September 22, 1961

electronics

Review of ferrite devices for modern uhf and microwave circuits, p 37

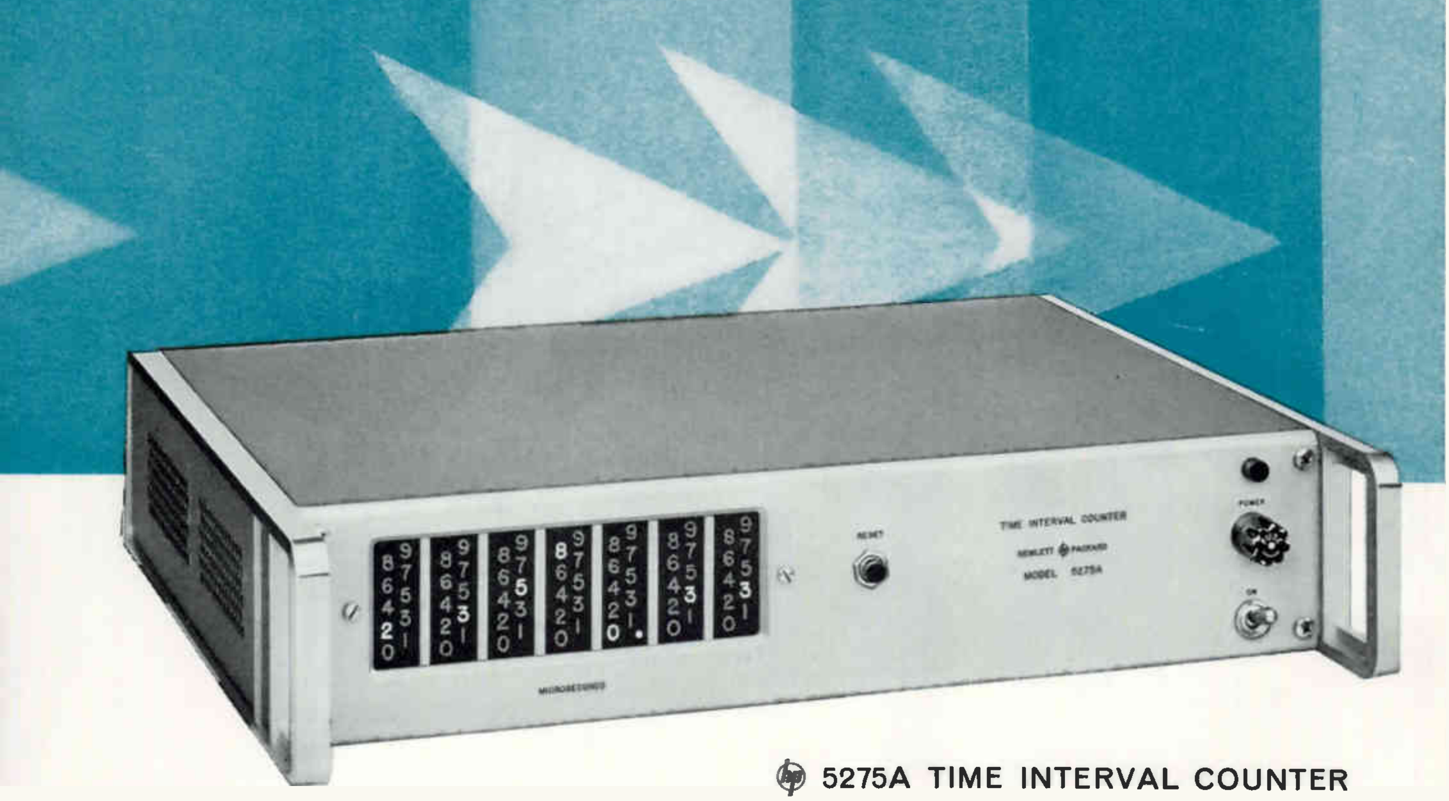
Details of infrared circuits used in Tiros II weather satellite, p 43

Telemetering system uses radioactive gage to determine depth of snow, p 52

A McGraw-Hill Publication 75 Cents

Solid-state timer (above) arms and fuzes atomic artillery shell, p 48

for time interval measurement



5275A TIME INTERVAL COUNTER

SPECIFICATIONS

5275A TIME INTERVAL COUNTER

Range:	10 nanoseconds to 0.1 seconds
Resolution:	10 nanoseconds
Accuracy:	± 10 nanoseconds, ± time base accuracy
Time Base:	External 1 MC required. 101A recommended
Registration:	7 places, direct digital presentation in neon columns
Reads In:	Microseconds, with decimal point
Input Requirements:	Start and stop trigger pulses through separate channels
Input Impedance:	Approx. 50 ohms
Output:	4-line 1-2-2-4 BCD
Minimum Trigger Pulse Requirement:	3.0 volts peak, 1.0 volt per nanosecond rise time, 5 nanoseconds width at 50% point
Trigger Polarity:	Selectable, positive or negative, for each channel independently
Reset:	Automatic, manual (from front panel), or remote through rear-mounted terminal
Standard Frequency Counted:	100 MC
Operating Temperature Range:	—20° to + 65° C
Dimensions:	16¾″ x 3½″ x 11½″ deep, 15 lbs.
Price:	$3,250.00.

101A 1 MC OSCILLATOR

Stability:	Short-term: 3 parts in 10^8; long-term, 5 parts in 10^8/week
Output Frequency:	1 MC sinusoidal, 100 KC optional. Rear BNC connectors
Output Voltage:	1 v rms minimum into 50 ohm load
Source Impedance:	Approx. 15 ohms
Distortion:	Less than 4% with rated load
Oven Temperature Indicator:	Front panel dial thermometer
Frequency Adjustment:	Front panel screwdriver adjustment with range of approximately 1 part in 10^6 for calibration from primary standard
Dimensions:	16¾″ x 3½″ x 11½″ deep, 10 lbs.
Price:	$500.00.

Data subject to change without notice. Prices f.o.b. factory

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Versatile programming

plug-in programming for each individual column, code options with plug-in column cards

Fast data transfer

takes just 2 msec; prints up to 5 lines per second

Flexible BCD input

1-2-2-4 BCD input is standard; dual input available

all yours with this new hp 562A

SOLID STATE DIGITAL RECORDER

SPECIFICATIONS

Printing Rate: 5 lines/sec. maximum

Column Capacity: To 11 columns (12 available on special order)

Print Wheels: 12-position, 0 through 9, a minus and a blank (Many special character wheels available from stock)

Driving Source: Parallel-entry 4-line BCD, 1-2-2-4. Other codes available on plug-in cards. Source reference voltages establish "0" and "1" states, which may be as much as 100 v above or below ground. "1" state 4 to 75 v above "0" reference. Driving power approx. 30 μa into 270,000 ohms.

Print Command: ± pulse, 20 μsec or greater in width, 6 to 20 v.

Hold Signal: (Available for each data source) —7 v to + 15 v and + 15 v to —7 v.

Transfer Time: 2 msec

Paper Required: Standard 3" roll or folded

Line Spacing: Single or double, adjustable

Size: Cabinet, 20¾" x 12½" x 18½"; Rack, 19" x 10½" x 16⅞" deep behind panel.

Price: hp 562A (cabinet) or hp 562AR (rack mount) $1,600.00 to $2,200.00 depending on options. hp 580A Digital-Analog Converter, price on request.

New, solid state hp 562A Digital Recorder prints digital data on 3" paper as fast as 5 lines per second, each line containing up to 12 digits. The instrument incorporates a unique data storage unit for each digit column that allows the data source to transfer data to the recorder in just 2 milliseconds, after which the source is free to collect new data.

Besides the standard parallel-entry 4-line BCD code (1-2-2-4), you can easily use other 4-line codes just by substituting plug-in column cards. Ten-line code operation (without data storage feature) is also available with plug-in cards.

Further, hp 562A accepts dual input (optional) and prints data simultaneously from two unsynchronized sources. A "patch panel" permits programming these two separate, unsynchronous inputs (even if coded differently) in any manner. Combinations of plug-in column code cards and "patch panel" column programming give complete flexibility in both dual-source data acquisition and data print positioning.

Analog output for high-resolution strip chart and X-Y recording is available as an extra-cost built-in feature of the 562A or through the new hp 580A Digital-Analog Converter, a separate solid state, high-precision instrument.

Designed for use with solid state and vacuum tube counters, Model 562A is ideal for a wide variety of individual and system applications. Call your hp representative today.

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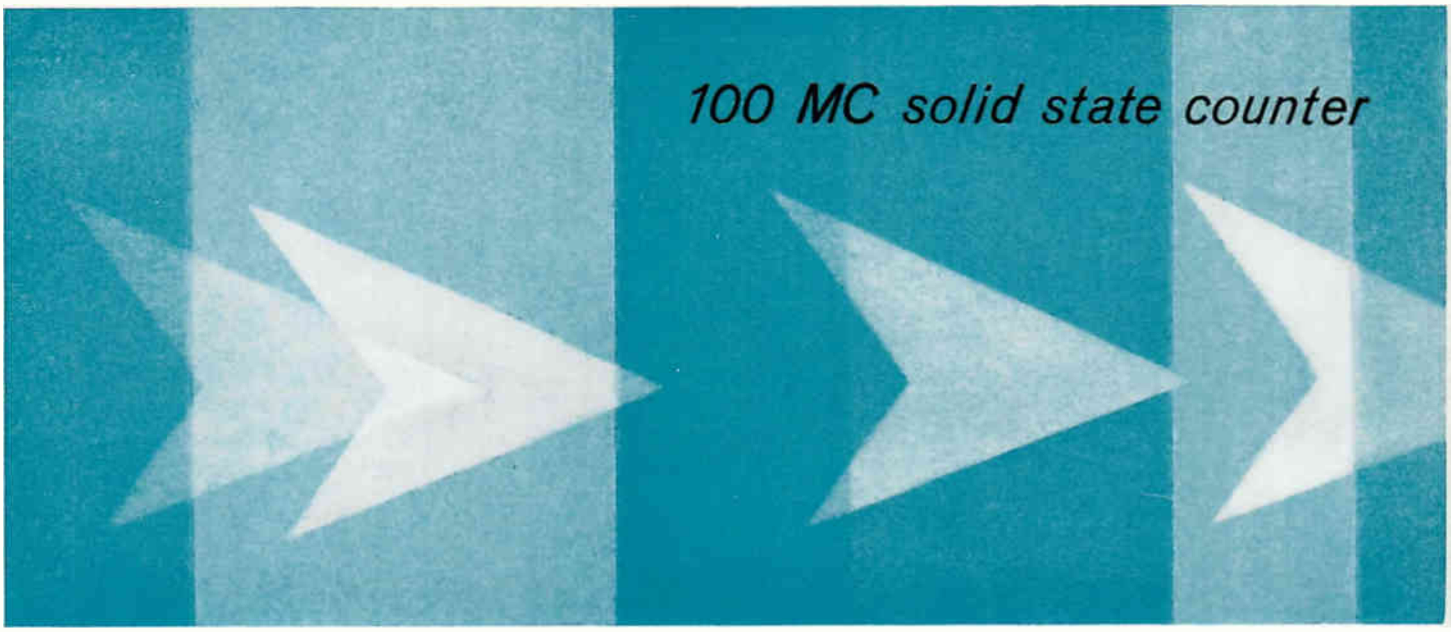


Measure Time Interval, 10 Nanoseconds to 0.1 Second— with 10 Nanosecond Accuracy!

Now you can get 10 nanosecond resolution in wide-range, automatic digital measurement of extremely short time intervals.

Electronic counter accuracy is yours for such measurements as explosive burning rates, speed and acceleration timing of test vehicles in free-flight wind tunnels, and measurements of a broad range of nuclear phenomena.

The new hp 5275A Time Interval Counter, incorporating solid state components, is packaged in the convenient new space-saving hp universal module. It counts 100 megacycles, obtained from an external 1 MC standard by a 100-to-1 multiplying circuit in the counter.

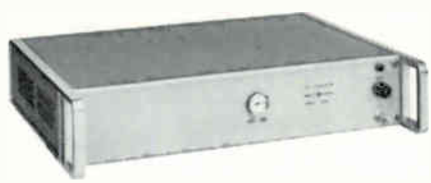
Standard features on the hp 5275A Time Interval Counter include manual front-panel reset, plus automatic and remote reset. A 4-line BCD output permits easy connection for automatic processing and analyzing of data and also may be used to drive the hp 562A Digital Recorder. The unique hp data storage technique provides a non-blinking display which reduces eye fatigue thus reducing reading errors.

Significant to many special measurement problems, as many as 20 hp 5275A Counters may be operated from a single external oscillator (new hp 101A described below). In addition to saving valuable rack space, this multiple counter operation from a single stable precision oscillator provides improved performance over multiple-time-base systems, saves operator time and offers real economy.

New versatility in a stable, accurate, rugged modular 1 megacycle oscillator! Use as a counter time base or moderately priced secondary standard!

hp 101A 1 MC OSCILLATOR Designed specifically as the time base for hp 5275A Time Interval Counter, the new hp 101A provides five parts in 10^8 per week stability. It also permits increased measurement accuracy as a time base for other electronic counters.

The hp 101A is a solid state version of the time-proved oscillator used in hp 524C/D Counters and in the hp 100E Secondary Frequency Standard. Long-term stability of $5/10^8$ per week is achieved by the use of a high quality quartz crystal and by housing critical components in a well regulated oven. Short-term stability, including effects of line, load and ambient temperature variation, is better than $3/10^8$. Its rated output of 1 v rms into a 50 ohm load makes it useful for improving the accuracy of counters limited by their own internal time bases. hp 523C/D Counters will operate directly from the 1 MC output of the 101A, and an optional 100 KC output is available for use with counters requiring it.



The 101A also is housed in the new hp modular package, equally suitable for benchtop or rack mount applications.

September 22, 1961

electronics

A McGraw-Hill Publication *75 Cents*

W. W. MacDONALD, Editor

AER -O- COM

DEFINITELY DEPENDABLE!

Aerocom's Dual Automatic Radio Beacon

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

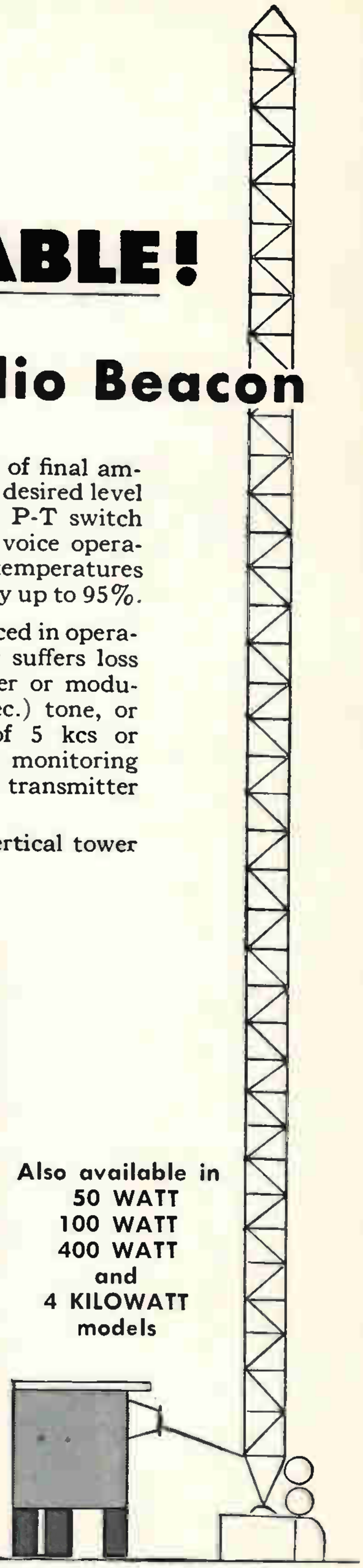
Uses single phase power supply, nominal 220 volts, 50 or 60 cycles. Consists of two 1 kw transmitters with 2 keyers, automatic transfer unit and weatherproof antenna tuner. Each transmitter housed in separate fan ventilated rack cabinet, with controls in center rack cabinet.

Nominal carrier power is 1000 watts.

High level plate modulation of final amplifier is used, providing any desired level of modulation up to 100%. P-T switch interrupts tone, permitting voice operation. Operates in ambient temperatures from −35°C to 55°C, humidity up to 95%.

Standby transmitter is placed in operation when main transmitter suffers loss (or low level) of carrier power or modulation, or continuous (30 sec.) tone, or carrier frequency change of 5 kcs or more. Audible indication in monitoring receiver tells when standby transmitter is in operation.

Antenna may be either vertical tower or symmetrical T type.



Also available in
50 WATT
100 WATT
400 WATT
and
4 KILOWATT
models

A-101

AER -O- COM

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SWEEP SIGNAL SOURCES

MODEL NO. X775A

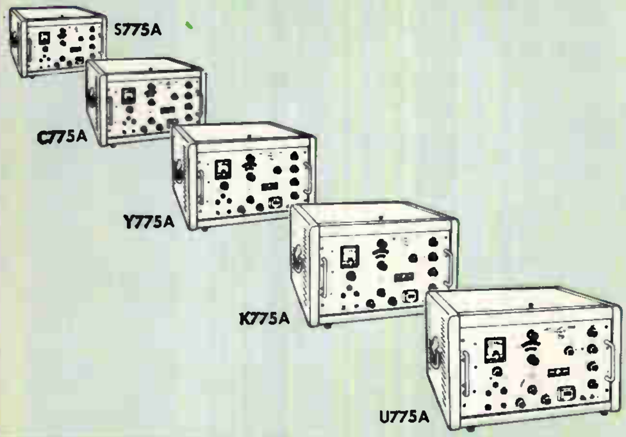
for fast, visual reflectometer tests ranges from 2 to 40 KMC

- Direct Reading Frequency Dials for Setting Upper and Lower Band Ends
- Integral AGC Circuit Keeps Output Flat to ±0.5 db
- AGC Provision Eliminates Need for Slow Response Ratiometer Set-ups
- Convenient, Portable, Versatile

Another breakthrough in measuring convenience has been achieved by the newly expanded FXR family of self-contained, direct reading sweep signal sources. Coverage is now provided as high as 40 KMC. Each unit utilizes a permanent magnet BWO as the tunable RF source.

Output power can be equalized at any detection point relative to the response of the detection element through use of FXR's exclusive built-in AGC circuit. This circuit provides a flat (±0.5 db level) on modulated signal throughout the swept frequency range when used with matched bolometers and directional couplers. This AGC provision eliminates the need for using slow response ratiometers, and allows for visual VSWR or Reflection Coefficient tests.

FXR FAMILY OF ALL ELECTRONIC SWEEP SIGNAL SOURCES



Model Number	Frequency Range (KMC)	Approx. Minimum Power Out.	OUTPUT Waveguide Type	OUTPUT Connector	Price
S775A	2.0 – 4.0	70 mw	(⅜" Coax Type N)		*
C775A	4.0 – 8.0	20 mw	(⅜" Coax Type N)		*
X775A	8.2-12.4	20 mw	WR-90	UG-39/U	$2900.
Y775A	12.4-18.0	10 mw	WR-62	UG-419/U	$3300.
K775A	18.0-27.0	5 mw	WR-42	UG-595/U	*
U775A	27.0-40.0	5 mw	WR-28	UG-599/U	*

Characteristics and prices subject to change without notice.
* UNDER DEVELOPMENT

GENERAL SPECIFICATIONS

SWEEP RATE (Resolution): 0.3 to 300 KMC/sec linear with time
SWEEP WIDTH: approximately 200 KC to full frequency range
OUTPUT SIGNAL: CW, square wave (internal 800 to 1200 cps)
FREQUENCY DIAL ACCURACY: ±1% for fixed frequency operation
±2% for sweep frequency operation
POWER REQUIREMENTS: 115/230 v., 50/60 cycles, 200 w.
DIMENSIONS: 12⅞" high x 21¾" wide x 18" deep
WEIGHT: 78 lbs.

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electronics
September 22, 1961 Volume 34, No. 38

Published weekly, with Electronics Buyers' Guide and Reference issue, as part of the subscription, by McGraw-Hill Publishing Company, Inc. Founder: James H. McGraw (1860-1948).

Executive, editorial, circulation and advertising offices McGraw-Hill Building, 330 West 42nd Street, New York 36, N. Y. Telephone Longacre 4-3000. Teletype TWX N.Y. 1-1636. Cable McGrawhill, N. Y. PRINTED IN ALBANY, N. Y.; second class postage paid.

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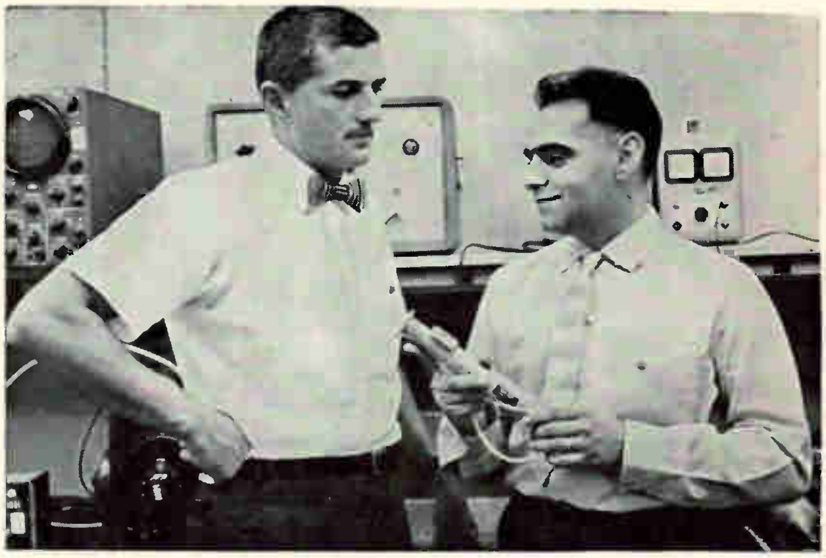


AUTHORS John Cacheris and Nick Sakiotis of Motorola (photo) discussing a high-speed broad-band switch for X-band. This and other uhf and microwave ferrite devices are described in their article beginning on p 37. You'll read about isolators, circulators, switches and phase shifters having the reliability and performance required by today's systems.

OCEANOGRAPHY, until fairly recently, has been hampered by limitations on available instrumentation, manpower and money. As pointed out in our special report, "Electronics Probes Nature" (ELECTRONICS, p 78, July 29, 1960), data gathering techniques are "somewhat antiquated". But the picture is changing rapidly. United States and other countries are stepping up research—and funding—in this field as the scientific, military and economic importance of fully understanding the oceans becomes more apparent. An ambitious project to break the data-gathering logjam gets underway this month at Texas A&M College. With Navy funds, an offshore platform in the Gulf of Mexico has been instrumented to demonstrate the feasibility of using high-speed telemetering and data processing techniques in oceanography. If the project, described on page 22, is successful, the gulf may become a vast oceanic laboratory.

Coming In Our September 29 Issue

SEMICONDUCTORS. With semiconductor device designers pushing for more power and speed, many unique devices have evolved and considerable progress has been made in microminiature circuits and improved materials. These developments have been reported in ELECTRONICS as they have occurred during the past ten years; they have been backed up with special in-depth reports on special topics such as transistors (p 53, July 31, 1959) and microminiaturization (p 77, Nov. 25, 1960).

Next week's issue will carry a special report wrapping up key technical developments in the field of semiconductors. Entitled "What's New in Semiconductors", the report will be authored by Managing Editor Carroll. Besides looking at business prospects, it will cover materials, majority-carrier devices, microcircuits, transistors, rectifiers and diodes.

COMMENT

Ions and Humans

Thank you for your letter of August 7th enclosing the listing of sources and references on the effects of atmospheric ions on the human system. Because of my work in the field of nuclear physics and instrumentation I am constantly searching technical magazines and books for new ideas that might improve my work. I noticed an item in *Comment* and found many references in your magazine by checking back a year or so, and I was able to trace several very interesting technical papers.

Since my letter of inquiry to you of June 22, 1961, I have made a small but intensive investigation and have compiled a very interesting file of research papers on the effects of negative ions on man. Apparently the negative ion serves a definite purpose in the biological function of the human body. I believe in time research will prove the reason for wide variation in the effects of the negative ion on individuals is due to the electrostatic charge of the human body. Negative ions may not be the key to man's life but apparently there is no question that they are a very vital link to man's very existence here on earth. I believe that the surface has just been scratched.

A paper from the University of Munich, Germany, gives an interesting explanation of the negative ion from the time of inhaling to its action in the bloodstream.

I presume in time ion generation will be extensively controlled in shop buildings and possibly will eliminate some of the occupational hazards such as fatigue, nausea, headaches, lack of physical endurance, and should improve resistance to various diseases. The fact that many viruses have a negative charge is quite important when one considers that man is an electromechanical plant (like charges repel, etc.).

An important point that I believe should be kept in mind is that the plus ion is a necessary factor for good health. Very little work seems to have been done on the quantity needed. I doubt that man could survive in a strictly negative atmosphere.

At present I am doing consulting work for a company known as United Laboratories, Ltd., of Pasadena, California, who have a new type environmental air treatment unit (12,000 cubic feet per hour) for use in hospital rooms, operating rooms, and anywhere where airborne contaminants are a hazard. I have adapted an ion generator to this unit. One of the most encouraging things to date is the detection and elimination of a very serious contagious infection (impetigo) in the nursery of one of the local hospitals.

RALPH E. WHITE
ALTADENA, CALIF.

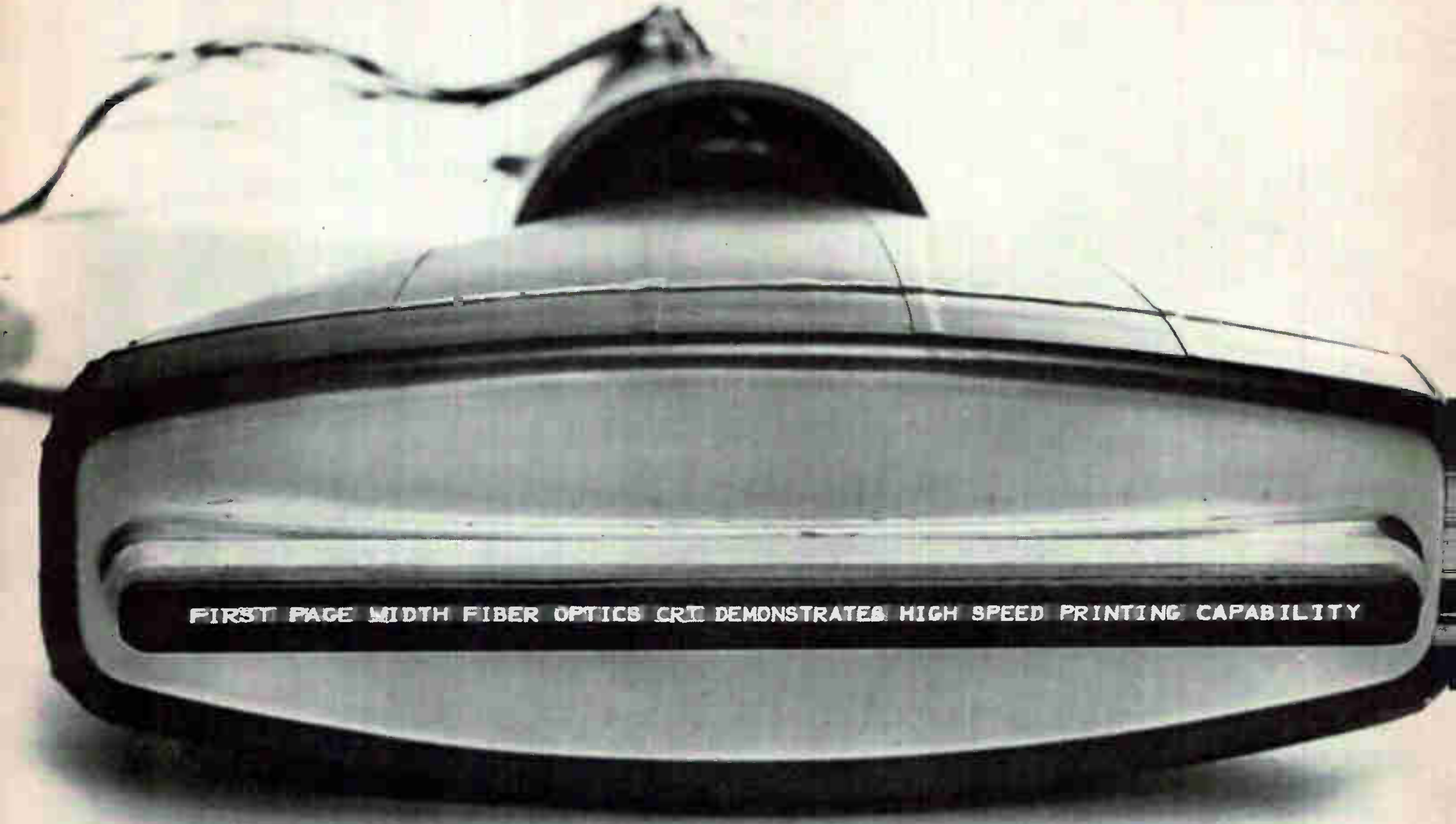
Patent Legislation

Regarding Albert Goodman's letter (*Comment*, p 6, August) relative to R&D employees' contracts requiring the signing away of all rights to inventions made during his employment: This standard practice follows precisely that of our early slave owners, whereby all children conceived by the slaves were the property of the owners. When employees exercise only engineering abilities, that is, the application of knowledge and ideas previously produced by others, the results of that work belong to the employer who pays him.

But when he exercises *creative* ability, in producing new and patentable inventions, his rewards should be something more than a mere subsistence salary, and beyond the nominal "suggestion box" boundaries. He should be allowed to share, as do independent inventors, in the fruits of his creations, which now are all taken by his employer. That such rewards would stimulate creativity as nothing less can, and hold capable employees to their employer organizations, goes without saying, and the cost would be miniscule.

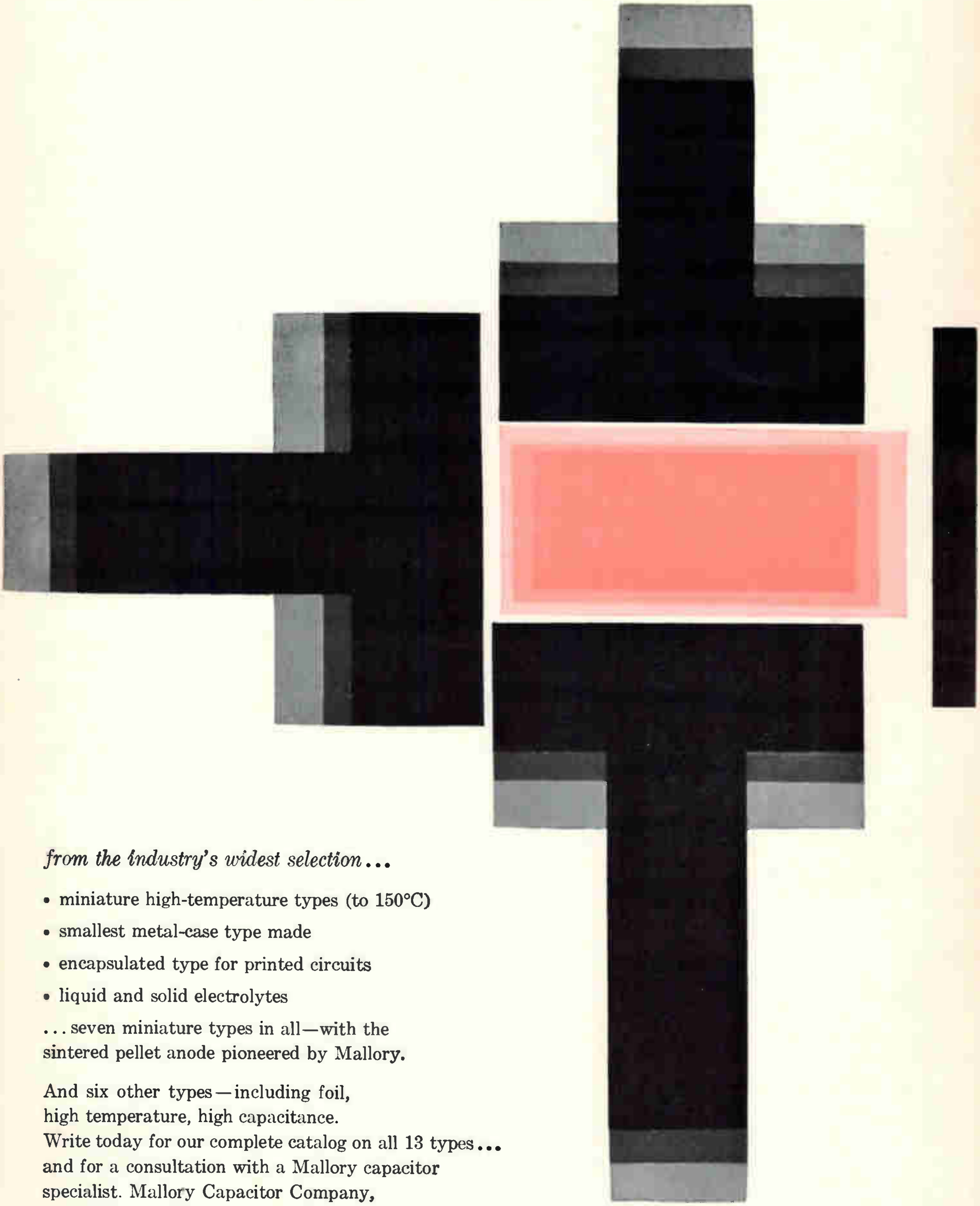
Under the present practice, when such a contract employee conceives something really big, the temptations to realize fitting rewards elsewhere are very great indeed, and account, I feel sure, for much of the now excessive turnover in R&D employment.

BENJAMIN F. MEISSNER
MIAMI SHORES, FLA.

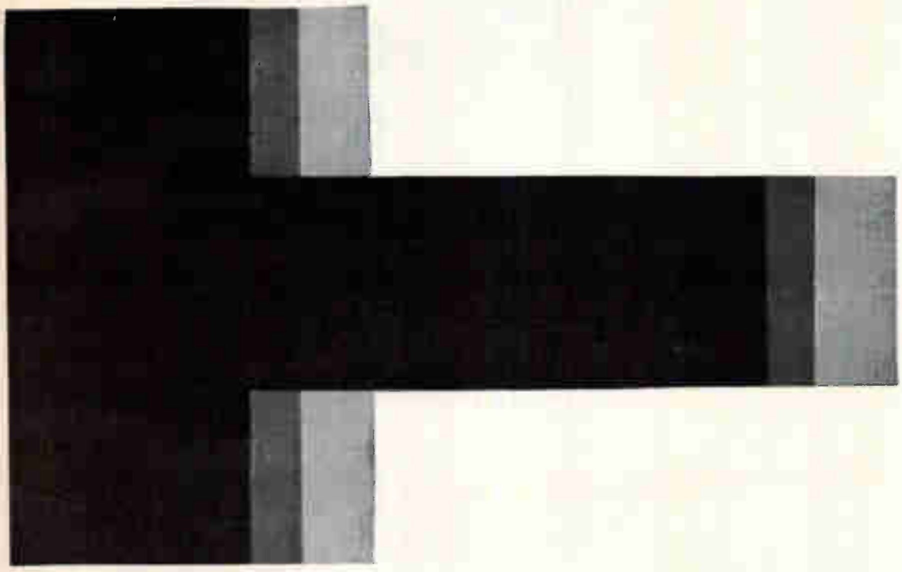


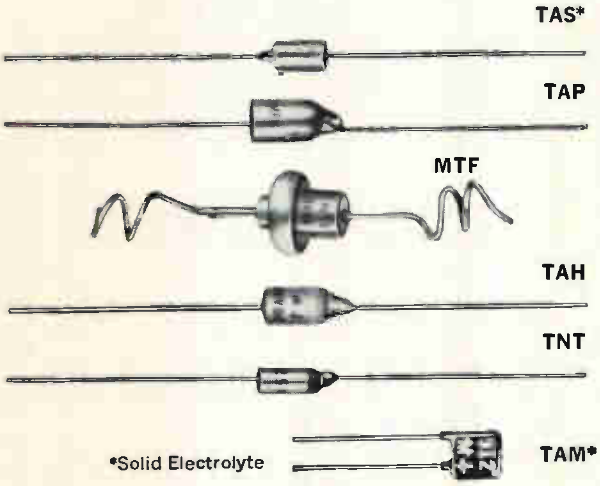
You are looking at the first page-width fiber optics cathode ray tube. The unretouched photograph shows the extraordinary brightness and resolution of this General Dynamics/Electronics development which results from combining an 8½ x ½ inch fiber optics bundle with the CHARACTRON® Shaped-Beam Tube. Halation, light scatter, diffusion and complicated optical systems are eliminated. Applications of the tube include high-speed line-at-a-time printing and recording of computer data. For further information about fiber optics or other advanced data processing devices, write General Dynamics/Electronics, Information Technology Division, Department B-55, Post Office Box 2449, San Diego 12, California.

GENERAL DYNAMICS | ELECTRONICS



for the squeeze on space





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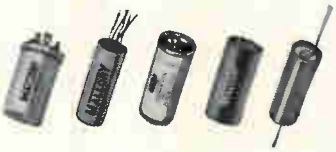

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MALLORY

CIRCLE 9 ON READER SERVICE CARD

FOR POWER MEASUREMENT

Bi-directional power monitors, 2 to 1000 MC, 1 to 1000 watts!

- Four power level ranges with each plug-in
- Power range down to 1 watt full scale
- Nine plug-ins for wide frequency coverage
- Linear scale on all power ranges
- No correction factor required for calibration on any range

Power is read directly on a linear scale with accuracy of ±5% on Sierra 164 Series Bi-Directional Power Monitors, which permit intermittent or continuous measuring of incident and reflected power, plus convenient matching of loads to lines. Direct connecting, they measure forward and reverse power merely by turning a plug-in control. No connections to switch.

Complete frequency coverage is provided with nine plug-in elements, each offering four power ranges selectable by the turn of a knob. Power capacity ranges from 1 watt full scale to 1000 watts full scale, frequency coverage from 2 to 1000 MC. Plug-in versatility is indicated in the adjacent table.

Calibration is adjustable on each range independently, so that no correction factor need be applied. The power monitors are available with Type N, C, LC, HN or UHF male or female connectors. High directivity and low insertion VSWR assure maximum accuracy with minimum disturbance to the transmission line under test. No auxiliary power is required.

Sierra Model 164
Power Monitor, $110.00.

PLUG-IN ELEMENTS FOR MODEL 164

Model	Full-Scale Power (Watts)	Frequency Range
180-52	0-1/5/10/50	25-52 MC
180-148	0-1/5/10/50	50-148 MC
180-470	0-1/5/10/50	144-470 MC
180-1000	0-1/5/10/50	460-1000 MC
181-250	0-10/50/100/500	25-250 MC
181-1000	0-10/50/100/500	200-1000 MC
270-30	0-50/100/500/1000	2-30 MC
270-75	0-50/100/500/1000	10-75 MC
270-470	0-50/100/500/1000	70-470 MC

Plus these Power Measuring Instruments

Directional Couplers for VSWR, reflection coefficient, power measurements, 1 to 1200 MC. Seven models available covering power levels to 1000 watts. $120 to $150.

50-Ohm Coaxial Loads, including the new 160-1200 three-way termination, 0-1000 MC, with associated accessories for power capacities of 1200, 2000 and 3000 watts. Model 160 Series Loads also available in 1, 5, 20, 100 and 500 watt sizes.

Low Pass Filters, to 400 MC, provide low insertion loss (max. 0.4 db in pass band), sharp cut-off, max. 1.5 VSWR, rejection greater than 60 db from 1.25 to 10 times cut-off frequency. Five models, cut-off 44, 76, 135, 230, 400 MC. Power range, 250 watts in pass band, 25 watts in rejection band. $100 each.

Termination Wattmeters: Sierra Series 185 average-reading termination wattmeters, to terminate rf coax lines and measure rf powers, 2 models 0 to 30/100 and 0 to 150/500 watts, 20 to 1000 MC, accuracy ±5%, max. VSWR 1.2. Model 185A-100, $260; Model 185A-500, $375.

Data subject to change without notice. Prices f.o.b. factory

7307

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ELECTRONICS NEWSLETTER

Mercury and Tracking Net Test Successful

ORBITAL FLIGHT and reentry last week of a Project Mercury spacecraft was a resounding success. It spurred hopes that the United States might put a man in orbit this year. This flight carried a crewman simulator, the next one is to carry a chimpanzee and then there is to be a manned attempt. Six weeks is about the minimum time possible between flights.

The program was set back several months by launching system difficulties. In April, a flight was aborted. The capsule was recovered for another attempt in late August (ELECTRONICS, p 20, Sept. 1, 1961), but nagging component failures caused a three-week postponement. The trouble was traced to a solder dust short in Atlas autopilot transistor, requiring double-checks on 65 transistors (see p 14), according to reports.

This time, all main goals were reached. The tracking net installed at 18 stations around the world by a team headed by Western Electric, "worked beautifully" the first time. A Bermuda station picked up the vehicle about one minute after launch. Other stations on the route reported in like clockwork, announcing acquisition, tracking and release of the capsule.

Prime reason for the net's success was a three-month series of drills and simulations which anticipated all known problems. Hawaii did not make contact, but this was expected. The island is too far north of the orbital path used last week. An Australian station tracked the capsule at a distance of more than 900 miles.

Ford to Buy Philco With $100 Million in Stock

FORD MOTOR CO. plans to purchase the assets of Philco Corp. under terms of an agreement signed last week. Acquisition of Philco, one of the oldest and largest electronics manufacturers (founded in 1892 as Helios Electric Co., sales of $400 million in 1960) would give Ford a strong position in space, military, industrial and consumer electronics.

Ford says it plans to make Philco a wholly-owned subsidiary and will continue Philco's business activities without interruption. Henry Ford II, chairman, said the purchase will enable Ford to "broaden its operations, provide entry into new fields and to make possible fuller participation . . . in the national defense and space effort."

Philco shareholders are to get one share of Ford stock for each 4½ shares of Philco stock. The exact ratio will be determined according to market price November 30. Philco had more than four million shares of stock outstanding, selling in the low 20's. Shareholders must approve the deal.

EIA Fall Conference Attended by Over 200

FALL CONFERENCE of the Electronics Industry Association wound up in New York last week with members calling it the biggest yet. Registration topped the 200 mark and the number of sessions neared 50.

One of the best-attended sessions was an all-day discussion on shifts in the defense electronics market. Among the predictions: a rapid upswing in Army spending on aircraft equipment in the 1960's, peaking at around $50 million in five years. Other session topics included exports, marketing techniques and patent laws.

Pulses Monitor Blood Pressure in Arteries

BLOOD PRESSURE monitoring techniques which do not cause patient discomfort and do not require obstruction or penetration of arteries were described at the ISA Fall Conference in Los Angeles last week. The techniques are also believed more accurate than ear lobe or fingertip monitoring, since measurements are made directly on arterial flow.

The instruments, designed by P. F. Salisbury, of St. Joseph Hospital, Burbank, and Tracy Wichmann, are based upon the correlation between pressure and wave propagation velocity in blood vessels.

Naturally occurring pulse pressure waves are labeled at a convenient point, such as a systolic peak, by a superimposed square wave of

New Role for R-F Energy: Rock-Busting

HAVE YOU EVER had to remove a large rock from a backyard? Canny handymen know the easy way: build a fire around the rock. When the rock gets hot, it shatters into several pieces. A modern version of this method has been tried successfully by General Electric's Industrial Control department, in cooperation with Montana School of Mines and Anaconda.

R-F energy is forced through the rock from electrodes. The energy finds a path in rock crystals, which contain about five percent water. Thermal stress splits the rock. A power level of 25 Kw at a frequency of 20-40 Mc is usually sufficient. Metal-bearing ores require less force than granite and other rocks low in metal.

The process, called thermal forcing, is expected to prove five or six times cheaper than blasting to fragment oversize rocks in mines. It eliminates drilling and dynamite, and personnel do not have to evacuate the mine shaft area. In open pit mines, savings would be nearer 25 percent. GE estimates there are more than 300 mines which could economically use the process. Commercial power sources would cost about $60,000. In its tests, GE took power from a Voice of America transmitter in Schenectady.

one to five milliseconds. The time it takes for the pulse to travel between two pressure transducers, placed on an arm or leg, can be accurately determined. Velocity of the natural wave cannot be accurately measured because of gradual slopes and other factors.

An alternate technique is to measure the imposed pulse amplitude needed to produce a noticeable affect on the natural pulse wave contour. Amplitude required varies with pressure. Both instruments can be calibrated to an individual patient and can sound an alarm when pressure reaches a critical value.

Firm Introduces Four New Business Computers

FOUR NEW business computers were to be introduced this week by Burroughs Corp. One of them, the B260, marks the company's entry into the punched card computer business. The company sees a lucrative potential market in the 50,000 owners of card tabulating business machines.

Three other systems include a ledger processing system, the B250; a satellite computer for banks, the B270, and a unit like the B260 but capable of handling up to six magnetic tape units. The B280 can be used as a satellite to the complex Burroughs B5000.

Japanese Export Hit Record High in July

TOKYO—Japanese electronics exports to the United States reached almost $8.9 million in July, a monthly record for this year and 40 percent more than June exports.

Big percentage increases were in tv receivers, mostly 14-inch chassis, up 79 percent (2,010 units worth $201,250); six-transistor radios, up 68 percent (472,428 worth $4,810,160); tape recorders, up 47 percent (68,819 worth $1,373,300); and toy transistor radios, up seven percent (428,000 worth $1,073,200).

Japan Electronic Industry Association (JEIA) reported last week that total Japanese exports of electronic instruments and devices for the first six months was $102 million, up 30 percent over the first half of 1960.

Total production for the 1961 first half-year was $653.1 million, an increase of 16.5 percent. The biggest increase in percent was scored by computers, which went up 293 percent to $6.5 million. Electric measuring instruments increased 28 percent to $15.7 million.

Bomarc B Interceptor Completes Flight Tests

EXPERIMENTAL flight testing the advanced Bomarc B interceptor missile, capable of carrying a nuclear warhead, was completed this month by Boeing. The company said the tests were successful. Firing of tactical versions will continue for several months at Eglin AFB, Fla., for service tests and crew training.

Some 35 missiles were fired, at ranges up to 400 miles and to altitudes above 60,000 feet. Targets included unmanned F-80 fighters, B-47 bombers and the 1,000-mph Regulus II missile.

Bomarc B squadrons are planned for Canada as well as the U. S. New bases are operational at Kincheloe AFB, Mich., and Duluth. A third base is nearing completion at Niagara, N. Y. Each squadron is to protect an area of one-half million square miles from attack by aircraft or air-breathing missiles.

Air Force Will Televise Its Next Weapons Meet

AIR DEFENSE Command is setting up a television network to cover the weapons meet scheduled for October 23-November 3 at Tyndall AFB, Fla. The system will allow judges and other viewers to watch all interceptor tactics, including night actions by intercepter planes and heat-seeking rockets. Chaser planes will be equipped with low-light level tv cameras. The system also includes ground cameras, studio controls and a coaxial line to Maxwell AFB, Ala. Thompson Ramo Wooldridge is technical advisor and its Dage division is providing the cameras.

In Brief . . .

GENERAL ELECTRIC announces it will produce a line of semiconductor signal diodes, starting with a silicon planar, epitaxial, passivated type.

SPRAGUE ELECTRIC is purchasing equipment for production and test of electrochemical precision-etched transistors, from the CBS Electronics plant recently sold to Raytheon.

JAPANESE Defense Agency awards General Precision and Mitsubishi contract to build four $1 million simulators for the F-104J fighter. Mitsubishi, which is making 160 of the planes, will get $2 million in components from Electronic Specialty Co., through an order from Lockheed International.

NAVY antisubmarine warfare contract awards include $8.8 million to General Electric, for transistor sonar sets; over $5 million to Bendix, for helicopter-borne "dunking sonar" with 360-degree active scanning, and $500,000 to Packard Bell Electronics for extension of a previous contract for airborne recorders. Packard Bell will also supply two micrometeorological data systems to Air Force.

NASA has selected North American Aviation to develop a second stage for the Saturn rocket, slated for the moon program. The 10-vehicle program will cost some $140 million. Saturn's first stage will be built at a government-owned ordnance plant.

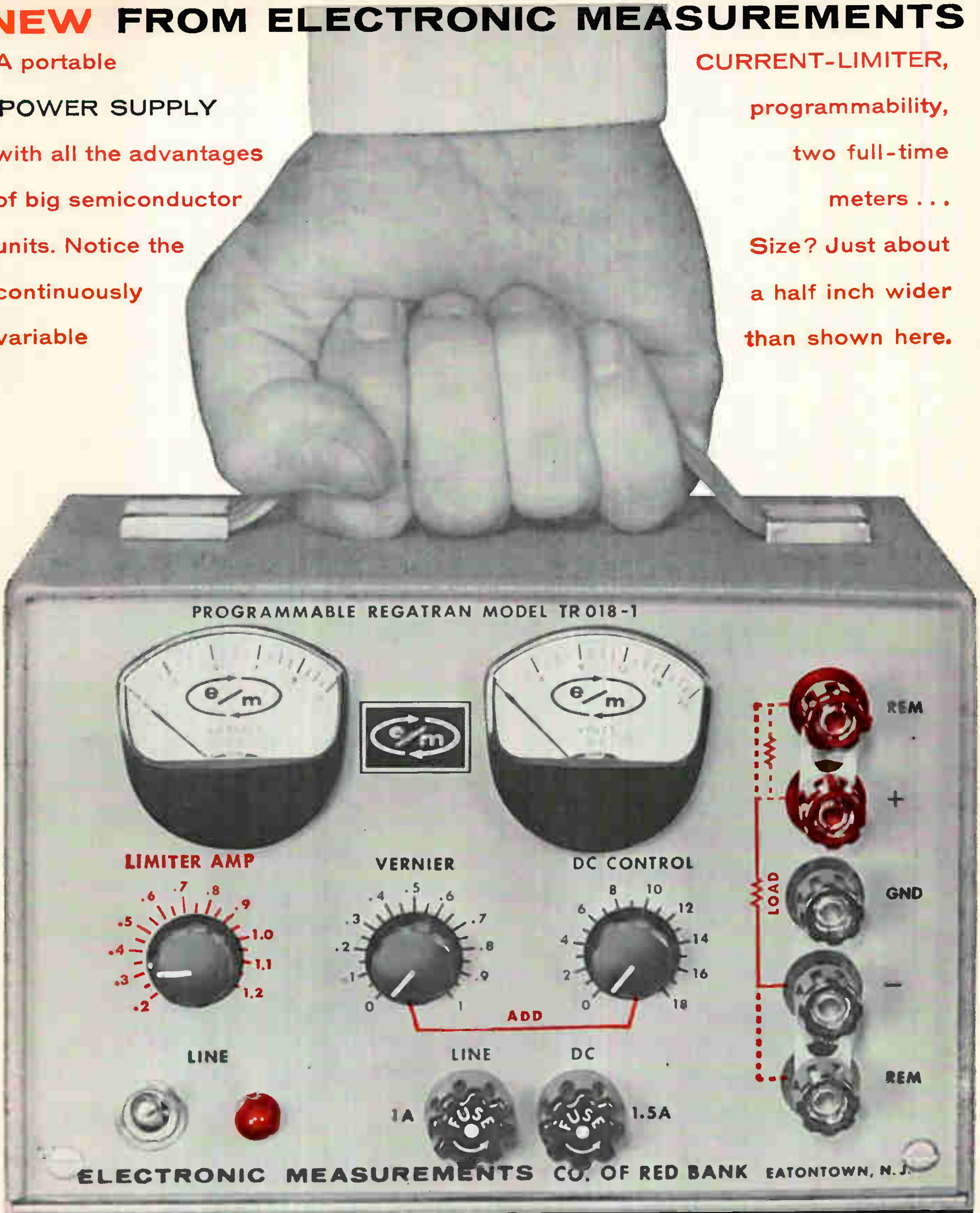
EURATOM is ordering from CSF of France a $770,000 linear accelerator for installation at Geel, Belgium. It will have a 20-megawatt battery of klystrons.

MOTOROLA is offering auto and truck manufacturers a new all-electronic alternator. It uses silicon diode rectifiers, a two-transistor voltage regulator which needs no adjustment and an isolation diode to light the dash indicator.

SAAB Aircraft, of Sweden, is producing a walkie-talkie that weighs less than a pound, fits into a pocket, has a range up to three miles.

NEW FROM ELECTRONIC MEASUREMENTS

A portable POWER SUPPLY with all the advantages of big semiconductor units. Notice the continuously variable CURRENT-LIMITER, programmability, two full-time meters . . . Size? Just about a half inch wider than shown here.



ELECTRONIC MEASUREMENTS
COMPANY OF RED BANK
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WASHINGTON OUTLOOK

DEVELOPMENT of a supersonic plane—to begin soon—will spur major new advances in electronic navigational aids, air traffic control and communications. The Federal Aviation Agency will award competitive design contracts in the next three or four months for the 2,000-mph aircraft, which probably will not fly until 1970. Present navigational and electronic tracking devices could not adequately monitor and clear a path for faster-than-sound flights spanning the continent in two hours.

A presidential task force has given the supersonic plane project a boost by assigning it a high priority among this decade's aviation goals. The Kennedy administration was at work long before the task force reported, persuading Congress to appropriate $11 million as a starter on the program, known as Project Horizon. The Project Horizon group also wants more R&D on new navigational aids and air traffic management systems for existing planes. It particularly urged that all existing airports with "a substantial volume of flights" have instrument landing systems and air traffic control towers. More specific recommendations for improving air traffic control will be made by another task force known as Project Beacon.

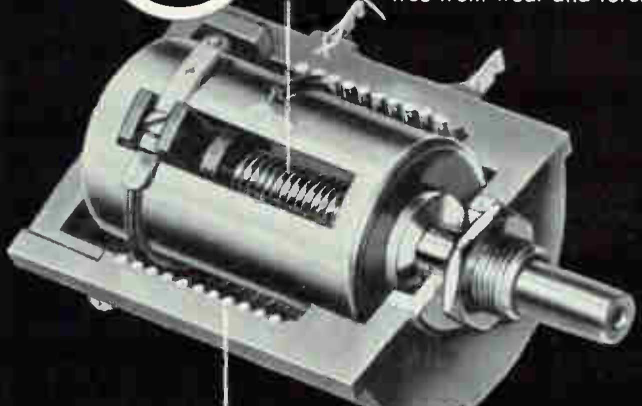
RESUMPTION of nuclear testing by the U. S. means progress can be made on Project Plowshare experiments in industrial uses of nuclear explosions. First of a series of experiments under Plowshare will likely be Project Gnome. This calls for exploding a five-kiloton device some 1,200 feet deep in a salt bed near Carlsbad, New Mexico, probably before the end of the year. Objectives are to determine if nuclear explosive energy can be converted into latent heat for producing electric power, experiment on the recovery of isotopes produced by an explosion, and observation of chemical and physical changes that take place. Other active Plowshare projects are Chariot and Wagon, to explore nuclear explosion excavations, and Oilsand, for oil recovery.

NEW ELECTRONIC DEVICE, Nomad I, (Navy Oceanographic and Meteorological Automatic Device) is the latest addition to the hurricane warning system. Designed to measure air and water temperature, wind speed and direction of surface currents, Nomad is a 20-by-10-foot aluminum platform, unmanned weather station. It transmits reports every six hours in normal weather, once every hour during storms.

Nomad I, moored in 11,000 feet of water in the center of the Gulf of Mexico, reported on hurricane Carla. Navy plans seven Nomads in the Atlantic and Pacific hurricane and typhoon regions.

Electronic devices already have demonstrated their value in weather forecasting and will be used more extensively in the future. The success of Tiros weather satellites has prompted Congress to vote an extra $50 million in fiscal 1962 to put the system into operation while the more advanced Nimbus system is still being perfected.

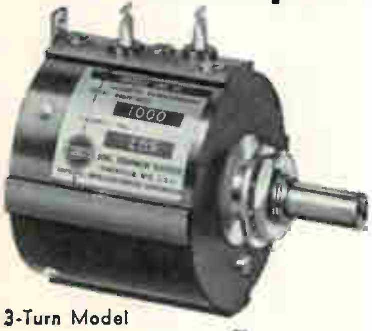
LIMITED LIFE of electronics is still the drawback to satellite performance, Hugh L. Dryden, deputy administrator of NASA, told the recent Joint Meeting of IRE and AIEE in Washington. Often, just poor workmanship plagues the space administration. Loose solder, no larger than dust particles, delayed the Atlas-Mercury man-in-space program last August. In fact, all firings of Atlas boosters were held for a week or more. Dust-like solder caused short circuits in programmers and timers in Atlas.



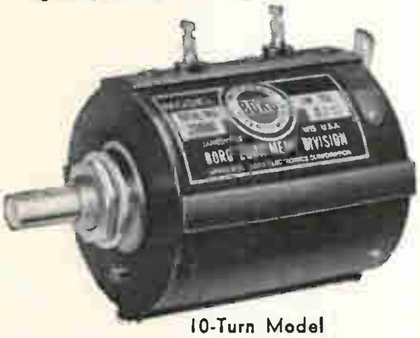
Nothing but the precious metal electrical contact touches the winding at any time. Resistance element remains free from wear and foreign matter.

43½" resistance element (10-turn model) provides space for many turns of resistance winding, thus providing a high resolution figure.

Double thread lead screw is a patented exclusive with Borg 205 Micropots



3-Turn Model



10-Turn Model

Here is a patented feature you'll find only on Borg 205 Series Micropot potentiometers — a stainless-steel, double-thread, precision lead screw drives the moving contact. This design does not depend on cumbersome contact wiper carriers riding the delicate resistance element to guide it. Nothing but the precious metal electrical contact touches the winding at any time. Result? The resistance element remains free from wear and foreign matter. Permanently accurate settings, smooth action and low, uniform torque are assured. Your nearest Borg technical representative or distributor has complete information on Borg 205 Series Micropots. See him now. Ask for catalog sheets BED-A131 and BED-A162.

Number of Turns	Mechanical Rotation	Electrical Rotation	Total Resistance*	Linearity Accuracy	Torque
Ten	3600° +15° −0°	3600° +14.4° −0°	to 100,000 ohms	to ±0.05%	1.5 in/oz running
Three	1080° +15° −0°	1080° +14.4° −0°	to 50,000 ohms	to ±0.1%	1.5 in/oz running

*Higher resistances available on special order.

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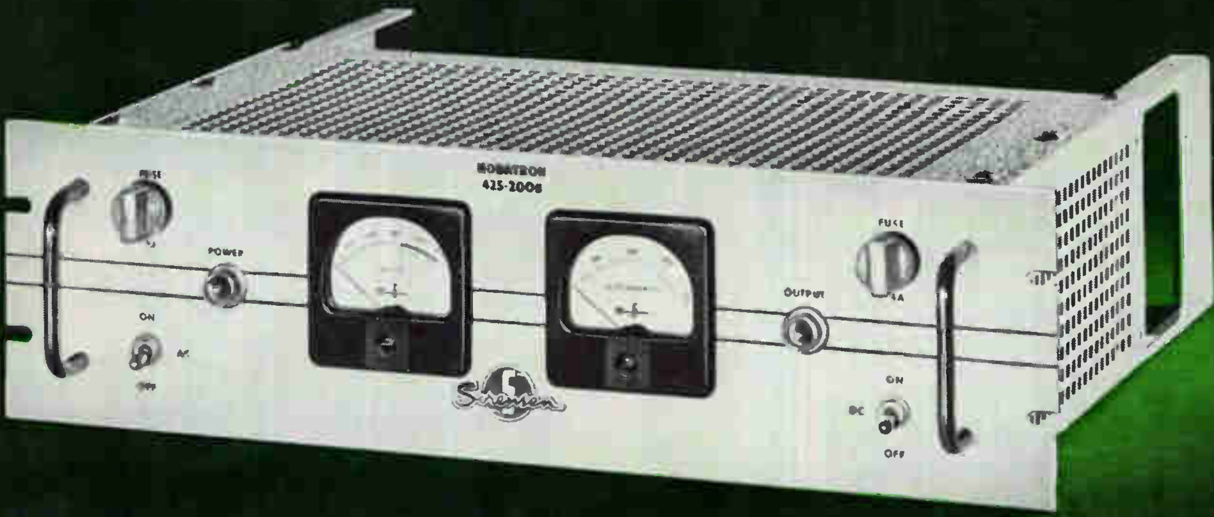

Regulated, variable-output

B SUPPLIES

2 voltage ranges at 200, 400 and 800 MA

TRANSISTORIZED SINE WAVE INVERTER – The QISB, a rugged, low-cost, compact inverter, provides up to 60 VA of 115V AC at 60 or 400 cycles from a DC source. Output will not vary more than ±3% with load variations. The QISB is easy to install and starts instantly. It has no moving parts and is not damaged by momentary overloads or output shorts.

3-PHASE FREQUENCY CHANGER – The FCR 3P300 variable frequency power source supplies 0-130 volts line to neutral; 300 VA 3-phase, 200 VA 2-phase, or 300 VA single phase with ±1% regulation for both output frequency and voltage. Frequency may be varied from 45 to 2000 cps in two ranges. Suitable for many laboratory and industrial applications.

Close regulation, constant current output and provisions for external programming distinguish these versatile new B Supplies. Available with 125-325 VDC or 325-525 VDC output, they also provide 6.5 VAC for powering external tube filaments. Mechanically designed for easy access to tubes and circuits, all models are designed for standard 19" rack mounting and include front-panel output voltmeters and ammeters. These compact new plate and filament supplies are ideal for use in a broad variety of industrial and laboratory electronic equipment. Ask for complete specifications and literature.

SPECIFICATIONS

INPUT VOLTS:	105-125 volts AC 50-400 Cycles All Models
DC OUTPUT VOLTS:	125-325 V DC or 325-525 V DC
DC OUTPUT CURRENT (MA):	200, 400 or 800
LINE & LOAD REGULATION COMBINED:	±(0.1% + .05 V)
RIPPLE:	3 millivolts RMS
AC OUTPUT VOLTS (unregulated):	6.5 V (at full load, 115 V AC input)

A UNIT OF RAYTHEON COMPANY Sorensen

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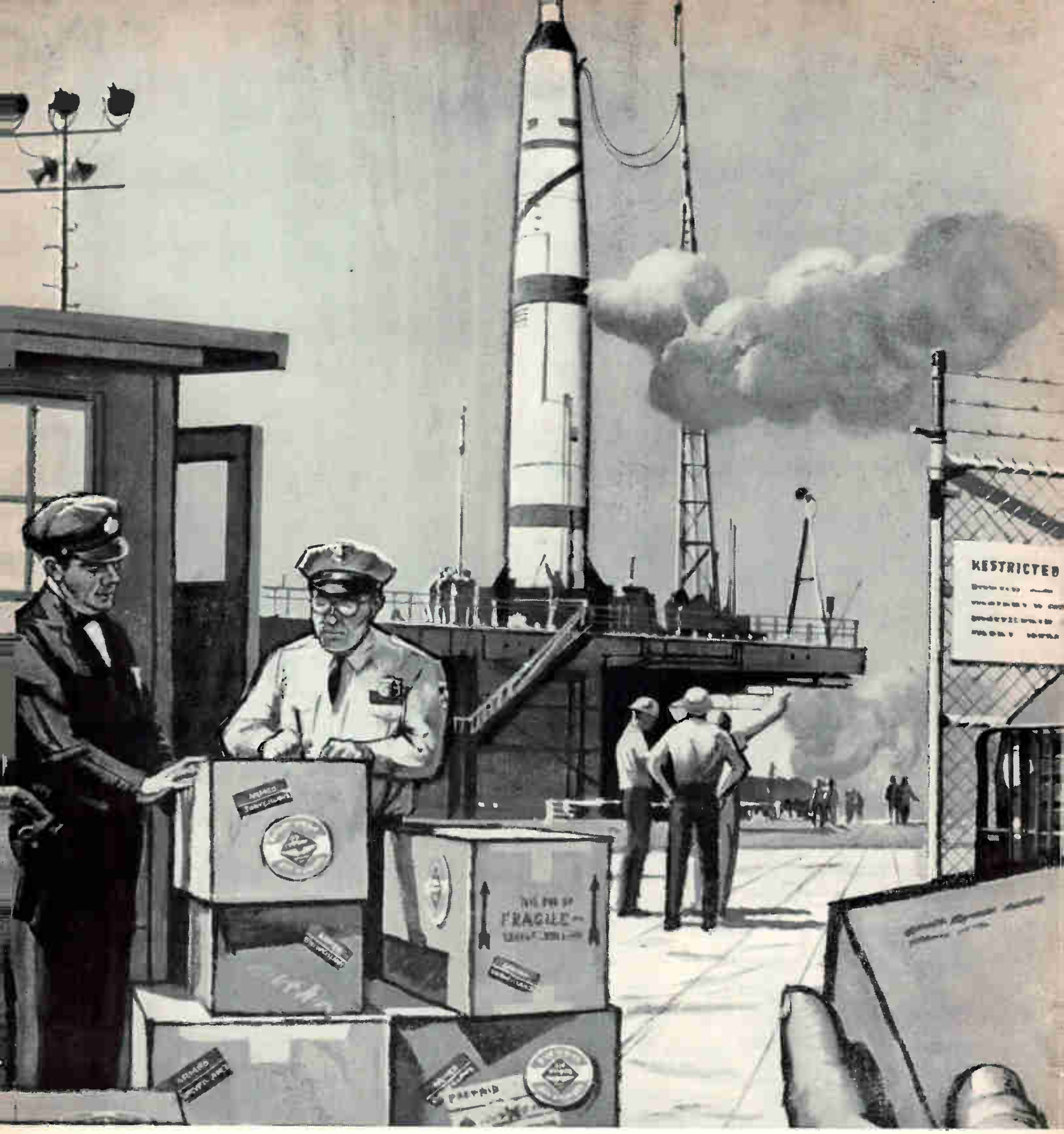
CIRCLE 17 ON READER SERVICE CARD



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Why is it
anchor man in
America's missile race?**

Anchor man on a relay team is the fellow who clinches victory with a final burst of speed.

That literally describes the role of AIR EXPRESS on America's missile team.

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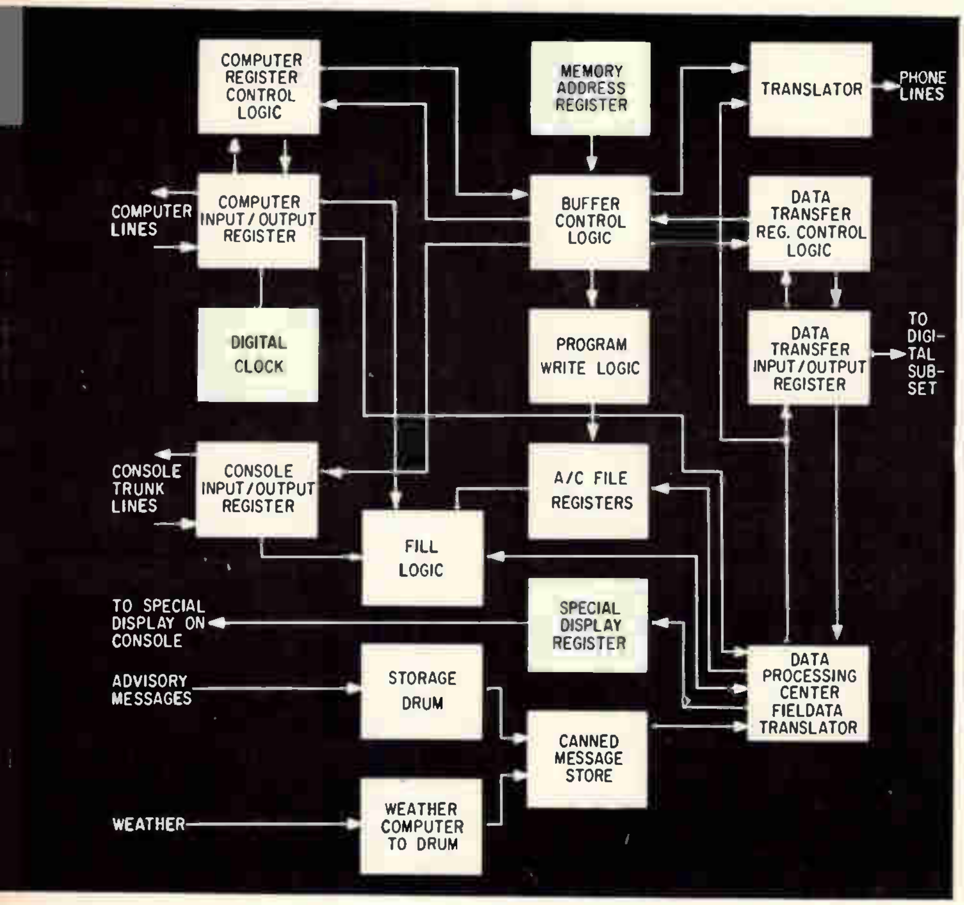
CIRCLE 19 ON READER SERVICE CARD

Digital-Voice Communications May



Block diagram outlines ACCESS buffer unit components and functions

TIME-SHARING of voice radio channels with electronic digital communications is the key technique in an air traffic control system proposed recently to the FAA by a technical team from Motorola and General Precision. The system, called ACCESS for Aircraft Communication and Electronic Signaling, would make use of existing communications facilities.

Evan Ragland, of Motorola, and Craig Immerman, of General Precision, say the system should handle anticipated increases in instrument air traffic for many years. A 360 percent increase in traffic is anticipated by 1975, on top of a 320 percent increase during the 1950's.

ACCESS calls for new air and ground equipment, but reportedly avoids modifications to existing air borne transceivers and ground equipment. It would accommodate private, business and commercial aircraft and military aircraft operating in commercial air traffic control (ATC) areas.

Routine, easily automated communications would be handled by a digital data subsystem. Voice transmission would be continued for communications that are variable and not routine. Elements of the system and their function are:

Ground elements

The controller—organizes voice-digital communications. Selective addressing enables him to contact exclusively a certain aircraft even though the same frequency is used by other aircraft.

Ground-based equipment—processes the pilot's request for voice-digital communications and displays it on the controller's console.

Existing controller's console—displays digital information generated by ACCESS system, including fix point and estimated time of arrival.

Existing air traffic control computer—provides ACCESS system with stored data such as route of flight, position report, position acknowledgement, altimeter data and handoff request.

Existing land-line and ground uhf and vhf transceiver equipment.

Airborne elements

The pilot.

Airborne ACCESS equipment—when requested it reads and displays to the controller the airborne navigational instrument readings of those aircraft digitally equipped. Reading errors are noted if the pilot is tuning his equipment.

Existing uhf or vhf transceivers.

In airborne ACCESS equipment, a digital communications capability compatible with voice communications is provided by a modulator-demodulator unit. The Minimum Airborne Digital Equipment (MADE) is designed with inputs and outputs appropriate for operation of digital devices and instruments and can be expanded by functional modules.

MADE's data converter and pilot display control panel connect to existing transmitting and receiving equipment. Automatic altimeters, page printers and message composers can be added. Aircraft with minimum equipment can enter the digital control complex and be identified by the controller, transmit a simple position report, exchange digital acknowledgements and transmit and receive private-line voice communications.

A ground-based buffer unit (see diagram) buffers the ACCESS data communications facilities and

Expand Air Traffic Control Capacity

the air traffic control data processing system. The buffer enables time sharing of a single channel for voice and digital communications between ACCESS-equipped aircraft and ATC centers. Digital communications are sandwiched between voice transmissions. The buffer holds digital information until voice information has been completed and interrupts digital communication to give priority to voice.

The buffer maintains a file of machine and English identification codes. Identifications are entered into the buffer by the ATC computer. The buffer can thus function with other equipments in a system in which the computer uses the holder code, the controller the English code and the aircraft the ACCESS code.

The entire file is modular by air traffic sector. Each file track contains all information pertinent to all aircraft within a sector up to a maximum of 20 aircraft. If a sector requires more file space, an overflow track is used. The buffer also stores "canned messages"—advisory information from data processing control, weather computer or teletype.

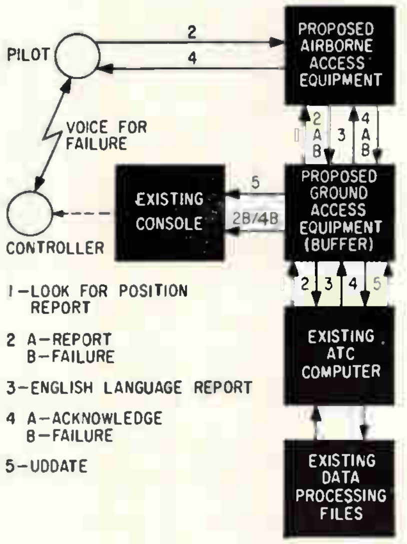
Messages from console or computer received by the buffer are sent to the air traffic control sector transmitter via data link after being assembled and translated into "Fieldata" code for transmission to aircraft. Messages from aircraft are translated into code and sent at proper rates to the console or computer. All input transmission to the computer will have digital time added. This information is necessary for an aircraft position report and if legal records of other transactions are desired.

The buffer stores a request for transmission by pilot, controller or computer. It then encodes, addresses, assembles, and routes the message. For voice transmission to the aircraft by the controller, the buffer also determines the class of airborne equipment and decides which frequency channel to use.

Messages to and from the computer use the synchronous buffer rate of 115.2 Kc. Console-to-buffer intelligence rate is 10 Kc.

When an aircraft enters an air traffic control sector the ATC computer sends an "initiate" message to the buffer. A programmed "search message" is transmitted to the aircraft. Upon aircraft response, the stored program is erased. If no response is made the buffer warns the controller via the console of unsatisfactory communications. When the aircraft leaves the sector, the computer sends a "delete" message to the buffer, enabling it to remove the aircraft from its files.

Buffer-to-aircraft messages are handled by data transfer link. The link terminals on the buffer side contain a 120-character register clock at 115.2 Kc. On the aircraft side, terminals are clocked at 1.2 Kc. The data transfer register is preceded by a translator.



Air traffic control position-report flow in proposed system

Survey Reviews Military Spending

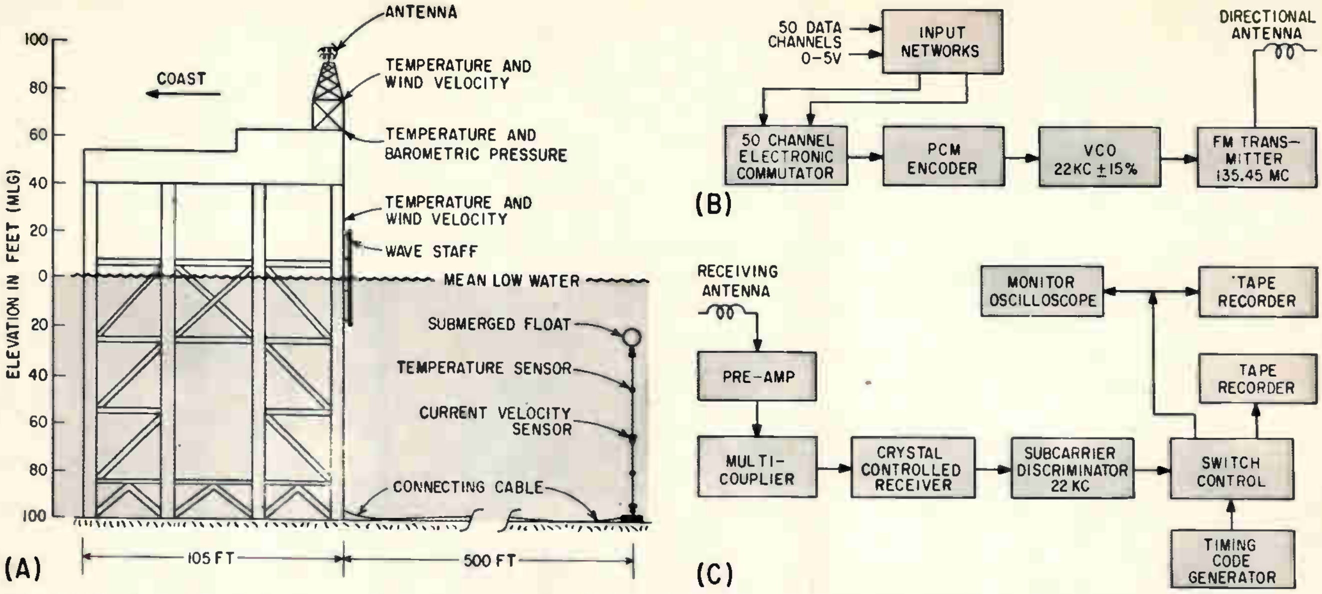
DEFENSE SPENDING analysis for April-June shows more funds went for transport and tanker aircraft than any other category. Total of prime systems awards in this and nine others of the top 10 categories for the period are listed in the table.

Other categories reflecting heavy military spending during the last quarter of fiscal 1961 include surface ships and parts, $111,010.000; ground-based and ship-based power systems, $109,749,000; aircraft jet engines, $105,680,000; space vehicles, $91,943,000; trainer aircraft, $89,022,000, and helicopters, STOL and VTOL aircraft, $64,525,000.

LARGEST DEFENSE CATEGORIES FOURTH QUARTER, FISCAL 1961

Transport and tanker aircraft	$1,069,641,000
Complete missile systems	255,534,000
Field maintenance and operation services	235,121,000
Nuclear submarines	190,226,000
Military trucks and autos	181,558,000
Land based combat vehicles	171,363,000
Warning and threat detection systems	168,869,000
Military construction services	157,386,000
Missile inertial guidance and control	138,691,000
Missile nuclear warhead systems	118,650,000

The above figures represent prime military systems awards. They are recorded exclusively for ELECTRONICS by Frost & Sullivan, Inc., New York, defense market specialists



Diagrams show location of sensors on stage (A), offshore data acquisition and transmission system (B) and receiving and recording system at shore station (C). The stage was built by the Navy for underwater acoustics research

Telemetry Automates Oceanographic Research

By LORRAINE SMITH,
McGraw-Hill News

AUTOMATED OCEANIC RESEARCH project gets underway this month off the coast of Florida. Its sponsors at Texas A&M College hope the project may lead to the Gulf of Mexico becoming a huge oceanic laboratory.

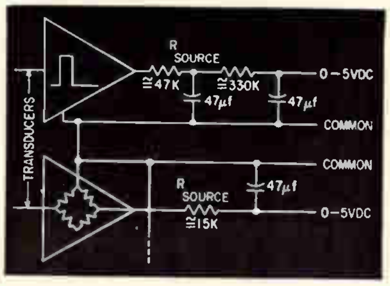
Electronic sensing and telemetering equipment is mounted on a Texas tower type of platform, called a stage, located in 100 feet of water 11 miles off Panama City. Data will be recorded at a nearby Navy shore station and processed at the college's new data processing center.

The program is financed by a $155,000 grant from the Office of Naval Research. Main objectives are:

- Establish and evaluate an automatic measurement, data gathering, recording and reduction system capable of handling information needed for a wide range of air-sea interaction research.
- Use the observed data to study long and short period variations in environmental features.
- Stimulate interest in and use of fixed station techniques for research.
- Gain experience in remote systems operations and develop techniques for high volume data handling and analysis.
- Provide an adequate facility for field test and evaluation of new instruments.

Researchers expect to collect and analyze in one year the equivalent of data obtained in several years by conventional shipborne techniques. They plan to analyze air-sea energy transfers and other natural influences on sea characteristics.

Data will be available to other researchers. Also, the telemetry system will have extra channels that other researchers can use.



Typical designs for compatible high impedance (top) and low impedance (bottom) senor outputs

R. D. Gaul, chief research scientist in Texas A&M's Department of Oceanography and Meteorology, is principal investigator. Dale Liepper, department head, is project supervisor. A field party will change tapes and make daily adjustments at the shore station. Offshore equipment is designed for unattended operation with periodic checkups.

If the project is successful, Gaul believes, the Gulf of Mexico could be used as an oceanic lab. Offshore drilling operations—there are hundreds of fixed stations in the gulf—could make many fixed stations available. These would feed data into a central processing facility.

Gaul points out that oceanography is receiving a great deal of military emphasis. But he feels that new methods, not money alone, are needed to rapidly advance research. Automation would make it possible "to deal with this complex phenomenon as an entity".

Looking ahead to such a major project, Texas A&M and Southwest Research Institute have already outlined a cooperative effort and have an industrial team selected in case funds become available. Team members include Airpax Electronics and Hytech Corp., instrumentation; Dynatronics and Telemetering Corp. of America, field data conversion and transmission systems; Radiation, Inc., platform-to-shore system; Hughes Aircraft, shore data recording system, and SWI, instrumentation and data systems engineering and management. Hytech and Telemetering Corp. are providing equipment for the present station.

Sensors, according to the staffers, pose the greatest problem in oceanographic telemetry. Most of the sensors to be used are either new in concept of unproven for long-term remote application. Standard sensors might deteriorate in a few weeks.

For simplicity and reliability, a 0-5 v d-c full scale range was selected as the standard electrical interface between sensor outputs and data acquisition system input. One lead from each sensor will be in common with the d-c power supply ground. The commutator can accept signals from high or low-impedance sensors incorporating output with circuits similar to those illustrated.

The pcm/f-m/f-m data acquisition and transmission system uses two channels for data control and has 48 available information channels. Each channel is sampled five times a second. The pcm encoder converts commutator output signals to 10 bit words. Each word has eight bits devoted to data, one bit for word synchronization and one bit for parity.

Encoder output, a serial bit stream, is fed to a standard voltage controlled oscillator (VOC). The VCO provides a 5.4-Kc f-m subcarrier which in turn modulates an f-m carrier. This is transmitted at 135.45 Kc, a frequency which avoids conflict with communications at a nearby airbase.

At the shore station, receiver output is fed to an f-m subcarrier discriminator whose output is the original serial pcm bit stream. Timing information is added and the pcm stream is recorded.

The data reduction system consists of a playback tape recorder, format converter and IBM 729 tape drive unit. The converter puts the pcm information into a format compatible with an IBM 709 computer. Storage tapes are prepared on the 729.

Radio-Tv Relay Band Under Study

RULEMAKING under study by the Federal Communications Commission would create a new private microwave category for broadcasters. The action would save spectrum space and, by decreasing costs of relays, could spur sales of new equipment.

FCC plans to change present rules governing voice transmissions by microwave between broadcast studios and remote transmitter sites. Also affected is program fare sent between cities by individual broadcast organizations. The change would mainly affect owners of multiple facilities, broadcasters owning combinations of a-m, f-m or tv stations. According to the National Association of Broadcasters there are 747 f-m/a-m affiliates. In addition, many of the 545 tv stations on the air also have a-m or f-m affiliate stations.

Broadcasters now wishing to use private microwave to link studios with transmitter site must have a separate channel for each service. They must also have an additional channel to transmit operational information. The same requirements exist for intercity facilities.

The new FCC proposal would combine all categories into one new service to be called the Aural Broadcast Studio Transmitter Link (STL). Multiplexing would play a major role.

Broadcasters commenting to ELECTRONICS about the FCC proposal say that their interest in private microwave has been slight because of the multiple requirements. "This new action could give private links a boost," said one station engineer.

Manufacturers are cautious about predicting a boom. A Raytheon spokesman says the action, if approved, will increase the demand for multiplex equipment somewhat, but that it will have only a modest effect on Raytheon's total volume. Radio Corporation of America says the increased flexibility of STL may step up sales.

The proposal is supported by the National Association of Broadcasters and some individual broadcast companies. Association comment specifically praised spectrum conservation and possible economies were seen as positive benefits that would allow stations in remote areas to tie in with major networks at lower cost than at present.

The Association asked that FCC spell out that a-m, f-m and tv aural signals may all be transmitted at one frequency. NAB feels that the intent of the regulation is not specifically expressed in the present wording.

The frequencies specified by FCC range between 942.5 to 951.5 Mc. Holders of licenses or construction permits for STL microwave links between 890 and 942 Mc may continue to operate on those frequencies for the duration of their licenses and may renew their authorizations provided no interference is caused.

The docket also provides for intermediate relay stations in cases of long distances or terrain difficulties.

Radio-TV Sales Jump in England

LONDON—Radio and television set sales in Britain scored sharp gains this summer, reports the Radio & Tv Retailer's Association. Uncertainty on tv line standards, however, cloud the long range sales picture.

The more-than-seasonal sales gains being noted in England since June are attributed primarily to the jump in demand for transistor radios. Average sales per retail shop went to 22.4 units in June compared to 12 in May and 15 in June, 1960. Tv retail sales were five sets per store in June as against four sets in May and 3.7 sets in June, 1960.

One British retailer said, "All this does not add up to a boom, but it is distinctly encouraging." Business was badly hit earlier this year by credit restrictions, and sales had been very slow. In July, a flurry of tv receiver buying by retailers was brought on by anticipation of higher purchase taxes in the government austerity program.

Tv set deliveries jumped to 159,000 in July, compared with 55,000 in June, according to England's Radio Equipment Manufacturer's Association. Shipments to manufacturers are 39 percent higher than a year ago.

Radio shipments to retail outlets rose 56 percent over last year with a July figure of 258,000 units. London observers say set deliveries usually do not pick up until the fall in preparation for peak selling periods in autumn and winter.

Despite optimistic predictions on tv receiver sales, uncertainty about line standards is creating uneasiness and buyer hesitation. Michael Keegan, director of RTVRA, estimates that it will cost about $84 to adapt most of the new convertible 405-line sets to the proposed uhf 625-line standard.

Uncertainty on standards was highlighted at the British National Radio and Tv Exhibit this month in London. Observers say the U.K. tv industry is divided on which line standard should prevail. Effects of the split in opinions showed up in a number of display units capable of handling either standard. One company is promising a five-year guarantee to convert its sets for about $45.

Technical changes from last year's models are slight although a number of new screen sizes have been presented with some sets featuring 19-in. or 23-in. screens. Prices range from $180 to $280. A transistorized portable tv set was priced at $275.

Instrument Designer

North American Aviation designs aircraft and space ship cockpit instruments with this device. Varying connections creates different images of instruments on the oscilloscope display tube, allowing engineers to experiment with instrument face design

At signing of contract are (from left) F. J. Parker, RAC president; F. J. Larsen, assistant secretary of Army, and Maj. Gen. W. J. Ely, Army director of research

New Firm Is Army Weapons Adviser

ARMY HAS CONTRACTED with a new non-profit firm, Research Analysis Corp. (RAC), of Bethesda, Md., for advice on weapons systems and other broad military planning problems. The Army expects the contract to give it "greatly increased potential for scientific inputs" for short and long-range planning.

RAC's list of research specialties runs to more than 80 areas, ranging from special technical problems to paramilitary warfare. Included are air defense, aviation, atomic weaponns, communications, computers, countermeasures, data processing, early warning, mathematics, mines, missiles, space reconnaissance, surveillance systems and weapons system analysis.

A RAC spokesman emphasized that the corporation will not take part in specific system or component design.

Representatives may visit manufacturers to evaluate approaches to weapons system problems. But RAC recommendations based on information gathered will be turned over to the Army for action, not to the manufacturer. Nor will RAC evaluate a firm's R&D capability, it was reported. However, the corporation will keep an "open door" for industry suggestions on R&D policies.

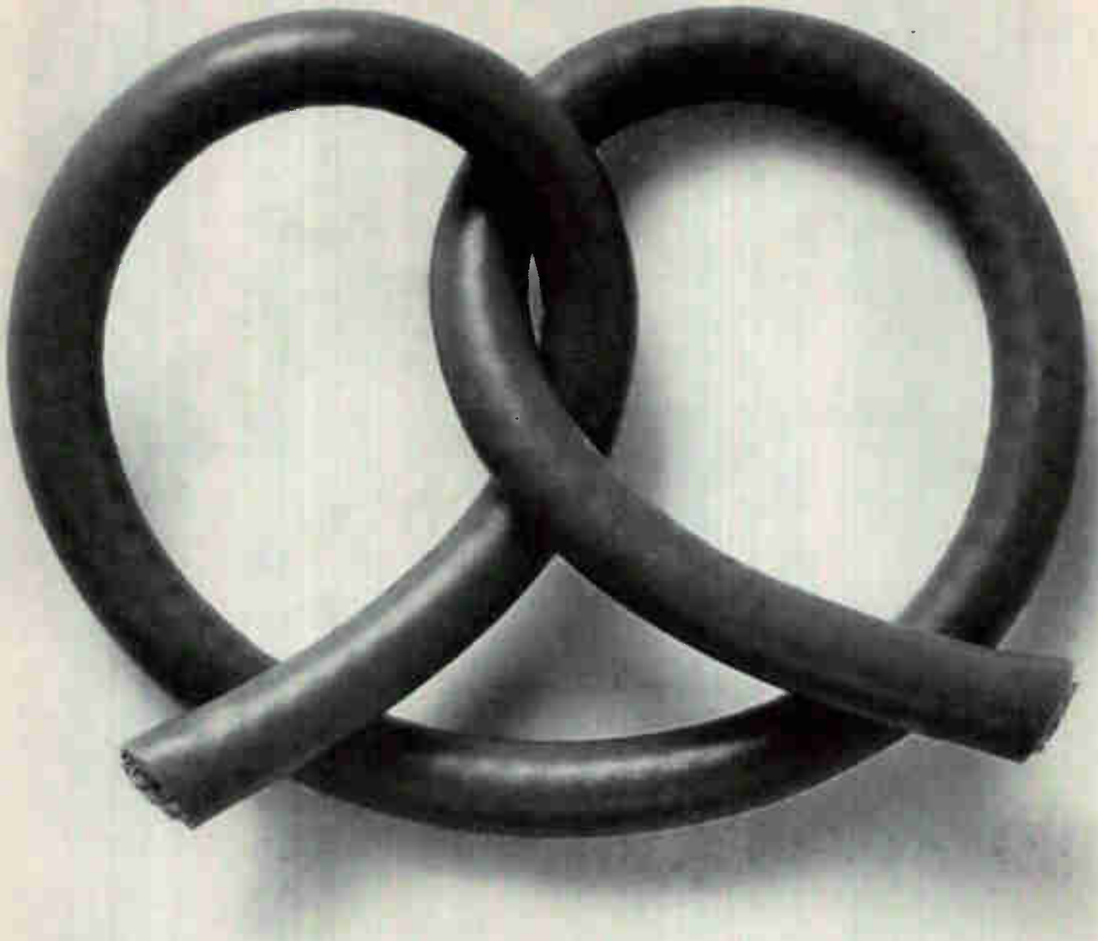
Specialized staff knowledge will be applied to system recommendations, but hardware details will be strictly between the Army and its industrial contractors.

RAC will continue work performed for the Army by The Johns Hopkins University Operations Research Office, founded 12 years ago. This group dissolved August 31 and its former personnel now form the nucleus of the RAC staff. The group was similar to MIT's Operations Evaluation Group (OEG) which advises the Navy. Formation of RAC is said to reflect increasing Army emphasis on long-range planning not under military control, to attain objectivity.

RAC plans close liaison with Mitre (ELECTRONICS, p 22, Aug. 25, 1961), OEG, Rand and Aerospace, other non-profit corporations serving military commands. But RAC reportedly does not plan to go into actual weapons system management.

Staff assignments will be kept flexible so each member can take part in as many study areas as possible. Final decisions on recommendations will be made by a staff board. Since RAC is not concerned with detailed hardware specifications, only 17 percent of its staff is engineers. The remainder have backgrounds in mathematics, physical sciences and humanities.

Frank A. Parker, Jr., former assistant director of defense research and engineering in the secretary of defense's office, is president. Hector R. Skifter, also a former assistant director of defense research and engineering, consultant to the President's Science Advisory Committee and president of Airborne Instruments Laboratory, is board of trustees chairman. Other trustees are Gen. Omar N. Bradley, Bulova Watch Co. chairman; Henrik W. Bode, vice president of Bell Telephone Laboratories; John T. Conner, Merck & Co. president, and John F. Floberg, former AEC commissioner and general counsel of Firestone Tire & Rubber Co.



MEETINGS AHEAD

Oct. 1-5: Electrochemical Society; Statler-Hotel, Detroit, Mich.

Oct. 1-6: Suppression of Radio Interference, International Comm., CISPR, ASA, PGRFI of IRE; Univ. of Pa., Philadelphia.

Oct. 2-3: Engineering Education, Engineers Council for Prof. Devel., Sheraton Hotel, Louisville, Kentucky.

Oct. 2-4: Communications Symposium, PGCS of IRE; Utica, N. Y.

Oct. 2-4: IRE Canadian Convention, Region 8, Automotive Bldg., Exhibition Park, Toronto, Canada.

Oct. 2-6: Society of Motion Picture and Television Engineers, SMPTE; Lake Placid Club, Essex County, New York.

Oct. 2-7: Astronautical Congress, International, IAE, ARS; Wash., D. C.

Oct. 3-12: British Computer Exhibition & Symposium, Electronic Engineering Assoc., Office Appliance Trades; National Hall, Olympia, London.

Oct. 6-7: Broadcast Symposium, PGB of IRE; Willard Hotel, Wash., D. C.

Oct. 9-11: National Electronics Conf., IRE, AIEE, EIA, SMPTE; Int. Amphitheatre, Chicago.

Oct. 9-13: 13th Annual Audio Engineering Society Convention and Exhibit, Hotel New Yorker, New York City.

Oct. 10-12: National Conf. on Standards, ASA; Rice Hotel, Houston, Texas.

Oct. 11-13: Application of Digital Comp. to Automated Instructions, ONR, Systems Devel. Corp., Dept. of Interior Audit., C. Street, Wash., D. C.

Oct. 16-17: Engineering Writing & Speech, PGEWS of IRE; Kellogg Center, Mich. State Univ., East Lansing, Mich.

Nov. 14-16: Northeast Research & Engineering Meeting, NEREM; Commonwealth Armory and Somerset Hotel, Boston.

Mar. 26-29, 1962: IRE International Convention, Coliseum & Waldorf Astoria Hotel, New York City.

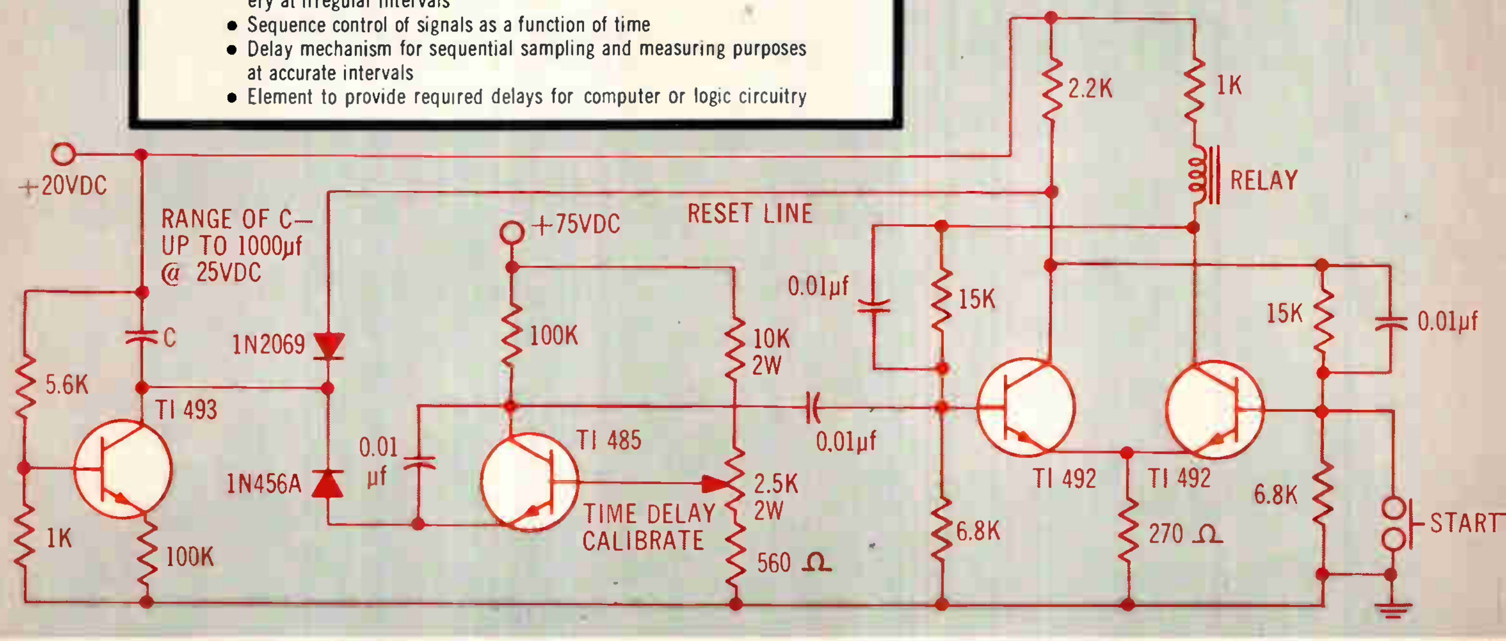
Variable Delay Timing Circuit

Typical Applications

- Safety device for sequential application of signals
- Warm-up delay mechanism for starting complex machinery
- Automatic on/off control to facilitate adjustment of process machinery at irregular intervals
- Sequence control of signals as a function of time
- Delay mechanism for sequential sampling and measuring purposes at accurate intervals
- Element to provide required delays for computer or logic circuitry

Features

Time Delay From 25 milliseconds to 3 minutes
Self Resetting or Externally Cycled
Temperature Range −40°C to +125°C
ON/OFF Relay Actuator



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Get greater margins of operational safety by applying these new silicon industrial transistors to your process control, communication, aviation system, electronic instrumentation, and computer applications today.

CHARACTERISTICS					APPLICATIONS					
TYPE	MIN BV_{CBO}	DC Beta Range	MAX I_{CBO} @ 100°C	$f_{\alpha b}$ (typ)	Servo and Relay Driver	Audio Amplifier Medium-Speed Switcher§	Audio Amplifier Medium-Speed Switcher**	RF Amplifier (to 40 mc)	VHF Amplifier, High-Speed Switcher	NIXIE® Driver
TI 480	50 v	9—36* @ 5 ma	50 µa @ 30 v	1 mc	TI 480					
TI 481	80 v	9—36* @ 5 ma	50 µa @ 30 v	1 mc	TI 481					
TI 482	20 v	>20 @ 30 & 150 ma	50 µa @ 10 v†	60 mc			TI 482	TI 482		
TI 483	40 v	20—60 @ 150 ma	50 µa @ 30 v†	60 mc			TI 483	TI 483		
TI 484	40 v	40—120 @ 150 ma	50 µa @ 30 v†	60 mc			TI 484	TI 484		
TI 485	20 v	15—60 @ 10 ma	20 µa @ 15 v†	200 mc					TI 485	
TI 486	80 v	20—80 @ 200 ma	300 µa @ 60 v‡	15 mc			TI 486			
TI 487	80 v	20—80 @ 200 ma	300 µa @ 60 v‡	15 mc			TI 487			
TI 492	40 v	15—45* @ 1 ma	50 µa @ 30 v	8 mc		TI 492				
TI 493	40 v	15—45 @ 10 ma	50 µa @ 20 v	20 mc		TI 493				
TI 494	40 v	40—125 @ 10 ma	50 µa @ 20 v	20 mc		TI 494				
TI 495	40 v	120—250 @ 10 ma	50 µa @ 20 v	20 mc		TI 495				
TI 496	40 v ″	>10 @ 3 ma	75 µa @ 40 v	1 mc						TI 496

*AC Beta † I_{CBO} @ 125°C ‡ I_{CBO} @ 150°C § 100 µa to 20 ma **20 ma to 500 ma ″ BV_{CEX} ® TRADEMARK OF BURROUGHS CORPORATION

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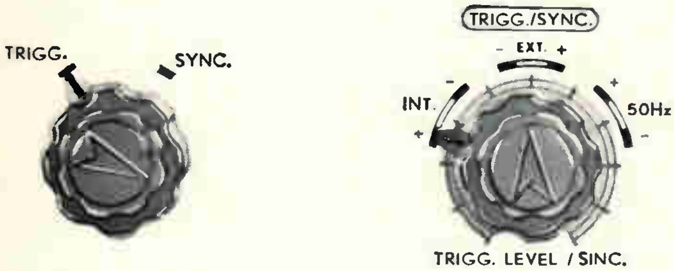
CIRCLE 29 ON READER SERVICE CARD

broad-band oscilloscope

with differential

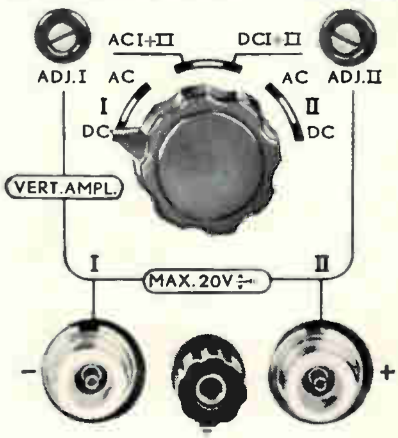


Trigger–Sync possibilities

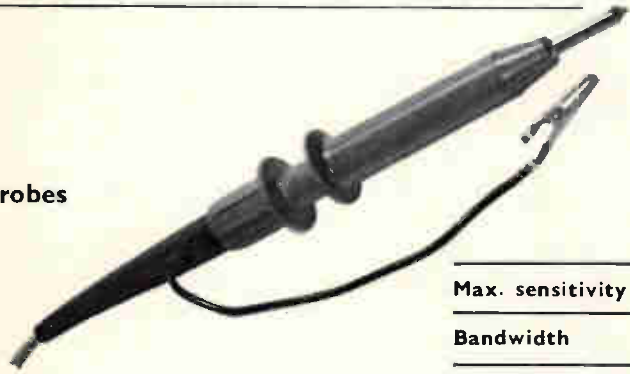
Due to the sensitive and highly stable trigger circuit operation is extremely simple. The delay-line incorporated in the vertical amplifier, and the excellent properties of the trigger circuit, enable pulses with a long rise time to be reproduced completely.
Triggering: up to 2 Mc/s (at 5 mm amplitude)
Synchronisation: up to over 14 Mc/s

DC-coupled differential amplifier

The two inputs can be used either separately (asymmetrically) or in combination as a differential input.
Bandwidth DC - 14 Mc/s (AC coupled from 1 c/s upwards)
Sensitivity 50 mV/cm
Rejection factor between 250 and more than 1000 depending on frequency and input voltage.
Special input plugs enable quick exchange of probes and measuring cables. The cathode-follower probes are fed from the oscilloscope via the same plugs.



Probes



Two attenuator probes and two DC-coupled cathode-follower probes are included in the delivery. Two screwcaps per cathode-follower probe enable AC coupling with different bandwidth and input capacitance.

	Att. probe	Cathode-follower probe		
		DC	AC(HF)	AC(LF)
Max. sensitivity	500 mV/cm	50 mV/cm	50 mV/cm	50 mV/cm
Bandwidth	0-14 Mc/s	0-14 Mc/s	100 c/s-14 Mc/s	1 c/s-14 Mc/s
Input impedance	10 MΩ//7 pF	0.5 MΩ//5.5 pF	0.5 MΩ// 7 pF	0.5 MΩ//10 pF

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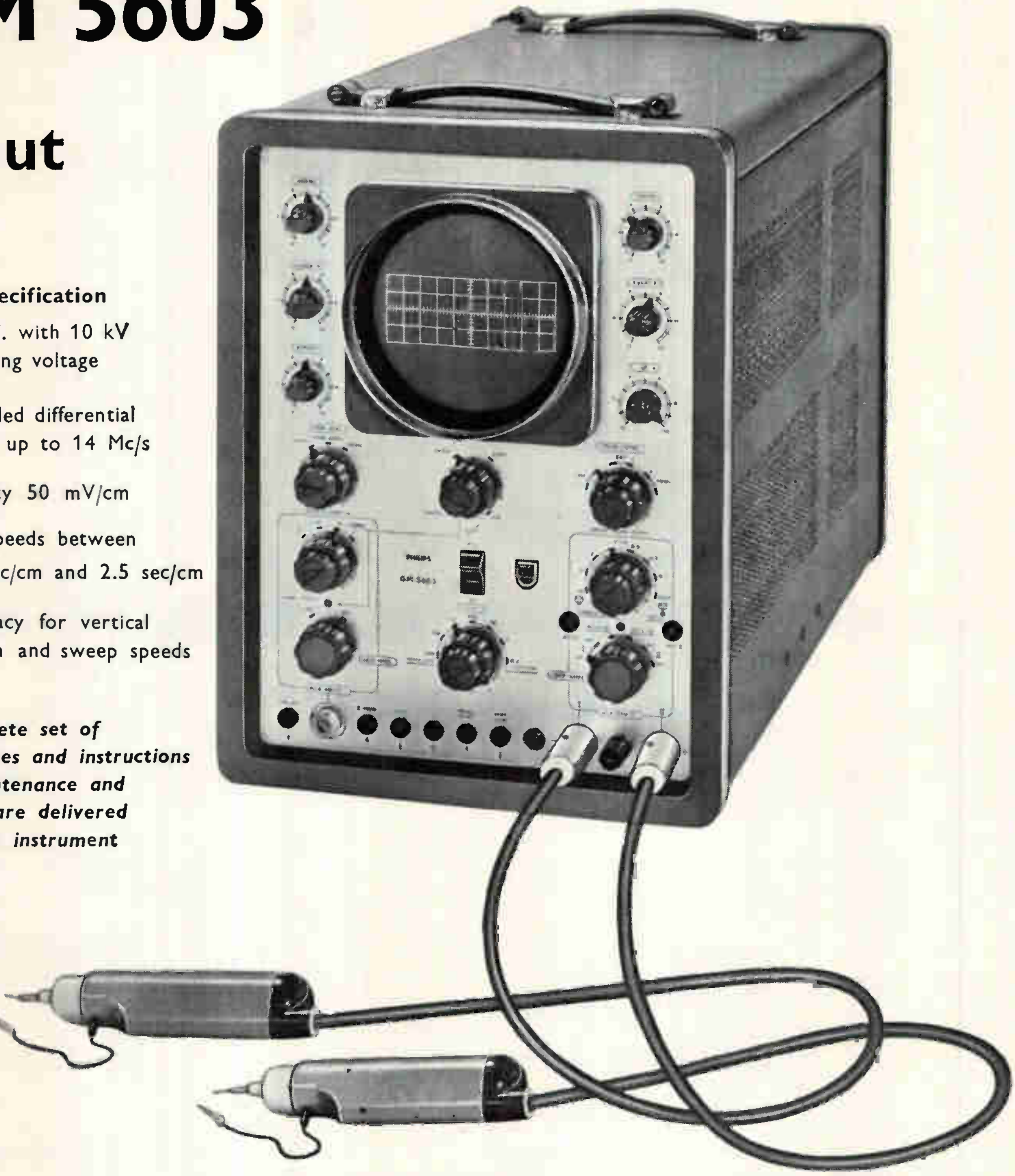
GM 5603

input



Main specification

5" C.R.T. with 10 kV accelerating voltage

DC coupled differential amplifier up to 14 Mc/s

Sensitivity 50 mV/cm

Sweep speeds between 40 mμsec/cm and 2.5 sec/cm

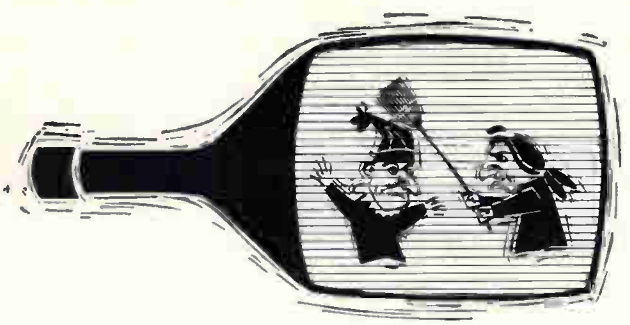
3% accuracy for vertical deflection and sweep speeds

A complete set of accessories and instructions for maintenance and service are delivered with the instrument

instruments: quality ***tools*** for industry and research

PHILIPS

CIRCLE 31 ON READER SERVICE CARD



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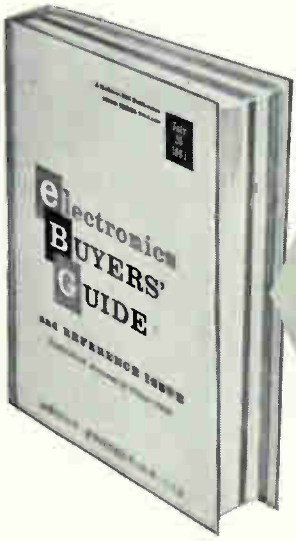

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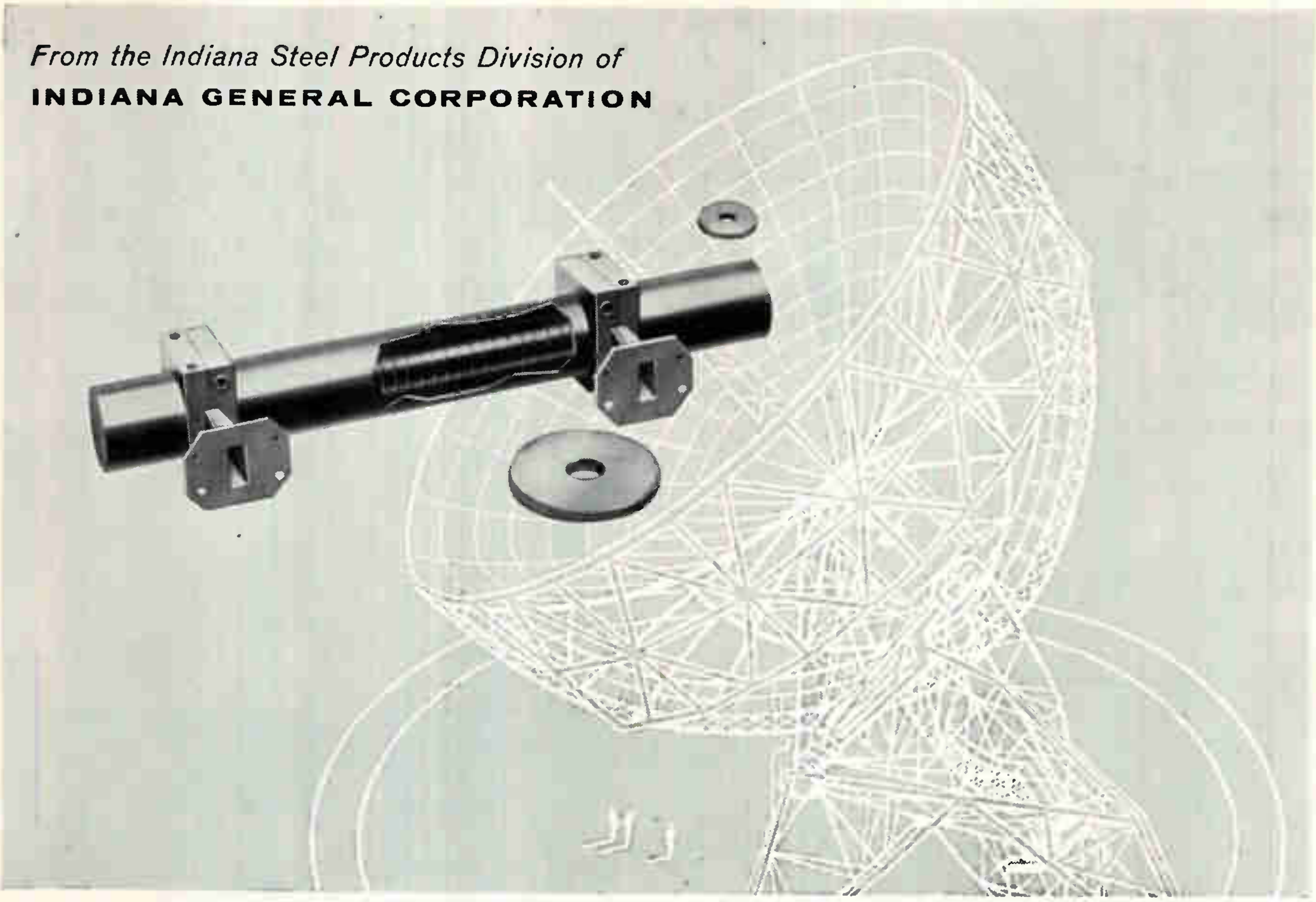


NEW INDOX® VI-A....
another ceramic magnet advance for microwave use

Developed by Indiana General's Indiana Steel Products Division, new INDOX VI-A has the highest coercive force of any commercially available magnetic material now in quantity production — plus better resistance to low temperatures, higher residual induction, higher peak energy product.

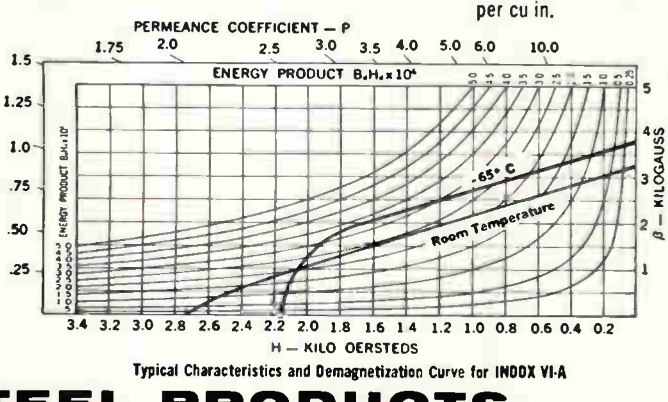
Indiana General's new INDOX VI-A is a highly oriented barium ferrite material that will effect substantial savings in both material and space in critical equipment such as periodic-focus traveling wave tubes.

One big advantage is that in many applications INDOX VI-A may be magnetized before assembly. Like INDOX V, INDOX VI-A is best suited for simple shapes: rings, discs, rectangles and squares. Magnet length (pressing direction) is limited to one inch or less; longer units can be built up from separate magnets.

Indiana design engineers worked closely with leading microwave manufacturers in the development of INDOX VI-A. The same characteristics that make this material outstanding for microwave application will open the door to other new applications and improve existing products.

New INDOX VI-A is another in a series of Indiana General's notable achievements in ceramic magnet design. For full details on this or other magnetic materials, write us or check your Indiana sales engineer.

	Room Temperature 20° C	-65° C
Residual Induction (B_r) gauss	3300	3830
Coercive Force (H_c) oersteds	2740	2140
Intrinsic Coercive Force (H_{ci}) oersteds	3000	2300
Peak Energy Product (B_dH_d) max.	2.55×10^6	3.4×10^6
Reversible Permeability	1.06	
Reversible Temperature Coefficient (magnetic)	−.19% ° C	
Magnetizing Field for Saturation, oersteds	10,000	
Chemical Composition	$BaFe_{12}O_{19}$	
Specific Gravity	4.5 or .162 lb per cu in.	



Typical Characteristics and Demagnetization Curve for INDOX VI-A

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CIRCLE 33 ON READER SERVICE CARD

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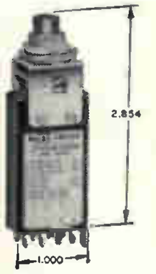
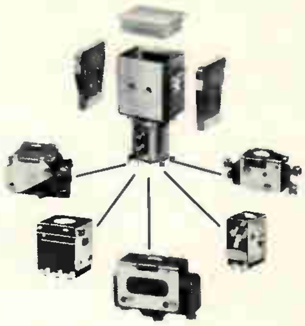
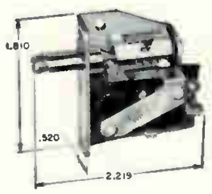


Direct Logic Input Switch generates single square wave output pulse in synchronism with an external clock pulse with each operation. Saves engineering time needed to develop flip-flop and gating networks for synchronizing one-shot circuits. Variations available to fit a wide variety of clock pulse rise times, voltages and frequencies and d-c supply voltages. Write for Data Sheet 172.



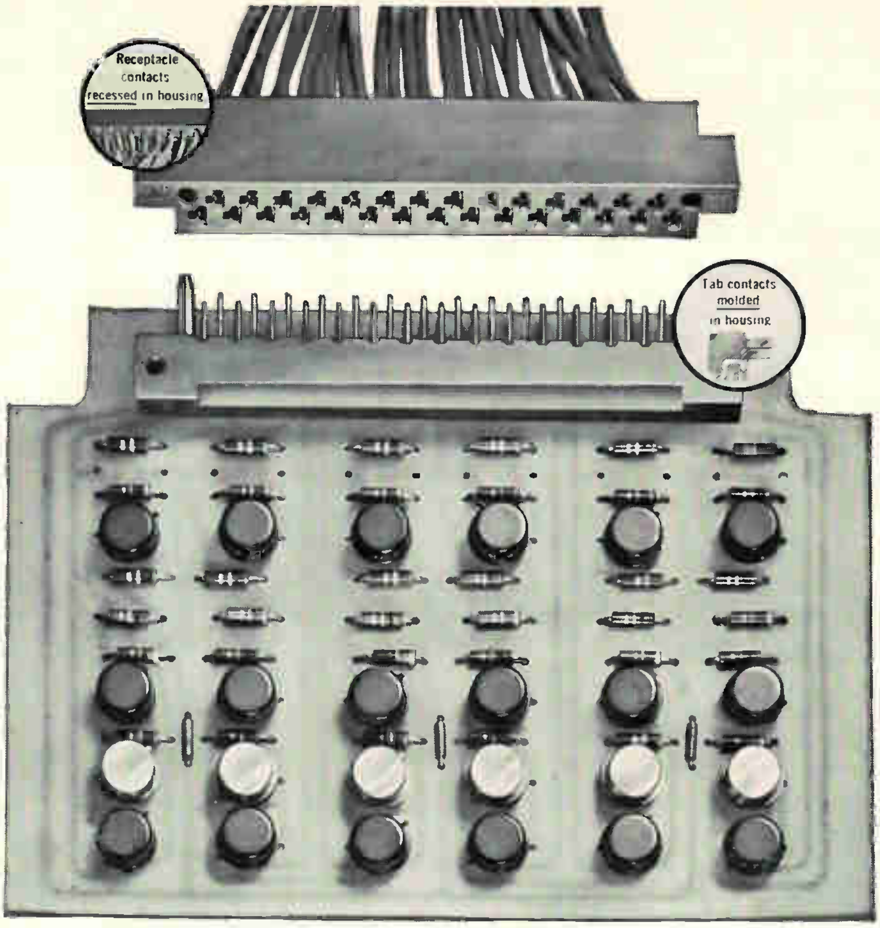
Modular Lighted Push-Button Switches offer customized combinations of eight different basic switches and dozens of colored display screens. Smart styling and enough flexibility to fit your control panel's design exactly. They simply snap together and then snap into your panel —all without tools. Display screens can be engraved. Write for colorful Catalog 67.

Decimal-to-Binary Switch Space-saving answer for computer control panels. Wiring requires fewer connections than wafer-type rotary. Snap-action gold contact, switching elements are enclosed and tamper-proof. Requires only 1.3 square inches of mounting surface on control panel. All operating positions are detented to give the operator positive feel of the switching action. For MICRO SWITCH reliability write for Data Sheet 170.



Door Interlock Switches Used on hazardous equipment cabinets to cut off power when service door is opened. Complete line is available including high-temperature, environment-free and subminiature models. A two-switch model controls two circuits simultaneously. Special design of brackets eliminates dangers of "tying down" that could occur with conventional type interlocks. Write for Data Sheet 186.

CIRCLE 35 ON READER SERVICE CARD



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- guaranteed individual contact forces
- large contact areas reduce connector pressures, avoid hard wear on plating and increase contact life
- raised barrier sections and large contact cavities prevent moisture entrapment
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Complete details will be sent on request.

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electronics
September 22, 1961

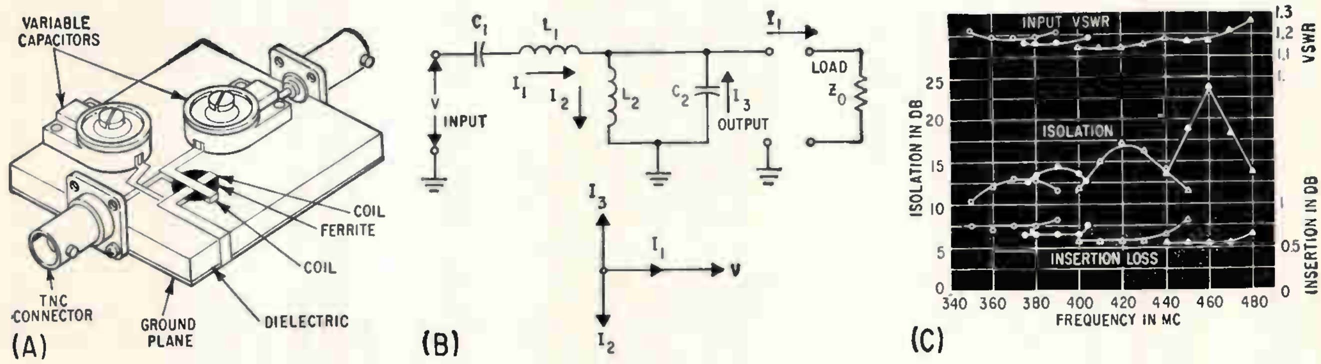


FIG. 1—Ultrahigh-frequency isolator (A), its equivalent circuit and vector diagram (B), and performance (C)

Ferrite Components for UHF and Microwave Systems

Describes recent designs of ferrite isolators, circulators, switches and phase shifters. Engineers can obtain high performance with reliability when applying these components to systems design

By JOHN C. CACHERIS
NICHOLAS G. SAKIOTIS
Solid State Devices Laboratory, Motorola, Phoenix, Arizona

RECENT DEVELOPMENTS have made it practical to apply ferrite components to systems design. Although ferrite components for low-frequency applications have been commercially available for about 15 or 20 years, it was not until 1952 that ferrite devices were developed for microwave frequencies. Since then, microwave components have been designed to give the systems engineer passive circuit elements having properties that were previously unobtainable except by active elements and mechanical components, or which could not be obtained at all. In the last eight years several hundred papers have been written on the microwave properties of ferrites and use of these properties in devices. Little attention has been given in the literature to ferrite devices having a high standard of performance and reliability for application in modern systems. This paper describes ferrite components that have the reliability and performance required by modern systems.

Microwave techniques have been developed recently[1] that have made possible the design of compact and lightweight uhf isolators such as the isolator shown in Fig. 1A. Operation of this isolator is similar to waveguide resonance isolators previously developed at microwave frequencies in that the ferrimagnetic-resonance properties of ferrites are used. A combination of stripline and lumped-parameter circuits has been used to reduce the size and weight of uhf isolators. The equivalent circuit and vector diagram are shown in Fig. 1B.

Since the r-f magnetic field is proportional to the r-f current, the circuit will be analyzed by setting up a circularly polarized current vector. Both L-C circuits are tuned for resonance. Therefore, L_2C_2 looks like an open circuit and L_1C_1 looks like a short circuit. Current $I_1 = V/Z_o$ and $I_2 = V/j\omega L_2 = -j V/\omega L_2$. If $Z_o = \omega L_2$, $I_2 = -j V/Z_o$; thus $I_2 = -jI_1$ As shown in the vector diagram, I_1 and I_2 are equal in magnitude and 90 deg out of phase. If L_1 and L_2 are placed physically at right angles with each other I_1 and I_2 will also be 90 deg apart in their space orientation. Thus, these currents produce a circularly-polarized magnetic field at the cross over point between L_1 and L_2. Interchanging the input and output ports of the cir-

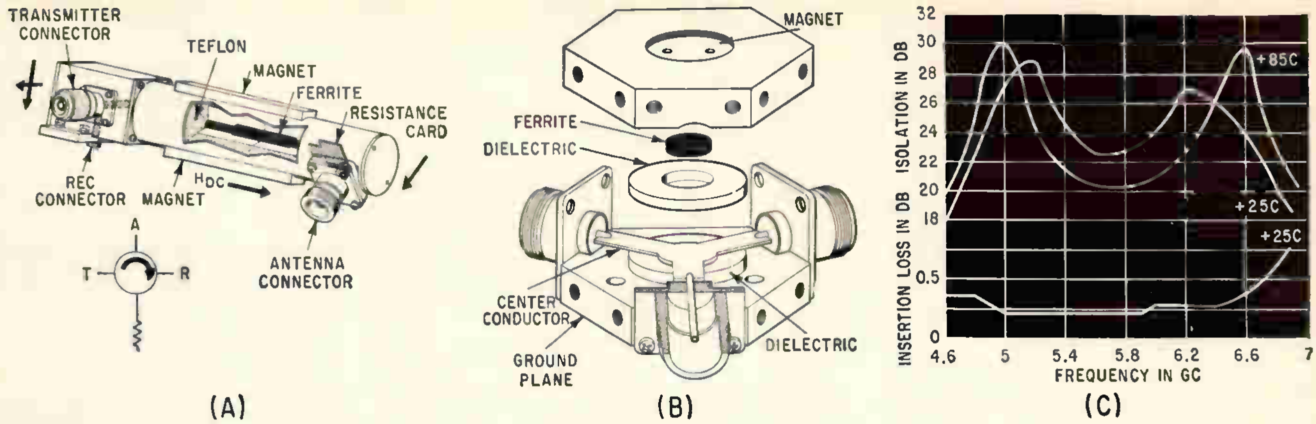


FIG. 2—Circulators shown in (A) and (B) use Faraday rotation, work in C-band. Performance of the wye circulator in (B) is given by (C)

cuit causes a reversal in the direction of I_1, while I_2 is unaffected. This interchange also reverses the sense of circular polarization at the crossover points of L_1 and L_2. With a ferrite disk and a transverse magnetic field at the crossover point, it is possible to obtain the nonreciprocal propogation characteristic of an isolator. The magnetic field is adjusted for ferrimagnetic resonance so that for the positive sense of circular polarization, the ferrite absorbs practically all the r-f energy. For the negative sense of polarization, that is, for propagation in the opposite direction through the device, virtually none of the energy is absorbed. Dimensions of the isolator are 3.5 by 2.5 by 1.0 in. and its weight is less than 7 ounces. Four units cover the 350 to 480 Mc band. As shown in Fig. 1C, each unit has at least 30 Mc bandwidth with over 10-db isolation and less than 1.0-db insertion loss. The isolators operate with these performance characteristics from 4 C to 43 C and with 95-percent humidity. They have been designed to withstand shock and vibration.

Present state-of-the-art design of microwave ferrite circulators is principally based on one of the following nonreciprocal effects that are characteristic of such ferrimagnetic ceramics as ferrites and garnets: Faraday rotation, nonreciprocal phase-shift, nonreciprocal mode-configuration, and anisotropic scattering.

The first two effects are combined in a gyrator element. The gyrator can then be combined with reciprocal elements such as hybrid tees, three-db couplers and two-mode transducers to obtain a variety of four-port circulators. This group of circulators includes the Faraday-rotation, differential phase-shift, turnstile and nonreciprocal half-wave types.

The nonreciprocal mode-configuration group of circulators use the large difference in field distribution that can be made to exist between waves propagating in two opposite directions in a transversely magnetized ferrite-loaded waveguide. This difference is exploited by placing ports along the waveguide so that they are primarily coupled to one direction of propagation. This group includes all the varieties of field-displacement circulators.

A number of authors[2, 3, 4] have shown that a ferrite obstacle will scatter an incident plane wave anistropically. This effect has been used in the latest group of circulators[5, 6, 7]. These circulators, which are usually among the simplest and most compact, generally consist of a three or four-port transmission-line junction that contains a ferrite obstacle symmetrically located and magnetized in a direction normal to the plane of the junction. The scattering properties of such a junction are nonreciprocal in that the coupling coefficients between the ports are just those that are required of a circulator. This group of junction circulators includes the tee, wye and cross types.

Faraday-rotation properties of ferrites are used in the circulator shown in Fig. 2A. The input signal from the transmitter is rotated 45 deg ccw (counter clockwise) in passing through the ferrite section and is coupled to the antenna. Similarly, a signal from the antenna will go to the receiver with practically no signal going to the transmitter. A resistance-card termination inside the unit absorbs signals reflected from the receiver. This circulator weighs approximately one pound and is seven inches in length. It operates from 5,400 to 5,900 Mc over the temperature range 0 C to 85 C. When this circulator is used as part of a duplexing assembly, the transmitter-to-antenna and antenna-to-receiver insertion losses are each less than 1.2 db. The antenna-to-transmitter isolation with the receiver port shorted and the transmitter-to-receiver isolation with the antenna port terminated are > 12 db.

Wye circulators have received considerable attention since they can be much smaller and lighter than other type of circulators. Figure 2B shows a miniaturized circulator based on the nonreciprocal scattering properties of ferrites. Wye circulators with isolations as high as 50 db can be designed with less than 0.5-db insertion loss. At C and X-band frequencies, 20 db of isolation can be obtained over a 20-percent band with power-handling capabilities of 2 to 10 Kw peak and 10 to 100 watts average. Similar performance is possible with symmetrical tee configurations. Wye circulators have been designed in waveguides and in strip transmission lines operating over a wide range of temperature and power levels from uhf to X-band. Recent developments in materials, temperature compensation, and matching have virtually eliminated the temperature and bandwidth limitations of earlier designs so that this type circulator has many applications. Stripline wye circulators have been achieved that can handle 40 Kw peak power and about 200-watts average power. Figure 2C shows the performance of a stripline wye circulator. At room temperature, it provides 20-db isolation and 0.5-db insertion loss over a 37-percent band from 4,600 to 6,800 Mc. At 85 C, bandwidth is 20 percent for the same isolation and insertion loss.

There are several types of switches. One is a single-pole, single-throw (spst) device that either transmits energy or absorbs it. An on-off resonance isolator is a spst device. A second type is a spst switch that either transmits or reflects energy. A third type is a single-pole, double-throw (spdt) switch that connects an input channel to either one of two output channels. This paper discusses only the latter type of switch.

Generally, a circulator whose direction of circulation is periodically reversed is an electronically controllable microwave switch. Switches have been designed with response times of 20 nsec, a speed that approaches the relaxation time of the ferrite material. Although many spdt switch configurations are possible, only three types will be described. The first type, a broadband switch based on Faraday rotation, has fast switching response and extremely broad bandwidth. The second type is narrow band, but operates at high microwave-power levels and over a wide temperature range. The third switch is a compact design that has many applications.

One of the major advantages of a microwave switch using the Faraday-rotation properties of ferrites is that the magnetic field to be reversed is relatively small, perhaps 40 oersteds.

Until recently the Faraday rotation switch was limited in bandwidth, but the switch shown in Fig. 3A has an 18-percent frequency band from 8,750 to 10,500 Mc with minimum isolation of 23 db in the OFF position and less than 1.25-db insertion loss in the ON position.[8] Spikes in the insertion loss characteristic at 8,700, 9,070, and 9,500 Mc increase insertion loss to 1.8 db over a 30-Mc region. This switch is capable of handling 80 watts of average power. The volt-ampere-μsec product is 1,340, and a switching time of less than 1 μsec has been achieved with a driver having a 1,400 volt-ampere capacity. The switch consists of a two-mode transducer, a ferrite-loaded quadruply ridged circulator waveguide section and a load termination. When the switch is ON the linearly polarized TE_{10} wave at the input port is rotated 45 degrees ccw by the ferrite. Since the load (at the right-hand end) is cross-polarized to the electric field, the signal is reflected through the ferrite section and rotated an additional 45 degrees ccw. The electric field is now in the proper orientation and the signal couples to the output port; this port is at the ON position vector. In the OFF position, the sense of rotation is reversed by reversing the magnetic field and the input signal couples into the load (as shown by broken-line vector). The three-port circulator used has several advantages over other three-port geometries. One is that the magnetizing field to be switched is relatively small. A second advantage is that the low cut-off frequency of the ridged waveguide decreases the change in Faraday rotation due to frequency in the band of interest from 50 to 5 degrees. A third is that the deviation in rotation angle from 45 degrees with frequency has a second-order effect on the isolation for the off position. Furthermore, the ferrite is operated at saturation to minimize hysteresis and to reduce overshoot and ringing in the current waveform. The quadruply ridged waveguide provides a good heat sink for cooling the ferrite.

The narrow-band switch shown in Fig. 3B, is based on the turnstile circulator described by Allen.[9] It consists of two crossed rectangular waveguides with a 45-degree Faraday-rotator ferrite in a shorted circular waveguide section orthogonal to the broad wall of the rectangular guides. With a signal into port 1 and with the remaining three ports of the turnstile terminated, one-half of the power is transmitted in the circular waveguide and the other half divides equally between ports 2 and 4. By adjusting the position of the short circuit in the circular arm, the signal reflected into port 2 can be phased so that it reinforces the di-

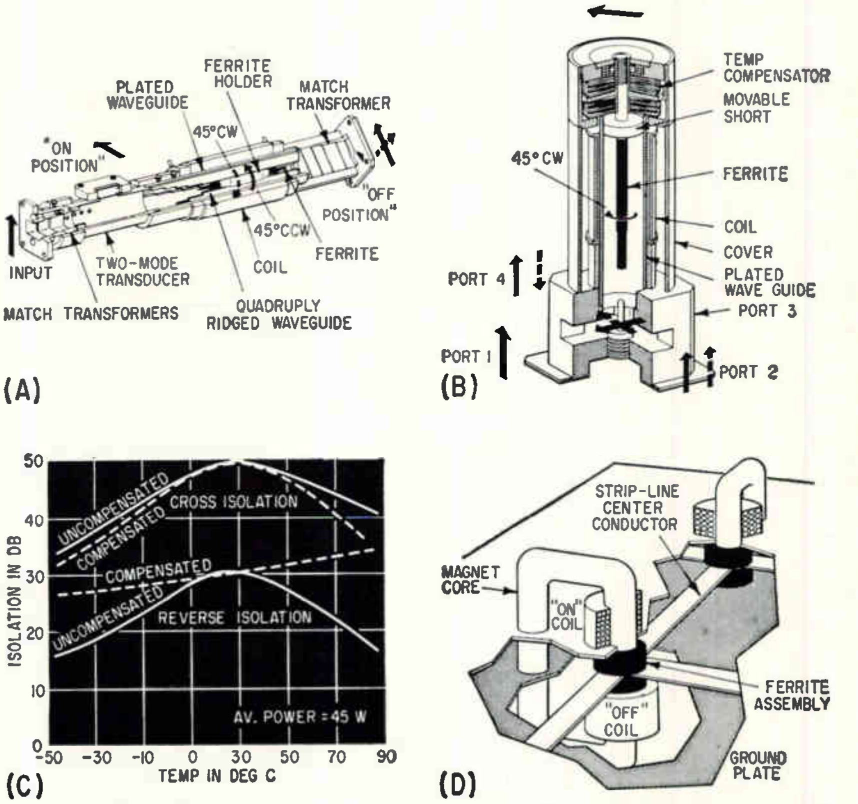


FIG. 3—The X-band switch in (A) is broad band; X-band turnstile switch in (B) is narrow band. Performance of turnstile switch is shown in (C). Strip line switches of (D) are part of a switching matrix

rect signal from port 1 to 2 while the signals in port 4 cancel. Thus, the circulator's direction of circulation can be reversed by reversing the magnetic field applied to the Faraday rotator.

Since the switch depends on the cancellation of two signals that travel over different path lengths, it is inherently a narrow-band device. However, it can have high reverse and cross isolations and the orientation of the terminals permits a symmetrical arrangement of the waveguide lines, thus simplifying the mechanical construction of the system. A turnstile switch for X-band frequencies has a 10-Mc bandwidth with 20-db reverse isolation (isolation between adjacent ports), better than 35-db cross isolation (isolation between opposite ports) and less than 0.5-db insertion loss. The power-handling capability is 65-Kw peak and 40-w average over temperatures from −40 C to 85 C.

The relative electrical length of the ferrite-loaded section is a function of the temperature. For a 100 C change in temperature the change in relative phase shift is approximately 16 degrees. A temperature compensator moves the shorting plate and thus maintains cancellation of the two signals as required at the waveguide junction. Movement of the short over the temperature range −40 C to 85 C is 0.156 inch. As shown in Fig. 3C, the adjacent isolation can be as low as 16 db without temperature compensation over −45 C to +85 C. With temperature compensation, the minimum adjacent isolation over the same temperature range is 26 db. The volt-ampere-μsec product for this switch is 3,000 and a switching speed of less than 200 μsec has been achieved for a driver having a 150 v-a capability. Although the response of 200 μsec is slow compared to the first switch described, it is adequate. It can be driven faster with a suitable driver. The turnstile switch was used to connect a transmitter and a receiver sequentially to either of two antennas.

Sometimes a large number of switching elements are required for a system. Therefore, the switch should have minimum size, low fabrication costs, small switching power and low insertion loss. The transmission line to be used must lend itself to ease of fabrication and provide for simple interconnection of the elements into the optimum network. The Farraday-rotation and the ferrite-loaded tee or wye junction types provide the best combination of small insertion loss and small switching power. The Faraday rotation devices, require the least amount of power, since they operate at lower applied field strengths; however, the ferrite-loaded junction circulator is capable of better isolation over the required band because of the sensitivity of the unmodified Faraday-rotation device to waveguide wavelength. Furthermore, the circular or square waveguide that is necessary for the Faraday-rotation type results in prohibitive fabrication costs for a multielement switching array whereas the junction-type switch can be built in a strip transmission line tee or wye junction that lends itself to low-cost manufacture. The whole network can be fabricated using printed circuit techniques which result in savings in cost, weight, and volume. Geometry of a strip-line tee junction switch is shown in Fig. 3D. The switch is energized by a C-type electromagnet consisting of magnet core and two coils, each of which produces the required applied field strength, but in opposite directions. Transferring current from one coil to the other switches the signal. This simplifies driver design and allows low-cost transistors to be used. A switching matrix of 31 switches and 16 driver units could be packaged in a volume having dimensions 10.5 by 15 by 21 inches. These units would be characterized by a v-a-μsec product of approximately 1,200. Switchtimes less than 20 μsec could be achieved with drivers having a 60 v-a capacity.

Although phase shifters have many applications, this discussion will be restricted to ferrite phase shifters particularly suitable for antenna scanning. Many phase shifters are impractical for scanning because of the large magnetic fields required to obtain the necessary phase shift. In others, the nonreciprocal phase shift obtained results in different transmitting and receiving antenna patterns.

One phase shifter consists of a ferrite rod mounted on the axis of a rectangular waveguide and magnetized longitudinally[10 to 18]. Above a critical rod diameter, large phase shifts with applied magnetic field are obtained. By choice of rod diameter and impedance-matching elements, phase shifts greater than 250 degrees-per-inch at X-band frequencies, together with variations in transmitted power of less than ±0.5 db, have been obtained with external control fields of less than 100 oersteds. The power-handling capability is about 2 Kw peak power and 2 watts average. An S-band version of this phase shifter has 360-deg phase shift with an insertion loss of less than 2 db. The device is approximately 2 feet long. For beam scanning at S-band and below S-band frequencies, this type of phase shifter is large, resulting in enormous antenna arrays. This phase shifter requires a mode of operation that does not give the familiar Faraday rotation of the polarization plane that occurs when a plane-polarized wave propagates through an axially magnetized, ferrite-loaded waveguide. The established mode of operation results in a concentration of the r-f energy in the ferrite rod, producing relatively small field intensities in the remainder of the waveguide cross-section. Because of the energy-concentration effect, this phase shifter should be susceptible to nonlinear behavior at high power levels. Also, the phase shifter is sensitive to frequency and temperature variations. For specific material and rod dimensions, the phase shift varies from approximately 150 degrees at 8,000 Mc to over a thousand degrees at 10,000 Mc. While the phase-shift variations due to temperature are often as large as the variations due to applied magnetic field, temperature sensitivity can be reduced, but not eliminated, by controlling the magnetic field to compensate for temperature changes. To increase the average power-handling capability from about 2 watts to about 250 watts, the ferrite can be placed in contact with the waveguide walls. The frequency and temperature sensitivity of this geometry is less than the axial-rod geometry; however, since the phase shift per unit length, approximately

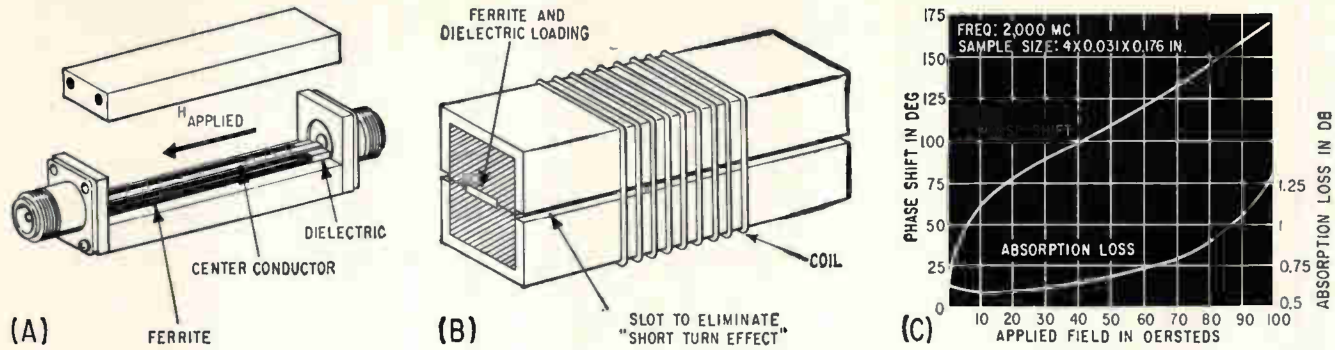


FIG. 4—Strip-transmission-line (A) and rectangular-coaxial-line (B) phase shifters. Performance of strip-line phase shifter is given in (C)

100 to 200 degrees per inch, is also less, longer lengths and larger values of applied magnetic fields are required.

At frequencies below C band, it is practical to use TEM transmission lines. These transmission lines can be compact as in the coaxial or the strip configuration shown in Fig. 4A. They are also nondispersive and are thus inherently broadband; the dependence upon frequency is due mainly to the ferrite material itself.

Figure 4B shows a compact phase shifter that uses a rectangular coaxial transmission line.[19] This line combines the best features of the more conventional circular coaxial line with those of the strip transmission line. The line and the ferrite pieces that load it are easy to fabricate while the closed structure affords better shielding and greater wall surface for the transfer of heat.

Operation of this phase shifter depends upon the change in effective permeability of the ferrite as the degree of magnetization is varied, which in turn results in a change in the refractive index of the material. Thus, this phase shifter is inherently a low-field device, operating at field intensities below saturation. The applied field to obtain 360 degrees of phase shift can be minimized by making the ferrite ratio of length to maximum transverse dimension greater than 15 to 1. Thus demagnetizing fields are minimized.

The amount of phase shift and energy absorption depend mainly upon the relative shape and dimensions of the ferrite and the center conductor. One study has shown how to optimize the cross-sectional geometry of such phase shifters for operation at 3,000 Mc.[19] Resulting designs produced phase shifts of one degree per oersted of applied field per inch of length, and had merit factors greater than 400 degrees per db. Versions of these designs capable of handling 15 kw of peak power have been demonstrated at 3,000 Mc. These versions had linear variations of phase with applied field intensity and required 30 oersteds to produce 360 degrees of phase shift in 12 inches with less than 1-db insertion loss, resulting in a 2 to 1 reduction in length and loss and a 10 to 1 reduction in control power over the rectangular-waveguide phase shifter.

The characteristics of a stripline phase shifter for operations at 2,000 Mc are shown in Fig. 4C. With overall dimensions of approximately 6 inches in length and a cross section of 0.75 inch square, including the coil for supplying the magnetic field, this phase shifter provides approximately 112 deg phase shift and 0.7-db loss for a field variation between zero and approximately 55 oersteds.

The length of the stripline phase shifter can be further reduced by using a slow-wave center conductor to reduce the guide wavelength, thus reducing the physical size to obtain the electrical length. At 400 Mc a stripline phase shifter produces 9 degrees of phase shift per inch of length when a conventional uniform center conductor is used. Substitution of a center conductor periodically loaded with capacitive stubs in the same phase shifter, so as to provide a slow-wave structure (Fig. 5A) results in 38 deg of phase shift per inch. This is equivalent to a reduction of greater than four in the length of the device for a given amount of phase shift. Characteristics at 300 Mc of a transversely magnetized slow-wave type of phase shifter are shown in Fig. 5B. This phase shifter provides 116 deg of phase shift with a max absorption loss of 0.35 db in an overall length of 6 inches.

The design of fast-acting devices such as phase shifters in electronic-scanning applications requires small values of applied magnetic field strength to maintain the amount of control power within reasonable limits. This application usually restricts operation to values of applied field strength less than that required for ferrimagnetic resonance, and usually to values less than that required to saturate the materials. The performance of a phase shifter over a frequency range depends upon the loss exhibited by materials at small values of applied field and upon the dependence of the effective permeability upon applied field strengths as the material is saturated.

The loss in ferrimagnetic materials depend upon both dielectric and magnetic properties. At frequencies above 100 Mc, dielectric loss is constant with frequency and can usually be reduced to an acceptable level by preparation of the material. The magnetic loss has a complex dependence upon material, frequency, applied magnetic field strength and the r-f field intensity.

A typical curve of the imaginary part of the initial permeability is shown in Fig. 5C for a nickel-ferrite aluminate.[20] Two loss peaks are evident in this curve. They represent the two magnetic loss mechanisms which are predominant at small values of applied field strength compared to those required for ferrimagnetic resonance. The lower frequency peak is due to a resonance associated with the displacement of the domain walls under the influence of the applied field and is usually important at frequencies below 1,000 Mc. The frequency at which this resonance occurs is proportional to the saturation magnetization of the material and varies inversely as the initial permeability exhibited by the material at low frequencies. The higher frequency peak is due to the Larmor resonance of the magnetic spins within the domains of the material in the presence of the effective anisotropy field. This loss peak usually extends in frequency from

$$f_1 = \frac{\gamma H_a}{2\pi} \text{ to } f_2 = \frac{\gamma}{2\pi}(H_a + 4\pi M_s)$$

where H_a and M_s are the effective anisotropy field and saturation magnetization, respectively. Center of this peak usually represents the lower frequency limit at which devices based on gyromagnetic resonance can be realized with a material.

Two regions exist for low-loss operation at small values of applied field strength. One is the region above f_2, where permeability of the material is due mainly to gyromagnetic effects. For most materials, the lower limit of this low-loss region is mainly controlled by the saturation magnetization. This limit can be lowered by using materials having a lower moment. However, ferrimagnetic materials that have a low moment also have a Curie temperature that is too low for most applications. To date, no material appears to be available that provides a value of f_2 less than 1,300 Mc and a Curie temperature greater than 150 C. Thus, at present, this region of low-loss operation includes all frequencies above 1,300 Mc. The other low-loss region on Fig. 5C is below 60 Mc.

Because a lower value of magnetization is required for operation at lower frequencies, the phase shift per wavelength that can be achieved by a phase shifter decreases with frequency in this higher-frequency region. Thus, the size of a phase shifter for a given value of phase shift increases rapidly as the design frequency becomes smaller. Phase shift and absorption obtained with a stripline phase shifter at 2,000 Mc, utilizing a material having a value of f_2 = 1,900 Mc and operating at the high frequency region of low-loss operation is shown in Fig. 4C. Phase shift is 28 deg per inch of ferrite material. The maximum value of applied field that may be used is limited by the ferrimagnetic resonance absorption characteristic of this region.

The second region of low-loss operation is that below the wall displacement resonance.

The phase shift and absorption obtained for a stripline phase shifter at 300 Mc with a material operating in the low-frequency region of low-loss operation is shown in Fig. 5D. The geometry is similar to the 2,000 Mc phase shifter discussed above. It is seen that 20 degrees of phase shift per inch can be obtained. The phase shift per unit length obtained at 300 Mc is approximately two-thirds that obtained at 2,000 Mc, even though the free-space wavelength is more than six times greater. This phase shift is a result of the larger values of initial permeability that are characteristic of the lower frequency region. In the range of interest there is no resonance absorption to limit the maximum value of applied field.

The work on the phase shifters described in this paper was supported in part by the Air Force Cambridge Research Laboratory, Contract No. AF 19 (604)-6171.

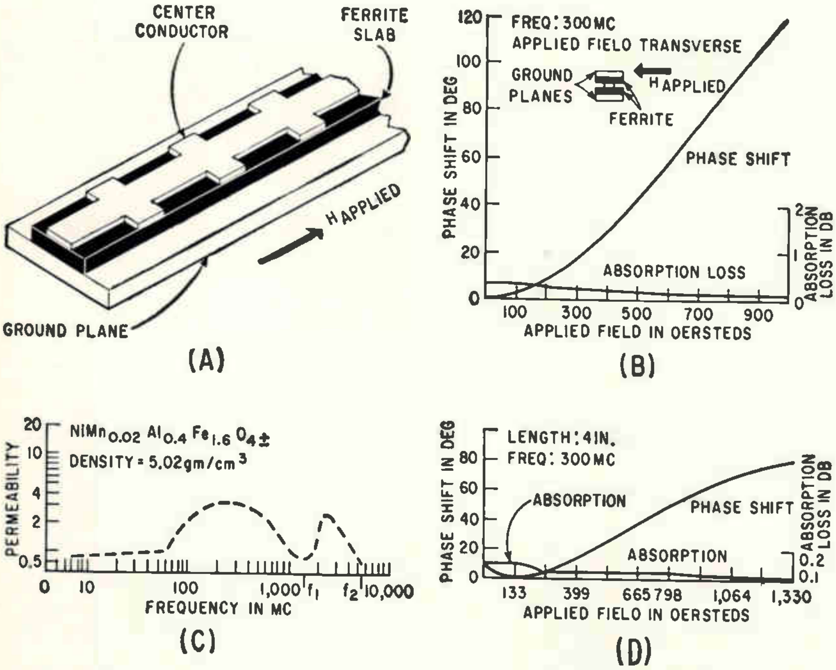
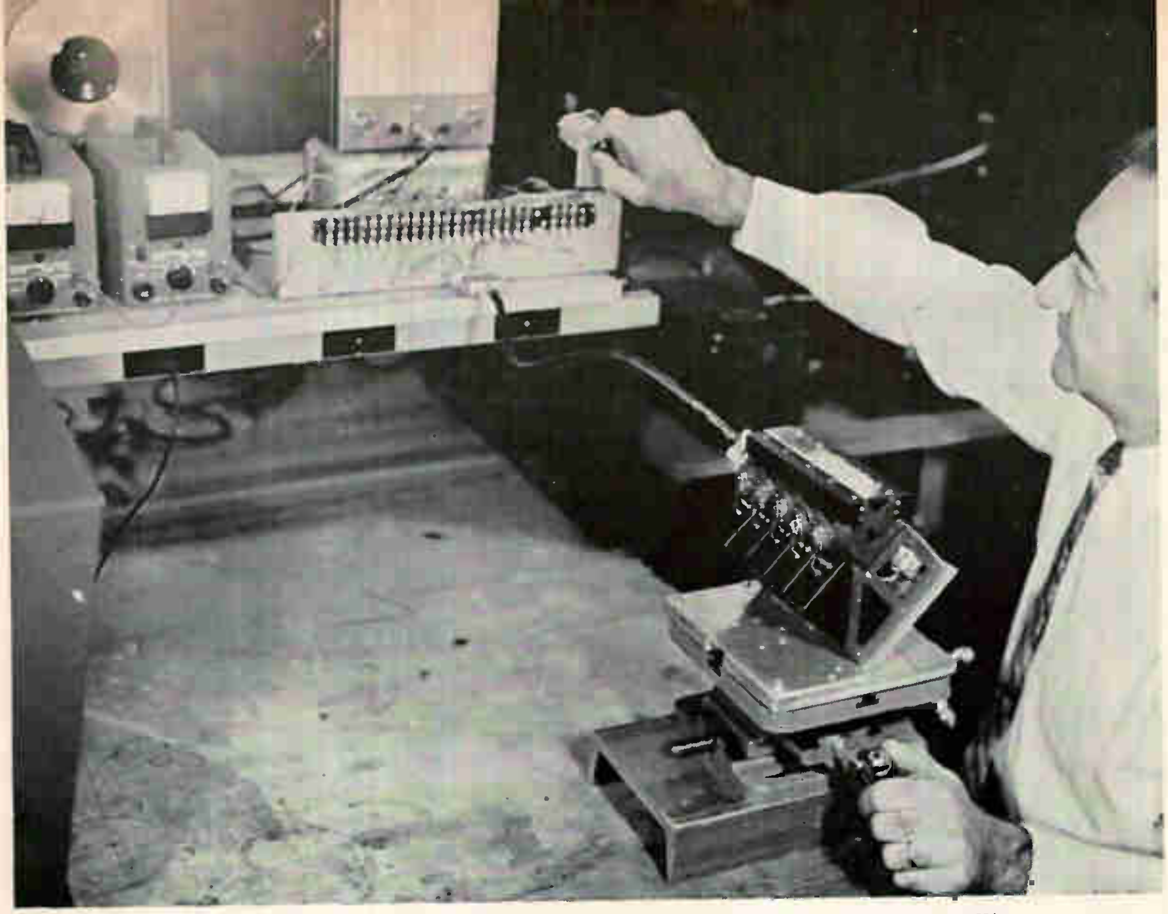


FIG. 5—Phase shifter in (A) has longitudinal magnetization; phase shifter in (B) has transverse magnetization. Chart in (C) plots permeability of a ferrite, and (D) gives performance of stripline phase shifter

REFERENCES

1. H. Seidel, Compact Passive Nonreciprocal Structures for UHF Frequencies, *J Appl Phys*, **30**, No. 9, p 1,565, April 1959.
2. J. H. Carlin, Principles of Gyrator Networks, Proc. Symposium on Mod. Adv. in Microwave Techniques, Polytechnic Inst. of Brooklyn, p 175-204, Nov. 1954.
3. G. S. Heller, Ferrites as Microwave Circuit Elements, *Proc. IRE*, **44**, p 1,386-1,393, Oct. 1956.
4. J. B. Thaxter and G. S. Heller, Circulators at 70 and 140 kmc, *Proc IRE*, **48**, p 110, Jan. 1960.
5. T. Schaug-Pettersen, Norwegian Electronic Research, ONR Technical Report (BR) ONRL-111-57, Sept. 1957.
6. H. N. Chait and T. R. Curry, Y-Circulator, *J Appl Phys*, **30**, p 1,525-1,535, April, 1959.
7. L. Davis, Jr., U. Milano and J. Saunders, A Strip-Line L-Band Circulator, *Proc IRE*, **48**, p 115-116, Jan. 1960.
8. D. E. Allen and N. G. Sakiotis, A Broadband, Fast-Acting Ferrite Switch, Solid State Circuits Conference, Feb. 11, 1960.
9. P. J. Allen, Turnstile Circulator, *Trans IRE*, **MTT-4**, p 223, Oct. 1956.
10. D. Bush, Discussion on Microwave Apparatus, *Proc IEE*, **104B**, p 368-369, Nov. 1956.
11. F. Reggia and E. G. Spencer, A New Technique in Ferrite Phase Shifting for Beam Scanning of Microwave Antennas, *Proc IRE*, **45**, p 1,510-1,517, Nov. 1957.
12. J. E. Tompkins, Energy Distribution and Field Configuration in Ferrites, Diamond Ordnance Fuze Laboratories, Washington, D. C., Tech. Rep. No. 634, June, 1958.
13. A. Clavin, Reciprocal Ferrite Phase Shifters in Rectangular Waveguide, *Trans. IRE*, **MTT-6**, p 334, July 1958.
14. P. A. Rizzi and B. Gatlin, Rectangular Guide Ferrite Phase Shifters Employing Longitudinal Magnetic Fields, *Proc IRE*, **47**, p 446-447, March 1959.
15. J. A. Weiss, The Reggia-Spencer Microwave Phase Shifter, *J Appl Phys*, **30**, p 153S-154S, April 1959.
16. J. A. Weiss, A Phenomological Theory of the Reggia-Spencer Phase Shifter, *Proc IRE*, **47**, p 1,130-1,137, June 1959.
17. A. Clavin, Reciprocal Ferrite Phase Shifters, *Trans. IRE*, **MTT-8**, p 254-255, March 1960.
18. A. Clavin, Problems Associated with Rectangular Waveguide Phase Shifters, National PGMTT Meeting, San Diego, May 1960.
19. H. N. Chait, F. Fine, N. G. Sakiotis and C. Banks, S-Band Ferrite Material and Phase Shifter Study, NRL Memorandum Report 951, July 1959.
20. J. E. Pippin and C. L. Hogan, Initial Permeability Spectrum in Ferrites and Garnets, SCI Report No. 1, AF19-1804, Gordon McKay Lab. of Applied Science, Harvard Univ., April 1959.



Calibrating 5-channel radiometer of the type used in Tiros II, the meteorological satellite

Infrared Circuits in Tiros Satellites

PART I—This part of a two-part article deals with a 5-channel radiometer that measures parameters dealing with earth's heat balance. Future article will deal with transient-type horizon sensor

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NASA's TIROS II, the meteorological satellite, carried into orbit three infrared instruments: a 5-channel meteorological radiometer to measure some parameters of the earth's heat balance, a transient type horizon sensor to furnish information on the satellite's attitude and spin rate and a wide-angle d-c radiometer to measure total solar radiation reflected and long-wave radiation emitted from a broad area of the earth. This article deals with the 5-channel meteorological radiometer. A future article will cover circuits useful for the transient type horizon sensor and will discuss in a more general way the characteristics of low-noise transistor circuits.

Tiros II completed about 2,200 orbits before it was disabled; this represents over five months of continuous operation. In this time millions of bits of information representing temperature of cloud cover, emission and reflection of energy from the earth's atmosphere, and other similar properties were supplied.[1, 2]

Design requirements for the radiometer proper included optical and mechanical, as well as electronic problems. It was necessary to design the electronic circuits for low power consumption, for compactness and low weight, and for the ability to withstand the temperature environment of −10 C to 50 C

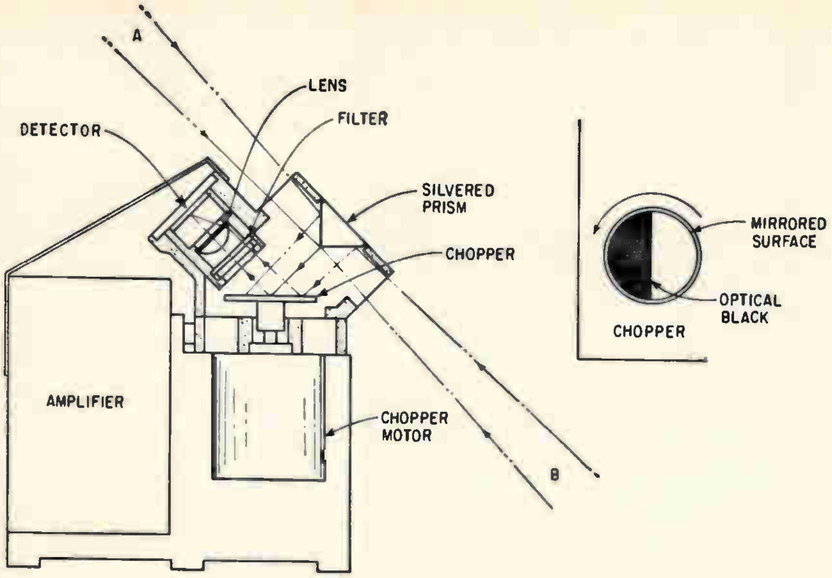


FIG. 1—Optical chopper is half blackened and half aluminized

and shock and vibration expected during launch.

The radiometer (Fig. 1) contains optical choppers consisting of half blackened and half aluminized rotating disk which allow each thermistor detector to view a prism and alternately receive energy from regions 180 deg apart. As the satellite spins about its own axis (approximately 10 rpm), it at times allows the thermistor detector to be irradiated with energy from the earth and its atmosphere. At 180 degrees from this position the detector sees a space background that is virtually 0 K and that constitutes the reference level. The thermistor detector's function is to convert the energy differences thus received into electrical signals that can then be amplified.

The chopper frequency (46 cps) becomes a carrier of amplitude modulation. This modulation represents differences in radiance that can be interpreted in terms of temperature of clouds, solar reflections and other measured parameters depending on the wavelength transmission of optical filters associated with each of the five thermistor detectors. The double chopping that occurs due to the action of the mirror chopper and spin of the satellite, as well as the need for a high signal-to-noise ratio, dictates use of a narrow-band and fairly sharply tuned amplifier. Output of the a-c amplifier is rectified by a diode bridge to give a push-pull d-c output to a voltage-controlled oscillator whose output is recorded on magnetic tape. Other requirements included: an input impedance of about 0.25 megohms for matching and thermal compensation of the detector; low power consumption, small size, and gains ranging in value from about 7,000 to one million for the various radiometer channels.

A bandpass requirement of ±8 cps at the carrier frequency of 46 cps was met by using a parallel-T filter in an amplifier feedback loop. Such a filter should be terminated in a high impedance. A differential input amplifier gives precisely the characteristics desired. In addition to its good d-c stability and common-mode rejection, the differential amplifier provides high input impedance both for the detector and the feedback connection.

Figure 2 shows how the parallel-T filter provides both the desired frequency characteristic and a d-c path for negative feedback around the four-stage direct-coupled amplifier. The d-c feedback stabilizes the operating point of the base and emitter of Q_2 as well as the succeeding stages. The Q of the parallel-T network is deliberately lowered by resistor R_1 to broaden the response around the chop frequency. Additional attenuation of low frequencies is provided by the combination of C_1 and R_2. A second high-frequency break results from the local feedback loop capacitor C_2.

Figure 3A shows how the differential amplifier is used as a part of the four stage direct-coupled front end of the circuit. Figure 3B is an equivalent circuit of the differential transistor amplifier by itself.

Letting $R_1 = R_g + r_{b1}$ and $R_2 = R_g + r_{b2}$, the loop equations are

$$e_1 = i_{e1} r_{e1} + i_{et} R_e + i_{b1} R_1 \quad (1)$$

$$e_2 = i_{e2} r_{e2} + i_{et} R_e + i_{b2} R_2 \quad (2)$$

$$i_{et} = i_{e1} + i_{e2} \quad (3)$$

$$i_{e1} = (\beta + 1)\, i_{b1} \text{ and } i_{e2} = (\beta + 1) i_{b2} \quad (4)$$

Since R_1 is assumed $= R_2$ and $r_c >> R_L$, there is a symmetrical circuit, and for equal source impedances R_g, $i_{e1} = i_{e2}$. Therefore,

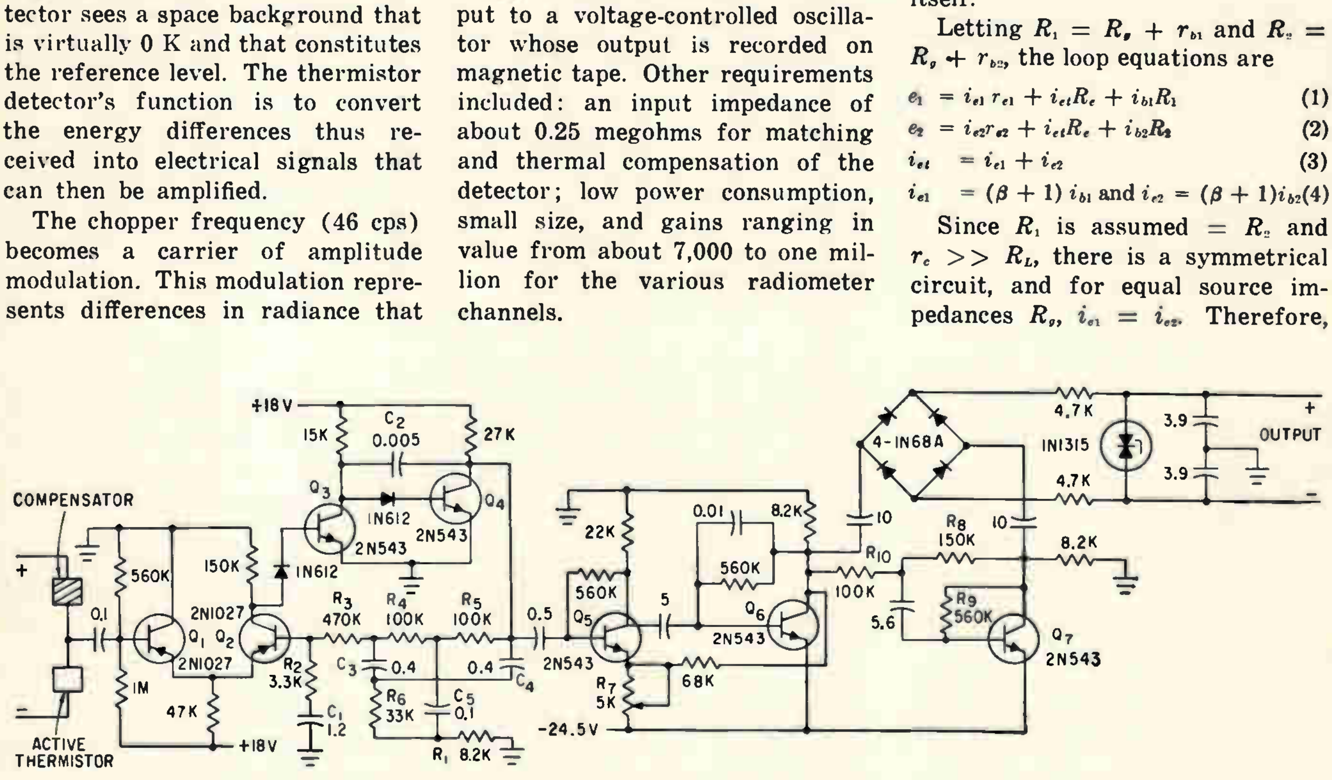


FIG. 2—Tiros II amplifier uses parallel-T filter in feedback loop

from Eq. 1 and 2, $e_1 - e_2 = (i_{b1} - i_{b2})\ R_1 = i_{b1}R_1 - i_{b2}R_1$.

In this case, $r_e \cong 100$ and $R_e = 50{,}000$, $\therefore R_e >> r_e$. Also, $\beta \cong 50$. If there were no feedback, then $e_2 = 0$ and $e_1 = R_1(i_{b1} - i_{b2})$ where i_{b2} is negative. Now, output voltage

$$e_0 = R_L i_{c2} \cong \beta R_L i_{b2}$$

$$\frac{e_0}{e_1} = \frac{\beta R_L\, i_{b2}}{2R_1\, i_{b1}} = \frac{\beta R_L}{2\ R_1} \text{ for } i_{b1} = i_{b2}$$

for $R_L = 150{,}000$ and $R_1 = 50{,}000$,

$$\frac{e_0}{e_1} = \frac{150{,}000}{2 \times 50{,}000} \times 50 = 75$$

This would be the open-loop voltage gain of the differential amplifier without loading by the succeeding stages. However, with gains of similar order of magnitude in each of the two following stages, a total open loop gain of over 100,000 would result. When the negative feedback loop is closed, the gain should be a function of the feedback factor. In the usual case, the feedback network is a resistive voltage divider and is simple to calculate. In this circuit the parallel-T network, except for R_1 of Fig. 2 which lowers the Q of the circuit, would look like a short-circuit path at the notch frequency. Components for the parallel-T are chosen using the equation in Fig. 3C.

Figure 4 shows the frequency response of the amplifier. Voltage gain at 46 cps, where the series path of the parallel T is a virtual short circuit, is determined by the product of the two frequency-dependent impedance dividers of the feedback network and is approximately 1,500. (In Fig. 2 these dividers are R_2 and R_3 in series with C_1 and the parallel T network consisting of R_1, R_4, R_5, R_6, C_3, C_4 and C_5.)

The succeeding stages, shown in Fig. 2, are more conventional. Transistors Q_5 and Q_6 are cascaded common-emitter stages with negative feedback from collector of Q_6 to the emitter of Q_5. Potentiometer R_7 in the feedback path controls the voltage gain of this pair. In addition to voltage stabilization, the feedback decreases output impedance and increases input impedance for this pair.

The last stage, Q_7, is a unity-gain phase inverter with both d-c and a-c feedback. Gain of this stage is the ratio of the parallel combination of R_8 and R_9 to the series re-

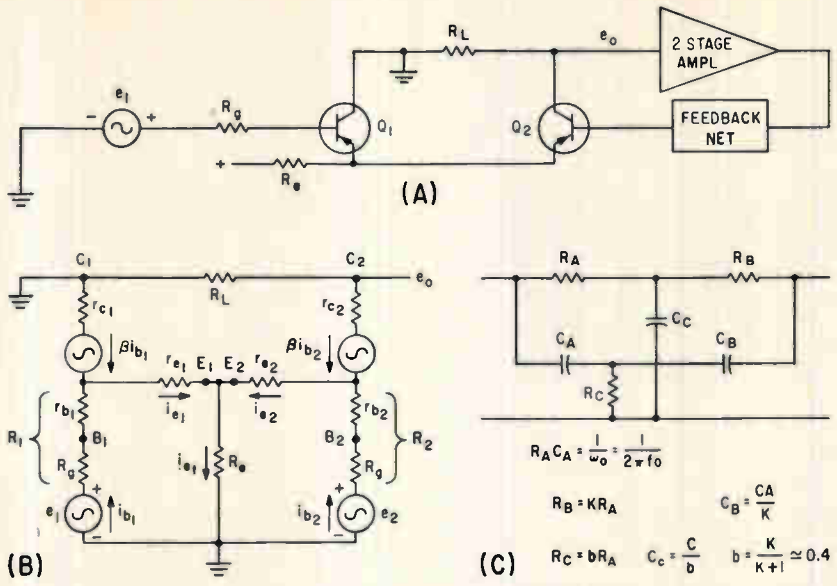


FIG. 3—Use of differential amplifier (A) and its equivalent circuit (B). Components for parallel-T fit relationship shown in (C)

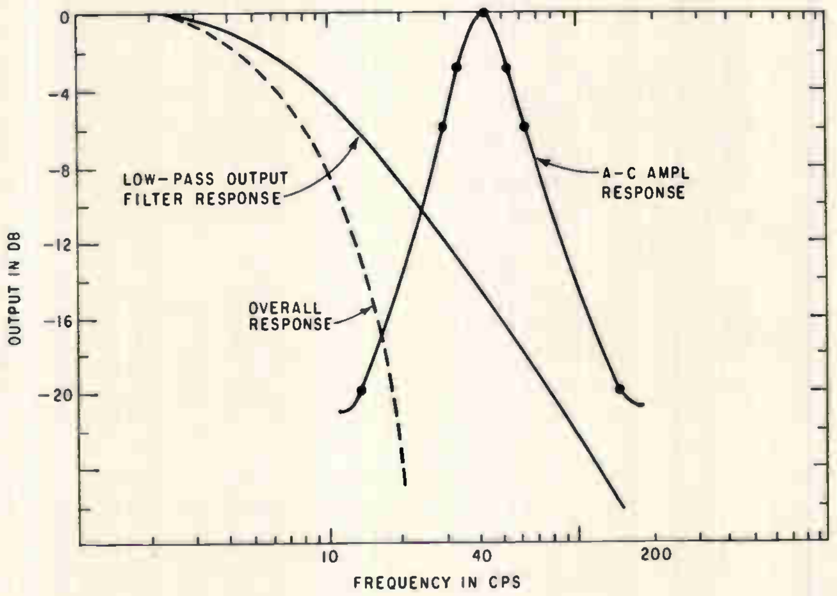


FIG. 4—Frequency response of amplifier

sistor R_{10} giving $A \cong R_8R_9/R_{10}(R_8 + R_9)$. This gain is adjusted to unity.

To protect the voltage-controlled oscillator from over-voltage the Zener diode at the output limits the d-c output to 12 volts.

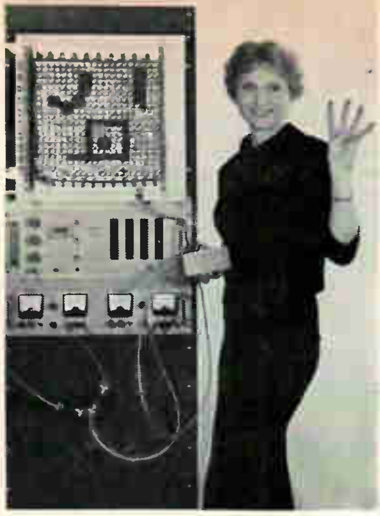
The characteristics of the amplifier are: gain Q_1 thru $Q_4 = 1{,}500$ at 46 cps; max. voltage gain to d-c output $\cong 0.3 \times 10^6$; frequency response 3-db points 38 cps and 54 cps; $Z_{in} = 250{,}000$ ohms; max output $= \pm 6$ v d-c into 27,000 ohm load with less than 10 percent ripple; power requirements -24 v at 5 ma, 18 v at 1 ma. for approximately 120 mw; size $= 3$ in. $\times$ 2 in. $\times$ 1 in.; and weight $= 170$ gm.

A sandwich of two printed-circuit boards was used for packaging and the amplifier was potted with Lockfoam.

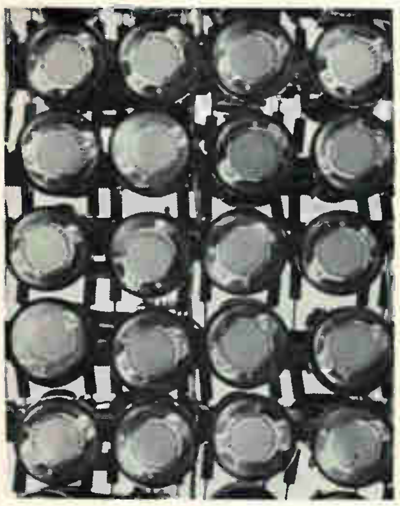
The instrument described here was built under contract with the Aeronomy and Meteorology Division of NASA's Goddard Space Flight Center. The support provided by NASA's R. Hanel and his associates is gratefully acknowledged.

REFERENCES

(1.) R. H. Hanel and W. G. Stroud, *Jour. of SMPTE*, 69, Jan., 1960.
(2.) R. W. Astheimer, R. DeWaard and E. A. Jackson, Infrared Radiometric Instruments on Tiros II. Paper delivered at Optical Society Meeting, Pittsburgh, Mar. 3, 1961.



Four objects on the photocell retina—one inside the loop of another—produce a readout of 4 on the counter



Closeup of photocell retina

PHOTOCELL FIELD

Objects placed on photocell field are counted quickly with

By PAUL WESTON,
University of Illinois, Urbana, Ill.

THE NUMA-RETE is a device that counts randomly arranged objects of various shapes and sizes. Two versions, one with 144 cells and one with 400 cells have been built. The 400-cell unit easily outperforms humans in counting irregularly arranged objects. Specifically, it will count a group of as many as 40 objects in 0.2 second. Further, the numa-rete is not confused by intricate shapes or by objects appearing within holes in other objects. The only requirement for accurate counting is a separation of at least one cell between all objects on its photo-cell layer.

The numa-rete uses a network that recognizes the presence of individual objects and develops a memory trace for each object. The retina is a square array of photo resistors, each connected to a unit lying beneath it in the computing layer. The computing layer is an array of active elements connected as shown in Fig. 1A.

Each active element is a transistor whose base is d-c connected to a resistance summing network; the summing network yields the relative input current values shown. In addition, a constant bias current holds the unit in saturation in the absence of inputs. If the total current at the base is greater than the threshold value of plus ½, the bias is overcome, the transistor cuts off and a current of plus 1 is transmitted to each of its four neighbors. If it happens that this current is able to cut off one or more of the neighboring units then the returning plus 1 currents complete positive feed-back loops. The group of units will hold each other cut off indefinitely, even if the original input is removed. Figure 1A shows that this can only be achieved if none of the units is receiving current from its photocell, since the minus 5 value from the photocell balances the maximum plus 5 from neighbor units.

This positive feedback is the basis of the memory trace. If an object shields some cells, photocell current is cut off and its active element has zero input; an input from the interrogation scanner drives those units under shadow to above the threshold of plus ½ and the resulting chain reaction causes all the units with darkened photocells to cut off. The action is limited by the boundaries of this particular shadow since all the units just outside it, in the light, are strongly biased by photocell current. Further, the block of cutoff units will maintain itself until the network is cleared. Further inputs to units under the same shadow will give no more responses from the network. The formation of only one such trace at a time is ensured

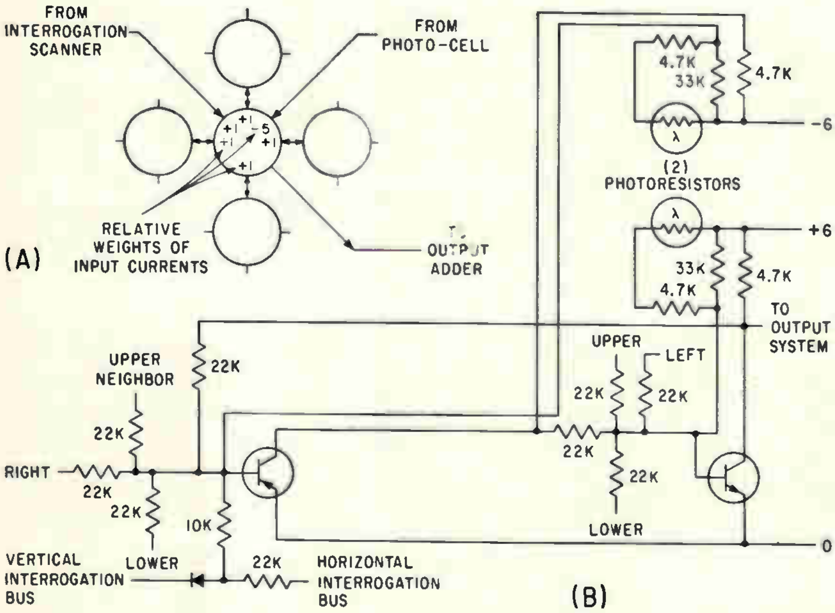


FIG. 1—Typical active element (A) receives a current of relative magnitude minus 5 from its photocell. Inputs from other sources must exceed relative magnitude of plus ½ for the element to register. Active element interconnections (B)

COUNTS RANDOM OBJECTS

electronic circuits. Counter can handle closed loops and other intricate shapes

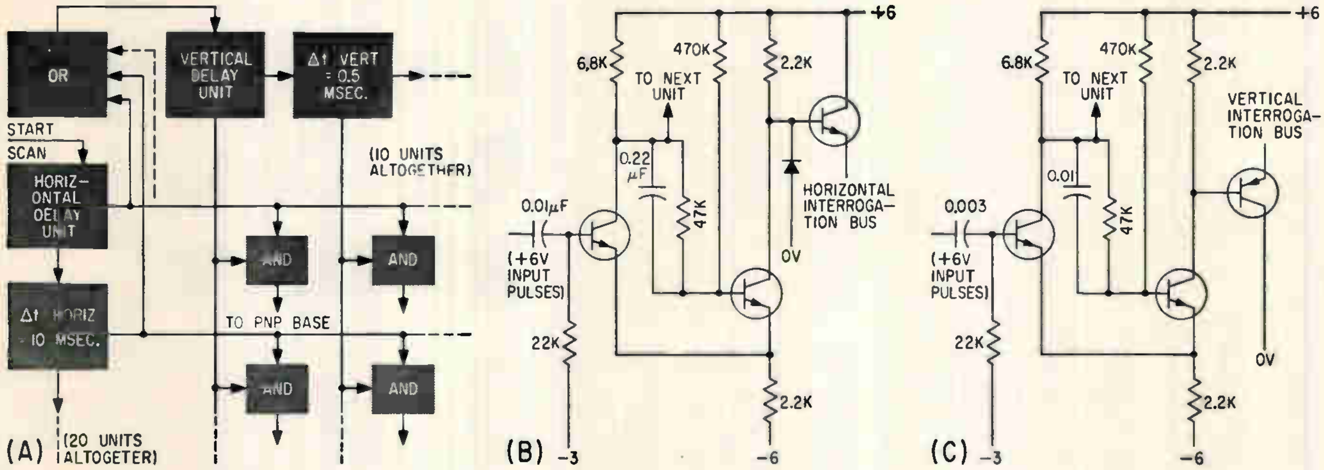


FIG. 2—Logic of photocell object counter (A). Delay circuits of interrogation logic (B) and (C)

by supplying interrogation pulses to only one unit at a time.

Figure 1B is a complete schematic of a typical pair of units. The over-all arrangement is a checkerboard array of npn and pnp elements. Fixed bias is provided by 33,000-ohm resistors returned to the collector supplies. When lit by normal room light, photocell resistance drops well below the 4,700-ohm value of its external series resistor and maximum forward bias results. If the cell is under a shadow its resistance rises to more than 100,000 ohms, and it contributes no effective bias current. The base of each unit is connected to the collectors of its four neighbors through 22,000-ohm resistors. No bias current flows in these if the neighbors are in the saturated state, but if one of them is cut off a drop of 4 volts is impressed on the resistor leading to that collector. The resulting current is strong enough to overcome the fixed bias and the unit cuts off, provided it is receiving no photocell current.

Figure 2A is a block diagram of the interrogation system; Figs. 2B and 2C show the delay unit circuits, which are monostable triggers. When each circuit returns to its stable state it triggers the following unit. In addition, when any of the horizontal units is triggered, it in turn triggers the first vertical unit.

Output is obtained as shown in Fig. 3. A summing network is attached to the 20 npn collectors in two adjacent rows of units, and the time derivative of the sum is fed to an amplifier. This is done for all ten pairs of rows. When one or more npn units are cut off a positive spike appears on at least one amplifier input.

The summing and mixing arrangement was chosen to avoid the harmful effect of small feed-through pulses from the scanning system, which appear at the npn collectors under some conditions. After two neighboring units are cut off, a vertical interrogation pulse will cause a slight positive shift in potential at the pnp base and thus also at the neighboring npn collector. Summing over horizontal rows minimizes the amplitude of these pulses relative to the desired outputs.

M. Knott, G. Goodall and G. Gunsalus assisted in the construction of the two versions of the Numa-Rete. The work was sponsored by the office of Naval Research, Contract Nonr. 1834(21).

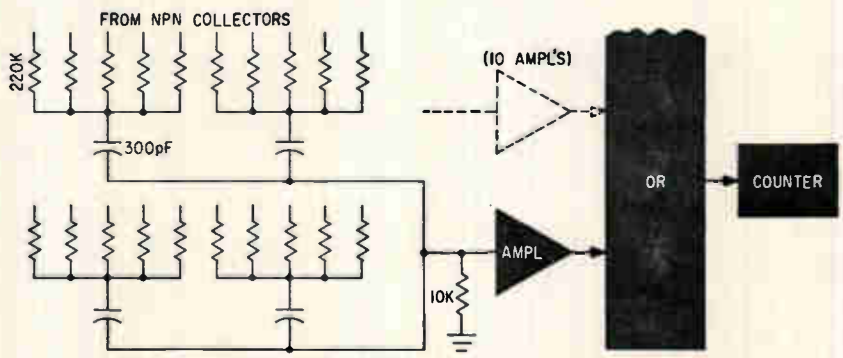


FIG. 3—Summing network feeds OR circuit to generate output pulses, which are then counted

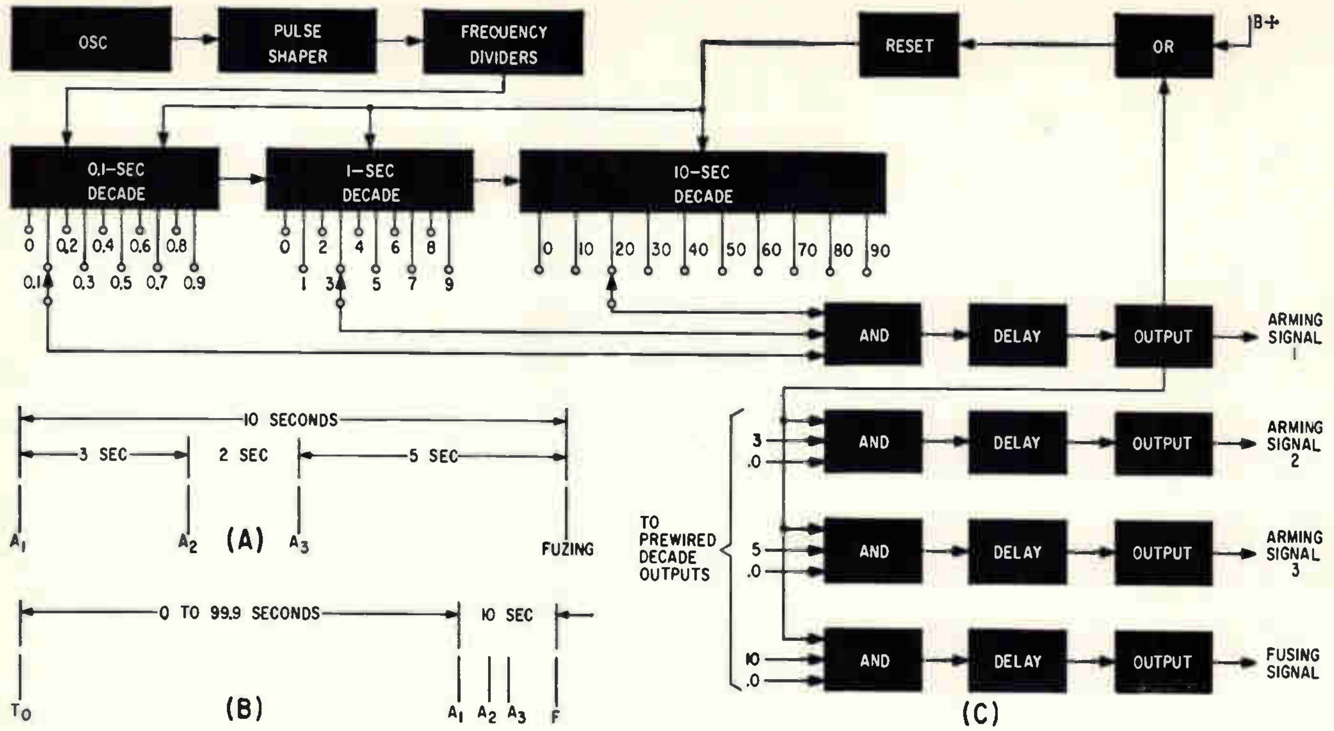


FIG. 1—Relationships of arming and fuzing time functions (A) and of application of power T_0 to timing functions (B); block diagram of timing programmer (C)

Rugged Arming-Fuzing Timer

Electronic timer gives a high current pulse at end of adjustable period.

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START with the high velocities encountered in modern atomic artillery missiles, add the extreme environmental conditions to which they are subjected, and then consider the safety, reliability and accuracy requirements encountered during handling, launching and travel to the intended target. This begins to convey the degree of importance attached to the "black box" used to control the critical functions of sequential arming and detonation of these weapons.

With these and many other factors to consider, the Army's Tactical Atomic Warhead Laboratory at Picatinny Arsenal conducted a study of arming and fuzing devices.

Most arming and fuzing devices presently in use contain mechanical subassemblies that, although reasonably adequate in terms of safety and reliability, have accuracy limitations when exposed to extreme ambient temperatures. Unless special heating units are incorporated, the devices tend to run slow as the ambient temperature drops below −40 F.

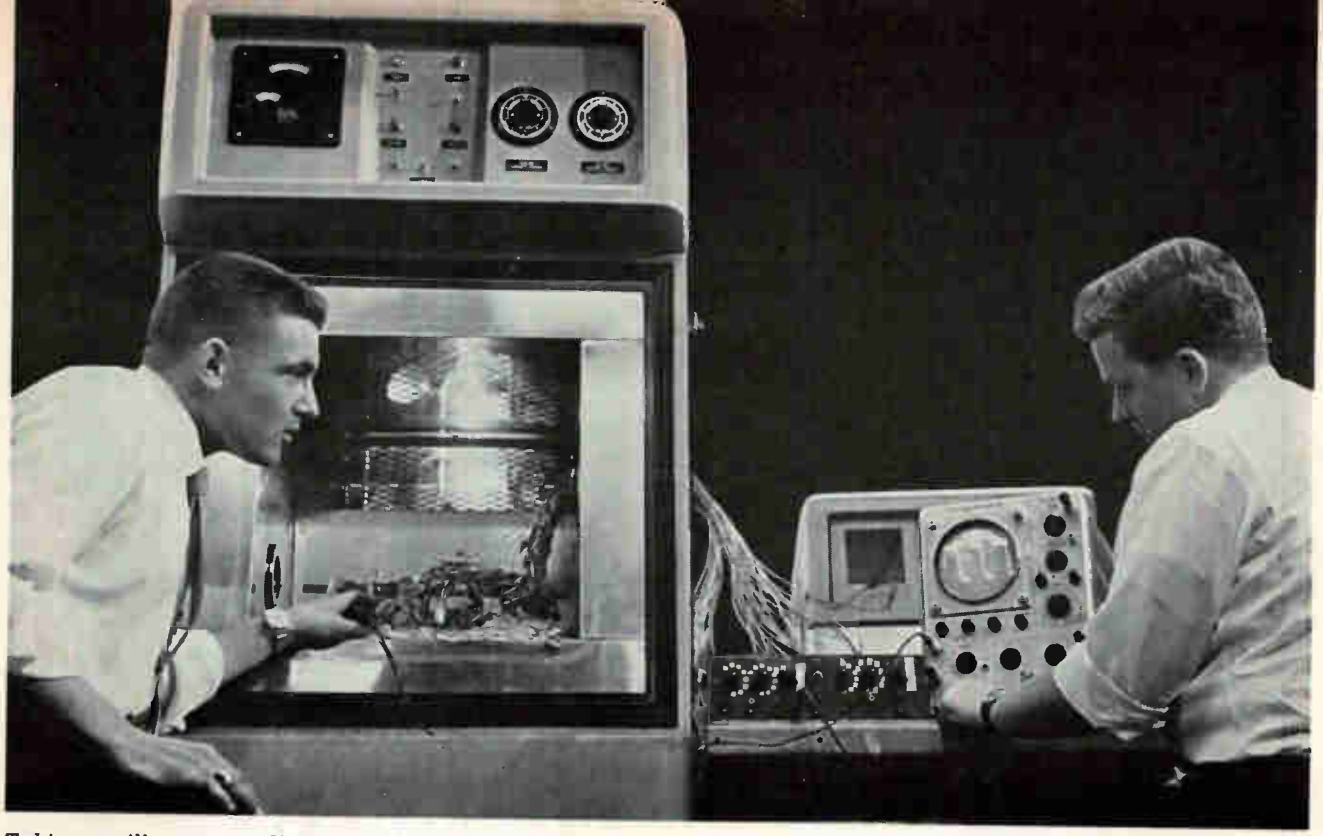
Realizing the limitations in present systems, the laboratory at Picatinny turned its attention to the feasibility of an electronic unit. A contract was awarded for the study and development of a solid-state programmer that would be both rugged and accurate under all environmental conditions.

The requirements were to develop a programmer that would provide four sequential arming and fuzing outputs, each maintaining a fixed time relationship (Fig. 1A). These functions were to occur after a time delay that was to be externally adjustable over a range of 0 to 99.9 seconds in increments of 0.1 second (Fig. 1B).

The programmer error was to be no greater than 0.1 second in 100 seconds. This accuracy was to be maintained over a temperature range of −65 F to +165 F; during 100 G shock and acceleration, and while being vibrated at 50 G to 2,000 cps.

Due to the stringent accuracy requirements and the extreme range of adjustment specified, an arming and fuzing programmer that employed digital techniques was developed.

The approach involved generating an accurate time base, counting the generated pulses, and sensing the preset time with AND gates. This technique enabled the retention of the basic clock accuracy throughout the timing range. Block diagram of the programmer is shown in Fig. 1C. The clock consists of the oscillator and pulse shaper. The clock, with the frequency dividers, forms the time-



Taking oscilloscope readings of printed-circuit disks in oven. Author is at left

For Atomic Artillery Missile

Accuracy is 0.1 second in 100 seconds. Packaging method allows high shock and vibration

base generator that provides pulses to the decade counters. The appropriate timing outputs from the decades are selected and coupled, through switches, to the input of the A_1 AND gate. After the passing of the preset time, 23.1 seconds in Fig. 1C, the A_1 AND gate fires, energizing the A_1 output. The decades are then reset to zero and one input on the other three AND gates is enabled. The remaining AND gates are wired directly to the decades to fire at 3.0, 5.0, and 10.0 seconds, respectively, after A_1. The three 10-position switches can be adjusted to select any time between 0 and 99.9 seconds, in increments of 0.1 second. In this manner, four output functions have been controlled by the timing adjustment of only one function.

The clock, which is the major accuracy-determining element, consists of a crystal-controlled oscillator and a pulse-shaping circuit.

A ruggedized crystal was developed to maintain an accuracy greater than the required accuracy of 0.1 percent under the combined conditions of temperature, shock and vibration. This crystal, of necessity a low-mass, high-frequency crystal, defines an oscillator frequency much higher than that required for the time base. The added system complexity, due to the necessity of frequency division, was more than offset by the system accuracy that was obtained.

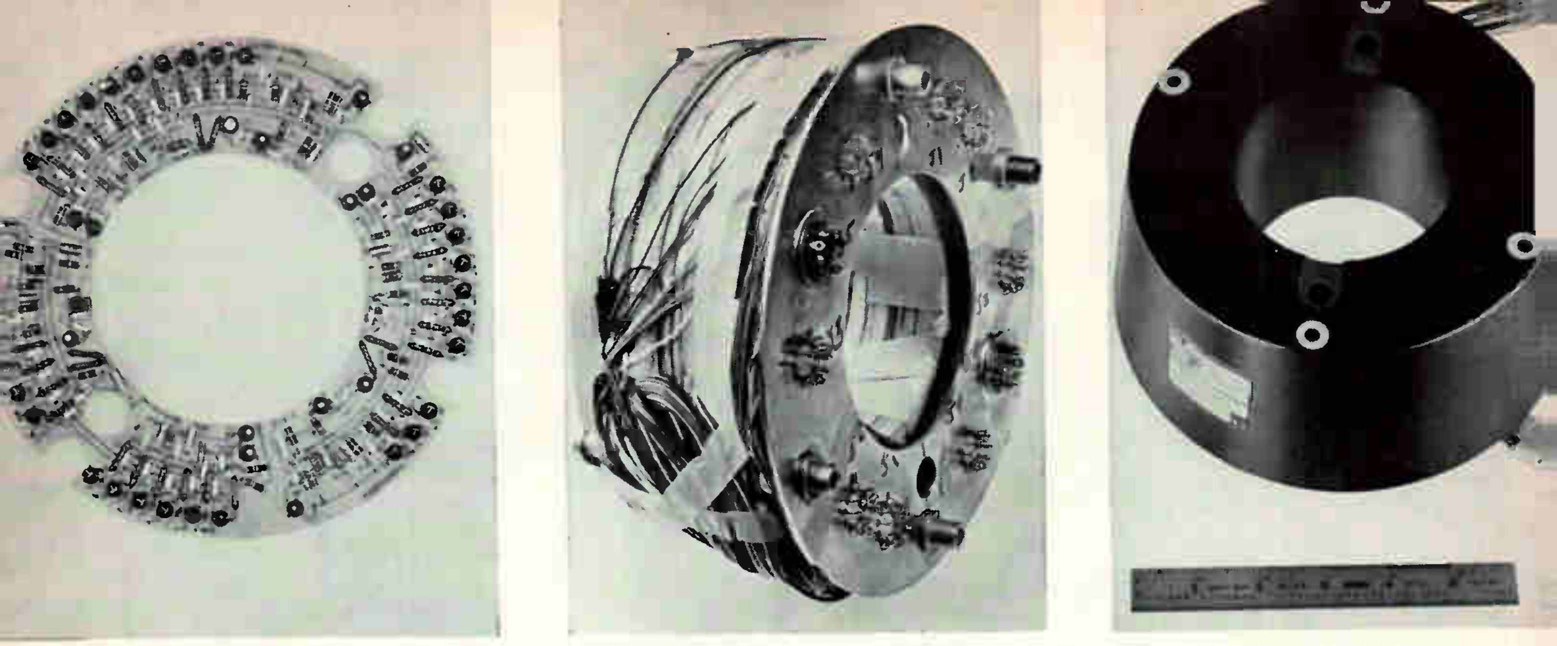
The oscillator output is coupled to a pulse-shaping circuit that modifies the oscillator waveform to provide a compatible signal for the frequency divider.

The schematic of the oscillator and pulse shaper is shown in Fig. 2A. Transistors Q_1 and Q_2 form the oscillator section, and Q_3 and Q_4 operate as the pulse shaper. Transistor Q_1 operates as a grounded-base voltage amplifier with a tuned collector load. Transistor Q_2 matches the impedance of the collector circuit of Q_1 to the crystal. The shaper consists of two grounded-emitter amplifier stages, the second operated as a switch. The output amplitude is limited by Zener diode D_1.

The clock operating frequency is reduced by frequency division to 10 cps, to provide a pulse train compatible with the time delay adjustment increments of 0.1 second.

The frequency division is accomplished by cascading synchronized intervalometers, each free-running at a frequency of one-tenth the frequency of its respective synchronization pulse. The accuracy of the free-running frequency and the level of the synchronization pulse are selected to insure a system accuracy dependent solely on the clock accuracy.

A result of this method of frequency division is that, due to the



The Printed-circuit disk containing three decades ring counters (left) is potted in a rigid polyurethane foam, and bolted together with four other disks. The disks are interconnected and the the leads to be brought out are wired to headers mounted on an inner cover (center). This assembly is mounted in an outer shell (right) and the volume between is filled with silicone rubber

free-running dividers, the programmer will function in the event of a clock failure.

Each divider consists of a standard timing module modified to operate as an intervalometer. The timing module (Fig. 2B) consists of an R-C timing network, resistor biasing network and gate circuit. The time delay is preset for the time required by the gate and circuit constants of the passive networks. Two inputs, timing and biasing, control the gate that drives the load. Upon application of voltage, bias on the gate is immediately established by the voltage dividing action of R_1 and R_2. At the same instant, timing capacitor C starts charging through timing resistor R (Fig. 2C). When the timing voltage across C equals the bias voltage, the gate triggers and a voltage step is applied to the load. The timing capacitor is then discharged by the gate which, in a standard timing module, electronically latches in the ON condition. In this intervalometer application, the latching circuit is removed, allowing the gate to discharge the timing capacitor and then reset to the OFF condition, removing the voltage step from the load. The timing capacitor then initiates a new timing cycle. Charging and discharging of the timing capacitor continues, allowing the static timer to operate as a free-running pulse generator, capable of one-percent stability. This intervalometer is operated at an output frequency lower than desired, with the clock output applied as synchronization (Fig. 2D). This forces the intervalometer to yield an output that is a constant submultiple of the input.

The pulse train produced at the output of the last frequency divider is applied to the first decade ring counter and is directly counted in the decimal system.

The switching element used in the ring counter is a silicon-controlled switch, a four-layer, bistable semiconductor that approximates the circuit function of a flip-flop. The silicon-controlled switch will turn on when a low-level positive pulse is applied to its base, and will remain on until it is turned off by a negative pulse. This characteristic allows the switch to be used as memory device that will retain the registered count until the following input pulse causes the bit to transfer to the following stage (Fig. 2E).

When a positive pulse is applied to the base of Q_1, the switch will go into saturation and remain ON, causing the voltage drop across C_1 to be at a minimum. Application of a negative pulse to the base of Q_1 will cause the switch to turn off, resulting in a rapid rise in the collector voltage of the stage. This rise is coupled to the base of Q_2 and appears as a turn-on pulse to the stage.

By applying a turn-off pulse to each counter stage, the ON state, or registered count, will be transferred to the following stage as each pulse is injected.

The requirement that a specific silicon-controlled switch must be ON at the beginning of the timing cycle is accomplished by injecting a reset pulse to each decade (Fig. 2F). When the programmer operation is initiated, the application of power will cause an initial set signal which instantaneously turns off all counter stages with the exception of the zero-count stage in each decade counter. At the same time a positive pulse is applied to the zero-count stages, causing the stage to switch ON.

The input pulse derived from the output frequency divider is then used as a turn-off pulse and is applied to each counter stage of the first decade causing the ON state of the SCS to transfer through the decade until the "count 9" transwitch is in the ON state. As the tenth input pulse is applied, the positive rise of the silicon-controlled switch voltage is coupled to the base of first decade switch, or the "count 0" stage. At the same time this ON pulse is used as the first input pulse for the second decade ring counter.

By cascading three decade counters, 999 pulses may be counted. Each output is derived from the collector of a silicon-controlled switch and is coupled to an AND gate through three selector switches. With a time base established as 0.1 second, the selector switch position can determine the time of the AND gate excitation with a resolution of 0.1 second over a range of time delays from 0 to 99.9 seconds.

The AND gate (Fig. 3A) consists of three diodes connected to a static timer. The diodes are connected to the decades through 10-position switches, selecting the decade stages corresponding to the desired preset time. The levels fed to the timer from the decades cut off the timer until the preset time elapses.

At this time, with all three inputs removed, the timer is activated (Fig. 3B) and will produce an output within a few milliseconds. The use of a delay timer in this application reduces the possibility of an output occurring on noise or ambiguous transitions in the ring counters.

The programmer is required to gate current to a load which draws up to seven amperes. Until the preset time has elapsed, the leakage current must be minimum. At the present time, the load current must be rapidly switched on, and remain on. These requirements, along with the shock and vibration requirements, indicated the use of silicon-controlled rectifiers.

The driver circuit is shown as Fig. 3C. Driver transistor Q_1 is pulsed on by the static timer at the preset time, supplying drive current to the gate of the rectifier. The rectifier will turn on and latch applying current to the load. The load is placed in the cathode circuit of the rectifier to enable the cathode voltage to rise above the gate voltage when the rectifier fires. This back-biases D_1, removing the rectifier gate from the driver output.

During vibration tests the programmer was continually operated, completing over 50 timing cycles per plane of vibration. The high operating duty cycle under these conditions caused internal heating of the programmer, changing the crystal frequency slightly.

Shock pulses at 100 G were applied during timing cycles in all cases, showing complete absence of shock sensitivity. At this time, the level of shock, vibration or acceleration required to destroy this unit is unknown.

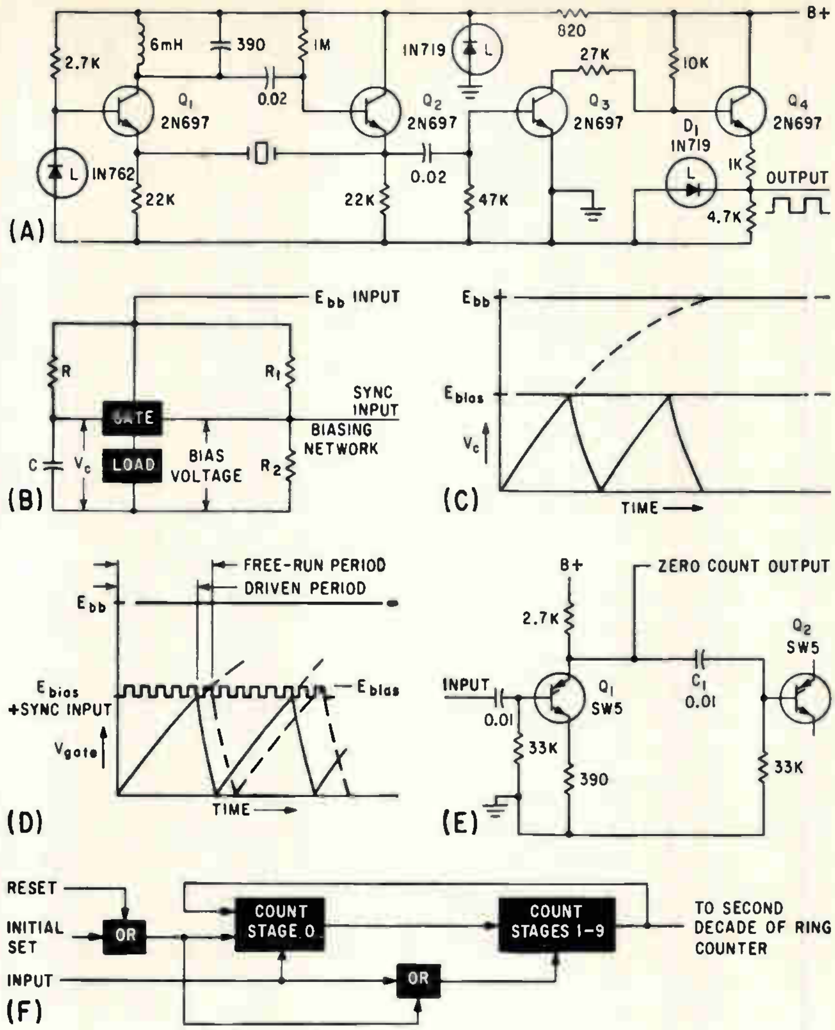


FIG. 2—Clock circuit (A) consists of oscillator and pulse shaper; basic circuit of frequency divider (B) and timing diagram without (C) and with (D) sync input; single stage of decade ring counter (E) and block diagram of decade (F)

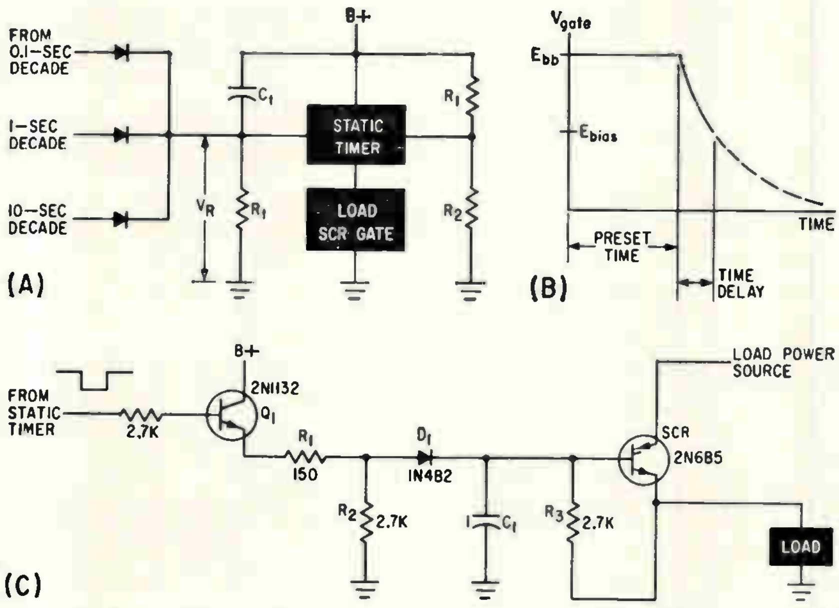


FIG. 3—Circuit AND gate (A) and timing diagram (B); output driver and SCR (C)

Snow-Gage Telemetering Systems

Radiation detectors on towers above the snow in the mountains determine sources on the ground, thus measuring snow's water content, which is

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EFFICIENT utilization and control of water resources have become increasingly important throughout the world as a result of increase and shifts in population centers. This is especially true along the Pacific coast, where water has become the life-blood of the West. In an area covering eleven states, Alaska and Canada, it has been found necessary to forecast the amount of water contained in mountain snowfields in order to effectively plan and operate irrigation projects, flood-control programs, hydroelectric plants, and water conservation facilities.

To improve upon present sampling methods, the Corps of Engineers developed a radioisotope gaging device, consisting basically of a source of radioactivity and a radiation detector.[1] This article describes a completely automatic telemetry and data recording system designed to use this gaging method of measuring and recording the water content of snow in the mountains.

The operational requirements may be summarized as follows: (1) nine consecutive months unattended, with capacity for 200 calls per gage station; (2) three gaging stations per system; (3) equipment to operate under severe winter conditions, such as sleet, snow, strong winds, and temperatures ranging from −20 to +100 F, at remote mountainous regions with elevations from 5,500 to 13,000 feet; (4) measurement accuracy of ±¼ inch when equivalent water content is 0 to 5 inches, of ±½ inch when 5 to 15 inches, and 5 percent when 15 to 50 inches; (5) a voice channel to permit maintenance and calibration of system between each gage (data) station and the base (central data collection) station through the intermediate radio relay stations; (6) manual and automatic interrogation for selectively calling any one or all of the data stations in turn, on a daily or periodic unattended basis; (7) battery-operated field equipment, using transistor circuits (except for the transmitter) for minimum drain; and (8) transportable units, not to exceed 75 pounds, to permit transportation by animal pack train or helicopters, if required.

The principle used by the snow gage is that the gamma radiation absorbed by materials of different density varies almost directly with the density. The emergent intensity, I, of radiation from a radioactive element, after passing through an absorbing medium, depends upon the original intensity of radiation, I_o, the thickness of the absorbing medium, x, and its coefficient of absorption, μ, in accordance with the equation derived from Lambert's law[2]: $I = I_o e^{-\mu x}$.

The coefficient of absorption, μ, (which is the reciprocal of the thickness that will reduce the intensity of an incident beam to $1/e$ of its original value) divided by the density of the substance, p, produces the mass absorption coefficient, μ/p, which is a constant regardless of the state of the absorbing medium, that is, whether gas, liquid, or solid. Thus, the measured intensity of the radiation that passes through snow may be ex-

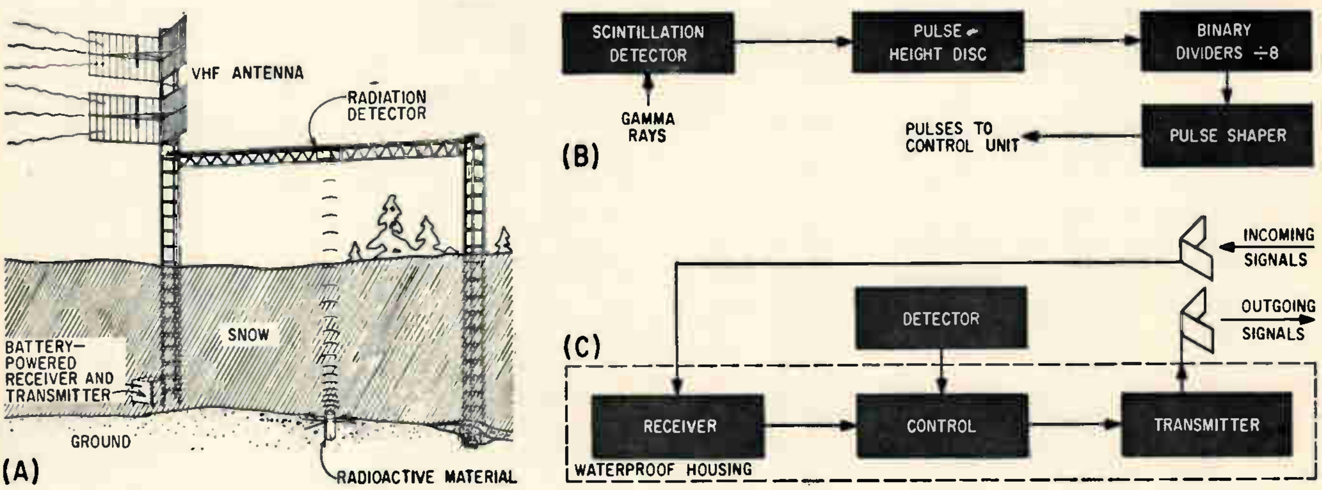


FIG. 1—Typical gage site (A) showing tower, antenna and waterproof equipment shelter; block diagram of detector and pulse shaper (B); and elements of gage station (C), which include a battery pack in the waterproof housing

Use Radioactive Source

the absorption by the snow of gamma rays from cobalt-60 telemetered to a base station

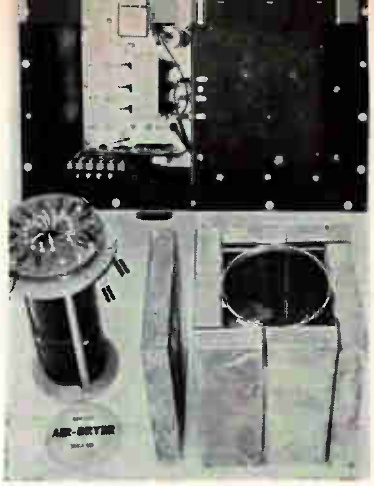


FIG. 2—Detector and pulse shaper unit, showing lead blocks for additional shielding against undesired background radiation

pressed in terms of the water equivalent of the snow pack regardless of its density or variations of density within the snow.

The measuring and recording techniques used is to print out the time in seconds required to count a predetermined number of electrical pulses emanating from the gage stations. The recorded time would then be a measure of the count rate and hence the water equivalent level. To conserve the on-the-air time of the field transmitters, and hence the storage battery strength, the base station equipment was designed to select automatically any one of three preset counts, depending upon the received count rate or water equivalent of the snow pack.

Since the electrical pulses, which are derived from the initial gamma rays, occur at a random rate and the count results are statistical, it is necessary to count for a long period of time when the water level is high, to preserve the accuracy of the water-level readings. Use of the largest preset count during incoming high count rates (low water levels) greatly reduces the counting time in comparison with the use of the smallest preset count when the count rate is low (high water level).

Field investigation revealed that two intermediate relay stations would be required for each system. Relay station separations of up to 70 miles accommodate total system ranges of up to 140 miles.

Since the incident gamma-ray radiations are converted by the scintillation detector to pulse rates proportional to the intensity of the radiation, this digital form was retained throughout the entire telemetering link for greatest accuracy. The single system parameter requirement, that is, the amount of water equivalent of snow, dictated a simple method of modulation. The pulses frequency-modulate a radio transmitter. Using time-sequential programming, it is thus possible to use one set of pulse-counting and recording equipment at the base station for all three gages in a system.

The method consists of measuring and recording the gamma rays or electromagnetic radiations that traverse through snow from a radioactive cobalt source located a measured distance from a scintillation detector. A small amount (40 to 60 millicuries) of radioactive cobalt is placed just below the surface of the ground and the radiation detector is placed 15 feet directly above it (Fig. 1A). As radiations pass from the cobalt source through the snow to the detector, some of the radiations are absorbed by the snow, according to its water content, and do not arrive at the detector. Only the water content, not the depth of the snow, affects the intensity of the radiation. Therefore, measurement of the resulting radiation at the detector measures the water equivalent of the snow.

The system can be operated both automatically and manually. In on-call operation, the radiation count can be recorded at any time by manually operating a switch lever on the front panel of the base station unit.

Two channels of communications are provided between the base station and each of the gage stations, one channel for transmitting on-call signals to the gage stations, and the other channel for transmitting the count or water-content information from the called gage station back to the base station. The snow-gage system includes two radio relay stations in the communications chain linking three remote gage sites with the base station.

In operation, query messages (steady tones of selected frequency) traverse the chain of stations starting from the base station and terminating at the snow-gage stations in the mountains.

In response to a query, one snow-gage station at a time transmits the radiation-count information back to the base station by the same radio relay station chain. To conserve electric power at the gage and relay stations, the radio transmitters, which contain vacuum tubes, are switched into service only when needed to transmit count information. However, the related transistor radio receivers, which consume relatively little power, operate continuously.

Each snow-gage station contains one receiver and one transmitter, with one pair required for each direction of radio transmission.

As each snow-gage station receives its interrogation, it causes its own transmitting equipment to reply with the radiation count information. This count information is then picked up at the nearest radio relay station where it is transmitted to the second radio relay station and then to the base station for recording on paper tape.

The sequence of operations necessary for obtaining radiation count information is controlled from the base station by the transmission of audio-frequency code tones over the vhf communications chain to the gage stations. During an inquiry, the first tone transmitted on the carrier from the base station energizes the radio transmitters at the relay stations in sequence, thus opening communications between base station and all of the gage stations simultaneously. However, each gage station responds to only one particular tone, selected from a

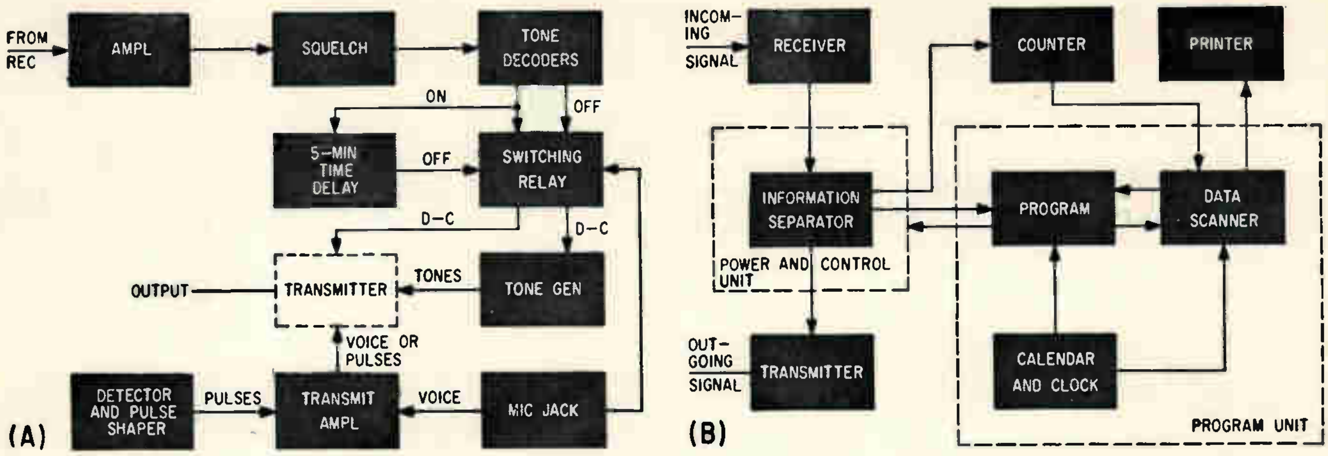


FIG. 3—Block diagram of gage-station control unit (A) and base-station equipment (B)

900 to 2,000-cycle band, which will cause its transmitter and its radiation detector to be energized, thus starting the transmission of water-content information in the form of radiation counts, as pulses.

All radiation-count transmissions from the gage station are accompanied by a code tone that differs in frequency from the tone that activates the transmissions. This second code tone energizes the transmitters at the two relay stations in the returning links, thus opening the communication circuit back to the base station. When received at the base station, this code tone initiates the actual counting and printing processes. The process of counting continues for a time determined by the count rate. Also, the second code tone turns off the transmitter in the base station, which in turn causes the outgoing link, used for the initial inquiry, to turn off, this saving battery power at the relay stations.

When the radiation count is completed, a third tone, differing in frequency from the previous code tones, is transmitted from the base station and relayed to the gage station to turn off the transmitter at the gage station. Subsequently, the other snow-gage stations are interrogated under the same program.

Each snow-gage station contains a radiation detector and pulse-shaper unit, in addition to the radio, transmitter, receiver, battery and control unit. Figures 1B and 2 show a detector and pulse-shaper unit. The unit incorporates a scintillation detector and transistor circuits that divide the count by eight and shape the count pulses.

The scintillation detector that receives the cobalt radiation consists of a 1½-inch thallium-activated sodium-iodide scintillation crystal and a multiplier phototube. This combination converts the scintillations of light in the crystal, caused by the radiation particles, into electrical pulses.

The pulsed output of the scintillation detector and multiplier phototube assembly is then passed through the pulse-height discriminator which is, in effect, an electrical window. The height of this window opening, as well as its height above ground, is adjusted to admit the pulses from the practically monochromatic radiations of the radioactive Co-60. Pulses due to radiations of other energy levels, such as those from the ground or cosmic rays, are blocked from admittance through the window because their pulse heights are either too small or too large. This arrangement reduces the count from sources extraneous to the Co-60 and results in an increased accuracy of water-content measurement, particularly when the snow is deep and the water-content count is near maximum readout.

After the pulses pass through the pulse-height discriminator, they are applied to three cascaded binary stages that divide the count by eight. The pulsed output of the dividers triggers a one-shot multivibrator, which generates pulses of uniform height and width at a rate of one for each eight scintillations in the sodium-iodide crystal.

The pulse-shaper output goes to the control unit in the equipment shelter on the ground and is subsequently transmitted to the base station, counted and printed out.

Figure 1C is a block diagram of a snow-gage station. Information picked up on the receiving antenna is fed by coaxial cable to the receiver. The demodulated output of the receiver is fed to the control unit which controls the transmitter and detector unit according to the signals transmitted from the base station. When the detector is energized, the pulsed output is fed to the control unit and then into the transmitter as modulation, and transmitted on the r-f carrier back to the base station through two relay stations.

A block diagram of the control unit is shown in Fig. 3A. The signal from the receiver discriminator is amplified and fed to the squelch circuit, which cuts off the battery power to the tone decoder when a signal is not present. Frequency-selective networks in the tone decoder control operation of the switching relay. When a signal is present, d-c supply voltages are applied to the tone generator and transmitter simultaneously. The transmitter is thus modulated by the combined tone and pulse signals. The modulation of both voice and tone signals is preset at 20 percent of the pulse signals, to minimize mutual interference. A five-minute time delay turns off the transmitter if a turn-off tone signal is not received at the gage station.

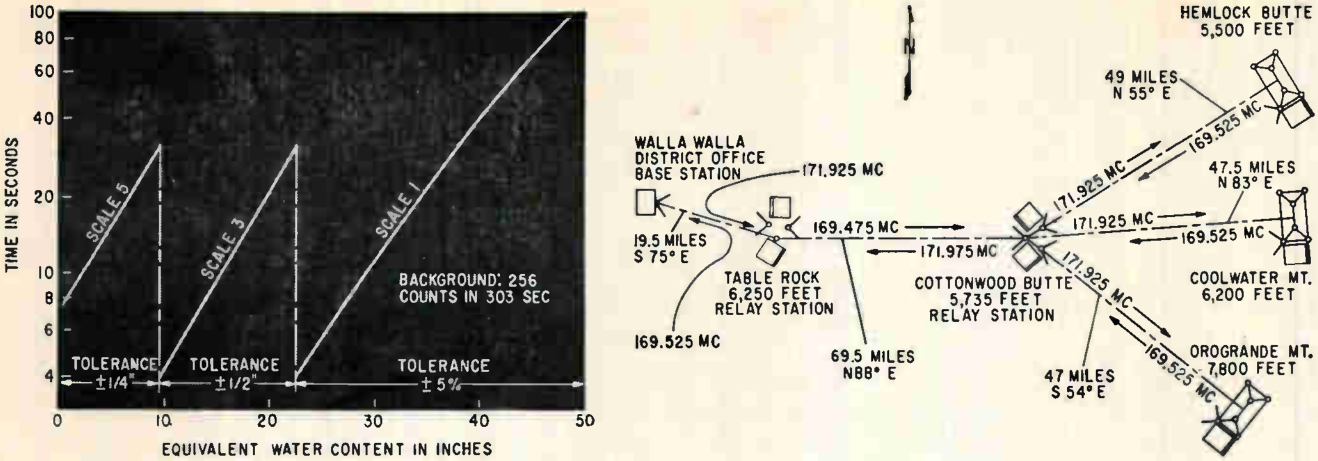


FIG. 4—Graph of performance data (A) and layout of snow-gage telemetering system at Clearwater (B)

Each relay station has two waterproof housings at the base of the antenna tower. One houses the outgoing relay link, the other the incoming or returning relay link. The two relay links are independent of each other. The r-f signals are received from the base station by the vhf transistor radio receiver. The r-f signals are demodulated in the receiver, and the tone actuates controls in the control unit to turn on the vhf f-m transmitter, which is modulated by the same tone, and retransmits it, either to the next relay station or to the gage stations. The incoming or returning relay link operates in the same manner except that it is retransmitting in the opposite direction. The transmitter uses filaments that are essentially instantaneous in heating. A single vertical tower is used at the relay stations, and four antennas are required.

Figure 3B is a block diagram of the base station. Consider the equipment set for automatic operation, in the stand-by condition and approaching the time for a set of interrogations. When the preset time for interrogations arrives, the calendar and clock section of the program unit initiates a signal that turns on filament power for the transmitter and primary power for the receiver. Power to operate these two units is supplied from the power and control unit. A time delay of 1.5 minutes is also started at this time to allow the transmitter and receiver sufficient time to warm up and stabilize before the interrogation sequence is started. One and a half minutes after start, the time delay closes and applies power to the transmitter and to a subcarrier audio oscillator in the power and control unit. The tone frequency modulates the r-f signal from the transmitter which is transmitted through two relay stations to the gage stations.

When a return signal from the gage station is received in the base-station receiver, it is demodulated and passed through the information separator which in turn de-energizes the base-station transmitter. Pulsed information from the snow-gage site is now being received at the base-station receiver, and fed to the information separator, which channels it to the counter, which counts the pulses and determines which scale factor to be used. When enough pulse information has been received by the counter, it sends a signal to the program unit to start the readout process. The program unit causes the data scanner to scan the counter and the program section, and causes the calendar to determine the time required (in seconds) to count the specified number of pulses, the scale factor, the gage station interrogated, and the date and time. This information is then printed out. The program section then repeats this same sequence of operations automatically for the rest of the snow-gage stations and shuts down the base station at the end of the sequence.

The three different preset total-count channels in the counter are indicated as a chart scale number that is initially calibrated for time versus water depth and plotted on a semi-log scale (Fig. 4A). The chart scale factor is selected automatically by the count mechanism within the base station equipment. This selection is made when the counting equipment first samples the rate at which the counts arrive, and uses this information to establish the number of counts to be accumulated.

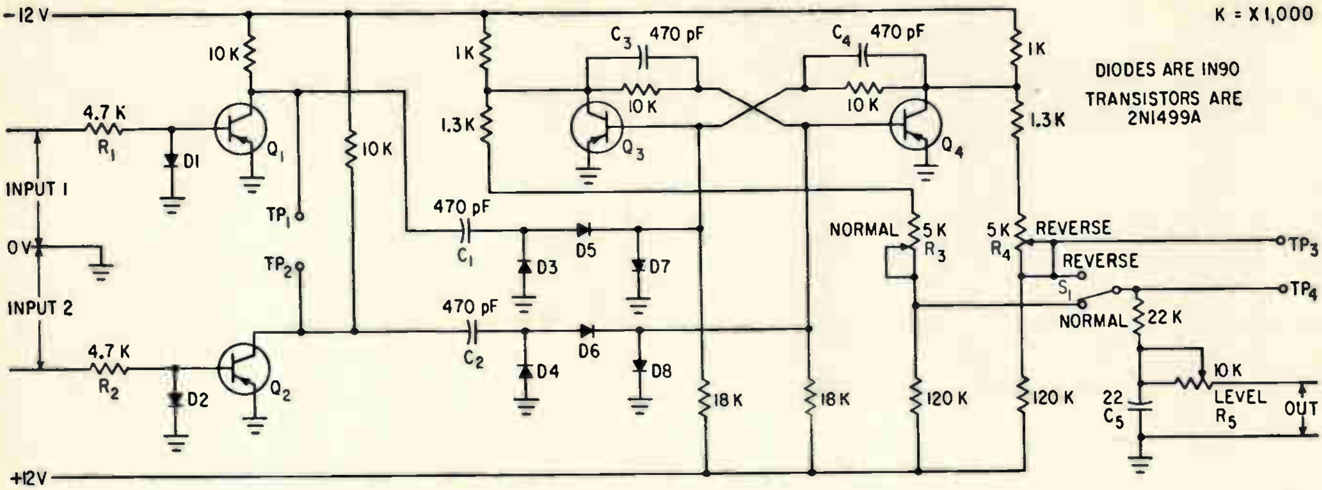
Two snow-gage systems have been installed, one in California, the other in Washington and Idaho. Both systems include relay stations in the communications chain linking three snow-gage stations with the base station. The Isabella system consists of a network of vhf radio antennas and towers constructed at six sites between Mt. Whitney in the Sierra Mountains, and the Isabella reservoir near Bakersfield, California. The highest gage station is at an elevation of 11,500 feet and the greatest distance between any two sites is 42 miles. This system covers the Kern River watershed of the San Joaquin Basin.

The Washington-Idaho Clearwater system (Fig. 4B) also consists of six sites in the Clearwater River watershed of the Columbia Basin. The gage stations are in the Bitter Root Mountain area of Idaho.

REFERENCES

(1) R. W. Gerdel, B. L. Hansen and W. C. Cassidy, The Use of Radioisotopes for the Measurement of the Water Equivalent in a Snow Pack, *American Geophysical Union Transactions*, 31, No. 3, p 449, June 1950.

(2) J. M. Cork, "Radioactivity and Nuclear Physics", p 142, D Van Nostrand Co., Inc., New York, N.Y., 1947.



Phase-measuring circuit determines phase difference between inputs 1 and 2. Useful range is about 0.2 to 20 Kc

MEASURING PHASE

WITH TRANSISTOR FLIP-FLOPS

By JAMES R. WOODBURY,
Stanford Research Institute,
Menlo Park, Cal.

THIS INSTRUMENT measures the phase difference between two sinusoidal inputs. The phase meter comprises two limiters, each driven by one of the input signals. Each limiter drives one side of a high-speed flip-flop through differentiating and clipping circuits. The output of the flip-flop is a square wave which turns on when one input signal goes negative and off when the other input signal goes negative. The d-c value of the output is therefore proportional to the phase difference of the two inputs.

Input impedance is determined by resistors R_1 and R_2 (see figure), which are in series with each input. Since the limiter is essentially a current amplifier, these resistors should be as small as possible, provided that the average base current rating of limiting transistors Q_1 and Q_2 (about 10 ma) is not exceeded, and provided that loading does not cause the input generators to shift the zero crossings of the input signals. The input resistor values can be changed to suit a particular type of input, if necessary.

The minimum slope necessary at the zero crossing of the input waveform to fire flip-flop Q_3-Q_4 is a function of the values of the input resistances and of differentiating capacitors C_1 and C_2, which couple the limiters to clipping-diode circuits. Larger values of C_1 and C_2 would fire the flip-flop on smaller input slopes, but capacitor recovery time, which must be less than ½ cycle for a sinusoidal input, then would be longer. Capacitors C_3 and C_4 also affect the triggering level and recovery time. The values of C_1, C_2, C_3 and C_4 could be adjusted if very high or very low speed signals are used.

The present circuit gives good results with 3-Kc sinusoidal inputs of about 4 v_{RMS} or greater on the inputs. This corresponds to a zero crossing slope of about 0.1 v/μs; slope $= 2 \times 2^{\frac{1}{2}}\pi f v_{rms}$.

A polarity switch (S_1) is provided so that either flip-flop output can be selected, dependent on the sign of the relative phase of the inputs.

Potentiometers R_3 and R_4 (NORMAL and REVERSE) should be adjusted to give zero output with no input signals and with switch S_1 in the corresponding position. The condition of the flip-flop can be changed by touching the appropriate limiter test point, TP_1 or TP_2, with a ground lead. Switching S_1 will sometimes cause the flip-flop to change its condition.

The d-c level of the output can be measured with a d-c voltmeter. About −11 v output corresponds to 360 degrees, (a scale factor of 30 mv/degree) and no adjustment of level potentiometer R_5 is required.

If a microammeter placed between output to ground measures d-c level, R_5 should be adjusted to give a 360-μa output with no input signal and the flip-flop output at −11 v. Either flip-flop output may be used for this calibration. The scale factor is then 1 μa/degree.

The square wave output can be monitored at TP_3, which is at the REVERSE side of S_1, or at TP_4, which is at the output of S_1.

When input signals are of the same phase and above the firing level, there will be some residual output (corresponding to from 0.2 to 1 deg at 3 Kc, depending on signal levels) due to transients in the flip-flop circuit. However, this should not contribute any error to the readings for phase shifts over one or two degrees.

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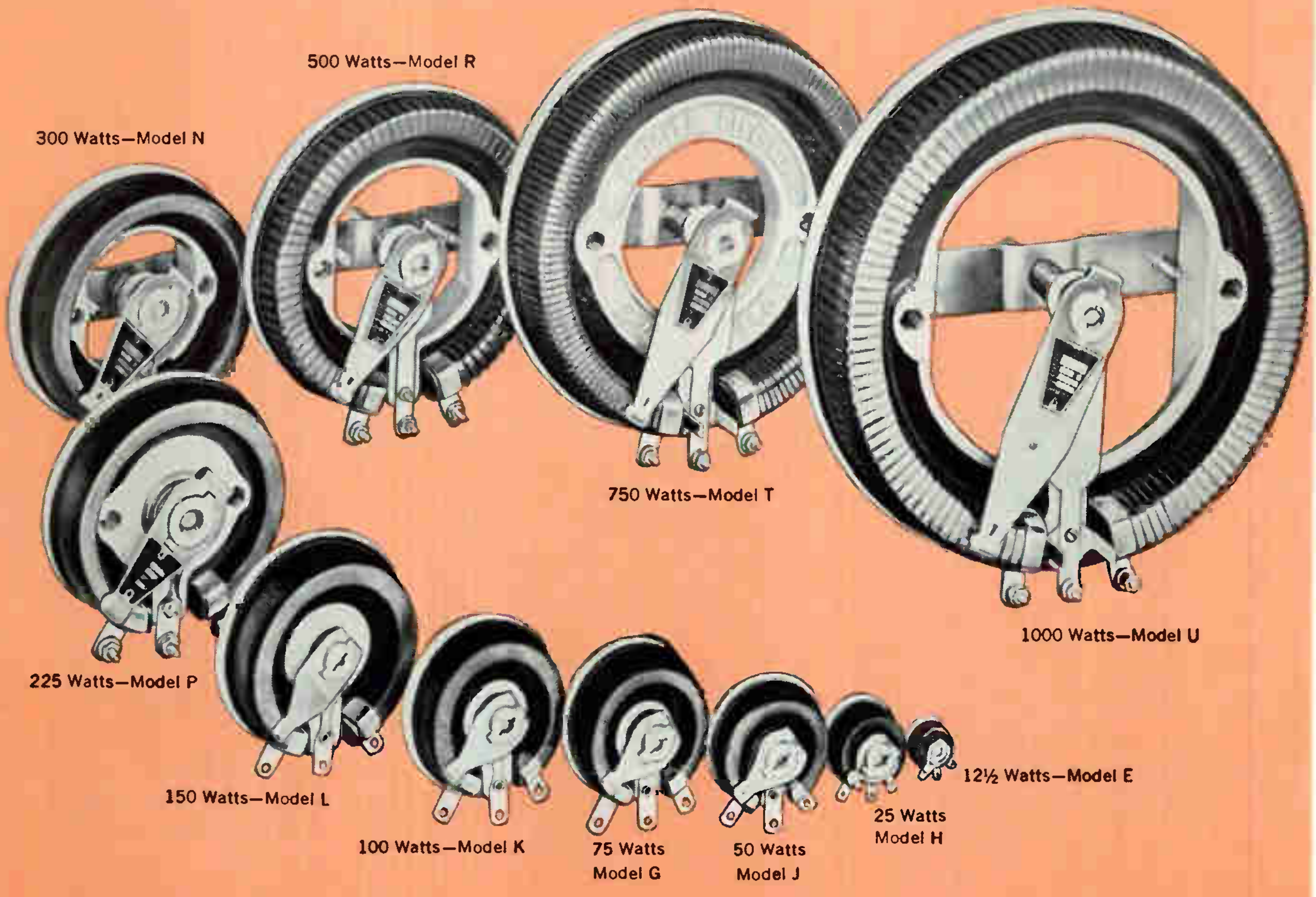

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CIRCLE 57 ON READER SERVICE CARD

Hot-Switching Surge-Current Nomograph for Diodes

By WAYNE AUSTIN, RCA Electron Tube division, Harrison, New Jersey

DIODE SURGE CURRENTS must be limited to a definite maximum during transient conditions that occur, for example, when a capacitance-input rectifier circuit is hot switched. In hot switching, the input capacitor is uncharged, and the full transformer supply voltage is applied to the plate of the diode causing the cathode or filament to emit sufficient electrons to provide damaging surge currents.

The short-duration surge current exists only until the input capacitor becomes charged to its steady-state value; if the surge current is not limited to its rated value, arc-back can cause failure in both diode and input capacitor. In less catastrophic cases, surge currents in excess of the rated value result in premature tube failure.

Proper circuit design limits the surge current to a time duration of 0.2 second and prevents it from exceeding the specified maximum surge-current rating. The amplitude of the current can be limited by adding resistance in series with the transformer source impedance; the time duration must be limited by the time constant of the circuit.

The total series resistance per plate (R_s) is

$$R_s = R_{sec} + N^2 R_{pri} + R_a \quad (1)$$

where R_{sec} is the d-c resistance of the transformer secondary per section, R_{pri} is the d-c resistance of the transformer primary, R_a is the added series resistance per plate and N is the transformer voltage step-up ratio per section.

Published data for most recently developed rectifiers include a rating chart that specifies a value of series resistance per plate for an applied value of rms sine-wave voltage. Values given in these charts are calculated to limit the surge current to the specified maximum rating. However, not all tube types have such charts, and even the existing charts give no indication of actual surge currents other than for the maximum rating. The nomograph shown in Fig. 1 provides the designer with one chart that can be used for most rectifier types when only the perveance and the surge-current ratings of the diode are known.

The equation for the nomograph expresses the peak voltage drop as the sum of two components

$$\sqrt{2}\, E_{rms} = I_m R_s + (I_m/G)^{2/3} \quad (2)$$

where $I_m R_s$ is the voltage drop in the series resistance, and $(I_m/G)^{2/3}$ is the voltage drop across the diode. The surge current I_m occurs at the peak of the applied rms voltage $\sqrt{2}\, E_{rms}$) if the applied voltage is a sine wave. The diode perveance G is

$$G = i/e_b^{3/2} \quad (3)$$

where i and e_b are any set of current and voltage readings from the tube characteristic curve. Normally, Eq. 2 is

$$\sqrt{2}\, E_{rms} = I_m R_s + I_m r_{ds} \quad (4)$$

where r_{ds} is the diode resistance

EXAMPLES OF DIODE CHARACTERISTICS

Diode Type	Applied Voltage	Milliamps Per Plate	Value of G
5U4GB	75	500	0.78
5Y3GT	75	175	0.27

(continued on pages 60 & 62)

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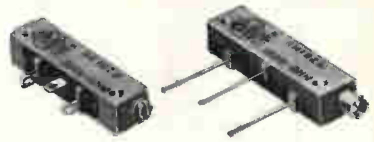

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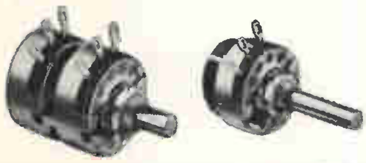
Exclusive Hot Molded Resistors are the "quality" standard of industry all over the world. Conservatively rated. Stable and uniform characteristics assure superior performance. No known instance of catastrophic failure. Rated 1/10, 1/4, 1/2, 1, and 2 watts at 70°C. Res. to 22 meg. Tol: 5, 10, and 20%.

Hot Molded Solid Resistors, hermetically sealed in ceramic tubes, remain stable. Rated 1/8, 1/3, and 1 watt. Res. to 22 meg.

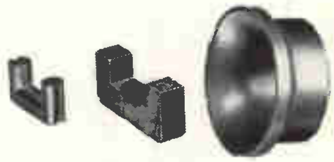
Precision Resistors—Metal Grid Construction—hermetically sealed. Noninductive. Tol: 0.1, 0.25, 0.5, & 1.0%. TC ±25 PPM/°C. Rated 1/4, 1/2, and 1 watt at 125°C.

Adjustable Fixed Resistors. Resistance element and terminals hot molded into integral unit with insulated mounting base. Stepless adjustment. Noninductive. Remains fixed in "set" position. Watertight. Rated 1/4 watt at 70°C. Values to 2.5 meg. Tol: 10% and 20%.



POTENTIOMETERS TYPE J AND TYPE K

POTENTIOMETERS TYPE G AND TYPE L



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Type J Potentiometers. Solid, hot molded resistance element. Smooth, quiet control which improves with long life. Compact. Rated 2.25 watts at 70°C. Values to 5 meg.

Type K Potentiometers. Same as the above but rated 1 watt at 125°C; 2 watts at 100°C; and 3 watts at 70°C.

Type G Potentiometers are miniature controls with solid molded resistance element. Only 1/2" diam. Smooth control—also improves with age. Rated 1/2 watt at 70°C. Values to 5 meg.

Type L Potentiometers are similar to Type G but rated 1/2 watt at 100°C. Can be used up to 150°C with reduced "load."

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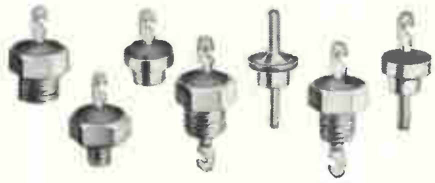

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Feed-thru and Stand-off Capacitors for use at VHF and UHF frequencies. Discoidal design eliminates all parallel resonance effects at 1000 Mcps and less. Standard values 470 mmf ±20% and 1000 mmf —0 +100%. Special values from 6.8 mmf to 1500 mmf. Rated to 500 v DC max.

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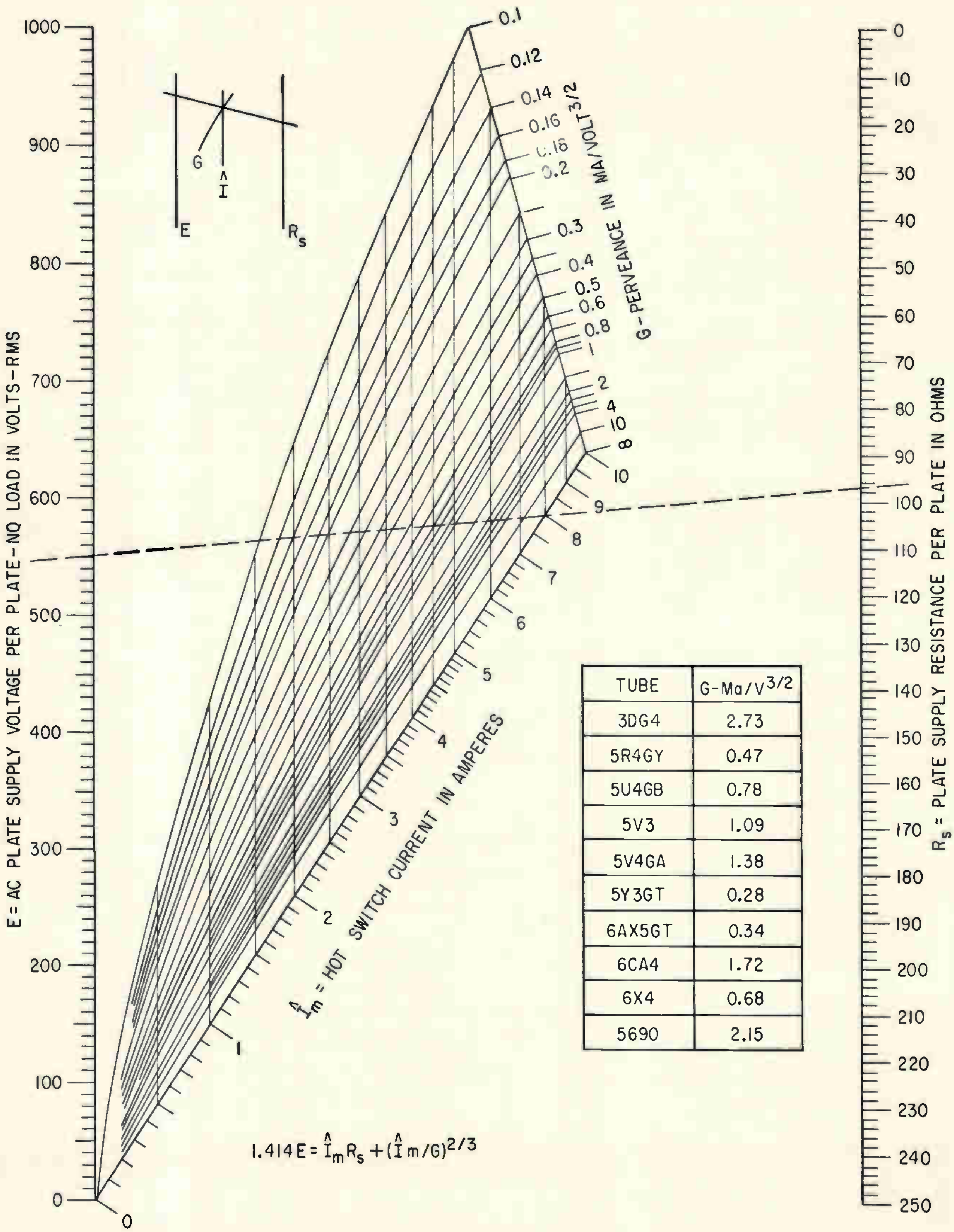
QUALITY ELECTRONIC COMPONENTS

Nomograph for Diodes (continued from page 58)



TUBE	G-Ma/V$^{3/2}$
3DG4	2.73
5R4GY	0.47
5U4GB	0.78
5V3	1.09
5V4GA	1.38
5Y3GT	0.28
6AX5GT	0.34
6CA4	1.72
6X4	0.68
5690	2.15

FIG. 1—Nomograph relates current and voltage to diode characteristics and series resistance per plate

(continued on page 62)

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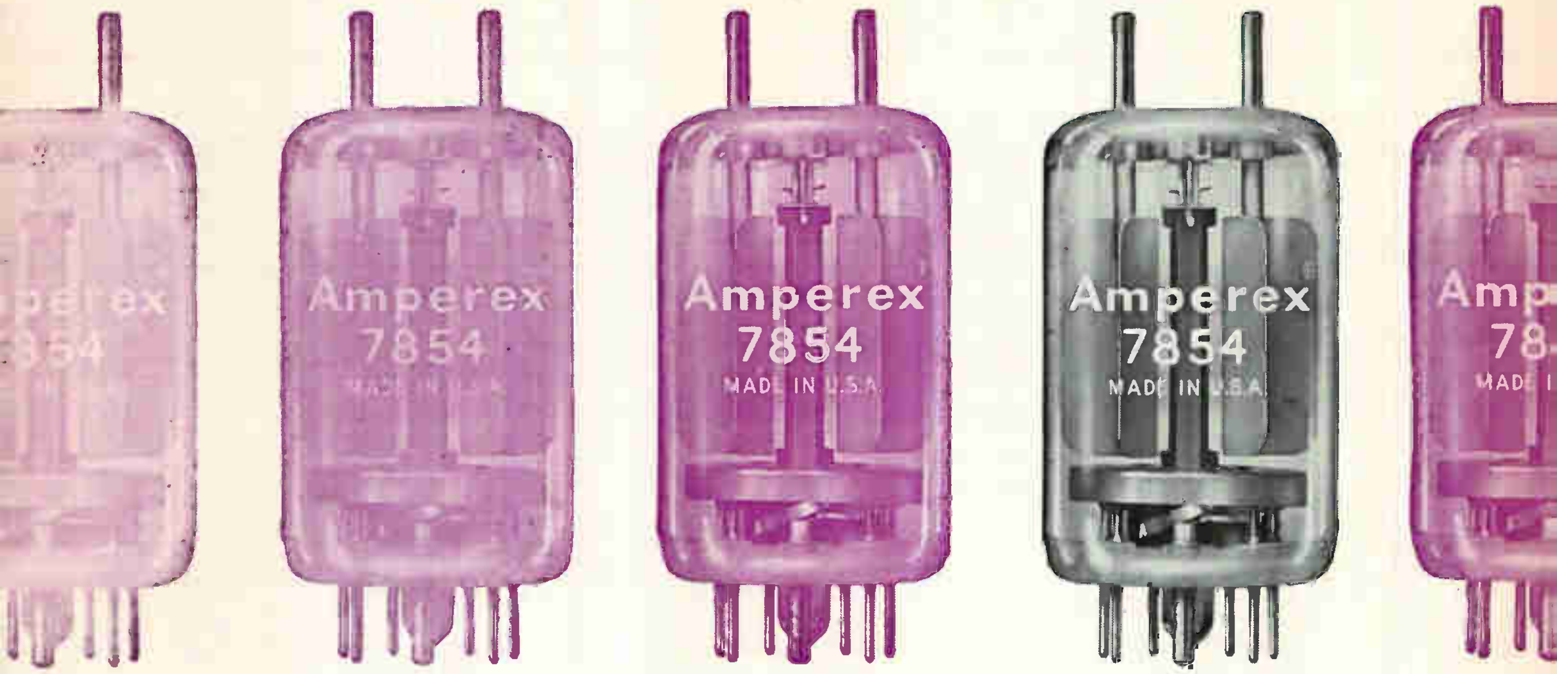

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	FORCED AIR ICAS	HEAT SINK ICAS
D.C. Plate Voltage	1000 volts	750 volts
D.C. Grid No. 2 Voltage	262 volts	260 volts
D.C. Grid No. 1 Voltage		
Fixed or from common resistor of	2x30 K ohms	2x30 K ohms
D.C. Plate Current	2x120 ma	2x120 ma
D.C. Grid No. 1 Current	5.7 ma	5.5 ma
Driving Power	3.5 watts	3.5 watts
Power Output	163 watts	123 watts
Frequency	175 Mc	175 Mc

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Nomograph for Diodes (continued from page 60)

corresponding to the peak value of the surge current.

The following equation for e_b can be obtained from Eq. 3

$$e_b = (i/G)^{2/3} \quad (5)$$

therefore, when i equals I_m

$$I_m r_{ds} = (I_m/G)^{2/3} \quad (6)$$

On the perveance line for the diode being used, mark the point at which the surge-current value and perveance value intersect. This point is used as a pivot for a straight edge along which the value of R_s for the applied rms voltage may be read. For example, the dotted line on the nomograph for the tube type 5U4GB has a perveance of 0.78 ma per volt, so that, when I_m is 4.6 amperes, E_{rms} is 550 volts and R_s is 97 ohms.

The chart may, of course, be used to determine any one of the four variables if the other three are known. The line connecting zero values of E_{rms} and R_s corresponds to infinite diode perveance or a short circuit in place of the diode. The infinite-perveance line can be used to determine the transformer source impedance if I_m can be read conveniently and if the input to the filter is shorted, and the transformer ratings are not exceeded. However, for infinite perveance, equation (2) reduces to Ohm's Law if E_{rms} is multiplied by 1.414. It is helpful in finding the perveance of a diode to determine first the value of current for a plate voltage of 100 volts from the tube characteristic curve. For this voltage, the perveance is equal to the current as read in amperes with units of ma/(volt)$^{3/2}$.

Perveance may also be calculated from published data using equation (3). For convenience in using the surge-current nomograph, a perveance nomograph based on Eq. 3 is shown in Fig. 2. Perveance values may be read from this nomograph by drawing a straight line through any set of published current and voltages readings on the circle and center line. The broken lines are examples for the 5Y3GT and 5U4GB tubes (see Table).

This nomograph may also be used to obtain corresponding values of current and voltage readings for any rectifier tube when the value of G has been determined.

"Since the hot-switching current nomograph plate supply voltage and plate supply resistance scales are linear, they may be extended beyond the scale limits shown.

The perveance nomograph current and perveance scales may be changed by multiplying both current and perveance by the same factor. As an example, all values of the current and perveance may be multiplied by 0.1. The voltage scale is fixed and cannot be changed."

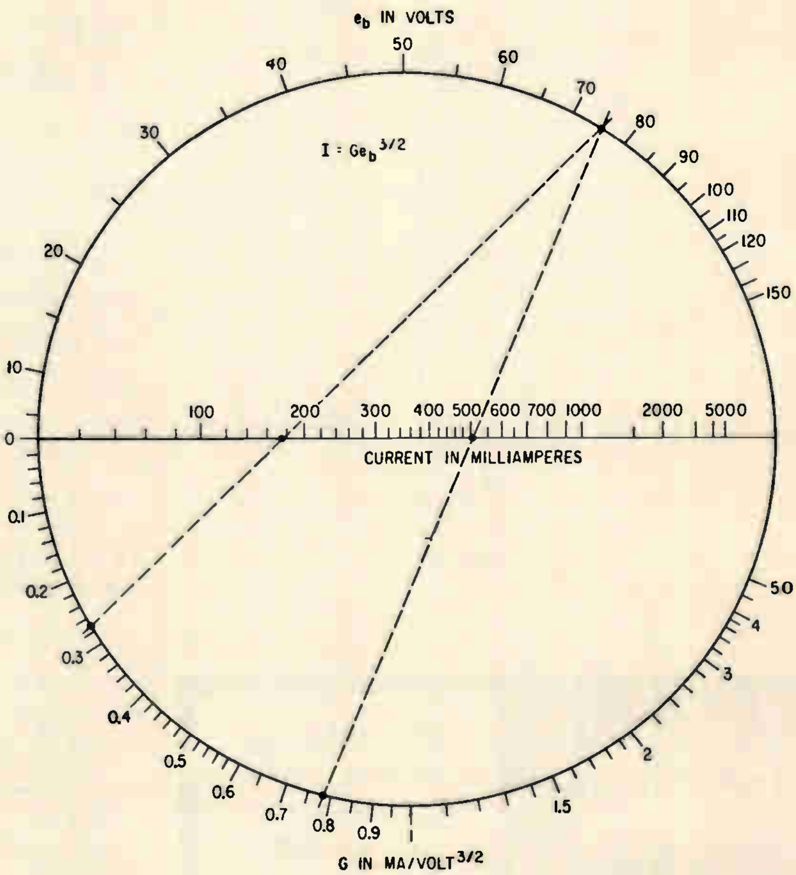


FIG. 2—Perveance nomograph gives the perveance value of a diode in voltage and current readings from the diode's characteristic curves

Dynamic Fluid Switch Senses Acceleration

By FRED W. KEAR,
Albuquerque, N. M.

PRINCIPLES of fluid dynamics are used in an acceleration-sensitive switching system. An accelerometer using this type sensing element resists the effects of cross-axis acceleration and other environmental conditions. Response of the device to frictional torques is also limited.

Acceleration-sensitive devices are frequently used with integrating systems to measure accelerations, velocities and distances. However conventional measuring methods are not completely satisfactory under extreme environmental conditions, such as those encountered in ballistics missiles and jet-powered aircraft.

Several desirable characteristics are inherent in the basic operating principles of the dynamic fluid switching accelerometer. They can be realized practically in a relatively simple system if some factors are considered in design of the sensing element and the associated circuits.

One type of device commonly used to measure acceleration and velocity uses a pressure transducer, and inertia of the integrating element acts on the pressure-sensing element. In a second common type, a rotating integrating element is used. In both types, inertia acts on the integrating element in the static condition. Accuracy is therefore greatest when the input to be integrated is at the highest input to output ratio.

This characteristic requires a substantial change in input force to produce a small effect on the integrating element. This effect can be resolved with high accuracy in rotating devices if accelerometer output provides a large number of pulses or a high analog voltage per unit of force at the input. Thus best results are obtained from a rotating integrating element when rotating speed is least affected by variations in input force. However, the rotating element must provide high enough output frequency or voltage so that slight variations in speed can be resolved easily and accurately. Because of this characteristic of integrating systems, a rotating device would normally be expected to provide more accurate information than a pressure-sensing device.

The greatest source of error in acceleration-measuring devices that use rotating elements is system nonlinearities, which can result from forces inherent in the system or from poor design or fabrication. Most inherent nonlinearities can be compensated by mechanical or electrical design of associated equipment if they behave predictably. However, faults in system design or construction are usually manifested in erratic performance that cannot be compensated but must be corrected by eliminating the fault or design error. Those nonlinearities produced by spurious forces in the sensing element are often the most difficult to eliminate.

Among several types of devices that provide measurable response to acceleration, dynamic fluid switching is least affected by cross-axis acceleration and other environmental conditions. This principle is used in the switching system shown in Fig. 1.

The fluid switch is used to control power to the accelerometer drive motor. The fluid is contained in a cylindrical section that is rotated so that centrifugal force tends to move the fluid toward the outer wall. However, the acceleration force parallel to the axis of rotation tends to move the fluid downward. The combined effects of these forces distorts the fluid into a truncated cylindrical section.

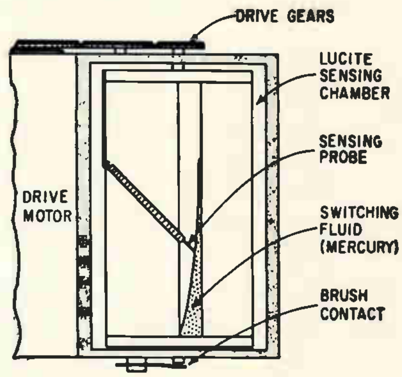


FIG. 1—Linearity depends on locating upper switch probe near vertex of parabola formed by distorted fluid

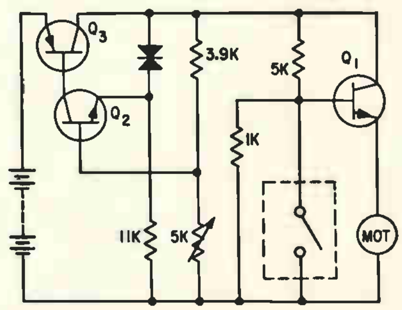


FIG. 2—Switch controls power to motor through Q_1 with Q_2 and Q_3 controlling motor current

For fluid switching to occur, centrifugal force must overcome the force of acceleration so that the fluid contacts the upper switch probe. Thus the required centrifugal force indicates acceleration and can be measured in terms of accelerometer motor speed. Motor speed can be closely controlled by varying the voltage applied to it, and the range of motor speeds determines the range of accelerations that can be measured.

When centrifugal force causes fluid switching, power to the motor is removed. As the fluid recedes causing the switch to open again, power is restored to the motor. Motor power is switched on and off in this manner to maintain the relationship between motor speed and acceleration.

The surface of the distorted fluid nearest to the axis of rotation

TUNG-SOL 6977

subminiature indicator triode saves display space

Here's an indicator triode for computer and business machine applications that will replace neon lamps in computer circuits. It has the advantage of low voltage drain with great economy of display area.

The Tung-Sol 6977 is a filamentary, high vacuum, subminiature triode with a fluorescent anode. Especially advantageous in transistorized circuits, its high input impedance and small signal requirements do not load these circuits.

Tung-Sol design and manufacturing skills are being applied constantly to the problems of improving componentry in all fields where industrial and special purpose tubes find their specialized uses.

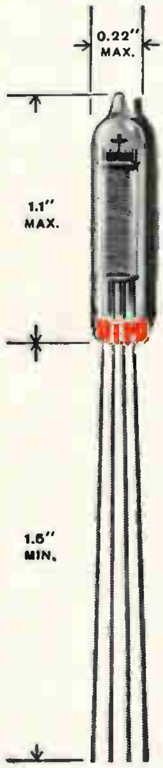
If you have questions regarding the application of type 6977, or any tube type, you are invited to bring them to Tung-Sol. You will be pleased with the results. Tung-Sol Electric Inc., Newark 4, N. J. TWX:NK193

TYPICAL OPERATION

Heater Voltage[B] AC	1.0	Volts
Anode Voltage DC	50	Volts
Grid Resistance	100,000	Ohms
Grid Supply Voltage for max. light output	0	Volt
Grid Supply Voltage at zero light output	-8	Volts

TECHNICAL ASSISTANCE IS AVAILABLE THROUGH: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Tex.; Denver, Colo.; Detroit, Mich.; Irvington, N. J.; Melrose Park, Ill.; Newark, N. J.; Seattle, Wash. In Canada: Abbey Electronics, Toronto, Ont.

TUNG-SOL®



CIRCLE 65 ON READER SERVICE CARD

forms a parabola. The extent to which the switch can maintain a linear relationship between motor speed and acceleration depends on how near the upper contact probe is to the vertex of the parabola. The accelerometer can maintain this relationship within 0.005 percent if bidirectional current switching is used.

The acceleration-sensing switch controls transistor Q_1 in Fig. 2, which provides power to the accelerometer motor. The switching circuit must be provided with effective noise filtration because noise pulses appear in the output. The noise results from perturbations in the fluid produced by the acceleration-deceleration cycle. These perturbations are produced when changes in rotational velocity of the switching chamber impart energy to the fluid and inertia of the fluid causes a shift in mass center. Perturbations are also induced by inertia of the fluid when rotation is started in the system.

Because the perturbations are magnified by motor overshoot, they can be compensated by limiting motor current. Although this compensation will have a damping effect that increases the time required for the system to change speed with each switching cycle, over-all system response to changes in acceleration will not be affected. Current limiting is effected by transistors Q_2 and Q_3 in Fig. 2. System damping of this type increases accuracy by almost an order of magnitude.

The circuit in Fig. 3 is another method of system recovery. It prevents overshoot and provides null capture in the indicated balance point at each level of acceleration. This circuit provides bidirectional current switching for the accelerometer motor. When the fluid in the sensing chamber contacts the upper probe, reverse current through the motor causes torque reversal that captures overshoot and undershoot very efficiently.

Time delays in the circuit allow the transistors to back bias before shorting occurs. The time delays are provided in the base-circuit R-C network of secondary switching transistor Q_6. Turn-on time delay for any of the current-switching transistors, Q_1 through Q_4, must exceed 25 microseconds.

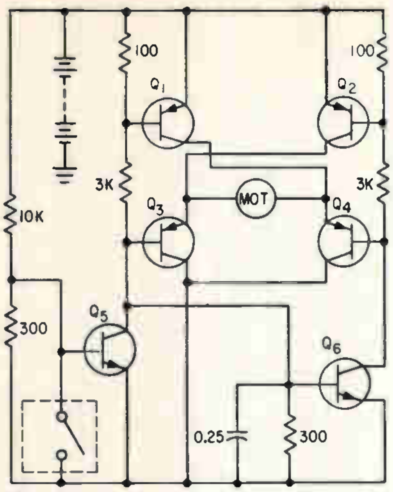


FIG. 3 — Bidirectional current switch provides capture of motor overshoot and undershoot

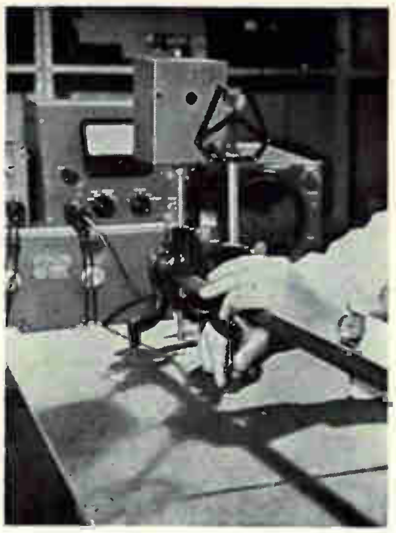
This time delay ensures complete back-biasing of these transistors, which normally requires less than 10 microseconds. To prevent very large inductive spikes from damaging these transistors, a diode can be used to remove them from the base circuits.

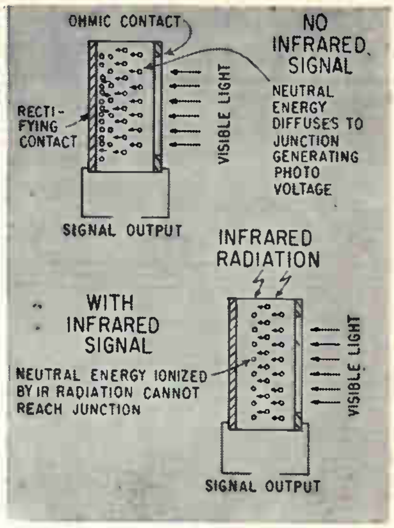
One of the most important design considerations is to ensure that the switch probe contacts the parabola as near to its vertex as possible. To compute the location of this point, the relationship between the volume of fluid and the capacity of the sensing chamber must be considered, and the configuration of the sensing element under its total force must be projected.

An important factor that affects accuracy of such computations is density versus surface tension of the liquid. Pure refine mercury has been the most successful media tested in the system to date. Its high density provides the system with a high input to output ration, which contributes to resolution.

The fluid selected must not interact with switch materials, and electrolysis through the switch must be prevented. If either of these conditions were allowed to persist, switching could become erratic and system response would deteriorate.

Fluid-dynamics integrators do not respond to frictional torques as readily as other types of acceleration integrators. Some errors are caused by frictional torques, but they are limited by the simplicity of the system.





Robert Robinson (left), Armour Research Foundation physicist, holds a crystal of cadmium sulfide in receptacle which transfers current to recording equipment (center). Varying intensities of ir react upon the CDS, and micron region sensitivities are recorded. Basic elements of photodetector are shown in diagram (right)

Infrared Detection Without Cryogenics

THE MOST SENSITIVE infrared detectors at present use photoconductive cells such as lead selenide, indium antimonide, and germanium, which have their maximum usefulness in a range well below 10 microns.

The peak response of these detectors occurs at 5 microns or less, and a detector should have peak response near 10 microns to better meet the military needs, since there is an 8 to 14 micron window in the atmosphere.

This means that one is operating in the region of the infrared spectrum in which atmospheric attenuation is small.

For effectiveness in the region of the infrared spectrum, the photoconductive materials being used now must be cooled. Most of the cryogenics now involve either liquid nitrogen which cools to 77 deg K, or liquid helium which goes down to 42 deg K. These cryogenic materials and the hardware required to handle the liquid cooling, comprise appreciable bulk and weight which tax the thrust when the satellite is launched. And the device no longer works when the liquid is gone.

A new long wavelength detector, developed at the Armour Research Foundation, Chicago, now solves the problem of obviating bulky cryogenics which are needed to cool photoconductive materials in existing systems, according to J. W. Buttrey, Assistant Director of Physics Research.

The Foundation's process involves the neutral transfer of energy in crystals of cadmium sulfide (see photos above). Visible light, entering a cadmium sulfide crystal at one end, causes a photoconductive response across electrodes placed at the other end of the crystal. Long wavelength radiation (approximately 10 microns) which strikes the crystal between the incident visible radiation and the electrodes, causes the photoconductive response to be quenched. The diffusion length of the neutral energy is much larger than the ambipolar diffusion length of the electron-hole pair into which it ionizes. The mechanism of the detection process is that the incoming absorbed ten-micron radiation ionizes the neutral energy and thereby quenches the photoconductivity.

This phenomena occurs at room temperature. Power requirements for this device are small and could probably be supplied by one of the new lightweight, long-life batteries.

Armour Research Foundation scientists foresee the development as a solution for existing detectors in the 10 micron window region in the infrared spectrum. Since the Armour system does not require cryogenics, problems involving loss of liquid coolants through leaks in the cryogenic system are also eliminated and system reliability goes up.

A detector which is sensitive in the 8-14 micron region would be able to pick up cooler targets and thus could also detect nose cones or leading edges of wings which have become heated by air friction during high-speed flight. Detectors whose response is at a smaller wavelength would have difficulty detecting these surfaces, which are cooler than the rocket nozzle or the jet exhaust.

Explaining how the system works, Buttrey said that the essential difference between the ARF photodetector system, and a thermal detector is that the former produces a signal upon absorption of radiation which does not depend upon a rise in temperature as an intermediate step.

The two most widely used photo-

detectors are the photoemissive and the photoconductive types. In the photoemissive effect, absorption of a proton of sufficient energy causes an electron to emerge through the surface of the cathode, and be drawn to the anode due to an applied field; hence an increase in current flow is observed in the accompanying circuit.

In the photoconductive effect, the signal is an increase in conductivity when radiation is absorbed. The photoemissive and the photoconductive effect both depend upon the generation of carriers and the interrelation is such that often the photoconductive effect is referred to as inner photoelectric effect. The carriers generated by the absorbed radiation move into a region within the detector in which they absorb energy, and hence, can contribute to the conductivity in an applied field.

The basic elements of the photovoltaic (photoconductive) infrared detector are shown in the diagram on p 68. A photovoltage is generated in the detector using a visible light source by diffusion of neutral energy to the rectifying current.

Infrared radiation in the 10 micron region incident close and parallel to the rectifying contact is absorbed by the particles of neutral energy, and they in turn are ionized. Once ionization has taken place, the electron-hole hair has a negligible diffusion length and, therefore, is stopped.

Thus, by removing neutral energy particles from the total number reaching the junction, one quenches the photovoltage. The infrared radiation is, therefore, detected by quenching of the photovoltaic or photoconductive effect.

Component Applications For Compound Materials

COMPREHENSIVE physical research programs are under way at many companies and universities aimed at further understanding and cataloging the properties of semiconducting compounds. Recent advances in the field indicate many potential component applications for compound materials.

A compound is defined as a homogeneous pure substance composed of two or more elements combined in definite proportions. Physical characteristics of a compound may differ considerably from those of its constituent elements, and materials displaying semiconductivity can be produced by combining elements other than semiconductors.

The elements silicon and germanium, the primary materials of the modern semiconductor industry, are located in group 4 of the periodic table. Properties of the elemental semiconductors have been studied so intensively in recent years that Ge has been called the best understood solid. Compound semiconductor research lagged for many years; strange when you consider that the compound galena, or ZnS, was first used as a detector in crystal receivers.

Present interest in semiconducting compounds stem from their widely varying characteristics. Parameters such as energy band structure, transport and optical phenomena for different compounds cover wide ranges. Eventually it may be possible to assemble a complete family of semiconducting compounds each tailored to a particular application. Compounds probably won't ever replace elemental semiconductors across the board, but they offer promise of increased efficiency in many design areas.

Present research is keyed toward material development; with less emphasis on actual device design and application. The recent Conference on Semiconducting Compounds sponsored by the General Electric Research Laboratory, Schenectady, N. Y., brought together leading researchers.

Papers presented fell into three broad categories: 3-5 compounds, 2-6 compounds, and other semiconducting compounds including the oxides. The numbers 3-5 and 2-6 refer to group headings of the periodic table. For example, the 3-5 compound GaAs is composed of group 3 element Ga and group 5 element As.

Initial work on the 3-5 compounds was done abroad during the early 1950's at the same time U. S. investigators were actively engaged in studying elemental semiconductors. Interest in 2-6 compounds including lead sulfide grew out of cathode ray tube screen phosphor research.

Welded Circuit Techniques

By LLOYD ARMSTRONG
Space Technology Laboratories, Inc.
Los Angeles, Calif.

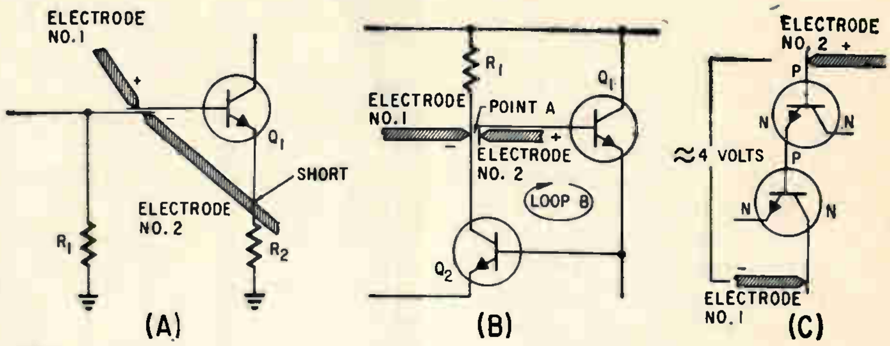


FIG. 1—Care must be taken in welding semiconductor elements to make sure that destructive currents are not generated by the welding voltage. Short at (A) provides a low impedance secondary path through the transistor. Loops as at (B), redrawn in (C), require special attention in welding schedule

WELDED CIRCUIT MODULES offer several significant advantages over conventionally fabricated assemblies. In addition to such important design considerations as increased reliability, lighter weight and reduced size, welded circuitry is less costly to produce and provides tighter control over manufacturing processes.

The greatest benefits are obtained when small or miniature components are used, although welding can also be used with large components, and when repetitious techniques for any given application require specific study.

Indications are that heat sensitive components will be damaged less during assembly by welding than by soldering. Heat is applied for a considerably shorter time in welding and is almost instantaneously dissipated into large copper electrodes. A controlled experiment in which transistor junction temperature was measured showed that temperature during welding (86.9 F) is much lower than dip soldering (115.5 F). In welding, heat is applied for only one to four milliseconds; in soldering, heat is applied for one to 10 seconds, depending on whether dip or hand soldering is used.

Thermal variation is difficult to control in hand soldering. In welding, the settings are determined and adjusted in advance. The operator simply aligns the leads and presses the switch. Presetting minimizes the effects of variations in assemblers' skills. For this reason, and because welded joints are a homogenous fusion of base materials, welded joints are more reliable than soldered joints. Welding also eliminates fluxing, preheating and cleaning.

There is insufficient evidence yet for a detailed cost comparison between welded and soldered assemblies. Cost per connection reductions of 3:1 and 10:1 have been claimed. System cost reduction should be substantial, since printed circuit boards are not required, interconnection is simplified and remakes and rejects are greatly reduced.

Field repair is practical, since portable welding equipment is available. The trend is toward throwaway encapsulated modules. Their replacement is facilitated by welded terminals that can be cut and rewelded, by wire-wrapped terminals, soldered terminals or connectors. Generally, equipment is designed so modules can be cut away from interconnecting wires.

To avoid parts damage during welding, precautions must be taken. Tests performed to determine the voltage present at the electrodes of a typical commercially available welder indicate that a four-volt pulse is not uncommon. Some investigators have found voltages between 5.5 and six volts peak-to-peak during normal welding.

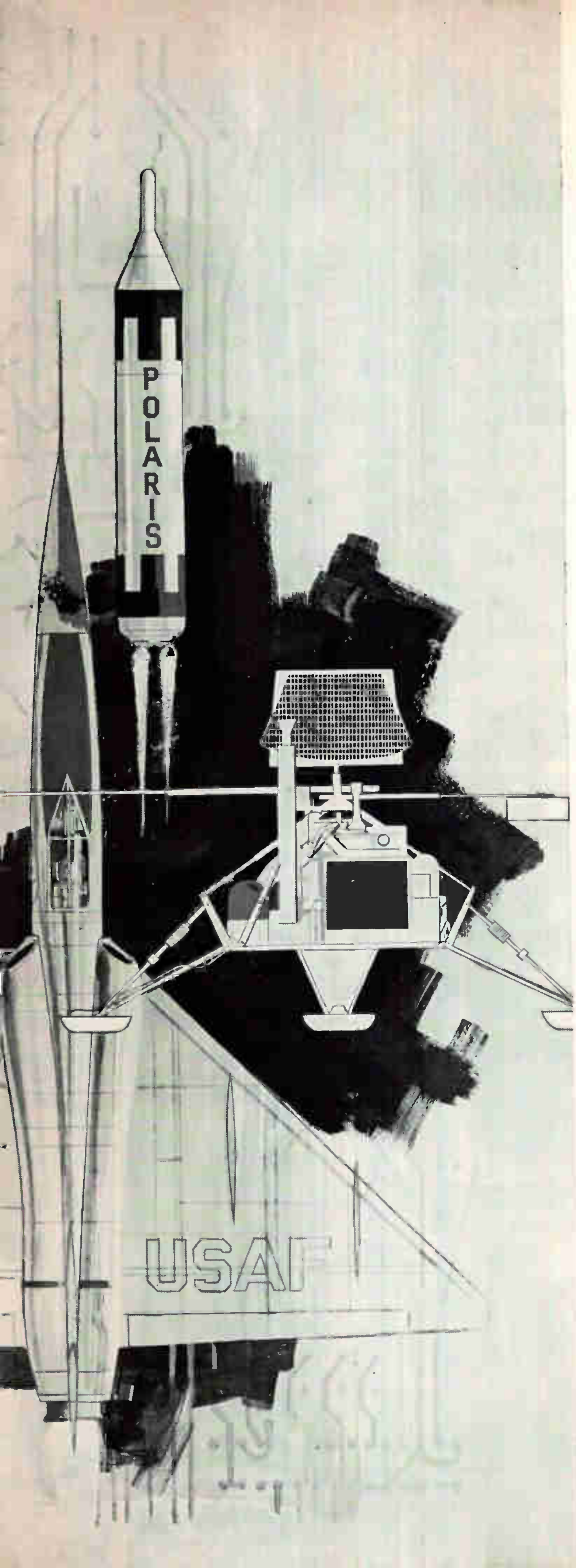
During welding, one or both electrodes may short a component lead. This will not damage such parts as resistors and capacitors. If the polarity of a d-c welder generates a current through the semiconductor junction in the forward direction, or if a-c welding is used, damage is probable.

The short shown in Fig. 1A is caused by accidental contact of an electrode. This can be prevented by electrode design and extreme operator discipline. A better preventative is to insulate all but the tips of the electrodes with a tough insulating material.

Another damage possibility is shown in Fig. 1B. If the connection at point *A* (or at any other point in the loop) is the last weld in loop *B*, and if electrode polarity is as shown, a potential of four volts is possible across the two transistor junction. This is shown more clearly in the simplified circuit of Fig. 1C.

There is no simple solution to this problem. If a d-c welder is used and negative pulse overshoot is small, proper polarization of the electrodes will suffice. If an a-c welder is used, the only absolutely safe way is to use some other method to connect the last point

Space Technology Laboratories has conducted an investigation of welded electronic circuits for ballistic missiles and space vehicles. The study was made for AFBMD (now called Space Systems Div.) under Contract AF 04(647)-610. This article and another to follow summarize portions of the report, STL/TR-60-0000-09178. The report also includes a review of welding methods and equipment, details on process control procedures and discussion of classes of circuits suited to welding



Opportunities for

circuit designers

Requirements of new and continuing projects, such as Surveyor and supersonic interceptor fire control systems have created new openings for circuit designers. The engineers selected for these positions will be assigned to the following design tasks:

1 the development of high power airborne radar transmitters, the design of which involves use of the most advanced components,

2 the design of low noise radar receivers using parametric amplifiers, solid state masers and other advanced microwave components,

3 radar data processing circuit design, including range and speed trackers, crystal filter circuitry and a variety of display circuits,

4 high efficiency power supplies for airborne and space electronic systems,

5 telemetering and command circuits for space vehicles such as Surveyor and the Hughes Communication Satellite,

6 timing, control and display circuits for the Hughes COLIDAR* (Coherent Light Detection and Ranging).

In addition, openings exist for several experienced systems engineers capable of analysis and synthesis of systems involving the type of circuits and components described above.

If you are interested and believe that you can contribute, please airmail your resume to:
Mr. Robert A. Martin, Supervisor, Scientific Employment, Hughes Aerospace Engineering Division, Culver City 81, California.

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We promise you a reply within one week.

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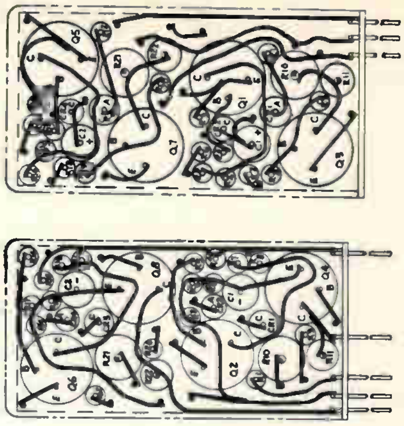


FIG. 2—Circuit interconnections are indicated on the wafer board with photographic techniques. Actual connections are welded.

in such a series loop. The schematic of every circuit to be welded must be examined for such series loops and steps taken to prevent damage.

Welded modules are generally made as three-dimensional assemblies, rather than two-dimensional, with components placed side-by-side in physical contact. Flat ribbon or wire is used for interconnections.

The wafer board with point-to-point wiring is a typical design. Component leads are placed in holes or notches in thin insulating material. Interconnections are made on the exterior surfaces. Patterns can be placed photographically on the wafers to guide assembly and inspection, as in Fig. 2.

Another type uses a welded wire matrix (see, for example ELECTRONICS, p 108, June 30, 1961). An insulating film separates two sets of parallel wires arranged in a right-angle grid. Interconnections are made by welding the wires at crossing points, before components are added. Components may be welded directely to the wiring or to side projections to which wiring has previously been welded. If desired, the wiring pattern and other details can be shown photographically on the insulating film.

Build-on-assemblies give higher parts density than other methods. Transistors or other large components are cemented back to back with leads protruding. Smaller components are cemented or taped to the periphery of this core. Interconnecting wires are welded to the leads, outer leads are added and the cluster is encapsulated. This type of assembly is easy to lay out and provides prototypes rapidly, but the possibility of shorts is high and uniformity of construction may be reduced.

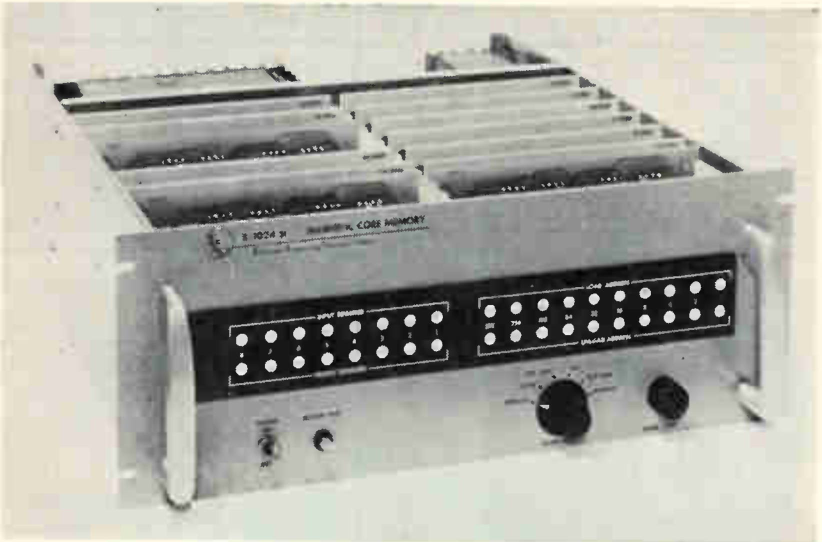
Components may be prepotted before welding. Parts are piled together like logs and encapsulated with the leads extending beyond the plastic. After wiring is welded to the leads, the wiring may be potted also. The potted parts are easier to handle than loose parts and are less likely to be damaged. However, if a part is faulty, it is not easily replaced.

Modules made by any of these methods can be interconnected by matrices, point-to-point wiring, printed wiring boards, wire-wrap connections or connectors. To prevent movement or damage to leads during electrical tests, separate test leads can be welded on and clipped off after testing.

Light Under Table Guides P-C Driller

PRINTED CIRCUIT board drilling with a manually-operated drill press can be done more accurately and quickly when the drill is centered with a point source of strong light. The operator can readily see if the drill point is over the hole position center. A simple way of providing a drill press with a lighted centering point is to drill through the steel table, then mount a reflector-type lamp under the table. The light can be seen clearly through thin stock or glass-based boards. Electronics Associates, Inc., of Long Branch, N. J., uses this technique when the size of a board run does not warrant setup of automatic drilling machines or punch presses.

New On The Market



Magnetic Core Memories
PRICED FROM $10,000 TO $15,000

ELECTRONIC ENGINEERING CO. OF CALIFORNIA, 1601 E. Chestnut Ave., Santa Ana, Calif. The 8-level series of magnetic core memories has a capacity of 128 to 2,048 characters and is available in three types—random access, sequential access, and sequential interlace. Speed is 200 Kc or 5 μsec between load and unload commands. Readout is nondestructive and data remains in the memory until new data is loaded or the ERASE signal is received. Unit uses all solid state circuits on plug-in cards.

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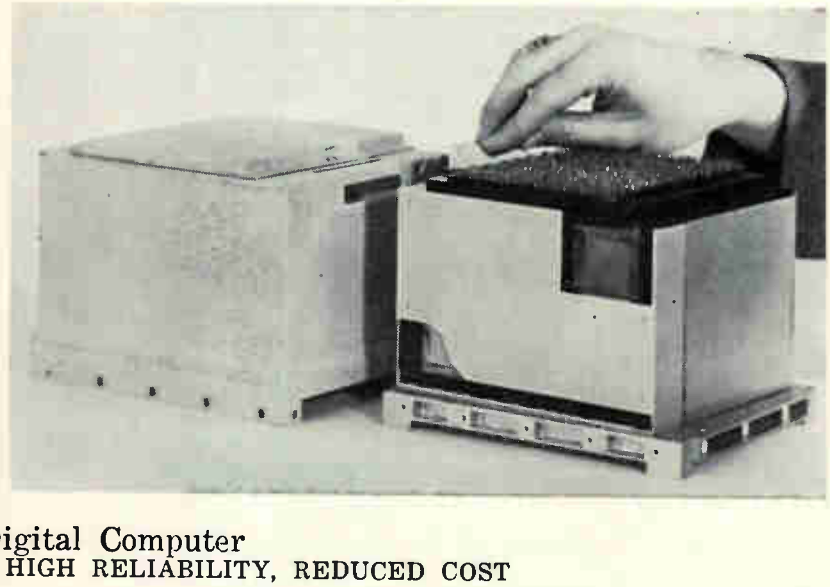

Digital Computer
HIGH RELIABILITY, REDUCED COST

SPERRY GYROSCOPE CO., Great Neck, N. Y. Magnetic digital computer weighs 19 lb and is less than ½ cu ft in the protective case. It can handle more than 12,000 computations a sec for up to 20,000 hr without maintenance. It is suitable for aircraft, missile and space applications. The inexpensive components used enable the company to produce the device at a fraction of the cost of semiconductor equipment.

CIRCLE 302 ON READER SERVICE CARD

Servo Computer
VISUAL READOUT

THE WAYNE KERR LABORATORIES LTD., 44 Coombe Road, New Malden, Surrey, England. Model SA100 computer provides visual readout of transfer functions, eliminating the previous need to calculate back from phase and gain characteristics through tedious mathematical formulas. It deduces over-all performance of a servo package, as well as individual functions. Applications are expected in analysis of inertial navigational guidance systems by the aerospace industry, as well as in other military and commercial electronic systems.

CIRCLE 303 ON READER SERVICE CARD

Autocollimator
ALL SOLID STATE

H H CONTROLS CO., 7 Leroy Drive, Burlington, Mass. Model R29A Refractosyn electronic autocollimator is completely solid-state and maintenance free. Angle-sensor detects motions of less than one second of arc. Unit is designed for ultrasensitive detection in strain, pressure and temperature gages, galvanometers, wattmeters, and many other instruments. Operating life is in excess of two years of total operating time.

CIRCLE 304 ON READER SERVICE CARD

Transistor
LOW NOISE FIGURE

FAIRCHILD SEMICONDUCTOR, 545 Whisman Rd., Mountain View, Calif. The 2N2049 transistor has a maximum guaranteed noise figure of 3 db. It features high gain (h_{FE}, I_C 100 μa, V_{CE} 10 v guaranteed 60

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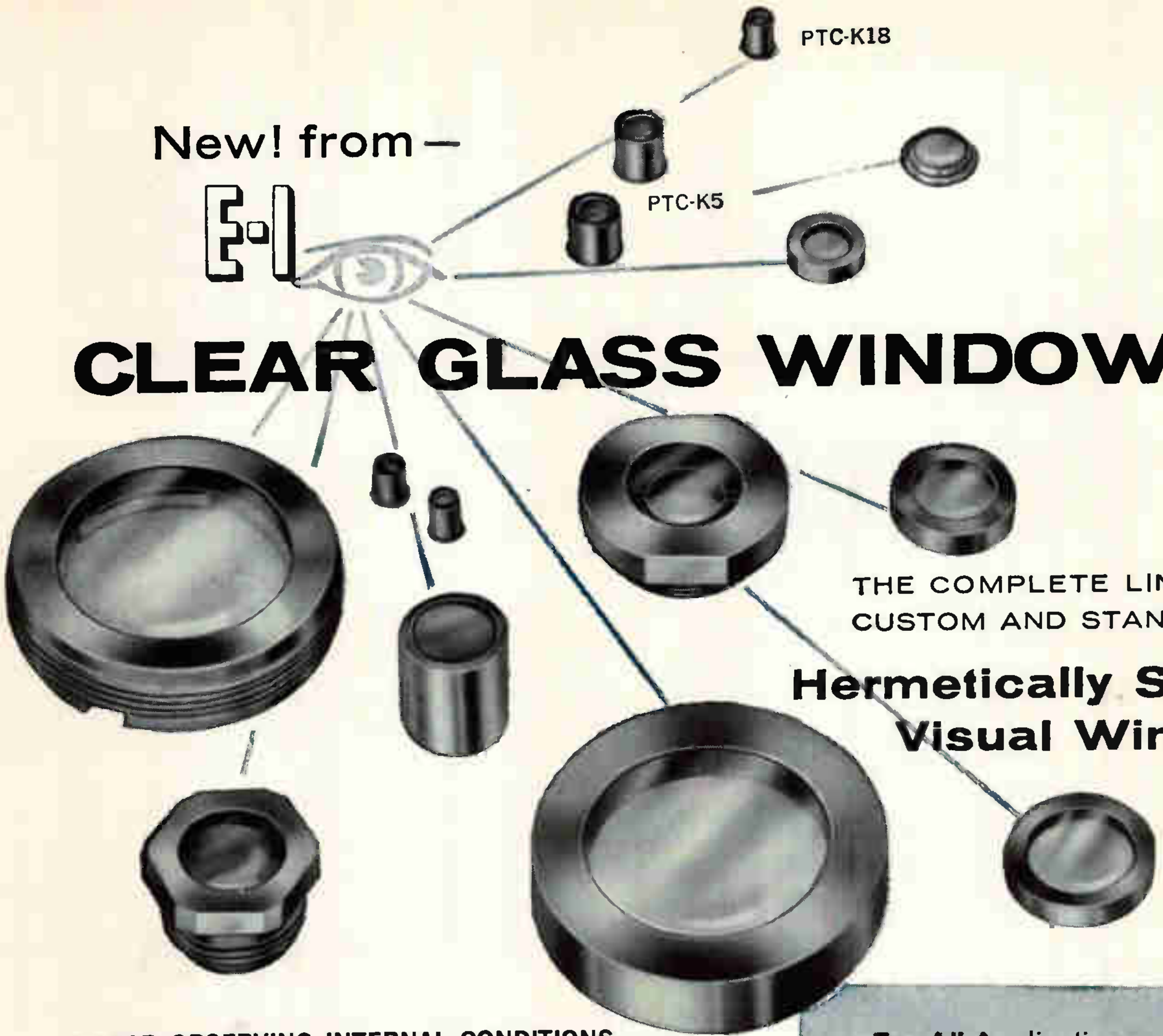
E-I

CLEAR GLASS WINDOWS



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Mechanical strength up to 10,000 P.S.I. depending on design and application; various finishes available, as well as special shapes and sizes.

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minimum) and the extremely low leakage and high reliability of the company's planar process. Transistor is suited to audio amplifier applications as well as differential and d-c amplifiers. Price: $24 in 1-99 lots, $16 in 100-999 quantities.

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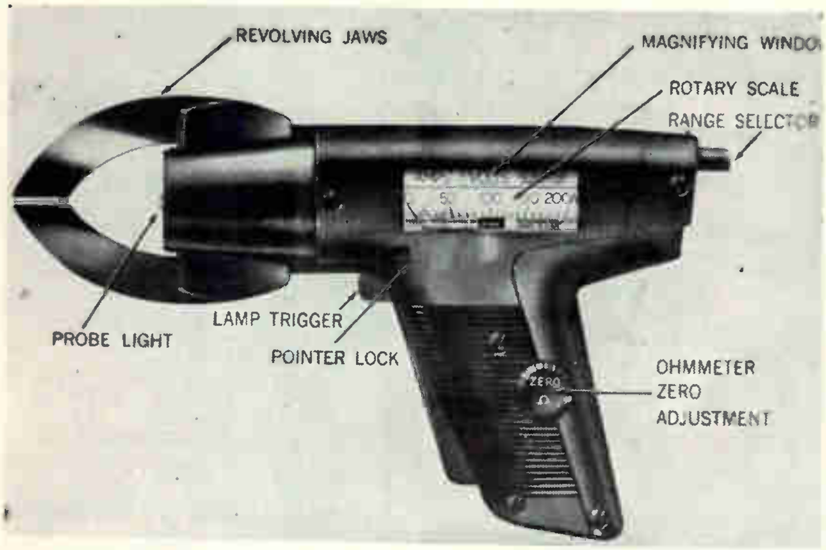


Test Meter
FOR TIGHT SPOTS

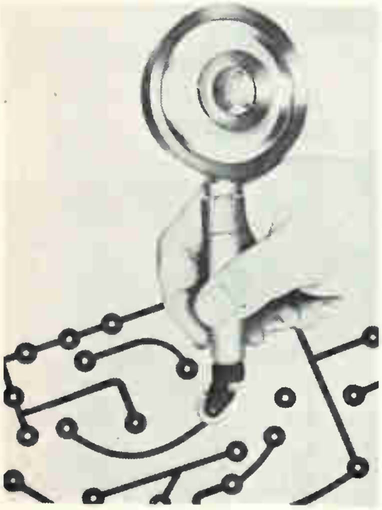
FEDERAL PACIFIC ELECTRIC CO., 50 Paris St., Newark, N. J. Pistol shape of new test meter allows one-hand operation and provides ease and safety in tight spots. This Pistolmeter has two voltage scales, four current ranges and two ohmmeter ranges. Accuracy and long life are assured by the unit's sturdy casing, printed circuitry and an advanced design coremagnet movement. A rechargeable battery reduces maintenance costs.

CIRCLE 306 ON READER SERVICE CARD

Lab Electromagnet
12 KILOGAUSS

MAGNION, INC., 195 Albany St., Cambridge 39, Mass. The UFS-3 is an optimized geometry iron bound air core solenoid suitable for many uses such as Zeeman effect, magneto-optics, Faraday effect and magnetic materials research. It is bored to provide both horizontal and vertical access to the gap. Its removable plug type pole pieces may themselves be bored for axial gap access as well. It is capable of producing up to 12 kilogauss over a working volume of 2 in. diameter by 1 in. wide gap with its poles installed.

CIRCLE 309 ON READER SERVICE CARD



Tape Pen
SAVES DRAFTING TIME

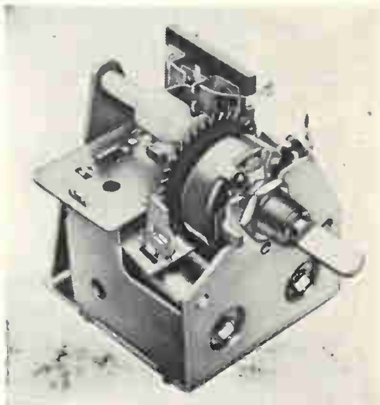
W. H. BRADY CO., 727 W. Glendale Ave., Milwaukee 9, Wis. The Quik Line tape pen is a drafting instrument for fast, accurate applications of self-sticking tapes to p-c masters, technical illustrations, etc. Straight, curved or irregular lines from 1/32 in. to 3/16 in. wide can be applied. Tape pen requires no filling until the entire roll of tape is used. Corrections are made fast. Simply lift up the misplaced tape and replace it.

CIRCLE 307 ON READER SERVICE CARD

Limit Switch
HIGH RELIABILITY

TEXAS INSTRUMENTS INC., P. O. Box 66027, Houston 6, Texas. The Statronic limit switch features solid state electronics and high reliability. A life test that commenced several months ago is continuing with the switch nearing 40 million trouble-free cycles. High reliability makes it suitable for position indicating and limiting, safety interlocks and similar applications. Operating temperature range is from 0 to 200 F.

CIRCLE 308 ON READER SERVICE CARD

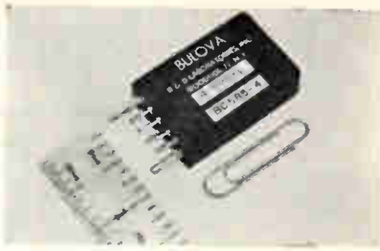


Pot/Switch
STEP-DRIVEN

CTS CORP., Elkhart, Ind., has combined a 15/16 in. diameter variable resistor on-off switch and 2-directional stepping device into a single compact unit, series 720, for tv, radio and other electronic equipment remote control applications. Fine control adjustment is achieved by pulsed input to either of 2 electromagnets. Nominal operating pulse is 25 ma and 75 millisec dura-

tion. Resistance of each coil is 5,400 ohms.

CIRCLE 310 ON READER SERVICE CARD



Four-Binary Module
MINIATURIZED

BULOVA RESEARCH & DEVELOPMENT LABORATORIES, 62-10 Woodside Ave., Woodside 77, N. Y., has developed a time interval counter module for military computer and counter applications. The 4-binary module was designed to meet or exceed MIL-E-5400 and MIL-E-5272. Unit operates at frequencies from d-c to 1 Mc, and can divide the input count by any number from 9 through 16 by interchanging bus connections. It is fully potted and weighs 1 oz.

CIRCLE 311 ON READER SERVICE CARD

Shift Register Bit

MAGNETICS RESEARCH CO., INC., 179 Westmoreland Ave., White Plains, N. Y., announces a microminiature magnetic shift register bit for missiles.

CIRCLE 312 ON READER SERVICE CARD

Relay Socket
MICROMINIATURE

BRANSON CORP., 41 S. Jefferson Rd., Whippany, N. J. Microminiature socket assembly No. 2999 is designed to fit the type AR 4-pole relay. It features a fiber glass filled diallyl FS5 body and terminals of heat treated beryllium copper with gold over silver plate. With a temperature range from −65 to +125 C, the units have a dielectric strength of 1,500 v rms between terminals. The 14 socket holes are numbered and have standard 0.1 in. spacing.

CIRCLE 313 ON READER SERVICE CARD

R-F Attenuators

ORTHO FILTER CORP., 7 Paterson St., Paterson 2, N. J. Variable step r-f attenuator line features high reliability, d-c to 500 mc range.

CIRCLE 314 ON READER SERVICE CARD

Capacitors

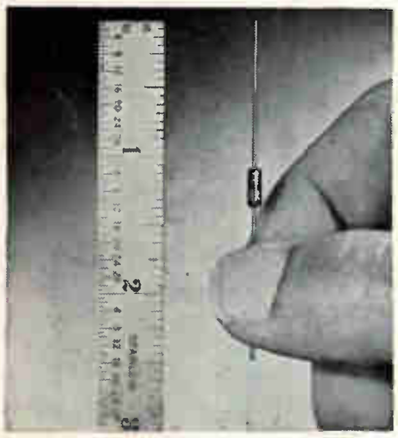
DEARBORN ELECTRONIC LABORATORIES, INC., P. O. Box 3431, Orlando, Fla. Hi-Pak high energy storage capacitors reduce self-inductance, series resistance.

CIRCLE 315 ON READER SERVICE CARD

Lab Power Supply

PERKIN ELECTRONICS CORP., 345 Kansas St., El Segundo, Calif. A 28-v 50-amp laboratory d-c power supply provides the dynamic regulation required by load transistors.

CIRCLE 321 ON READER SERVICE CARD



Glass Zener Diodes

JEDEC TYPES

INTERNATIONAL RECTIFIER CORP., 233 Kansas St., El Segundo, Calif. Two series of subminiature 250 mw glass Zener diodes provide very sharp Zener knees and excellent voltage regulation over the temperature range from −55 to +150 C. Types 1N1313-1320 span the 8.2 to 33 v range; 1N1927-1937 range from 3.9 to 27 v. All units possess low temperature coefficients (to 0.060 percent/deg C) and low impedance values (to 8 ohms at 10 ma) assuring optimum voltage characteristics and high regulating efficiency.

CIRCLE 322 ON READER SERVICE CARD

Wirewound Pot

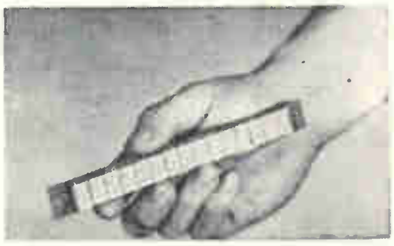
VOGUE INSTRUMENT CORP., 2350 Linden Blvd., Brooklyn 8, N. Y. Single-turn, infinite resolution-wirewound potentiometer has 0.01 percent linearity.

CIRCLE 323 ON READER SERVICE CARD

Polarimeter

DAYTON ELECTRONIC PRODUCTS CO., 915 Webster St., Dayton 4, O. An instantaneous microwave polarimeter determines polarization characteristics of S or X band radio frequencies.

CIRCLE 324 ON READER SERVICE CARD



Delay Lines
SECTIONALIZED

NYTRONICS, INC., 550 Springfield Ave., Berkeley Heights, N. J., announces WeeLines, sectionalized delay lines with each section designed and manufactured to be a discreet value of delay time. The total number of sections of the delay line determines the overall delay time. The total number of sections is a function of the delay to rise time ratio. WeeLines reduce the problem of meeting circuit delay line requirements to a simple ordering process for the engineer.

CIRCLE 325 ON READER SERVICE CARD

Converter

GENERAL DATA CORP., 11602 Ninth St., Garden Grove, Calif. Analog-to-digital converter is 0.5 percent accurate; conversion time is ½ μsec; cost, $750.

CIRCLE 326 ON READER SERVICE CARD

Time Delay Relay
VOLTAGE COMPENSATED

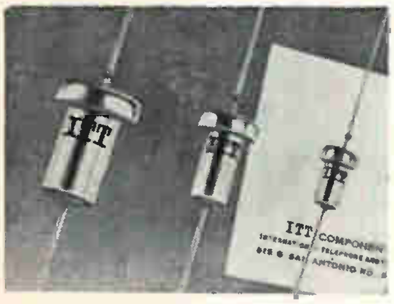
BRANSON CORP., 41 So. Jefferson Road, Whippany, N. J. Subminiature time delay relay offers instant recycling with 100 percent recovery of the pre-set delay time. Circuit design provides voltage compensation for both a-c and d-c in a range from 6 to 115 v. Delay time is factory pre-set at from 15 to 300 sec and the unit provides high accuracy.

CIRCLE 327 ON READER SERVICE CARD

Ferrite Core Memory

AMPEX COMPUTER PRODUCTS CO., P. O. Box 329, Culver City, Calif. The RQA has a 5 μsec memory cycle with an access time of 2.0 μsec, buffer cycle of 2.5 μsec.

CIRCLE 328 ON READER SERVICE CARD



Tantalum Capacitor
WET-ANODE

INTERNATIONAL TELEPHONE AND TELEGRAPH CORP., 815 S. San Antonio Rd., Palo Alto, Calif., announces type-Q wet-anode tantalum capacitors. They exceed the requirements of MIL-C-3965-B. Standard life expectancy is 3,000 hr. Units are available in standard capacitance tolerances of ± 10, ± 20, and + 50, − 15 percent. They are supplied in three case sizes with capacitance values ranging from 1.7 to 330 μf.

CIRCLE 329 ON READER SERVICE CARD

PRODUCT BRIEFS

ULTRAMINIATURE GEARMOTORS permanent magnet type. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, O. (330)

WAVEGUIDE ISOLATORS very high power. Airtron, 200 E. Hanover Ave., Morris Plains, N. J. (331)

TEN-TURN A-C POT high accuracy, low cost. Perkin-Elmer Corp., Norwalk, Conn. (332)

TIME DELAY RELAY for microminiature applications. Guardian Electric Mfg. Co. of California, Inc., 5575 Camille Ave., Culver City, Calif. (333)

PANEL INSTRUMENTS flush-mounting. Daystrom, Inc., Weston Instruments Division, Newark 12, N. J. (334)

DYNAMIC DIODE TESTER 2-Kv unit. Ling-Temco Electronics, Inc., P. O. Box S-1, Anaheim, Calif. (335)

PROGRAM RELAY versatile, dependable. Cornell-Dubilier Electronics, Fuquay Springs, N. C. (336)

TELEMETER RECEIVER 4-in. chart width. The Bristol Co., Waterbury 20, Conn. (337)

PROPELLER FANS two models for ventilating electronic racks. McLean Engineering Laboratories, Princeton, N. J. (338)

SINGLE SHOT MULTIVIBRATORS four adjustable sections. Ransom Research, Inc., 374 W. Eighth St., San Pedro, Calif. (339)

S-BAND PARAMETRIC AMPLIFIER high gain. Motorola Inc., 3102 N. 56th St., Scottsdale, Ariz. (340)

VHF TRANSISTOR silicon epitaxial mesa. Motorola Semiconductor Products Inc., 5005 E. McDowell Road, Phoenix 8, Ariz. (341)

MOLECULAR SLIDE RULE silicon multiplier-divider. Westinghouse Electric Corp., 3 Gateway Center, Pittsburgh 22, Pa. (342)

MICROCOMPONENTS KITS for the design engineer. P. R. Mallory & Co. Inc., Indianapolis 6, Ind. (343)

D-C POWER SUPPLY high-voltage. NJE Corp., 20 Boright Ave., Kenilworth, N. J. (344)

CIRCLE 85 ON READER SERVICE CARD

Literature of the Week

MAGNETIC METALS Magnetic Metals Co., Hayes Ave. at 21st St., Camden, N. J., has published a 40-page booklet on high permeability magnetic metals. **(345)**

NANOSECOND INSTRUMENTATION Lumatron Electronics, Inc., New Hyde Park, N. Y. A 6-page catalog covers a line of production and laboratory test equipment designed for use in semiconductor, computer, and h-f applications. **(346)**

GRAPHITE PRODUCTS Carbide Mold Service, Inc., P. O., Box 3111, Waterbury 5, Conn. An information bulletin announces the availability of custom-made graphite products for use in the electronics, missile, aircraft and other industries. **(347)**

RELAY SPECIFICATIONS Branson Corp., 41 South Jefferson Road, Whippany, N. J. A specification sheet on the transistor sized general purpose relay type JR is available. **(348)**

INTERVAL TIMERS Electro-Seal Corp., 938 North Ave., Des Plaines, Ill., has prepared bulletin 6151 describing the Electro-Time line of electronic industrial interval timers. **(349)**

CONTROL PANELS Bodnar Products Corp., 238 Huguenot St., New Rochelle, N. Y. A four-page brochure describes a line of illuminated plastic control panels for the aviation, electronics and computer industries qualified to MIL-P-7788A. **(350)**

DIGITAL DATA SYSTEM Monitor Systems, Inc., Fort Washington Industrial Park, Fort Washington, Pa. Brochure describes series 7000 digital data recording and alarm scanning system. **(351)**

CAPACITORS Corson Electric Mfg. Corp., 540 39th St., Union City, N. J., offers bulletin No. 106 on the type GS capacitors for radio frequency and pulse work. **(352)**

CABINET COOLERS Kooltronic Fan Co., P.O. Box 504, Princeton, N. J. A 12-page catalog covers a complete line of compact electronic cooling fans and blowers. (353)

FEEDBACK CONTROL Boonshaft and Fuchs, Inc., Hatboro Industrial Park, Hatboro, Pa. Six-page control equipment brochure illustrates and gives brief descriptions of high-performance feedback control hardware. (354)

COOLING EQUIPMENT McLean Engineering Laboratories, P.O. Box 228, Princeton, N. J. A line of packaged blowers, propeller fans, centrifugal blowers, ring fans and accessory items is presented in a 48-page catalog. (355)

MICROWAVE INSTRUMENTS Melabs, 3300 Hillview Ave., Stanford Industrial Park, Palo Alto, Calif., has issued a 6-page condensed catalog providing general data and key specifications on its line of microwave instrumentation and components. (356)

H-V POWER PACKS Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N. J. Catalog sheet No. 124 covers a line of miniaturized solid state high voltage power packs. (357)

INSTRUMENT CALIBRATOR Sensitive Research Instrument Corp., New Rochelle, N. Y. Volume 28, No. 7 of *Electrical Measurements* covers Pocketpot, a miniaturized pocket size potentiometer. (358)

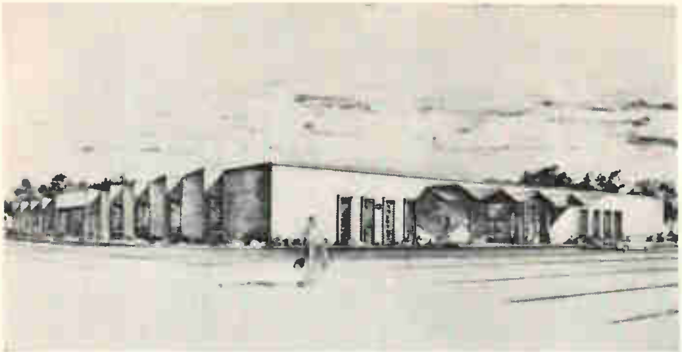
ULTRASONIC MICROPHONE Erie Resistor Corp., 644 W. 12th St., Erie, Pa. Ulstrasonic receiving or transmitting microphones utilizing piezoelectric barium titanate free edge transducers are described in bulletin 513. (359)

FILTERS Erie Resistor Corp., 644 W. 12th St., Erie, Pa. A line of high frequency, low pass filters is described in bulletin 512. (360)

BASIC SWITCHES Micro Switch, Freeport, Ill. Data sheet 190 describes a 22-ampere steady state current capacity switch. (361)

D-C POWER SUPPLY Perkin Electronics Corp., 345 Kansas St., El Segundo, Calif., has issued a mailing piece on a 0-40 v at 500 ma d-c power supply. (362)

DECADE COUNTER Robotomics, Inc., 2422 E. Indian School Rd., Phoenix 16, Ariz. Four-page technical bulletin describes solid state F1601 portable 12-v decade counter with in-plane display. (363)



IEC Adds Computer Building

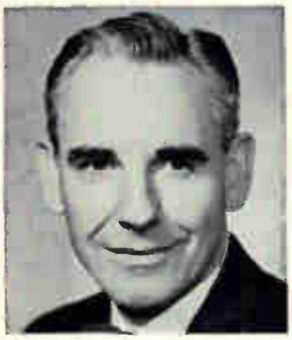
CONSTRUCTION is well underway on a new building to house the computer operations of International Electric Corp. It is the fifth building to be added to the company's Paramus, N. J., facilities.

An associate of International Telephone and Telegraph Corp., IEC was organized three years ago as systems manager for the development of the Strategic Air Command Control System, Project 465-L. The opening of the new computer center will mark IEC's first full-scale effort in the commercial data processing field within the United States.

The 55,000 sq ft addition will house a 7090 computer now on order as well as the company's computer programming staff which is comprised of over 150 specialists. Scheduled for completion next month, the new building will bring the company's available office and equipment space to 176,000 sq ft.

IEC has established a computer applications department within its marketing organization which will be responsible for the industrial market in programming, systems analysis, operation research and computer time.

Martin H. Dubilier, IEC president, said "With the opening of the center, our company will begin a full-scale effort directed at applying our data handling capabilities to private industry and non-military government agencies."



Research Group Hires Welcome

APPOINTMENT of Warren W. Welcome as a staff consulting engineer has been announced by Don Lebell Associates, research engineering group in Sherman Oaks, Calif. He comes to the firm from the Perkin-Elmer Co.

The consulting activity of the Don Lebell Associates group is specialized in the fields of design and analysis of control systems, instrumentation, data handling and circuitry, plus specialized technical consulting to management.

Set Up New Company In Massachusetts

INDELCO INC. (Industrial Electrophoretic Coatings), a new company, has set up a laboratory and offices in Beverly, Mass., for production and consultant work on application of the electrophoresis process to coatings for electronic and other industrial components.

The company was started by three former employees of the Sylvania Lighting Division: John L. Harrigan, Edward D. Parent Jr., and Arthur W. Dolan.

Covely Joins Hughes Group

FRANK D. COVELY has been appointed special projects manager for Hughes Aircraft Company's communications division, Los Angeles, Calif.

Before joining Hughes, Covely was surface communications manager for RCA in Camden, N. J.

Hazeltine Elects Board Chairman

DIRECTORS of Hazeltine Corp., Little Neck, N. Y., have announced the election of Webster H. Wilson as chairman of the board. Wilson, who is also president and chief executive officer of the electronics firm, succeeds W. A. MacDonald, who passed away recently.

The chairman and president joined Hazeltine in 1946 and was elected a director in 1958 and president in 1960.

Mallory Capacitor Promotes Boles

THE MALLORY CAPACITOR CO., a division of P. R. Mallory & Co., Inc., has appointed M. E. Boles manager of its plant in Greencastle, Ind. He will be responsible for all manufacturing operations of Mallory tan-

talum capacitors, which have been housed in the plant since its construction in 1960.

Boles has been superintendent of the Greencastle plant since April.

Saline Transfers To New Position

APPOINTMENT of Lindon E. Saline as manager of the specialty devices operation of the General Electric Company's defense systems department in Syracuse, N. Y., is announced.

Saline formerly was manager of the defense systems department's information systems section, Bethesda, Md.

Adler Electronics Advances Kaye

HAROLD W. KAYE has been named to the new position of technical assistant to the vice president and general manager of Adler Electronics, Inc., New Rochelle, N. Y.

Formerly manager of customer liaison in the military products division, Kaye also has served as engineering project manager during his ten years with Adler.

Bendix Executive Takes New Post

ROY J. SANDSTROM, general manager of the Bendix Systems division in

Ann Arbor, Mich., has been promoted to broader executive responsibilities at the Bendix Mishawaka, Ind., division.

Sandstrom replaces R. E. Whiffen, who recently was named general manager of Bendix Products—Aircraft division in South Bend, Ind.

Name Butterfield Chief Engineer

APPOINTMENT of Frank E. Butterfield as chief engineer of the Electronic Defense Laboratories (EDL) of Sylvania Electric Products Inc., Mountain View, Calif., is announced. He will continue to head EDL's equipment engineering laboratory in addition to his duties as chief engineer.

Surprenant Elects Alexander V-P

ELECTION of Donald C. Alexander as vice president-engineering of Surprenant Mfg. Co., Clinton, Mass., has been announced.

For the past nine years, Alexander has been chief engineer of the company, a subsidiary of ITT.

Nathan Snyder Joins Royal Research Corp.

NATHAN W. SNYDER has joined Royal Research Corp. of Hayward, Calif., a subsidiary of Royal Industries, Inc., of Los Angeles, as vice president and director of research and engineering.

Snyder was formerly with the Institute for Defense Analysis and has served as a scientific advisor to various government agencies on aerospace and nuclear problems.

Donner To Manage Additional Lab

APPOINTMENT of John B. Donner as manager of the microwave and antenna laboratory at the Waltham Laboratories of Sylvania Electric Products Inc., is announced.

With Sylvania since 1953, in March of this year Donner was appointed manager of the advanced development laboratory, a position which he will continue to hold jointly with his new responsibilities.

Lillibridge Joins Consultant Group

EDWARD H. LILLIBRIDGE, formerly assistant program manager for Litton Systems, has joined Marc Shiowitz & Associates, Inc., computer consultants in Hawthorne, Calif.

In his position as a senior consultant with MS&A, he will assist clients in the application of advanced computer technology in various military systems.

Invac Corporation Names Plaisance

STANLEY PLAISANCE was recently named vice president of engineering of Invac Corp., Natick, Mass.

Prior to joining Invac last year as chief engineer, Plaisance was a senior project engineer at the Anelex Corp. of Boston, Mass.

Invac designs and manufactures advanced peripheral data processing equipment and systems, including paper tape perforators and punches, tape readers and data processing system keyboards.

PEOPLE IN BRIEF

Walter R. Hicks, formerly president of Reevesound Co., Inc., is appointed vice president in charge of special projects for Reeves Soundcraft Corp., the parent company. **John N. Dempsey** moves up at Minneapolis-Honeywell to director of its research center and associate director of over-all research activities. **William D. Hogan** is promoted to manager of engineering services for Sylvania's semiconductor division. **Alex W. Warner**, ex-Detroit Gasket and Mfg. Co., has been elected v-p and g-m of Dytronics, Inc. **Dale E. St. John** is elevated to director of advanced development, communication and data systems, at Arnoux Corp. With Wyle Laboratories since 1956, **Lee N. Mortenson** is named manager, research and analysis department. **Richard K. Mosher** is advanced to vice president in charge of the systems division of LFE Electronics. Polarad Electronics Corp. promotes **Herbert W. Pollack** to engineering manager. **Russell T. Dean**, with the company since January, becomes chief engineer of Stackpole's resistor engineering dept. **Joe S. Kirk** leaves Sandia Corp. to rejoin National Electronics, Inc., as manager of commercial engineering. **Neal Pike**, formerly with Bell Labs and MIT Lincoln Lab staffs, is appointed lab director for Prodelin, Inc. **Donald P. Allen** moves up to manager of the products dept., tape unit division, Ampex Computer Products Co.

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electronics

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The advertisers listed here are seeking professional experience. Fill in the Qualification Form below.

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WHAT TO DO

1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *Please print clearly.*
6. Mail to: D. Hawksby, Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

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ERIE ELECTRICS DIV. Erie Resistor Corp. Erie, Pa.	96	2
ESQUIRE PERSONNEL Chicago, Illinois	96	3
THE GARRETT CORPORATION AiResearch Manufacturing Division Los Angeles, California	116*	4
HUGHES AEROSPACE ENGINEERING DIV. Hughes Aircraft Company Culver City, California	73	5
LITTON SYSTEMS INC. Data Systems Div. Canoga Park, California	32	6
LITTON SYSTEMS INC. Guidance & Control Systems Division Woodland Hills, California	101*	7
MOTOROLA INC. Military Electronics Div. Western Center Scottsdale, Arizona	117*	8
PAN AMERICAN WORLD AIRWAYS INC. Guided Missiles Range Div. Patrick AFB, Florida	29*	9
PERKIN-ELMER CORP. Norwalk, Connecticut	96	10
PHILCO WESTERN DEVELOPMENT LABS. Palo Alto, California	115*	11
POLYPHASE INSTRUMENT CO. Bridgeport, Pa.	96	12
REPUBLIC AVIATION CORP. Farmingdale, L. I., New York	95	13
TELEREGISTER CORPORATION Stamford, Connecticut	118*	14
TROPICAL RADIO TELEGRAPH CO. Hingham, Mass.	117*	15
P-7374	117*	16

*These advertisements appeared in the 9/15/61 issue.

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electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME ....

HOME ADDRESS..

CITY.......................... ZONE...... STATE...........

HOME TELEPHONE..

Education

PROFESSIONAL DEGREE(S)..

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check) 9221

☐ Aerospace	☐ Fire Control	☐ Radar
☐ Antennas	☐ Human Factors	☐ Radio—TV
☐ ASW	☐ Infrared	☐ Simulators
☐ Circuits	☐ Instrumentation	☐ Solid State
☐ Communications	☐ Medicine	☐ Telemetry
☐ Components	☐ Microwave	☐ Transformers
☐ Computers	☐ Navigation	☐ Other ....
☐ ECM	☐ Operations Research	☐ ....
☐ Electron Tubes	☐ Optics	☐ ....
☐ Engineering Writing	☐ Packaging	☐ ....

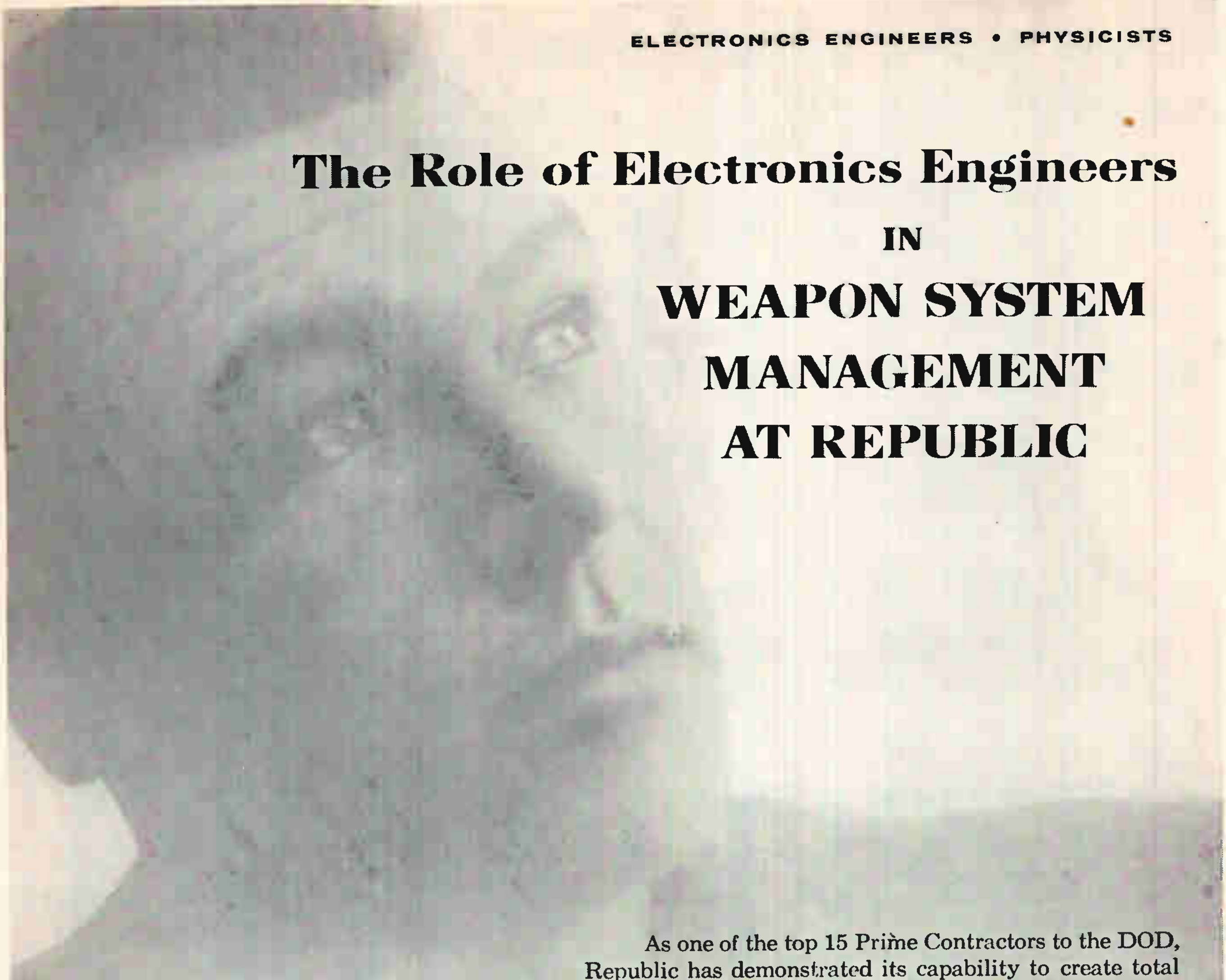
CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines.

	Technical Experience (Months)	Supervisory Experience (Months)
RESEARCH (pure, fundamental, basic)	......	......
RESEARCH (Applied)	......	......
SYSTEMS (New Concepts)	......	......
DEVELOPMENT (Model)	......	......
DESIGN (Product)	......	......
MANUFACTURING (Product)	......	......
FIELD (Service)	......	......
SALES (Proposals & Products)	......	......

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25



ELECTRONICS ENGINEERS • PHYSICISTS

The Role of Electronics Engineers

IN

WEAPON SYSTEM MANAGEMENT AT REPUBLIC

As one of the top 15 Prime Contractors to the DOD, Republic has demonstrated its capability to create total aircraft, missile, and space vehicle systems. Electronics is an important part of this capability.

Over 250 Electronics Engineers and Scientists at Republic are extending parameters in communications, navigation, guidance & control, detection and data handling. A recent prime contract award has placed special emphasis on reconnaissance. As Weapon System Manager, Republic is responsible for developing this capability for its F-105D "flying electronic platform," the free world's most versatile and sophisticated manned weapon system.

Defining system requirements, conducting analytical studies, evaluating overall design, and monitoring progress of subcontractors are engineering tasks requiring broad technical knowledge and high analytical ability. Difficult problems in subsystem integration, density packaging, and reliability must be solved.

Inquiries are invited from Electronics Engineers and Physicists with experience in: Radar (front & side looking) / Infrared & Optical Systems / Antennas & Radomes / Digital Computers & Data Links / Flight & Fire Control Systems / High Speed Tape Recorders / Aerospace Ground Support Equipment.

Opportunities are at 2 Republic Locations: Farmingdale and Mineola, Long Island, N. Y.
Write to:

Mr. George R. Hickman
Technical Employment Manager
Dept. 11J-4
Republic Aviation Corporation
Farmingdale, Long Island, N.Y.

Mr. Paul Hartman
Technical Employment
Dept. 11J-4A
Missile Systems Division
Republic Aviation Corporation
223 Jericho Turnpike
Mineola, Long Island, N.Y.

All programs are backed by the 8 laboratories of Republic's new Paul Moore Research & Development Center, the only fully integrated research complex exploring every vital aspect of the aerospace technology.

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These are permanent career opportunities that allow fullest utilization of engineering talents.

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Project engineer to design and build complex scientific laboratory instruments. Experience in gas chromatography desirable. Position requires keen technical understanding and an ability to design equipment suitable for manufacture. Requires BS degree in engineering, physics or chemistry plus a minimum of 8 years' related experience.

• ADVANCED DEVELOPMENT

Assume responsibility for developing special process for fabricating components of analytical instruments. Requires skills in design, development and testing of electro-mechanical devices, sub-miniature assemblies, unconventional materials and methods. Requires technical degree plus a minimum of 10 years' experience.

• SPECIAL LABORATORY INSTRUMENTS

Project engineer to design, build and test complex electro-optical scientific laboratory instruments. Work requires sound technical understanding and a practical ability to produce hardware. Requires bachelor degree in EE or Physics; advanced degree preferred, plus 5 years' designing and building electro-optical scientific laboratory instruments.

At Perkin-Elmer you will find a liberal fringe benefit program and excellent advancement opportunities.

Please forward your resume to Howard M. Moran, Employment Manager

Perkin-Elmer *Corporation*

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An equal opportunity employer

PRODUCTION ENGINEER

$10,000.00 up

Industrial engineer, experienced in production methods and processes for magnetic electronic components such as Filters, Delay Lines, Magnetic Amplifiers, Specialty Transformers, etc.

Location—Suburban Philadelphia
Call collect BRoadway 9-4660 or write to arrange for interview.

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Bridgeport, Pa.

SOLID STATE PHYSICIST

National leader in plumbing and heating recognized for technical excellence requires Solid State Physicist. Design and pursue new product investigations for thermo-electric devices, control circuits and novel solutions of industry's projects. To $16,000 per year.

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Research and design electronic controls, instrumentation and components. Work with Solid State Physicist. To $12,000 per year.

Fees Paid on above positions.

Send resume to M. L. Baas

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With experience in the design and development of Hi-Frequency and Pulse transformers for commercial and military applications.

Ideal opportunity for ambitious man to develop full potential of present small department. Salary—open. Location—Erie, Pa. Call or send resume to Chief Engineer

Erie Electronics Division

Erie Resistor Corporation

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GL 6-8592

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$8,000 ta $18,000 Year

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AN/FPN-32GCA. AN/APS-10 NAVIG. & WEATHER.
AN/APS-15B PRECISION. AN/APQ-35B PRECISION.
AN/APS-31A SEARCH. DOZENS MORE.
.5-1-2 MEGAWATT HIGH POWER PULSERS.
MICROWAVE PLUMBING—TEST EQUIP.
LARGEST RADAR STOCK IN U.S.A.
RADIO RESEARCH INSTRUMENT CO.
550 Fifth Ave. New York Judson 6-4691

RADAR SYSTEMS & COMPONENTS / IMMEDIATE DELIVERY

CIRCLE 460 ON READER SERVICE CARD

$10.95 Complete

Color Dial Telephones

Factory rebuilt Western Electric in white, beige, ivory, pink, green or blue. If 4 prong plug is required add $2.00. Fully guaranteed. Write for free list. All shipments FOB.

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CIRCLE 461 ON READER SERVICE CARD

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$10,000.00 up

3 Senior Engineers needed, each to be completely responsible for the development of products in one of the following fields:

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- MAGNETIC AMPLIFIERS
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Location—Suburban Philadelphia
Call collect BRoadway 9-4660 or write to arrange for interview.

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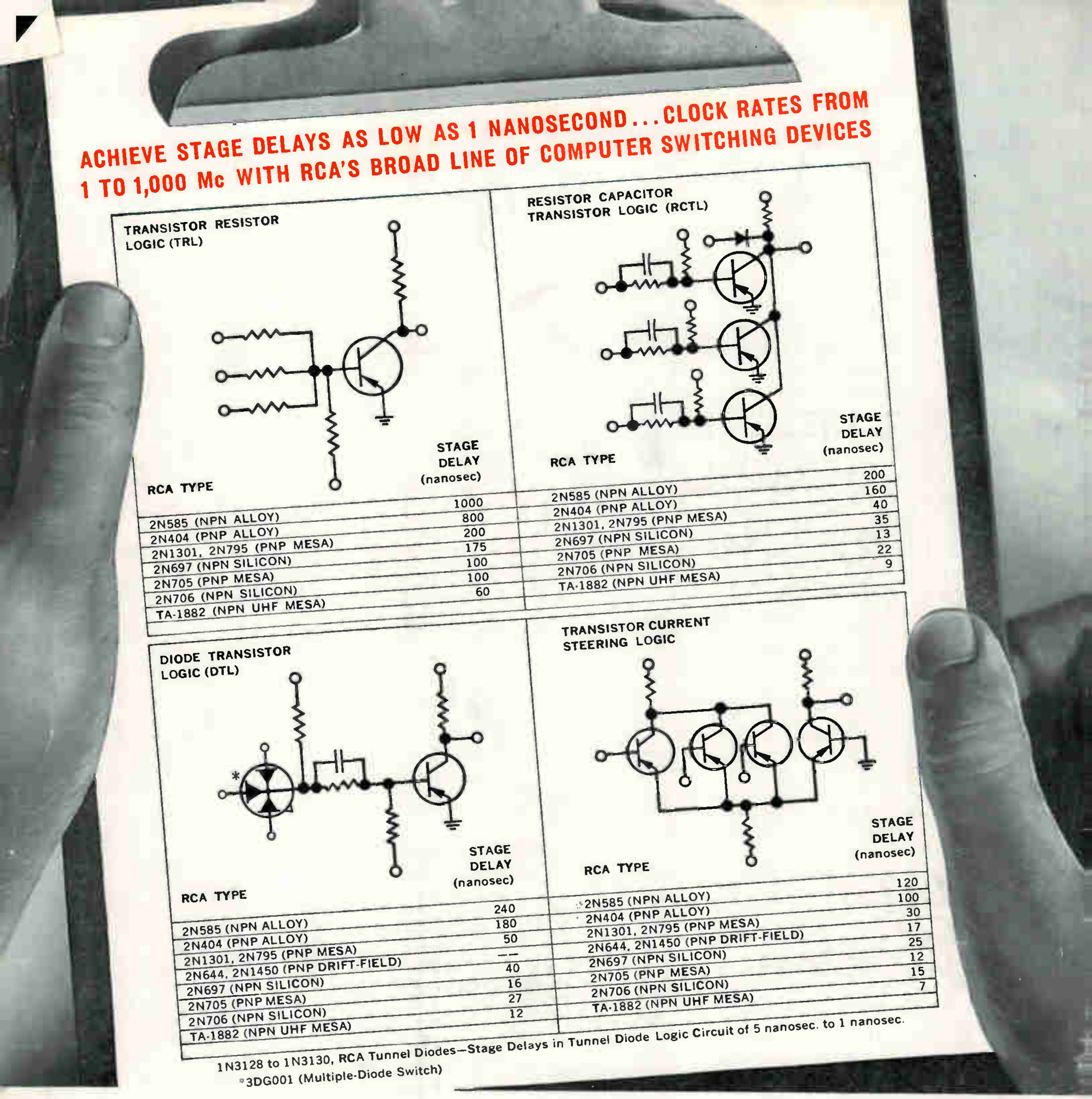

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2N705 (PNP MESA)	100
2N706 (NPN SILICON)	100
TA-1882 (NPN UHF MESA)	60

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2N404 (PNP ALLOY)	160
2N1301, 2N795 (PNP MESA)	40
2N697 (NPN SILICON)	35
2N705 (PNP MESA)	13
2N706 (NPN SILICON)	22
TA-1882 (NPN UHF MESA)	9

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2N644, 2N1450 (PNP DRIFT-FIELD)	——
2N697 (NPN SILICON)	40
2N705 (PNP MESA)	16
2N706 (NPN SILICON)	27
TA-1882 (NPN UHF MESA)	12

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2N644, 2N1450 (PNP DRIFT-FIELD)	17
2N697 (NPN SILICON)	25
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