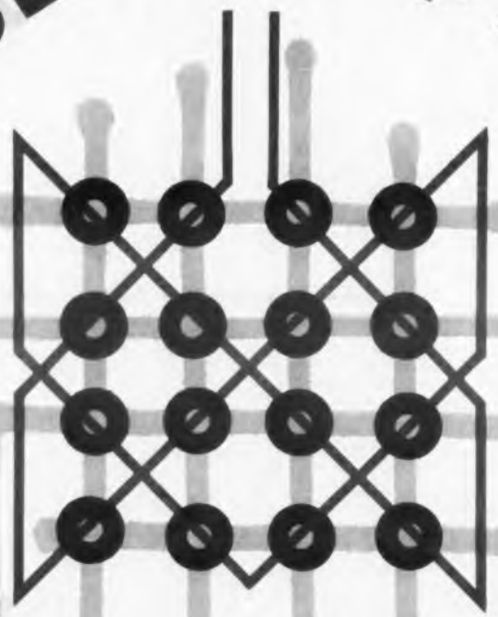
ELECTRONIC DESIGN

DIGITAL DESIGN • p 28 •



DIGITAL DESIGN FEATURE REPORT

MICROWAVES...p 101

ELECTRONIC DESIGN

DIGITAL DESIGN FEATURE REPORT

COVER: Artistic abstractions of essential elements in the design of digital data-processing equipment appear on the cover. Just as there are levels of design in designing equipment, so has our artist incorporated levels of artistic abstraction. Most obvious, of course, is the core array which symbolizes matrix memories. Less obvious is the rotating circle of type that represents cyclic memories. Most subtle is the representation of precise timing by the equi-spaced letters in alternating (binary) colors.

Sidelights of this Issue

There have been times when we have privately debunked and openly questioned the significance of those news releases talking about faster and faster computer speeds. We argued, fortified with the opinion of dependable computer experts, that machine speed was not as important now as better programing techniques.

While some of our staff may still be cynical of the emphasis in the direction of higher speeds, Editor George Rostky who pulled together the Special Report on Data-processing design today, is firmly convinced higher speeds are needed. See his introduction "The Race To Catch Up", p 28.

It is quite apparent from George's investigation that even the speed of light as a barrier is not daunting designers from developing computers with faster modes of operation.

To keep our readers up to date on the fast moving field of computers read the invited papers discussing three vital problems: logic and timing, matrix memories, and cyclic memories. Don't pass them up. The first starts on p 30.

ELECTRONIC DESIGN · ONE DAY SERVICE

USE BEFORE OCTOBER 11th, 1961

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Sidelights of this Issue

(continued)

Another WESCON Bites Dust, Upsets ED

For ELECTRONIC DESIGN's seven-editor task force filling notebooks at WESCON last week, the end of the giant convention marked the start of a race. In order to publish a report both comprehensive and thoughtful in this issue, we had to use extraordinary scheduling, logistics and production procedures. We are literally holding the presses to give technical editor Manfred Meisels maximum time to coordinate, edit and write a report that does justice to the ever-growing WESCON convention.

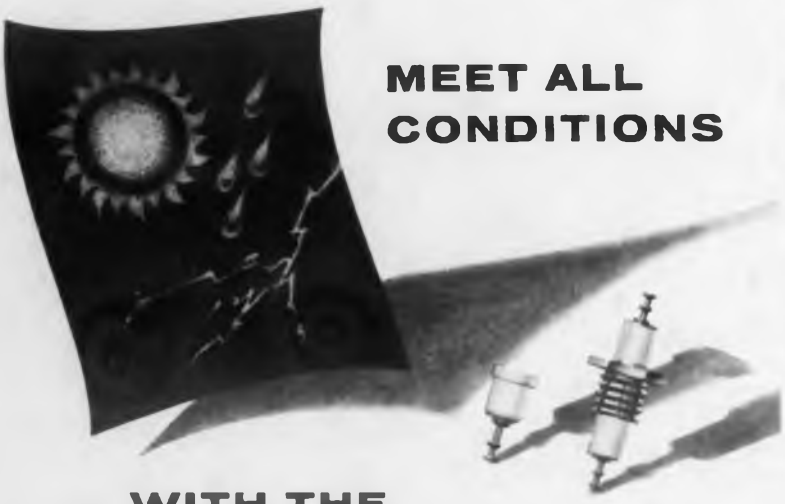
We try to avoid racing the news deadlines to concentrate on interpretation. However, where the situation warrants special measures we take them—jumping in with both feet. We're doing this now, still groggy from WESCON 1961.

Bionics Also Threatens ED Deadlines

If all goes well, our next issue should be bursting at the seams with the news of the latest developments in bionics—the science of applying knowledge of biology to solution of electronic problems. About a year ago ELECTRONIC DESIGN published the pioneer report in this specialty as bionics made its first public appearance. The report appeared in conjunction with the first Bionics Symposium, sponsored by the Air Force and held in Dayton, Ohio.

Now, a year later the Second Bionics Symposium, being held this week at Cornell, is the occasion of another bionics report. This survey due next issue, will, like the first, reach beyond the conference to include developments not discussed publicly.

By fencing with our deadlines we hope to be able to include news of the symposium in the same issue with the report, which was prepared in advance. We are taking the trouble, as with our WESCON roundup, because we believe the subject is important. There is every evidence that bionics research is growing and that the concept is gaining acceptance in designing circles as an important source of ideas. We intend to continue following the new discipline closely.



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CIRCLE 3 ON READER-SERVICE CARD

CONTENTS

August 30, 1961
Vol. 9 Number 18

Electronic Design

Hayden Publishing Company, Inc.
850 Third Ave., New York 22, N.Y.

Coming Sept. 27

Cynics shrug off the topic of reliability with the cryptic comment—"too much talk, too little action." Not true. Much has been accomplished and more gains are taking place each week in components and systems.

ELECTRONIC DESIGN's Sept. 27 issue, "Meeting the Reliability Challenge," will include a summary of the status of the Darnell Report, the basic concepts of reliability testing and its applications to the TACAN program and a list of military specifications relating to reliability. Also included will be practical articles discussing the organization and responsibilities of a reliability group and the technique of variation research, a tool to force defects to reveal their causes.


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ELECTRONIC DESIGN
NEWS

Semiconductors in Spotlight at Wescon

Advanced Transistor Concepts Reaching Hardware Stage; Eight Companies Must Give Pricing Data to Justice Dept.

GOOD news and bad in semiconductors dominated the exhibits, papers and coffee-break conversations at WESCON 1961.

The good news was that a host of useful new semiconductor manufacturing and packaging concepts are at last reaching the hardware stage. The bad news (see box) was the Justice Departments' subpoena of pricing records from eight major semiconductor firms.

Epitaxial techniques characterized the major semiconductor announcements at the show. A silicon epitaxial "Star Planar" transistor with surface passivation was previewed by Motorola. The new transistors are said to switch three times faster than 2N696 types. Order of magnitude improvements in saturation resistance high frequency current gain are also claimed.

Epitaxial silicon mesa transistors were also shown by Philco. Their unit combines a 150-mc gain-bandwidth product with 120-v collector breakdown voltage.

Epitaxial mesas in germanium and silicon for nanosecond switching were shown by Sylvania. The company announced a cut-price evaluation kit called Tri-Pak, containing six epitaxial mesa pnp units.

The germanium ECDC (Electro-Chemical Diffused-Collector) transistor, announced earlier this year, is now available in production quantities in three models, according to Sprague Electric. Designed for high-current core driving, the transistors are said to feature excellent beta linearity, high frequency response and low saturation resistance.

Other entries in the planar epitaxial line-up include General Instrument, RCA and Texas Instruments.

Semiconductor papers featured description of a new field-effect tetrode by C. T. Sah, of Fairchild Semiconductor Corp. The device has essentially infinite input resistance and very small input capacitance. The field-effect electrode is formed by a metal ring on the emitter-base junction of the transistor. Beta can be varied over five orders of magnitude at low currents.

Deny Semiconductor Price-Fixing

Angry words flew at WESCON as semiconductor manufacturers subpoenaed for pricing information by the Justice Department fought back against generally-circulated allegations that the Government's action was a prelude to indictments for price-fixing in the diode market.

The seven companies subpoenaed for records dating back to 1957 unanimously denied any involvement in price-fixing. They are: Pacific Semiconductors Inc.; Hughes Semiconductor Div.; Transitron Electronics Corp.; Raytheon Co.; Clevite Corp.; Sylvania Electric Products Inc.; and General Instrument Corp.

"There is no price-fixing in the semiconductor industry," declared a spokesman for Pacific Semiconductors Inc.

"Kennedy's in for a big surprise when he digs into this," said another semiconductor manufacturer.

"Washington doesn't know the difference between a price war and price-fixing," a third spokesman commented.

"With the bottom falling out of the semiconductor market, yesterday's prices may seem high by retrospect, but that doesn't mean that yesterday's prices were due to collusion," was another reaction from the semiconductor industry.

The many transistor manufacturers, large and small, not subpoenaed all rallied to the defense of those involved. Many believed that the Justice Department was "feeling its oats" after successful prosecution of price-fixing in other industries, but felt that the investigators should be sentenced to a short stretch in the semiconductor industry before exercising their legal muscles there.

Parametric Frequency Multiplier Generates 2w at 2Gc

A parametric frequency multiplier generating 2.5 w at 2 Gc was shown by Pacific Semiconductor scientists George Luettgenau, J. Williams and H. Miyahira. The device is being used in a missile telemetry transmitter.

The RCA universal transistor, actually a triple-difussed silicon npn planar transistor, drew considerable attention at WESCON. RCA indicated that the device could perform the functions of up to 40 percent of similar types now available, but show attendees were somewhat cautious about the units tentative 12 dollar price.

WESCON exhibits included an extensive array of new systems and components.

An automatic solar tracking system, entirely sun-powered was shown by Hoffman Electronics. Conventional solar cells are used, but the accurate tracking possible increases output five-fold over conventional units.

High Resolution Recorder Employs 2-Track System

A new system of high resolution data recording was unveiled by the Mincom division of Minnesota Mining and Manufacturing Co. Known as Tracklok, it employs a second data track to minimize the occurrence of drop-outs in the recording. The new unit was displayed with a wide-deviation fm recording that developed a bandwidth of 1.5 mc.

Hughes Aircraft showed its FACT (Flexible Automatic Circuit Tester) programmed checkout device. The unit is card fed and can be expanded to test an unlimited number of terminations for continuity, resistance, short circuit, and other static tests. Automatic programing at 100 tests per minute is reported for the system. Results are printed out on a tape or other convenient form.

New microwave test equipment was extensively displayed. Hewlett-Packard unveiled a group of 20 new test instruments,

Automatic solar tracking system is entirely sun-powered. Robert Paradise, consultant for Hoffman Electronics, adjust unit at the company's WESCON display. The unit achieve five-fold increase in efficiency over non-tracking solar converters.

many of them all-solid state. The company also showed a new cathode ray tube whose scales are engraved on the phosphor, thereby eliminating parallax error. The new tube will be available in many of the company's line of oscilloscopes.

Business as Usual Remains Wescon Theme

WESCON managements pre-announced policy of soft-pedaling the hardware hard-sell was obviously honored in the breach in the course of the four-day bazaar. It was hoped that exhibitors would attempt to educate visitors by manning booths with design and application engineers in addition to salesmen. While such personnel were present, no one missed an opportunity to make a sale at the 1,180 busy exhibits.

Educational activities were primarily reserved for the convention papers and several timely seminars. These seminars included one on optical masers and one on arms control.

The latter session, chaired by L. C. Van Atta, of Hughes Research Laboratories, discussed the technical, military, and political aspects of arms control. Emphasis was on the influence of research and development in providing a solution to the problems of inspection and monitoring in a disarmament system.

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440 W. Market St.
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INDIANAPOLIS, IND.
Law Instrument Co.
P. O. Box 27062
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KANSAS CITY 8, MO.
Design & Sales Eng. Co
2600 Grand Ave
GR 1-1640

LAWRENCE, MASS.
Richard D. Frink Assoc
46 Amesbury St.
MU 3-3252

LOS ANGELES, CALIF.
Instruments for Measurements
3455 Cahuenga Blvd.,
Suite F
Hollywood, Calif.
HO 9-7294

MINNEAPOLIS, MINN.
Northport Eng., Inc.
1729 Selby Ave.
St. Paul 4, Minn.
MI 6-2621

NEW YORK CITY AND NORTHERN NEW JERSEY
Gawler-Knoop Co.
178 Eagle Rock Ave.
Roseland, N. J.
N. Y. Tele. DI 4-2997
Roseland Tele. CA 6-4545

ORLANDO, FLA.
E. G. Holmes & Assoc.
1220 Edgewater Dr.
CH 1-2128

PHILADELPHIA, PA.
Gawler-Knoop Co.
835 Glenside Ave.
Wyncote, Pa.
Phila. Tele. WA 7-1820
Wyncote Tele. TU 4-8805

PHOENIX, ARIZ.
Brooks-Feeger Assoc.
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Scottsdale, Ariz.
WH 6-2111

SALT LAKE CITY, UTAH
Brooks-Feeger Assoc.
253 Rio Grande,
Rm. No. 5
EL 9-2427

SAN DIEGO 4, CALIF.
Instruments for Measurements
2420 University Ave.
JU 3-1972

SAN FRANCISCO, CALIF.
Cerruti & Assoc.
P. O. Box 509
116 Cypress St.
Redwood City, Calif.
EM 9-3354

SEATTLE, WASH.
Testco
Boeing Field – Rm. 108
PA 3-9000

ST. LOUIS 5, MO.
Design & Sales Eng. Co.
7603 Forsyth Blvd.,
Rm. 304-06
PA 1-6403

SYRACUSE, N. Y.
D-B Assoc.
P. O. Box 284
DeWitt (Syracuse), N. Y.
GI 6-0220

WASHINGTON, D. C. & MARYLAND
Gawler-Knoop Co.
8732 Flower Ave.
Silver Spring, Md.
JU 5-7550

WICHITA, KAN.
Design & Sales Eng. Co.
400 N. Emporia
Wichita, Kan.

CANADA
Electromechanical Products
Markham Rd.
Agincourt, Ont., Canada
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AUSTRALIA
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BELGIUM
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48 W. 48th St.
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CO 5-8323

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NEWS

Fairchild Controls Corp. introduced a differential pressure transducer, the model 3S-G for pressure ranges of 0 to 10 psid to 0 to 10,000 psid or plus or minus 10 to 10,000 psid. Standard outputs are 50 mv, 250 mv, and 5 v dc.

The Fairchild instruments are said to be operable over a temperature range from −65 to +250 F, in both corrosive and noncorrosive environments.

Strain gages offered by Integron, Inc., Waltham, Mass., a subsidiary of Tang Industries, Inc., offer gage factors of 130 plus

Parametric frequency generator delivers 2.5 w at 2 Gc. Unit is shown with one of its developers, H. Miyahira of Space Technology Laboratories. The device is used in missile telemetry transmitter.

or minus 10 per cent with resistances of 350 meg, also plus or minus 10 per cent. Temperature range for the Integron elements is said to be −320 to +650 F. The silicon elements have 3-mil gold leads attached.

A storage-tube oscilloscope introduced by Analab Instrument Corp., Cedar Grove, N. J., allows the operator to observe a number of displays at the same time. A preview area on the screen allows the operator to set up a display before putting it on the storage area. A raster display with either 1, 5 or 10 lines can be used on either single or dual-trace modes. The instrument can be set for automatic continuous tracing and erasing, so that data can be monitored over long periods.

The Analab preview-and-storage instrument displays signals up to 100 kc or single

Tracklok recording system developed by Mincom has improved resolution. Dual-channel recording minimizes drop-outs, say engineers Finn Jorgensen (left) and Richard Roelofs at the company's WESCON exhibit.

transients up to 10 kc on an 8-x-10-cm rectangular target area.

A line of miniaturized oscilloscopes using transistors and Nuvistor tubes was introduced by Allen B. Du Mont Laboratories, Clifton, N. J., div. of Fairchild Camera and Instrument Corp. The first two products in Du Mont's "700" line will be available later this year, according to the company.

Type 766 will use several plug-ins, including the 76-01 single-channel unit, with nominal 15-mc bandwidth and 5 mv/cm sensitivity. A 76-02 dual-trace plug-in provides two traces of similar bandwidth and sensitivity.

The Type 746 oscilloscope will provide nominal bandwidth of 5 mc.

Glass Delay Lines for Digital Memories Have Low Temperature Coefficients

Glass ultrasonic delay lines, with extremely low temperature coefficients of delay, were introduced at WESCON by Corning Glass Works, Corning, N. Y. The first product available in a planned line of these devices is a memory element designed to operate in the return-to-zero mode at data rates between 10 and 20 megabits per sec with a delay time of 50 μsec. The delay medium is "zero TC" glass (temperature coefficient of time delay of about 1 ppm/deg C) that accepts a bit length of 20 nsec.

Fused silica, which has an attenuation coefficient about a fortieth that of zero TC glass, can also be used for digital delay lines, Corning says. Temperature coefficient of delay for this material, however, is −80 ppm/deg C.

The new line was said to have followed development of a digital ultrasonic delay line to serve as a 100-μsec memory in a 10-to-20-megabit digital computer subsystem. ■ ■

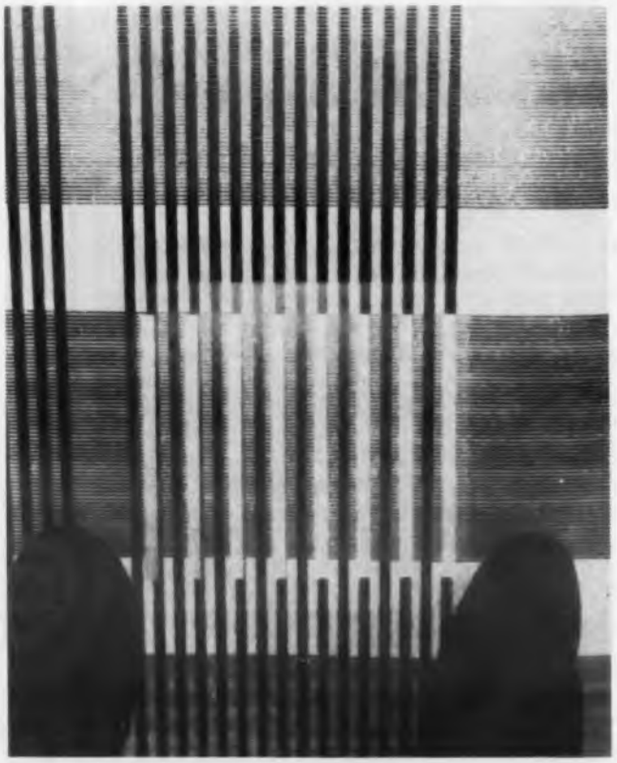
Thin-Film Memory Used In Ultra-High-Speed Computer

A thin-film-memory digital computer said to be the fastest ever built is now in operation at the Lincoln Laboratory of MIT, Lexington, Mass. Known as the FX-1, the computer has a memory read-write time of 0.3 μsec and a clock rate of 50 megapulses per sec.

Except for its thin-film memory, the FX-1 embodies conventional circuitry, components and fabrication methods.

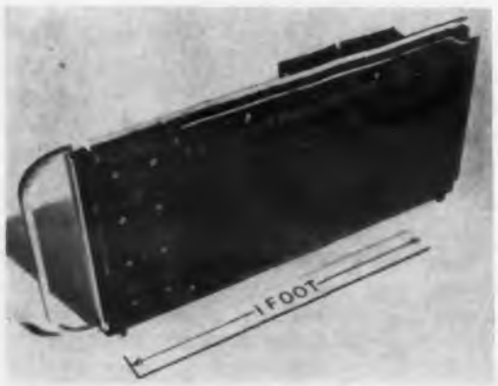
The FX-1 is the latest in a series of experimental computers developed by the Lincoln Laboratory's digital computers group that incudes the Whirlwind I, MTC, TX-0 and TX-2 machines.

Plug-in unit for FX-1. Computer uses 325 such units of 12 standardized basic types. Approximately 3,000 special high-speed transistors are included in the computer. These are Philco L-5447 germanium MADT's similar to the company's 2N769 transistor.



Computer memory (top) consists of glass plates carrying small, rectangular magnetic-film elements and sandwiched between flexible printed-circuit sheets. Film thickness is 1,200 A, giving strong signal from small spots. Complete 256 13-bit word memory, mounted on stiffening boards, is shown in lower photo. Provision is made for eventual four-fold increase in memory capacity.

FX-1 computer, said to be 10 times faster than any general-purpose digital computer now in use is adjusted by John Laynor, staff member of Lincoln Laboratory's digital computer group. The computer was built to test feasibility of high-speed operation with conventional components and fabrication techniques.



Plated circuit tray for FX-1 computer employs two layers of etched wiring and central copper ground plane. This wiring acts like a strip transmission line with uniform impedance characteristics for improved high-frequency performance. The computer contains 24 trays of 13 different types, most employing conventional point-to-point soldered wiring.

NEWS

SIGNIFICANT BITS

Important news items for electronic designers written for fast scanning.

The memory in TRANSIT IV-A, latest experimental navigation satellite to be placed in orbit, uses an acoustic wire delay line and is receiving and relaying signals with highly satisfactory results, according to Johns Hopkins University's Applied Physics Laboratory. The memory is releasing signals at precise intervals determined by extremely accurate pulses of an ultra-stable crystal oscillator.

100010

Miniaturized analog computers may be offered for missile, submarine and other military applications by Electronic Associates, Inc. The Long Branch, N. J., firm would make the miniaturized versions of its line available both as systems and subsystems. It is experimenting with various cordwood packaging arrangements. Soldered connections are used at this stage, but welded connections are also under investigation.

100101

Narrow-band TV system developed at Polytechnic Institute of Brooklyn (*ED*, Aug. 16, p 16) is attracting serious interest from potential manufacturers and users. One international news service is considering the 45-kc system for transoceanic broadcasts of newsreels. Film taken at standard speed would be taped for broadcast at a slower speed, then retaped at the receiving end and played back at normal speed.

101000

Digital feedback communications are under analysis at Sylvania's Research Laboratory at Waltham, Mass. Sought is a method for monitoring signal strength at the receiving end of a link from the transmitter location. Digital signals sent back to the transmitter would enable power output to be increased to compensate for fading. The study is for the Air Force Cambridge Research Laboratories.

111001

Automatic maneuvering control systems for five Polaris submarines have been placed under contract with Bendix Corp. In the systems, a solid-state computer will receive signals from speed, course and depth instruments and controls, and from electro-hy-

draulic valves in the steering, diving and fairwater planes.

011101

Aircraft noise studies will be made at a number of airports throughout the country by Polysonics, aviation acoustical consultants, under a contract with the Federal Aviation Agency. Specialized techniques will be used to obtain noise-level data on 16 aircraft types during take-offs and landings. Drawings defining noise-sensitive areas will be given to the FAA, which will disseminate the findings to guide local planning of new airports, runway locations and land use.

010010

Unsuccessful missile launchings have an extremely high correlation with the occurrence of magnetic storms, a survey shows. Of 98 launchings over a three-and-a-half-year period, it was found, 40 total and eight partial failures coincided with magnetic storms. Forty-six successes occurred at times of geomagnetic calm. One failure was on a clear day, and three successes were accompanied by moderate magnetic disturbance. Interference Consultants, Inc., of Boston has been checking missile correlation with magnetic storm forecasts.

Cybertron to Recognize Speech

Cybertron learning machine under development at Raytheon Co., Waltham, Mass., is a type of perceptron. This K200 version has vocoder-type input, and Flexowriter output to type phonetic symbols of speech sounds. It will be fed patterns and trained to respond as desired by an operator. Operation of the digital system is based on a special type of correlation, which allows convergence on a distributed memory that passes desired signals. Magnetic drum memory at left is used as an analog store. A smaller Cybertron is already working on practical problems, Raytheon says. It has paper-tape input and output.

THE CALL OF THE TALOS COMES IN LOUD AND CLEAR

through CECO's compact, low noise, telemetering preamplifier

CECO's Model 3010, wide band, telemetering preamplifiers, used aboard the Navy's new CLG-series cruisers, boost air-to-surface signals, minimize noise, reduce output and size requirements of missile transmitters. Used in the AN/UKR-10 telemetering and AN/USQ-11 miss-distance systems manufactured by Aircraft Armaments, Inc., for the Talos, Terrier, and Tartar missiles, the Model 3010 is simple, highly compact and flexible in physical configuration. It is characterized by extremely low noise and stable gain and features new tube types and conservatively rated components for trouble-free operation. CECO specializes in the design and manufacture of amplifiers. For additional information . . .
WRITE FOR BULLETIN AB

Official U.S. Navy Photo

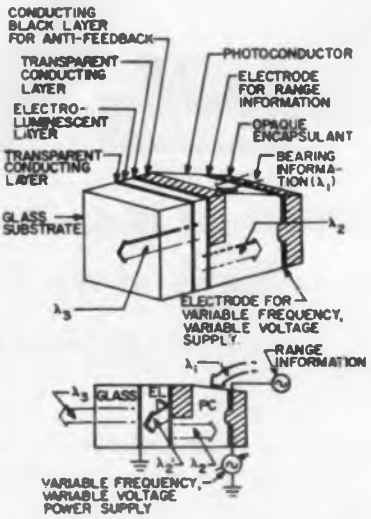
COMMMUNITY ENGINEERING CORPORATION
STATE COLLEGE
PENNSYLVANIA

CIRCLE 12 ON READER-SERVICE CARD

Solid-State Display Replaces Sonar CRT

Simplifies Circuitry and Provides Storage

Electroluminescent-Photoconductive Design



Sketch of a single-cell electroluminescent element shows the design principle. Not obvious in the drawing but basic to the design is the fact that there are two photoconductors. One is masked by an antifeedback layer, the other permits light to be reflected from the EL layer to the photoconductor. When a light beam is applied to a photoconductor, the material's resistance is lowered and most of the applied 200-300 v rms appears across the EL layer, causing it to light. In the drawing, τ_1 is bearing-information light beam from a lamp, τ_2 is reflected light from the electroluminescent surface, and τ_3 is light directed at the operator from the EL layer.

AN electroluminescent-photoconductive display is being designed to replace the conventional cathode-ray tube and associated equipment in a sonar system now under development.

Although the new display has low resolution (25 cells per sq in.) and slow response time (10 msec), this is not considered a serious drawback for sonar, a slow-scan, low-resolution system, according to Duane Gomez, head of solid-state research for Straza Industries Electronics Div., El Cajon, Calif. Straza is developing the new sonar display for the Navy's Bureau of Ships.

Mr. Gomez said he anticipated response times on the order of one msec within a year. "This is a reasonable mark to shoot for," he said. "Also, in a year we could expect to have a practical 75-line-per-inch display instead of the current five lines per inch."

By designing a solid-state display panel, Mr. Gomez was able to eliminate the cathode-ray tube, and all its associated circuitry. The display, its azimuth light source and a power supply replaced them.

Output of the sonar's transducers is a continuous-wave, frequency-modulated carrier. This is beam-rotated in azimuth over a 90-deg arc in the water. The frequency of the returned signal is dependent on the range. The return signal is heterodyned with the output to obtain a difference frequency, which may then be applied through a range analyzer—a series of tuned circuits—that separates the range data into increments.

A line of light is swept over the undersurface of the display. Signals are applied to appropriate sector contacts through the associated tuned circuit. When a cell has both light beam and signal applied, it lights up.

The principle of the display is shown in the accompanying drawing of a single cell. A soft glass is covered with a microns-thick layer of NESA—stannic oxide, a material of high transparency and low resistance (between 100 and 150 ohms per square in the Straza unit). On this layer is placed an electroluminescent layer, a mixture of a material,

Early model of solid-state display panel had 28 contacts, as shown here. Present model has 50 channels. Resolution is 5 lines per in., response time 10 msec. An advantage in solid-state panels is the ability to design configuration for eliminating circuitry.

such as zinc sulfide, and a translucent ceramic as a dielectric. It is about 0.002 in. thick. Another stannic oxide layer follows.

Half the cell is then covered with an opaque pigmented ceramic as an anti-feedback mask. It is a conducting layer. Next comes the photoconductor (sintered cadmium sulfide), a split metallic coating and the associated electrodes—the "signal" electrode and the "sustainer." Range information is appied through the signal electrode by the appropriate tuned circuit.

In operation a light beam—the "θ" sweep, keyed by a servo to the orientation of the sonar transducers—sweeps over the photoconductor, and lowers its impedance. Simultaneously the range signal, with an amplitude of from 200 to 300 v rms, appears on the metallic conductor covering the masked half of the cell. With the lowered photoconductor impedance, most of the voltage now appears across the electroluminescent layer, causing it to light up.

Since the signal is too brief in duration to keep the cell lighted (the sonar sweep covers the 90 deg in 6 sec and passes over the single cell in a matter of milliseconds). A sustainer electrode, which applies a continuous 200-300 v rms to the cell is used to maintain the light.

As this impedance is briefly lowered, the sustainer voltage appears across the electroluminescent layer, which lights up. Reflected light keeps the photoconductor impedance low, and the electroluminescent layer stays lighted. Since the gain of this optical feedback system is not unity at frequencies higher than 400 cps, the light will decay after a period of time.

Present model of the solid-state display has 50 signal channels. ■ ■

NEWS

He_3 Gas Proposed For Nuclear Gyro

Superconducting Shield Suggested To Reduce Magnetic Interference

Thomas E. Mount
West Coast Editor

DESIGN approaches for a nuclear gyroscope using gaseous helium-three, shielded by a spheroidal superconducting shell, have been proposed by Dr. William H. Culver of RAND Corp.'s Electronics Dept.

The performance of nuclear gyros tends to be degraded by relaxation effects from external sources.

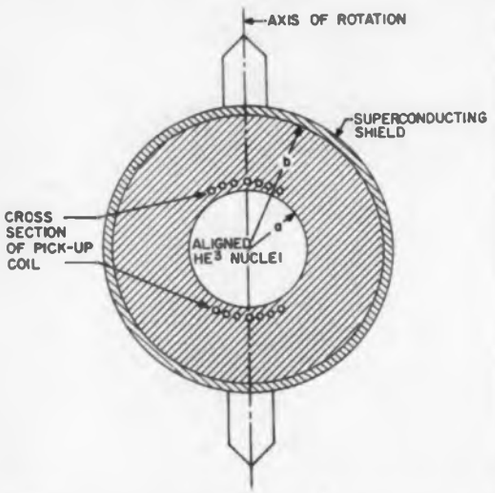
"Enclosing the aligned nuclei in a superconducting shield will greatly reduce the effect of an external magnetic field," Dr. Culver told the Guidance and Control Conference of the American Rocket Society.

"The utility of any nuclear gyro is clearly dependent upon obtaining long relaxation times," Dr. Culver explained. The longest relaxation times, under the conditions necessary for gyro operation, can be achieved in helium of isotope atomic weight 3. Relaxations of two hours have been achieved experimentally and much longer relaxation times appear possible. This depends largely on eliminating paramagnetic impurities from the region of the aligned nuclei and from the walls of the container.

The proposed gyro would exclude all external magnetic field. The magnetic field within the volume occupied by the nuclei must be parallel to the direction of alignment. "If this field were in a different direction, the nuclei would precess about this direction and lose their original orientation," Dr. Culver said.

An interrogation system that interests Dr. Culver is shown in the drawing. The whole assembly, including the superconducting shield, a pickup coil and the He^3, is rotated in bearings with a given angular velocity. If the nuclei are aligned along the axis of rotation the pickup coil will not cut any flux lines.

However if the rotation axis is rotated from the direction of orientation of the nuclei, the pickup coil will cut lines of flux and will have induced in it an alternating voltage proportional to the angle of rotation and having the frequency of rotation. Phase of



Alignment of nuclear spins of He^3 atoms, surrounded by superconducting shield, is the principle used in this proposed gyro.

this voltage will indicate azimuth angle of the new orientation of the rotation axis.

Dr. Culver cautioned that current flowing in the pickup coil gives rise to a magnetic field that precesses the nuclei. Interrogating nuclei tends to disorient them.

As a solution to this problem, too. Two pickup coils are used instead of one. They are each turned at the same rate, but in opposite directions about the same axis. If they are very nearly of the same diameter and can be made to have the same electrical characteristics, they will give rise to magnetic fields which will very nearly cancel each other when averaged over one cycle of rotation. In this way the drift of the nuclei may be cut down by a large factor.

Another variation of Dr. Culver's pickup method is to superimpose a shell between the aligned nuclei and the external shield. This shell, of a material which can be made superconducting, contains a large number of holes that trap the magnetic field present when the material becomes superconducting.

In operation, the magnetic field from the nuclei penetrates the shell, which is normally not superconducting. When a measurement is desired the shell is made superconducting by cooling, thus trapping the magnetic field of the nuclei.

When the shell is superconducting, any measurements of the external magnetic field can be made without disturbing the nuclei. When a reading is completed, the shell is returned to its nonsuperconducting state.

Dr. Culver cautioned that devices are still a long way from practical use. ■ ■

Microwave Designs Dominate Papers at WESCON

Developments Include Maser Light Amplifier, Coaxial Magnetron, Isomodulator and a Resonant-V, Log-Periodic Antenna Array

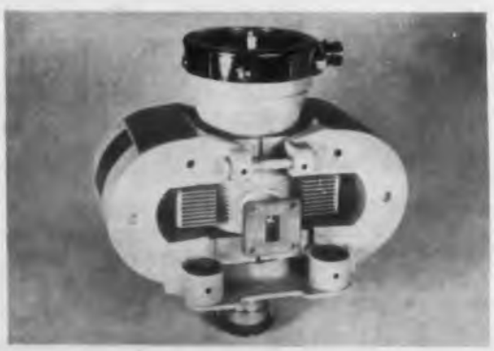
THE PUSH toward higher frequencies now stimulating so much design work is nowhere more evident than in the papers delivered last week at the 1961 Western Electronic Show and Convention. Concern with the microwave region shows itself in papers on theory and technique, on devices and analysis.

Among the most prominent developments discussed were:

- Operation of an optical maser as a light amplifier.
- A coaxial magnetron that produces 125 kw at K band with good frequency stability and a wide tuning range.
- An isomodulator that modulates an oscillator while simultaneously isolating it from load variations.
- A resonant-V array of log-periodic elements that forms an antenna with greater directivity than the usual log-periodic array.

Ruby Masers in Tandem Produce a Twofold Gain

The operating maser amplifier was developed at Bell Telephone Laboratories, Murray Hill, N. J. In experiments there, a twofold gain was measured when two pulsed ruby optical masers were set up in tandem so that one fired at the other. One of the masers operated as an oscillator signal source generating coherent light, bright enough to be readily detected against the background of fluorescence from the amplifier ruby.



Coaxial magnetron has coaxial cavity surrounding a conventional array of vane resonators. Bell Laboratories has developed three units for use in K-band radars, where as sources they would have greater frequency stability, output and wider tuning range than conventional magnetrons.

Previous attempts to measure amplification directly were hindered by the difficulty of distinguishing coherent maser light from fluorescence. At WESCON Dr. P. P. Kislink of Bell Laboratories reported that gains had been measured in a helium-neon gas maser but that they were much smaller than twofold.

In the Bell test, the rubies of the two masers were fired simultaneously. Output from the amplifying ruby was measured by a photomultiplier tube. Both the signal going into the amplifier and the signal coming out were displayed on an oscilloscope. Comparison of the output-to-input ratio, when using the amplifier, with the ratio obtained when the amplifier was removed from the beam permitted a gain reading. The net gain of 2 was observed at −40 C.

The K-band coaxial magnetron was also developed by Bell Laboratories. Researchers at Laureldale, Pa., based the device on a recently developed technique for controlling the mode of oscillation in a magnetron. The new technique compares with conventional strapping as follows:

In strapping-type mode control, points of high rf voltage that have identical phases in the desired mode are tied together by conducting straps. In the coaxial magnetron, rf currents rather than voltages are coupled at points of identical phase in the desired mode. In this magnetron the circular electric mode of a coaxial cavity surrounding a conventional array of vane resonators is excited by the π mode of the vane array.

According to H. M. Olson and L. H. Von Ohlsen, joint authors of the WESCON paper describing the device, the coaxial design has higher power output, greater frequency stability, higher efficiency and wider tuning range than conventional magnetrons. Only the coaxial cavity needs to be tuned in the new device, it was reported, rather than each individual vane cavity. Stability of the oscillating frequency against changes in load or input power is said to result from additional energy stored in the coaxial cavity.

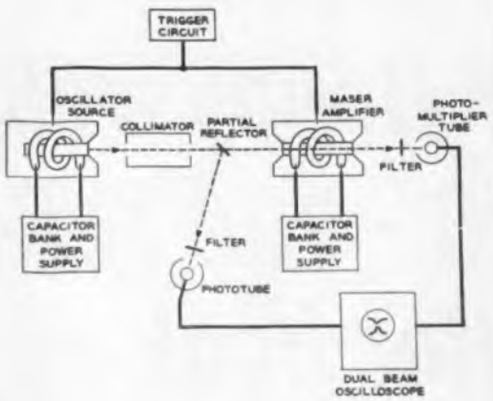
Three magnetrons based on the new principle have been designed to cover the range from 13.6 to 19.5 Gc, Dr. Kislink reported. Two other microwave sources were also described by Bell Laboratories researchers at the meeting. One, a backward-wave oscillator, provides at least 50 mw from below 45 to above 60 Gc. The other, a helix-type of traveling-wave tube, was reported to give more than a 1/2 w from 50 to 60 Gc. Both sources are intended for general laboratory use.

Ferrite Device Modulates And Isolates Simultaneously

The isomodulator, developed at Raytheon Co., Waltham, Mass., and described by Howard Scharfman, is a ferrite device said to be similar to a circulator of the Faraday rotational type. The device discussed at WESCON modulated a microwave oscillator while simultaneously isolating it from variations in load. It was designed for X-band operation in a 200-w cw system.

The isomodulator consists of two orthogonal-mode transducers placed at 45 deg to each other and connected to the ends of a ferrite rotator subjected to magnetic fields.

Also described at the meeting were log-periodic resonant-V arrays developed at the University of Illinois. These were said to provide essentially frequency-independent coverage of each of several frequency bands with greater directivity than conventional log-periodic arrays. According to Prof. P. E. Mayes of the university, replacing the



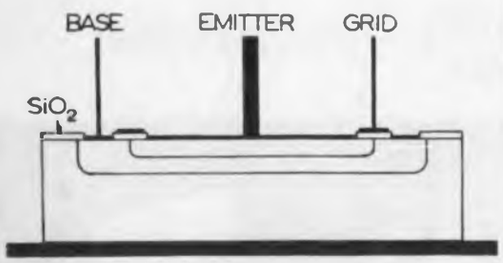
Direct observation of light amplification was made with this setup at Bell Telephone Laboratories. Collimator directs light from a conventional ruby maser, so that no part of it hits the side of the amplifying ruby or is masked. A twofold gain was measured by comparing signals on the scope display.

usual half-wave dipoles with directive resonant-V elements reduces the sidelobes in the radiation pattern of the linear elements at the higher frequencies. Estimated directivities of 17 db and more over an isotropic radiator in the higher order modes were reported by Professor Mayes. Key to performance of the array is the use of higher-order resonances of the resonant dipole elements.

The resonant-V array was said to be especially valuable when a number of discrete frequency bands must be covered, even though they are distributed over the frequency spectrum. The basic array can be modified in performance to the requirements of a particular distribution of frequencies. An important advantage reported for this type of array is that its directivity increases with frequency.

Surface-Potential-Controlled Tetrode Among the Semiconductors Described

Dr. C. T. Sah of Fairchild Semiconductor Corp., Palo Alto, Calif., described a surface-potential-controlled semiconductor tetrode for applications where conventional semiconductors would not be practical. In this device both the majority and the minority carriers are controlled by external field-effect electrodes on top of the transition region of the surface junctions. The physical structure was said to be very similar to the company's planar transistor. However, the new device has high input impedance



Surface potential-controlled semiconductor tetrode has essentially infinite input impedance and can be used for modulation, mixing and other functions. Device was designed by Fairchild Semiconductor and has the same basic construction as the company's planar transistors.

and an extra electrode for modulation, automatic gain control, mixing and other functions. Transconductance was given as several thousand micromhos. Input impedance was said to be 10^{15} ohms with 1- to 100-pf capacitance.

Other semiconductors discussed at WESCON were a double-diffused germanium switch, and a pn-junction storage diode useful for generating nanosecond pulses. ■ ■

Traveling Instrument Exhibit To Represent 55 Manufacturers

Instruments of 55 manufacturers will be demonstrated at 11 showings of the seventh annual Electronics Engineering Representatives' traveling exhibition in five New York-Philadelphia area localities.

More than 50 instruments direct from WESCON will be featured in this year's exhibition by the group of manufacturers' representatives. Included are Burlingame Associates, G. C. Engel & Associates, Gawler-Knoop Co., RMC Associates, and I. E. Robinon Co.

The itinerary for this year's show is as follows: Pines Ridge Country Club, Ossining, N. Y., Sept. 7 and 8; Roosevelt Field Shopping Center, Garden City, Long Island, N. Y., Sept. 12, 13 and 14; The Towers, Cedar Grove, N. J., Sept. 18 and 19; Wally's Tavern on the Hill, Watchung, N. J., Sept. 21 and 22; and Sheraton Hotel, Philadelphia, Sept. 26 and 27.

A technical forum will be held in connection with the Philadelphia show.

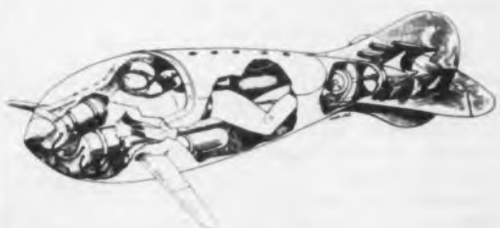
Undersea 'Chariot' Slated For Wide Application

A series of completely steerable underwater "chariots" for divers or remote-controlled equipment is under development at Loral Electronics Corp., New York City. The vehicles are variations of a basic French-developed model that operates at 3 knots for 2 hr at depths to 230 ft. An existing shielded version of the craft is said to travel at 12 knots under water.

The vehicles are part of a group of anti-submarine and oceanographic products acquired by Loral from a French inventor, Dimitri Rebikoff, who now heads a newly formed department of oceanography at Loral.

The key to maneuverability of the basic vehicle is said to be its joystick-operated, mechanically linked fin-and-plane-control system. The chariot can turn in its own radius and travel in tight spirals. The vehicle is propelled by silver-zinc batteries that drive a 1.5-hp electric motor; the motor turns a turbo-propeller. A gyrocompass, fathometer, chronometer and magnetic compass are provided for navigation.

Loral envisages a wide variety of applications for the undersea craft. These include use in mapping coastal floors, remote classification of sonar targets, search and rescue, and military amphibious assault operations.



Shielded version of chariot operates at 12 knots underwater. Upper cylinder in nose houses navigation aids. Operator's compartment is flooded.

Underwater propeller-driven craft travels at 3 knots, weighs 180 lb, including battery power supply in aluminum body. Torpedo-like device in foreground is a high-intensity light.

LARGE VALUES OF CAPACITANCE

IN SMALL PHYSICAL SIZE!

Sprague offers two series of "blockbuster" electrolytic capacitors for use in digital power supplies and allied applications requiring extremely large values of capacitance.

Type 36D Powerlytic® Capacitors pack the highest capacitance values available in their case sizes. Intended for operation at temperatures to 65 C, maximum capacitance values range from 150,000 μF at 3 volts to 1000 μF at 450 volts.

Where 85 C operation is a factor, Sprague offers the Type 32D Compulytic® Series, the ultimate in reliable long-life electrolytics for digital service. These remarkably trouble-free units have maximum capacitance values ranging from 130,000 μF at 2.5 volts to 630 μF at 450 volts.

Both 32D and 36D Capacitors have low equivalent series resistance and low leakage currents, as well as excellent shelf life and high ripple current capability.

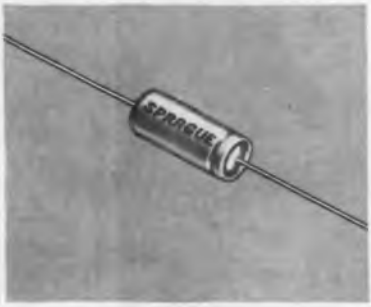
If you'd like complete technical data on Type 36D units, write for Engineering Bulletin 3431. For the full story on the "blue ribbon" Type 32D Series, write for Engineering Bulletin 3441B to the Technical Literature Section, Sprague Electric Company, 347 Marshall Street, North Adams, Massachusetts.

SPRAGUE

THE MARK OF RELIABILITY

CIRCLE 18 ON READER-SERVICE CARD

Solid-Electrolyte Tantalex® Capacitors Now Available in Non-polarized Design



The Sprague Electric Company, a pioneer in the development of solid-electrolyte tantalum capacitors, has announced the availability of Type 151D non-polar Tantalex Capacitors.

The famous Type 150D polarized capacitor, outstanding for miniature size, excellent performance characteristics, and reliable service life, is now joined by the non-polarized Type 151D, which consists basically of two hermetically-sealed, metal-clad polarized sections, with their cathodes connected back-to-back and enclosed within an outer metal tube. This results in a single homogeneous capacitor insofar as outward appearance is concerned. Where required, supplementary insulating sleeve of polyester film is applied.

Non-polarized Type 151D Capacitors are useful in many new applications, such as phase-splitting in small low-voltage motors, in servo systems, in low-frequency tuned circuits, in crossover networks, and in bypass applications where high ripple voltages are encountered.

Unmatched experience in this field has enabled Sprague to establish the largest and most complete production facilities in the capacitor industry. Producing more solid-electrolyte tantalum capacitors than all other supplies combined, the Sprague Electric Company offers, in addition to reliability of product, reliability of source of supply.

For complete technical data on Type 151D Capacitors, write for Engineering Bulletin 3521 to Technical Literature Section, Sprague Electric Company, 347 Marshall Street, North Adams, Massachusetts.

CIRCLE 19 ON READER-SERVICE CARD

WASHINGTON REPORT

Albert Warren
Washington Editor

FCC TRIES AGAIN ON ALL-CHANNEL TV SET LAW

The Federal Communications Commission continues to seek Congressional help in its efforts to produce more competition among TV stations by fostering the growth of uhf. Contending that more stations can be supported only if the 70 uhf channels are made viable, the FCC still wants legislation requiring all sets shipped in interstate commerce capable of receiving both vhf and uhf and subject to certain minimum technical standards.

Such legislative proposals must first clear the Budget Bureau. FCC sent the recommendation to the Budget Bureau early this year. Nothing was heard of it until a month or so ago, when the Bureau forwarded it to Congress with the notation that it didn't object. It's understood that White House officials explained the delay this way: "It was lost." Actually, there is known to be disagreement among Presidential advisers.

Congress has been very lukewarm about the idea in the past. Some lawmakers say they think the measure may be unconstitutional. FCC experts have no such qualms.

The Electronic Industries Association has strongly opposed the measure on many points. Basically, however, it doesn't want the government telling manufacturers what kind of sets to make. It argues that the public shouldn't be expected to pay extra for vhf-uhf receivers until it wants to—to receive uhf stations offering programs they want. Manufacturers see no sense in producing such receivers is the hopes that they'll gradually build a potential audience which would in turn encourage the construction of uhf stations.

POST OFFICE DROPS FACSIMILE PLANS

After spending $4.5 million on experiments for moving mail via facsimile, the Post Office has abandoned the project. Postmaster General J. Edward Day said that the cost appears prohibitive, that private firms are likely to do a better job—and that the government decided not to compete with them. Some tests were made between Washington and Chicago but the Kennedy Administration dropped the project soon after taking office.

RADIATION LABEL FOR TV & FM SETS PROPOSED

The Federal Communications Commission has apparently opened a fight by proposing that TV and fm set manufacturers place a large and easily read label on the back of each receiver—to indicate that the set meet the Commission's rules regarding the maximum amount of radiation permitted. The Electronic Industries Association asked for and received more time to study the proposal; comments are now due Sept. 29.

Recently, Zenith reported that it had bought at random 14 sets

made by eight manufacturers and found only four of them complying with FCC's current rules. Zenith wrote the Commission: "There is a cost penalty in the manufacture of sets which comply with the Commission's rules. Our investigation indicates that a substantial portion of the industry considers this cost advantage of greater importance than FCC certification." It suggested that the Commission get busy and enforce its rules. The offending manufacturers weren't identified.

HUGHES GETS NASA CONTRACT FOR SATELLITES

The National Aeronautics and Space Administration has again demonstrated its intention of exercising decisive leadership in the development of satellite communications and of encouraging maximum industry participation.

A $4 million contract with Hughes Aircraft for three experimental synchronous repeaters, light enough to be orbited at an altitude of 22,300 miles, will provide an important addition to the test and evaluation programs for next year.

Launching of the 50- to 60-lb Hughes "syncom" satellites will complement an initial test of the Army's more sophisticated 1,200-lb ADVENT satellite, which for lack of rocket power will have to be placed in a lower-than-optimum orbit next year. NASA already has provided for two experiments in 1962 with low-altitude systems. One will involve its own RELAY satellite, which RCA is building, and the other will result from the space agency's recent contract to launch and track at least two, and possibly four, AT&T experimental satellites. (See *ED*, Aug. 16, p 20.)

NASA's Contract with Hughes calls for a number of design changes in the 33-lb experimental payload unveiled by the company at the American Rocket Society's meeting last December. Hughes subsequently proposed a feasibility test in a brief filed with the Federal Communications Commission. (See *ED*, March 29, p 20.)

Hughes had proposed launchings from an equatorial island, contending that a NASA Scout rocket could do the job for as little as $500,000 per launch. However, the Syncom satellites will be launched with a three-stage Delta rocket and a small solid-propellant booster to give the payload a final push. The launchings, from Cape Canaveral, will cost about $3 million each.

The increase in the payload from 33 lb to from 50 to 60 lb presumably will allow for a second transmitter and receiver, since NASA was critical of the lack of redundancy in the original version.

The Syncom satellites will receive on 8,000 mc and transmit on 2,000 mc in order to utilize ground-station facilities for the Army's Project ADVENT. A narrow-band system, Syncom will be limited to a few channels for voice and digital transmission.

GREEN LIGHT FOR PROJECT WESTFORD

The President has given the Air Force the go-ahead to orbit a distributed reflector version of a passive communications satellite this fall, after both the National Aeronautics and Space Council and the National Academy of Sciences advised that the project would not interfere with optical or radio astronomy. Known as Project Westford, it will involve putting a belt of tiny dipoles into a 2,000-mile orbit (See *ED*, Aug. 2, p 20).

The Space Science Board of NAS concluded that the dipoles screen out only one part in a million of stellar radio emanations and only one part of light in a billion. A Space Council "policy paper" assured astronomers that no further dipole distribution would be made until the first test is evaluated.

at BENDIX

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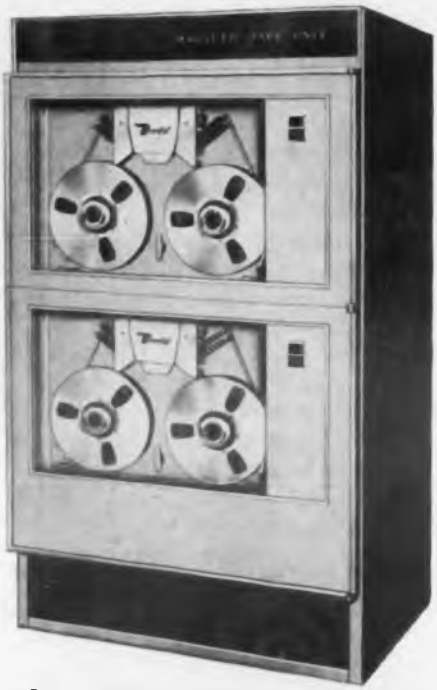

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INSTRUMENT CO. INC.

PLAINVIEW, NEW YORK

CIRCLE 147 ON READER-SERVICE CARD

Fiber Optics Pointed Toward Bright Future

4 Companies Exhibit at SPIE Show, But Concede Production Problems

FIBER optics held an important place in the Aug. 7-11 symposium of the Society of Photographic Instrumentation Engineers. Four companies had samples of fiber-optic technology on exhibit in Los Angeles.

Mosaic Fabrications, Inc., and American Optical Co., both of Southbridge, Mass.; Chicago Aerial Industries, Inc., Barrington, Ill.; and Bausch & Lomb, Rochester, N. Y.; showed fused-fiber image conduits. American Optical also exhibited flexible cable.

J. W. Hicks, president of Mosaic Fabrications, Inc., said the principal problems in fiber optics are the production of flexible cable without misalignment and breakage of fibers. Techniques have been developed for fabricating cables with fibers well aligned, but the breakage problem has not been solved. When a cable bends, the fibers, which are individually very strong, get entangled and tend to snap.

Mosaic Fabrications showed a 3-in. fiber-optic disk a quarter of an inch thick, comprised of 3-micron in diameter fibers. The disk contained 625 million fibers across its diameter.

Other exhibits included image tube face plates for high-speed electrostatic printing. Since an image appears directly on the surface of a fiber-optic device, a film can be run directly in contact with the readout. No lense system is necessary.

Electrical mosaics also shown consist of a glass matrix with metal wires running from one face to another. Electrical mosaics, as such, have been sold for more than a year by Corning Glass Co. and used in electrostatic printers. In the mosaics shown by Mosaic Fabrication, the wire center-to-center space is 0.001 to 0.004 in., with wire diameters from one-tenth to one-half of the space.

Improved electrical mosaics are nearly ready for commercial exploitation, Mr. Hicks said. Known as intagliated electrical mosaics, the surface on one or both sides of the new disk is sculptured to form a cell-by-cell pattern with any one of several designs. ■ ■

Thermoelectric Generator Of Ceramic Steps Up Output

A thermoelectric generator, said to be the first made of ceramics, has been developed by Minneapolis-Honeywell Regulator Co.

The generator can operate at temperatures up to 1,300 C, and produces four times the voltage of thermoelectric generators made of more commonly used materials, such as intermetallics, the company said.

Honeywell places the output of the new generator at 1,000-1,200 μv/C, compared with 250-300 for intermetallics. A pilot model delivered to the Army's Picatinny Arsenal, Dover, N. J., is designed to deliver 100 v under no load (T_H = 1,000 C, T_c = 400 C).

The generator uses nickel oxide (a ceramic) with a reference of platinum. Use of the nickel oxide permits operation of hot and cold junctions at extreme temperatures, according to Robert D. Fenity, project director.

The generator resembles a 14-layer cake. The nickel is sprayed on one side of each layer, and platinum on the other. The ceramic and metal then are scored with a diamond-bladed circular saw so that they appear to be wrapped around each layer like an unbroken wire.

Felt-like ceramic separates the layers. Even nuts and bolts are made of ceramic.

A second thermoelectric generator being built for the Army will substitute iron oxide for the platinum, Fenity said. The chemical stability of the ceramic material makes weighty protective containers unnecessary, the company said.

RCA's "Universal" Transistor Handles 5 W, Costs $12

A silicon transistor said to perform up to 40 per cent of the jobs done by the many different types of available transistors is going into commercial production next month at Radio Corp. of America, Somerville, N. J.

The transistor, expected to cost $12 in production quantities, is made by a combination of triple diffusion and planar techniques. Designated 2N2102, it dissipates 5 w max and has collector-to-base and collector-to emitter voltages of 120 and 65 v max.

Other specifications reported by RCA include: collector current, 1 amp; storage and operating temperature ranges, −65 to 300 and 200 C; gain-bandwidth product 60 mc; switching speed (nonsaturating mode), 30 nsec max; 60-v collector reverse leakage, 2 nsec max.

NEWS

Second Harmonic of Light Made By Beam from Ruby Maser

By focusing a beam of monochromatic red light from a ruby maser into a quartz crystal, researchers at the University of Michigan created a second harmonic of light. The first-time achievement may speed exploitation of light frequencies for communications by leading the way to a practical modulation scheme, the university says.

The overtone was a deep blue beam of 3,500-A ultraviolet light. It was considerably weaker than the 7,000-A red beam and was almost invisible.

One result of the achievement is to permit study of nonlinear optical properties of materials. University researchers are collecting various crystals preparatory to making such studies by observing light harmonics.

A commercial optical maser was used for the experiment. Its beam produced a power density of 100 megawatts per sq cm at the focus.

Haystack Research Antenna Takes Interchangeable Transmitters

The 120-ft-diam Haystack radio-research antenna being built in Tyngsboro, Mass., is designed to operate with interchangeable transmitters. These would require only several hours for plugging in and out, according to Radiation, Inc., Melbourne, Fla., which is building the initial X-band transmitter and 1-megawatt general-purpose power supply.

The Cassegrainian antenna will generate a beam of about 0.06 deg at 8 Gc. Continuous power of the transmitter will be 100 kw. This combination reportedly could permit detection of a golf-ball-sized object 1,000 miles away.

Scheduled to be in operation by the end of next year, the system will cover a wide range of frequencies at power levels beyond the range of presently available transmitting tubes, Radiation, Inc., says. It will be used for a variety of communications and radar astronomy research projects. One application will be as a test bed for development of satellite-relay transmitters and receivers.

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- Up to 5 million samples per second.
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- No need for sample and hold circuitry in most applications.
- Every output valid and usable immediately. Input and digital output controlled by interrogation pulse. Output cannot vary between interrogation pulses.
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- Militarized versions available on special order.
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- Up to 500,000 complete 10-bit conversions per second.
- Either serial or parallel binary output.
- Serial readout at 5 mc bit rate; parallel readout at 500 kc word rate.
- Synchronous or asynchronous operation.
- Plug-in modules mounted on inside of front cover (see photo above) give direct access to all circuitry during calibration and operation.
- 5 individual test points provided on each logic panel.
- Raytheon Model DPS-1A optional Power Supply unit, with built-in fault-indicators, can provide power for complete Multiplexer-Converter system, or for two AD-50A or two AD-10A Converters.

Either Converter can be combined with Raytheon's Multiplexer to produce a high speed data acquisition and conversion system with built-in expandability.

High Speed MEGACYCLE BUILDING BLOCKS

(−30 to +65 C)

- Adaptive circuitry adjusts power requirements to load, keeping power drain at minimum. In quiescent state, blocks draw 1/7th the power of conventional blocks.
- All block designs satisfy "Worst Case Analysis" criteria.
- Only one step from logical design to finished equipment because of unique "interchangeable wiring panels" feature.
- Novel packaging technique offers wide choice of chassis configurations.
- Standard logic symbols and nomenclature on all modules eliminate need to learn new logic language.
- Temperature specifications −30° to +65° C.
- Raytheon will do logical design, select appropriate blocks, test and ship complete system, according to customer specifications.
- Blocks, chassis, light and switch panels also available separately in any combination, for system integration by customer.

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- Most expandable, versatile, fastest-switching data handling Multiplexer ever designed.
- Up to 5 million samples per second.
- Minimum switching time 0.2 microseconds.
- Linearity 0.05%.
- Minimum input signal ±1.5 volts.
- Cross channel attenuation 60 db.
- Up to 63 channels (in one Multiplexer) expandable in bays of 7, without modifying circuitry. Expandable to several hundred channels (depending on input parameters) by stacking additional Multiplexers.
- Modes of Operation:
  Remote: switching by counter-register, stepped by external pulse.
  Local: sequences one channel or 10 channels on command.
- Patch Panel utilizes "Y" patching to random-sample one channel or group of channels at different sampling rates.
- Ground and signal double-ended switching.
- Front panel lights give positive channel identification (see photo above).

FOR BROCHURES MAIL RE

DATA-DESIGN

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The speed, accuracy and expandability of Raytheon Converters and Multiplexers (described at left) are unmatched in the digital field today. Together they form the fastest, most expandable data acquisition and conversion systems ever built.

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SPECIAL PURPOSE COMPUTERS

You also benefit from the lower cost advantages of modular techniques in Raytheon Special Purpose Computer concepts. With one exception (the memory storage unit) these Computers consist entirely of Raytheon Building Blocks. Shown above is a small, high speed, custom-designed Computer ideally suitable as a laboratory engineering tool. It can add a 20-bit word serially in 20 microseconds, can perform any desired number of cycles or shifts (right or left) in a single instruction. These and other exclusive features mean you can now obtain high computational ability at minimum cost, from Raytheon.

Get Complete Technical Details

For full information on Raytheon's DATA-DESIGN services and digital equipments, mail the attached reply card today. Be assured that your request for information will not result in a salesman's visit.

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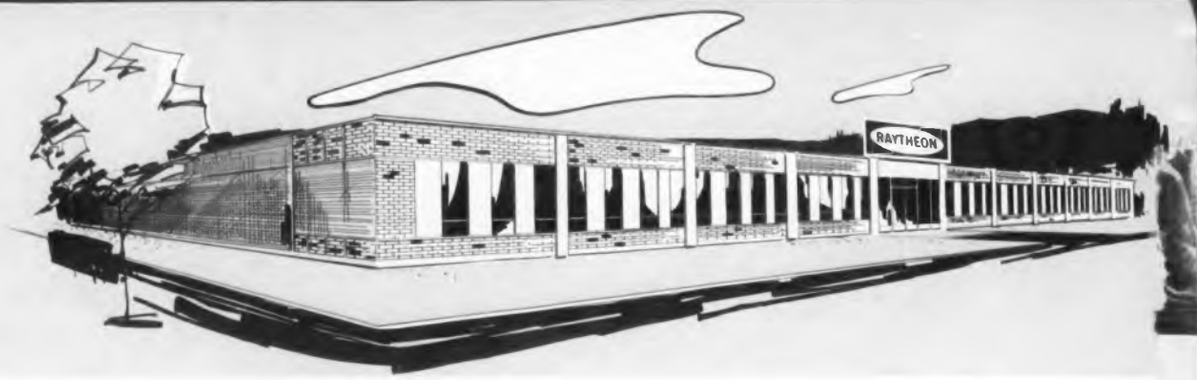

Communications And Data Processing Operation's modern 115,000 square foot facility in Norwood, Massachusetts, is a completely integrated, autonomous Raytheon organization, employing over 500 people of whom one out of four are engineers. "CADPO's" responsibilities are directed exclusively to development and production of advanced communications and data processing equipment and systems. Sales engineers in principal cities are ready to provide you with information and guidance.

About Raytheon . . .

One of the world's largest electronics organizations, Raytheon Company has been a pioneer and leader in electronics since 1922. Today Raytheon's 13 Divisions employ over 41,000 scientists, engineers, technicians and others in 42 major plants and laboratories coast to coast. International facilities are in Canada, Europe and many other parts of the world, with executive offices in Lexington, Massachusetts.

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Soviet Sells 50 Patents To American Developer

As a first step in a promised interchange of technology for profit between the United States and the Soviet Union, the Russians have sold the rights to more than 50 patents to an American company.

Included in the deal are patents on processes for making polyacrylonitrile organic semiconductors, a thermoelectric alloy and medical electronic instrumentation. The National Patent Development Corp., New York City, received the rights from Amtorg, the Soviet trading agency. The New York company hopes to sublicense the patents.

The patents fall into four main areas in electronics and are included in a group of 88 applications now being processed by the U.S. Patent Office.

The rights covering the organic semiconductor are reported to include details for making a semiconductor from polyacrylonitrile fiber. Depending on the particular thermal processing technique used, the material would have temperature stability to 700 C. Resistivity, as given in the patent, would be 10^{-6} to 10^{-5} ohm cm^{-1}.

Thermoelectric Material Is Alloy Of Bismuth Telluride

Another group of patents covers the thermoelectric-generator material used in the Soviet's widely publicized kerosene-lamp-powered radio. According to Dr. John Troll, National Patent consultant who discussed technical details with the Soviet, the thermoelectric material is a ternary alloy of Sb_2Te_3 and Bi_2Te_3 treated to obtain either positive or negative characteristics.

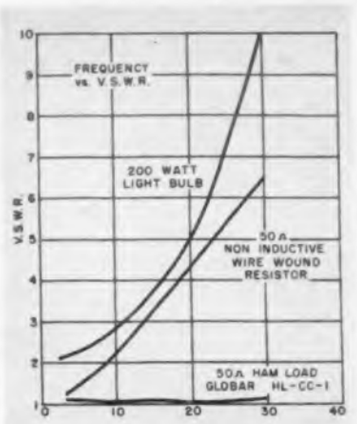
In the Soviet Union the material is said to be used in oil fields, as well as in heat-powered radios. Tap lines are taken from underground pipelines, filled with gas and ignited. Because the inside of the taplines is lined with the thermoelectric material, the heat generates a current, which counteracts earth electrolytic currents and protects nearby pipes against corrosion.

Another patent group, to which the Soviet attached the highest value, covers applications of electronic machining. Apparently offered are the details of several machines that drill and remove material by electron bombardment.

Included in the medical-electronics package is a sleep inducer that makes uses of electrode stimulation.

Electronic Products NEWS
by CARBORUNDUM®

New Dummy Antenna Load offered to ham operators



This new coaxial antenna impedance simulator HL-CC-1 was developed by Carborundum for use with ham radio equipment.

Specifications are: Short time power rating 250 watts (up to 5 min.); continuous rating 150 watts; V.S.W.R. 0-30 megacycles, 1.5 maximum.

With design changes, similar loads can be supplied for operation anywhere in the frequency range up to 1 kilo megacycle and for dissipating up to 1 Kw continuously.

Resistive component of the load is one of Carborundum's high temperature non-inductive resistors. It is furnished with coaxial terminations.

Available from electronic distributors, these ham antenna loads prevent radiation and interference while tuning, testing and making measurements.

For more information on Carborundum's dummy loads for other applications, write to Dept. EDL-81, Globar Plant, Refractories Div., Carborundum Co., Niagara Falls, N. Y.

Circle 774 on Reader-Service Card

High Purity Crushable Ceramic Preforms meet Govt. Specs.

Crushable ceramic preforms for precision swaged thermocouples for atomic energy and turbine engine applications are available from Carborundum.

The following materials exceed the requirements of A.E.C. Specification SPC-SR-101-(ORO), Oak Ridge National Laboratories Specification ORNL Spec. 7444-1 and Knolls Atomic Power Laboratories ORPM 7-1.

1. *High Purity Magnesium Oxide*—Type 0333, certified purity 99.4% min. MgO Al_2O_3 and less than 2 ppm boron.

2. *High Purity Fused Aluminum Oxide*—Type 1513, certified purity 99.6% min. Al_2O_3 and less than 2 ppm boron.

3. *Stabilized Zirconium Oxide*—Type 0956, certified purity 91.9% min. and less than 10 ppm boron.

Standard sizes are from .022 O.D. with holes from .005. Standard preforms are offered for 1, 2 and 4 hole applications. Others are available on request.

For Technical Data Sheet and other information contact Dept. EDP-81, Latrobe Plant, Refractories Div., Carborundum Co., Latrobe, Pa.

Circle 775 on Reader-Service Card

Carborundum insulators make possible 5-yr. guarantee for Electronic Air Cleaner

Key to the operation of an electronic air cleaner made by The Electro-Air Cleaner Co., McKees Rocks, Pa., is the ionizing collecting cell shown here.

Insulators supporting the electrically charged plates are exposed to extreme conditions of dirt and moisture, yet must prevent high voltage leakage. The search for a suitable material ended with Carborundum's steatite insulators. Operation is so successful that The Electro-Air Cleaner Co. is able to guarantee its product for a full five years.

Ceramic insulating materials and parts, including metallized ceramics and ceramic-to-metal assemblies, are specialties of Carborundum's Latrobe Plant. For more information, write Dept. EDC-81, Refractories Division, Carborundum Company, Latrobe, Pa.

Circle 776 on Reader-Service Card

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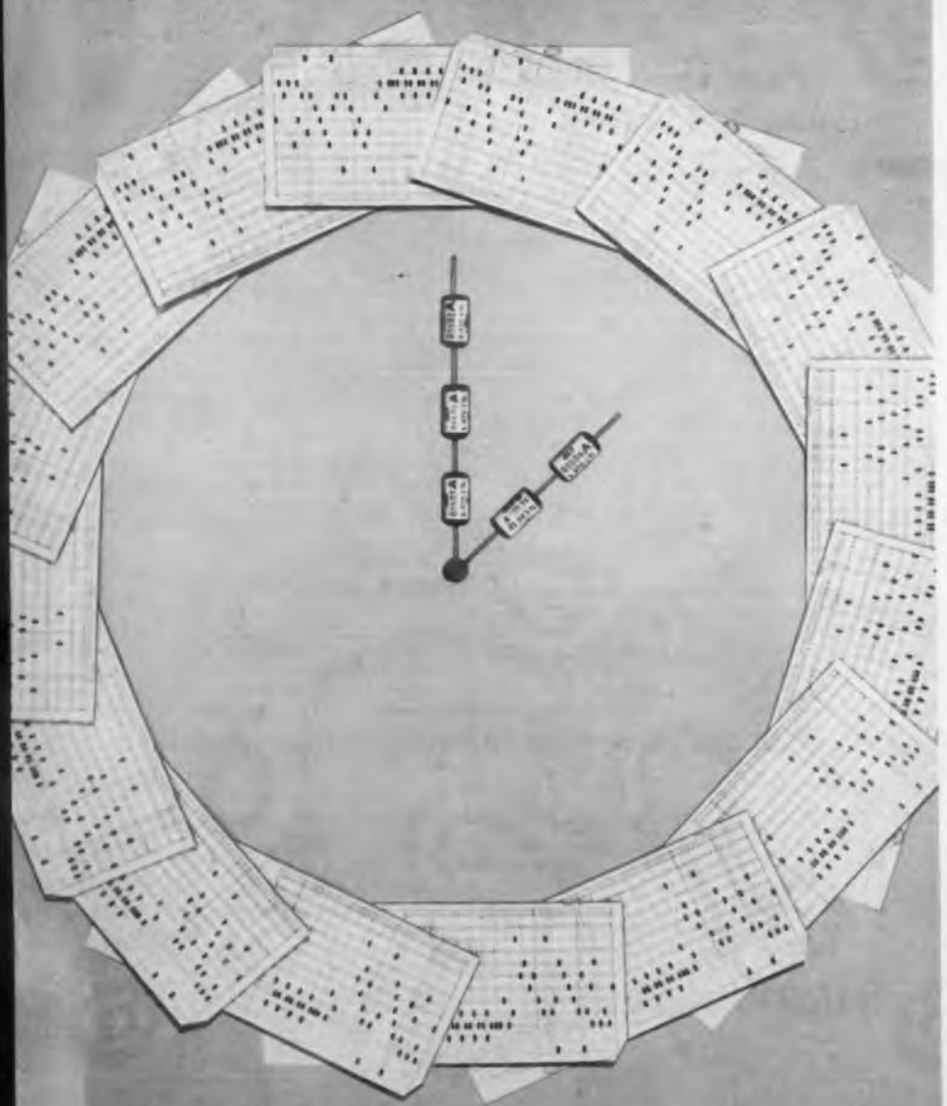

250,000,000 hours mean-time-to-failure rate. IRC's new Type XLT resistors have a failure rate of less than 0.0004%/1000 hours. This extreme reliability will be proven to a 60% confidence level, by testing 65,000 units for 4,000 hours. XLT failure is defined, not as a catastrophic "open" or "short", but as any resistance change greater than 0.5%.

To document this new high concept of reliability, the production history of each XLT is shown on a punched data card supplied with the unit. XLT's not allocated for MINUTEMAN are available now for other applications requiring ultra-reliable resistors.

Write for "Resistors with Documented Reliability." International Resistance Company, Documented Reliability Dept., 401 North Broad Street, Philadelphia 8, Pa.

CAPSULE SPECIFICATIONS

Power Rating	⅛ W at 125° C, derating to zero at 165° C
Tolerance	± 1%
Resistance range	10 ohms to 100K ohms
Temperature coefficient	± 25 PPM/°C, ± 50 PPM/°C, ± 100 PPM/°C — −55° to +145° C
Type	Evaporated metal film
Construction	Hermetically sealed glass, helium atmosphere
Leads	Weldable (gold-plated Dumet)
Body Length	.281 ± .030"
Body Diameter	.155 ± .015"

XLT Resistor developed for Minuteman Missile

When Reliability Counts Most IRC

EDITORIAL

Too Much Specialization? — No!

Critics of over-specialization can find much to decry in the electronics industry. They can trace the history of the industry back to the time when an electronic engineer was simply a specialized type of electrical engineer who experimented with a new curiosity called the audion. These critics can show how that first vacuum-tube triode led to an unheard-of degree of specialization.

The early rift between electrical and electronic engineers was to breed many more, the critics can show. Electronics specialties have been divided vertically, horizontally, and diagonally. Electronic engineers have been classified by the level at which they work—device, circuit, equipment, system; they've been classified by the frequencies at which they work—subaudio, audio, ultrasonic, hf, vhf, uhf, microwave; and they've been grouped by the nature of their products—entertainment, communications, instrumentation, radar, sonar, countermeasures, data-processing.

Some of these specialties are further divided and the divisions themselves suffer fragmentation. In data-processing, for example, the computer man can specialize in analog or digital work. If digital equipment is his specialty, he may work with logic or memory.

If he works with memories, he might specialize in bulk memory, cyclic memory, or matrix memory. Bulk-memory specialists have magnetic tape, punched tape, and punched cards. Cyclic memories men may concentrate on tape loops, recirculating registers, drums, or disks; and specialists in matrix memories may further specialize in cores, thin films, ferrite sheets, rods, Twistors, Toristors, cryoelectric elements, ferroelectric elements, or tunnel diodes.

What has this specialization led to and where will it lead? Have engineers dug deeper and deeper trenches for themselves as the critics suggest? Does each new development threaten to chip another segment off the engineering fraternity? Will tomorrow's engineers all be narrow specialists, alive only to their immediate technical challenges, and dead to progress in other fields and to their social, political, and cultural surroundings?

Talks with hundreds of engineering specialists suggest that the kind of de-humanizing that the critics warn against is extremely unlikely. With the help of technical trade journals and professional societies, engineers stay well abreast of developments in many fields. They are just as alert politically and socially as were the broader, all-encompassing engineers of yesterday. Their cultural interests and achievements match those of professionals in non-engineering fields. What's more, these specialists have designed some of the most elegant electronic equipment in the world.

Is this over-specialization? Is this stultification of the individual? Is this the way to hamper initiative and inventiveness? If it is—let's have more of it.

George Rostky

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CAP.	D	L	CAP.	D	L
.001	.156	⅜	.1	.281	⅞
.01	.156	½	.22	.328	1
.022	.203	⅝	.47	.468	1¼
.047	.234	¾	1.00	.593	1½

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digital design a feature report

The Race to Catch Up

George Rostky
Technical Editor

DIGITAL computers and, indeed, all types of digital, data-processing instrumentation have made enormous progress in the past decade. Yet, paradoxically, with each forward step, the state of the art seems that much further behind some goal.

Our data-processing needs are growing a lot faster than our capabilities. It seems a lot longer than a mere decade since laymen heralded the early electronic computers as "giant electronic brains," destined to relieve man of much of his drudgery.

Now, as we develop faster and faster computers, we develop needs for even higher computation speeds. As we make larger and larger memories, our requirements for large storage expand. As we develop more general, more sophisticated, and easier-to-use programing tools, our needs for more universal programing techniques and languages mushroom even faster.

Can we catch up? Some feel we cannot. This is a healthy situation, they say, since it keeps us on our toes and doesn't allow us the luxury of complacency.

In their efforts to advance the state of the computer art, designers are running into some really serious problems. At first glance, some of these problems seem insoluble. In some areas, it seems, we must find ways to outwit nature.

One of the major problems, for example, is speed. People are talking in terms of nanosecond computers—machines with gigacycle information rates. But here we bump into limits set by the speed of light.

It takes light about a nanosecond to travel a foot. Practically, this means that a computer signal would require a full nanosecond to move down a one-foot length of wire. With gigacycle machines, for the first time in the history of data processing, all transmission delays would become significant. All wire lengths would become critical.

Microminiaturization Proposed For Crossing Speed-of-Light Barrier

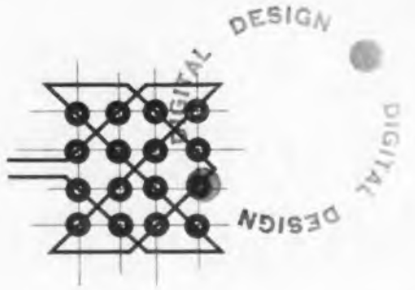
One obvious approach to this problem is to move things closer together—to avoid long lengths of wire. Great strides have already been made in miniaturization thanks to the leap from vacuum-tube computers to solid-state computers. But the levels of microminiaturization and the packing densities required for such super-speed computers are far beyond anything we now have on a practical scale.

The past two years have seen great progress in microcircuitry. Ultra-tiny digital circuits have laid claim to impressive packing densities. But such densities are merely theoretical extrapolations from findings with groupings of very few circuits. At best, such numbers represent packing densities on the shelf—not in active circuits.

Heat Dissipation, Interconnections Limit Micromin Progress

To achieve anything like such densities with the large number of circuits required in even very small computers (even if we could neglect the serious problem of interconnections), it would be necessary to overcome still another obstacle—heat. Even microwatts of dissipation can mount to dangerous, life-shortening watts when thousands of microcircuits are jammed into a tiny volume.

To beat the speed-of-light problem by miniaturization, we'd need densities of a billion components per cubic foot. At a panel



session on gigacycle computers at the Eastern Joint Computer Conference in December 1959, Dr. Ralph Meagher of the University of Illinois pointed out that such tightly packed systems would demand power dissipations of less than a tenth of a microwatt per element.

"We're not quite ready for this," said Dr. Meagher. "We can cope with 100 watts per cubic foot—maybe 1,000—but 10 kw is a bit difficult."

Now, more than a year and a half later, this "bit of difficulty" remains.

From the viewpoint of miniaturization, we seem to be caught between the Scylla of the speed of light and the Charybdis of heat dissipation. Fortunately, there is no law of physics that says we can't reduce component dissipations to a tenth of a microwatt.

Of course, all the theorizing on speed-of-light computers tacitly assumes the availability of good, reliable components that can switch of gigacycle rates. Some of these, like tunnel diodes, are already here. But tunnel diodes and the techniques for using them are by no means without their problems.

Asynchronism, Microwaves Studied For Beating Speed Barriers

Other approaches to the speed problem include asynchronous systems, microwave circuitry, and phase-locked oscillators. The first approach, wherein an operation doesn't start until a prior operation signals its own completion, does away with dependence on clock or timing signals and, at the same time, eliminates delays in waiting for clock pulses. But asynchronous systems tend to be complex and they require extreme care in design to overcome noise sensitivity.

The use of microwave circuitry and microwave components (including plumbing) has intriguing possibilities. But where does one find suitable engineering talent? How many accomplished computer designers are competent in microwaves?

The use of phase-locked oscillators, suggested two years ago by Dr. Jan Rajchman of RCA, is another intriguing possibility. It would entail representing units of information by two (or more) discrete phases of a microwave oscillator rather than by discrete voltage levels. But this approach runs into the same obstacle as does any approach that mixes microwave and computer talents.

Experts Scoff at Gigacycle Speeds But Work at Them, Anyway

In view of the difficulties involved in producing a gigacycle computer, it is no wonder that experts at leading computer companies tend to scoff at the likelihood of our seeing such machines in the foreseeable future. In public, these experts point only to the very real obstacles.

But in the privacy of their own companies, many of them may well be working on just such "impossible" ventures. It is a rather poorly held secret that many leading computer manufacturers are working towards advanced machines using gigacycle switching speeds.

It is obvious that even the single goal of super-speed machines poses problems aplenty. Nevertheless, this goal is but one of many.

Better, Faster Peripherals Wanted Despite Significant Recent Progress

Users of data-processing equipment want better peripheral equipment. They want faster paper-tape punches and readers, faster card punches and readers, faster magnetic-tape handlers, faster printers, and faster typewriters. And they want higher reliability at the same time.

In analog-to-digital converters, the 0.1 per cent accuracies available in as fast as 1 millisecond are still not good enough for some applications.

In storage devices like magnetic drums and disks, users want to store more information and they want to be able to get at the information faster.

In the past year or so, most hardware advances have taken place in peripheral equipment—virtually none in computers themselves. Laboratory for Electronics introduced a compact, flexible-disk memory; Telex and Bryant Computer Products introduced new rigid-disk files with vastly increased storage capacity and vastly improved access time; National Cash Register Co. and Uptime Corp. brought out 2,000 card-per-minute, punched-card readers. Input-output hardware advances were impressive this year, but hardware advances in the computers themselves were few and far between.

In the main, the past year saw computer manufacturers concentrate on software—on sophisticated, easy-to-use programs for different applications, and on "universal" computer languages. Even here, there is a tremendous amount of progress yet to be made.

Three Fronts, Offering Most Challenge, Probed by Pointed Evaluations

We are living in a most dynamic age of progress in data processing. In the midst of this progress, in the midst of a plethora of new developments—some evanescent and others of dramatic, long-lasting importance—it is no small task for an engineer to keep his bearings.

To help him, ELECTRONIC DESIGN offers this report on data processing. The report probes into three of the most challenging areas for future progress: logic and timing, matrix memories, and cyclic memories.

The authors of the articles in this report have presented penetrating evaluations in their respective fields with to-the-point, up-to-date evaluations of the state of the art and of the contending techniques and devices in each field. ■ ■

Logic and Timing In Digital System Design

The interrelationships between the different types of logic and timing are quite complex. It is no wonder then, that it is difficult for designers who specialize in one field to visualize the over-all situation. In this article, John Earle brings the picture into focus. Mr. Earle has had extensive experience in the intricacies of logic design. He was responsible for the logic design of the XM-200, a synchronous pulse machine, at Underwood Corp.'s Research Laboratories. At IBM, he has worked on the logic design of several large-scale, exploratory, asynchronous systems.

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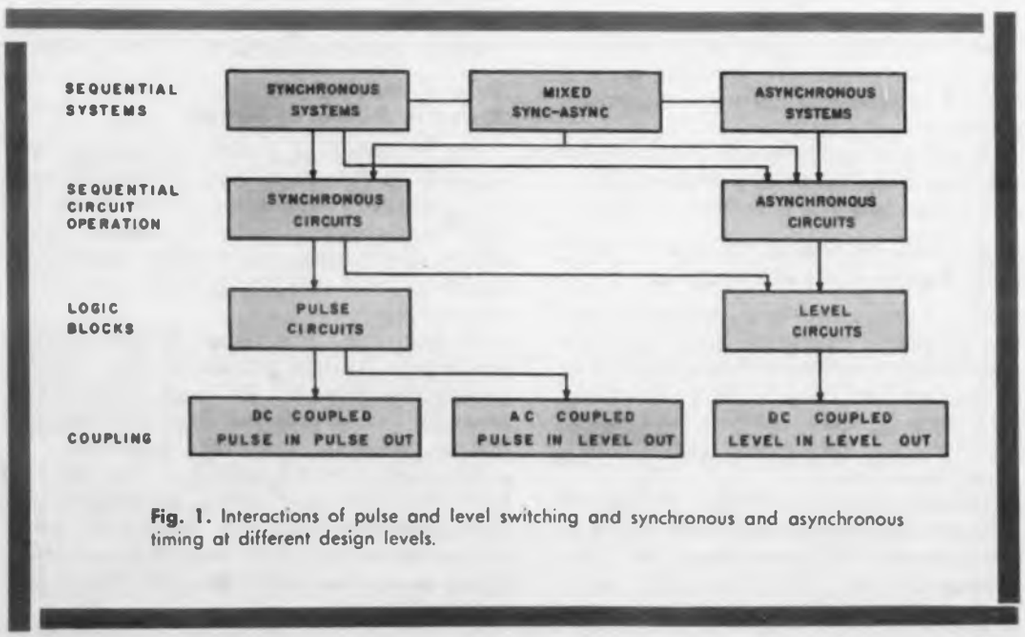

Fig. 1. Interactions of pulse and level switching and synchronous and asynchronous timing at different design levels.

DIGITAL systems are designed on roughly three levels. The basic building blocks are standard logic circuits. Except for a few non-logical elements like drivers, these basic circuit blocks mix digital input signals and quantize the result in a way which can be expressed by a Boolean logic function.

Typical functions are AND, OR, NOT, and NOR. Without feedback loops, networks of these blocks are called *combinational logic circuits*. Such networks constitute the first level of digital design.

When the basic logic blocks are interconnected with feedback loops together with any necessary gain elements lacking in the blocks, the network can exhibit memory or storage properties. With feedback loops and storage, the networks are called *sequential circuits*, and constitute the second level of digital design. Sometimes sequential circuits, are designed as standard packages, but the present trend is to build them from basic logic blocks.

At the third level of digital design, the designer organizes logic networks into a *sequential system* to perform the required system functions.

On each design level, the designer makes basic choices which relate to all levels. Fig. 1 shows possible combinations of pulse and level switching and of synchronous and asynchronous timing. An understanding of these basic choices and their interrelation-

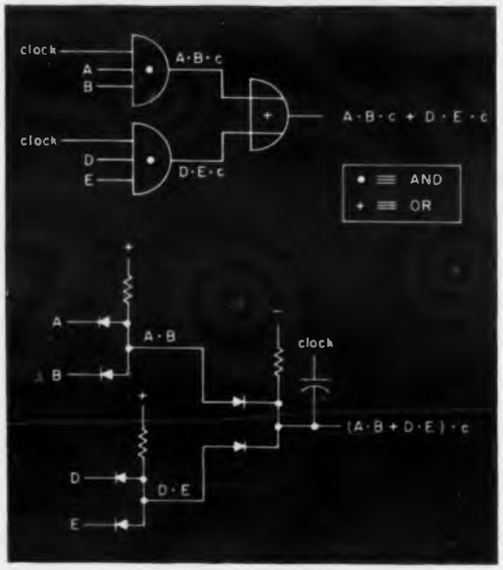

Fig. 2. Basic, dc-coupled, pulse-circuit blocks, shown in logic-diagram form and in circuit-schematic form.

ships is essential to any comprehensive digital-design effort.

CIRCUIT LOGIC

The *circuit logic block*, a first-level digital building block, performs a logical function such as AND, OR, NOT and NOR. It may use either *pulse* (ac or dc coupled), or *level* (dc coupled) switching. The difference between a pulse and a level is essentially this: The logic designer makes a pulse rise, but the circuitry makes it drop within a relatively fixed time. On the other hand, the logic designer makes a level rise and then drop at some later time.

Pulse-Circuit Blocks May Be DC or AC Coupled

Pulse-circuit blocks, dc coupled, are typically AND-OR logic with a clock pulse gating either the AND or the power supply of the OR (Fig. 2). Thus, the data, levels or pulses, are dc coupled, though the clock input may or may not be ac coupled. Every signal gated with a pulse is, of course, converted to a pulse.

Dc coupled pulse-circuits usually require delay lines, pulse reshaping circuits, and retiming circuits. Delay lines are required because the clock pulse is wider than the pulse generated by an ac network: pulse networks rely on a critical ratio of sequential, circuit-

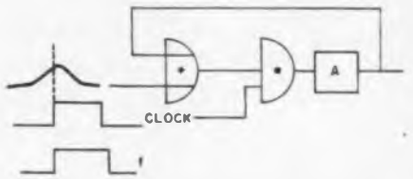

Fig. 3. A typical re-shaping and re-timing circuit required for dc-coupled pulse circuits. The block marked *A* represents a noninverting amplifier.

response time to input-pulse width; the delay increases the response to match the clock-pulse width.

Fig. 3 shows a pulse reshaping and retiming circuit. The input is a degenerate pulse, out of sync with the clock; the output is a full clock pulse, one-quarter period behind the input, so as to sample it at its peak (assuming a 50 per cent duty cycle). Monostable circuits are also used for this purpose.

The gate of Fig. 4 is an example of an ac-coupled pulse-circuit block. This gate always has the resistor input *C* driven by the level output of a flip-flop. The flip-flop gates the normal power-supply input of a diode AND, with a capacitor replacing one of the diodes. To the *B* input signal, the RC network looks like a differentiating, pulse-forming network, while to the *C* input, it looks like an integrating, delay network.

Level-Circuit Blocks Use Only DC Coupling

Examples of *dc-coupled level circuits* include the basic circuits for resistor-transistor logic, diode-transistor logic, and direct-coupled-transistor logic. These circuits are tending to replace pulse circuits in transistor technology, partly because of transistor variations in rise time and because of pulse-circuit noise sensitivity but mostly because of the simplicity and general flexibility of level circuits.

The advantages of the transistor logic circuits mentioned above are simplicity, flexibility, and minimum constraint on the types

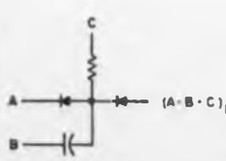

Fig. 4. This gate is an ac-coupled pulse circuit. Subscript *p* represents "pulse."

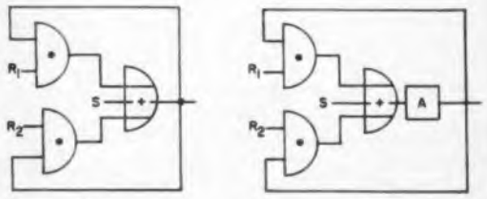

Fig. 5. A deceptive, single-feedback circuit before and after insertion of a noninverting amplifier. The symbol S represents the set pulse, R_1 and R_2 are reset pulses.

of interconnections (except, of course, on number of inputs and loads). The inherent gain in each stage of these circuits is also an advantage, in that it allows more than a drive of one from every gate and it provides gain in every feedback loop of a sequential circuit.

Systems need not be restricted to the exclusive use of pulse or level circuitry. Advantage can often be gained from the use of mixed pulse-level systems. However, they are usually more difficult to handle from a logical viewpoint and they require more circuit design than logic design.

SEQUENTIAL CIRCUITS

With suitable gain, circuit logic blocks may be interconnected with feedback to exhibit storage; that is, the output will depend on the state of the network as well as the input values.

It is fairly easy to tell how many amplifiers are needed in a sequential circuit, and where they must be placed. On casual examination, however, a circuit may be deceptive in this respect. Fig. 5(a), for instance, with its one feedback loop, requires only one noninverting amplifier.

The key is to find the minimum number of points in the circuit where lines can be broken so as to reduce the circuit to a combinational one. In other words, all feedback paths must be broken by breaking the least possible number of wires. Amplifiers are then placed at these nodes. (Both current and voltage must be amplified.)

Sequential-Circuit Operation May Be Synchronous or Asynchronous

Sequential circuit operation falls into two categories: synchronous and asynchronous. Synchronous sequential circuit operation depends critically on the timed relationship among some input signals. These generally

fall into two classes: pulse circuits and level circuits: With *synchronous pulse circuits*, the relationship is in the timed difference between the input data signal and the input from a feedback loop. With *synchronous level circuits*, it is in the timed difference between input control signals.

Pulse sequential circuits, ac coupled, typically use the gate of Fig. 4. Fig. 6 illustrates this application. Here, the feedback loops from the collectors drive the slow resistor input, and the input trigger signal drives the fast ac-coupled input. The timing chart of Fig. 6 shows how the trigger operates as a result of the timed relationship between input and feedback.

Pulse sequential circuits, dc coupled, generally require a larger feedback delay to compensate for the wider, clocked input pulse. The dynamic, pulse-recirculating binary-count trigger of Fig. 7 distinctly separates the delays and pulse-forming networks. (The top AND gate is part of the retiming-reshaping circuit of Fig. 3.) Here, the timed relationship between the input-clock pulse width and the feedback delays (and amplifier response) makes the trigger work.

Synchronous level sequential circuits operate on the timed relationship between input control signals. As in all synchronous circuits, these control signals often result in

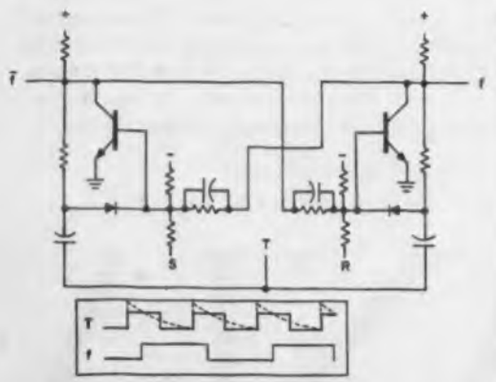

Fig. 6. Ac-coupled, pulse, sequential circuits typically use the gate of Fig. 4 as does this binary-count trigger.

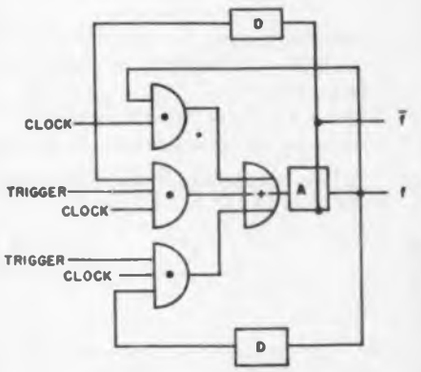

Fig. 7. The dc-coupled, pulse, sequential circuit, like this dynamic, pulse-recirculating, binary-count trigger, separates the delays from the pulse-forming networks.

multiphase clock systems; overlapping, nonoverlapping, and sometimes with different pulse widths. Fig. 8 shows a simple example. Here, a level shift register uses a two-phase clock with RTL (or NOR) circuits and diode AND's. C_1 gates the information into the upper register of flip-flops, and C_2 gates it back down to the lower register (shifted by one lower-register position). Both set and reset lines are driven, or a four-phase clock may be used.

Fig. 9 shows a mixture of the pulse and level techniques with a multiphase, multiwidth clock. Here, a narrow pulse, C_2, tries to reset the entire register dc. Closely following, however, a C_1 pulse (shortened by a capacitor), sets the stage (over-riding C_2) only if the preceding stage is a one. Even after C_2, the capacitive load holds down the preceding output for this transient time. In such a circuit, C_1 is usually synchronized with the data, while the narrow C_2 pulse can be used for logic between shifts.

There are many tricks possible with pulse circuits, but these have been limited since the change from tubes to transistor, and the consequent difficulty and expense in insuring a fast enough rise for the ac coupling.

Asynchronous sequential circuit operation does not depend critically on the timed relationship of any input signals. The only timing requirement is that the input signals must be maintained long enough to settle the circuit into its stable state; otherwise, the

operation may be unpredictable. The exact opposite is required of some pulse circuits (e.g., Fig. 6).

Some Circuits May Combine Aspects of Synchronous and Asynchronous

The transition from synchronous to asynchronous circuits can be seen in Fig. 10. This circuit forms a link between the synchronous, level, shift register (Fig. 8) and the asynchronous shift register.

Except for the interval of delay, C_1 and C_2 of Fig. 8 are almost complements. If we make them complements, however, we have the hazardous situation shown in Fig. 10 where C *and* $\overline{C}$ overlap (cross-hatched area) because of the delay in the inverter.

When information shifts into the first stage of Fig. 10(a) with C up, the gates to both stages are open during the overlap of C and $\overline{C}$. Thus, the information can pass through the first and into the second flip-flop, and alter the contents being transferred at that time to the next stage. Thus, we have the timing problems of the synchronous circuit without the reliability of the well-designed asynchronous. This points up the major problem in asynchronous design.

One solution to the timing problem illus-

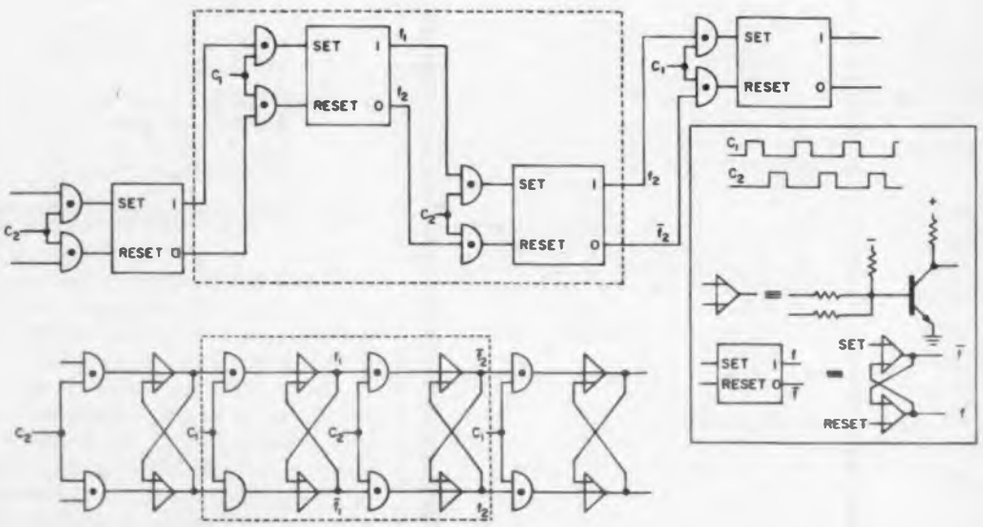

Fig. 8. Synchronous, level, sequential circuits often require multiphase clock systems. This shift register, shown in block-diagram and logic-diagram form, uses a two-phase clock. Triangles with input lines going through represent npn OR inverters. When input lines do not go through, the triangles represent pnp AND inverters.

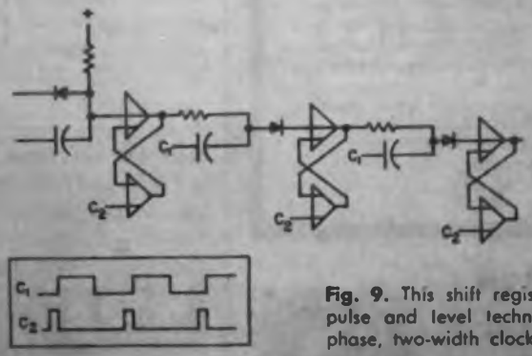

Fig. 9. This shift register uses a mixture of pulse and level techniques. It uses a two-phase, two-width clock.

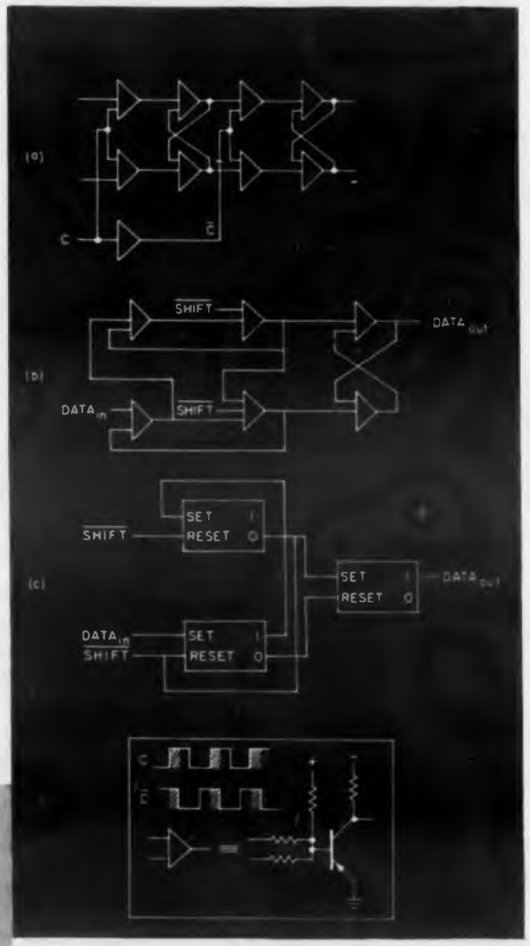

Fig. 10. These intermediary shift registers, using a clock and its complement instead of a two-phase clock, represent a link between synchronous circuitry and asynchronous circuitry.

trated in Fig. 10 (a) is to use two flip-flops—one on the set line and one on the reset line of each register—rather than one flip-flop on the output of each register as in Fig. 8. Surprisingly, this results in a more economical circuit than the one in Fig. 10 (a).

Shown in Figs. 10 (b) and (c), it uses only one shift signal and no complement; it requires only one output to be gated to the next stage; and there are no critical timing considerations beyond a minimum duration of the input signal.

The basic principle of asynchronous operation can be discerned without sophisticated tools in the asynchronous ring counter of Fig. 11. A four-stage counter, the circuit recirculates a single bit, and allows a variety of outputs. Each stage, L_k, of the ring is set by the rise or fall of S or $\overline{S}$ and the occurrence of a bit in L_{k-1}.

However, the reset line of L_{k-1} is an asynchronous function of L_k; $\overline{L_1}$ feeds back to the reset of L_3, and $\overline{L_2}$ feeds back to the reset of L_3, and so on.

When the bit is set into the L_k flip-flop, L_{k-1} is reset when and because L_k has fully latched, thus insuring that no bit is dropped in transfer. For example, we know that a one is latched in L_3 when $\overline{L_4}$ goes to zero; the zero then feeds back to reset L_3 because the transfer is completed.

In short, initiating the next operation as a function of the previous one is the essential characteristic of asynchronous operation. This is opposed to synchronous operation, in which the circuits simply wait out the worst-case time, and then, by the clock, start the next operation.

SEQUENTIAL SYSTEMS

The design of sequential systems deals with the problem of interconnecting sequential and combinational circuit blocks into a functional sequence of operations to meet the system specifications. Theoretically, even the most complex computer can be treated as a large sequential circuit and, therefore, be designed with the same techniques used for a binary-count trigger.

However, two considerations make this approach generally impractical: first, there is the number of variables involved. An eight-bit counter involves 25 variables; a 16-bit counter, 49 variables; and a computer control section, 1,000 or more. Second, the number of alternatives in synthesis grows exponentially with the size of the problem, and even the use of computers can become inadequate for selection.

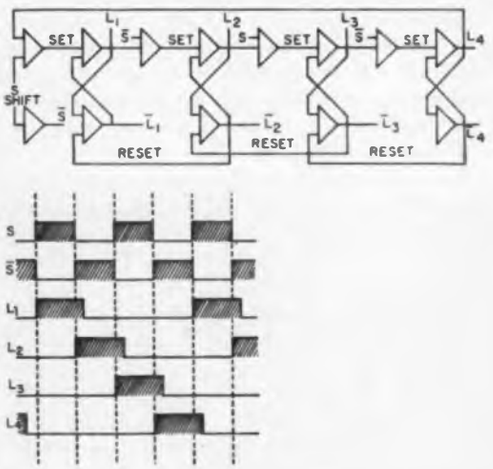

Fig. 11. An asynchronous, four-stage, ring counter. Note how each stage is set by the rise or fall of a shift signal, S, concurrent with the existence of a bit in the previous stage.

The most common way to break up the sequential-system problem into smaller interconnected problems is with synchronous or asynchronous coupling, or a mixture.

The synchronous system uses clock pulses or timing signals to uncouple the sequential circuits from one another. Thus, the timing breaks up the system into smaller pieces which can be treated separately.

Clock Pulses Cut Complexity In Synchronous Systems

During the nonstable transition states of a sequential system, interactions among changing feedback loops can be quite complex, with unpredictable response times. In synchronous systems, these and all other hazards caused by transients are eliminated by the clock pulse, which samples only the equilibrium states of the circuit, and thus isolates all feedback loops from one another.

In Fig. 8, for example, the clock gates only the dc of the preceding feedback loop into each flip-flop, while in Fig. 7, the clocked feedback loops ensure that neither feedback path is affected by what happens transiently in the other.

Historically, *synchronous pulse systems*, are distinguished by the fact that the clocks drive every AND gate in the machine, en-

suring a rigid synchronism. Any control or timing signal as well as any data signals to the AND's are gated with the clock pulse.

Synchronous level systems, by contrast, have the clock driving only the timing-ring counter, and the AND's into a register. These distinctions, however, are a matter of convenience rather than necessity.

An asynchronous system uses direct coupling of the asynchronous circuits, but an added half bit of information is carried along in the logic to aid in coupling the circuits together. For the feedback loops to remain coupled some constraint must be put on the ways in which they are allowed to change.

The extra half bit added to the logic is the system generalization of the asynchronous feedback reset line in the ring counter of Fig. 11. This augmented binary yields 0, 1, or "don't know yet" as information content.

Asynchronous Systems Must Signal Completion of Each Operation

Output signals indicate whether an operation is finished or not finished and whether a register is full or not full. These signals initiate the next operation as a function of the previous operation's completion and the circuit's equilibrium. Asynchronous-system problems revolve around how to generate these asynchronous control signals, and how to sequence operations using them.

The problem may by typified by two registers connected by transmission delays through logical gating, with data sent down these logic-block delay lines. We must know whether or not the data have arrived at the destination register; this requires a 0, 1, or N (nothing) at each terminal. One solution is to code the three states on two binary lines. The logic blocks for this double-rail technique are derived in the Karnaugh maps or the function tables shown in Fig. 12.

In Fig. 12(a), the tables of augmented values for the double-rail AND require the input-output relationships of a normal AND; that is, the output is 0 whenever any input is 0, and the output is 1 whenever all inputs are 1. Furthermore, the output is N whenever inputs are all N, or are N and one. The OR and the NOT follow similarly.

Encoding the one and a half bits of information (01=zero, 10=one, 00=N, and 11="don't care"), we distinguish the two lines by a capital and a small letter. When information is all present, $s=S$, but in general they are not complementary.

The subsequent tables of Fig. 12 derive equations and block diagrams for double-

rail logic. More generally, we require the logic network and its dual.

In general, whatever the circuit for achieving the control signals, the problem of register-to-register transfer is solved by the system shown in Fig. 13. Reset is dominant over the other inputs. When full, each register feeds back to the reset of the preceding register position, and forces it to N. As a spacer, this N keeps information behind from bunching up. This circuit is essentially similar to the asynchronous ring counter of Fig. 11.

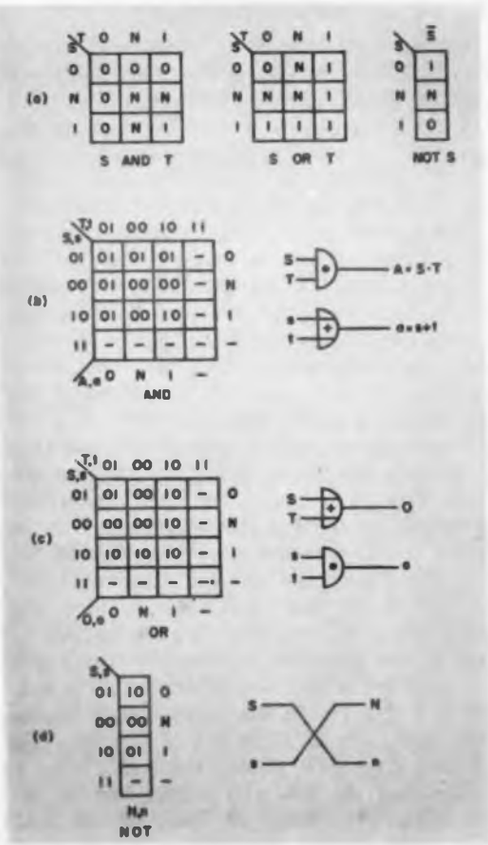

Fig. 12. Function tables for: (a) asynchronous AND, OR, and NOT logic, (b) a double-rail asynchronous AND, (c) a double-rail asynchronous OR, and (d) a double-rail asynchronous NOT.

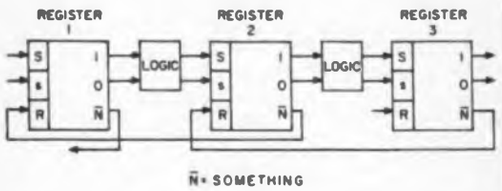

Fig. 13. This system solves the problem of asynchronous transfer from register to register.

Several other methods of asynchronous system design are available. For example, the double-rail, a 1-out-of-2 code, can be extended to a 1-out-of-n code. In a 1-out-of-3 code, for instance, there could be the numbers 001=1, 010=2, 100=3, and 000=N. The remaining four combinations may be treated as "don't care" conditions in the logic.

Another method is to design ternary (three-valued) circuits to accomplish the functions of the tables of Fig. 12. The main difficulty is in the inverter circuit, but the AND and the OR can be implemented with the usual diode circuits.

The remaining problem of designing an over-all asynchronous system with asynchronous building blocks is not well understood. This revolves around the unanswerable questions of additional cost and complexity relative to the average speed gain: indeed, the problem itself cannot be stated precisely.

Mixed Synchronous-Asynchronous Most Popular Systems Today

Mixed synchronous-asynchronous systems are the most common types today. Asynchronous coupling of the memory and input-output equipment allows the adaptation of a system to new and faster units without redesign or timing difficulties. Asynchronous adders may be used in synchronous systems by either stopping the clock until the finish signal, or by periodically strobing the finish signal, with a clock.

The adder, however, pinpoints the over-all difficulty of arguing either for or against asynchronous systems; to argue for either, we must compare the fixed computation times of synchronous systems with probability statements about average times of asynchronous systems.

Looking back over the techniques discussed, the essential contrast at all levels is between the techniques of synchronous design with pulse-width control and the techniques of asynchronous, level-circuit design. ■ ■

digital design

Matrix Memories— A Comparative Evaluation

There was a time when "matrix memories" meant ferrite cores. But now, a broad array of memory devices — proposed or actually available — can confuse all but those working very closely with memories. In an effort to show just where we stand — and where we may be tomorrow — authors Kevin Leenay (left) and Richard Petschauer present this article.

Rather than survey a very complex field exhaustively, they discuss only the most pertinent items — the memory devices which seem to have a reasonably good chance of appearing in practical systems. They start with the general considerations that apply to all matrix memories and conclude with specific evaluations of the most promising types.

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St. Paul, Minn.

WHILE workers are still searching for the single universal memory element and design concept, what actually is happening is that various classes of memory are being developed, each suitable for a particular application. For example, some recent large computers use two or three different types of random-access memories.

Many new ideas work well with only a few bits, but they present technical problems in large modules. Common difficulties encountered are noise, element nonuniformity, loss of stored information, or subtle interactions. Sometimes, though reasonably large modules operate well, a new concept is not developed further because of economic considerations or because it does not offer significant improvements over older techniques.

The random-access memory system most used today employs ferrite cores operated in the coincident-current selection mode. For many applications, this represents the best choice considering such factors as cost, speed, and capacity. However, since such a memory does have some limitations, there is considerable interest in different selection systems and elements.

STORAGE FEATURES

The characteristics of the storage medium used in a random-access memory greatly affect its general features. They also impose certain requirements on the circuitry in the memory system. Normally, some hysteresis property of the individual storage cell is used. This allows the energy state of the memory element to be stable in one of two remanent, or rest conditions.

It is desirable that the memory element maintain its state indefinitely, and, in so do-

Salient Features of Matrix Memory Elements

Element	Features
Ferrite Cores (Coincident-Current)	Readily available; least cost for large memories; for general purpose applications at 2 μsec or slower, best choice for at least several years.
Ferrite Cores (Word-Organized)	Raises speed barrier of coincident-current by a factor of about 5; increased selection costs.
Multiapertured Cores	Can provide NDRO in word-organized mode; larger and more costly than toroidal cores; relatively insensitive to temperature.
Thin Films	High speed switching; can provide NDRO; temperature insensitive; high bit density and mass fabrication capability; should be more available within a year or so; must be word organized.
Cryoelectrics	Good long-range potential, but considerable development must yet be done; high speed; high bit density; mass fabrication capability; coincident-current possible; cooling equipment needed.
Tunnel Diodes	Suitable for very high-speed, small memories; large memories not practical due to cost, power, and volume; components are available but not necessarily in best package for memory use.
Twistors	May find most application as semipermanent store which is potentially cheap even though word organized; rather bulky; availability unknown; medium speed.

ing, consume no power. Magnetic elements are one type of device that can do this. However, volatile-type memories, which lose their stored information after a certain period of time, have been used. Normally all the stored information is regenerated periodically in such a system. An example of a memory of this type is an electrostatic storage tube.

To sense the state of a memory element, excitation is typically applied in such a manner that a measurable response is obtained. The actual mechanism of readout can be either destructive or nondestructive.

Destructive readout (DRO) results in the selected bit being cleared out, so that the read operation must be followed by a write operation to regenerate the information if so desired.

With nondestructive readout (NDRO), the read excitation merely senses the state of the memory element without altering it. The advantages of a memory with NDRO are that there is no chance of a permanent change in the stored contents because of faulty readout or regeneration, and that no time or power need be expended to rewrite.

Storage Medium Should Be Fast, Reliable, Inexpensive

A storage medium should provide high speed, reliability, and relatively low cost. Several other factors are important. For example, high bit densities yield small, light memories which are important for some applications; they also minimize the propagation delay per bit. Reducing the delay is necessary if one is to take best advantage of any fast-switching capability of the storage device itself.

The degree of threshold, or sharpness of response of a memory element, regarding both its write-in and read-out properties is important, too. The threshold can greatly affect the memory-selection circuitry. Memory elements should operate at moderate power

levels with reasonable efficiency. That is, practical circuits must be used for address selection and writing and the output signals should not impose severe requirements on the read amplifier. Further, heat generated within the storage cell due to high losses may impair memory performance.

SELECTION SYSTEMS

Random access is fundamental to matrix memories. This requires that a set of elements, or words, be selected from the entire store in a fixed time, independent of the location of the desired word. The selection scheme used in a memory system can limit speed and capacity and can be an important factor in cost. Though matrix memories can be used in a serial computer, only selection systems that give parallel transfers to and from the memory are considered here.

Word-Organized Selection Uses Separate Driver for Each Word

Of the two common selection schemes—word organization and coincident current—the former offers more design freedom, a wider choice of memory elements, higher speed, and more readily obtainable nondestructive readout. But it does require more selection circuitry.

Coincident-current selection is less expensive and it uses fewer components, especially in large memories. It restricts the speed somewhat and requires more uniform storage elements and excitation pulses.

The word-organized selection system uses a separate driver, or gate, external to the memory matrix, for each memory word. A typical arrangement of a word-organized matrix is shown in Fig. 1. The word-select lines determine the memory word to be referenced; they carry pulses during write as well as read operations. The digit lines carry information pulses during a write mode, while the sense lines carry the output signals during a read mode.

Sometimes, one set of lines can serve both the sense and digit functions. While a small word-organized memory can easily be made in one plane, larger units usually employ some type of multiplane stack. In the stack,

Fig. 1. A word-organized selection system with four words of four bits each.

each word line is contained in one plane while sense and digit lines are connected in series from plane to plane.

Diodes, magnetic switches, or transistors are commonly used for the word gates. They usually act as two-input AND circuits and are connected in a rectangular matrix. This allows, for example, one of N^2 word gates to be selected by energizing one of N rows and one of N columns of the input lines.

Since an external gate is needed for each memory word, it is important that it be simple and economical. Detailed requirements of the word gate vary considerably depending on the memory elements and how they are used. Some of the pertinent factors are the required power, precision of word pulse, signal-to-noise ratio, and speed of operation.

The power required to drive the word line is normally not too high, since it links only as many bits as there are in a memory word. On the other hand, the power in some systems depends on the state of the memory elements. A typical ferrite-core memory of 36 bits per word might require about 500 ma at 7 v. For a comparable thin-film memory, the values could be 400 ma at 2 v. Since only one word gate is operated at a time, this would represent the total output requirements.

Sharp Element Threshold Simplifies Gate Design

A memory element with a sharp threshold permits more latitude in the gate design. The unavoidable leakage of the selection gates can be allowed to increase if the element's nonlinearity is high. A linear response to excitation can result in very noisy sense lines unless near-perfect gates are used.

While most memory elements have an adequate threshold, some memory systems have been suggested recently in which the memory

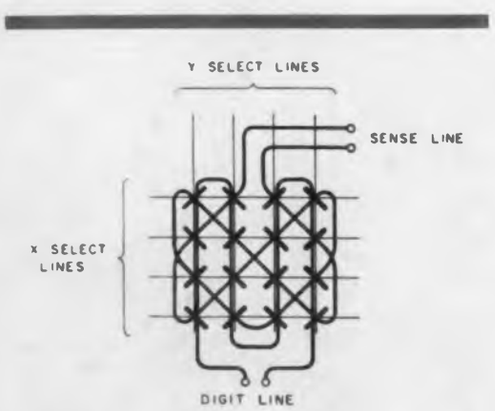


Fig. 2. A coincident-current selection system with 16 one-bit words.

element has no threshold. These systems require very high quality word gates or they must be restricted to rather small module sizes with short sense lines so noise cannot accumulate to large amplitudes.

The word gate is used efficiently for long memory words. One can sometimes take advantage of this fact and organize the memory so two or more words are driven in series, thus saving system components. For example, assume a 4,096-word, 36-bit memory is required. The direct approach would be to use 4,096 word gates, 36 sense amplifiers and 36 digit drivers. Another method would use 2,048 word gates (each driving two words in series), 72 sense amplifiers, and 72 digit drivers. Thus, at the expense of adding 72 data circuits, 2,048 word gates can be saved.

If the memory were an NDRO type the 36 data circuits would still suffice and only 72 switches would have to be added. The optimum configuration would depend on details of the memory system and the relative weight placed on word gates and digit circuits. The important point is that there is a means by which a trade-off can be made.

Word Organization Gives More Design Flexibility

The main advantage of a word-organized memory is that it allows more flexibility of design than does the coincident-current scheme. Usually, higher speed, or modes of operation otherwise unattainable can be achieved with less stringent requirements for uniformity in elements and excitations.

Some memory elements can be operated only if word organization is used. Sensing is also simpler because there is only one intersection between each word line and sense line. This allows ferrite cores, for example, to be operated with a smaller percentage of their total flux being switched. This increases switching speed and reduces back voltage and core heating.

X and *Y* Select Lines Pick Bits In Coincident-Current System

In coincident-current selection, the intrinsic gating action of the memory element performs what amounts to the last level of selection. A schematic arrangement of one plane of a 16-word coincident-current memory is shown in Fig. 2.

A 36-bit memory would normally contain 36 planes, each plane storing a given bit position for all the words. The *X* and *Y* select lines are connected in series through the stack, while the sense and digit lines are separate for each plane. In coincident-current operation, one *X* and one *Y* line is excited for either a read or write operation.

The storage elements do not respond to either excitation alone but only to the presence of both, simultaneously applied. Consequently only the bit which lies at the intersection of the excited *X* and *Y* lines is selected. The digit line carries an information pulse for writing, and the sense line picks up the output signal.

Two conditions must generally be met to allow coincident-current selection. First, the memory element must be able to respond with satisfactory discrimination, both regarding its stored information and its output response, to the equivalent of a 2:1 selection ratio. That is, it should respond to the currents it receives, simultaneously, from both *X* and *Y* lines, but it should not respond to a "half-select" current it may receive from either *X* or *Y* line alone.

Second, since many elements are common to each sense line, they will receive partial excitation during read time, so the system must insure that any small outputs arising from each element will not, for any stored pattern, add and produce false signals on the sense line. This latter effect is generally referred to as "delta-noise."

Some word-organized memories are called "coincident current," since writing may occur only if both a word pulse and digit pulse are present. In this case, the digit pulse actually carries an information current, rather than an address-select current. While it is true that this digit current does not affect the nonselected elements it drives, if the digit pulse did not carry information, separate gates per bit would be needed. This would be completely impractical for a large memory.

Coincident-Current Memory Requires Fewer External Gates

Since storage elements in a coincident-current memory take part in the selection operation, fewer external gates are needed. If a square matrix is used for each plane, N *Y*-select lines and N *X*-select lines will accommodate N^2 words of storage. That is, the number of selection gates required will equal twice the square root of the number of words. In the example used previously for a 4,096-word memory, only 128 selection gates would be needed. The precision of the pulse output of these gates as well as the power they deliver must be higher than those required for gates with word organization.

The higher power requirement results because the many partially selected elements driven by each select line generally absorb a certain amount of power. As an example, the power per selection gate for a medium-speed, 4,096-word, 36-bit core memory might be about 300 ma at 30 v. The current would have to be controlled to about 10 per cent, and the back voltage might vary about 10 per cent depending on whether all *ones* or all *zeros* were stored. Since two selection gates operate simultaneously, the total output requirement of the selection system is twice this value.

Coincident-Current Memory Offers Selection-Circuit Economy

The main advantage of coincident-current selection is the economy of the selection circuitry. This has allowed the design of large, practical, memory systems which can be made at reasonable cost and operated at fairly high speeds. The disadvantages of coincident current are that nondestructive readout, important for some applications, is difficult to achieve, and that certain problems tend to limit the speed.

For example, due to the 2:1 selection ratio, there is a limit on the overdrive a memory el-

ement can receive; therefore the time for it to be switched from one state to the other, or the time for readout, is limited. Also the increased delay of the longer select lines not only increases the access time but it can cause phasing problems within the memory. A coincident-current core memory can tolerate only a limited amount of partial switching because delta-noise becomes too large.

MEMORY ELEMENTS

The most common random-access memory today uses ferrite cores operated in the coincident-current mode. Though it represents the best choice available for many general-purpose applications, it does have definite shortcomings. Memory characteristics which should be improved for commercial applications chiefly involve higher speed, increased capacity, and lower cost. For random-access memories for military use one would also like nondestructive readout, lower power and weight requirements, and less sensitivity to environmental conditions.

Ferrite Cores

Coincident-Current Mode. Ferrite cores are widely available and relatively inexpensive if each one is considered as a separate component. Costs for the common types are about one cent per core. Memory-system costs for coincident-current operation run from about 10 cents to two dollars per bit depending on size, speed, and other characteristics.

Cycle times of about 2.2 μsec have been reported[2] and capacities up to 32,000 words are not uncommon. Readout is destructive and most cores are temperature sensitive, a change of 3 deg F being equivalent to about 1 per cent change in drive current. Some units have been reported recently which can be operated over a wide temperature range.[3] But they require increased drive currents and are somewhat slower.

Temperature-controlled stacks or automatic temperature compensation of drive currents can be used with normal cores to extend their useful temperature range. Ferrites are magnetostrictive, but they can usually be packaged to tolerate moderate shock and vibration levels.

The smallest core commonly used now has a 50-mil OD and a 30-mil ID and is about 15 mils thick. It can yield a density of 20 cores per linear inch with about 4 planes per inch. One manufacturer offers a stack which uses no interplane connectors and achieves about eight planes per inch. Smaller cores than the 50-30 size are available but they are more

costly and difficult to string. However, they are being considered for future designs.

The power required by a fast coincident-current core memory is quite large. For a fairly large 2.2 μsec memory, current pulses of about 600 ma at 60 v are needed. This not only poses problems in the design of the selection circuitry, but it can also cause troublesome core heating at high repetition rates.

Word Organized Mode. Word-organized core memories have been proposed for increasing the speed over that of coincident current.[4] These units would naturally cost more, requiring something like two diodes per word for selection, but they should operate down to a 0.5 μsec cycle time or lower.

Reasons for the higher speed are that more overdrive can be used on the word line, pulse shapes are not so critical, and only a small part of the core need be switched. This latter technique, called partial switching, is possible because there is no delta-noise problem in a word-organized memory (there is only one intersection between each word and sense line). Partial switching, minimizes core heating at high speeds and gives a somewhat faster mode of switching.

Two cores per bit have been suggested for a word-organized core memory. The idea is to operate them in such a way that the stored information depends on the difference of the stored flux in the cores. This yields a compensating action and allows switching of an even smaller amount of flux than if only one core were used. It has been reported that this technique may also allow NDRO, and may yield speeds down to 0.2 μsec cycle time for reading.[5]

Module size for a high-speed, word-organized memory will probably have to be smaller than for the slower, coincident-current units because long digit and sense lines produce a transient which tends to overload the read amplifier for a period of time. Also there are delays and selection problems associated with high speed. Initial applica-

Shockley TRANSISTOR unit of CLEVITE TRANSISTOR tests random samples of each day's production of type E diodes* at 100,000 G's. Mil-Specs normally call for just 20,000 G's. The extra G's prove that Shockley 4-layer diodes go far beyond the stresses they would encounter in any application. These tough, fast-switching 4-layer diodes are used in arming and squib firing circuits, alarm systems, high energy pulse circuits, memory circuits, relay driving circuits, logic matrices for airborne and portable radar, sonar, proximity fuses, encoders and decoders, communications equipment, missiles... Stanford Industrial Park, Palo Alto, California.

*type E diode: the new Shockley 4-layer, subminiature glass diode.

CIRCLE 37 ON READER-SERVICE CARD

CIRCLE 38 ON READER-SERVICE CARD FOR AMPHENOL-BORG ▶

Help stamp out close-quarter soldering

Miniaturization can be a mixed blessing. It's good when it conserves precious space and weight. It's bad when it creates a new gamut of how-do-you put-it-together problems.

Take miniaturized rack and panel connectors, for example. They must be small, lightweight and reliable. But many of them are tough to put together. Consider the plight of the worker whose job requires soldering 50 molded-in contacts in a space not much larger than an air-mail stamp. The job gets done, but when?

One way to unmix the blessings of miniaturization is, obviously, to stamp out this close-quarter soldering.

The same thought occurred to Amphenol designers. In fact, they asked themselves, "Why solder to contacts after the connector is assembled; why not terminate, then assemble?"

So, they designed the Min-Rac 17 ...the first miniature rack and panel connector with Poke-Home* contacts.

(To those who are not familiar with Poke-Home contacts—a brief exposition. Poke-Home contacts are so named because they are soldered or crimped to wires before the contacts are assembled to the connector. Contacts are then placed in the connector and pushed into the contact hole where they are firmly retained.)

►Although Poke-Home contacts were not new when Amphenol designers began work on the Min-Rac 17, the contacts were new to miniaturized applications. This spawned a few problems for Amphenol design engineers.

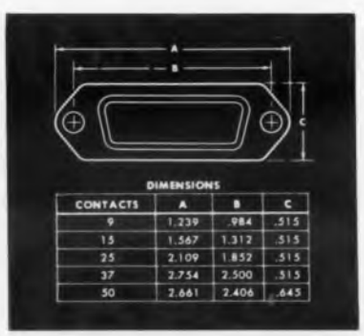
For instance: Working at contact spacings of .115 inch meant that extremely rigid molding tolerances had to be established. (Tolerances are held to ±.003" throughout the insert—some go down to +.001", −.000".)

Materials selection played an important part, too. A long and exhaustive study of over 100 phenolic resins and thermo-plastics conducted by the Amphenol Materials Laboratory convinced Amphenol designers that Zytel 101 offered the optimum combination of strength, insulation-properties, resilience, and weight savings. More testing, more evaluation followed. Strength tests. Insertion and withdrawal tests. Salt spray tests. Finally, the Min-Rac 17 was ready to go.

►How successful was all this effort? We can only judge by what our customers tell us. An equipment manufacturer on Long Island tells us that the Min-Rac 17 made a significant difference in his direct production costs—not to mention the fact that his reject rate took a nose-dive when he switched to the Amphenol Min-Rac 17. Another was most grateful that we had at last provided him with a way to get high-density crimped terminations into his equipment. (Imagine trying to crimp contacts by hand in a connector as small as the Min-Rac 17. Virtually impossible!) Still another customer in the San Francisco area is highly pleased with our float bushings, which allow him the leeway to correct for slight misalignment errors.

And so it goes.

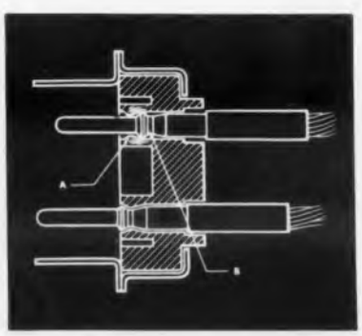
►To those in our audience who may wish additional information on miniature rack and panel connectors, we make this no-obligation offer. Get in touch with an Amphenol Sales Engineer or Industrial Distributor (if you're in electronics, you're not far from one). He will be most pleased to share his knowledge of the Min-Rac 17, and all Amphenol connectors for that matter, in the hope that a solution to your connection problem may be found. Or, if you prefer, write directly to Dick Hall, Vice President, Marketing, Amphenol Connector Division, 1830 South 54th Avenue, Chicago 5, Illinois.



DIMENSIONS

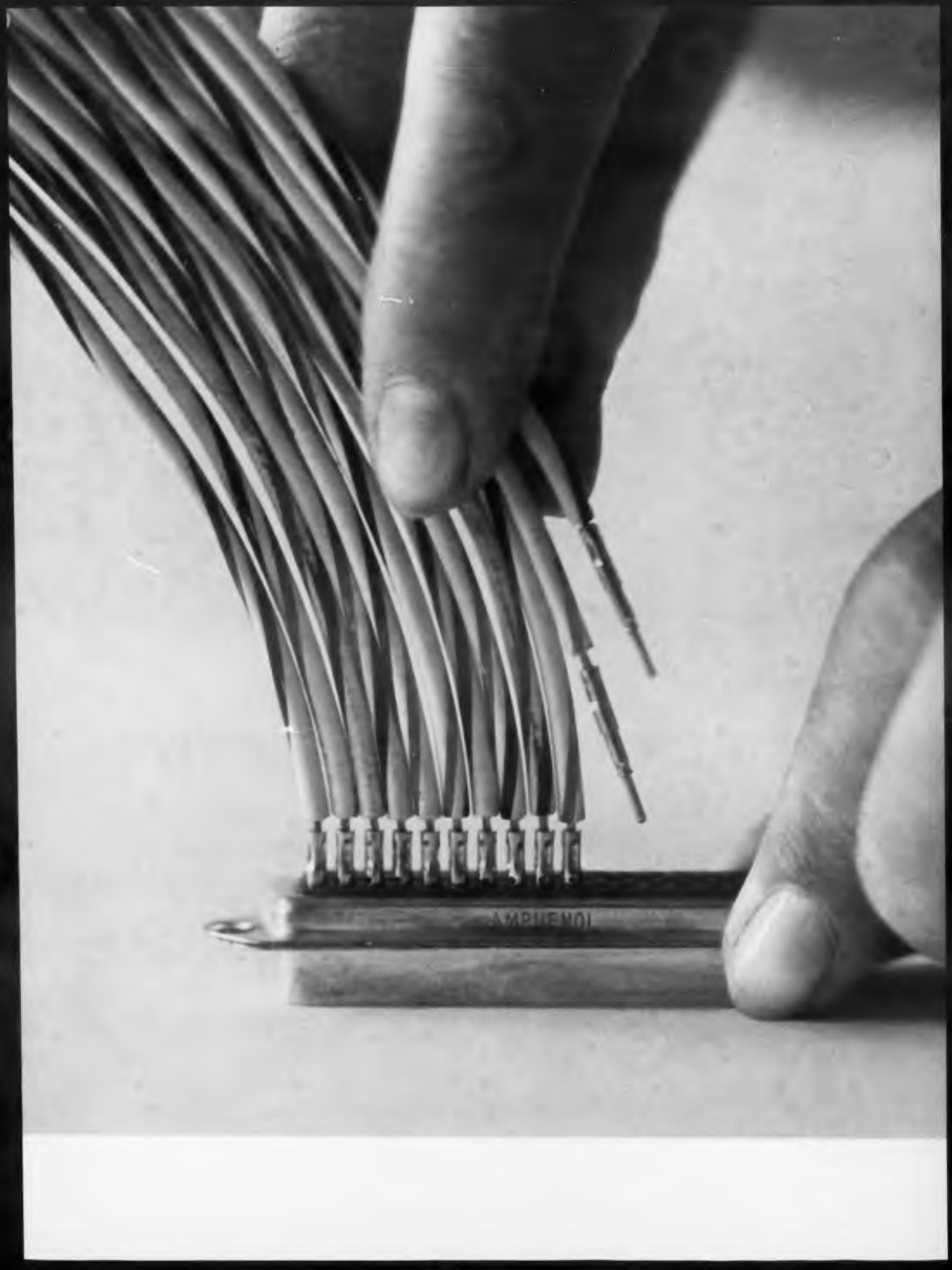
CONTACTS	A	B	C
9	1.239	.984	.515
15	1.567	1.312	.515
25	2.109	1.852	.515
37	2.754	2.500	.515
50	2.661	2.406	.645

The Min-Rac 17 is designed to mate with other popular miniature rack and panel connectors. Therefore you can immediately apply the advantages of Poke-Home contacts to your present equipment without tooling expense.

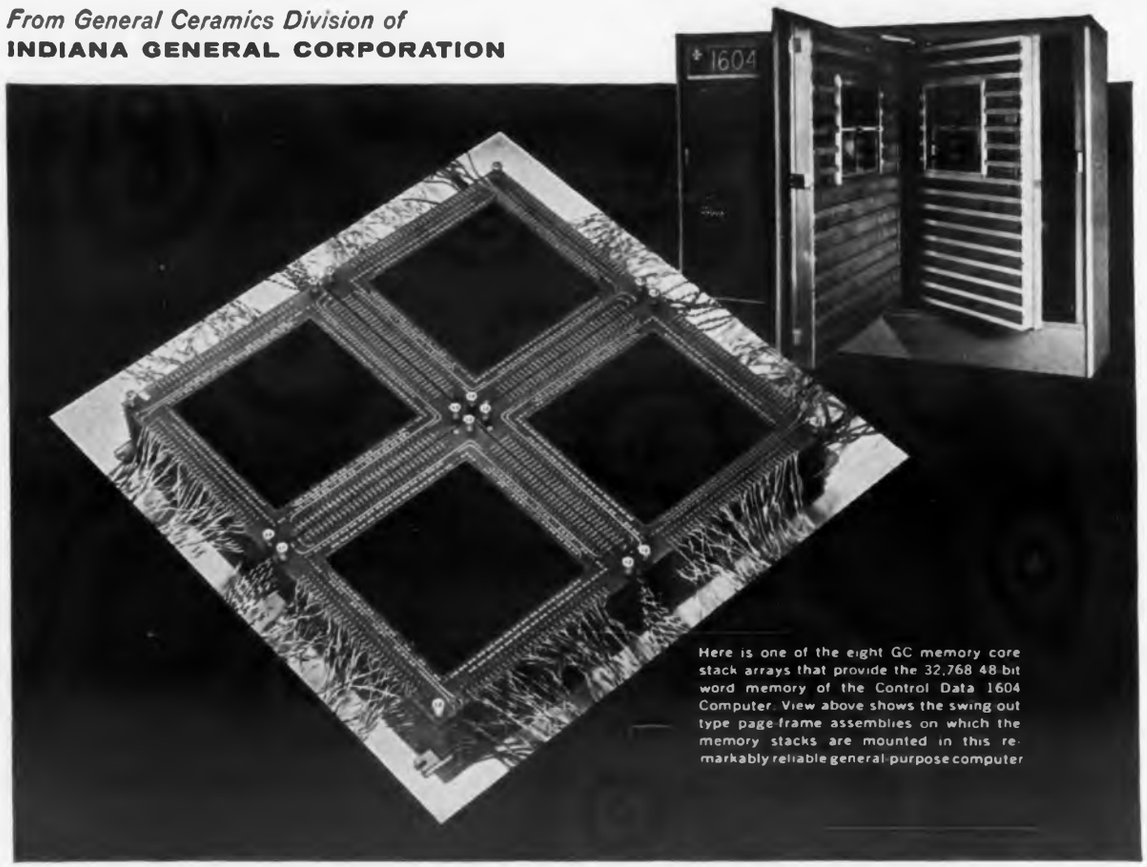


Poke-Home contacts "stay home" because of the precision-molded shoulder (A) and the groove (B) around the contact barrel. Although Poke-Home contacts are held firmly in place, they can also be easily removed if necessary.

AMPHENOL **Connector Division** / Amphenol-Borg Electronics Corporation



From General Ceramics Division of
INDIANA GENERAL CORPORATION



Here is one of the eight GC memory core stack arrays that provide the 32,768 48-bit word memory of the Control Data 1604 Computer. View above shows the swing-out type page-frame assemblies on which the memory stacks are mounted in this remarkably reliable general-purpose computer.

Reliability that Helps the **Control Data** 1604 Computer Achieve

"UPTIME" RATINGS THAT MEAN PROFIT

General Ceramics, the originator of the square loop ferrite, offers a complete line of job-proven cores, planes, stacks and memory systems — proven in many computer and control system applications where the ultimate in reliability is demanded.

A good example is Control Data's advanced, large-scale, solid state 1604 Computer which has set new reliability standards for the industry, maintaining one of the highest over-all average "uptime" ratings ever achieved for machines in its class. This high performance requires fail-proof output from every component, including the over 1.6 million GC cores wired into the memory stacks of the 1604.

According to W. F. Harrison, Control Data's Manager of Engineering Services, "GC was chosen on the basis of a careful evaluation which included criteria ranging from the supplier's reputation and background through his proven ability to produce required quantities with consistent quality."

General Ceramics reliability is assured through 100% quality control at all levels — beginning with mechanical and electrical testing of each individual core and continuing with both visual and electrical inspections at all stages of assembly. This means, for example, the meticulous microscope-checking of over 175,000 soldered connections alone in the eight banks of stacks used in each Control Data 1604 Computer.

Advanced techniques such as ultrasonic cleaning, automatic 12-per-second core testing and other electronic functional checks performed on specifically designed equipment provide that extra edge of quality which customers, such as Control Data Corporation, have come to expect from General Ceramics.

Compare GC with your present source — write, wire or phone today.

DIVISION OF INDIANA GENERAL CORPORATION

MEMORY CORE PRODUCTS DEPARTMENT

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TECHNICAL CERAMICS, FERRITES AND MEMORY PRODUCTS

CIRCLE 39 ON READER-SERVICE CARD

tions will probably be for small- to medium-capacity memories with cycle times of about 1.0 μsec.

Ferrite Apertured Sheets

Ferrite apertured sheets, rectangular plates of ferrite material containing arrays of holes, each representing one bit position, were originally proposed as a technique to reduce the cost of ferrite memories.[6] The idea was to fabricate an array of many bits in one operation and to use techniques which would allow one to print the wiring directly on the sheet. For the first few years, uniformity problems were encountered, but recently, workable units have been demonstrated.[7]

The general characteristics of a memory using these will be similar to those of a core unit, but the bit density will be somewhat higher. Though the cost of the plates at present is not lower than that of cores, lower cost potential is inherent in these devices. The outcome will depend on the yield obtainable and the extent to which manufacturers develop automatic production and testing equipment for them.

Multiapertured Cores

Multiapertured ferrite devices, operating in a coincident-flux mode, rather than coincident-current, were first suggested as a means of achieving higher speed and nondestructive readout. Today they are available from several sources.

The most widely mentioned practical embodiment is a two-hole device or Transfluxor.[8] Its most significant advantages seem to be the NDRO capability, and ability to operate in a mode which is relatively insensitive to temperature. The latter is because operation depends more on the geometry of the device than on the characteristics of the material.

Coincident-current modes for multiapertured cores have been suggested, but some are quite complex and they require separate selection lines for reading and writing. Controlling the delta-noise also seems to be a problem. Rather straightforward word-organized modes are possible. The highly nonlinear output-vs-drive response allows the use of a simple word gate. One form of the multiapertured ferrite, with orthogonal rather than parallel holes,[9] can be used for

REC's new literature on temperature and pressure sensors and accessory equipment

If you have anything to do with the accurate measurement of temperatures or pressures, there is information of value to you in this collection of REC technical literature. Check the list below and send for the items that interest you.

Platinum Temperature Sensors

7617 Immersion Temperature Sensors

Air Data Sensors

7597 Model 102 Series Total Temperature Probes

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CIRCLE 41 ON READER-SERVICE CARD

NDRO but it gives a linear output response and requires a high-quality gate to limit sneak currents.

Multiapertured cores, in the word-organized mode, should provide a means of achieving NDRO at cycle times of about 1.0 μsec. These devices are larger than toroidal cores, more costly, and probably somewhat more difficult to test and string.

Thin Films

Several years ago, the use of thin magnetic-film elements, deposited on suitable substrates was suggested for computer storage.[10] Such elements enable fast rotational switching and fabrication in multibit arrays. In addition, rather than threading wires through individual elements, one could use thin multilayer etched circuits, in close proximity to the film arrays, for drive and sense windings. Early work centered around a coincident-current mode of operation.[11]

Principal problems encountered were nonuniformity of film spots and crosstalk from drive to sense lines. Improved fabrication and design techniques and word-organized modes of operation have now circumvented these problems.[12, 13]

Word-organized film memories normally do not need accurately controlled drive pulses. They can be used in either the DRO or NDRO mode. In the DRO mode, a relatively large field, transverse to the preferred axis of magnetization (which lies in the plane of the film and is established during fabrication), is passed down the word line.

This allows a relatively small longitudinal field on the digit line to steer the magnetization vector so that, when the word current is removed, the magnetization will fall back to a remanent state determined by the polarity of the digit current. The Univac 1107 computer uses a 128-word, 36-bit memory of this type which has a 0.67 μsec cycle time.

For NDRO applications, Univac has de-

veloped the BICORE film-element array which uses two film cores per bit, deposited in a multilayer fashion. One of the cores is a high-coercivity alloy that stores the information and controls the state of the other, a low-coercivity alloy used for readout. A 1,024-word, 36-bit memory using this technique has been operated at a 1.5 μsec read cycle time.[13] It allows wide read-current variations and does not require a high-quality word gate.

Future film-memory design can be expected to make more use of the inherent advantages of film arrays:

1. Fabrication ease—memory arrays and etched windings can be fabricated by a batch process which should provide low cost and high bit density.
2. Fast switching properties—1 nsec is about the theoretical limit that has been demonstrated in the lab while 10 nsec is not difficult to achieve with proper drive currents. Low drive power, high bit density, and strip-line drive techniques also fit in well with high-speed operation.
3. Insensitivity to environment—films can be made with nearly zero magnetostriction. They have a Curie temperature of about 500 to 600 deg C.

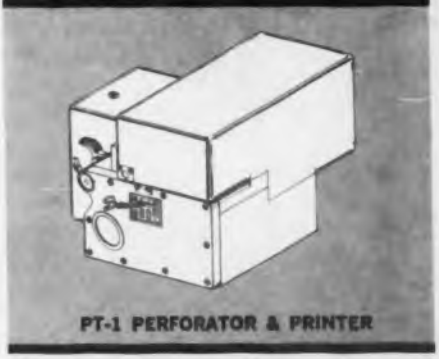
The principal disadvantages of films are the need for word organization, and the small output signal which requires careful design to eliminate crosstalk problems. Films also require magnetic shielding unless their position in the earth's field is fixed.

Most companies doing work with film memories fabricate their own arrays by vacuum deposition or electroplating. One firm sells 8 x 20 arrays measuring about 3 x 4 in. which seem suitable for destructive readout operation. For large memories and lower cost, higher bit density is desirable. Memories with 100 bits per in. have been reported,[12, 13] and 500 bit-per-square-in. arrays are under development.[14] Within the next few years, film memories of up to several thousand words with speeds of 0.1 μsec or less will probably be available.

Cryoelectric Elements

Superconducting or cryoelectric devices offer considerable promise. They can have the high switching speed, high bit density, an suitability for multibit arrays of thin films. The approach that offers most promise consists of multilayer deposition of metals and insulators. Some of the metals act as drive and sense lines, or as shields, while others store the information by being in either

Superb Engineering Achievements



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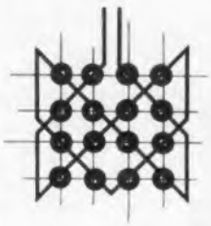
CIRCLE 44 ON READER-SERVICE CARD



digital design

the conducting or superconducting state. Early problems involved obtaining uniformity and satisfactory insulators. Experimental units have been successfully made recently, and most of the basic problems have apparently been solved.[15, 16]

Two of the practical problems of superconducting devices are their need for auxiliary cooling equipment and their low characteristic impedance. The long-range implication of this may not be significant; but it does require that a relatively large section of the memory be fabricated in one process so thermal and electrical interfaces are kept at a minimum.

No cryoelectric memory components are available for sale now. But the technique is regarded as having considerable potential. The extent to which it will be used will depend on the specific technical details and cost of fabrication as they will be several years from now.

Twistors

The Twistor is a relatively novel device that can store many bits along a continuous medium.[17] In its most common form it is made by spiraling a flat permalloy ribbon along a thin copper wire. The permalloy ribbon stores information, while the copper wire serves as the sense line and digit line. In one design a continuous Twistor wire stores 512 bits at a density of 4 per in.

Twistors are word-organized memories that typically use inexpensive biased-core switches for word gates. A flat copper strip forms a one-turn solenoid which passes around the Twistor wires for the word line.

Twistor systems have been made both as variable (DRO) and semipermanent (NDRO) memories. The advantage of the variable type is that it may be cheaper than a ferrite-core, coincident-current memory; it is not expected to give better performance.

However, there have been nonuniformity problems with the permalloy as well as sensing difficulties due to the common sense and write line. If these problems limit the size of the basic module, the need for additional sense amplifiers may unduly increase costs.

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105-301 to -313
(Patent Pending)

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105-601 to -613
(U. S. Pat. No. 2,704,357)

DELUXE TIP JACK—Molded nylon body with recessed silver-plated machined beryllium copper contact. Hot tin dipped solder terminal. Current rating: 10 amps. Voltage breakdown: 11,000 volts DC. Capacity to ⅛" panel: 2.0 mmf. ¼"-32 nut furnished.

105-801 to -813

STANDARD TIP JACK—Molded nylon body with recessed, silver-plated formed phosphor bronze contact. Current rating: 10 amps. Voltage breakdown: 9,000 volts DC. Capacity to ⅛" panel: 2.0 mmf. ¼"-32 nut furnished.

105-701 to -713

JACK AND SLEEVE—Includes Deluxe Tip Jack (105-601 to 105-613), less mounting nut, with inside threaded molded nylon sleeve. Ideal for patch cords, or insulated rear connection of panel mounted tip jack.

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105-251 to -263

STANDARD METAL-CLAD TIP JACK—Nylon body, nickel-plated machined brass jacket. Formed, silver-plated phosphor bronze contact. Current rating: 10 amps. Voltage breakdown: 7,000 volts DC. Capacity to ⅛" panel: 3.8 mmf. ¼"-32 nut furnished.

105-201-200 to -213-200

MILITARY METAL-CLAD TIP JACK—Complies with MS-16108 of MIL-STD-242A. Heavy nickel-plated brass jacket. Silver-plated, machined beryllium copper contact. Current rating: 10 amps. Voltage breakdown: 8,000 volts DC. Capacity to ⅛" panel: 3.8 mmf. ¼"-32 nut and lock washer furnished.

105-101-200 to -113-200 Like above, lower price. Formed contact. Voltage breakdown: 5,000 volts DC.

108-301 to -313
(Patent Pending)

BANANA PLUG—Molded nylon sleeve. Body and pin constructed of one-piece, nickel-plated brass with high grade nickel silver spring. For solderless connection of up to 16 gauge wire. Current rating: 10 amps.

108-201 to -213
(Patent Pending)

DUAL BANANA PLUG—High quality nickel silver springs—bodies nickel-plated. Machined brass studs extend full length of pins. Solderless connection up to 16 gauge wire. Polarity indication and strain relief hole. Voltage breakdown: 10,000 volts DC. Capacity plug-to-plug: 1.3 mmf. Current rating: 15 amps.

108-901 to -913

BANANA JACK—Molded nylon body with recessed cadmium-plated insert. Accommodates .175" dia. plugs. Voltage breakdown: 12,500 volts DC. Capacity to ⅛" panel: 2.4 mmf. 5/16"-32 nut furnished.

111-101 to -113
(U. S. Pat. No. 2,806,999)

BINDING POST—Nylon body, silver-plated brass shank. Self-captivated thumb nut. Insulation resistance greater than 200 meg. after MIL-T-5422B humidity test. Voltage breakdown: 8,000 volts DC. Capacity to ⅛" panel: 3.3 mmf. Current rating: 15 amps.

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The semipermanent Twistor provides NDRO operation, but it is not alterable electrically. Cards containing an array of small rectangular bar magnets are placed close to the Twistor. If a particular magnet is demagnetized it does not affect the bit it is associated with, so a double-polarity word pulse switches and restores the bit and induces a signal on the central sense wire.

If the magnet is switched to a remanent state, its external field is sufficiently large to bias off the permalloy next to it so no readout is obtained. The material requirements of this type of Twistor are not very severe and no write-in circuitry is required. It therefore has a good chance of being relatively inexpensive in some applications.

Twistor memories can be expected to have about the same speed range as coincident-current, ferrite-core memories. The physical volume they occupy is larger while temperature range of operation is similar to that of cores. Magnetic shielding should be used with Twistors for maximum reliability. Availability of these devices is not known.

Tunnel Diodes

The last year has seen considerable interest in the use of tunnel diodes as memory elements.[18] Bistability and nanosecond switching are not difficult to achieve. While dc holding power is needed to maintain the state of these elements, designs achieving as low as 1 mw per bit have been reported.[19] The principal disadvantage of this type memory is that generally two resistors and a tunnel diode are needed per bit and the costs of the units are relatively high for memory elements. Diodes are readily available, though not necessarily in the optimum case design.

The tunnel diode seems to offer a practical approach for achieving a very fast, small memory for special applications. Units of up to 100 words operating at cycle times of 25 nsec seem possible, but larger sizes can be expected to operate at somewhat slower speeds. Word capacities of greater than 1,000 words do not seem too attractive because of cost, reliability, packing density, and fabrication factors.

Rods

Electroplated memory elements in the form of rods have been suggested and experimental units have been demonstrated.[20] There are two basic types: one has a closed toroidal flux path while the other has an open flux path, the easy direction being par-

allel to the axis of the rod. The former type is similar to the Twistor while the latter has magnetic properties much like those of the thin film. These items are apparently not available to any large extent.

It is not known what advantages these devices offer over more developed ones, except possibly lower cost potential. Consequently, their future role as a memory element is difficult to predict.

Ferroelectric Elements

Almost 10 years ago, ferroelectric memory elements, exhibiting hysteresis properties, were suggested for storage. However, various problems prevented their operation in a practical system. Creeping, or loss of stored information when partial-select voltages were applied and lead fatigue were the most serious difficulties. Some research in this area is being done, but no significant breakthroughs have been announced.

Ferroelectric memories would have to be word organized due to sneak paths and sensing problems. If the problems were solved, ferroelectric elements might provide very high bit density, but some type of miniature word-selection gate would be needed to take full advantage of the small size. Switching times would probably not be too fast.

Special Devices Can Serve For Read-Only Memories

In an application where writing is done very infrequently, it can be done in a mechanical way, if some advantage such as low cost, small volume, or improved reliability results. The semipermanent Twistor is one such device, and other ways of doing this have been suggested. All of these inherently give nondestructive readout.

The earliest version used arrays of toroidal cores with the information "wired-in." This allows each core to store several bits with attendant volume savings. More recently, other devices have been suggested, among them, the Unifluxor,[5] a device in which the stored information is in the form of a specific pattern on a copper sheet, placed near a set of drive and sense lines. Output voltages result from unbalanced induced currents. Other devices include a card memory

which uses capacitive coupling, and an array that uses ferrite slugs that can be positioned at the intersections of drive and sense lines to produce output voltages.[22]

Using these latter devices, the designer must be careful because all of them have a linear response function which can result in unwanted cross couplings for certain stored patterns. In addition, sneak outputs from nonselected word lines can produce outputs along a common sense line. These can accumulate and result in a signal larger than that obtained from a stored "one." ■ ■

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Cyclic Memories—A Comparative Evaluation

Part 1 (Volatile Memories)

So rapidly are advances made in cyclic memories that one must virtually race ahead to stand still. No one, perhaps, is more conscious of this pace than author Lubkin. In an effort to keep his article timely, Mr. Lubkin repeatedly had to telephone changes to his editor so his already completed article could be updated.

Part 1 of his article, which appears here, covers volatile memories. The concluding part, to appear in ED, Sept. 13, will cover nonvolatile memories.

Yale Jay Lubkin
Loral Electronics Corp.
The Bronx, N. Y.

A CYCLIC memory stores information continuously. But it provides access, for reading or changing any piece of stored information, only at multiples of a fixed time called the cycle time.

Cyclic memory was not used in the first electronic computer, the Eniac, which was ready for use in 1945, but the second computer, the Edsac, ready in 1949, used a cyclic memory, and cyclic memories have been in general use in computers ever since.

Cyclic memories are popular because of their simplicity and low cost per bit stored compared to the more flexible, random-access memories, and because of their short access time compared to bulk memories like magnetic tape and punched cards.

Two Basic Cyclic Memories: Volatile and Nonvolatile

There are two basic types of cyclic memories—volatile and nonvolatile. Volatile memories lose their information if power is interrupted; nonvolatile memories do not. For this reason, volatile memory is seldom used for large amounts of storage, though earlier machines used such memories almost exclusively. In general, volatile cyclic memories appear as recirculating delay lines or shift registers, and nonvolatile memories appear as permanently recorded magnetic drums, disks, and tape loops.

The simplest form of cyclic memory is the dynamic flip-flop. It is a one-bit recirculating register whose output is zero when the flip-flop is reset and whose output is a train of pulses when the flip-flop is set.

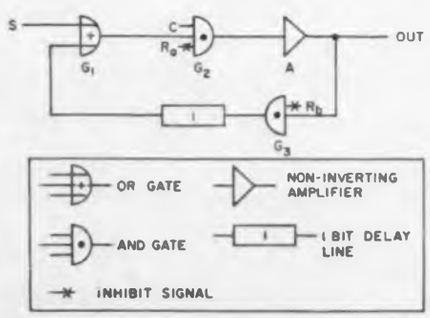

Fig. 1. The dynamic flip-flop is the simplest type of cyclic memory. Its storage capacity is determined by the length of the delay line in the recirculation loop.

Dynamic Flip-Flop Is Simplest Volatile Memory

Operation of the dynamic flip-flop can be followed by reference to Fig. 1. Consider the flip-flop as initially reset, i.e., it produces

zero output. A set pulse S passes through the OR gate $G1$ to the AND gate $G2$. If the clock pulse C is present, and an inhibiting reset pulse R_a is absent, the set pulse will be amplified by amplifier A.

The output of A is in phase with its input and a portion of the output goes to the feedback gate $G3$. If the reset pulse R_b is not present, the feedback signal will go to the one-bit delay line and will then act as a set signal for the flip-flop since it arrives at $G2$ just in time to catch the next clock pulse. As long as neither R_a nor R_b is present, the pulse will continue to circulate.

The presence of either R_a or R_b is normally sufficient to halt recirculation. If R_a is present, $G2$ will be closed and pulses will not get to the amplifier. The flip-flop output will immediately fall to zero and will remain at zero as long as R_a is present. This mode of operation is called reset dominated, since if set and reset signals are present simultaneously the flip-flop will be reset.

The flip-flop can also be reset by the presence of R_b. In this case, R_b inhibits the feedback pulse and thus stops the flip-flop from recirculating. Action here is set dominated, since simultaneous presence of set and reset pulses will set the flip-flop.

It is possible, of course, to be set dominated with respect to some signals and reset dominated with respect to others. This action is not possible with a multivibrator-type flip-flop, since simultaneous application of set and reset pulses results in an ambiguous situation. If operation in only the reset-dominated mode is required, then $G3$ may be eliminated.

Delay Line Determines Flip-Flop's Storage Capacity

The requirements on the delay line in Fig. 1 are modest. The delay should be about 80 per cent of the time between pulses; the rise time should be less than a quarter of the time between pulses; the attenuation should

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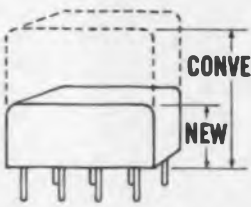

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CIRCLE 53 ON READER-SERVICE CARD

be minimal; and the impedance should be chosen to match the circuit. Lines meeting these characteristics have delay times ranging from about 50 nsec to 10μsec. They cost a few dollars each.

By increasing the length of the delay line, one can expand the storage capacity of the dynamic flip-flop. If the delay line is five bits long, for instance, a set pulse will produce a train of pulses separated by five clock times. Other set pulses can be used at different times, and the flip-flop can store five bits of data in the delay line. The flip-flop then becomes a five-bit recirculating register.

Electrical delay lines are convenient for storing a modest number of pulses, but delay, and hence the number of bits stored, cannot be made to increase without limit. Practical limits are set by the cost and size of good-quality lines and by the inability of many manufacturers to turn out delay lines with very high ratios of delay to rise time.

A more efficient way to build a long delay line is to connect a number of moderate-quality lines in series, with reshaping and retiming circuits between them. The Ordfiac (1954), built by the Electronic Computer Corp. for the Army Ordnance Corps, used a number of 40-bit registers built in this manner.

While electrical delay lines are convenient for storing a small number of bits, there is no need to restrict oneself to them. Any device which serves as a delay line can be used as the storage medium in a recirculating register, and many have been tried.

The early electronic digital computers (Edsac, Edvac, Seac, Binac, and Univac-I) used mercury acoustic delay lines for main memory. The lines were used as recirculation registers, basically as in Fig 1, except for gain and reclocking at the output, and additional controls.

Mercury Lines Had Advantages But Now Are Obsolete

Since sound travels in mercury at a rate of 145 cm/msec, a mercury delay line of modest physical dimension can provide quite adequate time delays. The bandwidth of a mercury delay line is limited by the transducers at the ends of the line and by the properties of mercury, but it can be made

about 5 mc wide, so a sizable number of pulses can be stored in a physically short line.

The transducers are comparatively easy to design and to match to the mercury, and mercury is a readily available medium, so the early popularity of mercury lines is understandable. At the present time, however, mercury lines are obsolete.

The factors leading to the demise of mercury lines are all related to the properties of mercury and not to the soundness of the delay-line approach. Mercury lines can be transported only with difficulty because waves in the mercury can set up shocks which will destroy the piezoelectric crystals used to convert between electrical pulses and sound waves. Mercury is poisonous; it contaminates easily; it is heavy; and it has a large temperature coefficient of velocity—about one part in 3,000 per deg C.

If a mercury line is to store 1,500 bits, the temperature of the line must be known to better than a degree, and probably better than half a degree, to prevent the effective line length from changing by one bit or more from the nominal value. This means that elaborate precautions must be taken to insure constant temperature, and it implies a high cost per bit stored.

Quartz Lines Use Faceted Slabs For Space Economy

Almost as soon as lines were conceived using mercury as the delay medium, the search was on for better materials. Several that fell by the wayside were magnesium, water, and water-ethylene glycol mixtures. One successful medium is fused quartz. It is strong, stable, and relatively inert. It is a solid, so it is easy to handle, and it is relatively nonpoisonous.

Also important, its temperature coefficient of delay is only a third that of mercury so three times the number of bits can be stored on a quartz line with a given temperature regulation. Since quartz is a solid, the shear mode of operation can be used—with less design problems than with the longitudinal mode used with liquids. Quartz is also useful for mobile applications since it is quite insensitive to shock and vibration.

One disadvantage is the high velocity of sound in quartz, about 540 cm/msec, or nearly four times the velocity in mercury. This means that a linear delay line of a given delay will be four times as long, physically, in quartz as in mercury.

Modern quartz lines avoid this difficulty by using a flat slab with faceted sides. They

INTRODUCING THE

VIDEOGRAPH

MODEL 980 CHARACTER GENERATOR

A low-cost, off-the-shelf "machine language" decoder compatible with any digital system

New from A. B. Dick Company electronic laboratories . . . a compact decoder (5¼" high x 17" deep x 19" wide) that nests in one cubic foot of space. Priced for production applications.

The Model 980 receives digitally coded signals and converts them to readable alphanumerics at speeds up to 20,000 characters per second—in any size, style or type font. Output can be displayed on any conventional CRT; standard rack mounting construction keeps intercabling to a minimum.

The Model 980 decoder also incorporates highly advanced electronic circuitry and component design. Use of transistors assures lasting reliability; printed circuit boards are highly accessible, readily removable.

For further information and specifications, contact: Mr. G. T. Gerlach, Marketing Manager, Videograph Data Presentation Systems, A. B. Dick Company, 5700 West Touhy Avenue, Chicago 48, Ill.

A. B. DICK COMPANY ELECTRONIC RESEARCH LABORATORIES. CHICAGO, ILL. - PALO ALTO, CALIF.

A·B·DICK
ELECTRONIC DATA PRESENTATION

Videograph is a trademark of A. B. Dick Company

CIRCLE 55 ON READER-SERVICE CARD

use multiple reflections to increase path delay length without increasing the size of the line. An example of a modern quartz delay line is shown in Fig. 2 while Fig. 3 shows a typical bounce pattern for a 2,778-μsec quartz delay line.

Coiled Acoustic Wire Lines Offer Long Delays

Probably one of the best of the sonic delay lines is the acoustic wire. Since the cross-section of the delay material has little effect on most desired characteristics of a memory line (delay per unit length, bandwidth, and delay stability), a designer interested in minimal bulk will try to minimize the cross-section. Such an approach is impractical with liquids, like mercury, and with brittle solids, like quartz. But it works well when the delay medium is a metal.

The use of wire leads to other advantages, too. The wire can be coiled, with negligible effect on its electrical characteristics when torsional-mode propagation is used.

Since signals are propagated on an acoustic line as sound waves, some means are required to convert electrical pulses to acoustic pulses. Both mercury and quartz lines use the piezoelectric effect for this purpose, but piezoelectric crystals couple poorly to wires.

The magnetostrictive effect, however, works well, and nickel-wire lines have been

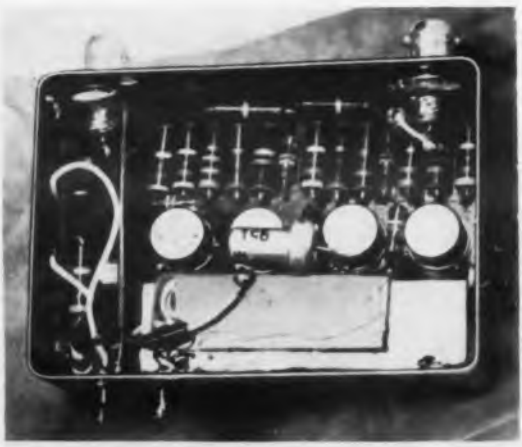


Fig. 2. This quartz delay-line memory manufactured by Andersen Laboratories can store 65 bits at a 10-mc counting rate. Access time is less than 4 μsec.

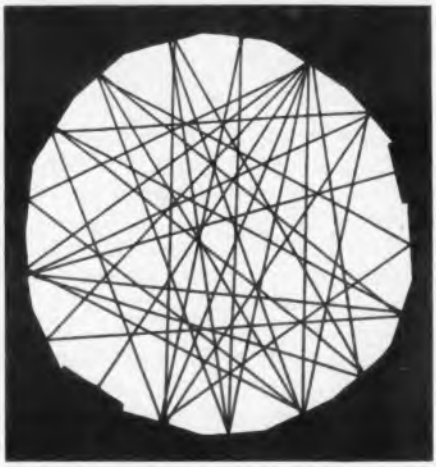


Fig. 3 A typical bounce pattern in a 2,778-μsec quartz line.

made for some time, since nickel is one of the best magnetostrictive metals. Some titanates have higher magnetostrictive coefficients but they are hard to couple to.

The nickel line has a velocity of about 520 cm/msec, just about the same as quartz. Bandwidth, (limited by the launch mechanism) is a few megacycles, which is adequately high. The temperature coefficient of delay is about one part in 40,000 per deg C, less than a tenth that of mercury. Many pulses can be stored on a line without elaborate temperature control.

The delay medium and the transducers need not be the same. Thus, nickel need not be used as the delay medium, and an alloy can be found with substantially zero temperature coefficient.

Standard wire lines are available at prices ranging from about $75 to $600 depending on line length, temperature coefficient, adjustability, environmental specifications, bandwidth, and quantity. Standard lines are available with temperature coefficients of one part in 100,000 and lines are available with coefficients of less than one part in a million. This level of temperature stability suggests that 5,000-bit, acoustic-line, recirculation registers can be used over a temperature range of −70 to +100 C with no temperature control.

Other Acoustic Registers In Advanced Design Stages

Several other forms of acoustic register are in advanced design stages, including glass lines with 10^{-6} temperature coefficient,*

*The commercial availability of these glass lines has just been announced by the Corning Electronic Components Dept. of Corning Glass Works. See *ED*, Aug. 16, p 56.

Rockbestos Firezone Aerospace Wire Resists Jet Engine Heat in B-52

Rockbestos Firezone Type 101 Aerospace Wire is used for power and control circuits in the B-52 jet bomber, renowned for its high performance and dependability.

Dependability is designed into Rockbestos Aerospace wire too. In jet aircraft Rockbestos Wire resists the high temperatures around engine and afterburner sections. It is also used for high impedance circuits in guided missiles.

Standard Rockbestos Aerospace wires cover a temperature range from 257 F to 750 F. Many special wires have been produced to operate at even higher temperatures. In addition to high temperature aerospace wire, Rockbestos supplies hook-up wire, coaxial cable, and ground support cable.

For complete information on Rockbestos Aerospace Wire & Cable write for Bulletin.

ROCKBESTOS WIRE & CABLE CO.

DIVISION OF **CERRO CORPORATION**

MAIN OFFICE AND FACTORY: Nicoll and Canner Streets, New Haven, Conn.

CIRCLE 58 ON READER-SERVICE CARD

NEW G-E "WEDGE BASE" LAMP SAVES SPACE, SAVES MONEY, SAVES TIME, SAVES MANPOWER

The new "Wedge Base", all-glass, incandescent indicator lamp is an exclusive G-E development designed to replace the old #57 and other similar bayonet-based lamps. It's available in 6.3 and 12 volts. See below.

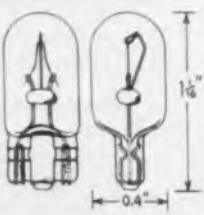
The Wedge Base saves space because, with its holder, it is considerably smaller than the old #57. It saves money because the holder and total installation costs are less. It saves time because the holder is easier to install and the lamp can be seated with just a push. And it saves manpower because installation can be automated and holders can be molded into plastic circuits. The G-E Wedge Base lamp can withstand ambient temperatures up to 600°F because it has no basing cement.

A major automobile manufacturer is already using G-E Wedge Base lamps; they're available in mass quantities. For more information write: General Electric Co., Miniature Lamp Department M-12, Nela Park, Cleveland 12, Ohio.

The Wedge Base is available in two ratings

G.E. Lamp No.	158	159
Circuit Volts	12	6.3
Amperes	0.24	0.15
Design Volts	14	6.3
Rated Av. Life at design volts	500 Hrs.	*
Filament	C-2V.	C-2R
L.C.L.	½"	½"
Bulb	T-3¼	T-3¼
Base Type	Wedge	Wedge
Candlepower	2	35

*In excess of 5000 hrs. at 6.6 volts



Progress Is Our Most Important Product

GENERAL ELECTRIC

CIRCLE 59 ON READER-SERVICE CARD

and various forms of quartz line designed to reduce bulk and cross-coupling between reflections.

One novel approach uses an ultrasonic, photoelastic, delay medium where the stress caused by an ultrasonic wave produces a varying birefringence in a glass bar. This line has continuously variable delay. Readout is photoelectric.

Though acoustic wire lines would seem to be ideal media for recirculating registers, the vast majority of recirculating registers do not use any kind of delay line as the storage medium, but use a portion of a rotating magnetic drum or disk. The comparison is a little unfair, since magnetic registers are not normally used as main memories of computers, while acoustic lines are.

The magnetic recirculation registers have two overwhelming advantages in many systems: they can have substantially zero temperature coefficient, and they can be readily implemented, without additional equipment, by adding another track to a magnetic disk or drum memory required for other purposes.

In a typical magnetic recirculation register, data are recorded on the magnetic surface by a recording head. Data are physically transported to the reading head by disk or drum rotation. The amount of data in storage depends on the spacing between read and write heads, and it can be varied within very wide limits. Virtually all memory drums and disks have provision for recirculation loops.

All the recirculating registers discussed so far stored data in a continuous medium. Storage of more data implied addition of more material, at a relatively low cost per additional bit.

Shift Registers Store Each Bit Separately

It is possible to store each bit separately, in one element of a closed chain of identical storage elements, and to shift the contents of each element of the chain from element to adjacent element, and thus around the chain. Such a device, called a recirculating shift register, has a number of advantages over conventional recirculation registers:

1. It is possible, by suitable design, to read or write at all points simultaneously so

Fig. 4. A 10-bit Amp-Mad shift register made by Amp Inc. The device uses 10 multiaperture ferrite cores.

data can be entered or read at any time.

2. Reading or writing can be done in parallel rather than in serial.

3. The cycle time can be varied over a wide range.

Though recirculating shift registers are more flexible than recirculating delay-line registers, they are seldom used because of their high cost per bit, seldom less than $10. Per bit cost can easily exceed $100 when speed is a primary requirement.

Early shift registers used one or two flip-flops per stored bit, but this technique lost out to a number of magnetic-core-and-diode circuits, and later, to magnetic-core-and-transistor circuits. The core units are more reliable and cheaper than flip-flop units, but they cannot operate very rapidly.

A practical upper limit for conventional magnetic-core shift registers is a 1-mc shift rate, and a cost-dictated upper limit for register length is about 100 bits.

Multiaperture Magnetic Cores Can Serve Shift-Register Function

In the search for high reliability, all-magnetic shift registers have been devised, using multiple-aperture magnetic cores. (Fig. 4). If their cost can be brought down to a few cents per bit, then long recirculating registers using multiaperture cores may compete with delay-line registers, particularly in high-reliability machines.

Another approach to the all-magnetic shift register is the use of deposited thin films. One company (Servomechanisms, Inc.), has announced the availability of prototype quantities of a 23-bit, thin-film register, which can operate at a 200-kc rate. But the cost, quoted at "well under $1,000," is much too high for most applications. If such devices can be put into mass production, they may replace most other types of shift registers. ■ ■

Part 2 of this article on cyclic memories will appear in *ED*, Sept. 13. It will cover nonvolatile memories.

NOW... an extra sensitive LIGHT MODULE for convenient readout

Visual display of logic circuit conditions is but one of many low-level signal applications for Raytheon's new highly sensitive light indicators.

Designed to fit into computer and instrumentation circuitry, the light indicators are triggered by typical transistor circuit signals. Response is fast. Power requirements are small.

Each light module is a miniaturized Weld-Pak assembly, designed for ½" center-to-center panel mounting. Components are welded for reliability . . . encapsulated for ruggedness. Light intensity is high and life exceeds 5,000 hours. Available in red and clear. Other color lenses on request.

For full technical data please write: Raytheon, Industrial Components Division, 55 Chapel Street, Newton 58, Massachusetts.

RAYTHEON LIGHT INDICATOR MODULES

Types	Neon Glow Lamp				Incandescent		Filamentary Thyratron	Cold Cathode Thyratron
	WM 2000	WM 2001	WM 2002	WM 2003	WM 2004	WM 2005	WM 2006	WM 2007
NEGATIVE LOGIC	Turn ON	Turn OFF			Turn ON	Turn OFF		
POSITIVE LOGIC			Turn ON	Turn OFF			Turn ON	Turn OFF
On power, mW	200	200	200	200	250	250	360	110
Standby power	−100V at 2mA, 6V at 0.1 mA				−12V at 20mA 6V at 0.1 mA		1.25 Vac at 250 mA	70 Vdc at 1.5 mA
Type of trigger signal	−6/−10V	−5/−10V	+6/+10V	+5/+10V	−5/−10V	+5/+10V	+4.5V	+4.0V

For Small Order or Prototype Requirements See Your Local Franchised Raytheon Distributor.

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RAYTHEON

CIRCLE 62 ON READER-SERVICE CARD

COUCH RUGGED ROTARY RELAYS

SPECIFICATIONS

CONTACTS — 4 PDT (4 form C) 5 A @ 30 VDC

SIZE — 1 3/32" D. x 1 1/2" H.

WEIGHT — 3.2 oz.

PULL-IN-POWER — ½ watt

VIBRATION — 50 G, 10 to 3,000 CPS

SHOCK, Electrical — 100 G minimum

TYPE — CVE with patented rotary armature

WRITE FOR DATA SHEET 7

Couch

COUCH ORDNANCE, INC.

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3 ARLINGTON STREET, NORTH QUINCY, MASS.

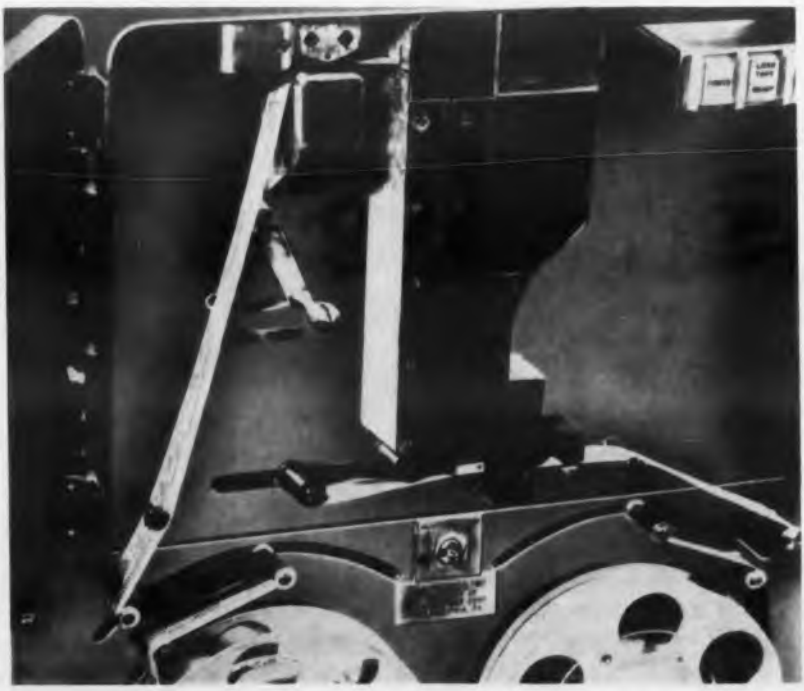
CIRCLE 63 ON READER-SERVICE CARD

Paper-Tape Recorder Prints Without Contact

INCREASED recording speed, higher density, and improved reliability are offered by a non-mechanical paper-tape recorder. Electrostatically recorded spots store information on the surface of the paper. At no time does the reading or recording head touch the tape.

Made by Omnitronics, Inc., 4035 Chestnut St., Philadelphia, the Omni-Data printer is used with the firm's photoelectric tape reader, which also accepts standard punched or printed, opaque or transparent tapes. The printer takes standard data pulses (−12 v for a mark and sprocket, 0 v for a space) and records them as visible spots in the same code as punched tape. Up to eight information channels plus sprocket channel are recorded.

The tape used is a high-resistivity, plastic-coated paper tape with a conductive backing. Width is 11/16 to 1-1/4 in. The writing head consists of two narrowly separated sets of electrodes. To write, the electrodes are pulsed, charging



Electrostatically printed rectangular spots store information on paper-tape surface.

the paper surface with ions migrated from the cloud to a precisely defined shape and area. A latent image in the form of the electrostatic charge remains on the surface of the tape. The image is made visible by passing the tape through a bath of dry powdered ink which adheres to the charged area. From the ink bath the tape is passed through the fixing station and the spots are permanently fixed on the surface.

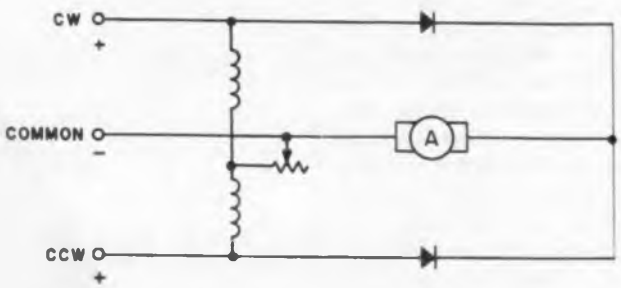
The speed of processing is limited only by the drive mechanism and the degree of control over tape handling, as the information is recorded in a few microseconds. Recorder model ETR-7 can operate at speeds up to 600 characters per sec at a density of 20 per in. Models in development can record at speeds approaching 2,000 characters per sec.

Start-stop control of the recorder is the same as that of the reader. A −10-v pulse on the start or stop line will cause corresponding action. A single positive-going 10-v signal will provide alternate stop and start, as will shorting of contacts provided. Start time is 5 msec max; stop distance is nominally 0.1 in.

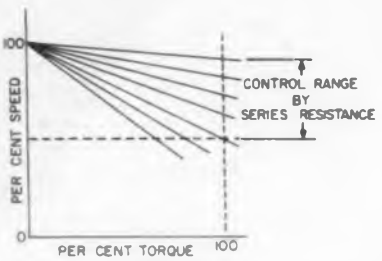
In use, the recorder is mounted above any of a series of unitized, servo-driven tape reelers. Bidirectional tape speeds up to 60 in. per sec are under the control of the recorder. Tape reels to 10-1/2 in. in diameter can be used.

Recorder model ETR-7 is priced at $6,500, and will be available in late fall. Options include tape speeds to 100 in. per sec, and edge-printed alphanumeric characters. Mounting in a standard 19-in. relay rack, the instrument has a panel height of 12-1/4 in.

For more information on this noncontacting paper-tape recorder, turn to the Reader-Service Card and circle 251.



Split-Shunt Motor Is Easily Reversed



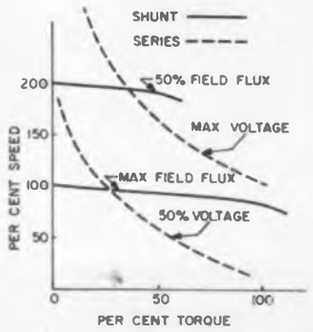
Speed/torque characteristics obtained by inserting a resistance in series with the armature circuit of a shunt-wound dc motor.

INHERENTLY good speed regulation of the shunt-wound motor is combined with ease of control in this solid-state reversing motor. The design is useful wherever constant speed over a wide range of loads is important.

Manufactured under private patents by Transco Products, Inc., 12210 Nebraska Ave., Los Angeles 25, Calif., the motor is available in packages ranging from size 8 up to multiple-horsepower units. The split-shunt design avoids complex reversing and switching circuits by use of a simple diode arrangement. The motor can be reversed by an spdt switch; in servo systems, power can be applied to both directions simultaneously to provide a mechanical output of the input differential.

Of special interest to systems designers is the linearity of the speed/torque curves. Where the speed regulation requirement permits use of this type of motor, mechanical governors, with their low reliability and radio noise problems, can be eliminated. An additional bonus of the split-shunt design is package size reduction and lower weight compared to the governed motor.

In servo systems, the slope of the speed/torque curve can be



Speed vs torque curves of shunt motor with reduced field flux control and series motor with normal and reduced voltage show relative high linearity of shunt design.

varied by a series resistance inserted in the circuit. Insertion in the common lead will affect each direction of rotation equally, or individual slopes can be adjusted by resistances in series with the positive leads.

Due to the higher field flux density, much higher efficiencies are obtained by split series at light loadings. Near-constant power output is available (through speed ranges in the order of 8:1) from shunt or split-shunt motors by application of the principle of field control. In the unit diagrammed, the common point of the field coils is connected through a variable resistance to one brush, allowing equal adjustment of rotation speed in both directions.

Speeds in different directions can be varied by changing resistances in the different field sections. This design can provide multiple-characteristic motors using the split-shunt circuit. The basic three-lead unit can be expanded to five leads.

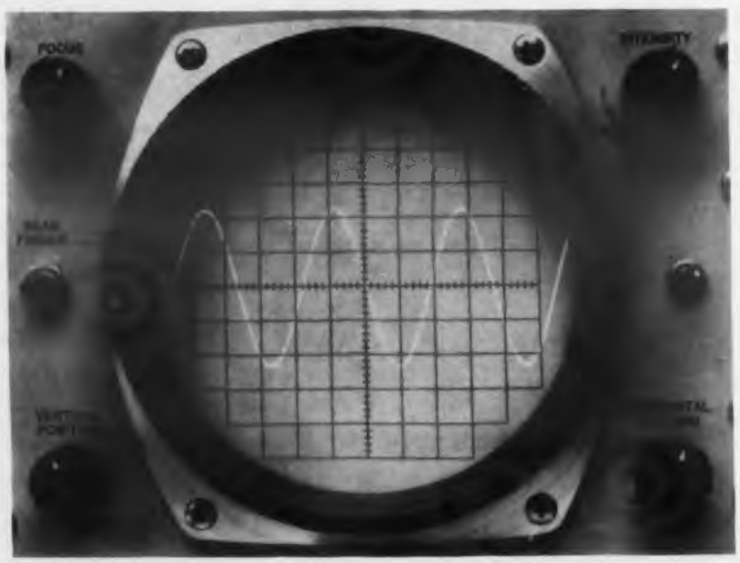
Price of the motors ranges from $30 up. Delivery can be made within 30 days.

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

CIRCLE 66 ON READER-SERVICE CARD ➤

NEW PRODUCTS

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



Internal Graticule Eliminates CRT Parallax 255

Parallax error arising from face plate and filter thickness is eliminated by mounting the graticule on essentially the same plane as the phosphor. The jet-black graticule stands out clearly against the phosphor background and the trace. The feature is standard on the general purpose, 200-kc oscilloscope model 120B, and optional on other models. Suitable for laboratory or production work, the oscilloscope is packaged in a modular cabinet for bench or rack use.

Hewlett-Packard Co., Dept. ED, 1501 Page Mill Road, Palo Alto, Calif.

P&A: *$450; 8 weeks.*

Low-Level Multiplexer Simplifies Data Systems 259

Multiplexer model LLM-1 accepts input signals from ±10 mv to 1 v, eliminating the need for an amplifier for each channel of information together with a high-level multiplexer. Noise, referred to input, is less than 5 μv; input impedance is 1,000 meg. Basic 16 channels can be expanded to 96. Switching speed is 750 channels per sec; switching elements have long life expectancy. Panel height is 6-1/2 in.

Packard Bell Computer, Dept. ED, 1905 Armacost Ave., Los Angeles 25, Calif.

Price: *$4,100 up.*

Time Interval Counter Combines Four Binaries 256

A single module measuring 1-1/2 × 1 × 1/2 in. houses four binary stages for time interval measurement. Operating at any frequency from dc to 1 mc, the module can divide the input count by any number from 9 through 16. Input is negative pulses or steps of 4 to 10 v amplitude, 1-μsec rise time. Output is 7.5 v with rise time of 0.1 μsec. Operating temperature range of the potted unit is −55 to +125 C.

Bulova Research & Development Laboratories Div., Bulova Watch Co., Inc., Dept. ED, 62-10 Woodside Ave., Woodside 77, N. Y.

P&A: *$255 ea, 11 to 50; 4 to 5 weeks.*

Flying Heads Improve Resolution 257

Packing density of magnetic drums and similar devices is increased to 19,200 bits per sq in. through improved resolution of 10-mil flying head series 10000. Double-reed head mount assures fail-safe operation; head does not contact drum surface on stoppage or high thermal expansion. Head provides 500-mv playback, unlimited recording modes, and inductance variability to match user circuitry. The 25000 series, with a 25-mil pole-piece, is made in fixed and flying models.

Bryant Computer Products Div. of Ex-Cell-O Corp., Dept. ED, 850 Ladd Road, Walled Lake, Mich.

P&A: *$12.60 ea, $35 installed; immediate.*

Tape Programed Directly From Drawings 258

Printed-circuit board drilling-machine program tapes can be prepared directly from drawings by this programer. Independent of the driller, it corrects errors in the art work and automatically follows a selected grid system. Eight-channel, 1-in. wide tapes are made for areas up to 24 x 24 in. in virtually all grid sizes. Scales of 1, 2, and 4:1 are handled. A positive hole-indicating device and an automatic safety control insure accuracy and reliability.

Edlund Machinery Co., Dept. ED, Cortland, N. Y.

P&A: *$8,500; 12 weeks.*

NEW PRODUCTS

Pressure Transducers 533

Withstand to 1,000 F ambient temperature and have a high resistance to nuclear radiation. Available as gage, absolute and differential pressure measuring devices, series 411 transducers have an output of 200 mv with an accuracy of 2-1/2% over −65 to +1,000 F. Accuracy is 0.5% at room temperature. Measurements can be from 0.6 to 5,000 psi.

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

Static Frequency Converter 525

Out from 380 to 420 cps is provided from a 50- to 60-cps input by this static frequency converter. Ratings from 600 to 3,600 va, three-phase, and 800 to 1,200 va, single-phase are available. Output voltage and frequency can be modulated. Phase and voltage regulation and frequency stability is 1%.

Basler Electric Co., Dept. ED, Highland, Ill.

Availability: *two to four weeks.*

Diffusion Furnace 529

Over 1,000 wafers can be handled simultaneously by the series DF-3 diffusion furnace. The flat zone, at least 12 in. long, can be maintained at 1,200 C with not more than 2% variation. Maximum operating temperature is 1,300 C.

Electroglas, Inc., Dept. ED, 841 Warrington Ave., Redwood City, Calif.


The stockholders of Chance Vought Corporation and Ling-Temco Electronics, Inc., on June 30, 1961, approved plans for combining these two companies into a vast new company — Ling-Temco-Vought, Inc., to be effective August 31, 1961.
Combination of these dynamic, experienced organizations will link depth of capabilities with depth of management to meet the advanced challenges of electronics, space, communications, aircraft, and missiles.
Ling-Temco-Vought will employ more than 20,000 people in the development and production of: AEROSPACE SYSTEMS . . . ELECTRONICS . . . COMMUNICATIONS . . . SOUND SYSTEMS . . . AERO SYSTEMS . . . INFORMATION HANDLING SYSTEMS.
This will be . . . . Ling-Temco-Vought, Inc. . . . a new industrial leader to serve America's future through science.
James J. Ling
Chairman of the executive committee
Robert McCulloch
Chairman of the Board
Gifford K. Johnson
President
Clyde Skeen
Executive Vice-President
EMCO-VOUGHT, INC.
LTV
DEPTH
MANAGEMENT
FOR PROGRESS
IN AEROSPACE
ELECTRONICS
AND COMMUNICATIONS

Capacitance Bridges 563

High-voltage capacitance bridges are available in mobile or stationary consoles at up to 500 kv or higher. Capacitance is measured to 0.2%, dissipation factor to 0.01%. Both measurements can be read directly.

General Electric Co., High Voltage Specialty Transformer Section, Dept. ED, Holyoke, Mass.

Laboratory Converters 564

Overvoltage protection, by means of an "overvoltage crowbar" which operates in 10 μsec, is provided on all 19 laboratory converters in the ST series, including 18- to 100-v models. Applications include semiconductor testing.

Mid-Eastern Electronics, Dept. ED, Springfield, N. J.

Availability: *stock.*

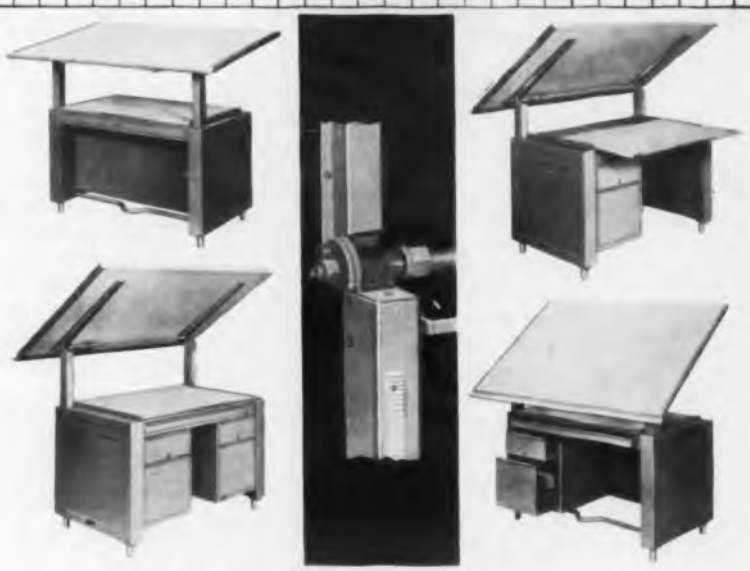
Balanced Gear Clamps 569

For subminiature components in computers, gear trains and other instruments. The subminiature balanced gear clamps have a 1/8-in. bore size. Clamps with tolerances of ± 0.001 with shaft sizes of 1/8 to 5/16 in. can also be furnished.

Tech-Ohm Electronics, Inc., Siamco Div., Dept. ED, Long Island City, N. Y.

Price: *$0.50 to $3.20.*

DRAFTING TRENDS



Four views of the versatile new Torsion Auto-Shift Table and the heart of its exclusive new design principle.

Efficient, Convenient, Contemporary . . . New Torsion Auto-Shift Table

Advanced design—A searching look will tell anyone who uses a drafting table that this is the equipment he'd create, given the time.

As any designer knows, simplicity is often difficult to achieve, and the appearance of simplicity even more difficult. Both are found in exclusive features of the new Hamilton Torsion Auto-Shift.

Tailored to the user—Unlike other designs, this is engineered, functional equipment for drafting, not just a drawing board slung on four legs or hung on a modified office desk. *It is designed without compromise to promote greatest efficiency by adapting to the work habits and convenience of the individual using it.* Its special characteristics will speed drafting substantially over conventional equipment in a one-man or one hundred-man department.

Unique features—The Hamilton Torsion Auto-Shift will counter-balance, regardless of table angle or weight of board accessories. It is attached and pivots at only two points—atop twin elevating columns, easily raised or lowered by foot pressure through a 12" vertical range. Operating and adjusting mechanisms are readily accessible—without the need for bulging sheet metal covers or protruding hardware.

Stratacore® board—Further features include the new Stratacore drawing board . . . a light weight, linoleum-surfaced top of remarkable strength and stability. Slide-type reference surface can be used from front or rear. All drawers are reversible for use from one side or the other. Tool and catalog drawers may be installed at left or right, or on both ends.

Clearly, the new Hamilton Torsion Auto-Shift now offers even greater dividends for long-term investment in space economies, increased drafting output and improved user comfort.

Ask your POST dealer for full details, layout aids and planning assistance to put this prestige drafting furniture in your *near* future. Or, write Frederick Post Company, 3644 No. Avondale Ave., Chicago 18, Ill.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

CIRCLE 70 ON READER-SERVICE CARD

NEW PRODUCTS

Transducer 556

Differential pressure transducer model 728 uses a Ni-Span-C spiral bourdon tube and a special isolation bellows to give a full complement of zero-centered pressure ranges with low error. Nominal resolution is 0.2 to 0.4% over ranges from ±400 to ±3,500 psid. Static error band is 1.3%, response time 15 msec or less. Weight is 8 oz.

Bourns, Inc., Instrument Div., Dept. ED, 6135 Magnolia Ave., Riverside, Calif.

Preset Counter 620

Dual preset quantities may be counted in add or subtract mode at speeds up to 100,000 per sec with predetermining counter model 330 4S. Solid-state standard models have 2 to 6 in-plane displays. Relay or pulse output is available.

Robotomics, Inc., Dept. ED, 2422 E. Indian School Road, Phoenix, Ariz.

P&A: *$750 to $710; 3 to 6 weeks.*

Potentiometer Tester 621

Function angle tester for precision potentiometers eliminates the need for a voltage divider. Model STE-2 permits evaluation at zero output and 100% of the excitation voltage. Output is monitored by an oscilloscope.

George Rattray & Co., Inc., Dept. ED, 101 New South Road, Hicksville, N. Y.

Availability: *Six weeks.*

Punched Tape Reader 617

Reading 300 characters per sec, the model RR-300 punched tape reader is adjustable for five to eight channel operation. The unit has photocell readers, with output amplifiers for each channel. Output is −15 v, 5 ma when on, 0 v, less than 50 μa when off. Models for rack or desk-top mounting are available.

Rheem Manufacturing Co., Dept. ED, 5200 W. 104th St., Los Angeles, Calif.

Price: *$845.00.*

Switching Transistors 523

Germanium-alloy switching transistors, approved for military use, provide a wide range of beta, frequency, and voltage control. Types 2N1306 through 2N1309, two npn and two pnp, are rated at 150-mw power dissipation at 25 C. The TO-5 devices have dc current gain ranging from 10 to 80.

Sylvania Electric Products Inc., Semiconductor Div., Dept. ED, Woburn, Mass.

P&A: *$1.28 to $2.12 ea, 100 to 999; distributors.*

Steatite Tubing 518

For resistor forms. Round steatite ceramic tubes are made for use as forms for vitreous enamel resistors. A wide range of tube lengths with OD ranging from 1/4 to 1-1/8 in., inside diameters from 1/8 to 3/4 in. can be supplied.

Ceramic Products, Centralab, The Electronics Div. of Globe-Union Inc., Dept. ED, 900 E. Keefe Ave., Minneapolis, Minn.

Teflon Terminal 618

For encapsulated components. Press-fit Teflon terminal FT-MM-3SL has a fluted section providing positive encapsulation seal to the potting compound. Over-all length is 0.510 in., internal stud diameter 0.030 in.

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

Power Supplies 613

Operation from −55 to +125 C is provided by the series L power supplies. Varying or fixed outputs are from 10 to 200 v. Overload protection is built in. Typical size is 2-1/2 x 2-1/2 x 7 in. Silicon transistors and rectifiers are employed.

Orion Electronics Corp., Dept. ED, 108 Columbus Ave., Tuckahoe, N. Y.

P&A: *$350 to $500; stock to four weeks.*

Printing Frame 609

Printed circuits are produced on this printing frame, called the Fanstretch frame. Wire mesh up to 8 ft long is held to the frame by floating clamps located along each side. Held uniformly tight, the mesh can be accurately registered. Screen changeover, requiring no special tools, takes about five minutes. Mesh need not be precrimped.

Colonial Process Supply Co., Dept. ED, 122 W. 22nd St., New York, N. Y.

Electronic Integrator 619

Accuracy is 0.25%. Used with any standard servo-drive recorder, integrator PX 592 computes integrals and records them in bar-graph form on strip chart with the original recording. Integration can be started or stopped manually or automatically at any desired time. Accuracy is 0.25% of full scale. Maximum deflection of the recorder gives full-scale integral in 1.4 sec.

Ridgefield Instrument Group, Dept. ED, Ridgefield, Conn.

Price: *$795.*

Time-Delay Relay 565

Instantaneous recycling type MTRH8 time-delay relay has an operating range of 15 to 300 sec. Type MTRH4 multiple-contact, time-delay relay has an operating delay range of 1 to 90 sec and an accuracy of ±10%, 0.5 sec min. Both are designed for limited space applications.

Branson Corp., Dept. ED, 41 S. Jefferson Road, Whippany, N. J.

Mica Paper Tubing 520

Rigid mica paper tubing type Isomica 6T is capable of continuous operation at 1,500 F. Electrical and physical properties are unaffected by long exposure to high temperatures. Arc and gamma resistance is very high. Tubing is available in lengths to 18 in., OD to 4 in. Minimum inner diameter is 1/8 in, minimum wall thickness 0.010 to 0.012 in.

Mica Insulator Div., Minnesota Mining & Manufacturing Co., Dept. ED, Schenectady 1, N. Y.

Availability: *2 to 3 weeks.*

Tape Switching Console 612

Up to eight magnetic tape units can be controlled by the model 7155 tape switching console. Made to operate with the firm's model 729 tape drives, the device switches computer from one tape unit to another, or tape unit from one computer to another or to some other instrument, all with push-button operation. Unit operates with solid-state systems.

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

Price: *$20,275, average.*

NEW PRODUCTS

Diode Tester 601

Reverse characteristics of Ge and Si diodes are monitored and tested by diode tester LT005. Maximum voltage is 2 kv, current 0.3 ma average. Accuracy is ±5%. Voltage sensitivity is 5 v per cm max, 200 v per cm min; current sensitivity is 10 μa per cm max, 500 μa per cm min.

Ling-Temco Electronics, Inc., Micromodular Components Div., Dept. ED, P. O. Box S-1, Anaheim, Calif.

Resistance Wire 602

Nickel-chromium alloy wire type B-800 provides easy soldering and low noise level for potentiometer applications. Temperature coefficient of resistivity is ±5 ppm, −55 to +125 C. Standard diameters range from 0.010 down to 0.00045 in.

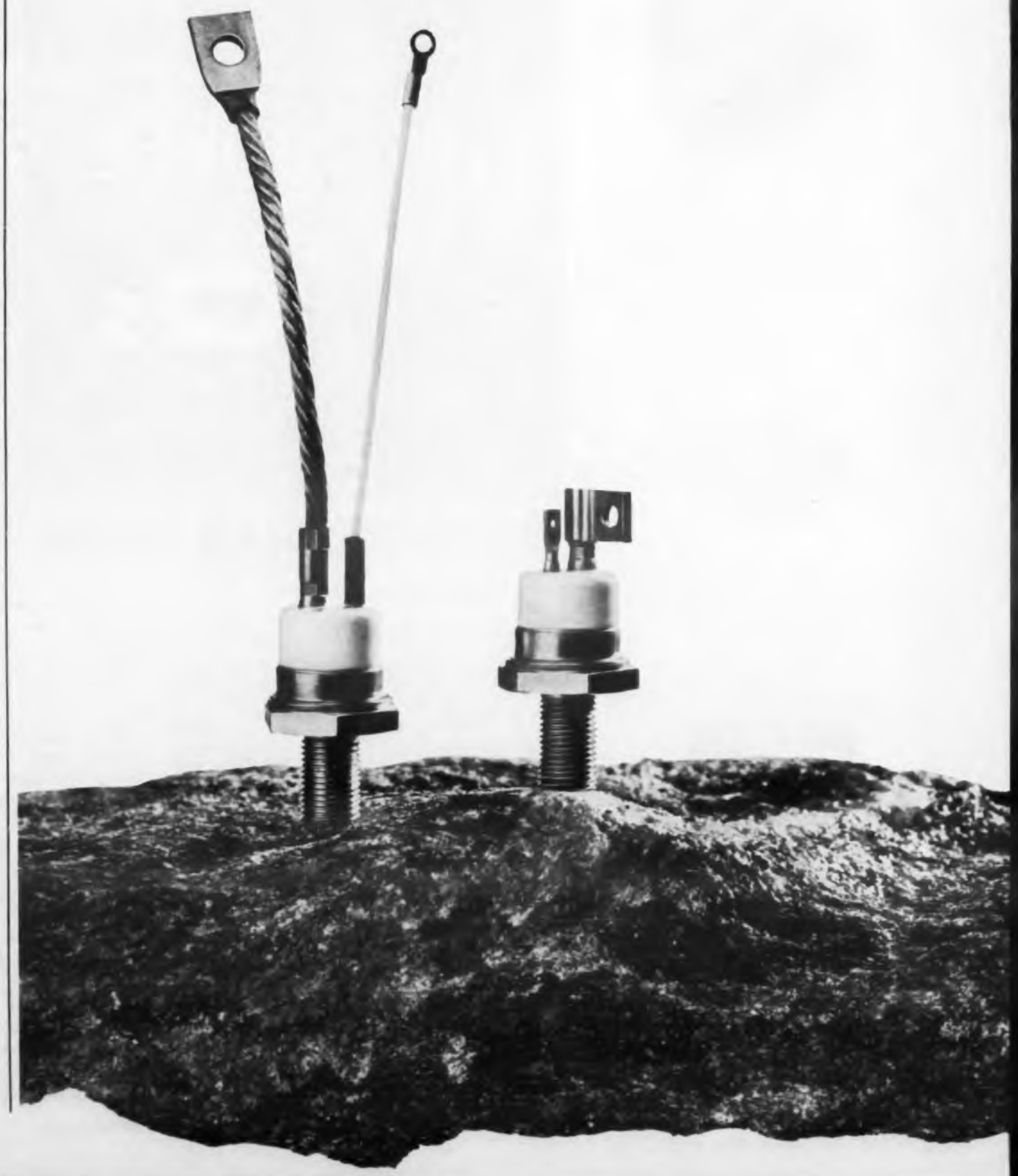
Consolidated Reactive Metals, Inc., Dept. ED, 115 Hoyt Ave., Mamaroneck, N. Y.

Binary Modules 596

Low-cost binary counter modules are made for count-down applications below 100 kc. They operate with a single power supply of 15 to 28 v, and consume 2.5 ma at 28 v dc. Nominal signal levels are 0 to +5 v, with rise times less than 1.0 μsec. Size is 3/4 x 7/8 x 9/16 in.

Walkirt Co., Dept. ED, 141 W. Hazel St., Inglewood, Calif.

Price: *Ge, $12.50 ea; Si, $24.80 ea, in 100 lots.*



Rectifier Tubes 528

High-voltage, high-vacuum rectifiers operate at high frequencies. Model 4B31 is a clipper tube for use in radar scopes. Model 8020W is a rugged half-wave rectifier, tested to withstand 375 g, for use in high ambient temperatures.

Cetron Electronic Corp., Dept. ED, 717 Hamilton St., Geneva, Ill.

Thermoelectric Generator Material 532

Lead-telluride thermoelectric generator material can be furnished with efficiencies of 6% or more. It is for use in generators supplying auxiliary power for space satellites, buoys and other devices. It can be furnished in various shapes.

Alloys Unlimited Chemicals, Inc., Dept. ED, 42-73 Hunter St., Long Island City, N. Y.

Aneroid Transfer Standard 597

Accurate within ±0.010 in. Hg, pressure standard model 451287 furnishes a direct voltage output. The portable device uses a capsule element to actuate a pot; resulting output can be read on a digital ratio meter or applied to a servo readout device. Pressure range is 0 to 31.5 in. Hg. gage, absolute or differential. Weight is 3.5 lb.

Giannini Controls Corp., Dept. ED, 1600 S. Mountain Ave., Duarte, Calif.

◀ CIRCLE 72 ON READER-SERVICE CARD

NEW PRODUCTS

Transistor Test Set 605

The $r_b'C_c$ of mesa, surface barrier, and drift transistors is tested by the model 1824 test set. Range, in three steps, is from 0 to 300 psec. Device, accurate to 5%, has a built-in calibrating standard. Sockets accepts both long and short leads. Emitter current and collector bias power supplies are required. Unit measures 5-1/4 x 19 x 8 in. and is rack mounted.

Dynatron Electronics Corp., Dept. ED, 178 Herricks Road, Mineola, N. Y.

***P&A:** $590; 30 to 60 days.*

Pulse Amplitude Discriminator 607

Transistorized, plug-in pulse amplitude discriminator, model 15-ZHS-001, also serves as a pulse shaper. Unit accepts input pulses from 1 to 20 v with rise time from 50 to 200 nsec and width from 0.2 to 1 μsec. Discriminator setting from 1 to 20 v is adjustable by an external potentiometer. Output pulses from 1 to 500 μsec, 14 to 24 v are provided.

Franklin Systems, Inc., Dept. ED, P. O. Box 3250, West Palm Beach, Fla.

High-Voltage Power Supplies 614

Up to 50 kv dc are provided by the series PHV high-voltage power supplies. Cases, hermetically sealed, measure from 3-3/4 x 2-3/16 x 5-1/2 in. to 12-1/2 in. cu. Units operate up to 85 C. Input is 118 v, 60 cps.

The Potter Co., Dept. ED, 7351 Lawndale, Skokie, Ill.

CIRCLE 901 ON CAREER INQUIRY FORM ➤

DATA PRESENTATION FOR GLOBAL DEFENSE — SAC's mission is to maintain a force instantly ready to conduct strategic air warfare, on a global basis. Data generated in the SAC Control System is automatically displayed at SAC Headquarters on large display panels. Data and information can be updated or changed in a matter of seconds. ■ International Electric, the systems manager in the development and perfecting of this global digital command and control system, offers Electronic Systems Engineers and Computer Programmers a rare opportunity to advance in technical skill and imagination. Write to Mr. S. J. Crawford, Director of Industrial Relations.

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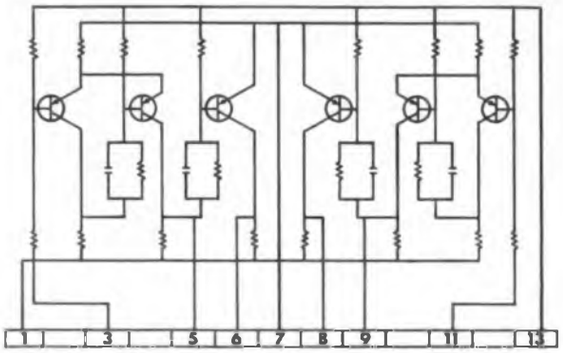
All qualified applicants considered regardless of race, creed, color or national origin

46 AUTOMATIC TESTS ON THIS LOGIC MODULE IN 20-25 SECONDS



(a typical example)

Cards marked by programmer . . .

. . . are inserted into the DIT-MCO Tape Preparation Center. Program tape is automatically punched ready for use.

Artist's Concept

Tape Programmed Model 720 will perform up to 1,000 precision and reliable tests on plug-in logic modules.

AUTOMATIC LOGIC CIRCUIT TESTING

SPECIFICATIONS

Voltage Measurements	0.001 - 39.9 V.D.C.
Resistance Measurements	0.01 - 9.99 meg
Current Measurements	0.1 - 999 ma
Tolerance Values	3 digit tolerance values can be programmed
Accuracy	± 1 digit
Test Voltage Sources	6 adjustable, regulated D.C. supplies. 0.001-39.9 V Power supply combinations selected by programming.
	1 programmable, regulated D.C. supply. 0.001 - 39.9 V. Voltage values selected by programming.
Loading Units	Up to 9 replaceable loading units. Selected by programming.
Dwell Time	0.1-10 seconds, in 10 adjustable steps. Programmable.
External Test Voltages and Detectors	Connections provided for external test voltages and detectors to be selected by programming.
Capacity	Standard model, 44 pins. Larger and smaller capacities available in 22-pin increments.
Speed	2 to 3 circuits per second without dwell time.
Programming	Tape Programmed.

TYPICAL TYPES OF MODULES TESTED INCLUDE:

Active logic circuits using transistors.
Passive logic circuits using diodes.
Pulse amplifiers, inverters, modulators and shapers.
Memory and storage networks.
Multivibrators, including flip-flops.
Gating circuits.
Diode matrices.
Decoders and counters.
Circuitry using Binistors.
Oscillators.
Micrologic elements.
Control rectifier circuits.

Automatically yours

DIT MCO

DIT-MCO, INC.
Kansas City 5, Missouri

911 BROADWAY
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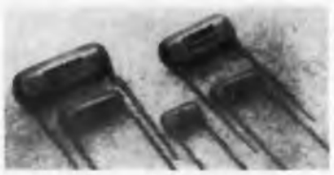
CIRCLE 145 ON READER-SERVICE CARD

Bridge-Control Readout 480

Gain stability is ±0.5% over 8 hr, after 15-min warm-up. Model BCR1-0 bridge-control readout, designed for laboratory use, requires no additional resistors when used with a strain-gage instrument. Transducer excitation voltage is 2.5 to 10 v dc; calibration check point is 40 K, nonlinearity and hysteresis are less than ±0.5% of full scale.

Statham Instruments, Inc., Dept. ED, 12401 W. Olympic Blvd., Los Angeles 64, Calif.

Capacitors 512



Made for printed wiring boards, the type 220P Difilm Orange Drop capacitors have radial leads. Capacitances from 0.0047 μf to 0.47 f and voltage ratings from 200 to 1,000 wvdc are available. Units measure from 11/16 to 1-5/8 in. long and from 21/64 to 13/16 in. in diameter.

Sprague Electric Co., Dept. ED, North Adams, Mass.

Frequency-Response Tester 434

For gyros and accelerometers. Model FRO1 frequency-response tester consists of a lightweight, variable-speed turntable on a right-angle mounting base. Slip rings provide for eight connections from base to turntable. Speed range is 1 to 25 cps. Control is from a remote-control box.

Humphrey, Inc., Dept. ED, 2805 Cannon St., San Diego 6, Calif.

***Price:** less than $3,000.*

NEW PRODUCTS

Sampling Oscilloscope 458

Extended bandpass sampling oscilloscope model 112A has a rise time of less than 0.2 nsec. Equivalent bandpass is 2 Gc, 6 db down, and 1.7 Gc, 3 bd down. Sensitivity is better than 3.0 mv per cm, noise less than 600 μv. Sweep rates to 0.05 nsec per cm are provided.

Lumatron Electronics, Inc., Dept. ED, New Hyde Park, N. Y.
P&A: *$4,000; 4 to 6 weeks.*

Tape Reeler 462

Bidirectional, high-speed tape reeler model RS-400 has speeds of up to 60 in. per sec. It can be used with 8 or 10.5-in. reels. Spring-loaded tension arms feed the tape and maintain constant tape tension and slack take-up.

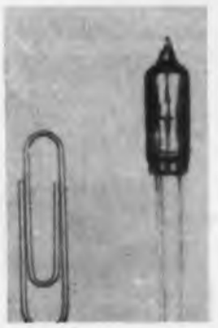
Omnitronics, Inc., Dept. ED, 511 N. Broad St., Philadelphia 23, Pa.

Crystal Filters 460

Lower and upper sideband crystal filters have 3 to 45 db carrier rejection at 200 cps. Housed in a single package, they occupy 11 cu in. The filter set has a carrier frequency of 5 mc with a passband width of 3.2 kc on each side.

Hughes Aircraft Co., Dept. ED, Florence Ave. and Teale St., Culver City, Calif.

Cold-Cathode Thyratron 530



Subminiature cold-cathode thyratron, type Eii-38, is made for medium-speed computing and data-processing applications. Anode supply voltage is 170 to 220 v; grid trigger voltage is 150 v dc min; average cathode current is 2 ma max.

Electronic Industries, Inc., Dept. ED, 18 Marshall St., S. Norwalk, Conn.

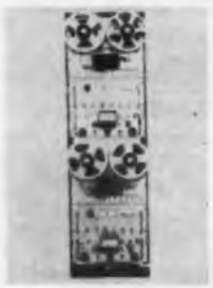
***Price:** $0.80 each in quantities of 1,000.*

Instrument Panel 531

With 30-deg tilt. Called the Consolet, the hinged instrument panel protects the instrument by means of a fully enclosed, ventilated aluminum shroud. Six instrument panel sizes, ranging from 12.625 x 10.312 to 16.875 to 11 in., can be furnished.

TA Manufacturing Corp., Dept. ED, 4607 Alger St., Los Angeles 39, Calif.

Tape Recorder 459



Four-track, bidirectional magnetic tape recorder model 2157 has a playing time of 8 hr at 3-3/4 ips. Frequency response is ±3 db, 80 to 7,500 cps. Wow and flutter are less than 0.25% rms, signal-to-noise ratio 46 db below 2% distortion level. Fast wind or rewind time is 1 min.

Telectro Industries Corp., Dept. ED, 35-16 37th St., Long Island City 1, N. Y.

◀ CIRCLE 75 ON READER-SERVICE CARD

NEW PRODUCTS

Fiber-Optic Cathode-Ray Tube 422

Direct optical printing on film at high speed is accomplished by the type E1E11 cathode-ray tube. Utilizing fiber-optic principles, the tube-face panel consists of an array of light-pipes which form an image without dispersion, so that film may be placed directly on the tube face. Digital codes can be reproduced, making the tube suitable for digital photographic recording systems.

Litton Industries, Display Devices Dept., Dept. ED, 950 Industrial Road, San Carlos, Calif.

Power Supplies 511

Transistorized power supplies offer from 5 to 18 v dc output. Designated type CVQ, the units have both static and magnetic regulation, including shunt regulators. Short circuits will not overload the devices.

Sola Electric Co., Dept. ED, Elk Grove Village, Ill.

Counter-Timer 514

Operating at 10 mc, this counter-timer, model 365RP, operates in nine different functional modes which can be selected or programed remotely. Measurements are performed directly, with reference to an oven-stabilized crystal accurate to 5 parts in 10^8 per wk. Nine timing intervals from 0.1 μsec to 10 sec are offered. Unit provides for three inputs. Nixie readout is provided, with printed or coded readouts optional.

Transistor Specialties, Inc., Dept. ED, Terminal Drive, Plainview, L. I., N. Y.
***P&A:** $3,875; 30 days.*

SOLVE 5 CRITICAL DESIGN PROBLEMS WITH TURBOTEMP®

Teflon FEP/Nylon WIRE

Until Turbotemp Teflon* FEP/Nylon wire was developed, no single wire ever solved so many combined heat and electrical problems. This new wire provides these advantages:

1. Overcomes the "short length" problem inherent in extruded Teflon TFE. Get the long continuous lengths (up to 6,000 ft.) that until now were available only in lower temperature wires or in those having less stable electrical properties.

2. Gives complete freedom to circuit designers when optimum performance demands low capacitance. The low dielectric constant of FEP/nylon shows minimum change over a wide range of frequency and temperature.

3. Provides utmost reliability to automatic wire wrap terminations. Of all conventional plastics or combinations tested, FEP/nylon has the best cut through resistance on wire wrap pins.

4. Is suitable for continuous operation up to 120°C, an important consideration if computers are for military use.

5. Meets flammability requirements of both MIL-W-16878 and U.L. Appliance Wire.

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WRITE FOR COMPLETE DATA!

CIRCLE 76 ON READER-SERVICE CARD

Transient Voltage Indicator 515

From 0 to 2,000 v transients are sensed and indicated by the model 741A transient voltage indicator. Pulses as narrow as 1 μsec will trip the circuit and cause a panel lamp to glow. Zener regulators provide repeatability of 0.25%. Adjustable voltage control, continuous over the entire range, is accurate to 2%. Device is portable, battery-operated, and weighs 8 lb.

Trott Electronics, Inc., Dept. ED, 412 Smith St., Rochester 8, N. Y.

***P&A:** $195.00; from stock.*

Load Cell 517

Stainless steel bellows are coupled inductively to a sensitive differential transformer in the type BL-1 load cell. Ratings from 5 to 500 lb are available. Temperature range is −85 to +500 F; hysteresis error is less than 0.1%. Unit is 1-1/4 in. high, 1-3/4 in. in diameter.

United Aero Products Corp., Dept. ED, Burlington, N. J.

High-Speed Silicon Switches 506

In TO-51 packages, transistor types 2N958 and 2N959 are triple-diffused silicon planar high-speed computer switches. Switching time is less than 25 nsec, and collector to emitter saturation is less than 0.2 v. Package is 0.165 in. in diameter and 0.06 in. high. Leads are flat ribbon 1/2 in. long.

Pacific Semiconductors, Inc., Dept. ED, 12955 Chadron Ave., Hawthorne, Calif.

***Price:** $24.00 each.*

DigiBits

TRANSISTORIZED DIGITAL LOGIC PACKAGES

Do NOT Meet MIL Specs
Do NOT Operate at 10 Megacycles
Do NOT Cost $50.00 per Package

BUT—if you do not need to meet MIL Specs, do not need high speed units, and do not want to pay premium prices for digital packages, DigiBits are worth investigating.

DigiBits are designed to fill the need for low-cost digital packages which can be assembled into networks in minutes instead of hours. They offer the utmost in simplicity of design, utilizing high quality components and maintaining high standards of manufacturing.

If 40kc clock rates will satisfy your system or breadboording requirements, DigiBits are the answer. Package prices start at $7.95.

For the maximum ease in lab breadboarding, we offer the DigiLab. A completely self-contained console including up to 71 digital elements, operating controls, displays, power supply, and all other necessary accessories.

Two Models available	DA-6a	$755.00
	DA-6b	$895.00

If your requirements demand higher speed, more sophisticated digital packages, our Series EX line is available to fill your needs.

Write for complete information on our product lines.

TECH SERV Inc.

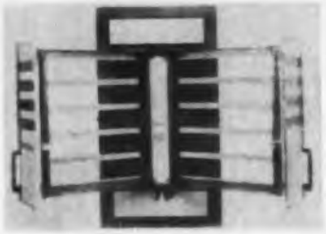
4911 COLLEGE AVE., COLLEGE PARK, MARYLAND

APPLETON 7-7173

CIRCLE 78 ON READER-SERVICE CARD

NEW PRODUCTS

Digital Module Case 507



With a 250-module capacity, the model MC-250 digital module case occupies less than 30 in. in a 19-in. rack. It slides out and opens like a book for accessibility to modules and wiring. The case provides for 200 signal lights.

Packard Bell Computer Div., Packard Bell Electronics, Dept. ED, 1905 Armacost Ave., Los Angeles 25, Calif.

***P&A:** $1,245; 60 days.*

Magnetic Starters 500

Flush-mounted magnetic starters may be cavity-mounted in machinery or in plaster walls. Units are rated to 600 v, 25 to 60 cps, in NEMA sizes 0, 1, and 2. Box and bracket-and-panel mounting styles are available.

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

Silicon Rectifiers 498

Rated at 50 and 70 amp respectively, the type 10A and 8B silicon rectifier cells may be stacked to operate 150 and 210 amp 3-phase, respectively. Cells and stacks have a piv rating of 50 to 600 v, inverse current of 15 ma max at 150 C, and forward voltage drop of 0.95 v. Ratings are based on 100 cu ft per min cooling air in ambient temperatures of 70 C.

Fansteel Metallurgical Corp., Rectifier-Capacitor Div., Dept. ED, North Chicago, Ill.

***Availability:** from stock.*

dial
BARCLAY
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for immediate delivery of

DALE
T-POTS AND
POWER RESISTORS
(factory prices up to 499 pcs.)

Available from IBM controlled stock when you dial BArclay 7-7777. Save design and purchasing time—call for free catalog.

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ENTERPRISE NUMBERS IN MAJOR AREAS

CIRCLE 80 ON READER-SERVICE CARD

DALE
...recognized by standards engineers as the mark of resistor reliability

Each incoming inspection adds weight to the conviction already held by standards engineers: You can depend on Dale resistors for performance as specified.

Dale resistor reliability is the result of Dale's advanced design and stringently controlled methods of manufacture . . . methods which have reached new levels of achievement as part of Dale's super-high reliability development program.

SPECIAL PROBLEMS? Let us help you with your requirements for special resistance products. We make modifications of standard products, resistor networks, matched pairs, etc. Send us your specs.

PROMPT DELIVERY: Whether your need is for a short "test run" or a large production release, Dale offers prompt service, direct from the factory and through a widespread network of distributors.

Write for Bulletin R-21 with handy cross reference file card

Hathaway INSTRUMENTS INC.

DALE ELECTRONICS, INC.
1328 28th Ave., Columbus, Nebr, U.S.A.

A subsidiary of HATHAWAY INSTRUMENTS, INC.

DALE TYPE RH RESISTORS
WIRE WOUND • MINIATURE • HIGH POWER

Designed primarily for application with high power requirements, coupled with precision tolerance. Mount on chassis for maximum heat dissipation. Operate under severe environmental conditions, offering complete protection from salt spray, moisture, vibration and shock.

- RATED AT 5, 10, 25, 50, 100 and 250 watts
- RESISTANCE RANGE from 0.1 ohm to 175K ohms, depending on type
- TOLERANCES: ±0.05%; ±0.1%; ±0.25%; ±0.5%; ±1%; ±3%
- TEMPERATURE COEFFICIENT 20 P.P.M.
- OPERATING TEMPERATURE RANGE from -55° C. to 275° C.
- WELDED CONSTRUCTION from terminal to terminal
- RUGGEDLY HOUSED; sealed in silicone and inserted in radiator finned aluminum housing
- SMALLEST IN SIZE, ranging from ⅝" x ⅜" to 3" x 4½"
- SURPASS applicable paragraphs of MIL-R-18546B (Ships)

CIRCLE 81 ON READER-SERVICE CARD

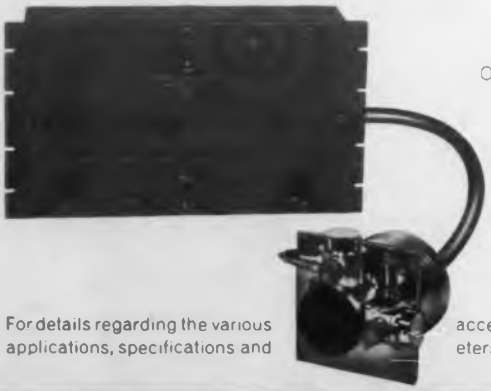
Cary Vibrating Reed ELECTROMETERS...

MODEL 31

Detects currents to 10 $\mu\mu\mu$ amps, voltages to 20 μv. Ten ranges, separate input preamplifier, and special features offer exceptional versatility.

MODEL 32

Provides excellent performance, similar to Model 31, at lower cost. Primarily designed for radiation studies. Four ranges, built-in preamplifier unit.



MODEL 36

Offers exceptional response, DC to 10 cps, sensitivity and stability for small currents to 10^{-15} ampere originating in a high impedance source.

For details regarding the various applications, specifications and accessories for all Cary Electrometers... ask for Data File M30-81.

...**outstanding instruments** for precise, reliable measurement of extremely small charges, currents and voltages. Several models along with many accessories serve a variety of applications including radioisotope assays, ion current measurements, pH determinations, and solid-state studies. Inquiries regarding special problems are invited.

APPLIED PHYSICS CORPORATION
2724 SOUTH PECK ROAD · MONROVIA CALIFORNIA

Cary
INSTRUMENTS

Raman UV IR Recording Spectrophotometers • Vibrating Reed Electrometers

NEW PRODUCTS

Mercury Arc Lamp 505

Providing 140,000 candles per sq cm, the model 951 power light source consists of a mercury arc lamp, lamp holder, and power supply. Three-electrode lamp is rated at 100 w. Power supply contains a current-limiting transformer.

Menlo Park Engineering, Dept. ED, 711 Hamilton Ave., Menlo Park, Calif.
Price: *$475 up.*

Thermistor Probe Assembly 503

For fluid measurement and control, the model IL-T5 thermistor probe assembly has a range of −40 to +265 F. The unit has a resolution better than 0.01 F and a 5-sec time constant. Nominal resistance changes from 1,448 ohms at 32 F to 36.4 ohms at 212 F. Device, made for installation in 1/4 in. pipe thread fittings, is molded of epoxy resin.

Instrumentation Laboratory, Dept. ED, 108 Cummington St., Boston 15, Mass.

Programing Switch 504

For cathode ray tube programing, the model 500736 is a 5-pole, 12-position, 5-rps time sharing and programing switch. Four poles control the horizontal and vertical axes, and the fifth provides blanking between data points. Switch handles signal levels from 10-50 mv to 0-150 v at 20 ma. Operating time exceeds 1,500 hr.

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

◄ CIRCLE 82 ON READER-SERVICE CARD

Electronic Timer 457

Vacuum-tube electronic timer model HC-100 has timing ranges of 0.06 to 120 sec with a repetitive accuracy of ±2%. The spdt plug-in relay output is rated at 5 amp. The unit is designed for industrial-control applications.

Syracuse Electronics Corp., Dept. ED, P. O. Box 566, Syracuse 1, N. Y.

P&A: *$37; stock.*

Load Cells 461

Seven models are rated at 1,000 to 100,000 lb. Temperature-compensated, the load cells can be used without damage from −300 to +750 F. Bridge impedance is 120 ohms; output is 25 mv; linearity and hysteresis are within 0.2%; total error is less than ±2% from −65 to +600 F.

Microdot Inc., Dept. ED, 220 Pasadena Ave., South Pasadena, Calif.

Transistor Heat Sink 524

Nearly any transistor can be accommodated by the model 2500 heat sink. Model 2505 heat sink has a smooth mounting surface for semiconductors without any additional machining. Thermal resistance is 1.9 C per w at 30 w.

Astro Dynamics, Inc., Dept. ED, Second Ave., Burlington, Mass.

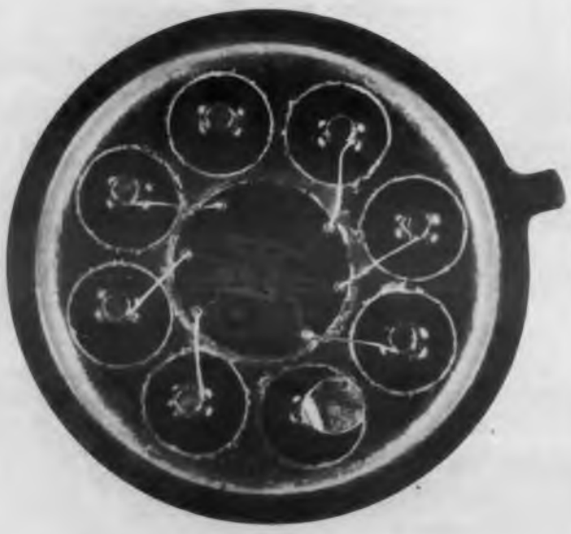
P&A: *$0.75; from stock.*

CIRCLE 84 ON READER-SERVICE CARD ▶

Actual size

MICROCIRCUITRY

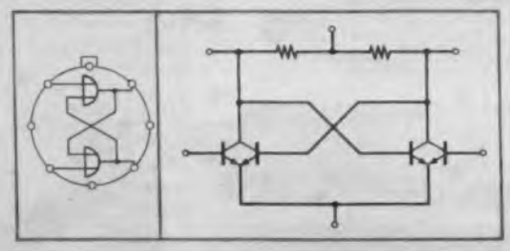
SILICON PLANAR SINGLE CHIP CIRCUITS

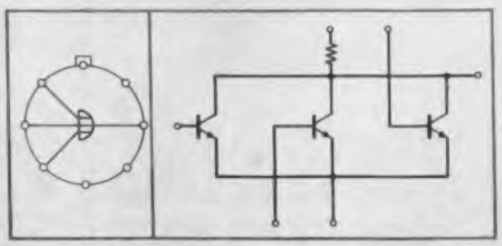


"F" FLIP-FLOP
TO-5 size header

"G" GATE
TO-5 size header

UNRETOUCHED PHOTOGRAPHS MAGNIFIED 9 TIMES





NOR DIAGRAMS AND CIRCUITS FOR EQUIVALENT FUNCTIONS

AVAILABLE IN QUANTITY

"S" HALF-SHIFT REGISTER
TO-5 size header

THREE NEW FAIRCHILD MICROLOGIC COMPUTER ELEMENTS

Available for immediate volume delivery are the Flip-flop, the Gate, and the Half-shift Register. These high-speed, low-power devices operate at bit rates in excess of 1 mc. For the first time complete arithmetic and control sections can be produced with SILICON PLANAR, SINGLE CHIP logic building blocks.

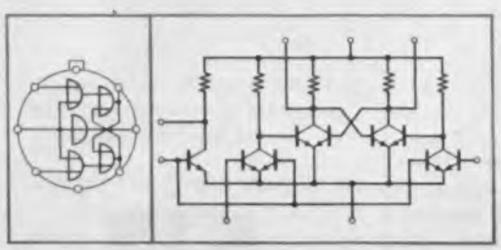
DESIGN AND ASSEMBLY COST REDUCTIONS — UP TO 90%

Fairchild Micrologic elements can reduce system design and assembly costs up to 90%, space requirements up to 95%, and power needs up to 75%, thus making many new computer applications practical and economically feasible. They can be used over the full military temperature range (—55° C. to +125° C.).

RELIABILITY — 500,000 HOURS AT 125° C

The equivalent of 3,000,000 component operating hours without a single failure. A new order of stability and reliability is made possible by the Fairchild Planar process with total protection of the passivated oxide surface.

For complete data, specifications and pricing information contact your Fairchild Field Sales Office. Or write direct. Three additional elements (Half-adder, Buffer and Counter Adapter) will be available soon to complete the Fairchild Micrologic family.



μL and μLogic are trademarks of Fairchild Semiconductor, a Division of Fairchild Camera and Instrument Corporation

FAIRCHILD
SEMICONDUCTOR

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A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

CIRCLE 85 ON READER-SERVICE CARD

ENGINEERING

REPORT

ON BENDIX COMPONENTS

HOW MUCH CAN BENDIX SAVE YOU IN ANTENNA PEDESTALS?

GET OUR SPECIFIC ENGINEERING PROPOSAL

Bendix experience in ground radar pedestal design, manufacture and installation can benefit *you*. It can meet your requirements without delay. Since basic design and tooling have already been accomplished, modifications, for your prototype needs, can be made quickly—and with important savings—or, we can design a completely new pedestal to meet your specific needs.

Bendix ground-installation radar pedestals are lightweight, compact, air transportable. They possess a high degree of accuracy, and have been completely proved in the field. Bendix also is widely experienced in airborne radar systems for weather and target tracking purposes.

If these demonstrated radar capabilities meet your needs, write today for further information, including a *specific engineering proposal*. What are your requirements?

EXAMPLES OF APPLICATIONS:

Weather Radar • Storm Detection • Meteorological Tracking • Mortar Tracking • Electronic Countermeasure • Satellite Tracking • Drone Surveillance • Telemetering

Eclipse-Pioneer Division

Teterboro, N. J.

Bendix

District Offices: Burbank, and San Francisco, Calif.; Seattle, Wash.; Dayton, Ohio; and Washington, D.C.
Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

CIRCLE 86 ON READER-SERVICE CARD

NEW PRODUCTS

Regulated Power Supplies 516

High-current dc power supplies have line and load regulation better than 0.03% and ripple less than 1 mv rms. Rated at 80-amp, 0 to 15 v dc, and 16 amp, 0 to 160 v dc, the units have adjustable current limiting protection against short circuits, and can be remotely programed. A constant-current mode is also available, regulated to 0.1%, with adjustable open-circuit voltage. Called the Century Series, units are all solid-state.

Trygon Electronics, Inc., Dept. ED, 111 Pleasant Ave., Roosevelt, N. Y.

***P&A:** $1,250 to $1,945; stock to four weeks.*

Two-Dimensional Dipole Array 510

Telemetering, receiving, and tracking antenna, model AD-250, is a two-dimensional array of crossed dipoles. Antenna can operate independently on two linear polarizations or two circular polarizations of opposite screw sense. Both sequential and simultaneous lobing modes are operable. Frequency range is 215 to 260 mc; beam width at 237 mc is 22-1/2 deg. Sidelobe level is −16 db max. Gain is 17-1/2 db.

Rantec Corp., Dept. ED, Calabasas, Calif.

Silicone-Coated Resistors 513

From 1 to 10 w rated resistors are available in silicone coating. Units exceed MIL-R-26 specifications. Operating temperature range is −55 to +350 C. Severe environmental testing, including mechanical and thermal shock, vibration, moisture, and salt spray, are withstood.

Tech-Ohm Electronics, Inc., Dept. ED, 36-11 33rd St., Long Island City 6, N. Y.

Photoelectric Scanner System 499

Having no amplifier, the type PE-1 photoelectric scanner system operates a relay directly from a power-type photocell. Objects 1/4-in. wide can be counted at 500 per min. Photocell, sensitive to infrared light, has a filter to protect from ambient visible light. Unit, with power supply and plug-in relay, measures 3 x 3-3/4 x 4 in. and operates from 120-v ac.

Farmer Electric Co., Dept. ED, 2300 Washington St., Newton Lower Falls, Mass.

Printed-Circuit Connectors 509

Wire-wrapping post terminals and spring contacts are combined in the Wrapost printed circuit connectors. Contacts, phosphor-bronze, are mounted on 1/16-in. thick board, and have a 1/25-in. grid spacing.

Precision Connectors, Inc., Dept. ED, 134-20 Jamaica Ave., Jamaica 18, N. Y.

Voltage Regulator 494

Nonfrequency sensitive voltage regulator, called Regohm, holds line voltage to within 2% of nominal, despite frequency changes from 50 to 450 cps, 20% line changes, and zero to full load shifts. Models rated from 15 to 1,000 va are available. Output may be either ac or dc; response time is less than 3 cycles for 60 cps input. Unit is miniaturized.

Electric Regulator Co., Dept. ED, Pearl St., Norwalk, Conn.

D.C. Power Supply Users:

Q. **Why are North Electric Company's new d.c. power supplies designed around G-E Silicon Controlled Rectifiers?**

A. "We design our power supplies to meet military specifications, and they have to combine sturdy construction with relatively low weight. General Electric Silicon Controlled Rectifiers give us the advantages of solid state devices with high-speed response, reliability and efficient operation."

A completely solid-state d-c power supply developed by the Electronetics Division of North Electric Company, Galion, Ohio. They can be manufactured for any voltage, with up to 3 K.W. power output. Another example of advanced equipment design made possible by General Electric SCR's.

Features of North Electric's d.c. power supply include:

- **Reliability**
- **High-speed response**
- **Precision regulation**
- **Maximum power conversion efficiency**
- **Reduced weight and package size**

Now lower-priced than ever before, the SCR opens new areas for engineering development. *Can you afford to wait any longer?* Write today for application information. Rectifier Components Department, Section 23H85, General Electric Company, Auburn, New York.

GENERAL ELECTRIC

CIRCLE 89 ON READER-SERVICE CARD

Aircraft Power Supply Users:

Q. **Why did Pesco design a new static inverter for the Centaur missile around the Silicon Controlled Rectifier?**

A. "We found that General Electric's Silicon Controlled Rectifier makes possible exceptional performance under space flight conditions and assures a high degree of efficiency and reliability."

Model R-135 Static Inverter, 26 volt input, 115 volt, 400 cps output, for airborne computer, developed by Pesco Products Division of Borg-Warner Corporation. Another example of an SCR circuit obsoleting other designs.

The SCR design makes possible:

- **Wide range of temperature operation**
- **Built-in short-circuit protection**
- **Fewer component parts for increased reliability**
- **Good heat transfer design**

Now lower priced than ever before, the SCR opens new areas for engineering development. *Can you afford to wait any longer?* Write today for application information. Rectifier Components Dept., Section 23H21, General Electric Company, Auburn, N. Y.

GENERAL ELECTRIC

CIRCLE 90 ON READER-SERVICE CARD

NEW PRODUCTS

Program Simulator 495

A manual programer and automatic punch control are integrated in the model PS-425 program simulator. Device transfers test configuration directly from the simulator to punched tape. Unit allows manual setup and crosscheck of test configuration before punching tape. Configurations with from 80 to 120 bits are available. Unit has an 8-level, 10-row keyboard.

Electronic Engineering Co. of California, Dept. ED, 1601 Chestnut Ave., Santa Ana, Calif.

P&A: *$1,150 fob Santa Ana; 6 to 8 weeks.*

LC Oscillator Package 501

With a built-in buffer amplifier, the model AFS17 LC oscillator package is a hermetically sealed octal plug-in unit. Any fixed frequency output from 100 cps to 1 mc is available, accurate to ±0.5%. Output voltage is 2 to 5 v rms, with 5-K impedance. Unit, transistorized, measures 1-1/4 in. diameter by 2-9/16 in. high. Device withstands extreme shock and vibration, meeting MIL specs.

Greenray Industries, Inc., Dept. ED, 5281 E. Simpson Road, Mechanicsburg, Pa.

P&A: *$57.50; stock to 6 weeks.*

Code Converter 496

Binary code characters up to six bits are accepted in any combination and converted to any other binary code arrangement by the model 770 code converter. Available separately are the model 770D code detector which decodes binary characters into 64 lines, and the model 770G code generator which creates any binary code from 64 input lines. The converter is a combined detector and generator.

Electronic Engineering Co. of California; Dept. ED, 1601 E. Chestnut St., Santa Ana, Calif.

P&A: *$4,100, $2,900, and $1,900; 60 days.*

Tension Recorder 521

Electronic tension recorder is useful in all preparatory operations of wire, cable, tape, yarn, and cord. Two chart speeds, 5 and 50 mm per sec, are provided. Hand-held transducers sense tension.

Tensitron, Inc., Dept. ED, P. O. Box 185, Harvard, Mass.

Servo Amplifiers 519

Solid-state servo amplifiers are available with power outputs from 10 to 6,000 w, capable of driving ac or dc servo motors of up to 8 hp. All requirements of MIL-E-16400 are met.

Litton Systems, Inc., Maryland Div., Dept. ED, 4910 Calvert Road, College Park, Md.

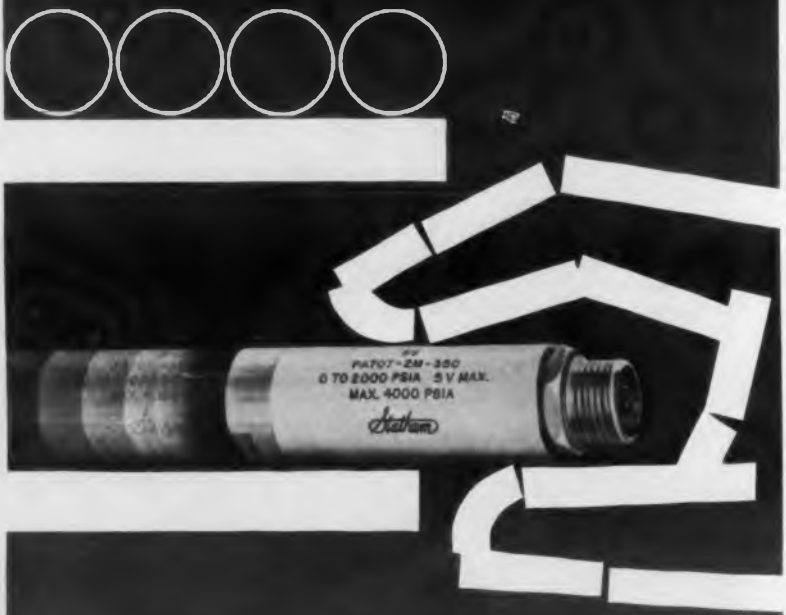
Analog Multiplier-Divider 492

Solid-state, plug-in multiplier-divider, model MD-1, is made to replace instrument servos in analog computation. Accuracy is better than 0.1%. Isolation permits use of both ac and dc input signals. Unit is suited for military applications and severe environmental conditions.

Elasco, Inc., Dept. ED, 5 Prescott St., Roxbury, Mass.

Availability: *six to eight weeks.*

NOW AVAILABLE FROM STOCK!!!



Statham's Multi-purpose P707 Pressure Transducers

Statham's Model P707 series of rugged, general purpose pressure transducers are now available for immediate delivery! The compact, lightweight P707 has been designed to withstand the stringent environmental conditions encountered in high performance aircraft, space probes, and ballistic missiles.

This Zero-length/dimensionless pressure transducer features a wide variety of ranges, low sensitivity to acceleration, and excellent thermal performance without sacrifice in frequency response or in non-linearity and hysteresis characteristics. Available for measurement of absolute and gage pressures from 0-5 psi through 0-5,000 psi.

For complete data on the P707 contact the Statham sales office in your area or write to:

Statham STRAIN GAGE DIVISION

Statham Instruments, Inc., 12401 W. Olympic Blvd.
Los Angeles 64, Calif. / GRanite 8-0361 / TWX: West Los Angeles CAL 6602

CIRCLE 94 ON READER-SERVICE CARD

NEW PRODUCTS

Power Supply 508

This 25-amp power supply, model S125-25, is a silicon rectifier unit which operates from 208-, 230-, or 460-v, 3-phase ac input. Output is continuously adjustable from 0 to 25 v dc. Regulation is 1.5%; ripple is 5% max. Made for dc motors, solenoids, and similar power devices, the unit measures 22 x 15 x 19 in. and weighs 125 lb.

Perkin Electronics Corp., Dept. ED, 345 Kansas St., El Segundo, Calif.

Telemetry Oscillator 553

Voltage-controlled millivolt oscillator combines a high-gain, differential input dc amplifier, a voltage regulator and a subcarrier oscillator in a single encapsulated module. Model TOE-304 covers IRIG bands 1 through 18; input range is ±10 mv or 0 to 20 mv, linearity within ±0.5%. Unit weighs 4.5 oz max, occupies less than 3.25 cu in.

The Bendix Corp., Bendix-Pacific Div., Dept. ED, 11600 Sherman Way, North Hollywood, Calif.

Temperature Detector 559

Resistance wires interwoven with fiberglass threads provide a rugged, accurate and inexpensive sensing element. Width ranges from 1/2 to 3 in.; length is unlimited. Detectors are suitable for use up to 1,000 F.

Control Indicating Corp., Dept. ED, Bradley Field, Windsor Locks, Conn.

Preamplifier-Demodulator 554

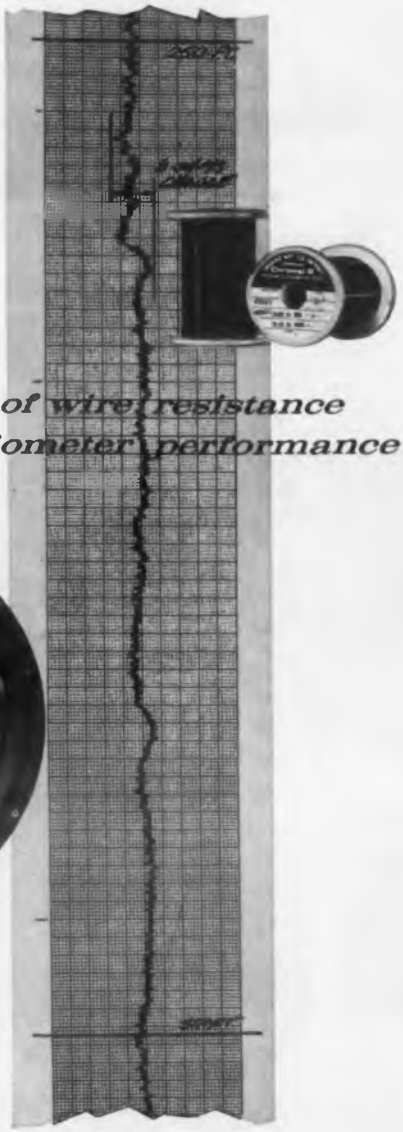
Miniature, self-contained preamplifier-demodulator model 1810-0600 has a typical output of 2.5 v dc into 1-K resistive load for 1-v ac input. Carrier frequency is 380 to 420 cps. Temperature range is −55 to +71 C. Weight is 7 oz.

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

Microminiature Feedthrough 573

For long-reach use. Type FT-MM-47-TUR feedthrough, having a stud as thin as a sewing machine needle, permits an over-all reach of 1.5 in. It is insulated from the chassis by a Teflon body and is easily installed.

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



This Tape Recording shows the actual deviations in Linearity of Resistance present in a representative length of .0014" Chromel-R wire having a total of 105,750 ohms. Note that greatest change recorded was 6 ohms—which is well within Hoskins Guarantee of .012% maximum deviation in any 250 feet.

How close linearity of wire resistance improves Potentiometer performance

Basic Function of a potentiometer is to control voltage in a circuit by varying electrical resistance. Thus use of wire which possesses superior controlled Linearity of Resistance assures finer accuracy and reliability of operation proportional to shaft rotation.

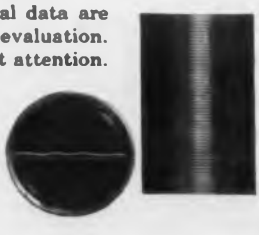
Three reasons why you should specify

Hoskins Chromel-R

Premium Potentiometer Grade 800-Ohm Wire

First, its fine linearity of resistance is controlled to the closest standard of uniformity ever established for potentiometer wire as specified above. Second, it is unconditionally guaranteed to have less than 40 ohms of equivalent noise resistance when received at your plant. And third, it possesses the superior wire roundness required for more uniform winding of mandrels.

Sample spools of Chromel-R with detailed technical data are now available to potentiometer manufacturers for evaluation. Requests on company letterhead will receive prompt attention.



HOSKINS MANUFACTURING CO.

4445 Lawton Avenue • Detroit 8, Michigan • Tyler 5-2860

In Canada: Hoskins Alloys of Canada, Ltd., Toronto, Ontario

Producers of Custom-Quality Electrical Resistance, Resistor and Thermoelectric Alloys Since 1908

NEW PRODUCTS

Sonar Amplifier 566

Wide-band, 3-kw sonar amplifier model S-3000 operates at full power from 50 to 20,000 cps and has load impedances of 15, 30, 60, 120, 250, 500 and 1,000 ohms. It delivers half power at 30,000 cps. Harmonic distortion over the entire frequency range is less than 2%.

Tenney Engineering, Inc., Communication Measurements Laboratory, Inc., Dept. ED, 350 Leland Ave., Plainfield, N. J.

Availability: *10 weeks.*

DC-DC Converters 567

Plug-in dc-dc converters are for use with nucleonic instruments, photomultipliers, cathode-ray tubes and high-altitude instruments. Series 350, 360, 310 and 320 have adjustable or regulated outputs ranging from 500 to 5,000 v. Regulation is to ±1%.

Universal Transistor Products Corp., Dept. ED, 380 Oak St., Copiague, L. I., N. Y.

Panel Meters 562

Rectifier-type, panel instruments DW-91, DO-91, and DO-92 measure 2-1/2, 3-1/2, and 4-1/2 in. respectively. Full-wave copper-oxide rectifiers are used for ac voltage and current measurement. Accuracy at 25 C, 60 cps, is ±3%. Voltmeter ranges of 10 to 300 v and ammeter ranges from 500 μa to 20 ma are available.

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

Wire Markers 497

Wires of 0.05 to 0.115-in. diameter can be marked by the type Z Beta markers. Markers are closed, flexible units, with an expandable, accordion-type pleat. Numbers, letters, and various symbols are available in different colors. Devices are of polyvinylchloride and meet MIL specs. Markers come in coils of 50 to 500.

Electrovert, Inc., Dept. ED, 124 E. 40th St., New York 16, N. Y.

Availability: *from stock.*

Digital Modules 552

Design and production service is offered on digital circuit modules. Standard components are mounted in tapered notches around the periphery of etched wiring boards. Potted modules operate from −55 to +65 C. Modules with custom circuit design may be obtained in prototype or production quantities.

Government Sales Dept., Bendix Radio Div., The Bendix Corp., Dept. ED, Baltimore 4, Md.

Transistor Testers 560

Positive acceptance or rejection is provided on a go, no-go basis by three transistor test sets. Computer test set evaluates switching characteristics. Reverse current test set performs seven tests of three parameters. A pulse beta test is made by the third set.

Designers for Industry, Inc., Dept. ED, 4241 Fulton Parkway, Cleveland 9, Ohio.

1/20th
CUBIC FOOT
of Dynamic Measurement

• • •

ACCURATE TO 0.1%

The Series BH100

MILLI-V-METER®

The Instrument with the TAPE-SLIDEWIRE

for PETROLEUM, CHEMICAL, STEEL, ALUMINUM and other processing plants...

to accurately indicate

TEMPERATURE, FREQUENCY, FLOW, LEVEL, PRESSURE, R.P.M., WEIGHT, etc.

Every function of the producing plant may be measured *and controlled* with high accuracy. Ideally small and designed for uniform panel installation, the MILLI-V-METER is completely self-contained...including power supply, servo unit, slidewire and amplifier. Every measurement exhibited on the counter is a precisely (electronically) calibrated value.

1/10 *the size*

10 *times the* accuracy

of standard instruments

QUALITIES

1) Accuracy 1 part in 1000. Laboratory precision for industry or the military.
2) Compatibility with any transducer—AC or DC.
3) For strain gage, linear differential transformer, thermocouple, thermistor, resistance thermometer, pulse or variable frequency circuits or systems.
4) Operates directly from 60- or 400-cycle power as specified.

SPECIAL FEATURES

For Recording...a re-transmitting slidewire may be provided within the case.

For Controlling...switch contacts may be provided to operate control units, remote indicators, or printers.

For Computers or Telemetering...counters with decimal outputs may be added.

Produced by the makers of JETCAL® *jet engine Analyzer ...in worldwide military and airline use!*

Full information is available for the asking!

Sales-Engineering Offices:

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HOWELL INSTRUMENTS, INC.

FORMERLY BELL INSTRUMENT CO., INC.

2470 WEST VICKERY BLVD. • FORT WORTH 7, TEXAS

CIRCLE 104 ON READER-SERVICE CARD

NEW PRODUCTS

Current-Modulated Testers 574

Determine dc and/or ac characteristics of dc excited components such as Zener diodes, matching diodes, rectifiers and other devices. Model MT302 current-modulated tester has a range of 0 to 80 v; model MT301, 0 to 40 v; model MT303, 0 to 250 v. The instruments use a 60-cps internal current-modulated circuit while providing for external modulation of frequencies of 20 cps to 100 kc.

Modutronics, Inc., Dept. ED, P. O. Box 368, Solana Beach, Calif.

Lamp-Switch Indicator 493

Miniature indicator is called the Logic Switchlite. Made for high-reliability circuits, unit has a momentary-contact spst switch, a transistorized circuit for operating the indicator at low signal levels, and a plug-in lamp and resistor unit which activates the switch. Unit is self-contained in a 2.3-in. long adonized case.

Eldema Corp., Dept. ED, 1805 Belcroft Ave., El Monte, Calif.

Transducer 555

Absolute pressure transducer model 311, made for industrial, laboratory or missile use, has a dynamic error band as low as ±1.0%. Response time is 20 msec, ranges cover 0 to 100 to 5,000 psia. Resolution is 0.25%, power rating 1.0 w at 165 F. Weight is about 5-1/2 oz.

Bourns, Inc., Instrument Div., Dept. ED, 6135 Magnolia Ave., Riverside, Calif.

Sweep Generator 568

With marker-adder. Model G-32 sweep generator covers 3 to 220 mc in five sweep-frequency ranges. Sweep width is 0 to over 20 mc on hf ranges and is continuously variable. The marker oscillator is crystal controlled.

Paco Electronics Co., Inc., Dept. ED, 70-31 84th St., Glendale 27, N. Y.

Module Rack 558

Mounting 40 plug-in series H digital modules, rack model BL-40 has prewired, low impedance clock distribution system and power distribution busses. Accessory cooling unit CU-40 maintains suitable operating temperatures. Height of the combination is 3-1/2 in.

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

POSITIVE TRACKING

plus higher reliability

Vought Electronics now has available for immediate delivery a Superheterodyne C-Band Radar Beacon designed to provide more positive, more reliable long range tracking.

The CVRT-6 beacon is used in conjunction with FPS-16 and MPS-26 radars and has been utilized successfully in testing the *Hound Dog* missile and in drone applications on both the Pacific and Eglin Missile Ranges. The compact magnetron type transponder is engineered for easy servicing and economical field maintenance. All adjustment controls are readily accessible, and no shock mounts are required. The unit can be powered by either ac or dc.

Other important specifications:

- sensitivity (for 100% triggering) is –70 dbm
- peak power is 500 watts minimum
- volume is less than .125 cubic feet

C-Band antennas are available for most applications and a two or three pulse decoder is available for specific applications.

For complete information about the CVRT-6, contact: *Chief of Product Sales*

CHANCE VOUGHT ELECTRONICS

P. O. Box 1500 *Arlington, Texas*

CIRCLE 107 ON READER-SERVICE CARD

still waiting for your pots?

Are your pot delivery schedules figured in weeks instead of days? If you're a member of the Pot Waiter's Club, read on:

At ACE, we fully inventory *all* parts for our complete standard line! And when a pot *has* to be made from scratch — we cut time there, too. All raw materials are warehoused, and a complete machine shop, including Swiss screw machines, is maintained. Our special prototyping department lops the time off special requirements.

Prepared engineering releases and part prints for standard pots await your incoming order. That's why, within hours after receipt, your order for standards is into manufacturing! So specify from Ace's comprehensive line of standards, in full resistance ranges, sizes, configurations and functions. Your "special spec" is probably among our standard line — and that means time and money saved for you!

This 1-1/16" ACEPOT®, typifying the entire standard line, is available on prompt delivery!

ACE ELECTRONICS ASSOCIATES, INC.
99 Dover Street, Somerville 44, Mass.
SOmerset 6-5130 TMX SMVL 181 West. Union WUX

Acepot® Acetrim* Acecal® Acechm® *Reg. Appl. for

CIRCLE 108 ON READER-SERVICE CARD

NEW PRODUCTS

Flash Generator 561

Tests semiconductor materials. Flash generator SC2 provides 1 to 10 flashes per sec. Duration is 0.1 μsec. Fresnel lens concentrates flash on a small area. Unit is used with an oscilloscope for measuring semiconductor carrier life.

Epic, Inc., Dept. ED, 150 Nassau St., New York 38, N. Y.

Price: *$1,395.*

Tunnel-Diode Envelopes 570

Made of high-purity alumina which is brazed to a flange on one end and a pedestal on the other. Tunnel-diode envelopes can be furnished in sizes as small as 0.080 in. OD and 0.030 in. over-all height, with concentricities of 0.001 in.

Ceramics International Corp., Dept. ED, 39 Siding Place, Mahwah, N. J.

Price: *$1 in lots of 5,000.*

Single-Sideband Filters 572

Carrier frequency is 1,400 kc with a 3-db bandwidth of 2.5 kc. Lower sideband filter type LSB-1400-2.5 and upper sideband filter type USB-1400-2.5 are suited for mobile applications. Carrier rejection is 20 db with at least 50-db rejection of undesired sideband.

Systems, Inc., Dept. ED, Box 7726, Orlando, Fla.

Availability: *3 to 4 weeks.*

Panel Meters 526

Of all-metal construction, the style 42 panel meters have a 3.97-in. scale and are accurate to 2%. Units, gasket-sealed, have steel enclosures which protect against magnetic fields and stray rf. Glass windows do not collect static charges. Meters measure about 4.1 x 4.7 in., and are available as ac and dc voltmeters, ammeters, milliammeters, and microammeters.

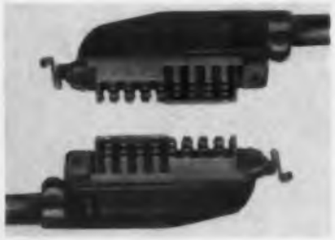
Helipot Div., Beckman Instruments, Inc., Dept. ED, 2500 Fullerton Road, Fullerton, Calif.
Availability: *30 days.*

Radio-Transmitter Tubes 534

For mobile applications such as on airplanes, boats and motor vehicles. Tube types 6146A, rated at 6.3 v; type 6159A, 26.5 v; 6883A, 12.6 v, offer higher outputs at lower heater voltages than previous units.

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

Telephone Cable Plug 527



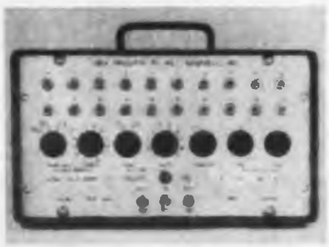
Hermaphrodite plug for telephone cables is called Morpho 51. A single style contact is used as both plug and receptacle, is flat and elongated, and extends out from the wall as far as the thickness of the connected cable. Lexan, stronger than cellulose acetate, is used as insulator material. Up to 51 contacts are handled. Contacts are crimped, either by hand or by machine.

Cannon Electric Co., Dept. ED, 3208 Humboldt St., Los Angeles 31, Calif.

CIRCLE 110 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Pulse Pattern Generator 551



From 10 to 100,000 bits per sec are produced by the model 151 pulse pattern generator. It offers NRZ, RZ, and keyed-tone outputs. Operating from either an internal or an external oscillator, the unit generates any pulse pattern up to 20 bits long in burst or continuous mode.

Data Products Div., Frederick Electronics Corp., Dept. ED, 414 Pine Ave., Frederick, Md.
P&A: *$675.00; stock to 90 days.*

Voltage Reference 557

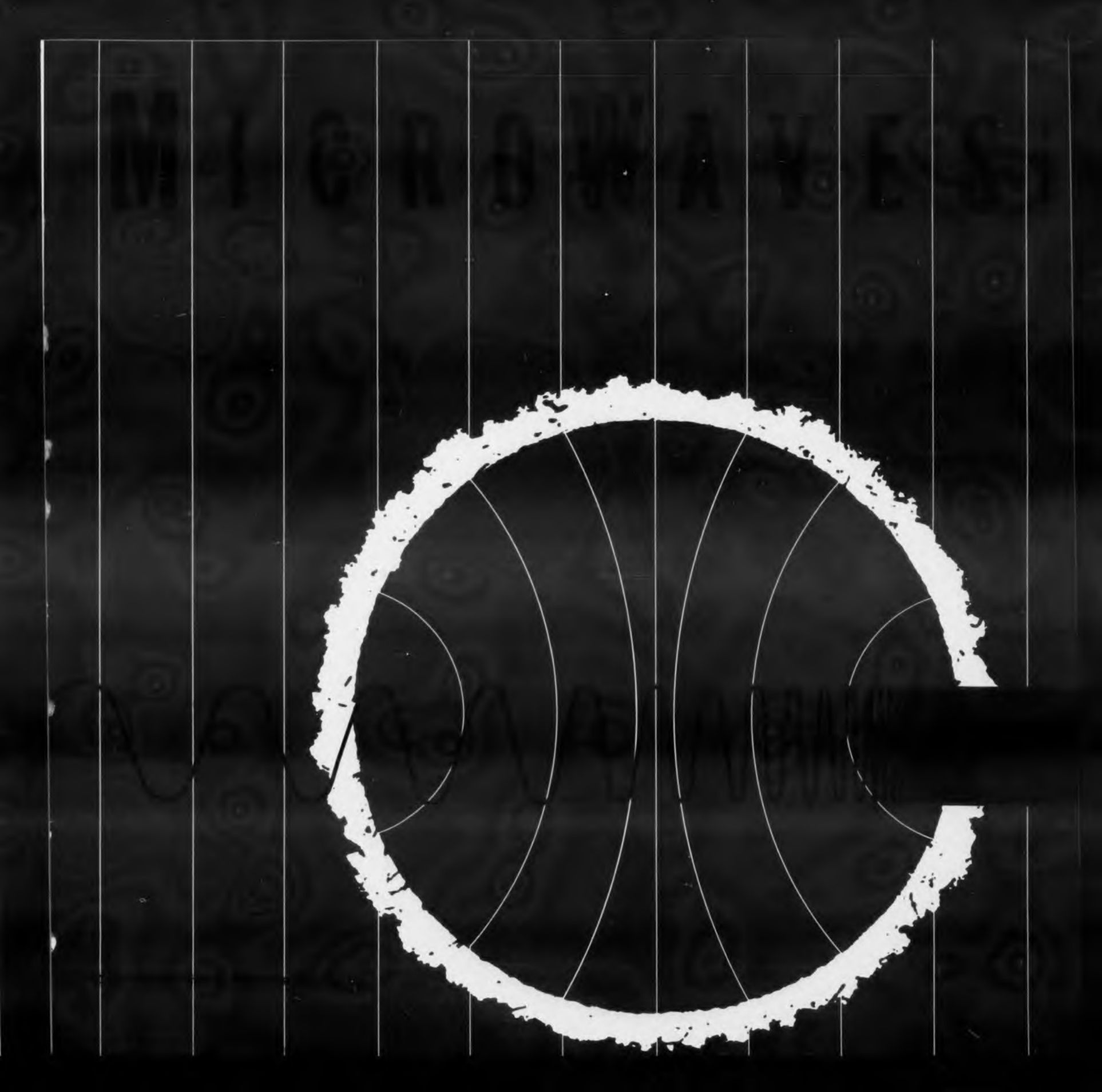
Primary voltage reference model PVR-6 has guaranteed stability of 2 ppm for 3 months, 3 ppm per year. Calibration accuracy is 0.0015%. Stability may be equal to or better than that of temperature-controlled saturated cell.

Calibration Standards Corp., Dept. ED, 1025 Westminster Ave., Alhambra, Calif.
Price: *$3,850.*

Plastic Film Capacitors 571

Range is 0.5 to 1 μf. Type SS precision plastic film capacitors have an insulation resistance of 10,000 meg min, a temperature coefficient of 105 $\pm$10 ppm per deg C, a long-term stability of $\pm$0.05% and a dissipation factor of 0.0005 max. Dimensions are 2-5/16 x 1-9/16 in.

Arco Electronics, Inc., Dept. ED, Community Drive, Great Neck, N. Y.
P&A: *$40 to $52; stock.*


MICROWAVES

MICROWAVES

No Bum Steers From the Cow Palace

As this section goes to press, the electronic industry's road show is playing to a packed house at the San Francisco Cow Palace. But from what we've seen there are few really new microwave products on view at WESCON 1961. In general, the stars of the IRE show have merely moved to an earlier time zone for a brief exposure to sunshine and the sport shirt contingent of the electronic industry.

In the idea department however, the technical sessions are providing raw meat for creative microwave engineers with emphasis on antennas, paramps and solid state. We'll stop mixing our metaphors long enough to wrap up the show in the opening pages of this issue of ELECTRONIC DESIGN and extract the most significant microwave design news from among the Cow Palace stampede.

Confidence in the accuracy of sensitive microwave measurements will be increased with

Agreement Nearing on New Precision Coax Connectors .....p 103

For moderate-power applications, the diode switch offers an attractive alternative to ferrites. Methods of design and practical applications are described in

Design of a High-Speed Diode Switch .....p 106

Microwave polarimeters for S and X bands, a 1,000-cps internally modulated twt and a highly tunable S-band receiver are featured in

Microwave Products .....p 112

Agreement Nearing on New Precision Coax Connectors

Manfred Meisels
Technical Editor

A MAJOR problem in microwave measurements may be overcome by the designation, early next year, of a standard, high-precision coaxial connector. The decision will be made by a standardization committee drawn from connector manufacturers, instrument companies, measurement laboratories and the National Bureau of Standards.

Several new connectors were presented to the committee at a recent meeting in Boulder, Colo. These and existing precision coaxial units are being evaluated.

New connectors discussed were:

- General Radio Type 900
- Rohde & Schwarz Dezifix A and improved Dezifix B
- P.R.D. rectangular element connector.

Other connectors being considered include:

- Marconi H-1
- Woods connectors as modified by NBS and Sandia Corp.

The principal requirement established for the high precision connector is a maximum vswr of 1.01. General-purpose connectors now available may have a vswr of from 1.1 to 1.5. Worse yet, these vswrs are not consistent among connectors of the same type and may even vary in an individual connector.

Because of the many different types of connectors fitted to measuring instruments, adapters are generally needed for interconnection. These adapters often introduce a vswr error that is greater than that of the connectors themselves.

"We've lived with this connector problem far too long and the measurement accuracies demanded today simply cannot be met with confidence as things now stand," committee chairman F. J. Tischer of the Ohio State University told ELECTRONIC DESIGN.

Standard, high-precision connector may well be selected from the ones in this photo. From left to right: General Radio 900, Rohde & Schwarz Dezifix, Marconi H-1 and NBS-modified Woods connector.

Other requirements for the standard connector include:

- Low leakage.
- Uniform contact resistance
- Reproducibility of performance with varying contact pressure.

Environmental resistance and ruggedness are, however, secondary. "We want a connector primarily for laboratory use and are not too concerned with how it might behave in the field," Dr. Tischer observed. Nevertheless, some of the lessons being learned by connector manufacturers working with the committee may eventually be translated into improved field equipment. All the manufacturers designing new connectors or improving existing types plan to incorporate them into their own equipment if they have not already done so.

As of the present, the committee hopes to standardize on a maximum of three coaxial connectors covering the microwave spectrum to perhaps 18 Gc. Typical connector sizes, specified by the inner diameter of the outer conductor, and their approximate upper frequency limits may be:

- 0.75 in.—2Gc
- 0.5625 in.—8 Gc
- 0.28 in.—18 Gc.

These and other sizes are being evaluated by the committee, with some proposals due at its next meeting in January 1962. Resistance of all connectors will be 50 ohms. A fourth size, useful to perhaps 50 Gc may be designated in the future.

While it is desirable that all three connectors be of the same type, this may not prove feasible. Manufacturing tolerances on an admittedly superior connector may be difficult to maintain in a scaled-down version of the unit.

Design of new connectors is generally proceeding with the two larger sizes and the committee may defer its recommendations for the 0.28-in. connector.

The committee presently has no means to obtain compliance with its recommendations other than the fact that its membership represents most of the groups now plagued by the connector problem. It is hoped however that the committee's recommendations would be adopted by one of the professional or industrial standards-setting groups. Conversations to this end are in progress.

Connector manufacturers working with the committee have agreed that design of the standard connectors will be made available to industry on a royalty-free basis.

Of the connectors described at the recent Boulder meeting, the General Radio 900 unit had the best claimed performance. This 0.5625-in. connector is said to have a vswr of less than 1.003 to 4 Gc and 1.01 to 8 Gc. These characteristics are quoted for a pair of mated connectors rather than for a single unit. Impedance tolerance of the GR-900 is ±0.1 percent.

The GR-900 is a sexless connector with contact between the center conductors effected by six-sector, spring-loaded butt contacts. The center conductor is supported by a Teflon or Rexolite insulator. The insulator is initially machined with one dimension oversize which is then individually trimmed for minimum vswr.

The Teflon insulator is retained in place by a machined shoulder while the Rexolite insulator is cold-shrunk into the connector. This technique has led to the design of a kit by which cavities and other components with inaccessible interiors can be readily adapted to the connector. A hole to accept the cold-shrunk Rexolite insulator and a machined surface with a threaded shoulder to mate with the outer conductor are the only modifications made to the cavity.

Minor modifications enable the connector to mate with a variety of other sexless connectors such as the Dezifix, Marconi H-1 and Woods types, according to General Radio.

Other features reported for the GR-900 connector include:

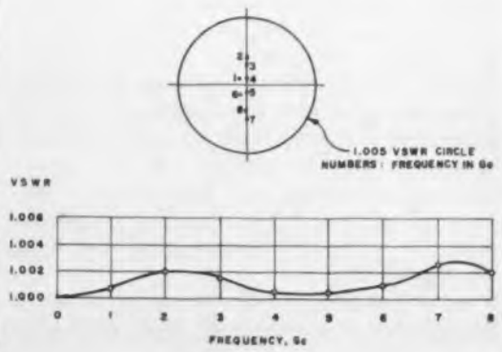
- Existance of a well-defined electrical reference plane physically located at the face of the connector.
- Connector body and center conductor made of solid silver alloy to permit repolishing of the butt-joint faces in the event of damage.
- Accurate centering achieved without locating pins.

General Radio plans to introduce the GR-900 in its line of microwave instruments and components where appropriate. A smaller version of the connector, useful to perhaps 16 Gc is contemplated.

The Rohde & Schwarz Dezifix connector is a flange type unit that has been progressively refined in the twenty years since its introduction. It is available in progressively smaller sizes with types A and B approximately equivalent to the smallest and largest sizes proposed by the committee.

The Dezifix B has a claimed vswr of less than 1.01 up to 4 Gc. A new 0.27-in. version, the Dezifix A, will be submitted to the standardization committee for testing. Performance details of this connector have not been disclosed.

Rohde & Schwarz also stress the adaptability of their connector in mating with other



Performance of a mated pair of GR-900 connectors. Smith chart shows all measured impedances well within the 1.005 vswr circle. Graph (left) indicates a maximum vswr of 1.003 to 8 Gc. Disassembled connector is illustrated above.

Dezifix connector mounted on signal generator. The 50-ohm connector is shown being mated with a 75-ohm cable connector.

flange-type units. A company spokesman noted that equipment with nonstandard connectors will remain in use for several years after the committee's decision and that designation of a standard connector should recognize this fact.

P.R.D. Electronics disclosed an unusual rectangular connector. Its design separates the problem of supporting the center conductor from that of giving it mechanical rigidity during coupling and uncoupling of the connector. This is achieved by a steel pin that is removed when the connector is actually in use. The connector was designed in the course of work on a wideband, highly directive directional coupler.

Improved versions of general-purpose connectors were also described at the Boulder meeting. While these were not represented as meeting the standards demanded by the committee, it was felt that their use would nevertheless be desirable in general-purpose test equipment. Weinschel Engineering, for example, reported development of a stainless-steel N-type connector to be used with rigid coaxial lines. Tighter tolerances and compensations are maintained as compared to off-the-shelf N-type connectors. These are being introduced on Weinschel terminations, attenuators and tuners.

Sandia Corporation engineers spoke on modifications to SC-type connectors. These units, originally designed for rugged environmental conditions were improved by eliminating certain sealing disks and washers that ordinarily introduce reflection. The modified connectors, while less rugged were found adequate for laboratory use. ■ ■

MICROWAVES

Design of a High-Speed Diode Switch

Diodes are a natural for fast, broadband microwave switching, but the niceties of designing such switches are not necessarily obvious. Author Robert Michal here describes a successful design for these versatile little switches.

Robert L. Michal
Sperry Gyroscope Co.
Great Neck, N. Y.

FOR moderate-power applications up to 3 or 4 w, diode switches are an attractive alternative to ferrite and mechanical switches. The diode switch described in this article operates at microsecond speeds within the band from 1 to 5 Gc. Minimum switching action is 11 db per diode with no limitation on the number of diodes.

The switch consists essentially of one or more point-contact diodes offering a high rf impedance at zero or negative bias. A positive bias signal increases barrier capacitance and decreases barrier resistance. The diode's rf impedance is thus decreased to present a low-loss near match to the transmission line. Since attenuation of the diode is a function of its bias, any desired value of attenuation between the stop loss and pass loss can be achieved.

The diode switch can be built in several forms, depending on its application and operating frequency. For X-band use, waveguide construction is feasible. At lower frequencies however, the switch is more practically installed in a section of coaxial line, strip line or slab line. Of these methods, the slab line appears most convenient to design and assemble.

The characteristic impedance (Z_o) of the slab line is determined by the formula

$$Z_o = \frac{138}{\sqrt{\epsilon}} \operatorname{Log}_{10}\left(\frac{4S}{\pi D}\right) \qquad (1)$$

where S = Ground plane spacing
D = Center-conductor diameter
ϵ = Relative dielectric constant

This formula is accurate to within 2 per cent for values of S/D greater than 1.5.

The ground plane spacing must provide sufficient clearance for the diodes. For example, an S of 0.167 will permit installation of a 0.107-in. diam diode. The appropriate center conductor diameter is then computed from Eq. 1.

The basic switch as illustrated in Fig. 1

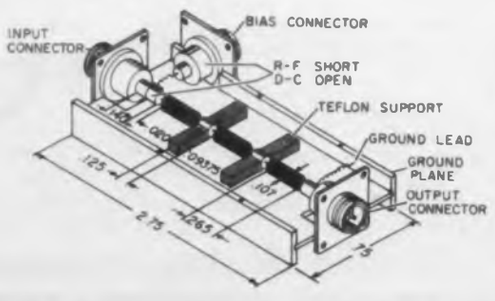


Fig. 1. Basic diode switch described in this article. The dimensions noted here determine the impedance of the switch. In the auxiliary schematic, the rf shorts are denoted as capacitors.

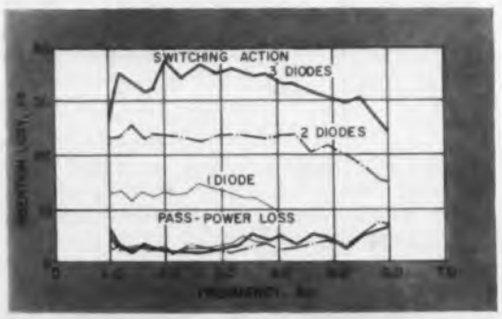


Fig. 2. Performance of switch using 1N118 diodes. Each diode yields approximately 11 db of switching action. Pass-power loss remains relatively constant for any number of diodes.

is machined of aluminum. Teflon slabs are included for mechanical support. A new S/D ratio is required at the Teflon because of the change in dielectric constant. It may prove convenient to mill out the ground planes at the Teflon rather than change the diameter of the center conductors. The center conductors are in any case quite small and can be machined either of aluminum or brass.

The particular diode used must match the transmission line in the pass-power condition. A 1N118 diode, for example, can be employed with a 50-ohm line. If diodes are used that require other than a 50-ohm line, suitable transforming sections must be added at each end of the switch to match to the rest of the system.

Teflon Coating Provides RF Short at Connectors

An important feature of the switch is the inclusion of an rf short (and dc open) at the input and bias connectors consisting of a thin coat of Teflon between two metal surfaces. This device controls the effective rf length of the bias lead and eliminates stray rf pickup. The dc open at the input connector prevents the bias current from escaping through the input circuitry. A ground return lead at the output transforms the switch into an independent unit that cannot be affected by any dc paths in the rest of the system.

Several precautions are necessary to minimize insertion loss. The bias and ground leads should be 1/4 wavelength long at the center frequency of the switch. The rf short at the

Table 1. Electrical properties of the 1N118 three-diode switch shown in Fig. 1

PROPERTY	RANGE
SWITCHING ACTION	30 db MINIMUM OVER FREQUENCY RANGE
FREQUENCY RANGE	1000 TO 5000 Gc
POWER-HANDLING CAPACITY	4 w MINIMUM OF rf POWER
BIAS POWER REQUIREMENTS *	
SWITCH ON	33 mw (+1.7 v AT 20 ma)
SWITCH OFF	0.25 μw (-0.5 v AT 0.5 μa)
RISE TIME	ABOUT 0.8 μsec FOR 20 ma PULSE (DECREASES WITH INCREASING PULSE AMPLITUDE)
DECAY TIME	ABOUT 0.1 μsec (INCREASES SLIGHTLY WITH INCREASING PULSE AMPLITUDE)**
INPUT VOLTAGE-STANDING-WAVE-RATIO:	
PASS-POWER CONDITION	ABOUT 2:1
STOP-POWER CONDITION	ABOUT 10:1 (MOST LOSS CAUSED BY ABSORPTION OF MICROWAVE ENERGY)
TEMPERATURE RANGE FOR EFFECTIVE OPERATION	-60 deg C TO +80 deg C
ON OR PASS-POWER INSERTION LOSS	AVERAGE 2.5 db

*SWITCH NORMALLY OFF AND PULSED INTO ON CONDITION, REDUCING AVERAGE POWER REQUIREMENT. BIAS APPLIED TO ANODE, CATHODES ARE GROUNDED
**RISE TIME INCREASES WITHOUT MUCH CHANGE IN DECAY TIME IF BIAS PULSE IS REDUCED BELOW 20 ma

Table 2. Pulse response of the 1N118 three-diode switch.

Frequency (Gc)	Reverse Bias (V)	Pulse (ma)	Rise Time μsec	Decay Time μsec	Pulse Width
2.0	0.5	20	0.8	0.08	1.8
2.0	0.5	5	1.2	0.08	1.4
2.0	0.5	40	0.7	0.10	1.9
2.0	0.5	20	1.0	0.10	1.7
3.0	0.5	20	0.9	0.10	1.7
4.0	0.5	20	1.0	0.10	1.8

Bias Pulse: Rise Time = 0.04 μsec
Decay Time = 0.04 μsec
Pulse Width = 2.00 μsec

input connector is reflected back to the center conductor as an open circuit or as a very high impedance, thereby limiting rf transmission over the bias lead.

Bias leads can be helical or straight; only their over-all length need be considered. By using thin wire for the bias lead, the characteristic impedance of the transmission path down the bias leads is rendered larger than that of the main line. Care should also be taken to lead the bias coils out of the slab line so that they interrupt a minimum number of field lines.

Diodes can be closely spaced for compactness and good bandwidth. Somewhat better switching action results when diodes are spaced out at 1/4 wavelength intervals, but the bandwidth is narrowed.[1]

Microwave Diodes Are Not Always Best for Switching Use

The choice of a suitable diode for the switch is not an obvious one, as the semiconductor material rather than the form of the package determines the effectiveness of the switching action.[2] In evaluating diodes at Sperry Gyroscope Co., it was seen that diodes designed for microwave use (such as detectors and mixers) yielded appreciable switching action over only a very narrow band. Tests were therefore extended to include other diode types.

The governing factor in selecting a diode is its variation of impedance as a function of bias voltage and current and frequency. Tests of the 1N118 diode in two-diode switch indicated a switching action of better than 20 db with a pass-power loss of 2 to 4 db ultimately used in several experimental ever the 10- to 5-Gc range. This diode was switches.

In testing different types of diodes, it became apparent that manufacturers' specifications, were not always indicative of good switching performance. In one instance, a diode with inferior dc specifications was su-

perior as a switch compared to a second diode with far better dc specifications.

During subsequent tests of another shipment of these two diodes, neither performed well. It was learned that manufacturing techniques had been altered in the interval between shipments. Among the changed factors was the donor density of each diode.

It would seem that the donor densities and processes by which the diode is prepared are closely related to its switching characteristics. Until these factors are fully determined, the designer cannot predict the possible merits of a diode as a microwave switching element on the basis of the manufacturer's specifications.

Performance of the 1N118 diode was confirmed by construction of several switches. Data for one-, two- and three-diode series switches appear in Fig. 2.

Additional Diodes Do Not Increase Pass-Power Losses

Each additional diode increases switching action by approximately 11 db—the difference between the pass-power and stop-power insertion losses of the diode. Note, however, that the pass-power losses do not increase as rapidly as the stop-power losses when diodes are added to the switch. This occurs because the diodes are well-matched to the transmission line and pass most of the rf signal to the output.

The first diode is generally the poorest match and introduces a 2- to 4-db loss. The second and third diodes match the line well and contribute relatively smaller insertion losses. This remains true even if diodes are interchanged.

Switching action decreases at higher frequencies. The bias causes progressively smaller reductions in rf impedance as frequency increases, thus decreasing stop-power losses. Additional power is lost via the bias coils, which no longer present a 1/4 wavelength to the rf signal at higher frequencies.

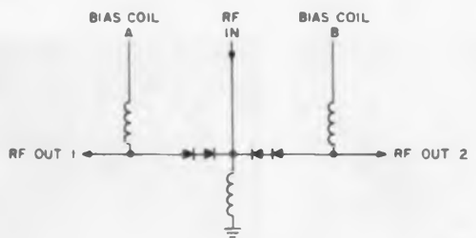


Fig. 3. Single-pole, double-throw diode switch. Device can also be used as a power divider. Each leg contains two diodes and construction shown is typical of the switches described here. The switch permits pulse repetition rates of up to 30 kc in moderate-power circuits.

Electrical characteristics of the 1N118 three-diode switch are listed in Table 1. Data on its switching speeds appear in Table 2.

The 10 to 90 per cent rise time of the switch resulting from a 20-ma bias pulse (with a reverse bias of 0.5 v) is about 0.8 μsec. Decay time is about 0.1 μsec.

If a 2-μsec bias pulse is applied, the half-power pulse width of the switch output is about 1.8 μsec. A weaker bias pulse results in a longer rise time, while the decay time is not appreciably affected. However, output pulse width for the smaller bias pulses is decreased because of the larger rise time. It is also seen from Table 2 that the pulse response is independent of frequency.

The pulse of rf energy transmitted through the switch when it is biased into the pass-power condition contains an overshoot at the leading edge. This is caused by the diode itself, and not by the bias circuit. The resistance of the diode does not change instantaneously from its high reverse value to its low forward value because the distribution of carriers in the bulk of the semiconductor cannot change instantaneously.

There is no limit to the switching action that can be obtained by the basic switch arrangement. Each diode contributes approximately 11 db of switching action, and diodes can be added until the desired switching action is achieved. To obtain 60-db switching, six diodes in series should be used. The pass-power loss remains about 4 db.

Extra Diodes Needed for High-Temperature Operation

The data presented in this article were taken at room temperature. While lower temperatures do not degrade switch performance, higher temperatures (up to 85 C for germanium diodes) will reduce the performance somewhat. It is necessary to add a seventh diode to a 60-db switch to compensate for the reduction in switching action. Likewise, a high-temperature 30-db switch should include a fourth diode.

The lower cut-off frequency can be decreased by lengthening the bias coil. However, upper frequency cut-off would also be decreased, because it is determined by the frequency at which the bias coil presents a low impedance to the rf energy. The upper frequency cut-off of the switch cannot be raised, as it is limited by the capacitive susceptance of the diode.

Useful variations of the basic switch arrangement are easily obtained. A device that can be used as a single-pole, double-throw switch or as a power divider is shown in Fig. 3. In the power divider mode, both sides of the switch would be biased positive.

A switch is combined with a narrow-band filter in Fig. 4. This device accepts wide-band information (1 to 5 Gc) and samples, in time, the portion of this signal within the pass-band of the filter. A set of tunable filters could be provided to cover the entire frequency range of the switch.

Other possible uses include rf pulse modulator, chopper and electronically variable attenuator.

Diode microwave switches offer many advantages. They operate over bandwidths comparable to those of mechanical switches,

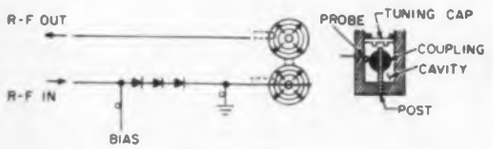


Fig. 4. A three-diode switch coupled to a tunable narrowband filter. Small portions of a broadband signal between 1 and 5 Gc can thus be readily sampled. Pass-power loss is 5 db. Filter details are shown at right.

and with adequate switching speeds. Only the ferrite switch (which is narrow band) with its large magnetic field is faster. In a specific application, using the proper diode, the speed of the semiconductor switch can be compared to that of the ferrite device.

Bias power is moderate, and the unit is lightweight and small. The major limitation —wherever this may apply—is that the power-handling capacity of presently available diodes is limited to a few watts of rf power.

As new diodes are perfected, switching times of nanoseconds, broadband operation above 5 Gc, much greater power-handling capacity, higher switching-action per diode, and temperature-stable operation to above 125 C will become feasible. ■ ■

References

1. M. R. Millet, "Microwave Switching by Crystal Diodes," *IRE Transactions on Microwave Theory and Techniques*, MTT-6, No. 3 (July 1958) pp 284-290.
2. M. A. Armistead, E. G. Spencer, and R. D. Hatcher, "Microwave Semiconductor Switch," *Proceedings of the IRE*, Vol. 44, No. 12 (December 1956) p 1875.

Microwave Power Measurement Breakthrough!

The state-of-the-art of microwave power measurement has taken a giant step forward with the introduction of the General Microwave Model 450 Precision Power Meter. Now it is possible to obtain a direct-reading accuracy of ±0.5% of full scale. The GMC Model 450 exhibits outstanding thermal stability, is easy to operate and can be used to obtain greater precision in the direct measurement of C-W and modulated microwave power. **Specifications:** Accuracy is ±0.5% of full scale. 0.5 microwatt to 10 milliwatts direct-reading power measurement range. Five full-scale ranges from 100 microwatts to 10 milliwatts. 12-inch scale length. Resolution is approximately 0.1% of full scale. Designed for use with GMC Series 402 temperature-compensated waveguide and coaxial thermistor mounts, covering a frequency range from 0.01 to 18.0 Gc. Thermal drift is less than 2 microwatts per degree centigrade. Price, $495.

GENERAL MICROWAVE
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47 GAZZA BOULEVARD, FARMINGDALE, N.Y.
MYRTLE 4-3434

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MICROWAVES

MICROWAVE PRODUCTS

Terminating Devices 386

A vswr of 1.03 or less is produced by these terminating devices known as arrows and spears when placed in corresponding waveguide and operated over the waveguide range. Made of a lossy microwave plastic material, the units are fungus proof, moisture resistant, and able to withstand severe temperature changes. Arrows produce a lower vswr over the frequency band, while spears can withstand slightly greater power levels.

Coax Devices, Dept. ED, Box V, Chelsea 50, Mass.
***P&A:** $10 to $20; two weeks.*

Polarimeter 387

Capable of determining polarization characteristics of S- and X-band frequencies, the DEPCO Polarimeter can be supplied for any frequency between 2 and 12 Gc. Any one unit will cover a range 20% either side of center frequency. The device has the ability to determine left- or right-hand sense of rotation of circularly or elliptically polarized carriers. Designed for antenna testing, radio astronomy and other applications, the unit is self-contained, capable of airborne operation and built to military specifications.

Dayton Electronic Products Co., Dept. ED, 915 Webster St., Dayton 4, Ohio.
***P&A:** $19,500; 90 days.*

Traveling-Wave Tube 388

Series 500 traveling-wave-tube amplifier has 1,000 cycle modulation, making possible increased versatility in handling and detection of low-level cw signals with the use of conventional laboratory equipment. The unit gives a saturated power output of 2 w over the frequency range of 7 to 11 Gc. Minimum gain is 30 db; input and output impedances are 50 ohms with a vswr of less than 2.5. The twt is ppm-focused and has all metal-ceramic construction.

Microwave Semiconductor & Instruments, Inc., Dept. ED, 116-06 Myrtle Ave., Richmond Hill 18, N. Y.

P&A: *$2,775; 30 days.*

Tunable S-band Receiver 389

Tunable from 2.7 Gc to 3.0 Gc, the model STR-1 receiver has a tangential sensitivity of −93 dbm. A flat, 10-mc wide rf pass-band, established by a 3-cavity preselector, makes tuning relatively uncritical, while the off-frequency signal rejection allows the receiver to be diplexed with transmitting equipment operating a few tens of megacycles away. The receiver has an intermediate frequency of 30 mc and an if bandwidth of 2 mc; image rejection is better than 60 db. The unit is designed for rack-mounting, occupying 5-1/4 in. of panel height and 15 in. of chassis depth.

Applied Technology, Inc., Dept. ED, 930 Industrial Ave., Palo Alto, Calif.

P&A: *$5,500, fob Palo Alto; 90 days.*

MICROWAVES PRODUCTS

Tunable Bandpass Filters 657

Frequency measurement is S, C, and X bands is provided by this set of tunable bandpass filters. Absolute accuracy of the calibrated frequency is ±0.01%. Bandwidths of 11 and 9 mc are 3 and 0.25 db down respectively. A thermistor terminating each filter provides spectrum power measurements. Total insertion loss is 5 db average.

Frequency Standards, Dept. ED, P. O. Box 504, Asbury Park, N. J.
P&A: *$3,500 to $4,500; 120 days.*

Quartz Oscillator 670

Bandwidth of 2 cps at 10 Gc is provided by the model 104AR quartz oscillator. Outputs of 0.1, 1, and 5 mc are stable to 5 parts in 10^{10} per day, or 1 part in 10^{10} short term. Harmonic distortion is 40 db min below rated output. Temperature range is 0 to 50 C. Unit is transistorized. Crystal is contained in a double oven. Regulated power supply is self-contained.

Hewlett-Packard Co., Dept. ED, 1076K Page Mill Road, Palo Alto, Calif.
Price: *$3,250.00.*

High-Power Diplexer 666

For the 800 to 1,000 mc band, the model FUU-401 diplexer has 120-db isolation between transmitter and receiver. Receiver pass band loss is 0.3 db; transmitter insertion loss is less than 0.1 db. Pass-band widths are about 20 mc.

Rantec Corp., Dept. ED, Calabasas, Calif.

◀ CIRCLE 122 ON READER-SERVICE CARD

Traveling Wave Tube 658

Miniaturized t r a v e l i n g-wave tube, model G200P, operates from 4 to 8 Gc and provides 10 mw power output. The device, lightweight and ruggedized, is suited for military applications.

Geisler Laboratories, Dept. ED, P. O. Box 353, Woodland Hills, Calif.

Coaxial Slotted Line 661

Operating from 425 to 4,000 mc, the model N200 coaxial slotted line has a residual vswr less than 1.04. Probe, self-contained, is tunable over the entire frequency range. The device uses parallel-plane transmission, said to result in low slot leakage.

General Microwave Corp., Dept. ED, 47 Gazza Blvd., Farmingdale, N. Y.

P&A: *$495.00; from stock.*

Broadband Phase Shifter 655

Over 600-deg phase shift at 9.8 Gc is provided by the model X111LP broadband phase shifter. Unit covers the 8.5 to 10.2 Gc band. Drive current is 0.8 amp dc and can be modulated. Insertion loss is 1 db max; vswr is 1.3 max.

E & M Laboratories, Dept. ED, 15145 Califa St., Van Nuys, Calif.

CIRCLE 123 ON READER-SERVICE CARD ▶

MICROWAVES PRODUCTS

Terminations 668

Input power of 20 w cw and 6 kw peak is handled by models 569 and 624 terminations. Units cover the 1,200- to 1,400-mc and 400- to 500-mc ranges respectively. Maximum vswr is 1.05. Bodies are of black anodized aluminum. Units have type N connectors and measure 1-5/8 in. in diameter, 4-3/8 in. long.

Weinschel Engineering Co., Dept. ED, Kensington, Md.
P&A: *$157.50; eight weeks.*

Silicon Mixer Diodes 664

Low-noise mixer diodes operate through 10 Gc. Types MA-449B through MA-449F have fixed-base cartridges; types MA-449BR through MA-449FR have reversed polarities; types MA-459B through MA-459F have reversible polarities. Calculated over-all noise figure is 6 db max for 30-mc if noise of 1.5 db. Units operate at 150 C, are hermetically sealed, and meet MIL-S-19500 specifications.

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

Variable Attenuator 663

Electronically controlled solid-state variable attenuator, model

◄ CIRCLE 124 ON READER-SERVICE CARD

AAE-1, has a 15-db attenuation range. Unit operates in the 200- to 600-mc band with flat attenuation-vs-frequency characteristics. At band edges and band center, respectively, vswr is 1.7 and 1.4 max, and insertion loss is 2 db and 1 db max. Unit performs at power levels up to 500 mw.

Merrimac Research and Development, Inc., Dept. ED, 517 Lyons Ave., Irvington, N. J.

Flexible Waveguides 656

For high-power transmission, the series WR-1800 flexible waveguide is made of a heat-treated aluminum alloy. The waveguide operates in the 410- to 610-mc range, and is rated at 112 megawatts. Attenuation is 0.05 db per ft, and vswr is 1.03. Outside dimensions are 9 x 18 in.; minimum bending radii are 10 and 20 in.

E M T Corp., Dept. ED, Syosset Industrial Park, 210 Michael Drive, Syosset, L. I., N. Y.
P&A: *$149 for 2-ft section; two weeks.*

Phase Measurement 665

Resolution to 0.1 deg is provided by the model ETS-10 phase measurement console. Readings are not affected by variations in amplitude of input signal. Readout can be on a calibrated meter, recorded plot, or oscilloscope display of phase shift vs frequency.

Rantec Corp., Dept. ED, Calabasas, Calif.

VHF-UHF TRANSMITTERS

Proved in history's most demanding environmental laboratory — outer space — the custom designed unit shown above is typical of the development skill and production capability available from Microdot. The unit shown in miniaturized, pressurized, and features a solid state power supply that cannot be damaged by input/output overloads. Units are available in a complete range of modulation — CW, FM, Phase, and Pulse, with frequency coverage 100 to 5000 mc/s and output from 100 mw to 10 watts.

Telemetry Capabilities at Microdot have been dramatically expanded with the recent acquisition of Spectralab Instrument Company. The highly regarded development skill, production capability, and working experience of Spectralab in the field of VHF and UHF cavities and related instrumentation is available from Microdot's Instrumentation Division. This equipment, outstanding in its attention to miniaturization and ruggedness, is a vital part of such important projects as Pioneer V, Jupiter, Atlas, Pershing, Redstone and Echo I.

UHF Telemetry Transmitters, Models 2406 and 2409, use a unique, automatically stabilized circuit, with the output frequency referenced directly to a quartz crystal. This approach allows a greatly reduced size compared to the multiplier chain conventionally required to achieve crystal stability, as well as increased reliability due to a fewer number of parts.

The transmitters have their own solid state power supply designed to provide a high ratio of rf output power to total power input. The frequency modulation circuitry is sufficiently linear to introduce completely negligible distortion to the modulation signal. For further information, Call Microdot or write for catalog sheet TT-1.

SPECIFICATIONS

Frequency Range:
Model 2406 2200-2300 mc/s
Model 2409 1435-1535 mc/s
Frequency Stability ± 0.001%
Power Output 10 watts
Power Output
Density 1.46
Modulation PCM/FM, PAM/FM, FM/FM
Input Voltage 28 VDC
Temperature Range -40°C to +71°C
Vibration 10 g, 5-2000 cps
Size 4.75" x 3.75" x 11"

MICRODOT INC.

220 Pasadena Avenue, South Pasadena, Calif

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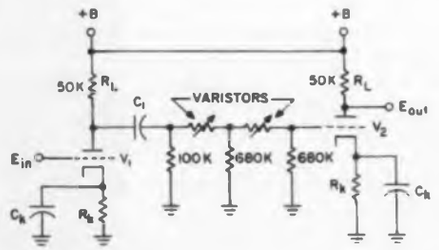
IDEAS FOR DESIGN

Varistors Limit Servo Error Signal Without Clipping — 747

Silicon carbide varistors, used in the preamp stage of a servo system, prevented the input signal from overloading the following stages. The varistors did this by limiting, but not clipping, the error signal which varied over a 20-to-1 range.



Silicon carbide varistors limit input error signal, protect following servo stages from overload.

The circuit, shown in the figure, should be operated at a signal level of about 1 v. If deposited carbon resistors having a negative temperature coefficient are used, the network will be independent of temperature over a wide range.

Because no clipping occurs, only a few per cent harmonic distortion is added to a normal sine wave. The circuit has a high input impedance and may be used with tubes as well as transistors if an emitter-follower impedance matching stage is added.

William Hotine, Senior Design Engineer, Lockheed Aircraft Service, Ontario, Calif.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 747.

$50 "Most Valuable of Issue" Award for Simple VTVM Safeguard

L. A. Stoll, senior engineer in the Electronics & Ordnance Div. of the AVCO Corp., Richmond, Ind. has been voted ELECTRONIC DESIGN'S eighth $50 Most Valuable of Issue award winner.

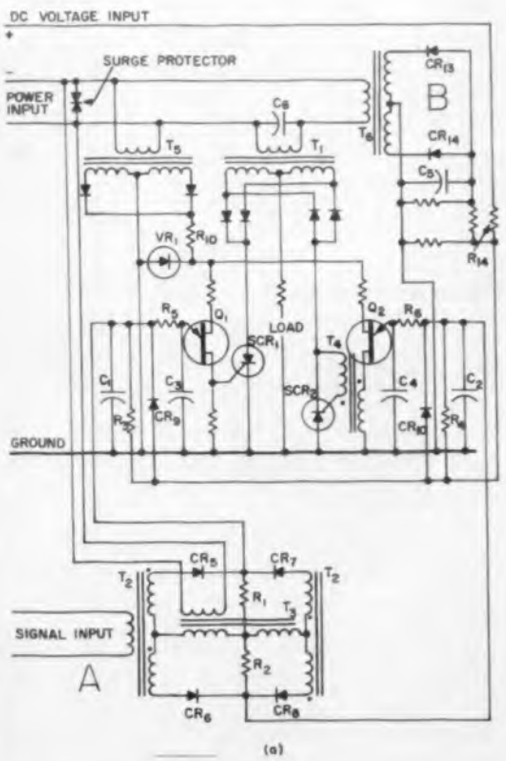
Mr. Stoll receives the award for his Idea for Design, "Ordinary Diode Protects VTVM From Overload," which appeared in the June 7 issue.

Variable DC Output Obtained From SCR Circuit — 746

Highly efficient, reversible-dc power sources can be quite easily built around silicon-controlled rectifiers (SCR's). In the circuit shown (*a*), two SCR's fired alternately by unijunction transistors Q_1 and Q_2, are used to control the dc power output. (The output characteristic is shown in (*b*). The rectifiers, in turn, are controlled by a varying-amplitude ac signal of reversible phase.

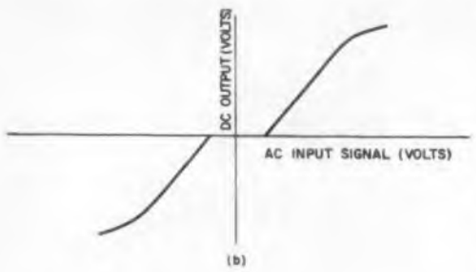
The controlling ac signal is fed into a diode discriminator, circuit *A*. Dc output appears across resistors R_1 and R_2, and is filtered by capacitors C_1 and C_2. Diodes CR_9 and CR_{10} clamp the negative side of the output to ground. Thus, a positive voltage feeds either charging circuit R_5 and C_3 or charging circuit R_6 and C_4.

Capacitors C_3 or C_4 charge until the peak voltage of the unijunction is reached. The



(a)

(a) Unijunction transistors fire SCR's in supply whose output depends upon varying-amplitude ac signal.



(b) Variable-phase ac input controls dc output. (zero phase to right, π-phase, left.)

unijunction then fires its associated SCR. The rectifier conducts until the supply voltage traverses zero. At this point the unijunction breaks down, discharging capacitors C_3 and C_4 to ground.

Negative feedback is used in the circuit (circuit *B*) to decrease the "dead space" in the output characteristic and to yield more linear control. A positive dc voltage is applied to the unijunction emitters through resistors R_{13}, R_{11}, and R_9 for Q_1 and R_{14}, R_{12}, and R_8 for Q_2. This voltage is set just below the firing potential of the unijunctions.

Negative feedback in the form of a negative voltage is applied to the unijunction emitters. This voltage is developed by current transformer T_{10}, diodes CR_{13} and CR_{14}, and capacitor C_5. With zero load current, there is negligible current in the transformers T_1 and T_{10}. As the load increases, current flows through transformers T_1 and T_9 causing a negative voltage across capacitor C_5. This reduces the dc voltage fed to the unijunctions. The greater the load current, the greater the current in transformer T_{10}, and the greater the negative voltage fed back to the unijunctions. With the arrangement shown, the dead band region can be reduced to below 5 per cent of the linear region.

Benjamin Fennick, Engineer, Kearfott Div., General Precision, Inc., Little Falls, N. J.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 746.

Accuracy Is Our Policy

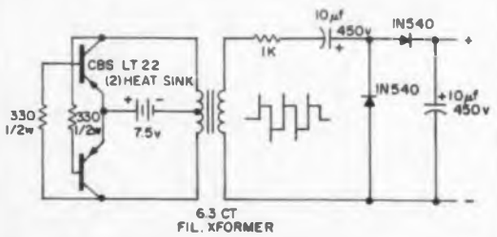
W. C. Whitworth's Idea for Design "Tuning Fork Oscillator Produces Square Waves Directly" in the Aug. 2 issue was inadvertently printed with its figures reversed. Readers may exchange either the places of the figures, or of the captions.

IDEAS FOR DESIGN

Junk-Box Converter Supplies High DC Voltage — 735

The simple and inexpensive dc-to-dc converter shown in the figure can supply 400 vdc and it is built from only junk box parts.

The converter consists of a multivibrator built from a pair of power transistors (pnp or npn), a 6.3-v CT filament transformer, and two 330-ohm resistors. After it is stepped



400-v output is supplied by this inexpensive dc-to-dc converter supplied from 7.5-v source.

up, the square wave output is voltage-doubled to provide the final high voltage.

Depending upon the transistors, transformer and supply voltage and (7.5 v for a 400-v output) the circuit can supply sufficient power for driving several low-power tubes.

William Gutman, Project Engineer, Kearfott Div., General Precision, Clifton, N. J.

If this idea is valuable to you, give it a vote by circling Reader-Service number 735.

Slide-Rule Converts Angles to Radians Quickly — 736

Anyone with a sine-tangent scale on his slide-rule can quickly convert angles between degrees and radians without multiplying by $\pi/180$ or its inverse.

Simply set the sine-tangent (ST) scale directly over the D scale. Then set the index on the angle in degrees on the ST scale, disregarding the decimal point. The angle in radians is read under the index on the D scale. Its decimal point is determined by inspection.

The ST scale gives those angles for which the sine equals the tangent, to the accuracy of the slide rule (that is, angles less than 5.73° or 0.1 radian). For these angles, both the sine and the tangent are equal to the angle in radians, to the same accuracy. Thus,

sine 2° = tan 2° = 0.0349 = 2° in radians. For angles between 5.73°, and 57.3°, the number of radians on the *D* scale lies between 0.1 and 1.0.

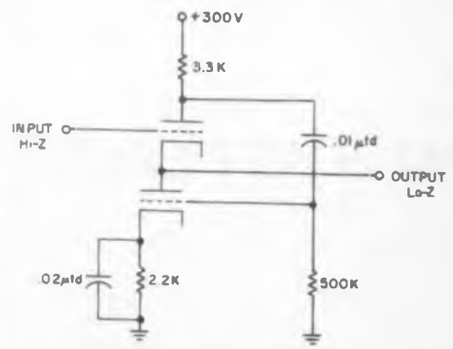
For example, let us express 20° in radians. First set the index over 2° on the *ST* scale. Read 349 on the *D* scale. The answer is 0.349 radians. Similarly 200° = 3.49 radians, etc. By the reverse of the above procedure, 0.5 radians on the *D* scale yields 2.86° on the *ST* scale. The angle is then 28.6° radians.

Solomon L. Linder, Technical Staff, Bell Telephone Laboratories, Whippany, N. J.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 736.

Modified Cathode Follower Dissipates Less Power 745

When a cathode follower drives a large capacitive load, good frequency response is maintained by using a small cathode resistor. However, if the resistor is replaced by a tube, as shown in the figure, the frequency response is still extremely good, while considerably less power is dissipated. In effect, the additional tube is used as an active cathode resistor.



Lower power dissipation and high-input and low-output impedances are obtained with this modified cathode follower circuit.

The "cathode" tube conducts heavily only when the applied signal is going negative. Its impedance drops to a value determined by its plate characteristics. The steady state current for both tubes is set by the 2.2 K resistor.

With the circuit parameters indicated, using a 12BH7 to drive a 700-pf load a square wave rise and fall time of 2.5 μsec is obtained.

William H. Eisenreich, Engineer, Electronics for Medicine, White Plains, N. Y.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 745.

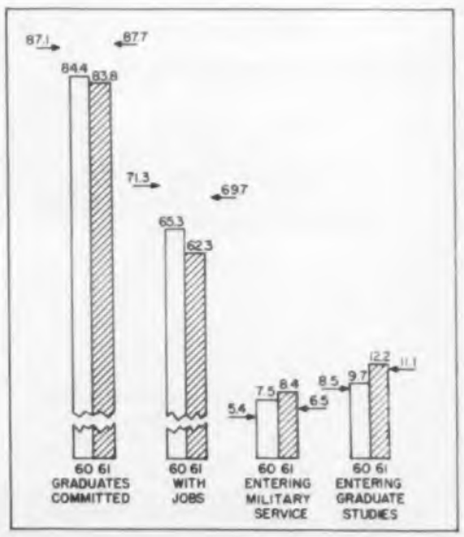
YOUR CAREER

Demand for June graduates has turned out to be better than earlier scattered pessimistic reports from graduating engineers would have indicated—even though there has been a 3 per cent drop in the total receiving jobs. The drop, a survey by the Engineering Manpower Commission shows, has been offset by a 2.5-per-cent rise in the number going into graduate studies and a 0.9-per-cent increase in the total entering military service.

Data gathered during May from 49 schools show 83.9 per cent of all types of engineering graduates definitely committed either for jobs, graduate school or military service. The comparable figure for 1960 was 84.4.

The results for electrical engineering graduates have been even more encouraging. The percentage of these definitely committed was not only the highest of any branch of engineering surveyed, but at 87.7 per cent the figure was also slightly over the 87.1 per cent for 1960. However, the number of electrical engineering graduates with job offers followed the over-all downward trend—from 71.3 in 1960 to 69.5 per cent this year.

Electrical engineering graduates planning to go on to graduate studies increased from 8.5 per cent in 1960 to 11.1 per cent in 1961. To what extent this reflected difficulty in finding jobs and to what extent it reflected industry's stepped-up emphasis on better-trained men is hard to say.



Comparison of this year's demand for June engineering graduates with last year's indicates that EE's have remained in the top position. The solid bars on the graph are for all enginering graduates, while the arrows are for electrical engineers only.

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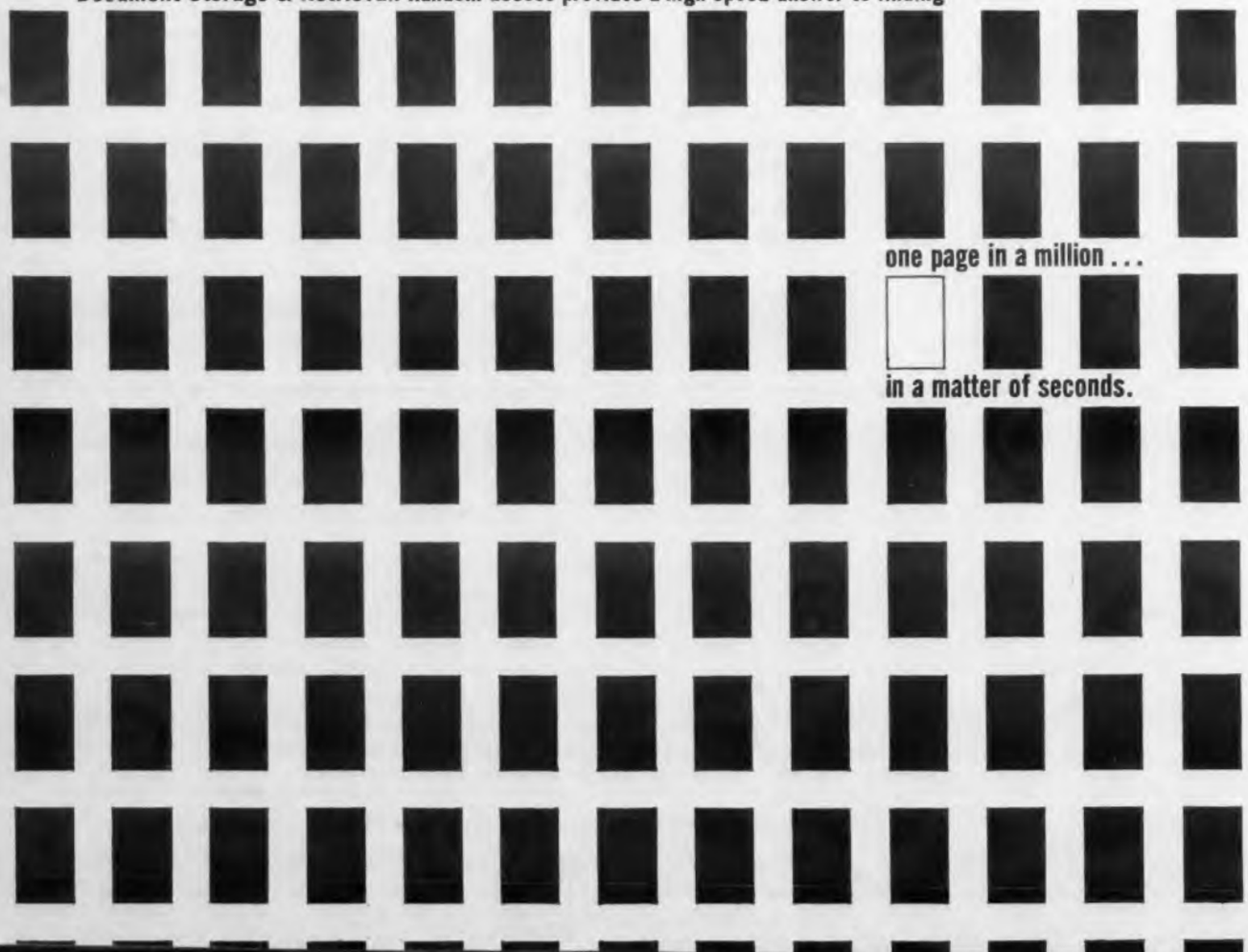

A new information retrieval system under development by IBM can store millions of printed or typed pages, yet locate and reproduce any one page on demand in a matter of seconds.

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◀ CIRCLE 903 ON CAREER INQUIRY FORM

ADVERTISERS' INDEX
August 30, 1961

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308	318	328	338	348	358	368	378	388	398	408	418	428	438	448	458	468	478	488	498	508	518	528	538	548	558	568	578	588	598
309	319	329	339	349	359	369	379	389	399	409	419	429	439	449	459	469	479	489	499	509	519	529	539	549	559	569	579	589	599
600	610	620	630	640	650	660	670	680	690	700	710	720	730	740	750	760	770	780	790	For employment brochures give home address _____					870	880	890		
601	611	621	631	641	651	661	671	681	691	701	711	721	731	741	751	761	771	781	791						871	881	891		
602	612	622	632	642	652	662	672	682	692	702	712	722	732	742	752	762	772	782	792						872	882	892		
603	613	623	633	643	653	663	673	683	693	703	713	723	733	743	753	763	773	783	793						873	883	893		
604	614	624	634	644	654	664	674	684	694	704	714	724	734	744	754	764	774	784	794						874	884	894		
605	615	625	635	645	655	665	675	685	695	705	715	725	735	745	755	765	775	785	795						875	885	895		
606	616	626	636	646	656	666	676	686	696	706	716	726	736	746	756	766	776	786	796						876	886	896		
607	617	627	637	647	657	667	677	687	697	707	717	727	737	747	757	767	777	787	797						877	887	897		
608	618	628	638	648	658	668	678	688	698	708	718	728	738	748	758	768	778	788	798						878	888	898		
609	619	629	639	649	659	669	679	689	699	709	719	729	739	749	759	769	779	789	799						879	889	899		

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- ☐ I Supervise Design Work
- ☐ I Do No Design Work

ELECTRONIC DESIGN · ONE DAY SERVICE

USE BEFORE OCTOBER 11th, 1961

B

Name _____ Title _____

Company _____

Company Address _____ City _____ Zone _____ State _____

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191	201	211	221	231	241	251	261	271	281	291
2	12	22	32	42	52	62	72	82	92	102	112	122	132	142	152	162	172	182	192	202	212	222	232	242	252	262	272	282	292
3	13	23	33	43	53	63	73	83	93	103	113	123	133	143	153	163	173	183	193	203	213	223	233	243	253	263	273	283	293
4	14	24	34	44	54	64	74	84	94	104	114	124	134	144	154	164	174	184	194	204	214	224	234	244	254	264	274	284	294
5	15	25	35	45	55	65	75	85	95	105	115	125	135	145	155	165	175	185	195	205	215	225	235	245	255	265	275	285	295
6	16	26	36	46	56	66	76	86	96	106	116	126	136	146	156	166	176	186	196	206	216	226	236	246	256	266	276	286	296
7	17	27	37	47	57	67	77	87	97	107	117	127	137	147	157	167	177	187	197	207	217	227	237	247	257	267	277	287	297
8	18	28	38	48	58	68	78	88	98	108	118	128	138	148	158	168	178	188	198	208	218	228	238	248	258	268	278	288	298
9	19	29	39	49	59	69	79	89	99	109	119	129	139	149	159	169	179	189	199	209	219	229	239	249	259	269	279	289	299
300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590
301	311	321	331	341	351	361	371	381	391	401	411	421	431	441	451	461	471	481	491	501	511	521	531	541	551	561	571	581	591
302	312	322	332	342	352	362	372	382	392	402	412	422	432	442	452	462	472	482	492	502	512	522	532	542	552	562	572	582	592
303	313	323	333	343	353	363	373	383	393	403	413	423	433	443	453	463	473	483	493	503	513	523	533	543	553	563	573	583	593
304	314	324	334	344	354	364	374	384	394	404	414	424	434	444	454	464	474	484	494	504	514	524	534	544	554	564	574	584	594
305	315	325	335	345	355	365	375	385	395	405	415	425	435	445	455	465	475	485	495	505	515	525	535	545	555	565	575	585	595
306	316	326	336	346	356	366	376	386	396	406	416	426	436	446	456	466	476	486	496	506	516	526	536	546	556	566	576	586	596
307	317	327	337	347	357	367	377	387	397	407	417	427	437	447	457	467	477	487	497	507	517	527	537	547	557	567	577	587	597
308	318	328	338	348	358	368	378	388	398	408	418	428	438	448	458	468	478	488	498	508	518	528	538	548	558	568	578	588	598
309	319	329	339	349	359	369	379	389	399	409	419	429	439	449	459	469	479	489	499	509	519	529	539	549	559	569	579	589	599
600	610	620	630	640	650	660	670	680	690	700	710	720	730	740	750	760	770	780	790	For employment brochures give home address _____					870	880	890		
601	611	621	631	641	651	661	671	681	691	701	711	721	731	741	751	761	771	781	791						871	881	891		
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603	613	623	633	643	653	663	673	683	693	703	713	723	733	743	753	763	773	783	793						873	883	893		
604	614	624	634	644	654	664	674	684	694	704	714	724	734	744	754	764	774	784	794						874	884	894		
605	615	625	635	645	655	665	675	685	695	705	715	725	735	745	755	765	775	785	795						875	885	895		
606	616	626	636	646	656	666	676	686	696	706	716	726	736	746	756	766	776	786	796						876	886	896		
607	617	627	637	647	657	667	677	687	697	707	717	727	737	747	757	767	777	787	797						877	887	897		
608	618	628	638	648	658	668	678	688	698	708	718	728	738	748	758	768	778	788	798						878	888	898		
609	619	629	639	649	659	669	679	689	699	709	719	729	739	749	759	769	779	789	799						879	889	899		

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ELECTRONIC DESIGN · ONE DAY SERVICE

USE BEFORE OCTOBER 11th, 1961

A

Name ____________________ Title ____________________

Company ____________________

Company Address ____________________ City ____________ Zone ______ State ______

10 20 30 40	50 60 70 80 90	100 110 120 130 140	150 160 170 180 190	200 210 220 230 240	250 260 270 280 290
1 11 21 31 41	51 61 71 81 91	101 111 121 131 141	151 161 171 181 191	201 211 221 231 241	251 261 271 281 291
2 12 22 32 42	52 62 72 82 92	102 112 122 132 142	152 162 172 182 192	202 212 222 232 242	252 262 272 282 292
3 13 23 33 43	53 63 73 83 93	103 113 123 133 143	153 163 173 183 193	203 213 223 233 243	253 263 273 283 293
4 14 24 34 44	54 64 74 84 94	104 114 124 134 144	154 164 174 184 194	204 214 224 234 244	254 264 274 284 294
5 15 25 35 45	55 65 75 85 95	105 115 125 135 145	155 165 175 185 195	205 215 225 235 245	255 265 275 285 295
6 16 26 36 46	56 66 76 86 96	106 116 126 136 146	156 166 176 186 196	206 216 226 236 246	256 266 276 286 296
7 17 27 37 47	57 67 77 87 97	107 117 127 137 147	157 167 177 187 197	207 217 227 237 247	257 267 277 267 297
8 18 28 38 48	58 68 78 88 98	108 118 128 138 148	158 168 178 188 198	208 218 228 238 248	258 268 278 288 298
9 19 29 39 49	59 69 79 89 99	109 119 129 139 149	159 169 179 189 199	209 219 229 239 249	259 269 279 289 299
300 310 320 330 340	350 360 370 380 390	400 410 420 430 440	450 460 470 480 490	500 510 520 530 540	550 560 570 580 590
301 311 321 331 341	351 361 371 381 391	401 411 421 431 441	451 461 471 481 491	501 511 521 531 541	551 561 571 581 591
302 312 322 332 342	352 362 372 382 392	402 412 422 432 442	452 462 472 482 492	502 512 522 532 542	552 562 572 582 592
303 313 323 333 343	353 363 373 383 393	403 413 423 433 443	453 463 473 483 493	503 513 523 533 543	553 563 573 583 593
304 314 324 334 344	354 364 374 384 394	404 414 424 434 444	454 464 474 484 494	504 514 524 534 544	554 564 574 584 594
305 315 325 335 345	355 365 375 385 395	405 415 425 435 445	455 465 475 485 495	505 515 525 535 545	555 565 575 585 595
306 316 326 336 346	356 366 376 386 396	406 416 426 436 446	456 466 476 486 496	506 516 526 536 546	556 566 576 586 596
307 317 327 337 347	357 367 377 387 397	407 417 427 437 447	457 467 477 487 497	507 517 527 537 547	557 567 577 587 597
308 318 328 338 348	358 368 378 388 398	408 418 428 438 448	458 468 478 488 498	508 518 528 538 548	558 568 578 588 598
309 319 329 339 349	359 369 379 389 399	409 419 429 439 449	459 469 479 489 499	509 519 529 539 549	559 569 579 589 599
600 610 620 630 640	650 660 670 680 690	700 710 720 730 740	750 760 770 780 790	For employment brochures	870 880 890
601 611 621 631 641	651 661 671 681 691	701 711 721 731 741	751 761 771 781 791	give home address	871 881 891
602 612 622 632 642	652 662 672 682 692	702 712 722 732 742	752 762 772 782 792		872 882 892
603 613 623 633 643	653 663 673 683 693	703 713 723 733 743	753 763 773 783 793		873 883 893
604 614 624 634 644	654 664 674 684 694	704 714 724 734 744	754 764 774 784 794		874 884 894
605 615 625 635 645	655 665 675 685 695	705 715 725 735 745	755 765 775 785 795		875 885 895
606 616 626 636 646	656 666 676 686 696	706 716 726 736 746	756 766 776 786 796		876 886 896
607 617 627 637 647	657 667 677 687 697	707 717 727 737 747	757 767 777 787 797		877 887 897
608 618 628 638 648	658 668 678 688 698	708 718 728 738 748	758 768 778 788 798		878 888 898
609 619 629 639 649	659 669 679 689 699	709 719 729 739 749	759 769 779 789 799		879 889 899

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B

Name ____________________ Title ____________________

Company ____________________

Company Address ____________________ City ____________ Zone ______ State ______

10 20 30 40	50 60 70 80 90	100 110 120 130 140	150 160 170 180 190	200 210 220 230 240	250 260 270 280 290
1 11 21 31 41	51 61 71 81 91	101 111 121 131 141	151 161 171 181 191	201 211 221 231 241	251 261 271 281 291
2 12 22 32 42	52 62 72 82 92	102 112 122 132 142	152 162 172 182 192	202 212 222 232 242	252 262 272 282 292
3 13 23 33 43	53 63 73 83 93	103 113 123 133 143	153 163 173 183 193	203 213 223 233 243	253 263 273 283 293
4 14 24 34 44	54 64 74 84 94	104 114 124 134 144	154 164 174 184 194	204 214 224 234 244	254 264 274 284 294
5 15 25 35 45	55 65 75 85 95	105 115 125 135 145	155 165 175 185 195	205 215 225 235 245	255 265 275 285 295
6 16 26 36 46	56 66 76 86 96	106 116 126 136 146	156 166 176 186 196	206 216 226 236 246	256 266 276 286 296
7 17 27 37 47	57 67 77 87 97	107 117 127 137 147	157 167 177 187 197	207 217 227 237 247	257 267 277 267 297
8 18 28 38 48	58 68 78 88 98	108 118 128 138 148	158 168 178 188 198	208 218 228 238 248	258 268 278 288 298
9 19 29 39 49	59 69 79 89 99	109 119 129 139 149	159 169 179 189 199	209 219 229 239 249	259 269 279 289 299
300 310 320 330 340	350 360 370 380 390	400 410 420 430 440	450 460 470 480 490	500 510 520 530 540	550 560 570 580 590
301 311 321 331 341	351 361 371 381 391	401 411 421 431 441	451 461 471 481 491	501 511 521 531 541	551 561 571 581 591
302 312 322 332 342	352 362 372 382 392	402 412 422 432 442	452 462 472 482 492	502 512 522 532 542	552 562 572 582 592
303 313 323 333 343	353 363 373 383 393	403 413 423 433 443	453 463 473 483 493	503 513 523 533 543	553 563 573 583 593
304 314 324 334 344	354 364 374 384 394	404 414 424 434 444	454 464 474 484 494	504 514 524 534 544	554 564 574 584 594
305 315 325 335 345	355 365 375 385 395	405 415 425 435 445	455 465 475 485 495	505 515 525 535 545	555 565 575 585 595
306 316 326 336 346	356 366 376 386 396	406 416 426 436 446	456 466 476 486 496	506 516 526 536 546	556 566 576 586 596
307 317 327 337 347	357 367 377 387 397	407 417 427 437 447	457 467 477 487 497	507 517 527 537 547	557 567 577 587 597
308 318 328 338 348	358 368 378 388 398	408 418 428 438 448	458 468 478 488 498	508 518 528 538 548	558 568 578 588 598
309 319 329 339 349	359 369 379 389 399	409 419 429 439 449	459 469 479 489 499	509 519 529 539 549	559 569 579 589 599
600 610 620 630 640	650 660 670 680 690	700 710 720 730 740	750 760 770 780 790	For employment brochures	870 880 890
601 611 621 631 641	651 661 671 681 691	701 711 721 731 741	751 761 771 781 791	give home address	871 881 891
602 612 622 632 642	652 662 672 682 692	702 712 722 732 742	752 762 772 782 792		872 882 892
603 613 623 633 643	653 663 673 683 693	703 713 723 733 743	753 763 773 783 793		873 883 893
604 614 624 634 644	654 664 674 684 694	704 714 724 734 744	754 764 774 784 794		874 884 894
605 615 625 635 645	655 665 675 685 695	705 715 725 735 745	755 765 775 785 795		875 885 895
606 616 626 636 646	656 666 676 686 696	706 716 726 736 746	756 766 776 786 796		876 886 896
607 617 627 637 647	657 667 677 687 697	707 717 727 737 747	757 767 777 787 797		877 887 897
608 618 628 638 648	658 668 678 688 698	708 718 728 738 748	758 768 778 788 798		878 888 898
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  - —Up to 2.2 amps.—6 rectifiers in 3-phase full-wave bridge circuit.
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RMS Supply Volts	840	1400	2100	2800	3500	4200	4900	5600	6300	7000
DC Blocking Volts	1200	2000	3000	4000	5000	6000	7000	8000	9000	10000
Average Forward Milliamperes: At 60°C ambient temperature	825	825	715	605	605	550	550	550	550	550
At 100°C ambient temperature	320	320	275	235	235	210	210	210	210	210
Peak Recurrent Amperes	5									
Peak Surge Amperes: (One-half cycle, sine wave)	15									
Ambient Temperature Range: Operating and storage	−65 to +125 °C									

- "CR"-Series types may be used in series up to 20,000 PIV without added voltage equalization.

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