic guidance system for the Titan ICBM. The basic problem in this application was to simulate missile flight under rapidly changing conditions. Information fed to the 709 included system equations and system logic.

The computer's output simulated the performance of Titan under the various conditions to be expected after the missile is launched.

Helicopter-Simulator Simulation

In Falls Church, Va., Melpar, Inc., a subsidiary of Westinghouse Air Brake Co., used an IBM 704 to simulate, digitally, an analog simulator for the H-37A helicopter trainer. The digital simulation was used to determine if the helicopter simulator would have the same "performance characteristics," and "flying qualities" as the actual helicopter.

The 704 helped design and analyze the HSS-2 helicopter anti-submarine-warfare weapons sys-

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tem trainer of which the H-37A is a part. Information supplied to the 704 or stored in its memory represented performance of the helicopter rotor over its entire range, pilot actions like throttle position, collective pitch, stick position and cyclic stick position.

The computer provided answers in terms of the results of pilot action such as forward velocity, heading altitude, rate of climb, fuel flow, engine rpm, and hydraulic pressure.

Signal-Environment Simulation

W. G. James of American Machine and Foundry Co. in Alexandria, Va., used an IBM 704 to simulate the electromagnetic environment of an airborne receiver for a large deployment of electromagnetic emitters. The program simulated emitter characteristics like antenna-gain patterns and scanning cycles of such propagation phenomena as atmospheric absorption and tropospheric refraction.

Mr. James used the 704 to simulate models of all transmitter parameters and propagation phenomena which could significantly affect signal strength.

The printed out simulation results included the set-by-set signal contribution to the environment (or the mean and standard deviation of the total number of pulsed or cw signals as a function of signal level), and the cumulative prf count and duty cycle of the signal environment.

Landing-Approach Simulation

Wolf Research and Development Corp. of Boston used the Bendix G-15 for an error analysis of the equations used in the Volscan AN/FSQ-7 (XD-1), an aircraft landing-approach control system. The exact values of the solutions were computed for a grid covering the area of interest.

These values were compared with approximations developed by the use of nonlinear potentiometers in Volscan. Error values at the grid points were typed out. Functions used for the nonlinear potentiometers were adjusted and recomputed to give a better error curve.

Input information included sample points in the nonlinear curve, and the exact analytical solution in two dimensions. In the final solution, errors developed by the nonlinear potentiometers were shown to be excessive. The Volscan cir-

Wiring list at Litton's Electronic Equipments Div. makes it easy to wire new computers, obviates wiring diagrams.

cuitry was redesigned to use resolvers which gave an exact solution of the problem.

Guidance-Computer Simulation

Engineers at Space Technology Laboratories, Inc. in Los Angeles used an IBM 709 to simulate a number of different airborne missile-guidance computers. Output media included magnetic tape, printer output, punched cards and paper tape. In some instances, paper tapes were sent to the ballistic missile launch site and used for pre-launch checkout. These tapes, in some cases, became part of the missile flight itself.

The simulation process included, basically, a compiler which produced a bit-by-bit, instruction-by-instruction simulation of what the airborne guidance system would produce. Input to the 709, on cards, then magnetic tape, consisted of Boolean equations describing the logic in the guidance computer.

In such computer-design applications at STL, the 709 produced specifications ranging from functional logic through wiring lists. In simulation work, the computer could produce functional descriptions or discrete instructions like those of the guidance computer being simulated.

In one application, a logic checkout program saved months of time and roughly half the normal checkout effort required. The computer runs necessary for the logic checkout were completed in three days.

Using a bit-by-bit simulation, STL engineers found errors that might not have been found otherwise. These errors could have caused malfunctions during a launch. Set against the cost of an unsuccessful launch and the loss of a missile, the cost of the simulation becomes extremely slight.

STL used the logic compiler with the 709 to check out guidance computers used in the Able series of booster vehicles and in the Titan and Minuteman ICBMs. Projects which benefited most from the program were those where the

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compiler was used in early development stages. However, even when the compiler was used after test models had been built, it provided valuable information and further verified the computer design. In one instance, the simulation showed several design errors which had not been caught during test-model checkout.

Circuit Simulation

Engineering consultants Marc Shiowitz and Associates have a computer program which, given a specific circuit with fixed parameters, generates a routine to simulate the circuit. A driving-signal-generating sub-routine is an integral part of the program.

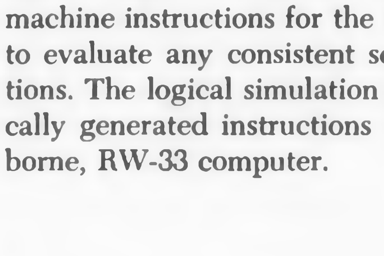
Using this program, the computer calculates the voltages at nodes, the currents in branches, the charge within transistor base regions and temperatures at junctions as functions of time.

Models used in the simulation, such as models of transistors, diodes, driving functions, etc., may be changed without altering the program.

MSA has a subsidiary program which, given a fixed circuit with parameters variable over a specific range and a formula for figure of merit, generates a routine to seek that allowable combination of parameters which provides the best figure of merit.

Logic Simulation

At Ramo-Wooldridge, Tom Connoly developed a logical simulation compiler to generate machine instructions for the IBM 709 which was to evaluate any consistent set of Boolean equations. The logical simulation generator automatically generated instructions to simulate the airborne, RW-33 computer.



eliability Control

In reliability analyses and in quality control, the digital computer has proven its value—not only in statistical evaluations—but even in determining the reliability of proposed circuit designs or in weighing the cost of given levels of reliability.

No longer needed are these hundreds of blueprints for some 10,000 circuit drawings. Wiring tables, recorded on magnetic tape, replace drawings in production of the Honeywell-800 data processor.

Circuit-Reliability Analysis

At General Precision Laboratory of Pleasantville, N.Y., engineers used a Librascope LGP-30 to check the reliability of already designed circuits and to redesign them when necessary to improve performance or to alter input-output specifications.

GPL's Herbert A. Seidman and Philip L. Hillman described one such application—a four-transistor flip-flop—at a meeting of the Association of Environmental Engineers. The circuit uses a basic two-transistor flip-flop with a transistorized inverting amplifier at each output.

To begin the analysis, an engineer writes separate, independent, nodal equations to satisfy the circuit. In these equations, the currents are expressed in terms of voltages across resistors. The engineer then establishes the criteria for circuit stability.

The basic equations describing the circuit and giving component values are then inserted in the LGP-30. The computer then makes a run for each set of data with different values of transistor characteristics. It assigns a value to each resistor and voltage in the circuit. Each run differs from others by a variation of one or more of the parameters involved.

The effects of aging, high temperature, fluctuations in power supplies, initial spread of transistor and other component parameters are considered. To reduce the number of machine operations the effects of several parameter changes can be lumped into a single, properly-weighted, hypothetical parameter.

If the computer finds a circuit inadequately reliable, it can "suggest" improvements by introducing modifications of component values.

Cost vs. Reliability Analysis

C-E-I-R has a program for the IBM 704 computer which determines minimum component cost for a required system reliability. Input includes cost vs tolerance information, the theoretical structure of the system expressed as a complex mathematical function, and the system reliability requirements.

The printed output gives the optimum mix of component specifications to achieve a specified reliability level at minimum cost.

Quality-Control Analysis

Autonetic's Recomp computer has been used for quality-control analysis too. In this application, Recomp computes maximum and minimum parameter limits for a product like transistors.

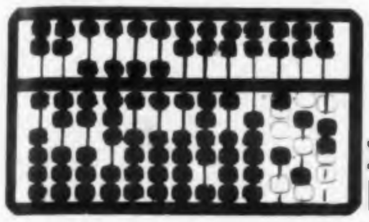
To determine quality acceptance limits for a lot of transistors, for example, the resistance between transistor elements is measured for each transistor in a sample lot. Measured resistance values are tabulated by number of transistors per resistance range.

The mean value of resistance for the sample lot is calculated by Recomp which finally expresses the maximum and minimum limits of acceptable transistor resistance.

Transistor Life Test Evaluation

At Lenkurt Electric Co., Kenneth Smith used the IBM 650 to evaluate the results of transistor life tests. Input to the machine included transistor parameters and performance readings of critical parameters. The computer gave information in terms of the mean, mid-mean, median, and standard deviations.

In this application, one hour of machine time per month replaced 40 hours of desk-calculator time.



Systems Design

In systems design, probably more than in any other field, the designer is less likely to know how much time or money he has saved by using a computer. The savings are real. But they are more difficult to measure than, say, the savings in a component design.

Instrumentation-System Design

A particularly interesting application of the Burroughs 205 was one by Stanford Research Institute of Menlo Park, Calif. SRI used the 205 to investigate the information transfer requirements for an instrumentation system. The system included position location, simulation, evaluation, and display, and considered fluctuating demands of a variety of servicing procedures and processing times.

Communications System Design

Page Communications Engineers of Washington, D.C., used a Bendix G-15 for a variety of related communications studies. They used the G-15 for research and for designing communications system, for radio wave propagation analysis, and for antenna analysis.

Information fed to the computer included: the noise probability density function, received signal intensities, two components at right angles, antenna dimensions, and transcendental equations for the binary error rate for amplitude-modulated, digital transmission systems using diversity techniques.

The G-15 provided information on the distribution of the signal-to-noise ratio for radio relay systems in cascade, diversity advantages which could be realized from polarization, antenna power patterns, and optimum threshold for minimum binary error rate. PCE estimates that these four solutions saved, respectively, one man-year, 30 man-weeks, 60 hours per set of antenna patterns and 40 hours.

Servo-System Analysis

An application by Douglas Aircraft Co. of Santa Monica, Calif., shows how a machine, designed basically for process control applications, can be used very successfully in design work. The machine, Ramo-Wooldridge's RW-300, was used by Douglas for closed-loop control of the testing of short-life, high-tolerance, airborne servo systems.

In this application, the RW-300 receives its input from a function generator. An *x-y* plotter at the computer output plots amplitude ratio and phase angle as functions of frequency. At each frequency, the computer samples the output amplitude and performs a Fourier analysis, computing the fundamental frequency of the usually distorted output, and from this, the amplitude ratio and phase angle. In addition, the computer takes the logarithm of the amplitude ratio so the plot can be printed on a decibel scale.

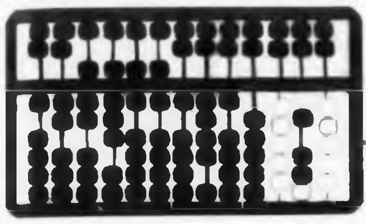
Gain-margin tests are made by automatically increasing loop gain until oscillations occur. The oscillation frequency, calculated by the computer, is recorded on the frequency-response graph. In this application, the RW-300 cut testing time from 90 minutes for each servo system to less than three minutes. In addition, it enabled Douglas designers to make more elaborate tests, and to scan and check more parameters.

Flight-Data Analysis

Space Technology Laboratories of Los Angeles used a computer to design a computer-entry

Checking a tape on Recomp, C. C. McConkle of Autonetics prepares the computer for an engineering problem.

processing machine. The processor takes flight data from ballistic missile and space flights (such as pulse-coded telemetry data from ICBM flights) and prepares the data for entry into an IBM 709. The system is flexible enough so it can be used at the receiving end of a data-carrying telephone link.



Other Applications

Computer applications by electronics designers are far from limited to those which can be encompassed by a few broad categories.

- Stanford Research Institute, for example, used a Remington-Rand 1103A to design magnetic characters for an automatic check-reading system. This led to the adoption of magnetic character reading as the standard for the American Bankers' Association.
- Engineers at Daystrom Electric in Poughkeepsie, N.Y., use an IBM-610 to calculate underwater acoustic Ray diagrams, (Ray diagrams show the path of sound waves through water under different conditions of pressure, temperature, and salinity.)

Daystrom engineers feel that, in 20 minutes with the 610, they can prepare Ray diagrams that would require at least a week of manual computation.

- The GPL Division of General Precision Inc. has used an LGP-30 for a wide variety of design applications. These include: (1) exploring the characteristics of filters for frequency trackers of doppler-radar navigation systems, (2) studies of the altitude-hole effect and its relation to antenna design in doppler systems, (3) space-navigation studies and error calculations and (4) calculations of the effects of frequency modulation in a carrier.
- The Link Div. of General Precision Inc. used an LGP-30 to prepare punched tapes to load a digital function generator, a storage bank for binary data. Input to the LGP-30 included selected points along a curve or family of curves.

The LGP-30 converted the decimal numbers defining the selected points to their binary equivalents. The binary equivalents were punched out on tape according to a prescribed format. It is estimated that the computer cut the time in preparing loading tapes by a factor of 20. ■ ■

Computer-Prepared Tables Enable Design of Ultra-Flat Networks

People who work in modern network theory, says author Philip Geffe, have trouble convincing engineers that network synthesis is a practical discipline. This article, with computer-prepared design tables, shows one way modern methods can solve problems which are hopeless by conventional means.

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RECENT ADVANCES in predistortion theory provide practical design data for ultra-flat networks. The design data included in the tables in this article have not been available before to the extent that they are available here.

The uniformly predistorted element values have been given elsewhere, but in limited fashion. The tables here offer a wider range of designs and they allow easy, accurate interpolation. In the lossy-L case, the design procedure has not been possible previously in any straightforward fashion.

Calculations, performed on an IBM 650, have been spot-checked with hand computations. Where appropriate, the results have been compared with the Weinberg tables, and no disagreements found.

Rounding off of last figures was done in such a way that rounding off again to three figures would give the correct result. Thus, a number such as 1.25493 was rounded off to 1.254 rather than to 1.255, since the correct 3-figure round-off would be 1.25.

Uniform-Dissipation Networks

Table 1 2-Pole

d	L_1	C_2	α-db
0	.7071	1.414	0
.05	.7609	1.410	.614
.10	.8236	1.398	1.22
.15	.8974	1.374	1.83
.20	.9860	1.340	2.42
.25	1.094	1.290	2.99
.30	1.228	1.223	3.53
.35	1.400	1.138	4.05
.40	1.628	1.034	4.52
.45	1.944	.9083	4.94
.50	2.414	.7630	5.30
.55	3.183	.5989	5.59
.60	4.669	.4188	5.82
.65	8.756	.2267	5.96

Table 2 3-Pole

d	C_1	L_2	C_3	α-db
0	.5000	1.333	1.500	0
.05	.5405	1.403	1.457	.868
.10	.5882	1.481	1.402	1.73
.15	.6452	1.567	1.334	2.60
.20	.7143	1.667	1.250	3.45
.25	.8000	1.786	1.149	4.30
.30	.9091	1.939	1.026	5.15
.35	1.053	2.164	.8743	5.98
.40	1.250	2.581	.6798	6.82
.45	1.538	3.806	.4126	7.66

Table 3 4-Pole

d	L_1	C_2	L_3	C_4	α-db
0	.3827	1.082	1.577	1.531	0
.05	.4144	1.156	1.636	1.454	1.13
.10	.4518	1.240	1.701	1.362	2.27
.15	.4967	1.339	1.777	1.250	3.39
.20	.5515	1.459	1.879	1.113	4.51
.25	.6199	1.609	2.039	.9400	5.63
.30	.7077	1.812	2.384	.7099	6.73
.35	.8243	2.124	3.848	.3651	7.82

Table 4 5-Pole

d	C_1	L_2	C_3	L_4	C_5	α-db
0	.3090	.8944	1.382	1.694	1.545	0
.02	.3189	.9199	1.412	1.712	1.504	.562
.04	.3294	.9468	1.443	1.730	1.461	1.12
.06	.3406	.9754	1.476	1.750	1.414	1.69
.08	.3526	1.006	1.512	1.771	1.364	2.25
.10	.3654	1.038	1.549	1.794	1.309	2.81
.12	.3794	1.073	1.589	1.822	1.250	3.37
.14	.3943	1.111	1.633	1.854	1.184	3.93
.16	.4104	1.151	1.681	1.894	1.113	4.48
.18	.4281	1.195	1.734	1.946	1.034	5.04
.20	.4472	1.243	1.796	2.018	.9452	5.59
.22	.4681	1.296	1.867	2.124	.8434	6.15
.24	.4911	1.354	1.953	2.300	.7242	6.70
.26	.5165	1.419	2.061	2.631	.5798	7.25
.28	.5446	1.493	2.204	3.453	.3965	7.79
.30	.5760	1.578	2.409	8.084	.1476	8.34

Table 5 6-Pole

d	L_1	C_2	L_3	C_4	L_5	C_6	α-db
0	.2588	.7579	1.202	1.553	1.759	1.553	0
.02	.2671	.7804	1.232	1.581	1.772	1.502	.671
.04	.2760	.8043	1.264	1.611	1.786	1.446	1.34
.06	.2854	.8297	1.297	1.643	1.802	1.386	2.01
.08	.2955	.8569	1.333	1.679	1.821	1.321	2.68
.10	.3064	.8860	1.372	1.714	1.844	1.250	3.35
.12	.3181	.9172	1.413	1.755	1.874	1.171	4.02
.14	.3307	.9508	1.458	1.802	1.917	1.083	4.69
.16	.3443	.9871	1.508	1.860	1.979	.9839	5.30
.18	.3594	1.027	1.558	1.923	2.080	.8690	6.00
.20	.3754	1.070	1.621	2.008	2.258	.7313	6.68
.22	.3931	1.117	1.690	2.122	2.646	.5586	7.34

Table 6 7-Pole

d	C_1	L_2	C_3	L_4	C_5	L_6	C_7	α-db
0	.2225	.6560	1.054	1.397	1.659	1.799	1.558	0
.02	.2297	.6759	1.084	1.428	1.684	1.808	1.496	.781
.04	.2373	.6972	1.114	1.461	1.712	1.818	1.428	1.56
.06	.2454	.7198	1.146	1.496	1.742	1.832	1.354	2.34
.08	.2542	.7440	1.180	1.533	1.775	1.851	1.274	3.12
.10	.2636	.7699	1.217	1.573	1.813	1.878	1.184	3.90
.12	.2739	.7980	1.254	1.614	1.860	1.923	1.085	4.68
.14	.2846	.8281	1.294	1.659	1.910	1.992	.9701	5.45
.16	.2966	.8608	1.344	1.715	1.979	2.111	.8350	6.23
.18	.3091	.8960	1.394	1.778	2.073	2.356	.6679	7.00
.20	.3232	.9243	1.453	1.862	2.233	3.177	.4220	7.77

Table 7 8-Pole

d	L_1	C_2	L_3	C_4	L_5	C_6	L_7	C_8	α-db
0	.1951	.5776	.9371	1.259	1.528	1.729	1.824	1.561	0
.02	.2014	.5954	.9636	1.290	1.558	1.752	1.830	1.488	.890
.04	.2081	.6144	.9918	1.323	1.590	1.777	1.838	1.409	1.78
.06	.2152	.6347	1.022	1.357	1.624	1.806	1.851	1.321	2.67
.08	.2229	.6564	1.054	1.394	1.662	1.839	1.872	1.224	3.56
.10	.2312	.6796	1.088	1.434	1.703	1.880	1.908	1.114	4.45
.12	.2400	.7046	1.124	1.478	1.750	1.932	1.972	.9856	5.33
.14	.2496	.7316	1.164	1.526	1.804	2.003	2.101	.8305	6.22
.16	.2600	.7608	1.208	1.579	1.869	2.110	2.414	.6307	7.10
.18	.2713	.7926	1.255	1.639	1.951	2.294	3.683	.3439	7.98

Theoretical Limits Restrict Network Choice

In critical applications it is often necessary to design selective networks in which the pass-band attenuation is constant within a small percentage tolerance. Severe theoretical limits on realizability greatly restrict the choice of networks which will be practical from the user's point of view.

For example, the highly selective Elliptic-Function filter[1] is, in general, not realizable in a ladder network[2] when we choose extremely small values of pass-band ripple together with a rapid transition from pass band to stop band.

If, in taking account of this, we choose the Tschebyscheff response (with equal ripples in the pass band, and a monotonic stop band), we find that arbitrary values of pass-band ripple always lead to ladder realizability.

But a further difficulty appears. The poles of the complex response function for this type of filter lie so close to the axis of real frequencies in the S-plane that both high-Q elements and close element-value tolerances are required for precision applications. These networks, therefore, require bulky, expensive materials, and manufacturing reproducibility is poor.

When an ultra-flat pass band is the prime requirement, we must choose networks whose response poles are remote from the $j\omega$-axis. In addition, we must accurately compensate for the use of low-Q elements.

Ultra-Flat Response Shapes Suggest Butterworth Networks

These restrictions lead immediately to the choice of the Butterworth family of response

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shapes. These responses have been fully described in the literature.[3,4,5] Our discussion is restricted to the normalization which employs a 1-ohm source, and the 3-db point occurs at one radian per second ($\omega_c = 1$).

Selectivity is sacrificed to obtain the ultra-flat property. Since the response is maximally flat, the pass-band flatness not only exceeds any previously assigned tolerance in some interval which contains the origin, but the interval is larger, for the networks chosen, than it would be for any other network using the same number of reactive elements.

Because of their poor selectivity, the use of these networks is almost completely restricted to the application discussed above. One exception to this rule, however, is their use in the narrow-band case, where the inherent low-Q requirement of the network is desirable.

Physical Forms of the Networks With Loss and Without

Fig. 1a shows a 5-pole low-pass network which, with lossless elements, can realize the 5-pole Butterworth shape if the element values are correctly chosen. In Fig. 1b, the incidental dissipation of the reactive elements is shown by inserting conductances in parallel with the capacitors, and resistance in series with the inductors.

In the synthesis of such networks, we encounter a step which requires factoring a polynomial of high degree. This can only be done approximately, and leads to enormously high computation costs.

When the load resistance, R, is open circuited, however, factoring degenerates into a trivial calculation, and we may proceed without difficulty. In the case of most desirable response shapes (e.g., Butterworth, Tschebyscheff, Elliptic-Function), the load resistor must be considerably larger, or smaller, than the source resistor; else the network will not be realizable at all. For these reasons, the tables given here are calculated for an open-circuit load.

In Fig. 1c, we show a 5-pole network in which allowance has been made for losses in the inductors only.[6] This feature corresponds closely with practical problems in which the physical capacitors are relatively lossless as compared with the inductors. In building the physical network, therefore, it is not necessary to wire physical resistors across the capacitors since uniform dissipation is not needed throughout the network, and the power losses in the filter are greatly reduced. The lossy-L designs, however, may only be used in low-pass networks.

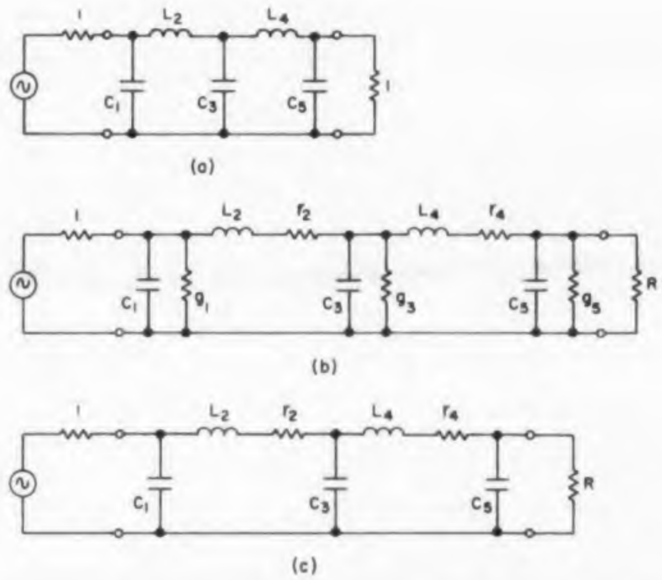

Fig. 1. A 5-pole, low-pass network: (a) as a lossless network; (b) as a uniformly lossy network in which dissipation of the reactive elements is represented by conductances in parallel with capacitors and resistors in series with inductors. Here, $r_i = dL_i$, $g_i = dC_i$; (c) as a lossy-L network in which losses are concentrated in resistors in series with the inductors. Here, $r_i = dL_i$.

Fig. 2a shows a typical network whose normalized design may be taken directly from the tables. When the number of reactances is even, the first element is always a series inductor, $L1$.

Uniform-Dissipation Networks

Table 8 9-Pole

d	C_1	L_2	C_3	L_4	C_5	L_6	C_7	L_8	C_9	α-db
0	.1736	.5155	.8414	1.141	1.404	1.620	1.777	1.842	1.563	0
.02	.1793	.5316	.8659	1.171	1.435	1.649	1.798	1.845	1.480	1.00
.04	.1852	.5488	.8921	1.202	1.469	1.680	1.822	1.851	1.388	2.00
.06	.1916	.5671	.9199	1.236	1.504	1.713	1.850	1.864	1.286	3.00
.08	.1984	.5867	.9496	1.272	1.543	1.751	1.884	1.891	1.171	4.00
.10	.2058	.6077	.9814	1.311	1.584	1.794	1.931	1.942	1.036	5.00
.12	.2137	.6303	1.016	1.353	1.630	1.844	1.997	2.054	.8735	5.99
.14	.2223	.6547	1.053	1.398	1.682	1.907	2.101	2.340	.6614	6.99
.16	.2315	.6812	1.093	1.448	1.742	1.991	2.293	3.620	.3486	7.98

Table 9 10-Pole

d	L_1	C_2	L_3	C_4	L_5	C_6	L_7	C_8	L_9	C_{10}	α-db
0	.1564	.4654	.7626	1.041	1.292	1.510	1.687	1.812	1.855	1.564	0
.02	.1614	.4800	.7854	1.069	1.324	1.541	1.714	1.831	1.855	1.471	1.11
.04	.1669	.4956	.8096	1.099	1.357	1.574	1.744	1.853	1.860	1.367	2.22
.06	.1726	.5123	.8353	1.132	1.392	1.610	1.777	1.882	1.875	1.249	3.33
.08	.1788	.5301	.8629	1.166	1.430	1.648	1.814	1.920	1.910	1.114	4.44
.10	.1854	.5493	.8924	1.203	1.471	1.692	1.860	1.976	1.991	.9508	5.55
.12	.1926	.5698	.9242	1.243	1.516	1.741	1.918	2.067	2.201	.7409	6.65
.14	.2003	.5921	.9584	1.286	1.566	1.798	1.997	2.239	3.051	.4349	7.76

Lossy-L Networks

Table 10 2-Pole

d	L_1	C_2
0	.7071	1.414
.05	.7330	1.364
.10	.7609	1.314
.15	.7910	1.264
.20	.8236	1.214
.25	.8589	1.164
.30	.8975	1.114
.35	.9397	1.064
.40	.9860	1.014
.45	1.037	.9642
.50	1.094	.9142
.55	1.157	.8642
.60	1.228	.8142
.6	1.309	.7642

Table 11 3-Pole

C_1	L_2	C_3
.5000	1.333	1.500
.5128	1.403	1.390
.5263	1.480	1.284
.5405	1.565	1.182
.5556	1.660	1.084
.5714	1.766	.9911
.5882	1.885	.9018
.6061	2.021	.8164
.6250	2.177	.7350
.6452	2.358	.6573

Table 12 4-Pole

L_1	C_2	L_3	C_4
.3827	1.082	1.577	1.531
.3979	1.087	1.698	1.362
.4144	1.091	1.834	1.205
.4323	1.095	1.990	1.061
.4518	1.098	2.170	.9289
.4732	1.100	2.380	.8072
.4967	1.102	2.628	.5955
.5227	1.102	2.926	.5933

Table 13 5-Pole

d	C_1	L_2	C_3	L_4	C5
0	.3090	.8944	1.382	1.694	1.545
.02	.3129	.9127	1.369	1.762	1.452
.04	.3168	.9316	1.355	1.834	1.363
.06	.3209	.9514	1.342	1.911	1.278
.08	.3251	.9719	1.327	1.993	1.197
.10	.3294	.9934	1.313	2.080	1.119
.12	.3338	1.016	1.298	2.173	1.046
.14	.3383	1.039	1.283	2.273	.9754
.16	.3429	1.063	1.268	2.380	.9086
.18	.3477	1.089	1.253	2.494	.8450
.20	.3526	1.116	1.237	2.620	.7844
.22	.3576	1.144	1.221	2.754	.7269
.24	.3628	1.173	1.204	2.901	.6721
.26	.3682	1.204	1.188	3.061	.6201
.28	.3737	1.237	1.171	3.237	.5706
.30	.3794	1.271	1.154	3.431	.5236

Table 14 6-Pole

L_1	C_2	L_3	C_4	L_5	C_6
.2588	.7579	1.202	1.553	1.759	1.553
.2629	.7631	1.235	1.519	1.850	1.436
.2671	.7683	1.271	1.485	1.947	1.326
.2714	.7736	1.308	1.451	2.052	1.223
.2760	.7789	1.347	1.417	2.165	1.125
.2806	.7843	1.388	1.383	2.288	1.034
.2854	.7897	1.432	1.349	2.421	.9487
.2904	.7952	1.478	1.315	2.565	.8684
.2955	.8007	1.527	1.281	2.723	.7932
.3009	.8063	1.579	1.248	2.896	.7227
.3064	.8118	1.634	1.214	3.087	.6567
.3121	.8174	1.692	1.181	3.298	.5949

When an odd number of reactances is used, the first element is a shunt capacitor, *C1*.

Incidental dissipation is not represented in Fig. 2, but various forms of the networks are shown there. Thus Fig. 2 employs a current source instead of a voltage source, and follows from Fig. 2a by reciprocity. In this case, the response function is not *E2/E1* as in Fig. 2a, but *E2/I1*.

Fig. 2c shows the network which is dual to that in Fig. 2a, and whose transfer function is *I2/E1*. Element values are numerically equal to those of Fig. 1a, but are read in henries instead of farads, and vice versa. Fig. 2d follows from Fig. 2c by reciprocity and is dual to Fig. 2b. It is important to note that the tables are labeled for the network form shown in Fig. 2a.

How to Use the Network Design Tables

In each table of element values, the first column gives the dissipation factor d. If, say, a low-pass 5-pole Butterworth network is desired with coil Q's of 10, then we use the lossy-L tables, and enter the row of Table 13 for which $d = 1/Q = 0.10$. This gives the design of Fig. 3a. It is important to realize that this network *does not* have the desired response. This is obtained only by adding the indicated losses, as shown in Fig. 3b.

Tables 1 through 9 are for networks in which all the reactive elements have the same Q. Tables 10 through 18 are for the lossy-L case, in which all capacitors are lossless. In the first nine tables, the column headed α gives the flat loss, in decibels.

Thus the lossy-L tables may be used only for low-pass filters, but the tables for uniform dissipation may be used for either. For instance, if paper capacitors, with a Q of 50, are to be used with coils of the same Q, then $d = 0.02$ uniformly throughout the network, and Tables 1 through 9 would be used.

If a bandpass filter were desired, it would be necessary to use tables for uniform predistortion[7,8] and then to effect the usual low-pass to bandpass transformation. The bandpass procedure, then, is summarized in the following steps:

Design Procedure For Bandpass Networks

Step 1. The normalized low-pass network (from Tables 1 through 9) is scaled to a cutoff frequency which is equal to the desired 3-db bandwidth of the bandpass filter:

$$L' = \frac{L}{2\pi\,(f_2 - f_1)} \qquad (1)$$

$$C' = \frac{C}{2\pi\,(f_2 - f_1)} \qquad (2)$$

where the unprimed L and C indicate the tabulated values.

Step 2. The scaled low-pass reactances are resonated to the desired center frequency, f_0, by inserting the appropriate capacitors *in series* with the scaled low-pass inductors and inserting appropriate inductors *in parallel* with the scaled low-pass capacitors.

Step 3. After the correct amount of dissipation has been added to all the reactive branches, the bandpass filter will have a bandwidth, at any given attenuation, which is equal to the bandwidth of the scaled low-pass filter which was obtained in Step 1.

Step 4. All impedances are multiplied by the desired factor. Thus, in a filter to be driven by a 600-ohm source, all impedances would be multiplied by 600.

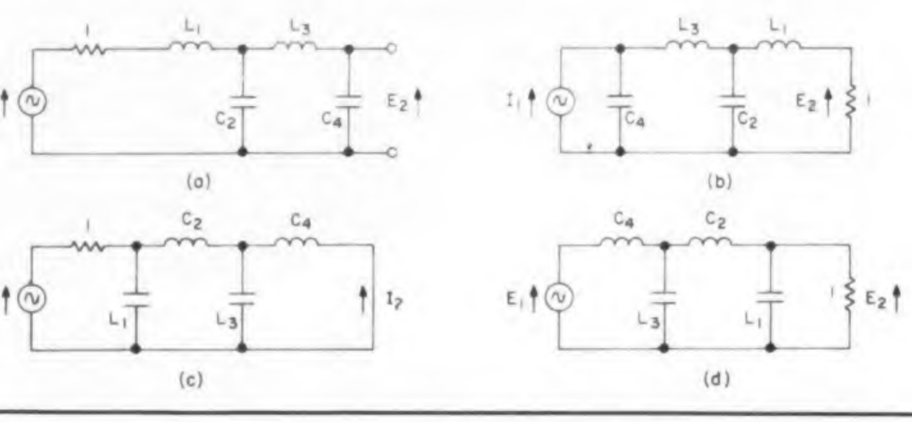

Fig. 2. Typical networks whose normalized design may be taken directly from the table: (a) uses a voltage source; (b) uses a current source; (c) and (d) are duals of (a) and (b).

Q of Network Elements Must Be Considered

In all cases, it should be apparent from Fig. 1b that the Q of series coils must be proportional to

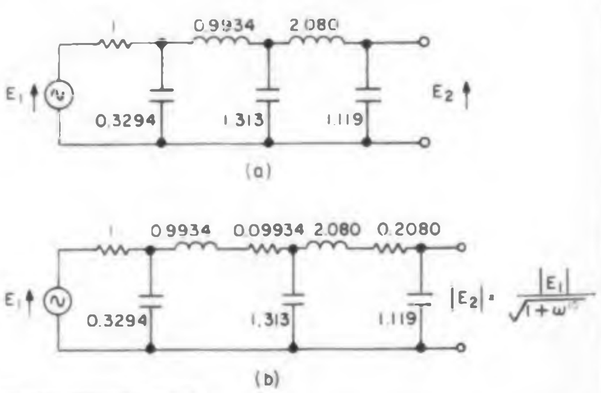

Fig. 3. A low-pass, 5-pole Butterworth network with coil Q's of 10 designed with the aid of Table 13. The lossless network (which does not have the desired response) is shown at (a). Adding the indicated losses for the proper response gives the network in (b).

Lossy-L Networks

Table 15 7-Pole

d	C_1	L_2	C_3	L_4	C_5	L_6	C_7
0	.2225	.6560	1.054	1.397	1.659	1.799	1.558
.02	.2255	.6688	1.053	1.449	1.602	1.913	1.417
.04	.2286	.6822	1.051	1.504	1.546	2.038	1.288
.06	.2318	.6960	1.048	1.564	1.490	2.173	1.167
.08	.2351	.7104	1.045	1.627	1.436	2.322	1.056
.10	.2384	.7255	1.043	1.694	1.382	2.484	.9532
.12	.2419	.7412	1.039	1.766	1.330	2.664	.8581
.14	.2454	.7575	1.036	1.842	1.278	2.862	.7703
.16	.2491	.7746	1.032	1.924	1.228	3.083	.6892
.18	.2529	.7924	1.028	2.013	1.178	3.330	.6144
.20	.2568	.8110	1.024	2.108	1.130	3.609	.5454

Table 16 8-Pole

d	L_1	C_2	L_3	C_4	L_5	C_6	L_7	C_8
0	.1951	.5776	.9371	1.259	1.528	1.729	1.824	1.561
.02	.1982	.5829	.9613	1.243	1.602	1.648	1.963	1.398
.04	.2014	.5884	.9868	1.227	1.680	1.569	2.116	1.249
.06	.2047	.5939	1.014	1.211	1.764	1.493	2.285	1.113
.08	.2081	.5996	1.042	1.194	1.856	1.419	2.472	.9894
.10	.2116	.6053	1.071	1.178	1.954	1.347	2.681	.8768
.12	.2152	.6111	1.102	1.160	2.061	1.278	2.914	.7743
.14	.2190	.6170	1.134	1.143	2.177	1.211	3.178	.6810
.16	.2229	.6231	1.169	1.124	2.302	1.147	3.477	.5962
.18	.2270	.6292	1.206	1.107	2.440	1.084	3.819	.5191

Table 17 9-Pole

d	C_1	L_2	C_3	L_4	C_5	L_6	C_7	L_8	C_9
0	.1736	.5155	.8414	1.141	1.404	1.620	1.777	1.842	1.563
.02	.1761	.5253	.8432	1.180	1.371	1.716	1.672	2.006	1.377
.04	.1786	.5354	.8450	1.221	1.338	1.821	1.571	2.189	1.211
.06	.1812	.5460	.8467	1.264	1.304	1.934	1.474	2.393	1.061
.08	.1839	.5570	.8483	1.310	1.271	2.058	1.383	2.623	.9261
.10	.1866	.5684	.8497	1.359	1.238	2.193	1.294	2.884	.8054
.12	.1894	.5802	.8510	1.412	1.204	2.342	1.211	3.180	.6971
.14	.1924	.5926	.8522	1.467	1.171	2.505	1.132	3.521	.6001
.16	.1954	.6054	.8533	1.527	1.137	2.686	1.057	3.917	.5132

Table 18 10-Pole

d	L_1	C_2	L_3	C_4	L_5	C_6	L_7	C_8	L_9	C_{10}
0	.1564	.4654	.7626	1.041	1.292	1.510	1.687	1.812	1.855	1.564
.02	.1589	.4704	.7812	1.034	1.348	1.457	1.807	1.682	2.044	1.357
.04	.1614	.4754	.8006	1.027	1.408	1.404	1.939	1.560	2.258	1.173
.06	.1641	.4806	.8209	1.019	1.472	1.353	2.084	1.444	2.501	1.010
.08	.1669	.4859	.8422	1.011	1.541	1.302	2.245	1.336	2.778	.8660
.10	.1697	.4913	.8603	1.003	1.614	1.251	2.423	1.234	3.096	.7387
.12	.1726	.4969	.8880	.9949	1.694	1.201	2.621	1.139	3.466	.6263
.14	.1757	.5024	.9127	.9861	1.780	1.152	2.842	1.050	3.901	.5270

frequency, and the Q of shunt coils must be inversely proportional to frequency. Thus, in high-precision applications, we must use components which substantially meet these requirements.

If high-Q inductors are available, a design for low element-Q can be chosen, and resistors can be wired in series with the series elements, and in parallel with the shunt elements. If element Q is limited, then series coils should be chosen whose Q-curves show maximum Q at a relatively high frequency. For the shunt coils, the frequency of Q_{max} should be low.

In bandpass filters, it is essential that the Q of the resonant branches be carefully considered. This number, which we call Q_B, is the net Q of the branch coil and capacitor together, measured at the center frequency, f_0. If the capacitors are nearly lossless, it is substantially the Q of the inductor alone. In either case, it must meet the requirement

$$Q_B = Q_p\, Q_c \tag{3}$$

where Q_p is the normalized low-pass Q, i.e., $Q_p = 1/d$, where d is the number tabulated here. This figure is always evaluated at the 3-db loss frequency. Q_c is the circuit-Q which is given by:

$$Q_c = \frac{f_0}{f_2 - f_1},\ f_0 = \sqrt{f_1 f_2} \tag{4}$$

where f_1 and f_2 are the 3-db frequencies of the desired bandpass filter.

The value of Q_B can be measured accurately by using a Wheatstone bridge with an ac signal whose frequency coincides exactly with the tuning frequency of the LC branch. At resonance, the branch is entirely resistive. Once this resistance is known, the Q can be calculated from an accurate knowledge of the element values. The result can be made accurate within one percent if due care is exercised. ■ ■

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Stripline Technique Produces A Simple 3-Db Directional Coupler

In this article, author John Dent describes a 3-db directional coupler which employs stripline techniques and provides directivity in excess of 20 db over a 30 per cent frequency band. The unit demonstrates excellent power division characteristics and contains no critical dimensions or construction practices.

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Falls Church, Va.

EMPLOYING stripline techniques in the design of directional couplers has led to a class of device that is compact and lightweight. This, together with the lack of an external termination, results in a unit well suited to airborne and missile applications. Fig. 1 illustrates one possible configuration of this device.

Radio-frequency power entering at *A* is divided equally between lines *AB* and *AC* by virtue of the symmetry of the directional coupler design. The resulting fields at *B* and *C* are equal in phase and amplitude. The result is that no power is dissipated in resistor *R* when matched loads are connected to the output terminals. However, by choosing the proper circuit components, a high degree of isolation between terminations (or sources) connected to terminals *ZOB* and *ZOC* will exist for power entering at either terminal. Experimental results of two units, operating about the 1100-mc and 3000-mc frequency bands, are shown in Figs. 2 and 3 respectively.

To obtain isolation, two possible paths of propagation are provided between *B* and *C* for power entering at terminals *ZOB* or *ZOC*. These paths must offer equal impedances to the signal, and they must be separated by 180 deg at resonance.

By making the line lengths from *A* to *B* and *A* to *C* 1/4-wavelength long, and by choosing the proper line impedance and resistor value, an equal power split and proper impedance matching exist.

A signal entering at terminal *ZOB* is split equally at junction *B*, and travels toward junction *C* via the resistor and the 1/2-wavelength long path, *B* to *A* to *C*. At junction *C*, the two parts of the signal are of equal amplitude and 180 deg out of phase, if the path length through the resistor is considered to be negligible, and complete cancellation occurs. This makes junction *C* a voltage-null point with zero impedance. As a result, no power will be transmitted to terminal *ZOC*.

Fig. 1. The stripline directional coupler with a 3-db insertion loss shown here is designed about a simple path-length difference.

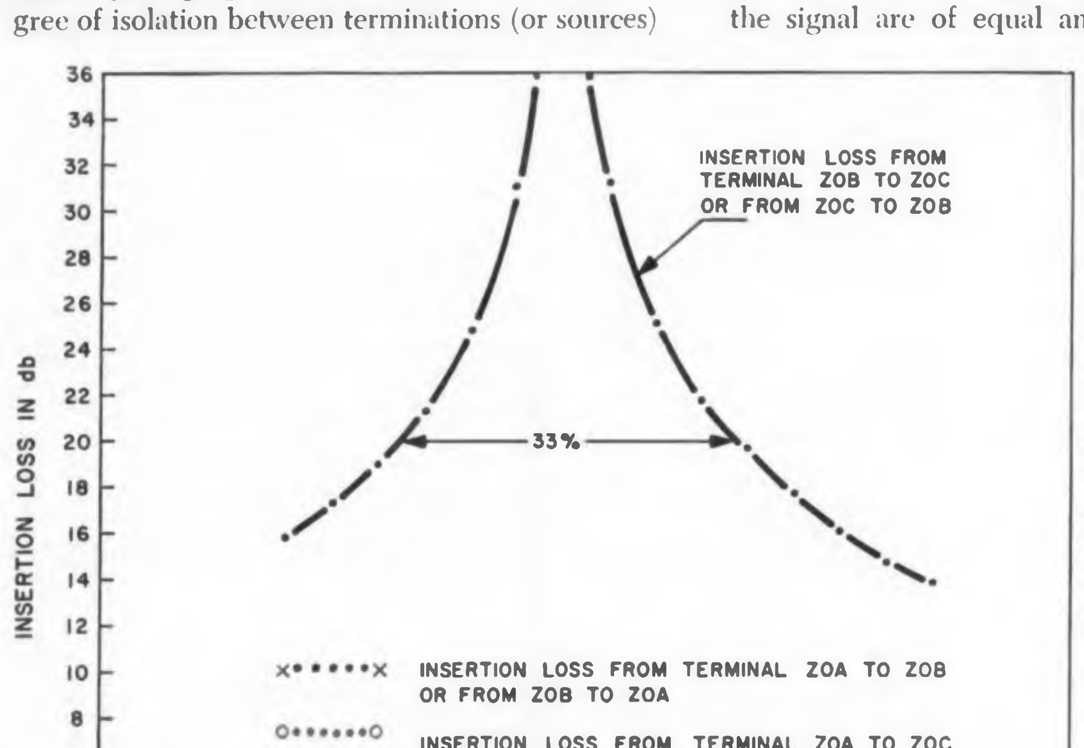


Fig. 2. Experimental stripline directional coupler achieved directivity of 20 db over a 33 per cent frequency band at 1,100 mc, with an insertion loss of 3 db.

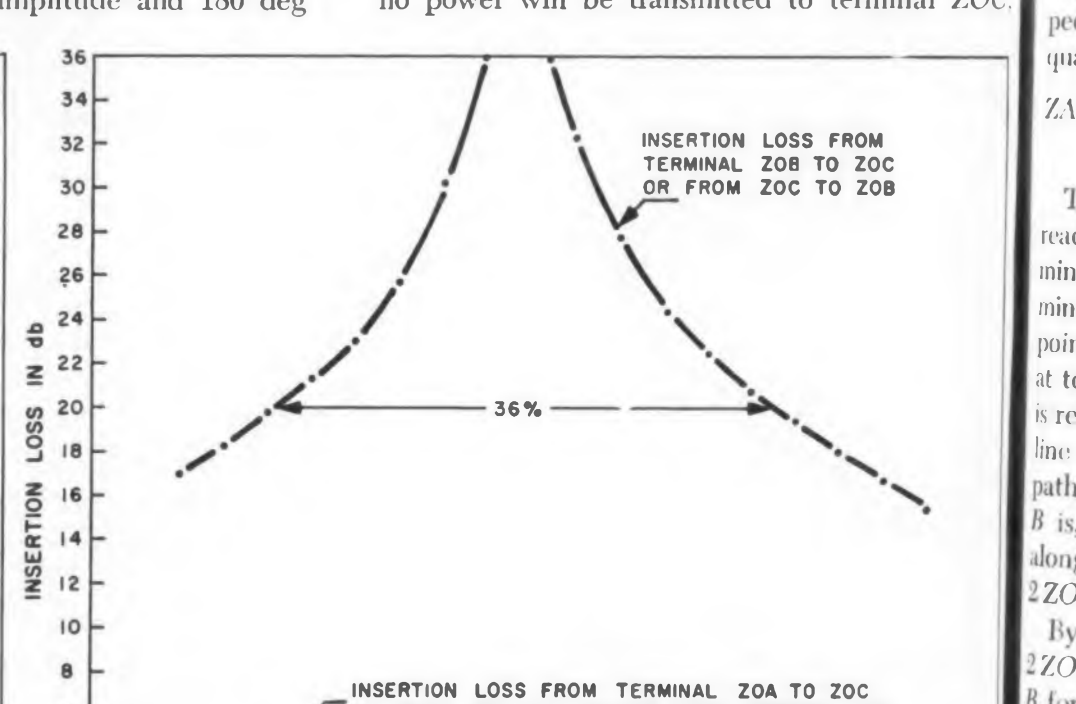
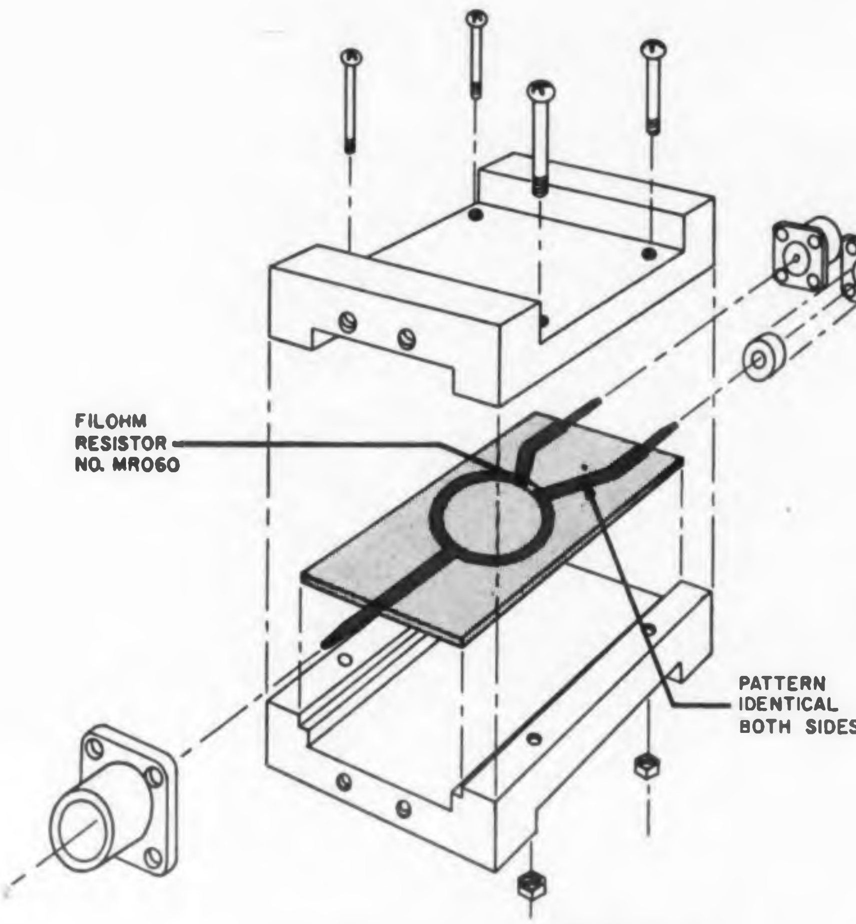


Fig. 3. A second stripline directional coupler, operating at a frequency of about 3,000 mc, achieved a 20-db directivity of 20 db over a 36 per cent frequency band.

Fig. 4. Construction of the stripline directional coupler, as shown in this exploded view, is simplicity itself.



and the power will be equally divided between the resistor and the termination (or source) connected to terminal ZOA.

By making impedance $ZOA = ZOB = ZOC$, the impedance of lines AB and AC for proper impedance matching can be determined from the quarter-wave transformer expression:

$$ZAB = ZAC = \sqrt{(2ZOA)(ZOC)}$$
$$= \sqrt{(2ZOA)(ZOB)} = \sqrt{2}\,(ZOA) \quad (1)$$

The impedance of the resistor is determined readily since junction C appears as a point of minimum impedance for signals entering at terminal ZOB. Conversely, junction B appears as a point of minimum impedance for signals entering at terminal ZOC. This minimum impedance at C is reflected along the 1/4-wavelength transformer, line AC, as an open circuit at junction A. The path impedance toward junction A from junction B is, therefore, the impedance ZOA transposed along the 1/4-wavelength transformer, line AB as $2ZOA$.

By making the value of the resistor equal to $2ZOA$, an equal power split can exist at junction B for power entering at ZOB and at junction C for power entering at ZOC (a requirement for maximum isolation), and proper impedance matching will exist.

To determine if the design could be realized in practice, units were constructed using the techniques shown in Fig. 4. The configuration was hand-cut in register on both sides of a copper-clad teflon fiberglass board 1/16-in. thick, with 3/16-in. ground place spacing. The strip widths for the desired impedance were determined from reference 1. The resistors employed are of the evaporated film type designed for microwave use. The higher frequency unit, less its housing, is shown in Fig. 5.

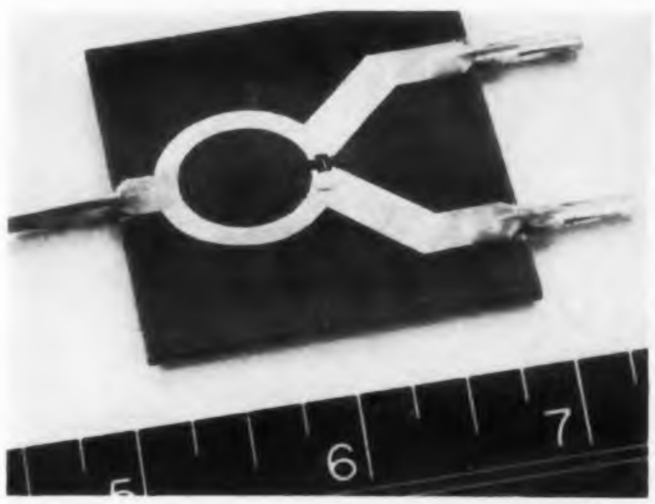


Fig. 5. The high frequency unit, minus the housing, comprises the stripline mounted in register on both sides of a 3-in. sq. of copper-clad teflon fiberglass.

With proper choice of dielectric materials, high-frequency resistors and connectors, this unit can be readily adapted to a wide variety of multiplexing and coupling applications, both commercial and military.

References

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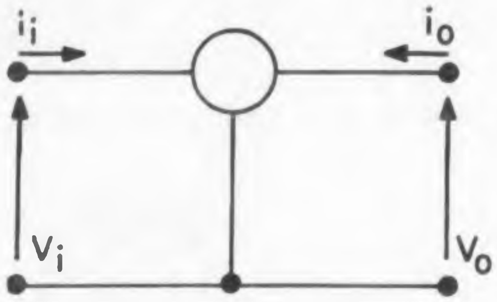


Fig. 1. Generalized transistor circuit.

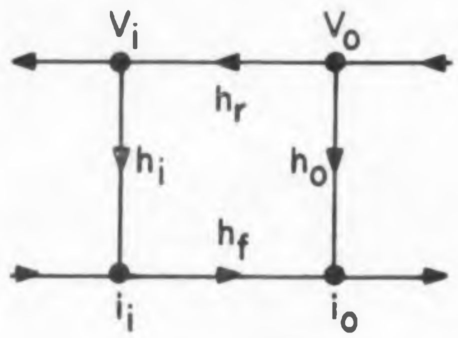


Fig. 2. Flow graph for generalized transistor circuit of Fig. 1.

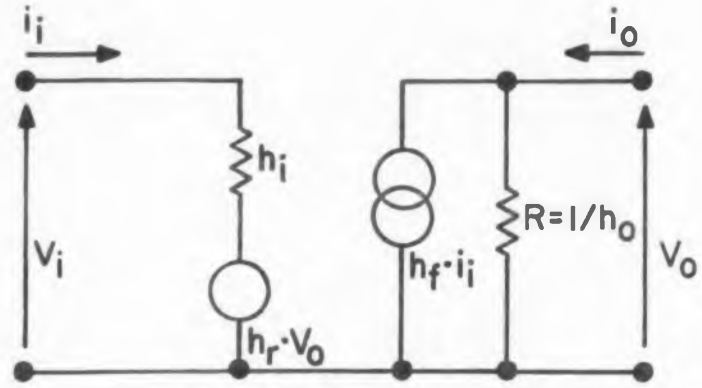


Fig. 3. Electrical equivalent of generalized circuit derived from flow graph of Fig. 2.

Flow Graph Speeds Transistor Circuit Analysis

What's going on electrically in a transistor circuit can be determined readily, and without looking up equations, from a flow graph. This application of flow graphs, presented by T. R. Nesbit, enables the designer to easily keep track of resistive parameters, hybrid parameters, voltages and currents.

T. R. Nisbet
Lockheed Aircraft Corp.
Palo Alto, Calif.

THE FLOW GRAPH is a useful device for tying together the equivalent circuit, the characteristic curves and the definitions of the various h-parameters of a transistor.

Fig. 1 defines what is meant by v_i, i_i, v_o, and i_o without reference to the type of circuit connection.

The flow graph, Fig. 2, illustrates all the relevant equations. Note the distinction between dependent and independent variables. To determine y in the equation $y = ax + b$, one must allocate a value to x. With the flow graph, one must allocate a value to the independent variables i_i and v_o to evaluate the dependent variables v_i and i_o.

Allocating a zero value gives the definitions. For example, if $v_o = 0$, then v_o contributes nothing along the h_r path to v_i (Fig. 2), so that v_i is equal to $i_i \cdot h_i$. In conventional form, $h_i = v_i/i_i]$ $v_o = 0$.

When the independent variables are not zero the system equations can be written from the flow graph. For example:

$$v_i = [h_i \cdot i_i + h_r \cdot v_o]$$

Because generators in an equivalent circuit represent dependent variables, it is easy to construct an equivalent circuit from the flow graph, as in Fig. 3.

When drawing a graph, one intuitively puts the independent variable on the X axis. The common-emitter characteristic curves therefore are plotted as in Fig. 4, with the second independent variable, input (base) current as a parameter. Similarly, the input characteristic would be plotted as base voltage (X axis) vs base current (Y axis) with collector voltage as a parameter.

The T equivalent-circuit parameters for the common emitter connection are shown in Fig. 5, and the flow graph in Fig. 6. The flow graph with the path i_c to v_{ce} inverted is shown in Fig. 7.

Comparison of the flow graph Fig. 7 and Fig. 2 shows that the arrangement of input and output variables is the same. Therefore to express h_r in terms of the equivalent-circuit parameters, note where it appears in the flow graph, in Fig. 2, and write down, from flow graph rules, (see *ED*, Dec 9, 1959, p 32) an expression for the same path in Fig. 7; by implication, the "unused" independent variable, i_i or i_b is set equal to zero in both cases. There is one loop, so h_r is evaluated as:

$$h_r = \frac{1}{r_d} \cdot r_e \left[\frac{1}{1 + r_e/r_d}\right] = \frac{r_e}{r_d + r_e}$$

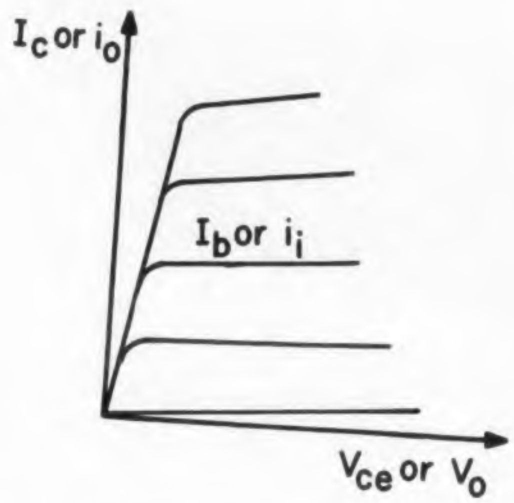


Fig. 4. Common emitter characteristic curves.

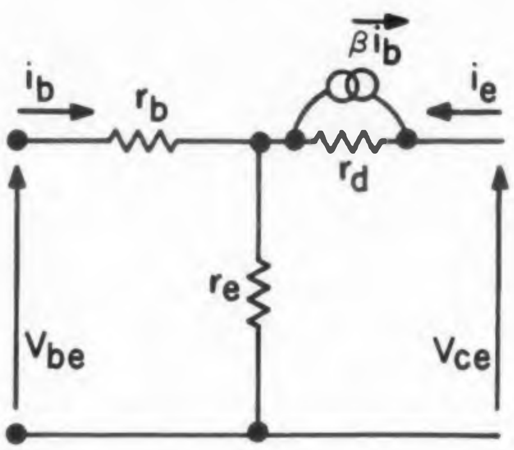


Fig. 5. Common emitter equivalent T circuit.

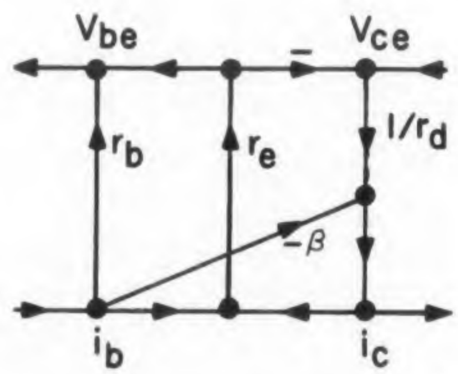


Fig. 6. Flow graph for equivalent T circuit of Fig. 5.

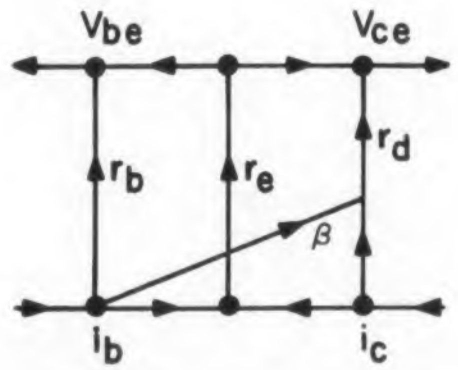


Fig. 7. Equivalent T flow graph with i_c-to- v_{ce} path inverted.

Power Sensing Circuit

Protects New Line of Power Supplies Against Overload

A CIRCUIT which provides overload and short circuit protection by sensing the power being dissipated in the output-regulating transistors, is the outstanding feature of the GE's new line of transistorized power supplies. Designed by General Electric's Low Voltage Switchgear Dept. (6901 Elmwood Ave., Philadelphia 42, Pa.), the supplies are available in 30 standard models with output voltages ranging from 1.5 to 100 v. Current output is rated up as 20 amp.

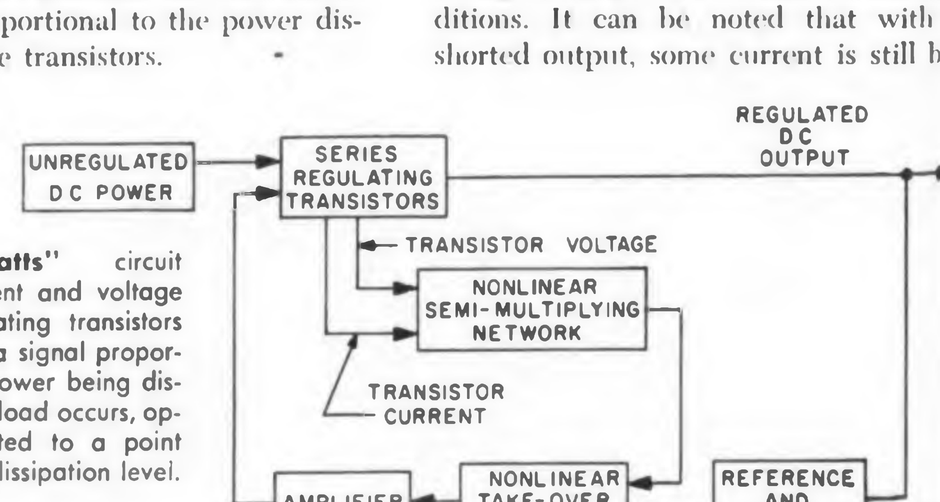
The supplies are protected against overload by a patentable "constant-watts" circuit. Because the patent has only recently been applied for, a complete discussion of this circuit cannot be given. However, some details have been made available.

The diagram shows how the constant-watts circuit is placed across the series-regulating transistors. Voltage across, and the current through the transistors are measured. These parameters are then mixed in a nonlinear network whose output is proportional to the power dissipated in the transistors.

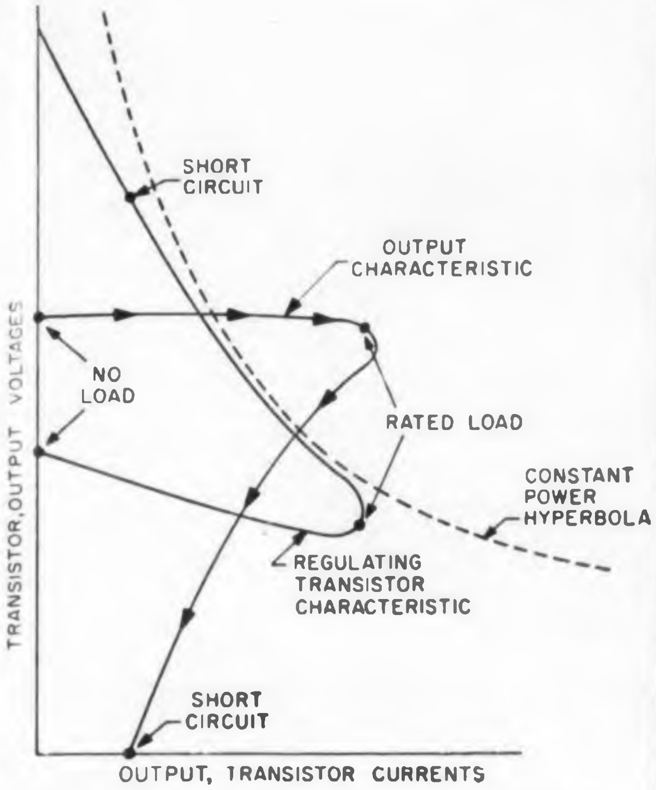
If excessive power dissipation occurs (as would be caused by an overload), the operating point of the transistors is shifted to a position having a safe dissipation level. When the overload condition is removed, normal operation is automatically resumed within 3 μsec.

Thus, the effect of the constant-watts circuit is to superimpose power-limited operation on the voltage-regulating system of the supply. This is illustrated by the graph which plots the voltage and current passing through the regulating transistor. The dashed line represents the locus of constant transistor dissipation and shows where the power-limiting circuit will take over from the voltage-regulating one. This curve, which approximates the constant dissipation hyperbola in the middle range, is produced by the nonlinear multiplying network.

Also shown is the power supply's output current-voltage characteristic. The direction of the arrows indicates the change from no load to short circuit conditions. It can be noted that with a shorted output, some current is still be-



"Constant-watts" circuit measures current and voltage in series-regulating transistors and develops a signal proportional to the power being dissipated. If overload occurs, operation is shifted to a point having a safe dissipation level.



Current-voltage characteristics are shown for the output of the supply and for the regulating transistors. Arrows show direction of operation as loading increases from no load to short circuit. (Curves are to scale and apply approximately to each unit.)

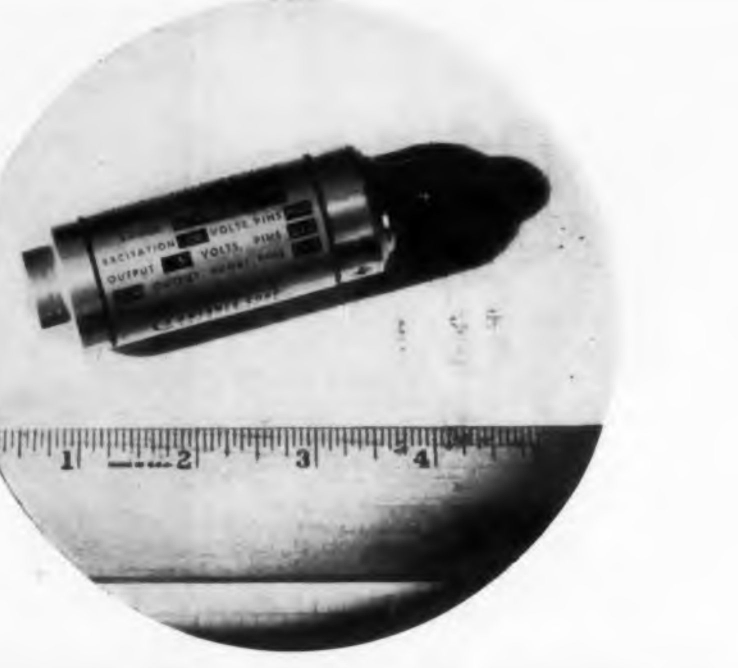
ing supplied—that is, the supply is not completely shut off. This characteristic makes these units very suitable for certain applications where initially the load is approximately a short. Such applications would include the charging of capacitors and dc motor starting.

All ratings in the standard line of supplies are for 115 or 220-v single-phase, 60-cps input. Units are also available for 400-cps, and three-phase inputs. Output voltage is variable from 0 to 100 per cent volts.

Line regulation is less than 10 mv for line changes of ±10 per cent, or 0.03 per cent, whichever is greater. Load regulation is less than 0.1 per cent or 30 mv, whichever is greater, for load changes of zero to 100 per cent. The dynamic regulation is 0.1 per cent instantaneously for 5 per cent step line, or a 50 per cent step load change.

The units are designed for mounting in 19 in. racks, or for bench mounting, and are convection cooled. Prices range from $350 to $1100 with slight increase in cost for such optional features as remote sensing and output voltage control, instantaneous overvoltage protection, and multiple-unit packaging.

For more information on these power supplies circle Reader-Service 251.



Solid-State Pressure Transducer

A SOLID-STATE pressure transducer that is reported to combine the best over-all characteristics of both strain gage and potentiometer-type transducers, but has the disadvantages of neither, is available from Fairchild Controls Corp. The unit, which is compatible with microminiature solid-state amplifiers, withstands military transducer environments.

Designated type 3S-G, the transducer is "conservatively regarded as representing a 10-fold increase in the state of the transducer art," according to the Fairchild Controls Corp. It "obviates the need for an amplifier, required by conventional strain gage transducers, to increase output signal strengths from an average 20 to 40 mv to approximately 5 v dc," it was added.

The transducer consists essentially of three modules contained in an anodized aluminum case 1-1/8 in. in diameter and 3 in. long. These modules perform the functions of energy conversion, signal conditioning, and calibration.

Energy conversion is accomplished by a sensitive element made of several piezoresistive semiconductor elements coupled to a resilient, high-alloy steel, low-mass diaphragm. These elements form the resistive arms of a Wheatstone bridge. The diaphragm is proportioned to fit selected pressure ranges from 0 to 100 psi and from 0 to 10,000 psi, full scale. Pressures which deflect the diaphragm create an unbalance in the bridge, producing a dc signal proportional to the deflection. Input excitation to the transducer is from 10 to 25 v dc

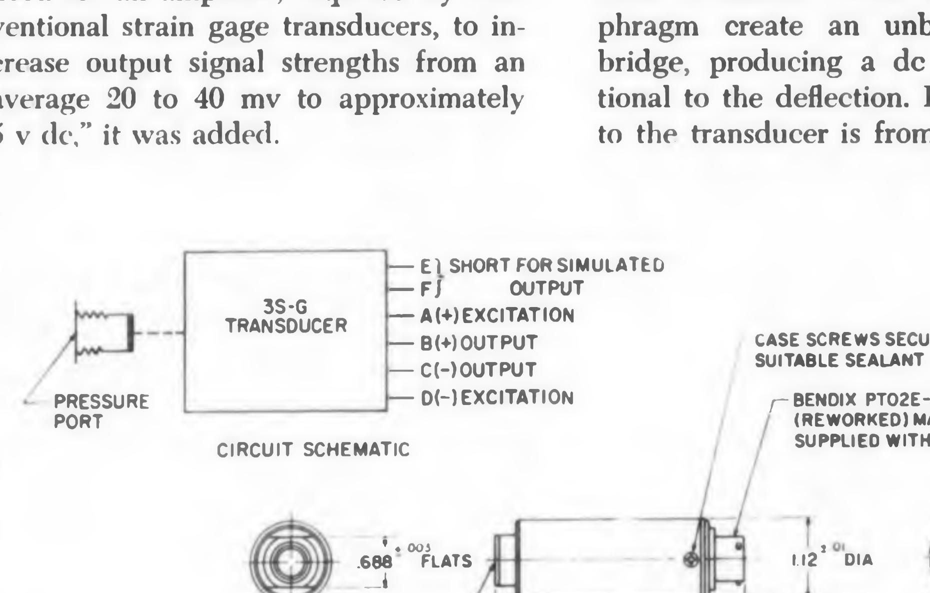


Diagram illustrates the configuration of the pressure transducer, and transducer excitation and output.

nominal; it can take up to 30 v dc without damage. Input impedance is approximately 700 ohms with an output impedance of less than 4,500 ohms. Input pressures up to 150 per cent of rated have negligible effect on instrument calibration while pressures in excess of 200 per cent have caused no damage.

Signal conditioning is accomplished by a completely transistorized amplifier which receives the differential signal generated in the sensing element and produces the output signal. The transducer transfer function is 25 per cent, giving a 5-v dc output signal for a full range change in pressure at 20 v dc.

Calibration is accomplished by an internally-contained shunt resistor. When it is keyed across one leg of the Wheatstone bridge, the transducer produces an output signal equivalent to one-half full scale rating.

The 3S-G transducer, made by Fairchild Controls Corp., Components Div., 225 Park Ave., Hicksville, N.Y., is responsive to static pressures and to dynamic pressures in the kilocycle range. Frequency response is limited only by the type of plumbing that conducts the measured pressure media to the 3S-G pressure port. It has better than ±0.1 per cent linearity, an 0.1 per cent hysteresis over a temperature range of −65 to +250 F; it has infinite resolution. Both zero and full range sensitivity change less than ±0.5 per cent over any 100 F temperature excursion within the rated temperature range. Designed to meet the Mil-E-5272C environmental requirements, it can withstand 50 g vibration to 2,000 cps without damage. Materials used allow the measurement of all gaseous and liquid media, including liquid oxygen, strong alkalies and acids such as nitrozene and red fuming acid. A ruggedized design, which adds 3/16 in. to the wall thickness, is available for usage where the most severe environments are encountered, such as a rocket test stand. The problem of noise pick-up and signal distortion are eliminated by the 5-v dc output that requires no amplification for instrumentation purposes.

These units are available in sample quantities up to 2 within 60 days, for larger quantities up to 10 the availability is 60 to 90 days after the date of order.

For more information on this solid-state transducer, turn to the Reader-Service Card and circle 252.

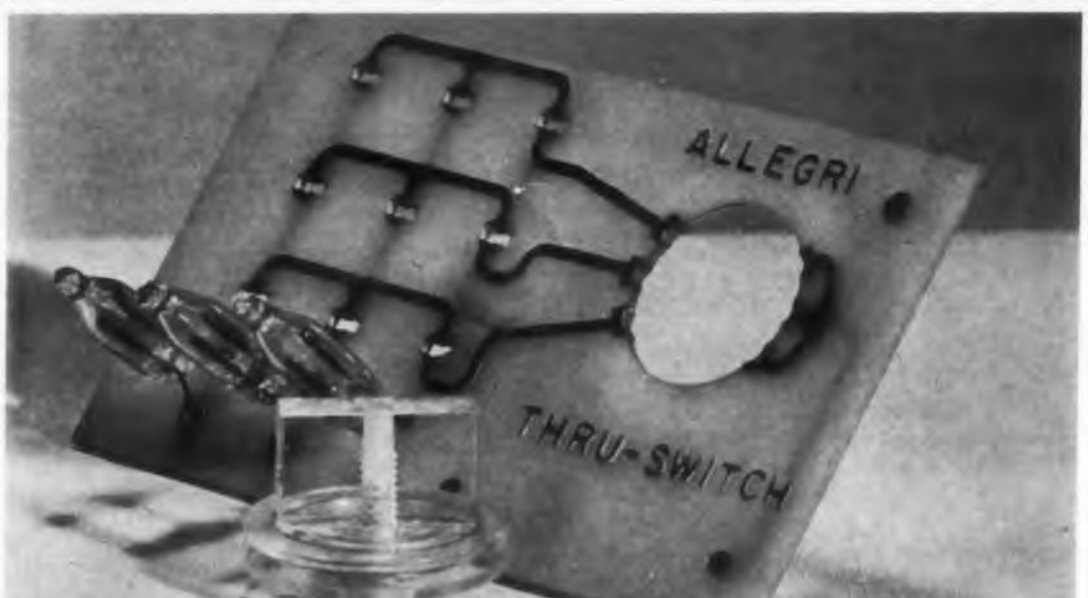
NEW PRODUCTS

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.

Miniature Circulators 455
Have No External Permanent Magnets

These miniaturized coaxial-line circulators have no external permanent magnets. They can be designed for operation in the C-, S- and L-bands. They operate over 10% bandwidths and provide more than 20-db isolation and less than 0.5-db insertion loss with a maximum input vswr of 1.3 in any arm. The size of the C-band unit is 1.4 in. in diameter and 1.4 in. height, exclusive of connectors; it weighs 6 oz.

Sperry Rand Corp., Sperry Microwave Electronics Div., Dept. ED, Clearwater, Fla.
Price & Availability: *C-band, $225; S-band, $245; L-band, $325. Delivery is from stock for small quantities; 30 to 60 days after order for production quantities.*



Miniature Wafer Switch 454
For Rotary-Type Applications

This wafer switch is designed for miniature installations requiring a rotary-type switch. As many as 20 circuits may be installed through a 1 in. hole. Plated-through segments of the hole provide contact to the desired circuits by means of a positive-stop rotary wafer. Up to 10 wafers per in. can be stacked in any design.

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Availability: *For quantities of 1 to 49, up to 4 weeks.*

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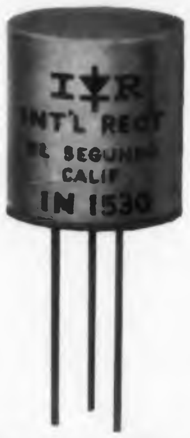
Babcock Relays, Inc., Dept. ED, 1640 Babcock Ave., Costa Mesa, Calif.



Low-Current Silicon Rectifiers Rated from 25 to 400 V, 4.7 Amp Avg — 450

Peak-inverse-voltage ratings from 25 to 400 v and average forward-current ratings up to 4.7 amp are provided by the series C11 low-current silicon controlled rectifiers. Typical gate current is 4 ma at 0.6 v; maximum gate voltage to fire is 2 v. Typical turn-on and turn-off times are 2 and 15 μsec, respectively. Maximum reverse or forward leakage current is 4.5 ma for the 25-v device, and 1 ma for the 400-v unit. Peak-surge-current ratings are 60 amp at rated load, or 125 amp during the turn-on time interval.

General Electric Co., Dept. ED, Charles Bldg., Liverpool, N.Y.

Price: *$4.50 to $35.50, depending on voltage rating.*

Voltage Reference Diodes Are Stable Within ±16 And ±8 Mv — 452

Stable within ±16 and ±8 mv from −55 to +100 C, these silicon Zener voltage-reference diodes have a temperature coefficient of ±0.002% per C. Designated types 1N1530 and 1N1530A, respectively, the units provide a reference voltage of 8.4 v at 10-ma bias current and have a dynamic resistance of 11 ohms avg. The devices, designed for insertion into printed-circuits, measure 0.56 in. in diameter and 0.59 in. high. They are said to withstand severe shock and vibration.

International Rectifier Corp., Dept. ED, 1521 E Grand Ave., El Segundo, Calif.

Price: *1N1530: $18; 1N1530A: $27.*

NEW PRODUCTS

Power Rheostats 564

Have torsion spring assembly

Types R-50, 75, 100 and 150 power rheostats have a torsion spring assembly that provides uniform pressure of the contact brush against the winding at all times. Current flows from the brush through a flexible shunt wire to a large size slip ring. Having all-ceramic construction, the rheostats can operate at extreme temperatures.

Tru-Ohm Products, Dept. ED, 2800 N. Milwaukee Ave., Chicago 18, Ill.

Availability: *Available from stock 10 days to 2 weeks after order received.*

Voltmeter 649

Accuracy is 1%

Type 300-G electronic voltmeter has an accuracy of 1% over the meter scale from 1 mv to 250 v and over the band of 20 cps to 20 kc. Accuracy is better than 2% up to 1,000 v and from 10 cps to 250 kc. The instrument covers 1 mv to 1,000 v in six decade ranges. It has a 5-in., mirror-backed scale.

Ballantine Laboratories, Inc., Dept. ED, Boonton, N.J.

Price & Availability: *$315 ea; from stock.*

DC Amplifier 666

Stability is ±1%

This dc, airborne, telemetry amplifier has ±1% stability and a voltage gain of 1000, adjustable to ±10%. Signal input is ±5 mv, resulting in an output of ±5 v. Bandwidth is dc to 100 cps with less than 1% attenuation. Linearity is within 0.5%. Input impedance is greater than 10 K; output impedance is less than 1.5 K. Ripple and noise referred to the output is less than 25 mv, peak-to-peak. The unit operates from 28 ±4 v dc with a current drain of less than 60 ma.

Networks Electronic Corp., Dept. ED, 14806 Oxnard, Van Nuys, Calif.

Availability: *The unit is made on order.*

◄CIRCLE 54 ON READER-SERVICE CARD

NEW PRODUCTS

Speed Control 667

Is power compensating

The Reactron, an ac saturable reactor, is essentially an inductor which has a laminated-iron core. It acts as a static power-compensating transformer and has a very fast response time. Typical uses are operation and control of ac-dc series universal type motors as well as dc shunt motors driven directly from an ac source.

Vee-Arc Corp., Dept. ED, Westboro, Mass.
Availability: *Made to customer specs.*

Noise Figure Bridge 405

Frequency range is 2 to 2000 mc

The Auto-Node automatic noise figure bridge is designed to obtain noise-figure meter displays for making noise-figure adjustment. Useful frequency range is 2 to 2000 mc. Sine-wave temperature-modulation is 10 cps with temperatures from 300 to 400 K. Noise-figure stability is better than 3.5 db and the gain is sufficient to raise the input noise to 10 v after final detection. The bandwidth is 2 mc and center frequencies can be 30, 60, or 70. The accuracy is 0.2 db for gain or loss measurements.

Kay Electric Co., Dept. ED, Maple Ave., Pine Brook, N. J.

Guidance Package 574

Takes shock of 15 g

Designed to supply stable reference data to a self-guided weapon, this guidance package takes 150 g of shock and 30 g of vibration to 2,000 cps. It consists of three subminiature, floated-rate gyros, type RG-101, and two subminiature, floated-pendulous linear accelerometers, type TA-400. Each of the three gyros is oriented in one of three mutually perpendicular axes: roll, pitch, and yaw.

Fairchild Controls Corp., Components Div., 225 Park Ave., Hicksville, L.I., N.Y.
Availability: *Made on special order only.*

Wirewound Resistors 354

Have bushings for stacking

The Series 400 R-Stack wirewound resistors have screw-mounted, bushing-terminated resistance elements. Tolerance is 1% through 0.005%. Units measure 1/2 in. in diameter, 3/4 in. long for 1/2-w resistors and 7/8 in. in diameter, 15/16 in. long for 1-w resistors. Mil specs are met.

Consolidated Resistance Co. of America, Inc., Dept. ED, 44 Prospect St., Yonkers, N. Y.

***Price & Availability:** $2.50 each with 0.05% tolerance in lots of 100. Normally available in 4 weeks, units can be delivered in 48 hours on special request.*

Diode Tester 686

For germanium and selenium units

Model DT-257A diode tester is for measuring the static characteristics of germanium and low-power selenium diodes. Offered as an accessory unit is a millimicroammeter, which measures low reverse currents of silicon diodes. The tester has separate forward and reverse power supplies that have continuously variable outputs or preset regulated reverse potentials to permit measurements at selected operating points.

Crosby-Teletronics Corp., Dept. ED, 57 Kinkel St., Westbury, L.I., N.Y.

***Price & Availability:** $295; from stock.*

Pulse Generator 404

Repetition rate is 10 cps to 1 mc

Model 130 pulse generator has a repetition rate of 10 cps to 1 mc, a rise and fall time of less than 10 mμsec, and two pulse outputs with a relative pulse delay between them of 200 mμsec to 50 msec. The instrument is suited for fast circuit applications in computer work, transistor testing, and missile applications.

E-H Research Labs., Inc., Dept. ED, 163 Adeline St., Oakland 20, Calif.

Detergent And Solvent Compounds 572

For epoxy and polyester resins

Meta-Terge 1405 is a safety cleanup detergent for uncured epoxy and polyester resins. It allows the insoluble resins to be cleaned with water. Meta-Strip 702 is a synergistic, non-corrosive solvent for removing and stripping cured epoxy resins. It can be used in salvaging expensive and sensitive electronic components that have been encapsulated. Both the materials are available in liquid and the thixotropic gel forms.

Metachem Resins Corp., Dept. ED, 530 Wellington Ave., Cranston 10, R.I.

Price: *Meta-Strip ranges from $1.25 to $1.50 per lb, depending on quantity; Meta-Terge ranges from $0.65 to $0.75 per lb, depending on quantity.*

DC Timing Motor 650

Speeds are 1/15 to 60 rpm

Model MD-83 dc timing motor is reversible by changing polarity. Speed is directly proportional to voltage. Constant voltage speeds are 1/15 to 60 rpm. Standard voltages are: 6, 12, and 28 v.

Haydon Div., General Time Corp., Dept. ED, Torrington, Conn.

Digital Computer 569

For scientific, industrial, military problems

Type PB250 digital computer can be applied to a broad range of scientific, industrial and military problems. For a word consisting of 21 bits plus sign, the speeds are: add-subtract, 12 μsec; multiply, 276 μsec; divide and square root, 252 μsec. The memory is expandable from 1,808 words to 15,888 words internally. The unit offers 46 commands including double precision operations, block transfer, and Gray-to-binary conversion. Programing is achieved by single-address instructions, command indexing, and automatic double-precision operations.

Packard Bell Electronics, Packard Bell Computer Div., Dept. ED, 12333 W. Olympic Blvd., Los Angeles 64, Calif.

Price: *$30,000.*

Servo Drive System 372

Volume is 1.75 cu in.

This solid state, subminiature servo drive system has a volume of 1.75 cu in. and delivers a torque of 2 in.-lb from a change of 0.001 v. Actuator arm speed is 270 deg per sec. The device consists of a servo amplifier, a precision gear train and a high-torque servo drive motor.

Electrosolids Corp., Solidtronics Div., Dept. ED, 14751 Keswick St., Van Nuys, Calif.

Impedance Bridge 371

Portable, self-contained, direct-reading

The model 385 general-purpose impedance bridge is a portable, self-contained, direct-reading unit which contains a Wheatstone bridge (ac or dc) with a range of 0 to 1 meg, a modified capacitance bridge with a 0 to 100 μf range, or an inductance bridge with a range of 0 to 100 h. The instrument provides for tests at 1 kc as well as at dc. External signals from 60 to 10,000 cps can be introduced. A separate oscillator-amplifier accessory is available.

The Winslow Co., Dept. ED, 701 Lehigh Ave., Union, N. J.

Elastic Flexible Wire 568

Stretches to three times its length

Elasticable, elastic flexible wire, stretches to three times its relaxed length without losing its electrical properties. Cables can be furnished with single and multiple conductors. Commercial types have a natural rubber core with insulation of braided nylon and conductors of copper magnetic wire, bronze tinsel, or copper tinsel. Military types have a silicon rubber core with insulation of braided nylon and conductors of copper wire or bronze tinsel.

National Radio Co., Inc., National Co., Inc., Dept. ED, Malden, Mass.

Availability: *Both commercial and military types are in stock. The products can also be made to order for individual needs.*

Silicon Diodes 519

Are rated at 750 ma

This series of miniature silicon diodes are diffused-junction units rated at 750 ma. Reverse current is 200 μa, surge current rating is 50-amp peak for one cycle, and forward voltage drop is 0.92 v. Designated types X5A2, X5A4, X5A5, and X5A6, the units have piv ratings of 200, 400, 500, and 600 v. Operating temperature range is —65 to +130 C. A typical unit measures 0.29 x 0.2 in., not counting leads.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

Price: *$0.95 to $1.45 ea in quantities to 100.*

IMMEDIATE DELIVERY!
MILITARY TYPE
1N746A thru 1N759A

IE PSI POLICY OF 100% OSCILLOSCOPE TESTING OF ALL ZENER diodes
d assemblies is your protection against circuit instability due to double
eak, soft knee, hysteresis and the many other "ailments" commonly found
less carefully screened zener diodes. Reliability and electrical performance
us *substantially higher power dissipation of 500 mW* make this broad line
zener diodes well worth your early investigation. Tight leakage at 75% or
% of zener voltage may be specified when ordering.

W! LOW VOLTAGE REGULATING DIODES...1.5 TO 3.0 VOLTS. These
w types are characterized by extremely low dynamic impedance and ex-
ded operating temperature range. Available in ±5% and ±2% types.
gged and compact, the units measure 3/8" diameter by .53" long and are
ished with wire leads for easy mounting on printed circuit boards.

W VOLTAGE REGULATORS—PSI offers the highest surge, power and
rent rating of any subminiature regulator available.

LTAGE REFERENCE DIODES—These six types, with nominal voltage
ging from 6.8 to 40.8 volts, provide a temperature coefficient of less than
%/°C and by specifying version "A" can be supplied at less than .0025%/°C.

All types available now in production quantities

acific Semiconductors, Inc. PSI

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500mW POWER DISSIPATION

PSI Type Number	Elect. Equiv.	Zener Voltage @5mA @25°C E_Z Min. (v)	E_Z Max. (v)	Maximum Dynamic Resistance (ohms) 1	Maximum Inverse Current I_b @25°C (µA)	I_b @100°C (µA)	At Inverse Voltage (v)
PS6465	1N465	2.0	3.2	60	75	100	1
PS6466	1N466	3.0	3.9	55	50	100	1
PS6467	1N467	3.7	4.5	45	5	100	1
PS6468	1N468	4.3	5.4	35	5	100	1.5
PS6469	1N469	5.2	6.4	20	5	100	1.5
PS6470	1N470	6.2	8.0	10	5	50	3.5

1. Measured at 10mA DC Zener current with 1mA RMS signal superposed.
Also available PS6313-6318 covering 7.5v to 27v Zener Voltages.

EIA Type	Zener (Breakdown) Voltage @5mA E_Z Min. (v)	E_Z Max. (v)	Maximum Inverse Current I_b @25°C (µA)	I_b @100°C (µA)	At Inverse Voltage (v)	Maximum Dynamic Resistance (ohms) 1
1N702	2.0	3.2	75	100	−1	60
1N703	3.0	3.9	50	100	−1	55
1N704	3.7	4.5	5	100	−1	45
1N705	4.3	5.4	5	100	−1.5	35
1N706	5.2	6.4	5	100	−1.5	20
1N707	6.2	8.0	5	50	−3.5	10

1. Measured at 10mA DC Zener current with 1mA RMS signal superposed.
Also available 1N708-1N723 covering 5.6v to 27v Zener Voltages.

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

EIA Type[1]	Zener Voltage E_Z (Volts)[2]	Max. Inverse Current $E_B = -1V$ µa 25°C	150°C	Max. Dynamic Resistance I_Z=20mA I_{AC}=1mA Ohms (Max.)
1N746	3.3	10	30	28
1N747	3.6	10	30	24
1N748	3.9	10	30	23
1N749	4.3	2	30	22
1N750	4.7	2	30	19
1N751	5.1	1	20	17
1N752	5.6	1	20	11
1N753	6.2	0.1	20	7
1N754	6.8	0.1	20	5
1N755	7.5	0.1	20	6
1N756	8.2	0.1	20	8
1N757	9.1	0.1	20	10
1N758	10.0	0.1	20	17
1N759	12.0	0.1	20	30

1. ±10% Zener Voltage Tolerance. 2. E_Z measured at Test Current I_Z=20mA. All of the above types can be supplied in ±5% Tolerance. Add "A" suffix to indicate units with ±5% Tolerance of center Zener Voltage Value.

LOW VOLTAGE REGULATORS

PSI Type	E_f + 1mA (volts)	I+1 min. (mA)	Max. Dyn. Res. @1mA (ohm)	I_b @25°C (µA) Max.
1N912	0.62 ± 10%	100	60	1.0 @ −5v
1N913	0.62 ± 10%	250	60	5.0 @ −5v

VOLTAGE REFERENCE DIODES

EIA Type Number	REFERENCE VOLTAGE @7.5mA @25°C (volts) Min.	Avg.	Max.	Max. Voltage change from 25°C Reference Voltage (volts) −55°C to +100°C	Max. Dynamic[1] Resistance (ohms)
1N2765	6.46	6.80	7.14	±0.050	20
1N2766	12.92	13.60	14.28	±0.100	40
1N2767	19.38	20.40	21.42	±0.150	60
1N2768	25.84	27.40	28.56	±0.200	80
1N2769	32.30	34.00	35.70	±0.250	100
1N2770	38.76	40.80	42.84	±0.300	120

1. Measured with 1mA AC superimposed on 7.5mA DC.
Max. Operating Temp. @ I_Z = 7.5mA: −65°C to +175°C.
Also available in "A" version—.0025%/°C.

CIRCLE 59 ON READER-SERVICE CARD

DC Power Supply 415

For photo multiplier tubes

This dc power supply provides an output of −55 to −1,000 v. Its principal use is powering an RCA 6655-A photo multiplier tube. The supply operates from an input of 115 v ±10% at 60-cps or from the firm's model 1935 multivibrator switch. Ripple does not exceed 0.1% peak-to-peak.

Lumen, Inc., Dept. ED, P. O. Box 905, Joliet, Ill.

Pyrotechnic Free Gyro 524

For one-time missile use

Type PHM pyrotechnic free gyro is for one-time use in short range missiles. Measuring 4.5 x 2.75 in. and weighing about 800 g, the unit stands 100 g shock. It has 2 deg of freedom. Active gyro life is 3 min with an average drift of 1 deg per min.

Greenleaf Manufacturing Co., Dept. ED, 7814 Maplewood Industrial Court, St. Louis 17, Mo.

Power Connectors 396

For 25- or 250-amp duty

These single-conductor plugs and receptacles with 25- and 250-amp ratings incorporate a fishtail plug design and provide simplified, quick assembly. All current-carrying parts are of brass, gold-plated for stable electrical contact and resistance to corrosion.

The Superior Electric Co., Dept. ED, Bristol, Conn.

Price & Availability: Price ranges from $1.30 to $5.50. Delivery is from stock.

NEW PRODUCTS

Thermal Inductor 424

Is stable from —55 to +375 C

The Therm-L high-Q, fixed inductor is stable under temperatures from —55 to +375 C. It is offered in inductances from 0.068 to 0.56 μh and in close tolerances. Completely inorganic, the unit is of one-piece construction and complies with MIL-C-15305-A, class C.

Essex Electronics Div., Nytronics, Inc., Dept. ED, 550 Springfield Ave., Berkeley Heights, N.J.

Signal Generator 401

For measuring reflection coefficients

Model X775A sweep signal generator, with automatic gain control, provides a means of measuring the reflection coefficient of microwave components by direct oscilloscope presentations. The rf power source of the instrument is an electronically-swept permanent magnet type backward-wave-oscillator tube. A built-in amplifier can be used with an external detector to provide a reference source that is flat within ±0.5 db over the range of 8.2 to 12.4 kmc. Dial settings are provided for the upper and lower frequencies; dial accuracy is ±1%.

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

Trimmer Potentiometers 392

Range is 10 ohms to 65 K

The W4 series trimmer potentiometers are offered in resistance values of 10 ohms to 65 K. The units are miniature. They are rated at 1 w up to 70 C, derating to 0 at 200 C.

Atohm Electronics, Dept. ED, 7648 San Fernando Road, Sun Valley, Calif.

***Price & Availability:** $7.50 to $12 ea in quantities of 1 to 24; from stock.*

Silicon Rectifier Stack 412

With choice of two diode types

Having standard and reverse polarity double-diffused diodes, this silicon rectifier stack can be furnished with style 40 or style 51 diodes. Bridge assemblies using the style 40 are rated up to 180 amp, single phase, and 270 amp three phase. Bridge assemblies up to 260 amp, single phase, and using the style 51 diodes are rated 390 amp, three phase. The design used permits rapid adaptation to any current configuration.

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

Availability: Delivery time is two to three weeks.

Parabolic Antennas 410

Range is 5,925 to 7,425 mc

For performance over the range of 5,925 to 7,425 mc, these parabolic antennas are offered in 2, 4, 6, 8 and 10-ft diameters. They are suitable for industrial applications such as data transmission, operational relay, and local point-to-point communications.

Gabriel Electronics, Dept. ED, Millis, Mass.

Microwave Mixer Diodes 562

Have low noise figure

Types 1N53C and 1N53RC microwave mixer diodes, made for use at 35,000 mc, have a maximum over-all noise figure of 9 db. Also available, types 1N23F and 1N23RF, for 9375-mc use, have a noise figure of 7 db; types 1N21F and 1N21RF, for use at 3000 mc, have a noise figure of 6 db. Uses are in microwave communications links, long range radar, telemetering, and countermeasures.

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

Price & Availability: Types 1N53C and 1N53RC are priced at $60.50 and $90.75 ea for orders of 1 to 9 units. Delivery is immediate.

CIRCLE 61 ON READER-SERVICE CARD ➤

New Series of Indium Antimonide Infrared Detectors by Radiation Electronics Co.: l. to r.–PC-02, A-04 (J-02 same dewar as PC-02).

Indium Antimonide Infrared Detectors

PHOTOVOLTAIC detector, Model J-02, operates at liquid nitrogen temperature and exhibits high sensitivity from the visible region to 5.7 microns. Because of its very small area (0.1 × 0.1 mm²), fast response, and sensitivity, the J-02 detector permits the design of infrared systems with high optical gain, high resolution, and very rapid scanning rates. Impedance is approximately 50,000 ohms. The J-02 is efficiently coupled to both transistor and vacuum tube preamplifiers. Linear arrays of detection elements can be fabricated for special applications.

PHOTOCONDUCTIVE detector, Model PC-02, operates at the dry ice point with sensitivity from the visible region to 6 microns. The PC-02 is conveniently coupled to both transistor and vacuum tube amplifiers. Standard detector area is 1 × 1 mm²; other detector areas available from 0.5 × 0.5 mm² to 2 × 2 mm². Time constant less than one microsecond.

PHOTOELECTROMAGNETIC (PEM) detector, Model A-04, operates at ambient temperatures and does not require bias supply. Sensitive from the visible to seven microns with a time constant of less than one microsecond. Standard detector element is 1 × 1 mm², and other sizes from 0.5 × 0.5 mm² to 2 × 1 mm² can be furnished. Normally used with an input transformer for efficient coupling to transistor or vacuum tube amplifiers. Housed in a hermetically sealed, ruggedized package, the A-04 is supplied with a magnesium oxide window. Other window materials, such as sapphire or arsenic trisulphide, are also available.

Radiation Electronics Company also manufactures high speed radiometers, industrial radiation thermometers, thermal scanning devices, blackbody reference sources, and low noise preamplifiers. Prompt attention will be given to your special problems by our experienced scientific and engineering staff. Contact RADIATION ELECTRONICS COMPANY, Division of Comptometer Corporation, 5600 Jarvis Avenue, Chicago 48, Illinois. Dept. D.

SPECIFICATIONS

	PEM	PHOTOCONDUCTIVE	PHOTOVOLTAIC
Operating Temperature	20°C	−78°C	−196°C
NEP* (500°K), watts	3.3×10^{-9}	1.5×10^{-10}	7×10^{-12}
NEP* (5 microns), watts	1×10^{-9}	3×10^{-11}	1.4×10^{-12}
Spectral Cutoff, microns	6.9	6.1	5.7
Sensitive Area, mm²	1 × 1	1 × 1	0.1 × 0.1
Time Constant, microseconds	<1	<1	<1
Typical Resistance, ohms	5	100	50,000

*1 cps bandpass at 500 cps

CIRCLE 62 ON READER-SERVICE CARD

NEW PRODUCTS

DC Power Supplies 406

Panel height is 3.5 in.

The QR power supplies have a panel height of 3.5 in. The units have an ammeter and a voltmeter accurate to 2% of full scale. A 10-turn potentiometer provides resolution of one part in 10,000. Model QR-36-4, shown, has an output of 0 to 36 v at 0 to 4 amp, which may be used as negative or positive and may be floated up to 500 v above or below ground. Input is 105 to 125 v at 55 to 65 cps. Ripple is 1 mv rms, static load regulation is ±0.01% or ±1 mv, static or dynamic line regulation is ±0.03% or 3 mv. Maximum load transient response time is 25 μsec.

NJE Corp., Dept. ED, 20 Boright Ave., Kenilworth, N.J.

Price: Model QR-36-4 is priced at $485 ea.

Triode 363

Switches 180 amp at 25,000 v

Type 7545/XD-45 forced-air-cooled triode is for use in pulsed service as an amplifier and modulator switch tube. It will switch 180 amp at 25,000 v with a duty of 0.002. Peak power handling capacity is 3.4 megawatts. Additional ratings up to 0.06 duty are provided. Plate voltage is 25 kv dc in pulse applications, 8 kv dc in cw applications.

Central Electronic Manufacturers, Dept. ED, 2 Richwood Place, Denville, N.J.

***Price & Availability:** $380 ea; 30-day delivery time.*

Size 8 Servo Motor 375

Device is viscous damped

A size 8 servo motor, type 5702-03 is an adjustable viscous damped unit for feedback damping applications. The unit is 1-3/4 in. long and weighs 2 oz. Damping, gain and no-load speed are adjustable. Rotor moment of inertia is 0.65 g-cm^2; stall current is 0.113-amp fixed phase and 0.077-amp control phase; stall power is 2.4 w per phase; stall torque is 0.2 oz-in. min. Housing is bright finish stainless steel.

John Oster Manufacturing Co., Avionic Div., Dept. ED, Racine, Wis.

Availability: Delivery, from stock, is about 30 days.

AC Servo Amplifier 382

For aircraft and missile use

Developed for 115-v, 400-cps servo systems used on aircraft and missiles, this solid-state amplifier drives standard size 11 or smaller 40-v center-tapped servo motors. It can also be used to operate 40-v motors in larger frame sizes where the 3.5-w output is adequate. The unit has a gain stability of ± 2 db over an operating temperature of -55 to $+102$ C and operates with only slightly reduced gain at $+125$ C. Normal power gain is 90 db max with no feedback or 70 db min with feedback.

United Control Corp., Dept. ED, 4540 Union Bay Place, Seattle 5, Wash.

Price & Availability: $250 ea in quantities to 10; $241 in quantities of 11 to 25. Delivery is from stock.

for maximum flexibility in rectifier circuit design

CHOOSE HUGHES SILICON RECTIFIERS

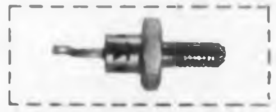
With over 100 different JEDEC types available, Hughes offers you one of the industry's largest selections of stud mounted and top hat silicon rectifiers. And with their hermetically sealed, corrosion resistant packages, these rectifiers give you maximum reliability!

To order any of these devices please contact the Hughes Semiconductor Sales Office or Distributor nearest you. Or, for further information write Hughes, Semiconductor Division, Marketing Department, Newport Beach, California.

For export write: Hughes International, Culver City, California.

PIGTAIL TOP HAT SILICON RECTIFIERS

E.I.A. Number	*PIV*
1N536	50
1N599	50
1N599A	50
1N1217	50
1N440B	100
1N530	100
1N537	100
1N600	100
1N600A	100
1N1100	100
1N1218	100
1N601	150
1N601A	150
1N1219	150
1N441B	200
1N531	200
1N538	200
1N602	200
1N602A	200
1N1101	200
1N1220	200
1N442B	300
1N532	300
1N539	300
1N603	300
1N603A	300
1N1102	300
1N1221	300
1N443B	400
1N533	400
1N540	400
1N604	400
1N604A	400
1N1103	400
1N1222	400
1N444B	500
1N534	500
1N605	500
1N605A	500
1N1104	500
1N1223	500
1N445B	600
1N535	600
1N547	600
1N606	600
1N606A	600
1N1096	600
1N1224	600
1N1225	700
1N560	800
1N1226	800
1N561	1000



STUD MOUNTED SILICON RECTIFIERS

E.I.A. Number	*PIV*
1N607	50
1N607A	50
1N340	100
1N338	100
1N349	100
1N348	100
1N347	100
1N253	100
1N608	100
1N608A	100
1N609	150
1N609A	150
1N336	200
1N337	200
1N346	200
1N345	200
1N254	200
1N610	200
1N610A	200
1N334	300
1N335	300
1N344	300
1N343	300
1N611	300
1N611A	300
1N332	400
1N333	400
1N342	400
1N341	400
1N255	400
1N612	400
1N612A	400
1N613	500
1N613A	500
1N256	600
1N614	600
1N614A	600
1N562	800
1N563	1000

Creating a new world with ELECTRONICS

HUGHES

SEMICONDUCTOR DIVISION

CIRCLE 64 ON READER-SERVICE CARD

NEW PRODUCTS

DC Voltmeter 566

Rated at 200,000

Model M200DC Kilovoltmeter is rated at 200,-000 v dc and is constructed in two pieces for remote metering. Composed of a high-voltage multiplier resistor in a tall bakelite tube and an indicating instrument in a small metal cabinet at ground potential, the device has an input resistance of 2,000 meg. It takes an overload of 150%. The indicating instrument is 4.5-in. sq.

Peschel Electronics, Inc., Dept. ED, Towners, Patterson, N. Y.

Price & Availability: *Made on order only; delivered 60 days after receipt or order. Price per unit is $800.*

Attenuator 383

For operation from dc to 4 kmc

Model A 101, 10-w coaxial power attenuator is designed for operation from dc to 4 kmc. It can be supplied in attenuation values from 0 to 60 db. The attenuator accuracy of pads up to 30 db, including absolute accuracy and variation of attenuator as a function of frequency is 0.5 db; the accuracy of pads from 30 to 60 db is 0.75 db. The units are calibrated at 1.2 kmc and 2.8 kmc and can be supplied with type N, TNC, C, and BNC connectors. The vswr of units having type N connectors is 1.3 max from dc to 4 kmc.

R L C Electronics, Inc., Dept. ED, 805 Mamaroneck, N. Y.

Price & Availability: *$115 to $170; delivery from stock to 30 days.*

Ultrasonic Immersible Transducers 567

End fitting and bulkhead type

This line of both end-fitting and bulkhead type, immersible ultrasonic transducers can be used to add ultrasonic cleaning stages to existing tanks or vapor degreasers. They are designed for use with most cleaning solutions, solvents and detergents, mild acids and caustics at temperatures to 180 F. The transducers are produced in three standard sizes with a rated input power of 60, 125, and

250 w, respectively; they can be used either individually or in combination.

National Ultrasonic Corp., Dept. ED, 111 Montgomery Ave., Irvington 11, N.J.

Price & Availability: *Delivered 7 days after order received; prices range from $115 to $625 for various models.*

Impedance Analyzer 378

For precision measurements

Model W-2 impedance analyzer is designed for precision measurement of polar parameters, phase angle and ohmic values of impedance. It computes and directly indicates phase angle as well as its sin, cos, and tan, power factor, Q, and D. Measurements can be made at the actual operating voltage and frequency of the component being tested. Accuracy is 1% from 60 cps to 12 kc, impedance measurements can be made to 1 meg.

Western Electronic Products Co., Dept. ED, 2420 N. Lake Ave., Altadena, Calif.

Price & Availability: *Price is $135 fob Altadena, Calif., with immediate availability.*

Resistive Heating Devices 685

For continuous use at 450 F

These electric heating elements or power resistors use silicone rubber and fiber-glass cloth insulation and are capable of continuous operation at temperatures above 450 F. Width is 1 in., over-all lengths are 1.5 to 12 in., and thickness is 0.12 in. or less. Resistance per unit of length is 1.27 to 1,800 ohms per in. of heated length. Resistance tolerance is ±7%. Units cemented to metal dissipate up to 25 w per sq in.

Electro-Flex Heat, Inc., Dept. ED, 83 Woodbine St., Hartford 6, Conn.

Price & Availability: *Available for 15-day delivery, units with lugs are priced at $0.33 ea plus $0.07-1/3 per in. of length (in quantities of 200 or more). Units with leads are priced at $0.42 ea plus $0.07-1/3 per in. of length.*

NEW PRODUCTS

Servo Motor-Generator 573

Size 11

Model R830-26 servo motor-generator is a size 11 unit. It has 0-deg phase shift and a signal-to-noise ratio of 290:1. It is designed primarily as a low-inertia rate generator, but can also be used to replace most size 15 units in high-gain applications. The motor section operates on 115 v, 400 cps and draws 53 ma. The generator section requires an excitation of 115 v at 400 cps and 65 ma.

Genueral Precision Inc., Kearfott Div., Dept. ED, 1150 McBride Ave., Little Falls, N.J.

Power Supply 366

For servos and transistorized amplifiers

An output of 29 v dc at 300 ma, filtered and unregulated, and two isolated ac outputs rated at 4 w and 0.5 w respectively are provided by the model H3900-01 power supply. The dc source is suitable for transistorized amplifiers and small servos. Input is 115 v, 400 cps. The device can be used to circumvent noise and severe transient voltages in 28-v dc lines of aircraft and missiles. Units, weighing 28 oz, are potted and sealed.

Kearfott Div., General Precision Inc., Dept. ED, 1150 McBride Ave., Little Falls, N. J.

Magnetic Amplifiers 664

Servo-motor type

These servo-motor, magnetic amplifiers meet full Mil specs for temperature, shock, and vibration. Model 224, typical of the series, drives a standard 3.5 w, size 11 servo motor from 115 v at 400 cps. Less than 1 ma dc is required for full motor torque.

Acromag, Inc., Dept. ED, 22515 Telegraph Road, Southfield, Mich.

Price & Availability: *Model 224 is priced at $148; delivery is from stock.*

High-Torque AC Motors 351

Units weigh 10 oz

These Rotorac motors, having a typical weight of 10 oz, are capable of delivering a 6 lb-in. at 20 rpm from a 115-v, 60-cps source at 0.75 amp. The units have rapid starting and stopping characteristics, and are not damaged by stalls.

Airborne Accessories Corp., Dept. ED, 1414 Chestnut Ave., Hillside 5, N. J.

Price & Availability: *Units are available from stock, and are priced from $25 to $40 each in quantities of 100.*

Microwave Monitor And Alarm 357

Handles 480 functions

This alarm and fault-finding system will monitor as many as 480 functions in a microwave system. The system, Model MA-1, indicates station condition, over-all system conditions, and individual function condition of up to 20 functions at any of 24 remote reporting stations. Faults are indicated at a master alarm station, illustrated. Such functions as tower lights, illegal entry, operation of emergency power unit or auxiliary rf units, high temperature or low pressure could be indicated.

Motorola, Inc., Communications and Industrial Electronics Div., Dept. ED, 4501 W. Augusta Blvd., Chicago 51, Ill.

NEW PRODUCTS

Instrument Wire 665

Has 1 to 6 mil insulation

This instrument wire has Teflon-insulated walls measuring from 1 to 6 mil. Silver-plated copper conductors from AWG 28 to 36 are available. The wire is rated for 300 v at temperatures from −90 to +250 C. Any length can be furnished.

Tensolite Insulated Wire Co., Inc., Dept. ED, 1000 N. Division St., Peekskill, N.Y.

Precision Band-Pass Filters 352

Available for 90, 150 and 180 cps

The Series F bandpass filters, available in 90-, 150- and 180-cps models, have bandwidths of 8, 11 and 12 cps respectively a 1 db down. Insertion loss, input and load impedances are the same for the three units. The instruments are designed for navigational aids, instrument landing systems, receivers, control units, monitors and associated test instruments. Units are hermetically sealed in 3 x 3-1/2 x 3-13/16 in. metal cases. Ambient temperature range is −20 to +60 C.

Barker & Williamson, Inc., Dept. ED, Bristol, Pa.

Availability: Units are made to order and can can be delivered in 30 days.

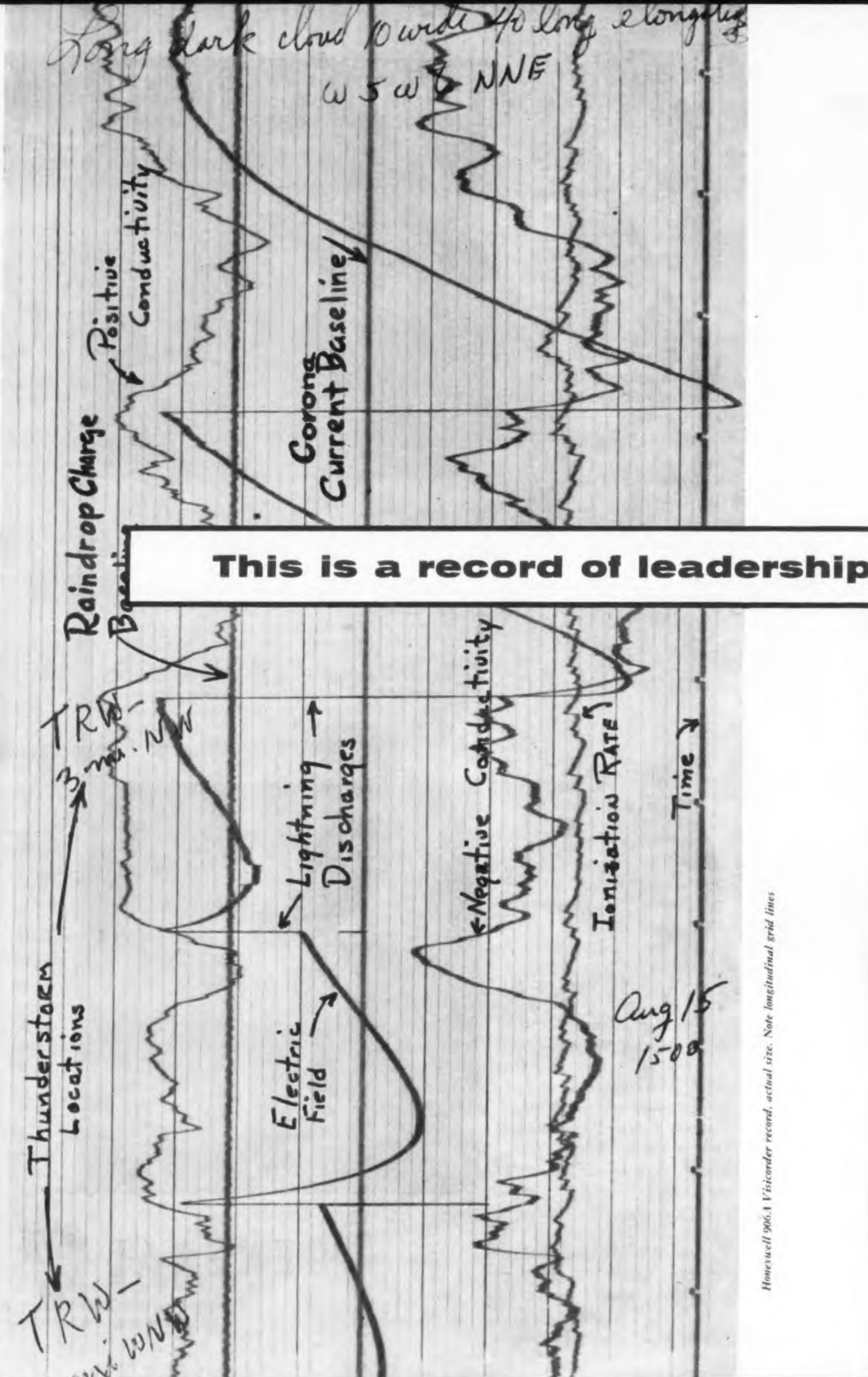
Image Orthicon Tube 360

Field mesh improves image

Type GL-7293, designed to replace the standard 5820, uses a field mesh in the scanning section to improve beam landing by creating a more uniform electric field in back of the target. The tube is interchangeable, electrically and physically, with the 5820, but differs slightly in construction and operation. Spectral response is close to that of the human eye.

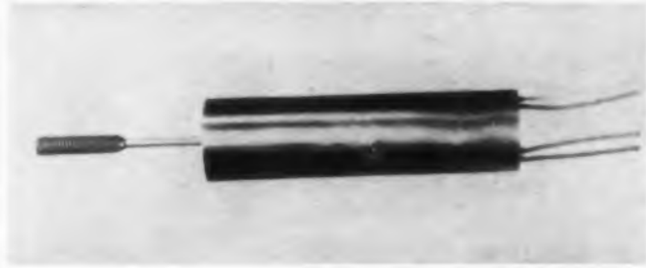
General Electric Co., Dept. ED, Schenectady 5, N. Y.

***Price & Availability:** The tube is available in sample quantities at a user price of $1,300.*



Displacement Transducers 353

Have solid-state circuitry



These displacement transducers have built-in solid-state circuitry and provide a dc output signal from dc excitation. Electro-mechanical response is beyond 1,000 cps. Units have germanium components for 6-v excitation, silicon components for 10-v dc excitation. The devices replace carrier amplifier systems to permit direct operation of recorders and indicators.

G. L. Collins Corp., 2820 E. Jullett St., Long Beach, Calif.

Price & Availability: *Units, available from stock, are priced from $87 to $174.*

Pressure Transducers 384

For missile applications

Designed to meet the requirements of telemetry and control applications in advanced missiles, type P104 pressure transducers measure 1 in. in diameter and 2 in. long. They weigh 3.5 oz, including pleasure and electrical connectors. Standard units are furnished in eight ranges from 0 to 500 and 0 to 5,000 psia. Output up to 75-v full scale may be obtained without amplification. Effects of linearity, hysteresis, resolution, friction, repeatability, and interchangeability are within a static accuracy band of ±1.5%. Time constant is less than 2 msec and temperature sensitive is less than 0.005% per deg F over the operating temperature range of −150 to +225 F.

Trans-Sonics, Inc., Dept. ED, Burlington, Mass.

Price & Availability: *$400 ea, from stock.*

NEW PRODUCTS

Coaxial Mixer 680

Comes in frequencies of 250 to 8,000 mc

The PC-Mix printed-circuit broadband coaxial mixer is available in frequency ranges of 250 to 8,000 mc in five basic units. Signal vswr is 2:1 max; line-open vswr is 1.5:1 max; and noise figure is better than 9 db. Mixing is single or balanced. The unit is capable of withstanding severe shock and vibration.

Premier Instrument Corp., Dept. ED, New Broad St., Port Chester, N.Y.

Lead and Quadrature Rejection Amplifier 376

Rejection is 20:1 or better

Model 1805-0100 amplifiers provides a transistorized compensating lead network for 400-cycle servo systems. Quatrature rejection of the unit is 20:1 or better. Input impedance is 10 K, output impedance is 2 K. Dynamic voltage gain is 4. Power source is 28 v dc and 115 v, 400 cps. The unit is hermetically sealed and meets MIL-E-5400 specifications. It measures 1-3/16 x 1-11/16 x 2-5/8 in. and weighs 7 oz.

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

Price & Availability: *Price is $290; delivery is 4 weeks.*

Taper-Pin Plugs 696

In solder and solderless types

For use in connections of all types of circuits, types 2471 and 2472 machined, taper-pin plugs are solder and solderless types, respectively. Made of brass, the plugs measure 0.053 in. in diameter with a 0.061-in. taper per in. Finish is 0.0002-in. silver plate plus 0.0001-in. gold plate, or 0.001-in. copper plate and 0.005-in. electro-tin plate.

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

Price & Availability: *Type 2471, $41.75 per 1,000 in quantities of 5,000; type 2472, $19.21 per 1,000 in quantities of 5,000. Delivery is from stock.*

Oscilloscope Accessory 358

Provides 0 to 300 v dc

Designed for coupling to an oscilloscope, the Scope-O-Trol accessory unit provides an output of 0 to 300 v dc operating from an input of 115 v at 60 cps. The unit observes on the oscilloscope the regulation, ripple, transient response and other characteristics of dc power supplies by removing the dc component and using the scope to its maximum capacity. Voltage adjustment of the unit is in 75-v steps for coarse adjustment. Ripple is less than 1 mv rms.

Acme Electric Corp., Dept. ED, Cuba, N.Y.

Price & Availability: *Units are priced at $125 and are furnished from stock.*

Toggle Switch 380

With circuit breaker

By combining both toggle switch and circuit breaker in this miniature unit, the need for replaceable fuse, fuse holder, and switch is eliminated. Weighing less than 50 g, the unit is suitable for use in radio, aircraft, and industrial electronic equipment. Its dielectric strength is over 3,500 v. Called the 3100 series, the device can interrupt circuits carrying up to 5,000 amp at 120 v, 60 cps. Units have current ratings of 5 to 50 amp.

Wood Electric Corp., Dept. ED, 244 Broad St., Lynn, Mass.

Availability: *Up to 100 pieces can be furnished from stock.*

How Reader Service Can Help Solve Your Design Problems

PROBLEM:

You have narrowed the selection of a product to three or four brands. You want more detailed information . . . a sound basis for making the best selection.

PROCEDURE:

You circle the Reader Service Numbers of the advertisements or new product articles you're interested in, and mail the postage-free card to ELECTRONIC DESIGN. Our Reader Service Dept. speeds your requests to the manufacturers of the products you're considering.

RESULT:

The manufacturers then provide data in depth; product descriptions, specifications, diagrams. Your product search is simplified—the problem soon solved.

CONCLUSION:

When seeking more information about products displayed in ELECTRONIC DESIGN, simply circle the corresponding Reader Service Numbers. It's the fastest way—the most convenient way.

NEW PRODUCTS

Six-pdt Relay 523

Has 2-amp contacts

Type JH-18 6 pdt miniature relay has 0.2 in. grid spacing, 2-amp contacts, and occupies less than 1 cu in. of space. It weighs less than 1.8 oz. Standard coils include nominal voltage ratings of 6 to 115 v dc with a power rating of 2.5 w. Dielectric strength is 1,000 v rms at sea level or 750 v rms across open contacts. Insulation resistance is 1000 meg min. The unit stands shock to 50 g and vibration of 28 to 2,000 cps at 20 g or 5 to 28 cps at 0.5-in. double amplitude.

Allied Control Co., Inc., Dept. ED, 2 E. End Ave., New York, N.Y.

Ceramic Capacitors 386

Measure 0.25 in. long

The Ceramin ceramic capacitors measure only 0.25 in. long without leads. Units having a diameter of 0.098 in. are for capacitances of 47 to 560 pf and units with a 0.125-in. diameter, 680 to 1,200 pf. These barium-titanate units are tuned to a tolerance of ±5% up to 125 C or 10% up to ±150 C. They comply with applicable portions of MIL-C-11015A and EIA-SMC-1 specs.

Electramics Corp., Dept. ED, Solana Beach, Calif.

Price & Availability: $10; from stock.

Limit Switch 702

Temperature range is —65 to +250 F

Designed for missile, aircraft, and general mobile applications, this subminiature limit switch operates over the temperature range of —65 to +250 F. The spdt switching unit is housed in a sealed enclosure which has been evacuated and filled with inert gas to insure constant operating characteristics. Electrical rating at 28 v dc is 24-amp in-rush, 4-amp resistive, 1.5-amp inductive, at 100,000 ft, 4-amp motor, and 2.5-amp lamp load.

Micro Switch, Dept. ED, Freeport, Ill.
Price: $32.50.

Servo Motor-Generator 367

For rate servo applications

This size 23 precision servo motor-generator is designed for application as a rate servo and to provide damping in very high gain systems. Motor stall torques are available from 5.5 to 9 in.-oz. No-load speed is 9,000 rpm. Generator characteristics include 2.9 v per 1,000 rpm and a linearity of 0.2% to 3,600 rpm. The unit is available with either a plain or pinion shaft.

Kearfott Div., General Precision Inc., Dept. ED, 1150 McBride Ave., Little Falls, N. J.

Analog Computer 697

Provides real time solutions

Model CM-3 solid-state analog computer provides continuous real time solutions for mathematical computations and real time control of variables in process industries. A single cabinet contains up to 12 amplifiers. Any number of amplifiers, square root and logarithmic networks may be specified according to functional requirements. Two or more of these computers can be used with their programing boards interconnected.

Southwestern Industrial Electronics Co., Inc., Dept. ED, 10201 Westheimer Road, P.O. Box 2187, Houston 27, Tex.

Price & Availability: Made to customer specs, unit can be delivered in three to four months at prices ranging from $5,000 to $20,000 ea.

NEW PRODUCTS

Slicing Machine 394

Reduces scrap loss

The I/D Micro-Slicer for slicing friable materials cuts scrap loss in half and yields more wafers per ingot. Cutting wheels 0.006 to 0.01 in. thick are used. Slicing is automatic. This unit is supplied with the MTA-70 high-production, automatic slicing machine.

The DoAll Co., Dept. ED, 254 N. Laurel Ave., Des Plaines, Ill.

Printed Board Chopper 407

Operating frequencies are 1 to 500 cps

This miniature, printed-circuit board chopper package is suitable for low-level signal applications in military and commercial equipment. Models are available for operating frequencies from 1 to 500 cps. Both MBB and BBM switching configurations are offered. The package can be either directly soldered into a printed circuit board or plugged into standard transistor sockets. The temperature range is —55 to +125 C. Units stand shock to 50 g and vibration of 30 g from 10 to 2,000 cps. Residual noise is less than 15 mv at 400 cps into 1 meg.

James Electronics, Inc., Dept. ED, 4050 N. Rockwell St., Chicago 18, Ill.

Coaxial Connectors 400

For 50-ohm use

These type N, coaxial connectors for 50-ohm use are offered in two types. Type 920 provides a vswr of less than 1.2 to 1 over the frequency range of dc to 5,000 mc. Type 921 has the same vswr range for a frequency range extending to 11,000 mc. Dimensions for both types are 0.824 in. OD and 1-13/32 in. in length.

Saga Laboratories, 3 Huron Drive, Natick, Mass.

Price & Availability: Type 920 is priced at $12.50 ea; type 921, $40 ea. Delivery is from stock.

Microwave Isolators 422

Covers 8,200 to 12,400 mc

Model IXH7 resonance-type isolator covers X-band frequencies of 8,200 to 12,400 mc. It handles a peak power of 25 kw and an average power of 150 w. Minimum isolation is 23 db, insertion loss is 0.8 db max and 0.5 db min, and vswr is 1.17 max and 1.04 min. The unit is equipped with a RG-52/U waveguide and UG-39/U flanges; it weighs 25 lb and measures 3.75 in. long.

Raytheon Co., Special Microwave Device Operations, Dept. ED, 130 Second Ave., Waltham 54, Mass.

Price & Availability:* *$175; 30 days.

Socket Screw 397

Has up to 2-1/3 times more holding power

The Unbrako socket screw combines the strong head and large bearing area of the recent 1960 series with the smoothly radiused root configuration of the Hi-Life thread. The large socket head provides up to 2-1/3 times more holding power without indentation of softer materials; the new thread increases fatigue performance.

Standard Pressed Steel Co., Dept. ED, Jenkintown, Pa.

Crystal Discriminators 418

Bandwidths are 1 to 21 mc

The KCD series crystal discriminators can be made with a range of bandwidths from 1 to 21 mc. A unit having a center frequency of 11.5 mc has a peak-to-peak bandwidth of 75 kc, an input impedance of 10 K, an output impedance of 500 K + 20 pf, and a linearity of ±20 kc. Its size is 1 cu ft. The discriminators are suitable for close-loop feedback networks, fm detection, demodulation, and wherever high-stability, narrow bandwidths are required.

The Keystone Electronics Co., Dept. ED, 65 Seventh Ave., Newark 4, N.J.

◀ CIRCLE 76 ON READER-SERVICE CARD

NEW PRODUCTS

Epoxy Resin Powder 703

For insulating electronic components

Scotchcast XR-5026 one-part, epoxy-resin powder is for use in insulating rotors, resistors, capacitors, and intricately shaped objects. The powder adheres to a hot object, melts, flows slightly, then cures. Electrical strength is 500 to 800 v per mil, dielectric constant is 3.61 at 23 C, and dissipation factor is 0.0053 at 23 C and at 60 cps.

Minnesota Mining and Manufacturing Co., Dept. ED, 900 Bush Ave., St. Paul 6, Minn.

Price & Availability: *An aerator test kit is available from the manufacturer at the price of $25.*

Transistorized Power Supply 370

Regulated to 0.005%

The model LQ35-2A dc power supply has an output voltage of 0 to 35 v at 0 to 2 amp. Regulation is 0.005% or 1 mv, whichever is greater, per 10% of line change at any rated load. Load regulation is less than 5 mv from no-load to full-load. Ripple is less than 50 µsec. Line input is 105 to 125 v ac, single phase, 60 cps. Panel measures 3-1/2 x 19 in.; chassis is 17-7/8 in. deep.

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

Environmental Chamber 571

For temperature-shock, temperature-humidity work

Model WD-585-50-50-50-50 environmental chamber is for temperature-shock and temperature-humidity applications. It has independent refrigeration, heating and humidity systems for the left half and the right half of the chamber; each half is controlled independently. It is possible to have +500 F on one half and —100 F on the other half of the chamber. Gages show the equipment's performance characteristics. The humidity control range is 20% to 98% from 35 F dew point to +185 F dry bulb limits.

Conrad, Inc., Dept. ED, 141 Jefferson St., Holland, Mich.

Availability: *Deliveries can be made promptly.*

CIC

PRECISION FILM POTS

AVAILABLE FROM STOCK!

You can have any of these precision film pots on their way to you within hours. No need to wait for "custom" pots.

LINEAR SINGLE TURN FILM POTENTIOMETERS

Diameter	Resistance	Linearity
1/2"	1K	± .5%
	10K	± .5%
	50K	± .5%
7/8"	1K	± .5%
	10K	± .5%
	50K	± .5%
	1K	± .25%
	10K	± .25%
	50K	± .25%
1-3/32"	1K	± .5%
	10K	± .5%
	50K	± .5%
	1K	± .25%
	10K	± .25%
	50K	± .25%
2"	5K	± .25%
	20K	± .25%
	50K	± .25%
	5K	± .1%
	20K	± .1%
	50K	± .1%
3"	5K	± .1%
	20K	± .1%
	50K	± .1%
	5K	± .05%
	20K	± .05%
	50K	± .05%

SINE-COSINE SINGLE TURN FILM POTENTIOMETERS

Diameter	Resistance	Conformity
1-3/32"	10K	± .75%
	20K	± .75%
2"	10K	± .25%
	20K	± .25%
3"	10K	± .15%
	20K	± .15%

LINEAR MOTION FILM POTENTIOMETERS

Size	Resistance	Stroke	Linearity
1" Sq.	10K	1" Stroke	± .5%
	20K	1" Stroke	± .5%
	10K	2" Stroke	± .25%
	20K	2" Stroke	± .25%
	10K	3" Stroke	± .1%
	20K	3" Stroke	± .1%

Write or call in your order! Potentiometers will be in your plant within 24 hours.

COMPUTER INSTRUMENTS CORPORATION

90 MADISON AVE., HEMPSTEAD, L. I., N. Y.

CIRCLE 78 ON READER-SERVICE CARD

WHY GAMBLE?

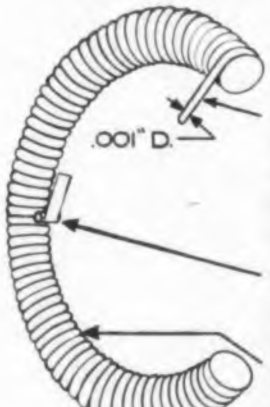
RELIABILITY

is a NATURAL...

WITH CIC PRECISION FILM POTS!

HERE'S WHY!

WIRE-WOUND... THE HARD WAY

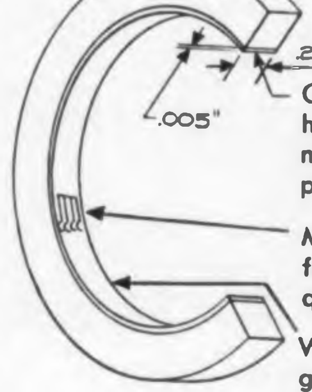


All current carried by a single fragile hair-like wire. Cutting any one turn causes no-warning, catastrophic failure—for 2,000 turns, 2,000 chances for element failure!

Single bar contact wiper — one microscopic dust particle can cause an open — 1:1 odds on failure!

In one traverse wiper must make switch-like contact to each turn for continuity — for 2,000 turns, 2,000 chances for opens!

FILM POT... THE EASY WAY



Current carried by broad band of hard carbon film with an *infinite* number of current paths — *ZERO* probability of element failure!

Multiple fingered wiper — each finger with different natural frequency — odds on opens 1:16!

Wiper rides on continuous film, glass smooth, self-lubricating carbon — *ZERO* probability of opens!

Precision film potentiometers are *inherently* four million times more reliable than wire-wound types! Write for our Tech Note "Reliability Factors in Precision Potentiometers" for the whole story.

FIRST IN FILM POTS

COMPUTER INSTRUMENTS CORPORATION

92 MADISON AVENUE, HEMPSTEAD, L. I., N. Y.

CIRCLE 79 ON READER-SERVICE CARD

NEW LITERATURE

Instrument Catalog 261

This 48-page catalog, No. 604, describes and illustrates the company's complete line of noise and field intensity meters, impulse generators, power density meters, modulation meters, coaxial attenuators and terminations, crystal mixers and microwave components. Line drawings and tabular data are included. Empire Devices Products Corp., Amsterdam, N. Y.

Telemeters 262

This 52-page bulletin, No. M1715, describes the company's Metameter telemeters. Included are principles of operation, application to various measurands, and electrical quantities. Computer control, pump control, remote control, selective calling, and Metaphone are also illustrated. Bristol Co., Waterbury 20, Conn.

Magnetic Shielding 263

Bulletin No. F-1 gives design and performance data of magnetic alloy shields for high gain input transformers and electron beam tubes. Charts show shielding efficiency of single and multiple layer rectangular as well as cylindrical shielding containers of several magnetic alloys. Magnetic Metals Co., Hayes Ave. at 21st St., Camden 1, N. J.

Resistor

A new type of glass-enclosed resistor is described in data sheet No. CE-2.02. Illustrated in the bulletin are the 1/8 watt and the 1/4 watt NF-60 and NF-65. Resistance range is 100 ohms to 360 K; voltage ratings are 250 and 300 v. *Write on company letterhead to Corning Glass Works, Electronic Components, Dept. ED, Bradford, Pa.*

Transformer Kit 264

This catalog page gives complete technical specifications of model C-2650 microminiature transformer kit. The kit is complete with 10 precision transformers, case, technical manual and test data. James Electronics Inc., 4050 N. Rockwell St., Chicago 18, Ill.

Power Supplies 265

Information and specifications on dc-dc converters, dc-ac inverters and ac-dc power supplies for laboratory, airborne, mobile, communications and automation applications are given in this four-page brochure. Output and dimensions are covered. Electrodynamic Instrument Corp., 1841 Old Spanish Trail, Houston 25, Tex.

Trimming Potentiometers 266

Two 1/2-in., square, high-performance trimming potentiometers are featured in this four-page bulletin. Photographs, outline drawings, power input charts, electrical and mechanical specifications, standard coil data, and a list of available modifications tell the complete product story. Helipot Division of Beckman Instruments, Inc., 2500 Fullerton Road, Fullerton, Calif.

Rotary Switch 267

Manufactured to BUShips and MIL specifications, this rotary multipole switch is the subject of two-page bulletin No. 19. Included are dimensional drawings, special-assemblage drawings, technical data, and a photograph of the switch. Electro Switch Corp., King Ave., Weymouth (Boston 88), Mass.

Frequency Discriminator 268

Details of a 115-v, 400-cycle, 0 to 5 v dc frequency discriminator appear in this data sheet. Specifications, outline drawings, a schematic diagram, signal frequency graph, and a description of operation and applications are included. Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif.

Infrared Source 269

This data sheet describes a miniature infrared source for calibrating the seeking head of infrared guided missiles and other sensitive elements in the 200 to 600 C temperature range. Construction, operation and specifications of the infrared source and temperature controller are included. Perkin-Elmer Corp., Norwalk, Conn.

Application Notes 270

This four-page index of some 40 "Application Notes" issued by the firm over the past months contains abstracts of a variety of subjects for users of electronic measuring instruments. The "Application Notes" themselves describe electronic theory, measurements, and applications of the firm's instruments. Typical topics covered are traveling wave amplifiers, solid-state devices, masers, various frequency, microwave and current measurements, and applications for oscilloscopes and oscillators. Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif.

Complex Ratio Bridge 271

Technical specifications, a detailed circuitry description and a simplified block diagram of a complex ratio bridge appear in this four-page, illustrated brochure. Also shown are schematics of typical applications involving transformers, resolvers, transducers, and synchros. Gertsch Products, Inc., 3211 S. La Cienega Blvd., Los Angeles 16, Calif.

Trimmer Potentiometers 272

Technical descriptions, outline drawings, performance data, a power rating curve, price and availability data are included in this two-page, color bulletin on trimmer potentiometers. Fairchild Controls Corp., Components Div., 225 Park Ave., Hicksville, L.I., N.Y.

Chart Drives 273

This catalog describes chart drives that offer quick, easy chart speed changing, savings in chart paper costs, and an ability to match chart speed to test requirements. Included are instructions for ordering proper models and photographs of unit installed. Barry Controls Inc., Insco Co. Div., Hollis St., Groton, Mass.

AC Motors 274

This six-page, two-color catalog presents information on horsepower, torque, speed, duty cycle, weight and size of the firm's ac motors. These motors, designed for electro-mechanical linear and rotary actuators, servos, pumps and valves, have qualified for Mil specifications. Lear Inc., P.O. Box 688, Grand Rapids 2, Mich.

Solid-State Circuits 275

The firm's capabilities in solid-state circuits is illustrated in this four-page, two-color brochure. In addition to specifications and characteristics of major circuits, the brochure outlines the design and development capabilities of the company. Pennon Electronics, Inc., 7500 S. Garfield, Bell Gardens, Calif.

Precision Bearings 276

"How to Reduce Cost and Eliminate Overdesign in the Selection of Precision Miniature Bearings" is a four-page, illustrated catalog that describes how sintered bronze bearings have been designed to replace miniature precision ball bearings in a variety of applications. Included in catalog No. 60-04 are MIL specs, design features, available styles and sizes, specifications, applications, and installation procedures. Northfield Precision Instrument Corp., 4400 Austin Blvd., Island Park, L.I., N.Y.

Trimmer Capacitors 277

Seven models of direct-traverse, trimmer capacitors with pan terminals and five models with wire terminals are described in reference sheet CE-4.01. In addition to a picture and diagrams of the trimmers, the sheet covers dimensions, capacitance range, core and shaft plating, material, and finish of the models. Corning Glass Works, Electronic Components Dept., Bradford, Pa.

Instrument Cases 278

Brochure No. 403-G gives details of a comprehensive line of instrument cases, covering features, sizes and colors. This 12-page, color, booklet describes the standard hardware that may be obtained when ordering the predesigned cases. TA Manufacturing Corp., 4607 Alger St., Los Angeles 39, Calif.

Pulse Switch 279

An adjustable industrial pulse switch is described in this two-page data sheet, No. 173. In contains photographs, dimensional drawings, characteristics and pricing information. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill.

NEW LITERATURE

Power Transistors 280

Specifications, illustrations and technical data for silicon, intermediate-power transistors, types 2N1047, 2N1048, 2N1049 and 2N1050, are included in this one-page data sheet. Silicon Transistor Corp., Carle Place, L.I., N.Y.

Mil-Spec Knobs 281

Illustrations and dimensional drawings of Mil-Spec knobs are included in this two-page bulletin, No. 59-3A. These knobs are available in five sizes, six styles, three shaft diameters and three finishes. National Radio Co., Inc., 37 Washington St., Melrose 76, Mass.

Oscilloscope 282

A transistorized, battery-operated, portable oscilloscope is featured in this four-page pamphlet. Specifications, photos, block diagram, and performance details of the 3-in. instrument are provided. Tektronix, Inc., P.O. Box 500, Beaverton, Ore.

Mobile Tracking Antenna 283

Specifications, antenna pattern data, and detailed information and illustrations are reported in this two-page, two-color bulletin. The antenna features a folding 28-ft reflector, tilting mast, and hand operated azimuth. D. S. Kennedy & Co., Cohasset, Mass.

Power Supply Transformers 284

Wiring diagrams and schematics of transformers for transistor power supplies are contained in this brochure, No. TY-61. Electrical and mechanical specifications on all units of the firm's line are included. Triad Transformer Corp., 4055 Redwood Ave., Venice, Calif.

Screws and Bolts 285

The advantages of Holtite Nylok screws are explained in this eight-page booklet. Included is a graph of manufacturing standards. Continental Screw Co., New Bedford, Mass.

Digital Voltmeter 286

Performance characteristics of a digital voltmeter designed for military applications are covered in eight-page bulletin 19-77. History, design and construction, and environmental design goals for the voltmeter are included. Kin Tel, Div. of Cohu Electronics, 5725 Kearny Villa Road, San Diego 12, Calif.

Teflon Terminals 287

This 18-page catalog, No. T110, provides engineering and technical data such as voltage and capacitance micromicrofarad ratings on the firm's subminiature Teflon terminals. Tri-Point Plastics Inc., 175 I.U. Willets Road, Albertson, L.I., N.Y.

Electronic Catalog

This 228-page, full file-size catalog lists specifications for hundreds of products and systems including photomultiplier tubes, klystrons and cavities, secondary emitters, travelling wave tubes, oscilloscopes, analog computers, tape decks, stroboscopes, transducers, balancing machines, closed-loop TV systems, power supplies, signal generators, attenuators, and others. *Write on company letterhead to Hoffman Electron Tube Corp., 804 Newbridge Ave., Westbury, L.I., N.Y.*

Silicon Diode 288

Type FD200, diffused silicon diode having ultra-fast recovery and ultra-high conductance, is described in data sheet No. SL-110/1. This two-page bulletin is illustrated with performance graphs and a test circuit diagram. Fairchild Semiconductor Corp., 4300 Redwood Highway, San Rafael, Calif.

Silicon Rectifier Handbook 289

Illustrations, specifications and dimensional drawings on the firm's entire line of silicon, power rectifiers are included in this 42-page handbook. Extensive technical data on the selection and application of the products is outlined. The company's national network of representatives and a customer price list are covered. Standard Rectifier Corp., 620 E. Dyer Road, Santa Ana, Calif.

LETTERS

ASW: How To Meet The Challenge

Although our consulting group has been in the ASW field for nearly a decade, your article covered several developments we had not seen mentioned before. Your work in delineating the ASW field in such a thorough manner is appreciated.

In my opinion, careful consideration must be given to the division of responsibility in the Department of the Navy. For example, BuShips is responsible for sonar, and BuWeapons for fire control. Without perfect coordination and the freest flow of information, we will not get the perfect ASW system in the shortest possible time, at the lowest possible cost, when sonar is the detection means in an ASW fire control system. Perhaps joint responsibility is the answer, as demonstrated by BuShips and the AEC in the atomic submarine program.

Since we are committed for many years to come to supplying our bases overseas by water, we are forced to strengthen our ASW posture. It is discouraging and alarming to have to vote to be on the submarine in an ASW battle.

N. A. Denman
Manager, Basic & Experimental Physics
Engineering Services
Falmouth, Mass.

▶ *The last line of the letter refers to a question the authors of the ASW article asked frequently: "In a battle between a submarine and an anti-submarine task force, would you rather be in the task force or in the submarine?" Unanimously, the answer was, "The sub."*

From the Navy

You will appreciate the fact that I cannot comment on our technical advantages and disadvantages in the anti-submarine warfare field without immediately prejudicing classified information. In this technical connection I find the largest void in the article is its failure to mention the participation of the National Security Industrial Association in the ASW technical field.

The Anti-Submarine Advisory Committee of the NSIA is composed of representatives of about 100 industrial concerns who study all phases of ASW technical problems. The chairman of the committee made the annual report to the Secretary of the Navy at a recent meeting of the Secretary's ASW Committee. The report should be most beneficial in dissemination to industry of classified information concerning ASW technical problems.

The efforts of ELECTRONIC DESIGN and the resulting space devoted to the Anti-Submarine Warfare problem is appreciated. The broader awareness of ASW provided by the article is of course beneficial.

Adm. James S. Russell
Vice Chief of Naval Operations
Washington, D. C.

Kudos

My congratulations on the anti-submarine warfare article. It was a job well done and deserves commendation. We found much useful information in it.

George Kaufer
Assistant to Vice President—Engineering
Polarad Electronics Corp.
New York City

We have passed your article on ASW around the shop. The general consensus here is that you have produced a first-rate wrap-up story on what is probably the Navy's greatest operational problem. Keep it up.

T. Leonard Mikules
United States Naval Institute
Annapolis, Md.

Having struggled ourselves with the problem of discussing this particularly sensitive subject without violating security regulations, we can fully appreciate your accomplishment in putting together such a useful story.

George G. Barker
Technical Publicity Manager
Raytheon Co.
Walthan, Mass.

Congratulations on your fine article. Your handling of a very complicated subject through the novel approach of presenting it in the form of a proposal is to be commended. The sections outlining the needs for electronic design engineers' ideas, I thought, were particularly good.

I. R. Howland
Manager, Advanced Radar & Countermeasures Engineering
General Electric Co.
Ithaca, N.Y.

The urgent problems facing this country in the anti-submarine defense areas cannot be overemphasized. It was with great interest, therefore, that I read your recent ASW report. Its coverage and scope were indeed broad and its content informative.

Edward J. Garrett
Loral Electronics Corp.
New York City

(continued on p 96)

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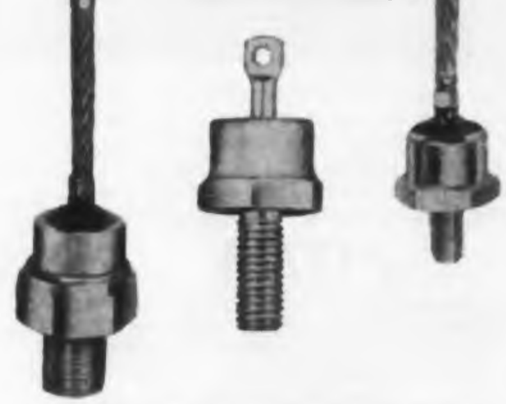

CIRCLE 95 ON READER-SERVICE CARD

LETTERS

(Continued from p 93)

From the Senate

My reaction to the article on anti-submarine warfare is that it is informative and timely. On the Senate floor, during the debate on the Defense Appropriations bill, I again urged greater emphasis on anti-submarine warfare capability. The following is quoted from my Senate statement:

"Anti-submarine warfare capability should be increased on a high-priority basis.

"I recommend an increase of $465 million over and above the budget request for building up our capability in this field, and introduce an amendment for that purpose.

"This money would provide additional attack submarines, specialized aircraft, sonobuoys, torpedoes, mines, depth charges, and a wide range of electronic equipment."

Stuart Symington
United States Senator

Sonar Is the Key

Those of us involved in helping to solve the ASW problem feel that one reason the problem exists is that very little money and effort have been put into its solution. "Very little" is used in a relative sense as compared to the kind of money that has developed radar to its present state and has given the warning networks which exist today.

We also feel that the solution rests in sonar and not in the many so-called "unsound" methods which are being pursued. There has been a lot of wishful thinking that someone will come up with a magic device which will make the oceans of the world transparent. Our feeling is that the best results will be obtained by developing the only known method of finding a submerged submarine—sonar.

A. M. Brown
Vice President, Edo Corp.
New York City

Naming the ASW Officer

The Anti-Submarine Warfare problem deserves the attention you focused on it. The urgency of the situation may be even more clearly underlined by what we do *not* know of the Russian submarine development program.

Well-written and informative from beginning to end, your entire "ASW—Designers' Challenge" was adequately spiced and, at the same time, driven home by the item titled, "We Need More and Better Information."

It would be interesting to know the identity of the "ASW officer" who speaks with authority on a topic too frequently obscure to the design engineer. Are his views based on post-World War II experience in the ASW field?

Arthur S. Kramer
Staff Engineer
Grumman Aircraft Corp.
Bethpage, N. Y.

▶ *The officer referred to in "An ASW Officer Speaks" is Robert Shaw, currently with DuMont, a division of Fairchild Camera and Instrument Corp. Mr. Shaw spent 11 years with the fleet in ASW operations. This included time spent in actual ASW problems during the World War II, simulated submarine attacks with the latest post-war equipment available, and a tour of duty as Sonar Project Officer at the Surface Anti-Submarine Detachment in Key West evaluating new electronic ASW equipment.*

Inhale! Exhale!

In the otherwise fine article on speech making ("So You've Got to Make a Speech," ED, June 8, p 166) there are two points I would like to comment on.

Although it was widely reported in the press at the time that the American hockey team was helped by inhaling oxygen at Squaw Valley, it is doubtful if it really accounted for their victory. In the first place, the body does not store oxygen for any appreciable length of time, especially during violent activity. The most convincing argument against the efficacy of oxygen inhalation is that another team (Canada's, I believe) inhaled from what they believed were tanks of oxygen prior to a game which they subsequently won. Later it was revealed that the valves to the oxygen tanks had never been opened and the team members had actually inhaled air. A compliment to the clean air of the Sierra Nevada perhaps, but not to O_2.

The second comment is more of an opinion. Breathing deeply 10 or 15 times before delivering a speech is more likely to induce dizziness than clarity, at least in my experience.

Following the Olympics of 1932, held in Los Angeles, the victory of the Japanese swimmers was attributed to their use of oxygen before each event. As in the case of the American hockey team, I believe that the effects were more psychological than physiological, the Japanese being motivated—as was, probably, our hockey team—by nationalistic fervor and the good athlete's desire to win.

Richard G. Gould
Menlo Park, Calif.

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 conesecutive 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

Vibration Testing Course

The fourth in a recurring series of courses on vibration testing is being offered space age engineers from Sept. 12 to Sept. 23 by Ling Electronics, a division of Ling-Altec Electronics, Inc., at the company's Anaheim, Calif., plant.

According to Cameron G. Pierce, president of Ling Electronics, the course covers sine, complex and random wave vibration in theory and practice.

Moderator of the session will be John C. Jordan, research engineer for Ling and a graduate of the Georgia Institute of Technology.

Technical information presented in the course will include the most recent and pertinent data derived from the developments and papers of Pierce, Charles Theodore, vice president, marketing, James A. Ross, vice president research and development, and many other experts.

For further information write "Study in Vibrations Registrar," Ling Electronics Division, Ling-Altec Electronics, Inc., 1515 S. Manchester Ave., Anaheim, Calif.

Stevens Industries Training School

Industrial employees who wish to add to their knowledge of electrical technology, machine and tool designing, production supervision may do so at the Stevens Industries Training School during the fall semester which starts on Wednesday, Sept. 20.

Highlighting the course sequences offered during the fall and spring semesters are: Manufacturing Processes—Manufacturing Planning; Plastic Product Design—Plastic Mold Design; Instruction Techniques—Effective Speaking; Properties of Metals—Welding Processes; Human Relations I—Human Relations II; and Industrial Organization—Industrial Economics.

Courses are taught in the evening by members of the Stevens Institute of Technology faculty and by experts from nearby industries. Further

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information may be obtained by contacting the Industries Training School office at Castle Point Station, Hoboken, N.J.

Seminar on Creative Action

Methods of achieving "scientific creativity" in large-scale organizations will come under intensive study at a seminar for administrators of scientific and engineering functions to be held at Syracuse University's Minnowbrook Conference Center Sept. 11-17.

The Seminar on Creative Action in Large-Scale Organizations will bring together managers of research institutes, training programs, engineering services, product development, development laboratories and engineering laboratories to explore some of the problems of human relations within large organizations.

Faculty for the seminar will include: William W. Bender, Director, Research Institute for Advanced Science (RIAS); Dr. Donald W. Taylor, Professor of Psychology and Personnel Administration, School of Engineering, Yale University; Dr. Joseph Tussman, Professor of Philosophy, Syracuse University.

Resident faculty for the seminar will be: Dr. Paul Meadow, Professor of Sociology and Chairman of the Department of Sociology and Anthropology, Syracuse University and Warner Bloomberg, Jr., Assistant Professor of Sociology, Syracuse University. The program is being offered under the direction of University College, the adult education division of Syracuse University.

One-Day Seminars

The Industrial Education Institute, Aug. 30-Sept. 29

The Industrial Education Institute of Boston, Mass., is presenting a one-day seminar on Measuring and Improving the Effectiveness of the Maintenance Department. The seminar schedule is as follows: Montreal (Hotel Sheraton-Mt. Royal)—Aug. 30; Toronto (Hotel Westbury)—Sept. 19; Detroit (Hotel Sheraton-Cadillac)—Sept. 20; Cleveland (Hotel Pick-Carter)—Sept. 22; Chicago (Hotel Sheraton-Gibson)—Sept. 27; St. Louis (Hotel Sheraton-Jefferson)—Sept. 29.

The seminar will be conducted by George J. Martin, president. The registration fee, which includes attendance, luncheon, coffee break, necessary supplies and a complete package of reference material, is $50 per man. A 10-per-cent Team Discount is extended to companies having three or more men attend. For further information write Industrial Education Institute, 221 Columbus Ave., Boston 16, Mass.

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Evaluation

BSEE. Prefer 1-8 years in test, design, or related areas. Work involves testing specific unit systems, parts, or materials. May involve designing and building non-standard testing equipment; field or simulated field testing; tests on production instruments.

All above openings are in Minneapolis area. For complete information, write Allan J. McInnis, Professional Manpower Staff, Ordnance Division, Honeywell, 600 Second St. North, Hopkins, Minn.

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