A McGraw-Hill Publication 75 Cents November 9, 1962

electronics®

FREQUENCY-SHIFT KEYING

How to get rid of transients, *p 58*

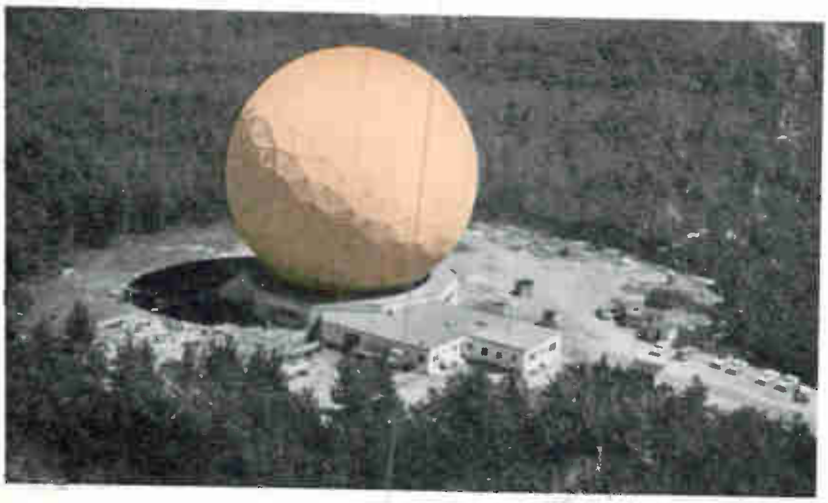
CERAMIC FILTERS

Design and application, *p 54*

GLASS DIGITAL DELAY LINES

New computer components, *p 60*

Golf ball and stained-glass window—or outside and inside the giant Project Haystack radome. *See p 49*



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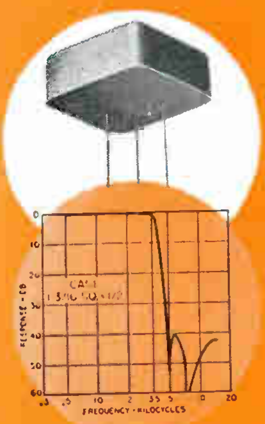

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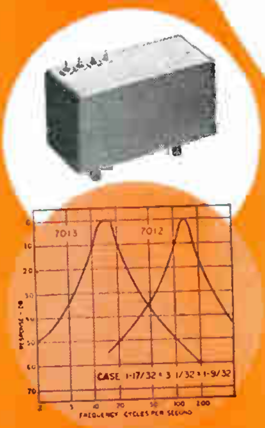

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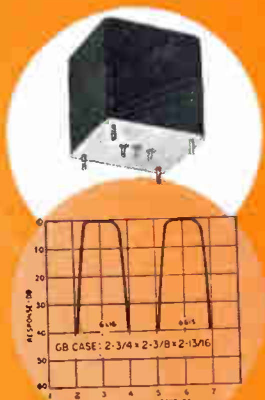

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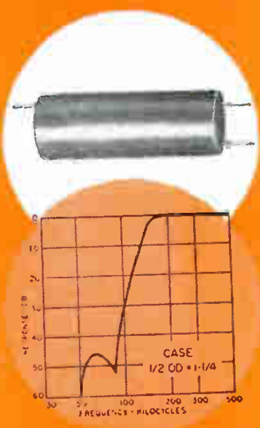

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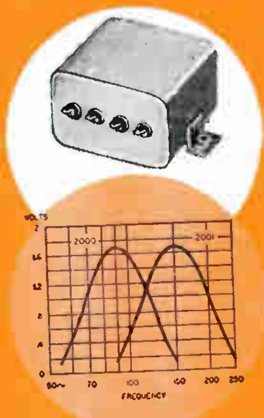

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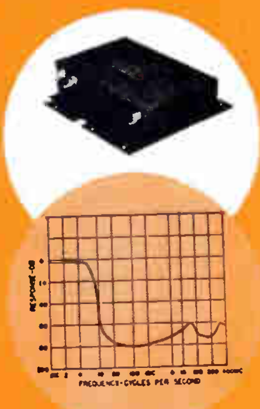

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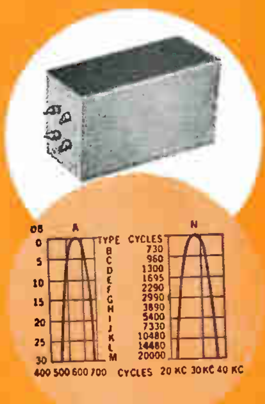

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November 9, 1962

electronics

A McGraw-Hill Publication 75 Cents

W. W. MacDONALD, Editor

Contents Continued

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CONTENTS continued

DEPARTMENTS

After Cuba, Space?

IF THERE IS ONE LESSON to be learned from the Cuban incident it is that the precarious balance of power between East and West can be upset almost overnight by some unexpected development.

What if the next crisis comes in space?

Suppose, for example, the Russians put up several satellites ostensibly to serve as communications relays. Suppose they put up more and more to replace those in which power supplies had "failed." Suppose the orbits of these satellites could be readily altered to place them within striking distance of any spot on earth. And suppose some or all of them contained nuclear warheads.

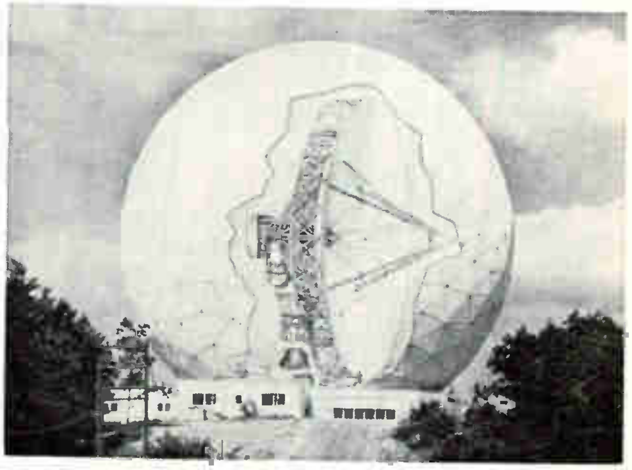
How would we know, and what would we do about it?

All of this is speculative, but it is a possibility that cannot be overlooked. What are we doing to police space? Not enough. And we are not doing enough because we are not devoting enough of our space effort to strictly military needs.

We have been plowing three to four times as much money and effort into peaceful space programs as into military programs. It is explained that what NASA finds out is immediately made available to the military, and this is quite true. But it is not necessarily true that the answers our space agency is looking for are precisely those most needed by the military. For example, detection and interception are not the primary peaceful goals, but they could be vital to military needs in space.

The United States has a great deal of scientific and technical competence in space. Its space defense equipment and facilities in being do not match this competence. Let's see that they do.

We hope the crisis now apparently passing causes the Administration to revise upward its ideas about the urgency of purely military space programs. We hope it realizes that the peril in space could quickly become as real and as great as the peril in Cuba.



LOOKING FOR NEEDLES. Between the era of the SCR-584 radar of World War II and the advent of BMEWS and Millstone Hill radars, radar system sensitivity has improved by about 80 db. We are now witnessing a further gain increase of about 35 db, as exemplified by the experimental Haystack system designed by MIT Lincoln Lab for the USAF. "And the radar people haven't run out of gas yet," says Herbert G. Weiss, Lincoln Lab Project manager for Haystack, commenting on further tricks held up his and his radar colleagues' sleeves.

It wasn't so long ago, 1946, that radar came dramatically to attention of astronomers, when the Army Signal Corps used war-developed equipment to bounce signals off the moon (ELECTRONICS, p 92, April, 1946.) Now, 16 years later, successive advances in system sensitivity hold out the possibility of bringing all the planets of our solar system into radar view. Straightforward improvements along the lines of Haystack system techniques could achieve this.

Gains in system sensitivity have been made by using larger-apertured antennas, higher frequencies, better receivers, higher power, and more sophisticated data processing methods. When arrays finally come into their own, they will probably take over the job of further extending—to what limits of sensitivity we don't know—the reach of radar.

The Haystack system is a milestone in communications and radar techniques, and was realized by combining the latest hardware with the designer's skill in pushing contemporary knowledge into future usage.

Haystack Hill in Tyngsboro, Mass., is connected by road to Millstone Hill, less than a mile away in Westford, Mass., site of the five-year-old tracking station which made the first radar contact with Venus in 1958. Haystack and the newly modified L-Band Millstone Hill system will be working together on space physics problems.

A description of the system, by New England Editor Maguire, begins on page 49. The illustration shows the installation with a sketch of the antenna.

COMMENT

More on Avalanche Breakdown

In rereading the September 28th issue just to make sure that I didn't miss anything, I found something that I had missed the first time around. The *Comment* column (p 4) carried several letters by Frommer and Fairchild, discussing a point to which neither really had the answer [—placing voltage divider resistors in parallel if diodes are used in series]. I have had to solve this problem in the past for a case where the resistors simply could not be used because of space limitations. I asked the same questions that reader Frommer did, but came up with the following answers:

1. One of the most important factors in any discussion of transient diode failure is the capacitance to ground from the junction points between diodes. Thus, with two diodes in series, the midpoint may not assume a potential based on current flow through the diodes alone, since a displacement current also flows through the diode that is not grounded at either end, which will not flow through the other diode. This displacement current will cause a larger voltage drop across one diode, *even though the diodes themselves are exactly equal in all respects.* This analysis can be extended for more than two diodes where the capacitances from each of the junctions to ground do not have identical values.

2. Although author Fairchild quotes a classic equation that describes the avalanche current in a diode, it just isn't so in very many diodes that come in our receiving door. The best way in the world to select diodes for series-string operation is to sweep the reverse-voltage curve from 0 volts up to about 2,000 volts (with suitable current-limiting resistors, of course). Higher voltages could be used in some cases; this value was arrived at for 600-volt diodes. A test like this will show up diodes that will pass every constant-current voltage-limited test in the world, and yet fail soon after placed in series-string operation. The reason: many diodes possess a perfectly adequate reverse-voltage capability until they once experience avalanche. Then for some reason, their reverse curve drops sharply and their reverse rating may assume a new low value—sometimes even zero. This does not mean that the diode shorts, merely that it has a reverse curve that leaves the zero-current axis at a large slope for any reverse voltage. Other strange behavior, together with this effect, caused us to reject nearly 60 percent of all diodes tested. Our acceptance criteria was simple: every diode must be taken out to its avalanche point three times, and left there for three seconds each time, during which time its reverse characteristic must exhibit a sharp knee at higher than 600 volts and remain perfectly stable. The improvement in diode reliability following this procedure was startling.

I hope that these comments don't come along too late to be of value. I'll read the next issue of ELECTRONICS more closely the first time through.

THOMAS P. PROUTY
MHD Research, Inc.
Newport Beach, California

Canadian Kudos

My congratulations to you on Electronics in Canada in the Sept. 28 issue of ELECTRONICS (p 37). We feel that it did quite a complete survey of this complicated field.

F. W. PRICE
Northern Electric Company Ltd.
Ottawa, Ontario
Canada

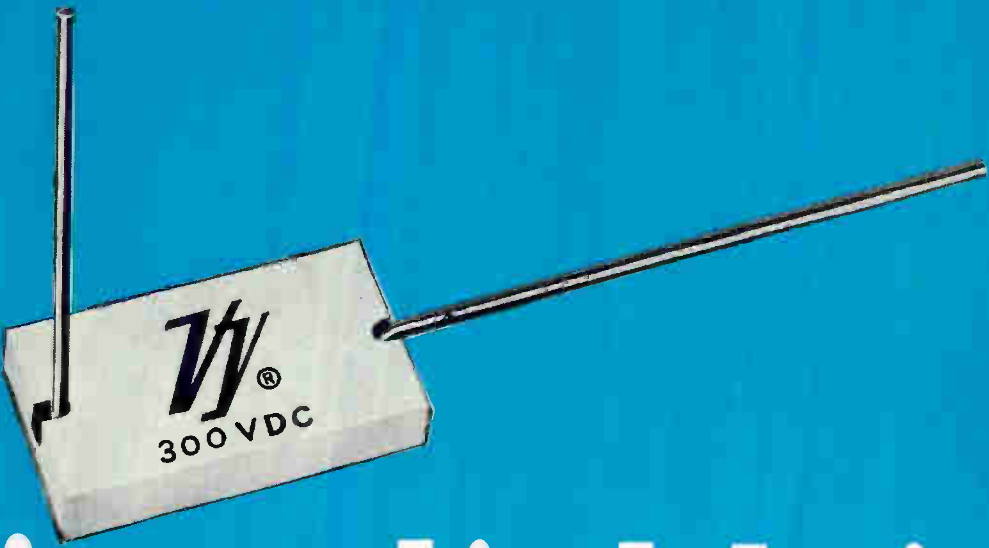
Feet, Not Inches

In the small item at the bottom of p 26 of the October 12 issue, about the Commonwealth Scientific and Industrial Research Organization radio telescope at Sydney, Australia, I'm afraid 210 *inches* doesn't get one very far in radio astronomy these days!

CHET YOUNG
Walter V. Sterling, Inc.
Claremont, California

On page 50 of this issue, the table of characteristics of six high-gain steerable antennas includes the 210-foot Australian radio telescope.

10,000 hours without parametric drift...



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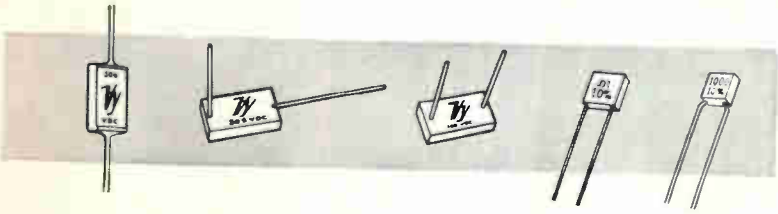
Write for complete catalog and TR 321



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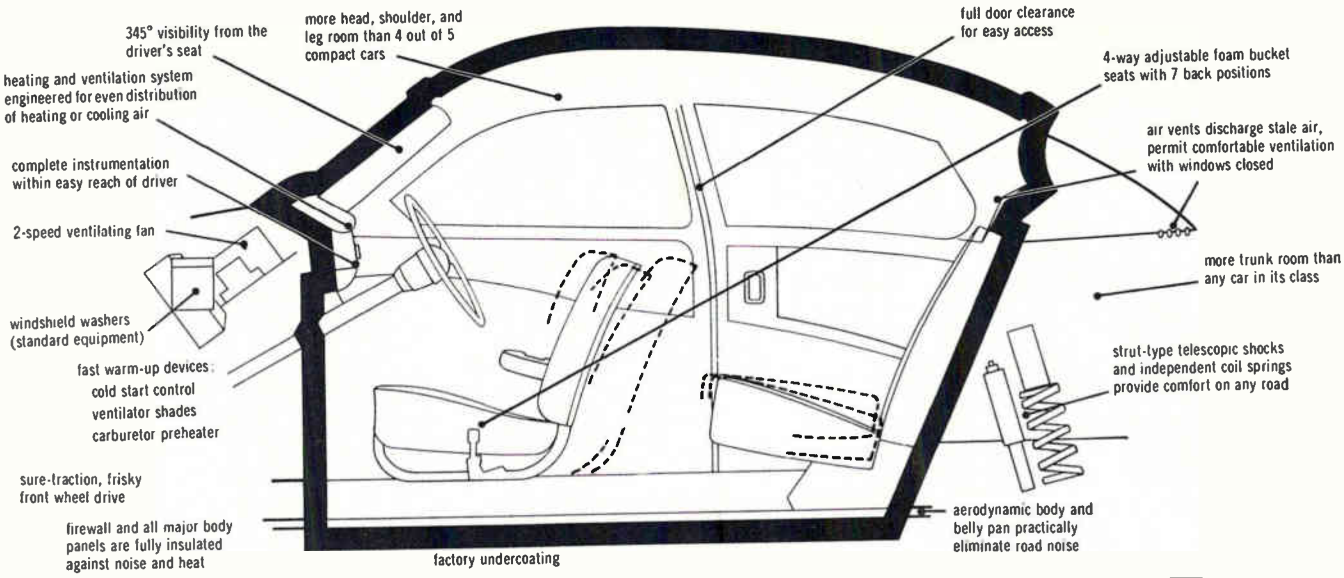

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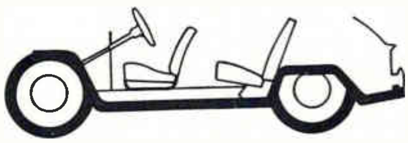

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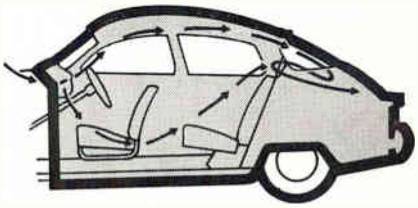

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ELECTRONICS NEWSLETTER

Diode Injection Laser Off and Running

LASER DEVELOPMENT took a new turn last week with announcements by IBM (p 7, Nov. 2) and GE that coherent infrared emission has been obtained from gallium-arsenide diodes. One effect may be diverting a large part of industry's R&D effort from ruby and gas lasers to the new injection types.

The injection laser is simpler than previous types. It is pumped electrically by d-c pulses rather than by light or r-f energy; this may make it easier to modulate.

Both IBM and GE formed their diodes from junctions of *p* and *n* GaAs doped with zinc and tellurium, respectively. Both were operated at a temperature of 77 K. IBM says its diode also lased at room temperature. Emission is at a wavelength of 8,400 angstroms when the device is forward-biased by 5 to 20 μsec pulses with current densities of 8,000 to 20,000 amp/cm². Both firms anticipate c-w operation soon.

Several organizations have been working in this area, as evidenced by recent reports of noncoherent infrared emission from gallium-arsenide diodes (p 27, Feb. 9; p 7, Aug. 3; p 44, Oct. 5 and p 28, this issue).

MIT Lincoln Laboratory says it has achieved "very satisfactory" laser action, but won't elaborate. RCA, GT&E Labs, Texas Instruments and Bell Labs are also working on gallium-arsenide lasers; none has reported coherent emission. A GT&E spokesman said that scientists there had succeeded in making gallium-arsenide-like radiation with other materials. This new radiation is visble and may be made highly efficient and coherent, he said.

Lasing at Ultraviolet Wavelength Reported

STIMULATED EMISSION of ultraviolet radiation at a wavelength of 3,125 angstroms has been achieved by the U. S. Naval Research Laboratory. The device employs a gadolinium-activated silicate glass pumped by xenon flash tubes.

The work was performed by H. W. Gandy and R. J. Ginther, who observed a 55-angstrom wide luminescence emission at the operating wavelength, at room temperature. Most of the pumping is concentrated in the range of 2,700 to 2,800 angstroms.

The scientists believe that the device may prove to be a laser where non-axial modes dominate. A spatial analysis of the far field pattern has not been attempted yet. Optical inhomogeneities in the laser material presently being used may preclude achievement of a pencil type of far-field pattern.

Is Mariner in Trouble? Solar Power Drops

LOS ANGELES—Sudden sharp drop last week in voltage supplied by Mariner II solar panels indicates the Venus mission may be in jeopardy. Mariner was 11.7 million miles from earth and in its 65th day of travel when the voltage drop occurred.

To conserve power for operation of the microwave and infrared radiometer experiments during Venus fly-by on December 14, the four interplanetary experiments (p 26, Oct 26) have been shut down by signal from the Goldstone DSIF transmitter. These are solar plasma, cosmic dust, magnetometer, and radiation detector experiments.

Unofficial speculation points to two possible causes of the voltage drop—collision by a solar panel with a fair-sized meteorite, and failure of a spaceborne voltage regulator. Jet Propulsion Laboratory reports it hopes that the rechargeable battery aboard the vehicle may provide sufficient power for successful operation of the two planetary experiments.

Submillimeter Detector Goes Into Production

LONDON—Mullard is going into production of a submillimeter photodetector with a response time less than 1 μsec. The physics department of the Royal Radar Establishment, Malvern, made the initial design of the detector (p 44, Feb. 16).

Wavelength range of the first detectors will be 0.1 mm to 8 mm, but later developments are expected to extend the range down to 0.01 mm or lower by using a variety of doped

Mother Nature Is a Teacher, Not a Model

BOSTON—Air Force Major Jack E. Steel, who coined "bionics" (p 38, Feb. 9), said this about bionics at NEREM this week:

As the art of copying or borrowing principles and techniques from living systems to design synthetic ones, bionics "is at best a technique for solving design problems, at worst an excuse for building cute models." Copyable virtues of living systems are usually more subtle than microminiaturization ("generally more of a handicap to observation than an inspiration to design") and sensitivity ("more apparent than real").

Over-identification is a common problem. There has been little profit in considering a relay as a neuron, the eye as a camera and the retina as a phototransducer. It's better to treat the retina as a data-processing net. Nor have servo engineers used the complex or dual feedback of living motor control systems to provide complete information when properties of both controlled and controlling systems are subject to variation germanium crystals interchangeable with the indium-antimonide crystal.

The detector element is a slice of indium antimonide, 5 × 5 × 2 mm, placed in the field of a superconducting magnet made of niobium wire. The whole assembly is immersed in liquid helium. Radiation is fed to the detector by a light pipe.

Weather Program Would Give Thin Films a Lift

YORKTOWN, N.Y.—Putting thin-film circuits on the surface of large meteorological balloons—instead of hanging gear from the balloons—to reduce hazards to aircraft was proposed last week at a geophysics conference at the IBM research center here. If a plane accidentally struck the balloon, the balloon would fly apart.

The plan, put forward by V. E. Lally, of the National Center for Atmospheric Research, has been under consideration for some time. Negotiations with other countries on the use of the balloons is underway and a small transmitter for a balloon application has been made.

Lally said global coverage for research on large-scale atmospheric processes could be provided by 4,000 such balloons, constrained to fly at a constant-density atmosphere and coupled with a satellite locating system.

Guidance Computer Fits Into 34-Pound Package

GENERAL MOTORS' AC Spark Plug division reports development of a 34-pound, airborne digital computer. The weight includes a random-access core memory with a capacity of 4,096 24-bit words. It uses some 2,100 Fairchild Semiconductor micrologic elements. Memory, memory circuits and logic elements are all assembled on seven magnesium plates, bolted together, that also serve as heat sinks.

The memory stores the program, constants and variables. Serial in organization, it handles the 24-bit words 2 bits at a time in 12 successive read-write cycles, each lasting 4 μsec. This allows for double instead of triple coincidence for operation, substantially reduces the circuits required and provides wider operating margins, AC says.

The company plans to integrate the computer with the inertial measurement unit of its inertial guidance system for further lab evaluation. It should also be useful in aircraft navigation systems, it was reported.

Sonic Phase Shift to Show Altitude of Boat

AUTOPILOTS on hydrofoil landing vehicles being developed by Lycoming for the Marine Corps will include sonic height measuring units. The autopilot will control the height of the craft above water so all the driver has to do is steer it, at speeds to 35 knots. The sonic units, to be built by Arma division of American Bosch Arma, will measure height by detecting the phase shift in a sonic signal reflected from the water.

Eight-Dish Antenna Tracks Mars Probe

MOSCOW—The Russians are reportedly using a huge radiotelescope of unusual design to maintain contact with the Mars probe launched last week. Transmitters in the space probe operate at frequencies of 922.76 and 183.6 Mc. The probe is expected to reach Mars in June.

Konsomolskaya Pravda said the "distant space radio communication center" was equipped with an antenna that resembles "a family of large radiotelescopes placed close to one another and revolving on the same axle." It consists of eight concave, Duralumin mirrors, each some 16 meters in diameter, placed in two rows of four each.

The upper part of the antenna was said to be about 12 stories high. Weight, without land foundation, was put at more than 1,000 metric tons. A "huge" foundation maintains antenna dimensions within 1 mm, the newspaper said. The antenna can move in both horizontal and vertical planes, it was reported.

In Brief . . .

NASA IS EXPECTED to launch the RCA Relay communications satellite (p 46, Oct. 5) around mid-December. Relay and Telstar II launches had been postponed so their launch vehicles could be used for Explorer 15, now probing the artificial radiation belt.

BELL TELEPHONE is extending its Data-Phone service for facsimile transmission, eliminating need for private-line transmission. It was also announced by Digitronics Corp. that its Dial-o-verter system, working with regular Data-Phone will be used by the *New York Times* to transmit news copy to Los Angeles for its western edition.

HALLICRAFTERS CO. has bought Radio Industries, Inc., of Kansas City. Power Designs, Inc., is negotiating to buy Carad Corp., of Palo Alto. Epoxy Products has entered into 10-year manufacturing, marketing and technical agreement with Ciba Ltd., of Switzerland.

UNIVAC is going into the OEM market, starting with computer subsystems. Company anticipates OEM market for peripheral computer equipment will double in two years to $150 million a year and reach $350 million by 1970.

PHILCO has a $3.6-million contract to develop a data-processing system using a Philco 2000 computer. System will be used by North American Air Defense Command to test real time information systems.

LEACH CORP. has a $1-million contract from Lockheed to develop radiation-resistant satellite tape recorders. They are to have life spans five times previously supplied recorders.

NAVY AWARDED $7.5 million more to Sperry Gyroscope for missile submarine navigation subsystems. Collins Radio will provide two air - transportable communications systems to Air Force for $3.8 million. Air Force also ordered $1 million worth of airborne early warning radars from Hazeltine.

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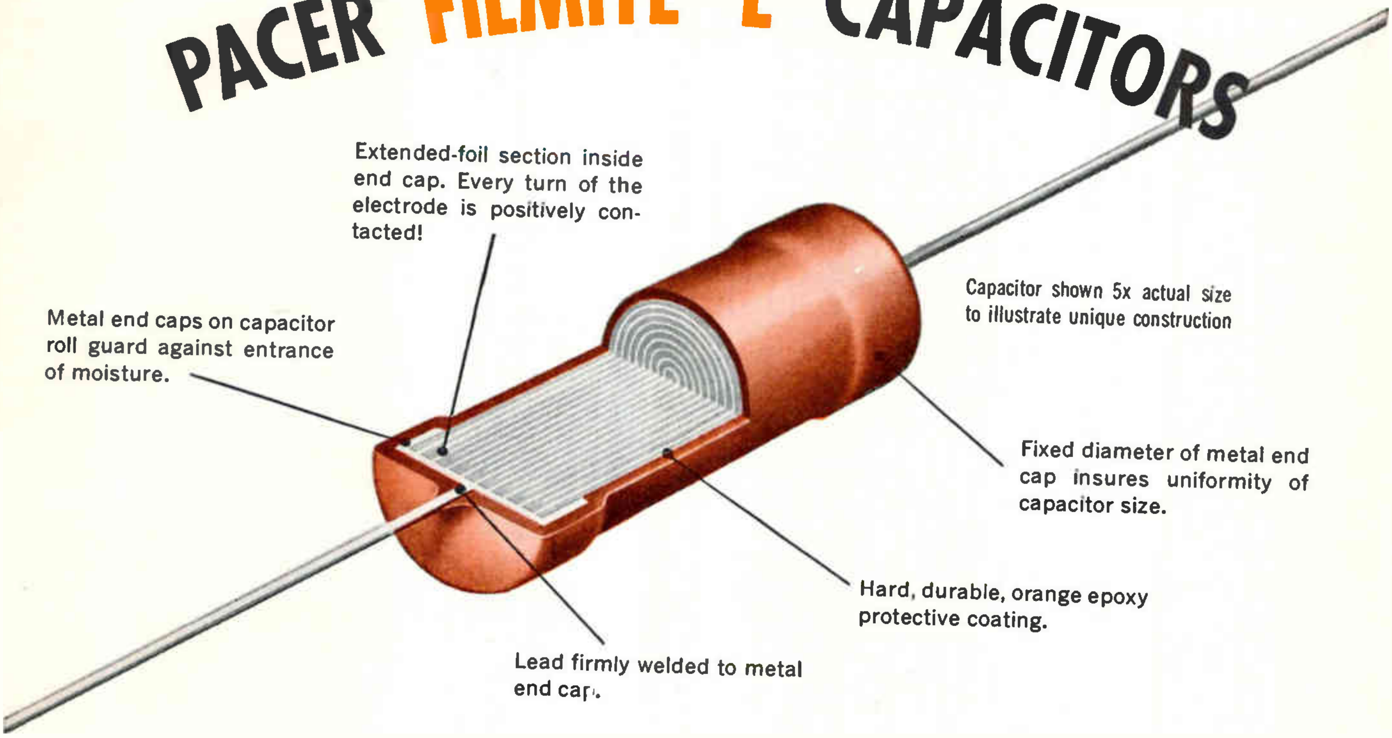

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End caps act as effective moisture barriers. Capacitor sections are further protected by hard, durable, orange epoxy coating.

UNIFORMITY OF SIZE—
Unlike other epoxy-coated units, the end caps on Pacer Capacitors assure the rigid fixed diameters needed for use with automatic insertion equipment. The two smallest sizes are identical with resistor and diode sizes, making them especially suitable for 'cordwood' packaging.

For complete technical data on Pacer Capacitors, write for Engineering Bulletins 2066 and 2067 to Technical Literature Service, Sprague Electric Co., 35 Marshall Street, North Adams, Massachusetts.

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4S-442

CIRCLE 9 ON READER SERVICE CARD

Vol. 1, No. 1

NEW PRODUCTS FOR SOLVING YOUR DESIGN PROBLEMS

Texas Instruments Announces New Field-Effect Transistor Line

Operation From —196° C to +200° C Now Possible With New Silicon Field-Effect Transistors

Four new P-channel Planar diffused silicon field-effect transistors have been announced by Texas Instruments.

Outstanding parameters include high input impedance greater than five megohms at 1 kc, and noise figures as low as 1 db at 1 kc. These devices operate at temperatures ranging from –196°C to +200°C, and are resistant to radiation intensities as high as 10^{15} neutrons (E>100 kev)/cm^2. Circuit design problems are minimized because input impedance and bias requirements are similar to vacuum tubes. Many circuits originally developed for vacuum tubes may be modified to use field-effect transistors.

These units are especially well adapted for use in satellites and space vehicles. Their high tolerance to temperature extremes and radiation simplifies application and increases reliability.

In addition to the usual transistor advantages of small size, light weight and ruggedness, silicon field-effect transistors generate less noise at low frequencies than vacuum tubes. Since they have no filaments, they can be used in infrared applications where heater filaments would cause interference.

Suggested applications include: high-input-impedance, low-noise amplifiers; active low-frequency filters; timing circuits, and differential amplifiers. They can be used with either positive or negative power supplies, and are compatible with either NPN or PNP transistor circuitry.

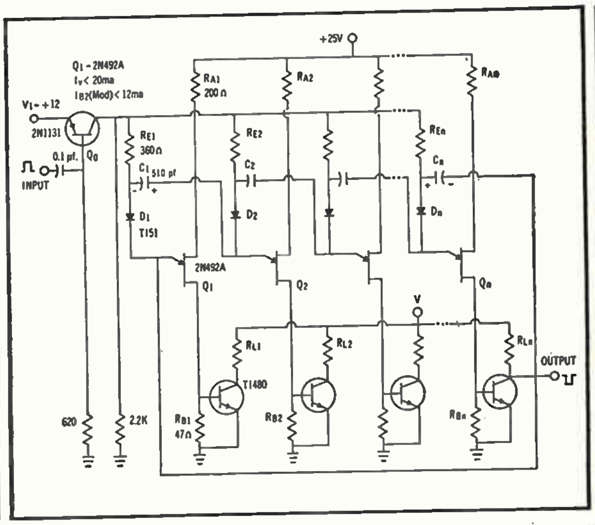
For more information, write for Bulletin 485-1.

New TI Unijunction Transistors Offer Greater Circuit Economy And Reliability

A full line of 22 grown silicon unijunction transistors has been announced by Texas Instruments. These three-terminal devices exhibit a stable negative incremental resistance region under certain conditions. This negative resistance makes possible the design of unique switching circuits comprising fewer components than conventional transistor circuits. Input impedance in the OFF state is high — about five megohms. This feature makes the unijunction suitable for high-input-impedance, voltage-sensing circuits.

Circuit simplicity is a major advantage. In many applications, the number of circuit components can be reduced by as much as half those required with conventional transistors, giving you lower cost, greater reliability and ease of design.

For more information, write for Bulletin 485-3.



The ring-counter circuit shown here illustrates how TI's unijunction transistors can enhance the over-all economy and reliability of your equipment.

WASHINGTON OUTLOOK

NASA EASES UP ON ITS PATENT REGULATIONS

NEW PATENT AND LICENSING REGULATIONS issued by NASA will make it easier for contractors to get exclusive patent rights on inventions rising out of government contracts. However, the new rules extend NASA control over such rights to more categories.

The licensing changes are now in effect. They permit granting to all applicants non-exclusive, royalty-free licenses. If after two years there is still no commercial development, non-exclusive licenses can be revoked and an exclusive license granted to a single developer.

Changes in patent waiver regulations are held up pending a hearing December 10. Contractor would get exclusive patent rights if an invention is in his established commercial area, if development cost is so high that exclusivity is necessary, or if patent applications were filed before a NASA contract was signed. NASA listed a number of exceptions to the waiver rule.

RUSH IS ON FOR UHF-TV LICENSES

DEVELOPMENTS IN UHF TV have resulted in something akin to a rush by tv broadcasters to get in on the ground floor. FCC officials are beginning to worry if there will be enough channels in key markets. Behind the new interest are all-channel set legislation, $32 million in federal aid for educational stations, and advance reports that an FCC test of uhf reception in the New York area was successful. The test report purportedly will show that uhf reception in skyscraper cities is as good as vhf if outside aerials are used.

FCC is getting a swell of applications for commercial stations and, for the first time, has channel contests on its hands—in New York and Paterson, N.J. Educators feel they may need as many as 1,000 uhf stations. Kaiser industries has applied for five uhf stations. Sylvester (Pat) Weaver, former president of NBC, is talking with key broadcasters about the possibility of a uhf network.

LUNAR ROCKET IN PRODUCTION

LARGER EXPENDITURES FOR ELECTRONICS are coming as large boosters for manned lunar landings reach the production stage.

NASA has made a $319.9-million award to North American Aviation for nine flight rockets plus test units for the million-pound-thrust S-11, second stage of the big advanced Saturn C-5. Boeing is expected to get an even larger contract by the end of the year, for the 7.5-million-pound-thrust first stage booster. Contracts call for first flights in 1965.

AEROSPACE WORKERS NIX UNION SHOPS

AUTO WORKERS AND MACHINISTS UNIONS failed to get the necessary two-thirds majority to win union shops contracts at the West Coast plants of North American Aviation and General Dynamics. The "for" votes barely reached 54 percent among IAM members at GD, just under 60 percent among Auto Workers at NAA.

The defeat came in an area of a growing labor force—the space technician and white collar worker. This manpower group has one of the largest growth potentials in industry. The outcome means the missile unions will be fighting an uphill battle to organize industrial technicians and skilled workers.

Globe small precision gearmotors offer **every**

Tell us the kind of power you have (d.c. or a.c., 60, 400 cycle, variable or special frequency, or square wave). Tell us the speed you want. Or tell us the torque you want. If it can be met in a motor of 1/10 hp or less, Globe will deliver the gearmotor you need in 30 days or less. **Many combinations are available for 24-hour delivery from stock.** We can send your prototype quickly because we already have a head start!

Globe is the largest manufacturer of precision miniature a.c. and d.c. motors. This lets us recommend a motor no larger than you **really** need — advantages: size and weight. Second, every Globe motor can be fitted with a precision gearhead—of spur or planetary design using case hardened gears. Note that Type MM and MC motors offer a choice of 101 **standard** planetary ratios, plus 28 **standard** spur ratios. In-between speed-torque combinations are provided by changes in the armature winding. Globe gear reducers are up to 90% efficient per stage; special gearing is always welcome. The reason Globe precision gearmotors are economical is that we meet custom requirements from standardized components. And we have the capability to modify, design, test, and manufacture new types quickly.

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¾"	planetary	SD	21	300 oz. in.
⅞"	planetary	SS, SC	21	300 oz. in.
1 1/16"	spur	SC, (SS, MM, LL, MC)*	28	50 oz. in.
1¼"	planetary	MM, LL, MC, (FC, GJ)*	101	1000 oz. in.
1½"	planetary	BD, BL, (GN)*	18	3200 oz. in.
3"	planetary	BL, (BD, GR, LC)*	10	16000 oz. in.

* not illustrated

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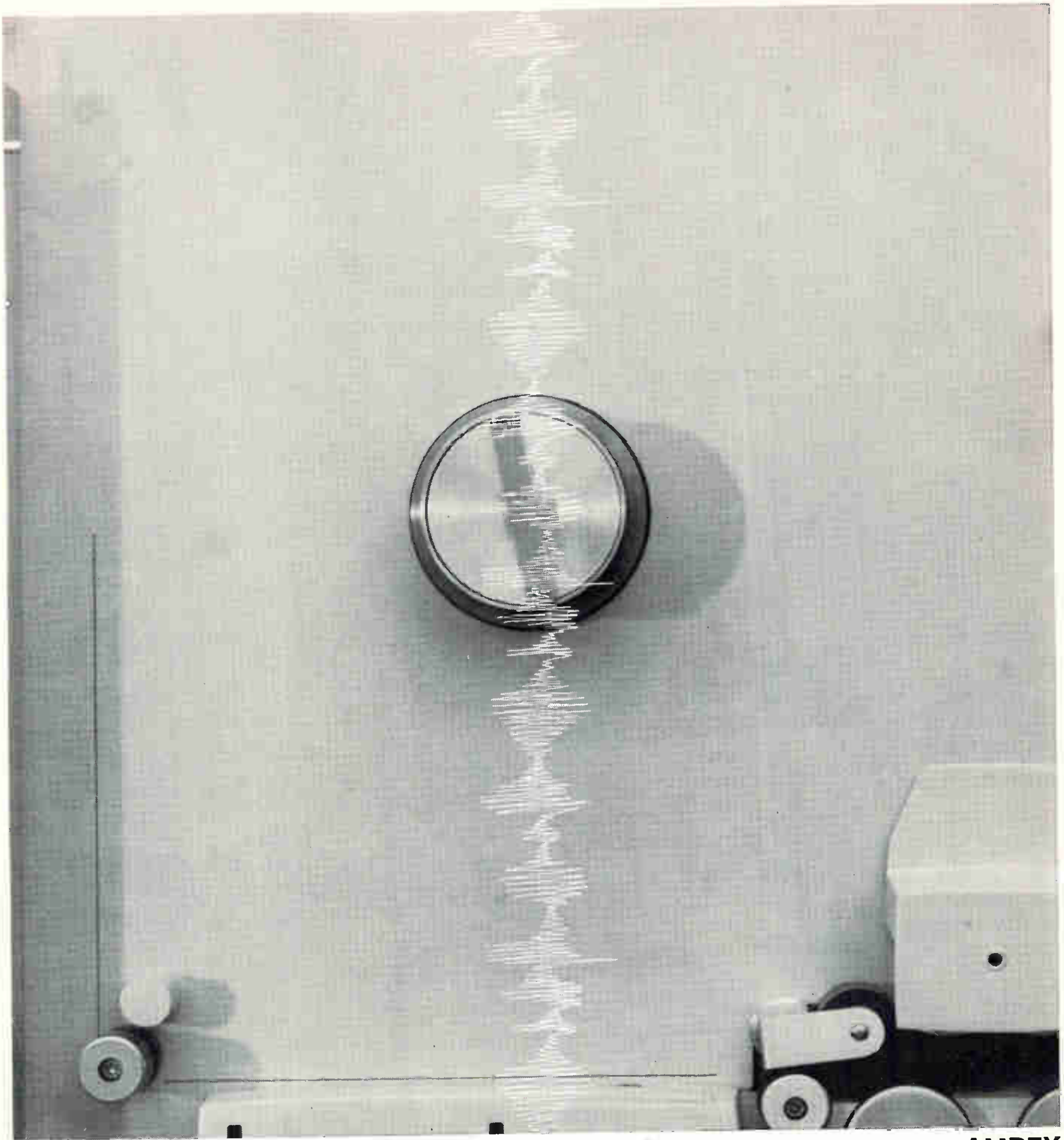
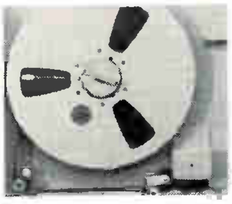


Who has both: 1.5 Mc recorder and 1.5 Mc tape?

AMPEX

We just don't like to leave things undone. Recently, our engineers developed the first 1.5 Mc per track, multi-track recorder—the FR-1400. Like every Ampex recorder, it gives you outstanding performance. We felt we had to develop a tape that equalled the FR-1400 in quality of performance. Hence: Ampex 9101—a 1.5 Mc tape. This new tape is a high resolution, heavy duty type with excellent wear characteristics. It offers high reliability and superior performance. And can record 1.5 Mc of data at a speed of 120 ips. Ampex 9101 tape rounds out a recording system that gives you the highest frequency in longitudinal recording today. For more information write the only company providing recorders, tapes and memory devices for every application: Ampex Corp., 934 Charter St., Redwood City, Calif. Worldwide sales and service.



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SANGAMO
RESIN-DIPPED SILVERED-MICA
CAPACITORS

Incorporating Nearly Forty Years Experience in the Design & Manufacture of Mica Capacitors

New Sangamo Type D dipped-mica capacitors are designed for applications requiring high stability, high reliability and low-loss characteristics.

Multiple coatings of the thermosetting resins provide excellent environmental protection and thermal shock characteristics. The case resists the high temperatures of soldering without damage.

Standard Type D dipped-mica capacitors are available in 4 case sizes corresponding to sizes CM05, CM06, CM07 and CM08 of Mil-C-5B and in voltage ratings of 300 and 500 wvdc. Units can be supplied with C, D, E or F characteristics for operation over a temperature range of −55°C to +125°C. Special units are available with voltage ratings up to 3000 wvdc and a temperature range to +150°C.

STANDARD RATING		
STYLE	VOLTAGE	CAPACITANCE RANGE PF
D-15	500 300	1– 400 1– 820
D-19	500 300	5– 5,100 5– 6,200
D-30	500 300	470–22,000 470–30,000
D-42	500 300	3,300–51,000 3,300–68,000

Write for complete information.

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DIPPED-MICA CAPACITORS

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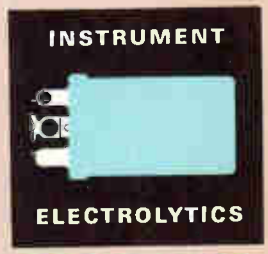
THAT SET NEW STANDARDS OF RELIABILITY!



Here's a "twist-tab" electrolytic capacitor designed specifically for the rigorous requirements of instrument manufacturers. Check this list of advantages over conventional "twist-tab" electrolytics.

- LONGER OPERATING LIFE (at 85°C)
- LONGER SHELF LIFE
- LOWER LEAKAGE
- LOWER POWER FACTOR
- LOWER ESR
- BETTER TEMPERATURE CHARACTERISTICS
- BETTER HIGH FREQUENCY CHARACTERISTICS
- BETTER END SEAL

The new blue-cased Sangamo Type 505 capacitor has everything the instrument manufacturer needs in a dry electrolytic and . . . no other capacitor can match this performance.

Write today for engineering test data . . . convincing proof that the new blue Sangamo Type 505 does establish new standards of quality and reliability.

In electronic instruments of tomorrow look for the Blue 505—symbol of quality.

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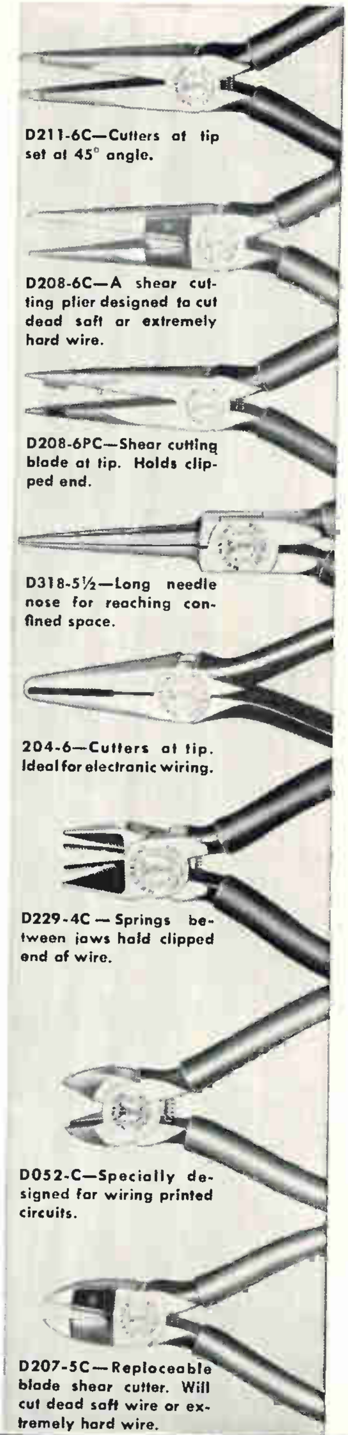
Special Pliers for the Highly Specialized Electronics Field



D211-6C—Cutters at tip set at 45° angle.

D208-6C—A shear cutting plier designed to cut dead soft or extremely hard wire.

D208-6PC—Shear cutting blade at tip. Holds clipped end.

D318-5½—Long needle nose for reaching confined space.

204-6—Cutters at tip. Ideal for electronic wiring.

D229-4C — Springs between jaws hold clipped end of wire.

D052-C—Specially designed for wiring printed circuits.

D207-5C—Replaceable blade shear cutter. Will cut dead soft wire or extremely hard wire.

When the early transmission lines were strung in this country a century ago, it was Klein Pliers in the hands of linemen that helped do the job.

Klein has kept pace with the development of the electrical field, meeting each new challenge with tools specially designed to do the wiring job better . . . more economically.

Shown here are a few of the many highly specialized Klein Pliers carried in stock to meet the needs of electrical and electronics manufacturers.

You will find your assemblies go together more smoothly and wiring is done more rapidly when the right Klein Plier is used.

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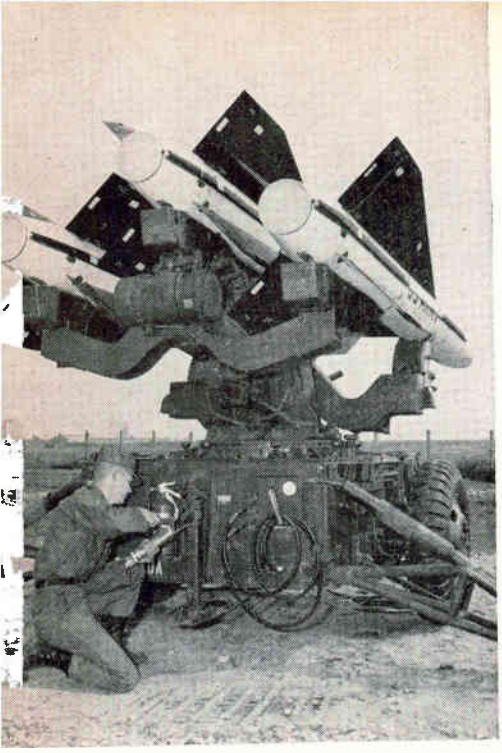
CIRCLE 19 ON READER SERVICE CARD

Electronics Industry Is



SOLDIER WORKS *on trailer for Hawk surface-to-air guided missile. Missiles like this are now deployed in Florida for defense against low-flying planes and missiles. Electronics content is about 65 percent*

There is plenty of capacity to meet any military stepup

By LEON H. DULBERGER
Assistant Editor

INDUSTRY LEADERS say the electronics industry can readily cope with any government demands arising from the Cuban crisis.

Military electronic manufacturers assert they can put on extra work shifts, use inactive production space and facilities, and realign engineering efforts to meet emergency demands.

Several electronics firms reveal they have already been queried by the Department of Defense, or alerted to standby for requests. Even companies not queried said they have studied their own capabilities, and know they are ready

Sergeant Missile Ready to Replace Army's

Overseas U. S. troops and Germans will get missile by early 1963

By JOHN F. MASON
Senior Associate Editor

WHITE SANDS, N. M.—Success of the first firing by a tactical unit of the second-generation, field artillery, ballistic missile, Sergeant, late last month means the Army will go ahead with plans for the missile system.

• Sergeant, representing a $½-billion investment—although not all of this money has been spent—will go into full-scale production.

• More contracts will be awarded, and subsystems may be bid on competitively in the future when such a change "does not jeopardize the system."

• More battalions will be activated—three are already equipped with the weapon and are in training at Ft. Sill, Okla.

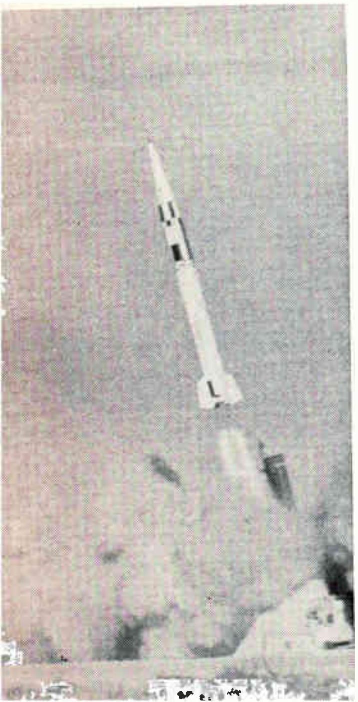
• The missile will be deployed overseas early next year by U.S. troops.

• The Federal Republic of Germany has bought the Sergeant system, and will deploy it in Germany early next year for the defense of NATO. The German missiles will be bought from the U.S. government and produced in this country.

• Other NATO countries, although not named, "have shown interest." Indication of which countries these might be is revealed in a Sergeant missile brochure printed in English, German, French and Italian, distributed by Sergeant's prime contractor, Sperry Utah Co., a division of Sperry Rand Corp.

• In the meantime, test firings will continue through 1964. Before June, three Sergeants will be fired from the Pacific Missile Range and three at White Sands.

WARHEAD SECTION *being removed from container and mated to rest of Sergeant missile on mobile erector-launcher*



FIRST FIRING *by a tactical unit hits a target 75 miles up the White Sand range. The missile burned 30 seconds, reached a speed of 2,000 mph and an altitude of 45 miles*

REPLACES CORPORAL—Advantages of the Sergeant over the

Ready for Emergency

to react on short notice to military needs.

NO SHORTAGES—Industry leaders add that large stockpiles of raw materials and partly finished goods are available. Few shortages should be experienced.

Leon Alpert, president of Loral Electronics Corp., declared his firm always has a plan ready to meet such emergencies. The company has already responded to a government request to evaluate its two-shift production capability, and find out how long it would take to put it into effect.

Loral feels it can meet any new requirements effectively. It keeps a list of subcontractors that it would call upon for certain jobs during stepped up production. Alpert said this list is constantly being screened and updated by visits to vendors to find out what they can do in an emergency. He thinks his firm and the entire electronics industry are prepared to meet any possible emergency.

Many electronic companies wouldn't talk about their proposed role in a growing emergency, but all said they would do their best to satisfy government needs if called upon.

General Electric Co. says the electronics industry is in a much better position today than it was in the 1950 Korean emergency. Planners declare that industry production can be more than doubled by going to a second shift. They say that the defense business has excessive capacity today.

The electronics industry can build up to limited-war capacity in six months if off-the-shelf equipment rather than newly developed items can be used. The industry has sufficient engineering personnel, manufacturing space and production capacity.

CONSUMER PRODUCTS — GE adds that there will be no supply problem in consumer, industrial and utility electronic goods unless a large-scale emergency erupts. This again is because of excess production capacity.

NASA officials said that in a large emergency NASA would be particularly able to serve the country in aeronautics, missile technology and space operations. NASA already has the management staff, scientific ability and a total capability that could be pressed into effective service as a unit.

Some NASA personnel might don uniforms; the operation would be similar to that of the National Advisory Committee for Aeronautics during World War II. NASA could quickly apply many of its space techniques in a military manner.

Corporal

Corporal, which it will replace, are mobility, reliability and reaction time.

The entire system is packed in six pieces, and is air transportable and mobile: launcher, field maintenance test station, organizational maintenance test station, two transport trailers, and a communications vehicle. It can be quickly emplaced and fired by a six-man crew.

The Sergeant missile is 34.5 feet long, 31 inches in diameter, and weighs 10,000 lb. The warhead—nuclear, chemical or biological—weighs 1.600 lb. Guidance is inertial and propulsion is solid propellant. Range is 25 to 75 nautical miles.

Inertial guidance system consists of an inertial platform, computer and control assembly. The computer was built by Sperry-Utah and the four guidance-fin servos by Lear Siegler, Inc. The servos, which actuate both the aerodynamic and rocket blast guidance vanes of the missile, are the first electromechanical servos to be selected for a current-production guided missile, according to the producer.

Three GG-49 gyros (MIG) built by Minneapolis-Honeywell are used in the system.

"Computing" data logger simplifies complex test problem

By WILLIAM KIEVIT • *District Manager*
Nutley, N.J. Office • *Non-Linear Systems, Inc.*

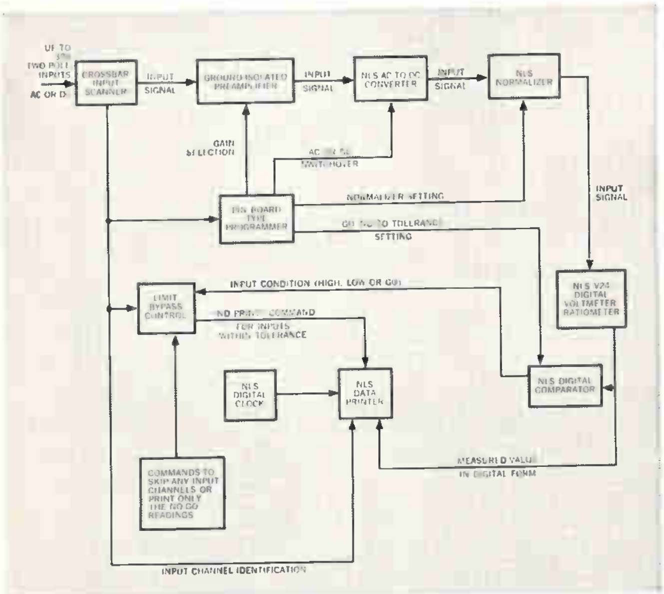
MILTON BAXTER • *Group Leader*
Product Development Laboratory
Cities Service Research and Development Co.
Cranbury, N.J.

THE PROBLEM: Making valid performance comparisons of fuels and lubricants posed a problem for Cities Service Research and Development Company that has a familiar ring. Many scientific, industrial, and military establishments encounter a similar set of requirements:

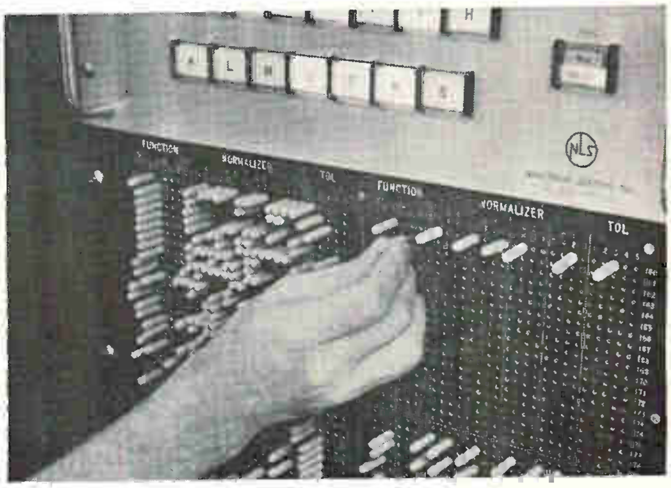
- To collect, measure, record large amounts of data with speed, accuracy and reliability in addition to performing rudimentary computation. In this case, Cities Service required a system that would monitor operation of many internal combustion engines running simultaneously to ensure that performance with fuels and lubricants would be compared under identical operating conditions.
- To automatically evaluate each measurement as it is made and, when desired, record only data deviating from specified operating conditions. Both features would eliminate the need for reviewing substantial quantities of insignificant data.
- To present measurements in the most meaningful terms for each situation. For Cities Service, this meant displaying any measurement in terms of (1) voltage, (2) percentage (with 100% as "normal"), (3) per cent of deviation from "normal," or (4) engineering units such as pressure, temperature, flow rate, etc.
- To provide uninterrupted testing in the absence of technical personnel.
- To sound an alarm for abnormal conditions.
- To make the resulting instrumentation easy to understand and easy to program.

THE SOLUTION: The requirements were met by a versatile data logger formed of an NLS V24 Digital Voltmeter-Ratiometer, DVM accessories, and other standard instruments together with simple programming. The V24, with a speed of three measurements per second, was selected primarily because its reliability had been demonstrated for four years in such applications as measuring and transmitting data from unattended power stations, nuclear facilities, missile checkout operations. Much of the interconnecting circuitry was designed on-the-spot by engineers of Cities Service and Non-Linear Systems, Inc.

In 15 seconds, the system can make and record (complete with time of measurement and channel identification) 20 measurements of temperature, fuel flow, engine speed, engine torque and pressure. In 3¾ minutes, all such pertinent data can be collected from as many as 15 different makes of engines running simultaneously. The system also sounds an alarm whenever any measurement varies from its pre-set range of limits. Or it can be easily programmed to record *only* abnormal values, eliminating tedious data sorting.



Simplified functional chart illustrating the versatility of the system.



Changing pin locations permits Cities Service to program the system for any desired set of test conditions.

The key to obtaining immediately interpretable data lies in the system's automatically programmed variable gain preamplifier and normalizer which act as computing elements. They perform the input signal multiplication and division operations which furnish data in terms of engineering units such as pressure, temperature, etc., or in terms of percentage, with 100% representing "normal" pressure, "normal" temperature, etc. Preamplifier gains of 1, 10, or 100 and normalizer settings of x0.0001 to x0.9999 (in steps of 0.0001) can be programmed for any input channel. Thereby, a digital voltmeter display of 100.0 can be achieved for any input signal from 0.001 v. to 9.999 v. DC, or 0.007 v. to 6.999 v. AC, or for a DC voltage ratio up to .9999.

Elimination of insignificant data results from use of an automatically programmed digital comparator which permits the system to be programmed to record only those measurements which deviate too far from their normal (100%) value. Coincident with such recording (which includes the measurement, input channel number and time of occurrence), visual and audible warnings can be activated to notify the operator of abnormal conditions. One advantage of expressing the data in terms of percentage shows up in the digital comparison system; i.e., the programmer and interconnecting wiring can be simplified since only one digit (10 numerals) of tolerance data need be handled for tolerances from ±1% to ±9%. For example, if percentage expression were not used, a 4-digit tolerance number would be required; e.g., the tolerance number .2628 would be required to represent 5% of the measurement 5.250.

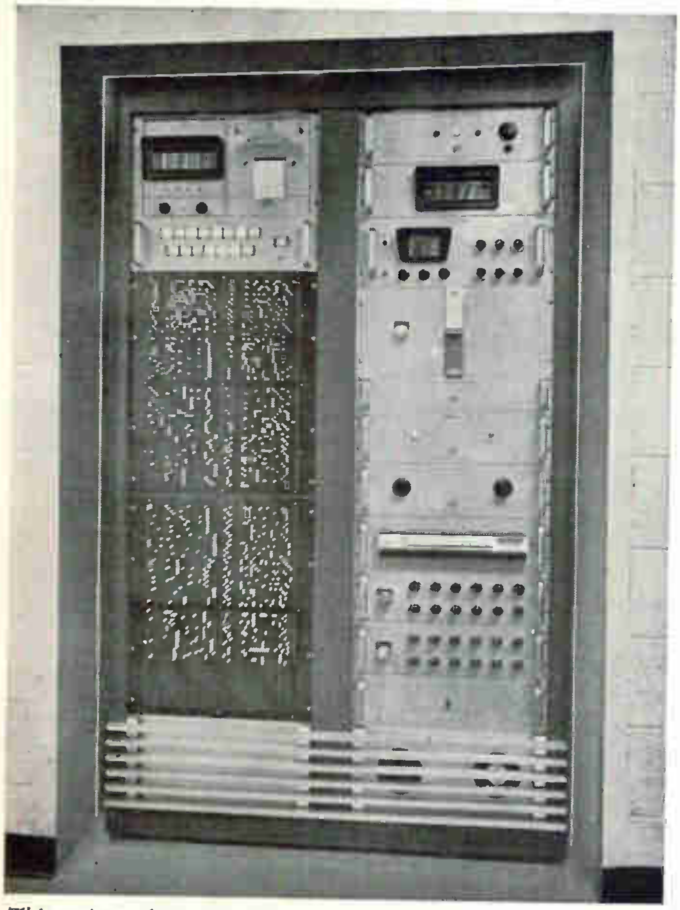
Programming through use of the programmer, which resembles a king-sized cribbage board (left section of the system), is fast and simple. Rearranging position of the small pins programs amplifier gain, selection of AC or DC measurement, normalizer setting and go/no-go limits for each input channel

A "start-up" system, composed of an NLS V60 Digital Millivoltmeter and selector switch with built-in normalizers, is used to adjust each engine's operating conditions to standard values prior to connecting that engine into the automatic system. Above, a pressure of 34.89 psi is being displayed.

— over 3 billion individual settings in all. Pre-drilled plastic overlays can allow the operator to quickly program the system for any pre-established test situations simply by placing the appropriate overlay on the programmer board and filling the overlay's guide holes with pins. Up to 300 input channels can be sequentially scanned by the Cunningham Crossbar Scanner. Each time the scanner selects a new input channel for measurement, it issues channel identification data which tells the programmer which set of gains, normalizer settings, go/no-go tolerances, etc., to apply to the system for the channel being measured. Channel identification is also utilized by the limit bypass control to inhibit data recording for channels that are within tolerance.

If desired, some measurements can be displayed in engineering units and others in percentage. Or an engine can be checked twice, once in engineering units and once in terms of percentage. In addition to indicating and recording time with each measurement, the system's digital clock can repetitively initiate new test runs at time intervals from less than 1 minute up to 2 hours, as selected on the clock panel. This timed cycling makes it possible for Cities Service to operate the system overnight and throughout weekends in the absence of technical personnel.

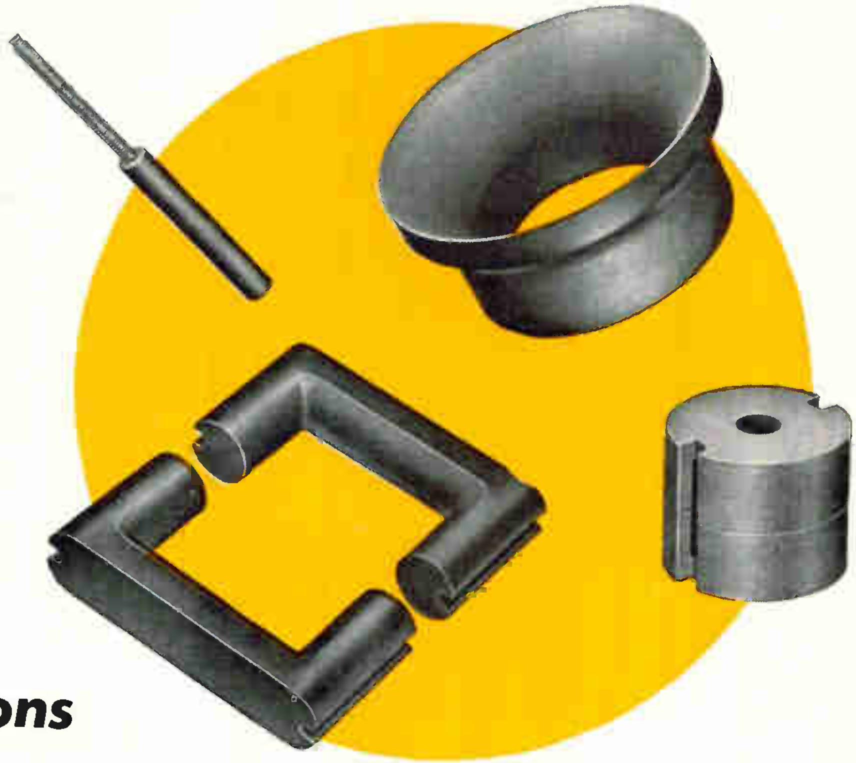
OTHER USES: The system has proved to be a practical, relatively low-cost approach to this over-all problem of data acquisition, computation and logging which lies in the "no-man's-land" of testing — between the simple, standard data logger and the expensive, complex computer. Built-in versatility of the system makes it particularly attractive for a wide range of applications in electronic systems checkout, research and development involving hundreds or thousands of data points, and industrial processing supervision. Where required, similar systems with greater versatility are quite feasible; measuring range can be extended to 1,000 volts and can include resistances from 0.01 ohms to 10 megohms, voltage digitizing speed can be increased to 67 microseconds, and scanning capacity can be increased to over 1,000 channels and to 4 or 6 poles per channel.



This universal data logger features simplicity in programming, as illustrated by the pin-type Sealectro programmer board (center and bottom left portion of system).

FOR ADDITIONAL INFORMATION ON DIGITAL MEASUREMENTS: Circle the reader's service number or contact one of the 19 NLS factory offices located throughout the U.S.A., or write Non-Linear Systems, Inc., Del Mar, California.

NLS **non-linear systems, inc.**
originator of the digital voltmeter



Ferrite core applications

KNOWN or UNKNOWN

are handled best by STACKPOLE

Stackpole CERAMAG® ferrite cores have been the standard of the industry since their introduction in 1946. Flyback transformers, deflection yokes, R-F and I-F transformers, magnetic amplifiers, filters of all types . . . these are some of the known areas where CERAMAG cores have licked design and production problems.

Right now, Stackpole research is adding to one of the industry's most impressive variety of ferrite grades . . . perfecting new types and uses for CERAMAG ferrite cores . . . looking for those areas where they can help you make your product better or easier to produce.

Maybe you have pending applications where CERAMAG ferrite cores can offer distinct advantages over other materials or methods . . . or maybe you are searching for fast, on-time deliveries of ferrite cores for present applications with each core as accurate physically and electrically as the lab sample.

In either case, you should see Stackpole.

STACKPOLE

CARBON COMPANY, *Electronic Components Division*

St. Marys, Pennsylvania

CIRCLE 25 ON READER SERVICE CARD

Electrostatic Focusing Gives Klystrons Greater Efficiency

By SAMUEL WEBER, Senior Editor
MICHAEL F. WOLFF, Senior Associate Editor

BARREL-SHAPED *550-lb permanent magnet focuses Sperry's new high-power klystron*

Device designers also report new progress in semiconductor techniques

WASHINGTON—Use of electrostatic techniques in a wide variety of devices showed up as a trend at the 1962 Electron Devices Meeting sponsored by the IRE-PGED late last month.

Electrostatic focusing reduces weight and sometimes power requirements as compared with magnetic systems, but devices using electrostatic focusing have been limited in power output and versatility.

NEW KLYSTRONS—An electrostatically focused klystron amplifier was described by J. R. Hechtel, of Litton Electron Tube Corp.

The new tube avoids using focusing magnets with their weight and power penalties and resultant reduced efficiency. According to Hechtel, the 5-pound tube gives a big watts/lb increase over present klystrons. It uses an electrostatic Einzel lens system, that allows the lens electrode to be connected internally to the cathode, thus providing single-voltage operation.

The tube operates at S-band and produces a peak power of 15 Kw at an efficiency of around 25 percent. Hechtel told ELECTRONICS that these figures may be revised upward by new designs. With scaling for higher voltages, the tube may achieve 1 Mw peak at S-band, and several megawatts at L-band, at an efficiency of 35 percent. Cooling may extend these limits further.

Another departure in focusing methods was announced by John Romaine and Henry Striegl, of Sperry. They have developed 24 Mw five-cavity klystrons using permanent magnet focusing, for Stanford's two-mile linear accelerator.

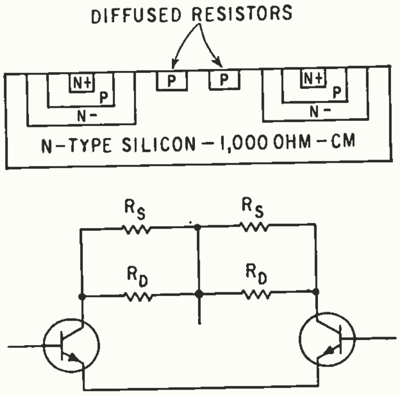
Electrostatics also provided new advances in display tubes.

A zoom lens for an experimental image-converter tube has been developed at Mullard Research Labs by P. Schagen. Conventional zoom lenses mechanically vary the lens' focal length. Several years ago, electromagnetic focusing was employed successfully, but was limited to a magnification of only two. The new lens system using electrostatic techniques achieves continuously variable magnification over a range of at least a factor of six.

DIELECTRIC CAMERA—W. G. Reininger said Westinghouse's Applied Research Department has been developing for the Air Force's Aerial Reconnaissance Lab an electro-optical tape-storage camera tube with storage capacity of 10^{11} bits.

Information is electrostatically written and stored on storage tape reeled on spools inside the vacuum. It comprises a nickel or copper base that is an electroformed replica of a diffraction grating. Over the broad slope of the grooves in the grating is deposited a dielectric such as magnesium fluoride, cadmium fluoride or silicon oxide, while the narrow and almost vertical surface of the grooves is left exposed.

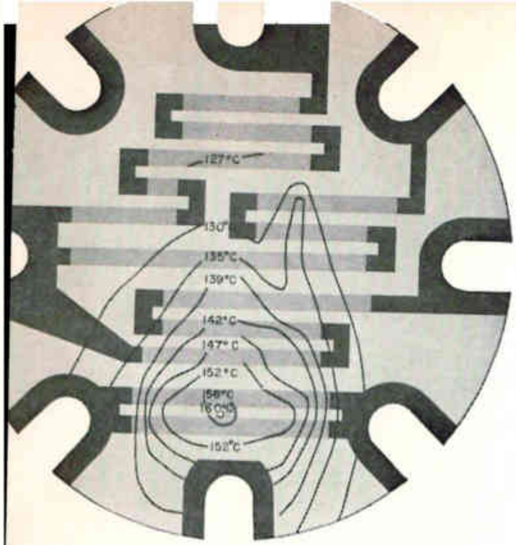
The tape moves first beneath an erasing and priming device that showers electrons on the tape, bringing the surface potential to equilibrium with respect to the spaced barrier grid on the tape. Information can be written by scanning the tape with an electron gun, or with photoelectrons from the image section of the tube. Nondestructive reading is done by an image-orthicon scanned reading beam of small diameter. Reininger reported storage times of more than eight hours with negligible signal loss. Image signals with resolution greater than 2,000 lines an inch were stored and read, and more than 20,000 halftone copies were read out from a single frame.



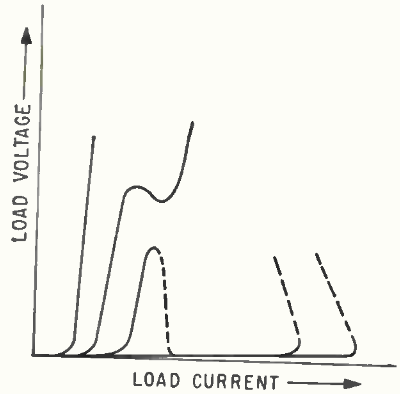
LINEAR AMPLIFIER *by Motorola and its equipment circuit*

SEMICONDUCTORS — Advances in semiconductor technology and microelectronic techniques were also reported at the meeting. Feasibility of constructing integrated circuits by alternately applying epitaxial growth and selective diffusion was demonstrated in work reported from two companies.

Papers by L. O. Hill and F. E. Boerger, of Westinghouse, described how this technique gave



THERMAL PROFILE *of microcircuit under load at ambient temperature of 100 C, obtained by Philco with infrared scanning*



CHARACTERISTIC *of emitter-controlled pnpn switch*

more design freedom to silicon planar integrated circuits than completing all epitaxial growths prior to diffusion. The new technique permits modifying the electrical properties of internal regions and electrically isolating multiple epitaxial layers. Hill said it was successfully used to construct adjacent bipolar and unipolar field-effect transistors with well-matched characteristics.

Variations of this process have also been used at Motorola. D. S. King described the fabrication of a silicon integrated flip-flop having a 2-Mc clock rate and 50-mw power dissipation, a NAND circuit with an average propagation delay of 80 nanoseconds, and a two-stage linear amplifier whose cascaded gain (with a hybrid capacitor of 10,000 pf) was 30 db at 12 Mc.

The linear amplifier was constructed by first forming transistors in opposite ends of a high-

NEW CIRCUIT GEOMETRY NEEDED?

ONE TREND *in microelectronics is to develop devices capable of operating at very low supply power levels. Microwatt levels have been reached and researchers are now pushing toward nanowatt levels.*

Describing the problems of building nanowatt devices, W. W. Gaertner, of CBS Laboratories, said that to achieve significant speeds it will be necessary to reduce size an order of magnitude beyond that of the smallest present devices. He says the present planar surface passivated transistor may have to be abandoned for a filamentary construction that would avoid junction capacitance problems. Such a structure would be supported by or embedded in an insulator of high resistivity and low dielectric constant. Electron beam technology will be valuable in achieving this, he said

resistivity silicon bar, as shown. Temperature coefficient of resistance was then reduced from 12,000 ppm/deg C to approximately 3,000 by paralleling the bar resistance (R_s) with the sheet resistance of two diffused resistors (R_D).

M. Walker of Philco described a thermal mapping method for thin films. He reported being able to generate isothermal patterns (see illustration) in tantalum microcircuits at temperatures from 50 C to above 250 C with an infrared scanning system using a photosensitive indium antimonide cell. Hot spots 1.3 mils in diameter were detected.

NEW DEVICES—An emitter controlled *pnpn* switch was reported by E. A. Karcher, of Army Signal R&D Lab. He said the characteristic shown occurs because the electron current gain of the *npn* section varies with load current even though the current across the electron injecting junction is constant. Ability to control oscillation with the emitter current makes the device suitable for a controlled oscillator, he said. No data on temperature dependence of the characteristics were available, as yet.

F. P. Heiman of RCA Labs reported new data on the insulated-gate, field-effect transistor. In this thin-film transistor the control mechanism can be either depletion of the conducting channel charge, enhancement of the charge, or a combination of both. Units fabricated to date have these typical characteristics: 2.8 × 10^{-6} ohms transconductance, −8v cutoff bias (depletion mode units), 10 nanosecond rise time, and input impedance of 7 pf, 10^{16} ohms. Goal is integrated logic circuits; 16-NOR-gate blocks have been fabricated.

INFRARED DIODES—Conferees showed high interest in three papers on gallium arsenide infrared diodes. The papers dealt with their mechanism of operation (see also ELECTRONICS, p 44, Oct. 5).

J. R. Biard, of Texas Instruments, Inc., said the infrared that is generated by the diodes is an area effect, and that terminal quantum efficiencies of 1 to 2 percent and internal efficiencies of 44 percent had been observed. Claiming that the four-terminal device application seems a fruitful area of research, he said power gain has been exhibited in such a device, constructed by optically coupling a diode and a silicon phototransistor in a loop with a 500-cps feedback network. Modulation was observed at 900 Mc.

Flight Plotter

NAVIGATION *display by ACF Electronics division receives bearing and distance inputs from Vortac ground stations and shows plane's position as luminescent dot (at pencil tip). Pilot inserts navigation chart under cursor disk*

Optical Techniques Can Raise Computer

Developments in fiber optics and lasers have broken the trail

WASHINGTON — General-purpose optical digital computers may be nearer than you think. More research is needed but progress stood out prominently at the Symposium on Optical Processing of Information here last week.

W. F. Kasonocky, of RCA Labs, declared that an all-optical computer using laser devices as the active components could be built if right materials were available. Such a computer might operate at gigacycle rates. The computer would use laser action in optic fibers. These fibers would be active transmission lines working either as neuristor lines or other types of digital lines.

REQUIREMENTS — Kasonocky said a study for the Air Force showed that the main requirements for a digital computer could be met,

Hitching Computer Data to Telstar

Eleven manufacturers participate in communications tests

OCTOBER was a busy month for the data channels of AT&T's Telstar, with 11 business machine manufacturers transmitting and receiving information on the last three Thursdays and Fridays of that month, in tests to show that the experimental satellite communication system can work with data-processing equipment.

Bell Laboratories made several preliminary tests earlier in the month, transmitting at 875,000 bits per second from Andover to Andover, between Great Britain and Andover, and then from France to Andover. During the 18.5-minute test of data transmission from France, there was only one bit error in almost a billion bits. The transmission rate was equivalent to 1,460,000 English words a minute.

COMPUTER TESTS—IBM and Tally Register transmitted data across the Atlantic.

In a 17-minute test, IBM sent computer data from a 1401 in Endicott, New York, to a 1401 at La Gaude, near Nice, France, by the stations in Andover and in Pleumeur-Bodou, France. The trans-Atlantic experiment was performed both from computer memory to memory and from computer to magnetic tape, and was conducted in cooperation with the French postal, telephone and telegraph service.

Tally Register transmitted perforated-tape information between their Seattle office, by the Andover station, to their London subsidiary, by the Goonhilly station. Messages included machine-tool programming instructions, medical data, bookkeeping data and computer input information.

The other manufacturers sent and received data using only the Andover station. These were Burroughs, Control Data, General Electric, Honeywell, National Cash Register, Smith-Corona Marchant, Stewart-Warner, Univac, and Victor Adding Machine.

Burroughs used their new D285 data processing system to send computer messages between Detroit and Paoli, Pennsylvania.

General Electric transmitted computer messages between GE-225 computers at Phoenix and Schenectady, using GE's Datanet-15 data-communications system, at 70 characters per second.

National Cash Register transmitted 10 different types of simulated savings-account transactions, in a test of their on-line banking computer system.

Univac transmitted over 16 million bits from its 490 computer, and received them back with only 4 bit errors, which were attributed to an open electrical connector. Some photographer kicked it apart accidentally.

COMPUTER ENGINEERS *send messages from an IBM 1401 in Endicott, N.Y., to a 1401 in France by Telstar. Other channels were used for voice communications* namely: establishing a threshold for signal amplification, achieving pulse inhibition or control, and standardizing the pulse amplitude.

He said that optical directional coupling is possible when two optic fibers are in close proximity. And this means laser logic circuits can be built.

Here are the major problems: obtaining a suitable combination of emissive and absorptive resonant ions in the fiber line and achieving sufficiently high pumping rates for gigacycle repetition rates to keep the lines short enough.

For 1-Gc repetition rates, a 1-micron-diameter line might handle an average power of approximately 10 milliwatts if the lifetime of fluorescence is 0.4 millisecond and pulse duration is 10^{-10} second.

LOGIC—Elias Snitzer and D. J. Koester, of American Optical Co., discussed the possibility of optical computer logic. They said studies of dielectric waveguide modes in glass fibers showed there were differences in phase velocity for various modes, as well as crosstalk between closely spaced fibers.

Also, when radiation from one neodymium glass laser is sent into another, the radiation from the first reduces the degree of population inversion in the second laser, thus causing oscillation to cease. This implies the possibility of NOR logic.

They also said the fiber laser has potential as an amplifier.

BEAM DEFLECTION—Techniques for rapidly deflecting light beams were discussed by U. J. Schmidt, of Thompson Ramo Wooldridge. Deflection at a rate of around 1 Mc would allow for addressing memory cells, multichannel switching, and display devices.

One approach changes the refractive index of the active laser material during optical pumping. He predicted that new laser materials would permit deflection through large angles with high resolution.

Another technique is to pass a plane polarized laser beam through a Kerr cell and a birefringent uniaxial crystal prism. Sending a beam through n such combinations allows deflecting the beam in 2^n directions, he said. Switching time could be in the 10-nanosecond range.

STORAGE—Design study of a large-capacity, fixed store or memory for a high-speed digital computer was described by G. R. Hoffman, of Manchester University. Information in the store would be recorded on a photographic matrix at half a million bits per square inch. For interrogation light pulses would be transmitted along optic fibers. Access time is 20 nanoseconds, repetition rate is 100 nanoseconds. A practical store could hold 7.5×10^6 bits in 300 square inches and a total volume of 6 cubic feet.

Experimental opto - electronic functional block was described by E. E. Loebner, of Hewlett Packard Associates. The device is a chopper assembly. It consists of two silicon phototransistors and two electroluminescent gallium arsenide diodes mounted on a 7-pin TO5 transistor header.

The symposium was co-sponsored by ONR's Information Systems Branch and American Optical Co. Registration exceeded 600.

Vostoks Did Not Rendezvous

Pravda requotes earlier statements by Vostok pilots

MOSCOW—*Pravda* has published a lengthy report on the group space flight last August. It requoted the statements by the pilots that no attempt was made to rendezvous Vostoks 3 and 4.

The target distance, the report indicated, was 5 kilometers and the ships actually came within 6.5 kilometers of each other. The report claimed that both Vostoks took off from the same launching pad, one slightly less than 24 hours after the other.

The pilots could have selected the landing locations, it added, but elected to parachute. The unmanned ships landed safely, it was reported.

Cabins were shielded and neither the pilots nor biological objects experienced harmful radiation doses. Flights lasting several hundred hours were considered feasible.

COMMUNICATIONS—Only a general description of electronic equipment was given.

Communications equipment was based on that used in previous flights. Pilots had their choice of three radiotelephones and could also communicate to ground by telegraph code through the telemetry transmitter. Both transmitters and receivers were made with semiconductor devices. Transmitter sensitivity was listed as within 1 microvolt.

Frequencies were specified as "shortwave" and "ultra shortwave." Receivers could be tuned to the 25, 31 and 49-meter bands and also between 190 and 580 meters (h-f and m-f). The pilots used recorders which played back at an accelerated rate on ground command.

Pilots were viewed with two low-power vidicon tv cameras. These operated at 10 frames a second, 400 lines, with progressive scanning. *Pravda* said this permitted the standard signal of 6 to 6.5 Mc bandwidth to be reduced to 800 Kc. The signal was converted on the ground for tv broadcasting.

DATA PROCESSING—Communications lines linked telemetry and communications stations, at unspecified locations in USSR territory, to digital computing stations. Data was converted to code before ground transmission and was placed on punched cards for computer input.

Several computers worked the same problems simultaneously to avoid possible errors. Incoming data was keyed to astronomical time. Flight parameters were computed several orbits in advance with the aid of radar fed to computer stations, *Pravda* said.

MEETINGS AHEAD

RADIO FALL MEETING, IRE-PGBTR, PGRQC, PGED, EIA; King Edward Hotel, Toronto, Canada, **Nov. 12-14.**

MAGNETISM & MAGNETIC MATERIALS CONFERENCE & EXHIBITION, IRE-PGMTT, AIEE and Amer. Instit. of Physics; Penn Sheraton Hotel, Pittsburgh, Pa., **Nov. 12-15.**

ASTRONAUTICAL EXPOSITION, American Rocket Society; Pan Pacific Aud., Los Angeles, Calif., **Nov. 12-18.**

LOUDSPEAKER INDUSTRY MEETING; EIA; Pick-Congress Hotel, Chicago, Ill., **Nov. 14.**

CANADIAN IRE COMMUNICATIONS SYMPOSIUM, IRE Montreal Section; Queen Elizabeth Hotel, Montreal, **Nov. 16-17.**

MID-AMERICAN ELECTRONICS CONFERENCE, IRE; Continental Hotel, Kansas City, Mo., **Nov. 19-20.**

VEHICLE SYSTEMS OPTIMIZATION SYMPOSIUM, IAS; Garden City Hotel, Garden City, N. Y., **Nov. 28-29.**

ULTRASONIC SYMPOSIUM, IRE-PGUE; Columbia University, New York City, **Nov. 28-30.**

FALL JOINT COMPUTER CONFERENCE, IRE-PGEC, AIEE, ACM; Sheraton Hotel, Phila., Pa., **Dec. 4-6.**

VEHICULAR COMMUNICATIONS CONFERENCE, IRE-PGVC; Disneyland Motel, Anaheim, Calif., **Dec. 6-7.**

SPACE PHYSICS CONFERENCE, American Rocket Society; Philadelphia, Pa., **Dec. 26-31.**

MILLIMETER & SUBMILLIMETER CONFERENCE, IRE Orlando Section; Cherry Plaza Hotel, Orlando, Florida, **Jan. 8-10.**

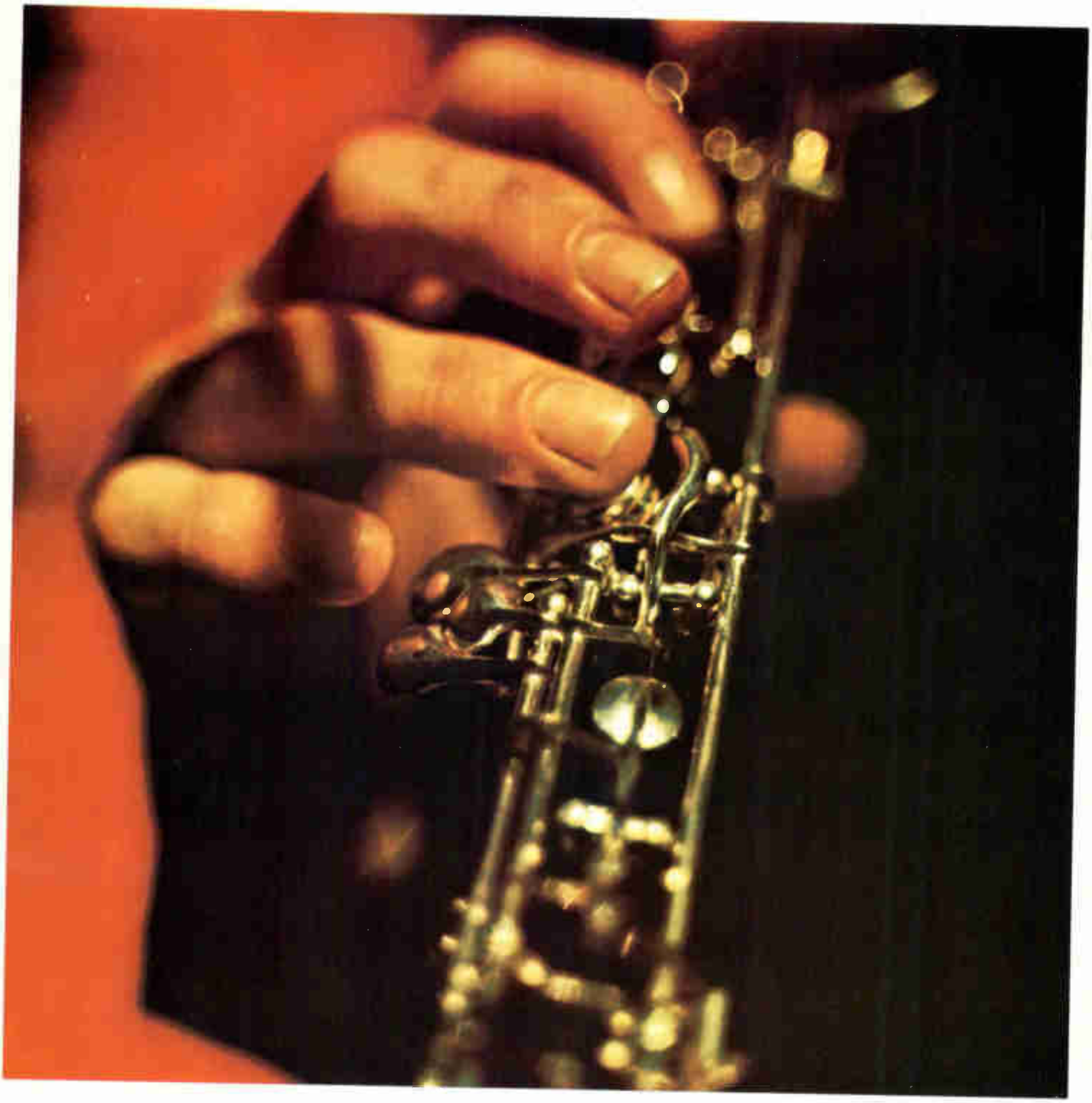
RELIABILITY & QUALITY CONTROL SYMPOSIUM, IRE-PGRQC, AIEE, ASQC, EIA; Sheraton Palace Hotel, San Francisco, Calif., **Jan. 21-24.**

MILITARY ELECTRONICS WINTER CONVENTION, IRE-PGMIL; Ambassador Hotel, Los Angeles, Calif., **Jan. 30-Feb. 1.**

IEEE INTERNATIONAL CONVENTION, Institute of Electrical and Electronic Engineers; Coliseum and Waldorf-Astoria Hotel, New York, N. Y., **March 25-28.**

ADVANCE REPORT

THIN FILMS FOR ELECTRONIC APPLICATIONS SYMPOSIUM, ELECTROCHEMICAL SOCIETY (*Electronics, Electric Insulation, Electrothermics and Metallurgy Divisions); Penn Sheraton Hotel, Pittsburgh, Pa., April 15-18. Dec. 14 is the deadline for submitting three copies each of a 75-word abstract and a 500-1000 word extended abstract to: Electrochemical Society Headquarters, 30 East 42nd St., New York 17, N. Y. All aspects of thin film technology having electronic application are of interest including: materials (metals, insulators, semiconductors) and combinations thereof (ie., cermets): monitoring and testing techniques for thin film deposition: materials for specific application (magnetic, dielectric, superconducting, tunneling); properties of thin films (experimental and theoretical); ageing effects in thin films; compatibility of thin films.*



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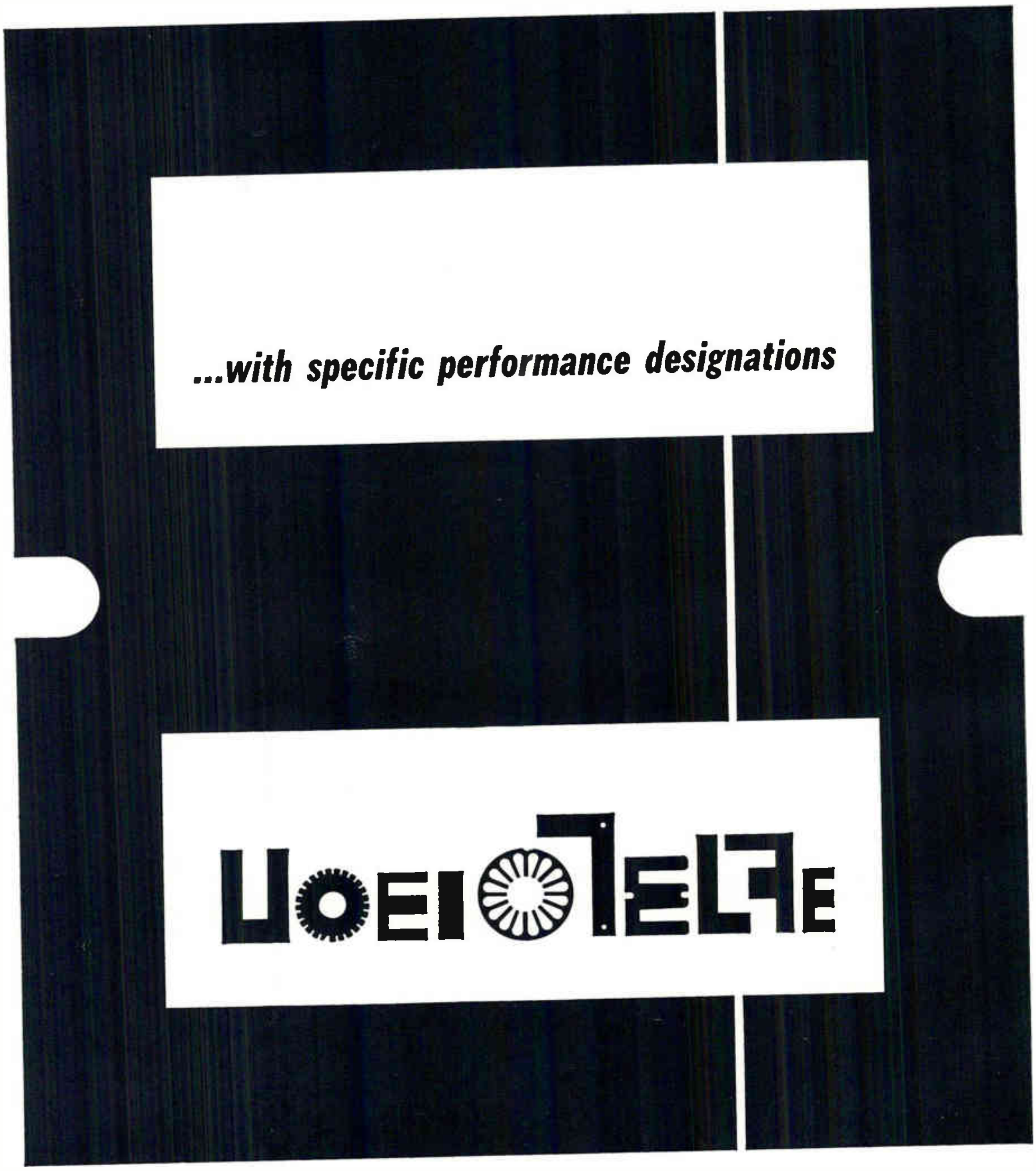

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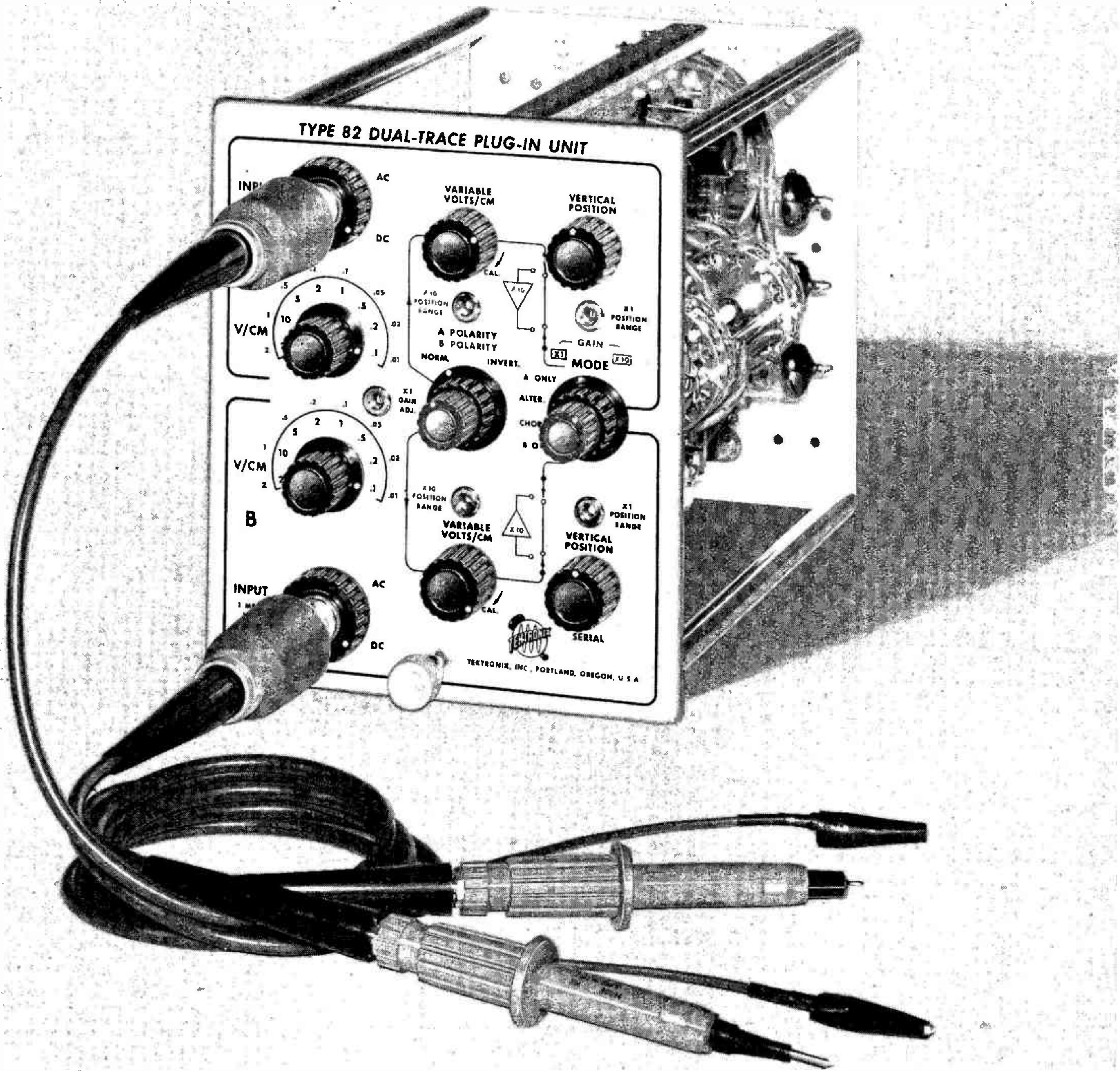

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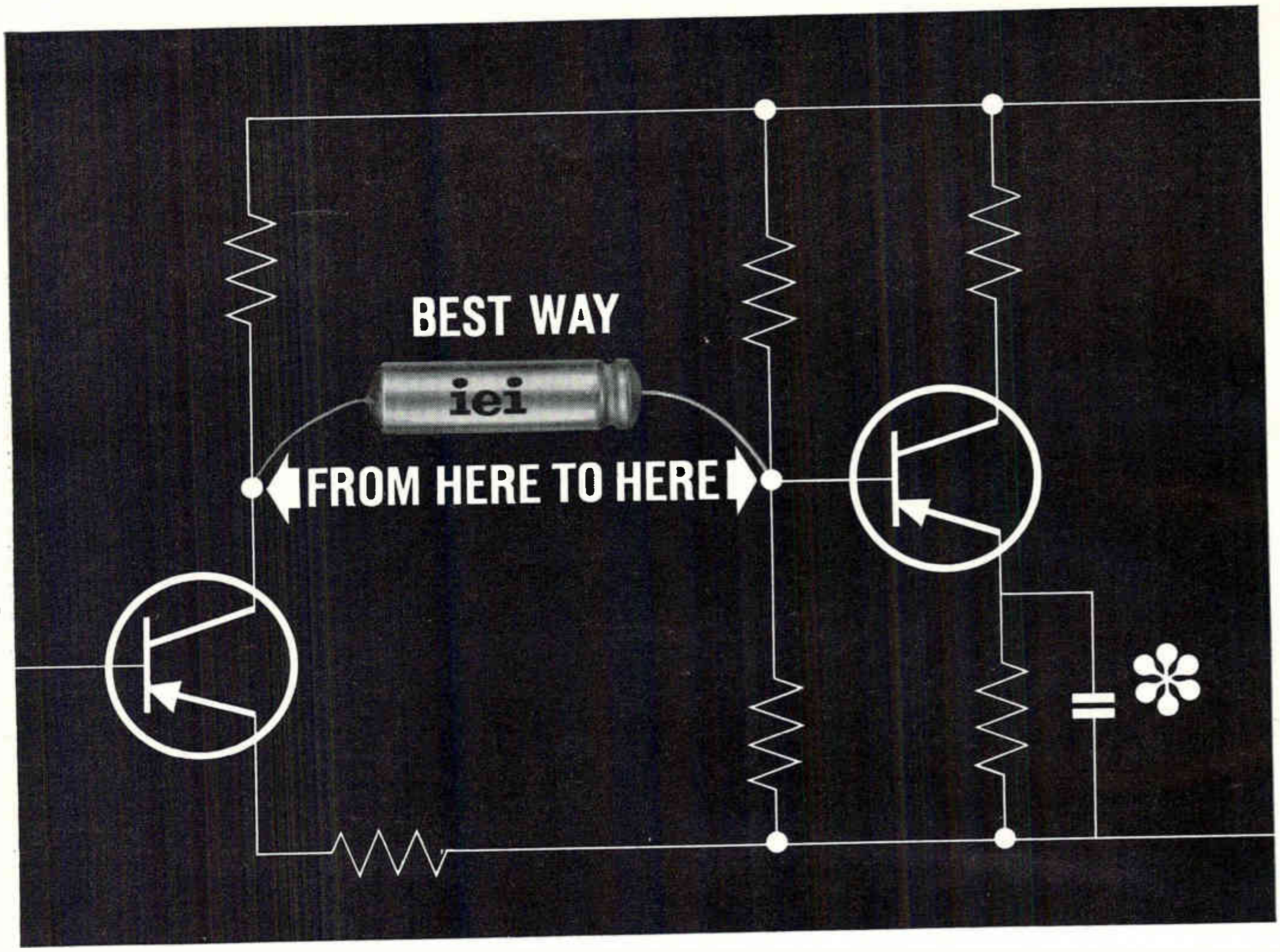

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C5	580	1160
C4	400	800
C3	200	400
C2	60	120
C1	15	30

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282002

Rear panel mount Microfuse holder (with the round nut mounted from front of panel). Rugged aluminum body and knurled cap; both can be anodized in color. Fungus and shock resistant. Sealing "O" rings in cap and on body. "Eye" type terminals specially designed for easy soldering.

281002

Front panel mount Microfuse holder (with the hexagon nut rear of panel). Molded from high strength, high dielectric material. Knurled cap for easy grip, with skirt for positive "O" ring seal. Rugged "Eye" type plated brass terminals separated by molded barrier to provide complete insulation.

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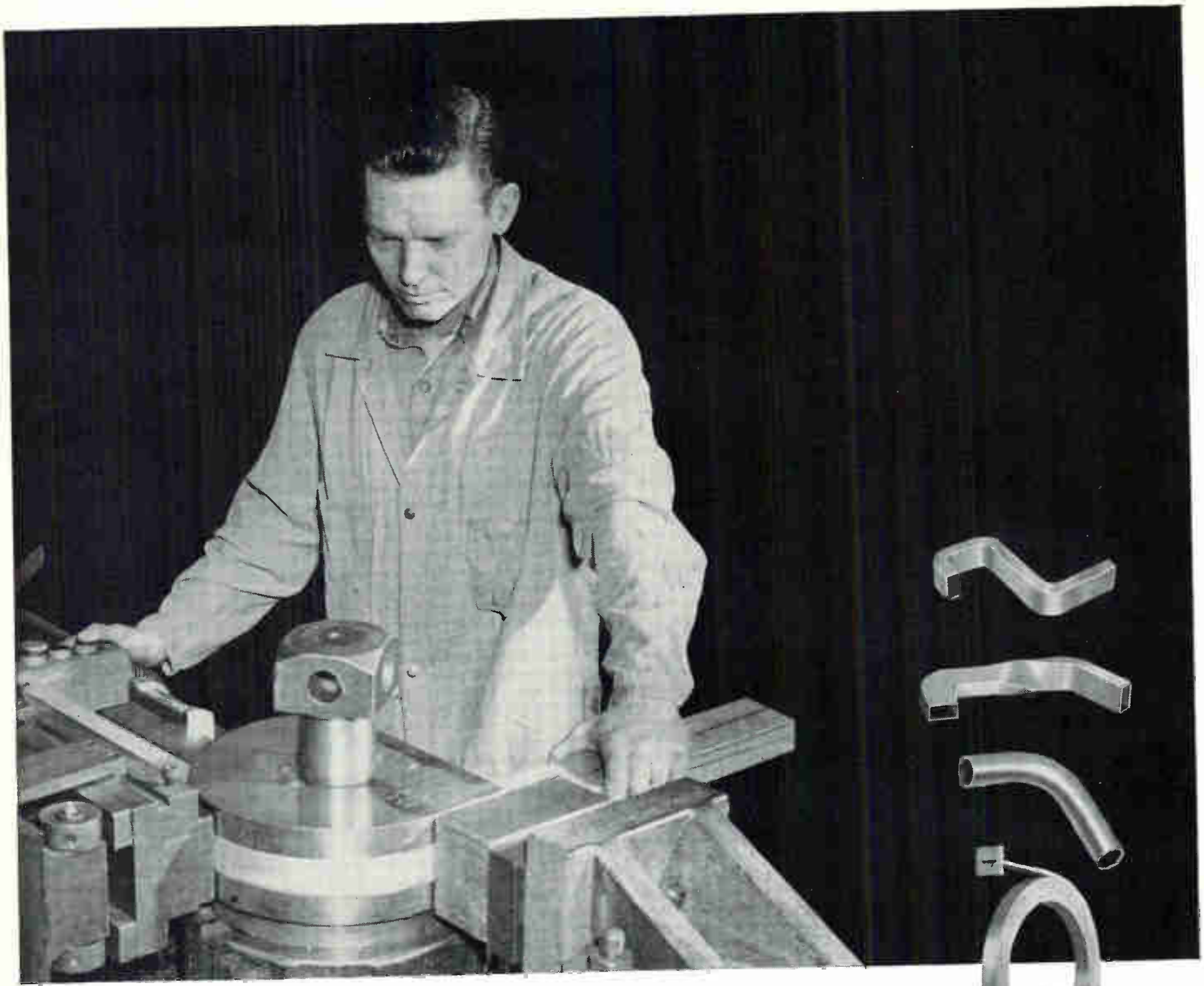

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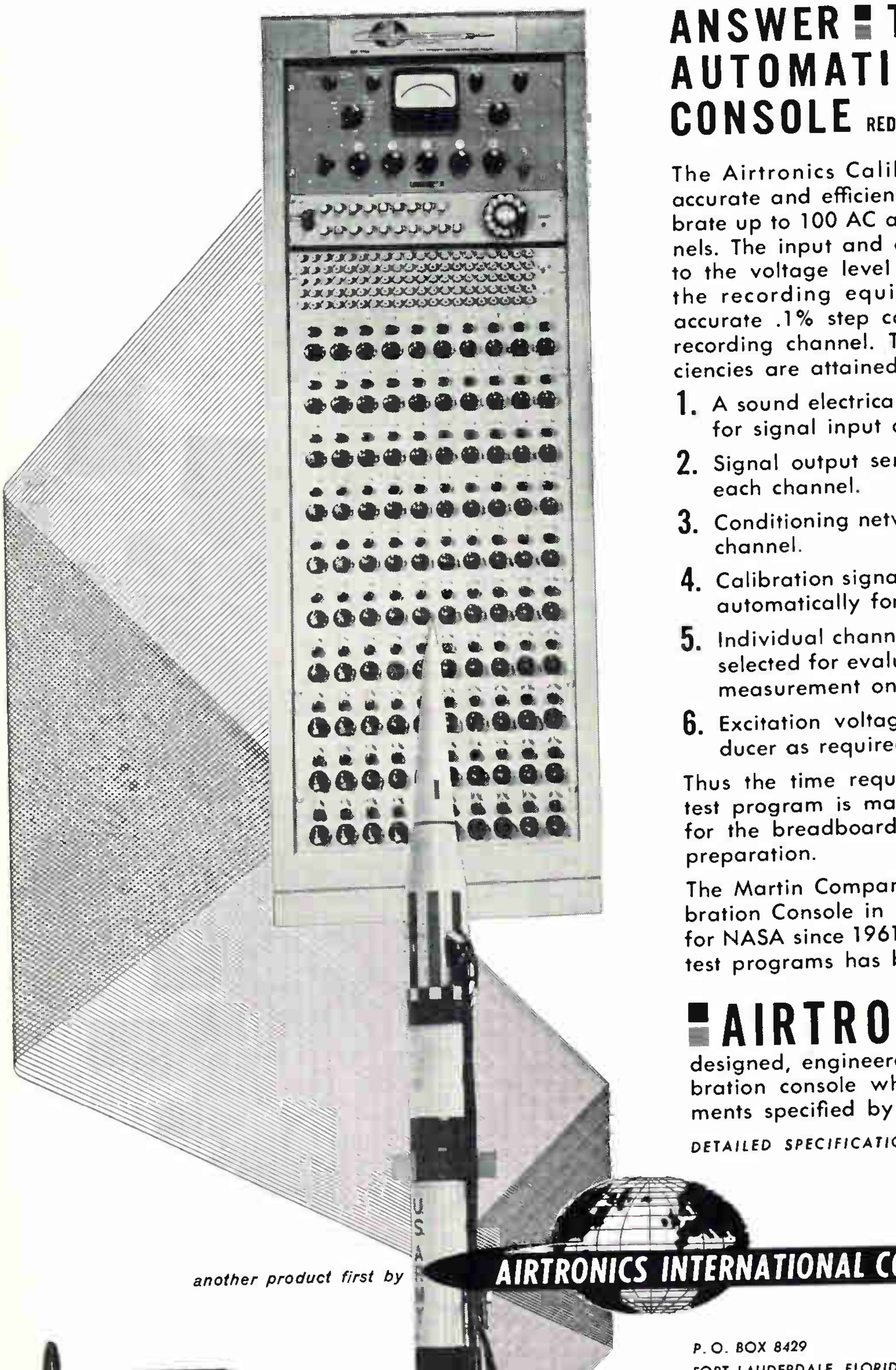

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Thus the time required to set up and perform a test program is materially less than that required for the breadboard and patch panel type of test preparation.

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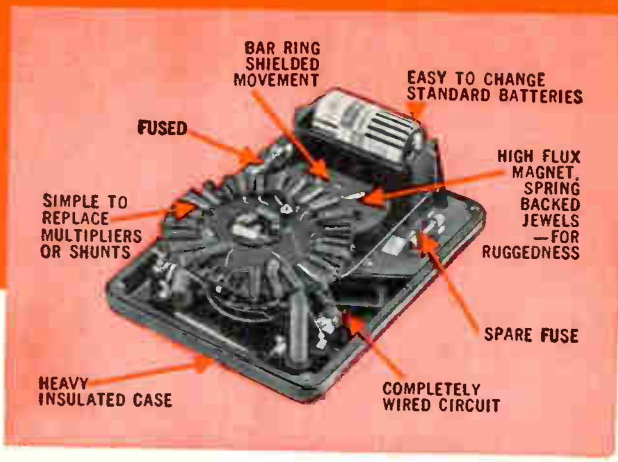

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2 Single control knob selects any of 32 ranges—less chance of incorrect settings and burnouts.

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Attention to detail makes the Triplett Model 630 V-O-M a lifetime investment. It has an outstanding ohm scale; four ranges—low readings .1 ohm, high 100 megs. Fuse affords extra protection to the resistors in the ohmmeter circuit, especially the XI setting, should too high a voltage be applied. Accuracy 3% DC to 1200V. Heavy molded case for high impact, fully insulated.

†*630A same as 630 plus 1½% accuracy and mirror scale only $59.50*

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DC VOLTS	0-3-12-60-300-1,200-6,000 at 20,000 ohms per volt.
AC VOLTS	0-3-12-60-300-1,200-6000 at 5,000 ohms per volt.
OHMS	0-1,000-10,000.
MEGOHMS	0-1-100.
DC MICRO-AMPERES	0-60 at 250 millivolts.
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DB: –20 to +77 (600 ohm line at 1 MW).

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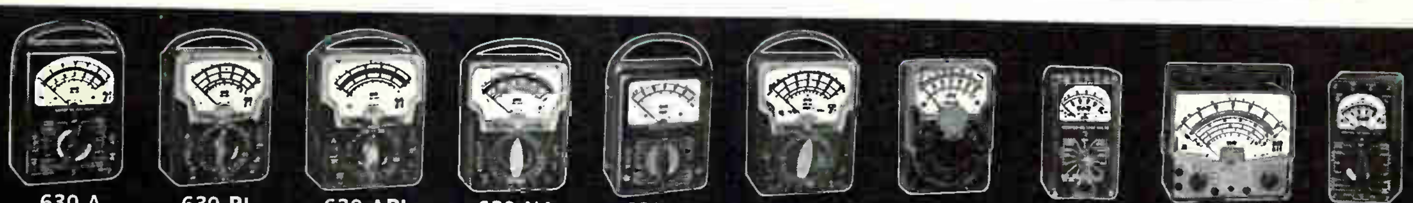

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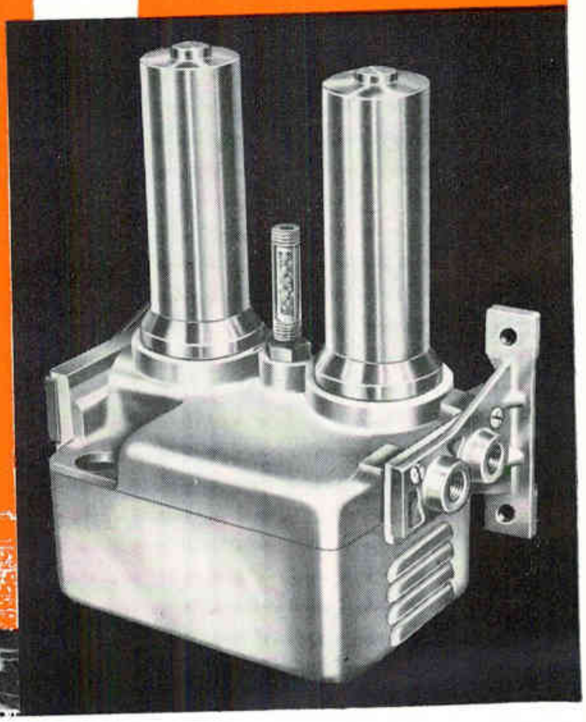

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SPECIFICATIONS

Model No.	HF-200-4	HF-200-6	HF-200-9	HF-200-12
Flow Operating at 100psig	1 SCFM	2½ SCFM	5 SCFM	7½ SCFM
Model No.	**HF-201-4**	**HF-201-6**	**HF-201-9**	**HF-201-12**
Flow Operating at 125psig	1 SCFM	2½ SCFM	5 SCFM	7½ SCFM
Weight (approx.)	4 lb.	5 lb.	6 lb.	7 lb.
Height (approx.)	9"	11"	14"	17"
Width (approx.)	8"	8"	8"	8"
Depth (approx.)	5"	5"	5"	5"
Power Requirements	110 volts or 220 volts, 50 cycles or 60 cycles, single phase 15 watts. Other voltages and frequencies available.			

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electronics

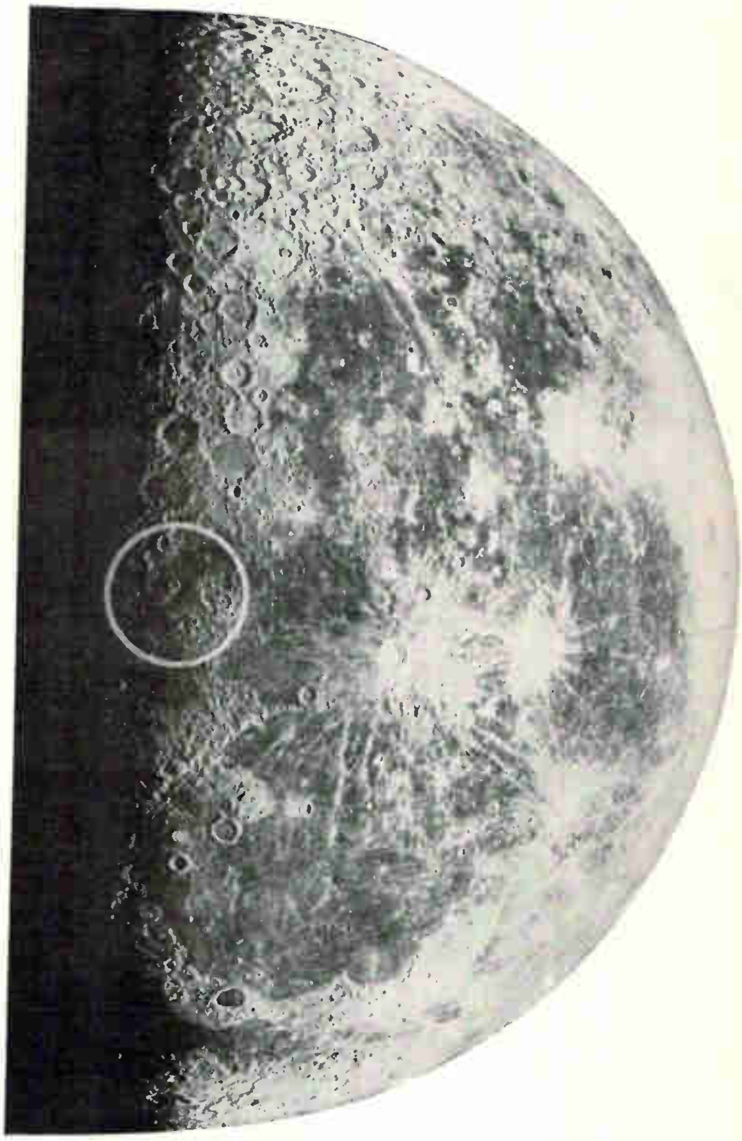
November 9, 1962

FIRST SYSTEM DETAILS ON

Giant Haystack Radar Facility

Haystack—first U. S. system for simultaneous operation of two-way communications, beacon-tracking radar, and skin-tracking radar in a unified package—will be a high-precision facility that will find wide usage

By THOMAS MAGUIRE, New England Editor



RESOLUTION *of Haystack radar at 8 Gc is 250-mile-diameter circle at moon's surface, shown for comparison on this Mt. Wilson Observatory photo—Fig. 1*

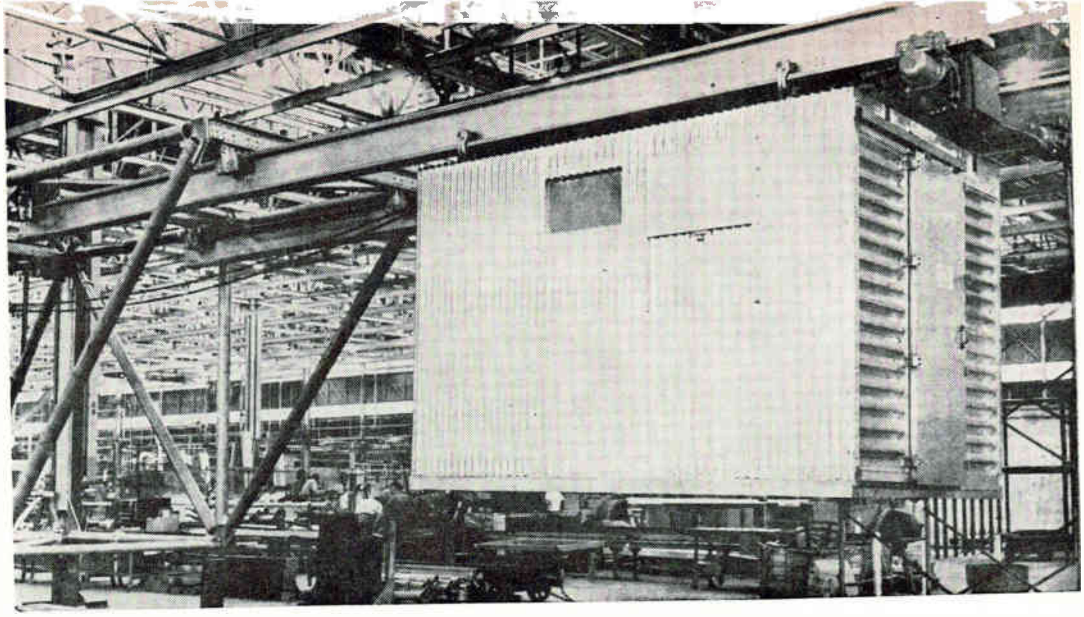
A NEWS STORY GROWS UP

At NEREM in Boston this week, Project Haystack is being discussed. Our New England Editor, Tom Maguire, started out to get a news story, talked to Herbert Weiss who supervises Lincoln Lab's role in Haystack, and ended up with technical story on details that are being revealed at NEREM for the first time. For those who can't be in Boston this week, here it is . . .

HAYSTACK, a powerful and sensitive experimental radio and radar facility using the most precise large movable antenna ever built will go into operation next summer in Tyngsboro, Massachusetts. The 120-foot Cassegrainian reflector will be sheltered by a rigid metal-space-frame radome 150 feet in diameter.

Project Haystack (ELECTRONICS, p 51, Nov. 25, 1960), costing the Air Force an estimated $10 million, is bringing a new generation of capability in space communications and high-power radar trackers. Initially it will be used to explore the potential of orbital scatter communications.

Haystack will be America's first system designed for simultaneous operation of two-way communications, beacon-tracking radar and skin-tracking radar in a unified instrumentation system. The facility takes on added significance in view of two recent DOD decisions: abandonment of the Navy's 600-foot Sugar Grove antenna project; and discontinuance of the Army's Advent program and assignment of



PLUG-IN *equipment room under construction for West Ford communications experiments. Incorporated into the antenna structure, this room will hold two tons of electronics, including feed-horn assembly, transmitter components and low-noise receiving equipment—Fig. 2*

CHARACTERISTICS OF HIGH-GAIN STEERABLE ANTENNAS*—TABLE I

	Diameter (D)	Estimated** RMS Surface Tolerance (t)	Shortest Operating Wavelength (λ_{min}) [where $t = \lambda/16$]	D/λ_{min}	Calculated Beamwidth (degrees)
Jodrell Bank Manchester, England	250 ft (76 m)	±3 cm	48 cm (625 Mc)	160	0.4
National Radio Astronomy Obs. Greenbank, W. Va.	300 ft (91 m)	±1.3 cm	20 cm (1.5 Gc)	450	0.15
C. S. I. R. O Parkes, Australia	210 ft (63 m)	±0.7 cm	10 cm (3 Gc)	630	0.1
Lincoln Laboratory Lexington, Mass.	28 ft (8.6 m)	±0.05 cm	0.8 cm (35 Gc)	1,070	0.06
P. N. Lebedev Institute Serpukhov, USSR	72 ft (22 m)	±0.05 cm	0.8 cm (35 Gc)	2,750	0.025
Haystack (Lincoln Lab.) Tyngsboro, Mass.	120 ft (37 m)	±0.07 cm	1.1 cm (27.5 Gc)	3,300	0.02

* Compiled by H. G. Weiss, MIT Lincoln Laboratory
** Exact surface tolerance data not available

military communications satellite development to the Air Force.

Conceived and designed by MIT Lincoln Laboratory in Lexington, Mass., Haystack will be used initially as an X-band system. The precision being built into the antenna, however, assures operation at 20 Gc, and indicates the possibility of reaching 35 Gc, with perhaps 80 percent of the reflector surface employable at this 8-mm wavelength. Its nominal operating frequencies will be 7,750 Mc and 8,350 Mc in the communications mode, and 7,750 Mc and 8,050 Mc in the radar mode.

OBJECTIVES—The system is being built under the sponsorship of the Directorate of Communications Programs at AF Electronic Systems Division, Bedford, Mass., as part of the SPACECOM program, to provide communications for support of

ANTENNA CHARACTERISTICS—TABLE II

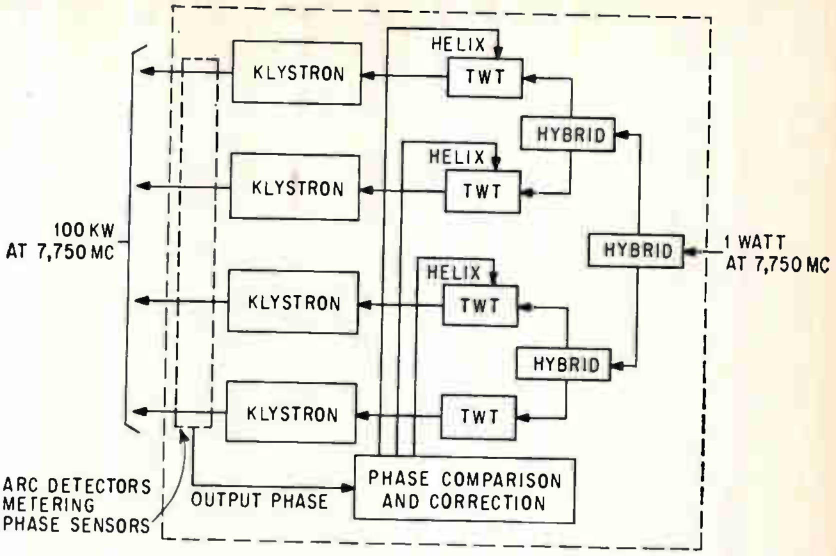
Type	Paraboloidal reflector—Cassegrain optics
Size	Primary reflector: 120 ft dia. Secondary reflector: 9 ft 4 in. dia.
Useful Frequency Range	1 Gc through 10 Gc (to 35 Gc with reduced efficiency)
Gain at 10 Gc (theoretical)	69 db, half power BW = 0.05 deg
Dynamic Pointing Accuracy	±0.005 deg
Max Rotation Rate	3.5 deg/sec in az and el
Feed Horn	Monopulse, dual polarization
Plug-in Room Behind Reflector	Size: 8 ft × 8 ft × 12 ft; 4,000 lb capacity

RADOME CHARACTERISTICS—TABLE III

Electrical	
Transmission Loss at 8 Gc	0.7 ± 0.1 db (measured)
Temperature Contribution at 8 Gc	20 deg ± 5 deg K (measured)
Boresight Shift	< 0.1 milliradian
Mechanical	
Diameter	150 feet
Height	131 feet
Cross Section of Frame Members	3 inches × 5 inches
Length of Frame Members	9 feet to 15 feet
Thickness of Glass-Fiber Panels	0.032 inch

R-F BOX NO. 1—TABLE IV

(1) Main Transmitter	
Function	Communications and radar (long pulse)
Frequency	7,750 Mc
Power Output	100 Kw (c-w)
System Bandwidth	30 Mc
(2) Receivers	
2 Masers	7,750 Mc and 8,350 Mc (temp = 20 deg K)
6 Parametric Amplifiers (cooled)	7,750 Mc and 8,350 Mc (temp = 90 deg K)
Overall System Temp	< 75 deg K maser; < 150 deg K paramp
(3) Tracking Radar	
Frequency	8,050 Mc
Power Output	50 Kw peak
Pulse Length and PRF	Variable



HIGH-POWER, *X-band transmitter uses 4 phase-locked klystron amplifiers to generate 100 Kw of output power at 7,750 Mc—Fig. 3*

global Air Force operations. Herbert G. Weiss is supervising Lincoln Laboratory's part in this program, and Lt. John H. Shock is the AF project manager.

Haystack will test out new communications concepts, first of which is Project West Ford, orbital scatter communications by tuned dipole belts.

Other possible communications applications involve moon-bounce experiments and work with Echo, Syncom and future satellites. It will develop techniques applicable for communications with Gemini, Apollo and other space vehicles; and may be used in developing long-haul, low-capacity emergency military communications with forces around the world.

In the radar mode, Haystack's high resolution capabilities could be employed for detection and tracking of satellites and space vehicles, to provide more accurate orbit information. It could be used also for testing navigation aids for space vehicles, and for observing missile firings from Cape Canaveral and Wallops Island. No system now in operation could radar skin-track Advent-type high-altitude satellites if the beacon went dead. Haystack will have that capability.

With a half-power beamwidth of 0.06 degree at X-band, Haystack will illuminate an area only 250 miles wide on the moon (Fig. 1). Its high system sensitivity will be capable of tracking a 0.22 caliber shell at 1,000 miles.

In radio physics, Haystack should permit the first radar echoes from Mars, Mercury and Jupiter; it will receive emissions from planetary atmospheres and from the solar corona. It will be used for interplanetary distance measurements and will probe the atmosphere and rotation rate of Venus.

Because of system sensitivity, it will be able to see Venus at all times of the year, not just during the planet's closest approach to earth.

"Unless there are unforeseen anomalies in space transmission," Lincoln Laboratory Associate Director William H. Radford said at NEREM this week, "the Haystack system will be able to receive 10-cps bandwidth signals from a deep-space probe at ranges approaching 10^8 nautical miles."

ELECTRONICS—Interchangeable antenna-mounted r-f packages will contain the Haystack transceiver equipment. The first package is shown in Fig. 2. Measuring 8 ft. × 8 ft. × 12 ft., it can be lifted by crane to be plugged into the system behind the reflector, where it will be part of the moving system. Thus, different modes of operation can be undertaken within a few hours time. First working-package will be the West Ford transmitter and receiver. Next will come "the best pulsed radar that can be dreamed up within the present state-of-the-art."

For the West Ford experiments, two tons of electronics will be plugged into the dish: a high-power transmitter, low-noise receiver system and low-power tracking radar. Frequency separation techniques will allow simultaneous operation of the three modes.

The transmitter, under construction by Radiation-at-Stanford, will put out 100 Kw of c-w power in the band from 7,125 to 8,500 Mc. Two transmitters are being built for the Air Force at a total cost of $1.7 million. The second is for Rome Air Development Center and will be used at the Floyd Communications Terminal Site, Griffiss AFB. Final amplifier will consist of four Varian klystrons each capable of putting out 25 Kw of average power and all four phase-locked as one source, as illustrated in Fig. 3. The power supply, located on the ground, will be capable of producing 1 Mw on continuous d-c over a wide voltage range.

The receiver front end will consist of several masers and up to nine liquid-helium-cooled parametric amplifiers recently developed at Lincoln Laboratory, where the masers are also being built.

A closed-cycle helium system, A. D. Little's cryodyne, will provide refrigeration for the masers and paramps. The refrigerator will be in the r-f box, and the compressor mounted on the antenna yoke.

The West Ford r-f package will also include a radar, which will have high performance because of the 69 db of antenna gain at X-band. Its 1-Kw power will provide about the same capability as the Millstone Hill radar of Lincoln Laboratory. The two tons of electronics in the r-f package will enable researchers to transmit and receive communications and to radar-track simultaneously. They will have the option of using one or more paramps or a combination of paramps and masers. Paramps will be used most of the time, but masers will be available "when we're really fighting for db's."

The r-f configurations for the three modes of system operation are outlined in Fig. 4.

In this first r-f working-package, designers are shooting for an overall system noise temperature of less than 60 deg K—equivalent to a noise figure of about 1.1 db. In the radiometer package, which will be used for calibration and pattern measurements, a system temperature of about 35 deg K is expected.

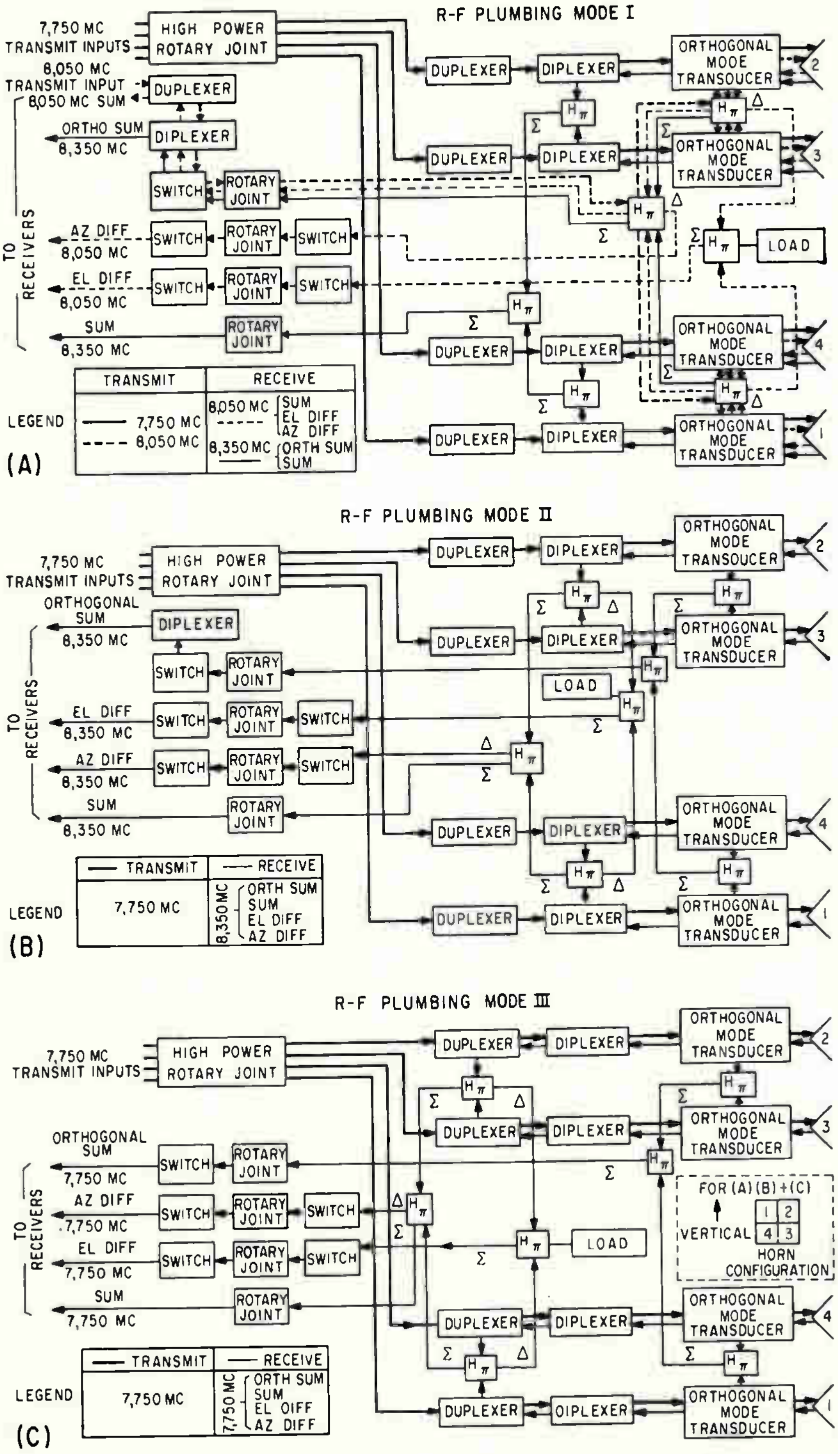
About 450 gallons of water per minute will be pumped up, into, and out of the r-f box for heat dissipation. In addition to automatic arc detection and monitoring, the high power level of the transmitter necessitates water-cooled waveguide in the 12 feet of plumbing from the r-f box to the focus of the reflector system. From this point, feed horns will be beamed at a secondary reflector, which will in turn illuminate the main dish.

DATA HANDLING—A new computer under construction at Lincoln Laboratory will be the interface between Haystack's wide-band communications channel and conventional high-speed signal-processing equipment.

Eventually, the facility will be operating a 30-Mc bandwidth, and this will require a real-time, high-speed buffer and data sorter. The interface computer will be a second-generation FX-1, with logic circuits capable of 100-megapulse operation. The FX-1, with 50-megapulse transistor logic, has been operating at Lincoln Laboratory for almost two years. It was designed as a test vehicle for high-speed logic circuits, new packaging techniques and magnetic-film memories.

In the Haystack application, the FX-2 will probably use cores for bulk storage, and thin films for internal memory. Operation at 100 Mc will require 5-Gc transistors, and Lincoln Laboratory has in-house and contractor programs for development of these components on a reproducible basis. Circuit designers are meanwhile taking a second look at tunnel-diode logic and at hybrid circuits.

For real-time detection and processing of narrow-band radar re-



HAYSTACK SYSTEM MODES. *Modes I (A) and II (B) are for satellite communications particularly, Mode I being appropriate for passive satellite communications. Target will be tracked and antenna steered by low-power 8,050 Mc radar integrated with simultaneous high-power communications. In Mode II, small radar is turned off, system is transmitting at 7,750 and receiving at 8,350 Mc. Antenna is controlled, target tracked by the received signal. Mode III (C) is the long-pulse-radar mode for interplanetary probes—Fig. 4* turns falling in a wideband noisy spectrum, Lincoln Laboratory has developed a new two-step system: the first step giving a coarse, high-false-alarm indication of range and doppler, and the second providing high-quality detection and parameter estimation. This sequential detection and processing method will replace the filter-bank system previously used at Lincoln Laboratory's Millstone Hill facility.

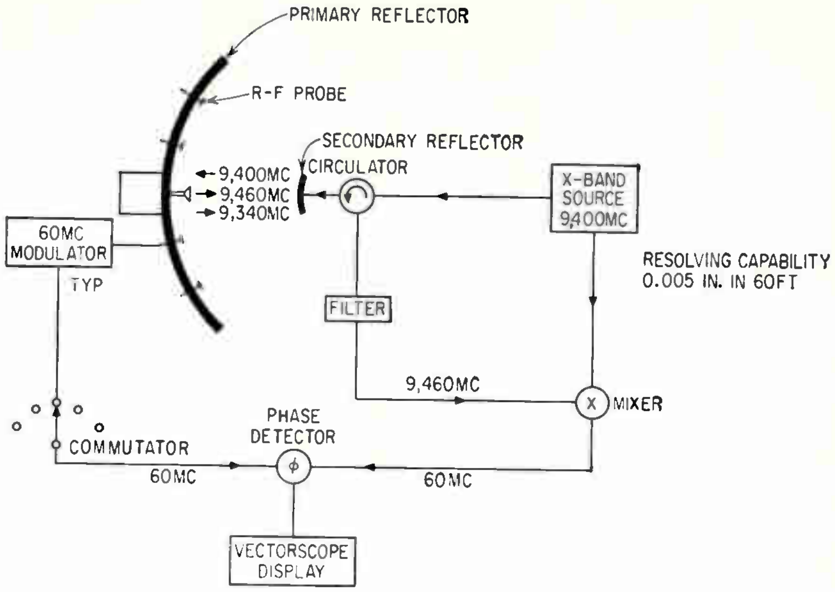
CONSTRUCTION — Nearly two years of engineering work went into design analysis and materials pretesting before any part of the Haystack antenna was fabricated.

Designers pioneered in the technique of using digital computer analysis to determine the behavior of large, redundant mechanical structures, a technique that may have wide applications in large civil engineering projects involving complex structures, such as bridge-building.

Design and construction of the antenna is being carried out by North American Aviation, Inc. in Columbus, Ohio; a concurrent supporting program at Lincoln Laboratory critically monitors the design as it is developed and provides an independent analysis of the behavior of the antenna structure. The Haystack antenna design was computer-evaluated and optimized at least 40 times before construction was begun, says Herbert G. Weiss of Lincoln Laboratory.

Besides extensive computer optimization, the project included the development of a 1/15 scale model, built and intensively tested by North American at Columbus, where in-plant final assembly of the full-scale Haystack antenna has been going on since May. Vibration and static loading tests are now underway. The antenna will then be disassembled and shipped to Tyngsboro, where it will be erected under the huge radome.

TOLERANCES—To achieve high-frequency operation and required system gain at microwave frequencies, extremely fine mechanical tolerances are required of the antenna. The reflector surface must remain within 0.075 in. of an ideal parabolic contour under all environmental conditions and for all angular velocities and accelerations.



MICROWAVE INTERFEROMETER *measurement system designed at Lincoln Laboratory will continuously monitor actual displacement of selected points on the reflector surface. Antenna test range measurements indicate interferometer is capable of determining displacement with an uncertainty of only 0.005 in.—Fig. 5*

Design analysis, therefore, dictated a high stiffness-to-weight ratio and a simple deflection compensation system as well as a protective radome.

Both optical and electrical surveying techniques will minutely check the reflector surface. Over $120,000 of the special optical tooling has been built by Keuffel & Esser Co. for initial setup and for once-a-year calibration. This optical probe which can be plugged in behind the antenna focus like an r-f package, will look at 384 optical targets around the surface of the dish. The surface can then be aligned by adjustable struts and locked to keep it within the required tolerance.

The electrical survey technique is shown in Fig. 5. Designed at Lincoln Laboratory, it will operate like a microwave interferometer or an r-f bridge-balancing system and will permit continuous, real-time surveying and calibration. Dipoles embedded in the surface of the reflector will operate as fixed-array antennas. Phase differences in the signals from these antennas will be displayed on a scope to fix their positions within 0.005 inch.

The 180 tons of movable structure must be pointed with a precision of better than ±0.005 degree, requiring special bearings, shaft-angle-encoding and control equipment. For operation at mm-wave frequencies, the half-power beamwidth will be so small—about 0.02 degree—that it will be necessary to steer the giant dish with an even greater accuracy. Steering instructions will be generated by a Univac 490, which will also have additional capacity to assist in data processing.

Incorporation of a general-purpose digital computer in the antenna control system will provide flexibility for the antenna search and track functions. The computer will accept pointing information from remote sensors, by standard teleprinter circuits, and will accomplish real-time parallax and time coordinate corrections.

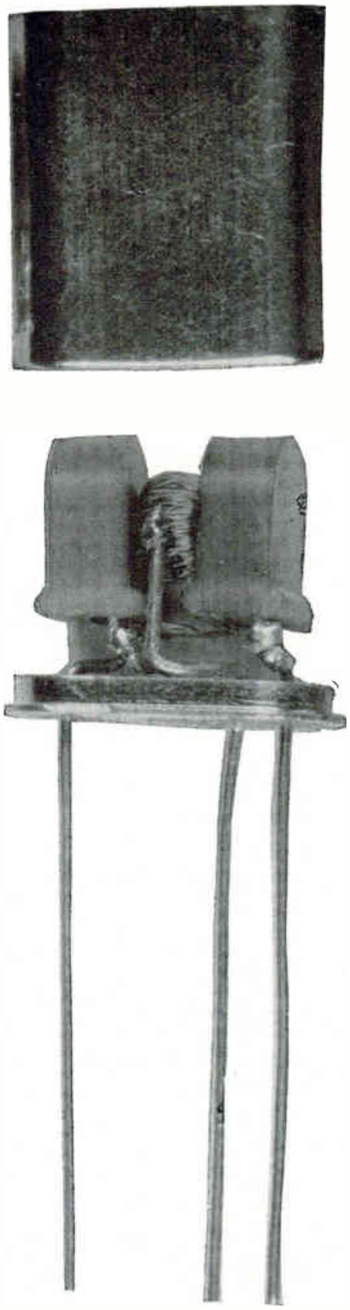
The antenna yoke will rest on a 14-ft.-diameter hydrostatic bearing, believed to be the world's most precise, and the whole antenna will be floating on a film of oil 0.003 inch thick. At a rotation rate of 3.5 deg./sec. in each axis, Haystack will be able to track even low-altitude satellites.

Telecomputing Corp. will supply a precision shaft-angle-encoding system for Haystack. Pulse-timing and frequency translation equipment will be furnished by Hughes. The rigid radome was built by H. I. Thompson Fiber Glass Co.

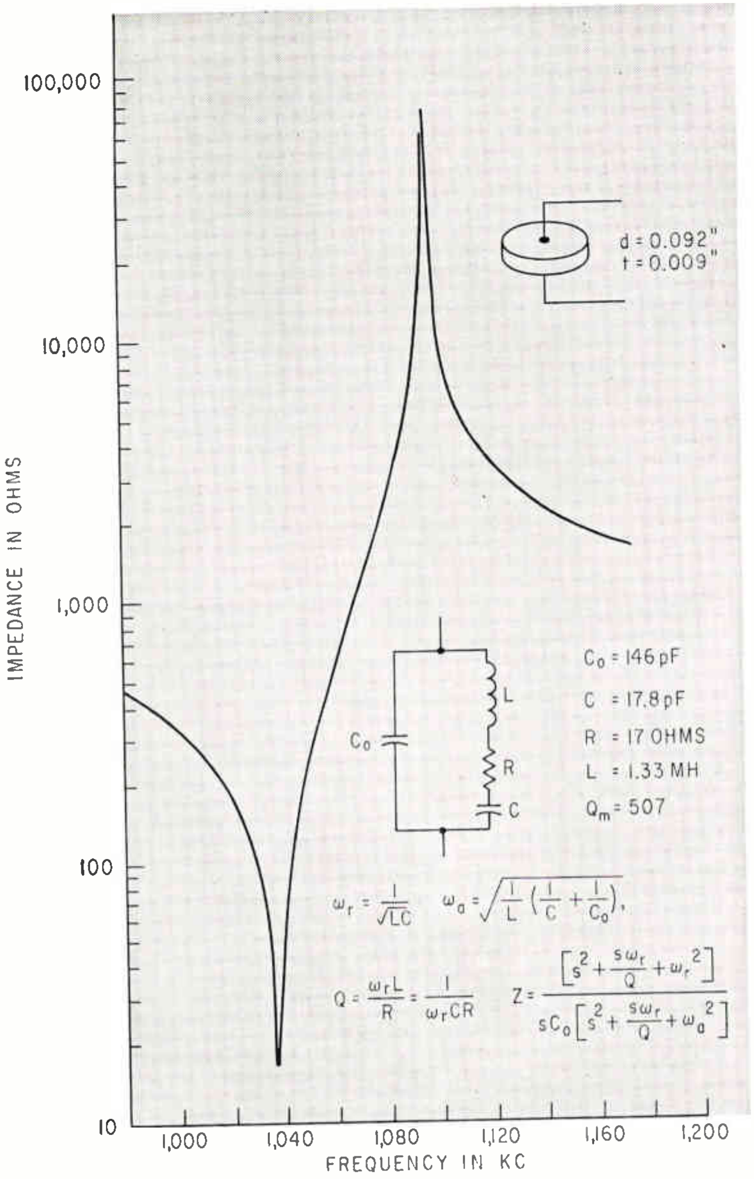
PIEZOELECTRIC PARTS

Piezoelectric ceramics are versatile and have excited the imagination of filter designers for many years. Some recently developed devices include simple resonators, multielectrode resonators, cascaded combinations of resonators, mechanically coupled pairs and lattice filters. Commercial versions of these units in the 455-Kc range are in use in both military and commercial equipment

Easy Way to Design



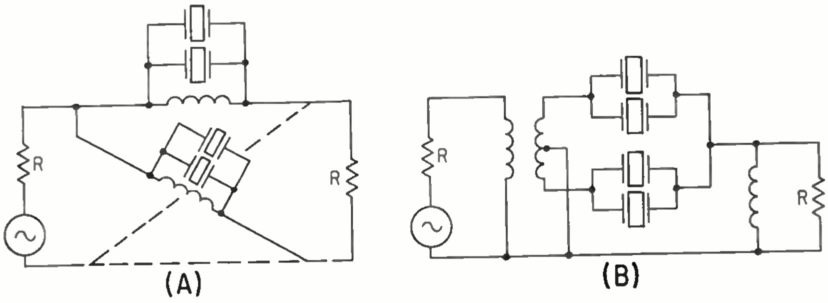
PIEZOELECTRIC *ceramic resonators packaged in a commercial can. Toroid autotransformer is mounted between the ceramic elements*



$$\omega_r = \frac{1}{\sqrt{LC}} \quad \omega_a = \sqrt{\frac{1}{L}\left(\frac{1}{C}+\frac{1}{C_0}\right)},$$

$$Q = \frac{\omega_r L}{R} = \frac{1}{\omega_r C R} \quad Z = \frac{\left[s^2 + \frac{s\omega_r}{Q} + \omega_r^2\right]}{sC_0\left[s^2 + \frac{s\omega_r}{Q} + \omega_a^2\right]}$$

CERAMIC RESONATOR CHARACTERISTICS *and their equivalent circuit—Fig. 1*



BALANCED LATTICE FILTER *(A) and an equivalent unbalanced version (B) using a transformer—Fig. 2*

Ceramic Resonator Filters *Use of insertion loss technique enables filter designers to get precise passband and delay characteristics*

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CERAMIC FILTERS have been designed and fabricated, using resonators operating in the flexural, radial extensional and thickness modes of vibration, to cover a frequency range of 5 to 12,000 Kc. Although ceramic filters can be designed using image parameter methods developed for crystal filters, insertion-loss design, which realizes a prescribed insertion loss as a function of frequency, is attractive when the filter response must be carefully controlled. For example, the behavior of the filter near the edges of the passband or the time delay of the filter as a function of frequency can be controlled this way. Insertion-loss design proceeds from a mathematical specification of insertion loss versus frequency to a specification of the values of the individual circuit elements, in this case, the characteristics of the individual ceramic resonators. Thus resonators are required that have a wide range of characteristics.

CERAMIC RESONATOR—Selection of a type or shape of resonator depends on the mode of vibration to be used and on the frequency range. Over a frequency range of 150 to 6,000 Kc, radial extensional modes of disks are applicable.

A thin ceramic disk with fully electroded faces and polarized normal to these faces has its lowest excitable resonance in the fundamental extensional radial mode. This is a strong mode, inherently free from spurious responses and has its first overtone at about 2.5 times fundamental frequency. The zero and pole of impedances of the disk occur at the resonant and antiresonant frequency respectively. Response of a typical ceramic disk with its equivalent circuit is shown in Fig. 1. Z is the resonator impedance at a complex frequency s. Available ceramic resonators have Q's from 400 to 1,400 and dielectric constants from 600 to 1,100. Resonant and antiresonant frequencies are stable within ± 0.1 percent from -40 to 85 C, and increase slowly and logarithmically with time by less than 0.1 percent per decade.

The ceramic resonator can be characterized either in its equivalent circuit elements using relationships in Fig. 1, or by its resonant frequency, shunt capacitance, Q, and $\Delta f/f$ ratio defined by

$$\frac{\Delta f}{f} = \frac{f_a - f_r}{f_r} \qquad (1)$$

where f_r and f_a are the resonant and antiresonant frequencies and the $\Delta f/f$ ratio gives the percentage of the separation between these two frequencies.

Ceramic resonators are versatile because each of these parameters can, to first order, be controlled independently. For the radial mode, f_r is inversely proportional to diameter, and C_o directly to diameter squared over thickness. The $\Delta f/f$ ratio is determined by the electromechanical coupling coefficient, a physical property of the material that can be controlled over a wide range in processing. Q is principally a function of composition and is normally made as high as possible consistent with other properties. Ranges of characteristics for radial mode ceramic resonators are shown in Table I with typical values for a resonator operating in the radial mode at 455 Kc.

INSERTION LOSS DESIGN—The physical form of the filters is the symmetrical lattice with each arm broadbanded by a single inductor, Fig. 2A. While this network needs a transformer for grounding, it does allow realization of a wide range of insertion-loss characteristics. The presence of the inductor is convenient, because the unbalanced version of the lattice has transformers to absorb the shunt inductor, and thereby reduce the problem of transformer design (Fig. 2B).

For convenience, the band-pass filter is designed by first designing a low-pass filter, which need not be realizable, then transforming to a band-pass filter realizable with ceramic resonators. For convenience the low-pass prototype is chosen to have its cutoff frequency at 1 radian per second and to be terminated in 1-ohm resistors. The various forms of insertion loss such as the Butterworth, Chebychev and Darlington elliptical forms are directly applicable. Most of the design is independent of the center frequency and bandwidth.

The transmission function of a network is the ratio of load power to maximum power available or $|\tau(\omega)|^2$ where ω is the angular frequency in rad/sec. Insertion loss in db is then defined as $-10 \log_{10}$ of the transmission function. The design starts from a specification of the transmission function

$$|\tau(\omega)|^2 = \frac{1}{1 + (P/Q)^2} \qquad (2)$$

the reciprocal of 1 plus the square of a rational function of frequency. If $P(\omega)$ and $Q(\omega)$ are even or odd functions of frequency, the insertion loss is symmetrical about center frequency. But for odd functions of frequency, the passband is nonsymmetrical about center frequency, thereby allowing the design of single sideband filters and other unsymmetrical filter forms. Typical insertion loss specifications might include the Butterworth functions

$$|\tau(\omega)|^2 = \frac{1}{1+\omega^{2n}} \quad (3)$$

Other examples are Chebychev and Darlington or elliptic functions. A Darlington elliptic filter is designed as this example, but the design technique is valid for any insertion-loss function that can be written in the form of Eq. 2.

First the insertion loss of the lattice network is written in terms of admittances of arms y_a and y_b

$$|\tau(\omega)|^2 = \left| \frac{y_b - y_a}{1 + y_a + y_b + y_a y_b} \right|^2 \quad (4)$$

This is equated to a mathematical expression for insertion loss (Eq. 3 for example) and the resulting equation solved for y_a and y_b. These admittances are then transformed by the low-pass to band-pass transformation to yield admittances of the desired band-pass filter. An additional transformation is applied to these admittances to make them realizable by ceramic resonators. Actual circuit elements are obtained from these admittances.

DESIGN PROCEDURE—Design an unbalanced two resonator filter terminated in 1,000 ohms at each end to have a maximum of 0.5 db attenuation in the passband, a minimum of 20-db attenuation in the stop band and a 20 percent bandwidth centered at 455 Kc.

Step 1. Choose an analytic expression for the transmission function of the equivalent low-pass filter.

The two-resonator filter is the unbalanced equivalent of a one-resonator-per-arm lattice, Fig. 3. The Darlington elliptic form for the equivalent low-pass filter is selected to achieve

$$|\tau|^2 = \frac{1}{1+\epsilon^2 F^2} \quad (5)$$

$$F = \frac{\omega^2 \omega_1^2 - 1}{\omega^2 - \omega_1^2}$$

Insertion loss is $-10 \log |\tau|^2$. Maximum loss in the passband occurs at $\omega = 0$ and the minimum loss in the stop band at $\omega = \infty$. Thus

Insertion loss at $\omega = 0$ is $+10 \log \left[1 + \frac{\epsilon^2}{\omega_1^4} \right] = 0.5$ db, and

Insertion loss at $\omega = \infty$ is $10 \log [1 + \epsilon^2 \omega_1^4] = 20$ db.

From these two relations, $\epsilon = 1.87$ and $\omega_1 = 2.31$ rad per sec.

Step 2. Identify the polynominals P and Q by comparing this transmission function with Eq. 2, and determine the polynomial $A + jC$ containing the upper half ω-plane, usual left half s-plane, roots of $P^2 + Q^2 = 0$.

From Eq. 5 and 2 $P = 10\omega^2 - 1.87$ and $Q = \omega^2 - 5.35$. Then $P^2 + Q^2 = 10\omega^4 - 48.1\omega^2 + 32.1$.

The polynomial containing the upper half ω-plane roots of this polynomial is $A + jC$ and is given by $A + jC = -10\omega^2 + 5.66 + j8.08\omega$, from which $A = -10\omega^2 + 5.66$ and $C = 8.08\omega$.

Step 3. Form the admittances of the arms of the lattice.

Use any of the expressions

$$y_a = \frac{j(C+Q)}{A \pm P} \text{ and } y_b = \frac{j(C-Q)}{A \pm P}, \text{ or}$$

$$y_a = \frac{A+Q}{j(C \pm P)} \text{ and } y_b = \frac{A-Q}{j(C \pm P)}.$$

Each of these sets of admittances satisfies Eq. 2.

It is important that the admittances have a pole at infinity so that capacitances result that can be incorporated into the ceramic resonators. This dictates the choice of the four possible arm admittances. Equation 4 is unchanged if y_a and y_b are replaced by their reciprocals. Hence if a choice for arm admittances yields zeros at infinity rather than poles, the expressions can be replaced by their reciprocals without affecting the insertion loss. If no pole at infinity can be obtained, the admittance will be a constant at infinite frequency and this can be realized with a real capacitance or inductance using Baum's approximation. In this example, no choice yields a pole at infinity, so the admittances are selected so that y_a and y_b are nonzero at infinity. Choose

$$y_a = \frac{A+Q}{j(C+P)} = \frac{j(9\omega + 1.70)}{10\omega + 9.95}$$

$$y_b = \frac{A-Q}{j(C+P)} = j\frac{11(\omega - 1)}{10(\omega - 0.19)}$$

Step 4. Form the partial fraction expansions of the arm admittances

$$y_a = j0.9 - j\frac{0.7255}{\omega + 0.995}$$

$$y_b = j1.1 - j\frac{0.90}{\omega - 0.19}$$

Step 5. Transform the low-pass equivalent to the desired band-pass form by the low-pass to band-pass transformation, and scale the impedance level from one ohm to the desired level by dividing each arm admittance by R, the desired terminal resistance.

In Step 4, replace ω by $\frac{\omega^2 - \omega_0^2}{B\omega}$ where ω_0 is the center of the pass band ($2\pi \times 455 \times 10^3 = 2.86 \times 10^6$) and B is the ratio of the desired bandwidth to the low-pass bandwidth. Plotting of Eq. 5 shows that cutoff (0.5 db) occurs at 0.61 rad per sec. Hence

$$B = \frac{0.2(2.86 \times 10^6)}{0.61} = 0.938 \times 10^6$$

Transforming the arm admittances with impedance level raised to 1,000 ohms yields

$$y_a = j0.9 \times 10^{-3} - j\frac{684\omega}{\omega^2 + 0.935 \times 10^6\,\omega - 8.19 \times 10^{12}}$$

$$y_b = j1.1 \times 10^{-3} - j\frac{850\omega}{\omega^2 - 0.178 \times 10^6\,\omega - 8.19 \times 10^{12}}$$

Step 6. Transform the arm admittances to a form realizable by ceramic resonators.

Each term of the arm admittance is generally of the form

$$\frac{-jk\omega}{\omega^2 + a\omega - \omega_0^2} = \frac{-jk\omega}{(\omega - \omega_a)(\omega + \omega_b)}$$

or its reciprocal and this form is not realizable by resonators because ω_a and ω_b are different. Terms of this form can be replaced by

$$\frac{-jk\left(\frac{\omega_a}{\omega_0}\right)\omega}{\omega^2 - \omega_a^{\ 2}}$$

with small error near the passband, because the term $(\omega + \omega_b)$ does not vary significantly in the vicinity of the passband, and the changed residue corrects the value at the center of the band. In this example, the leading term of the arm admittances is a constant not yet realizable since no constant reactance element is available. Baum's approximation yields a realizable term

$$jk = \frac{jk\omega_0}{\omega_0} \approx j\left(\frac{k}{\omega_0}\right)\omega$$

Thus there finally results for the transformed arm admittances

$$y_a = 314 \times 10^{-12} j\omega + \frac{580 j\omega}{-\omega^2 + (2.43 \times 10^6)^2}$$

$$y_b = 384 \times 10^{-12} j\omega + \frac{875 j\omega}{-\omega^2 + (2.95 \times 10^6)^2}$$

Each of these admittances is of the form

$$y = j\omega C_0 - \frac{j\omega/C}{\omega^2 - 1/LC}$$

and is realizable with passive components.

Step 7. Break up the shunt capacitance.

Associate part of it, C_i, with each tuned circuit. The resonant frequency of the ith resonator is $(f_r)_i = \omega_a/2\pi$. The antiresonant frequency, at which C_i and its resonant circuit have zero impedance, is

$$(f_a)_i = \frac{1}{2\pi}\left[\omega_a + \frac{k}{2C_i\,\omega_o}\right]$$

Then

$$\left(\frac{\Delta f}{f_r}\right)_i = \frac{k}{2C_i\,\omega_o\,\omega_a}$$

The only restriction on breaking up the shunt capacitance is that the sum of the individual resonator capacitances must add up to the calculated C_o, $(\Sigma C_i = C_o)$. The breakup is arbitrary but should be done so that realizable $\Delta f/f_r$ ratios result.

Only one resonator appears in each arm and all of the capacitance is associated with that resonator. The specifications for the resonators in the two arms then become:

Arm	Capacitance	$\Delta f/f$ Ratio
a	314 pf	6.15 percent
b	384 pf	4.98 percent

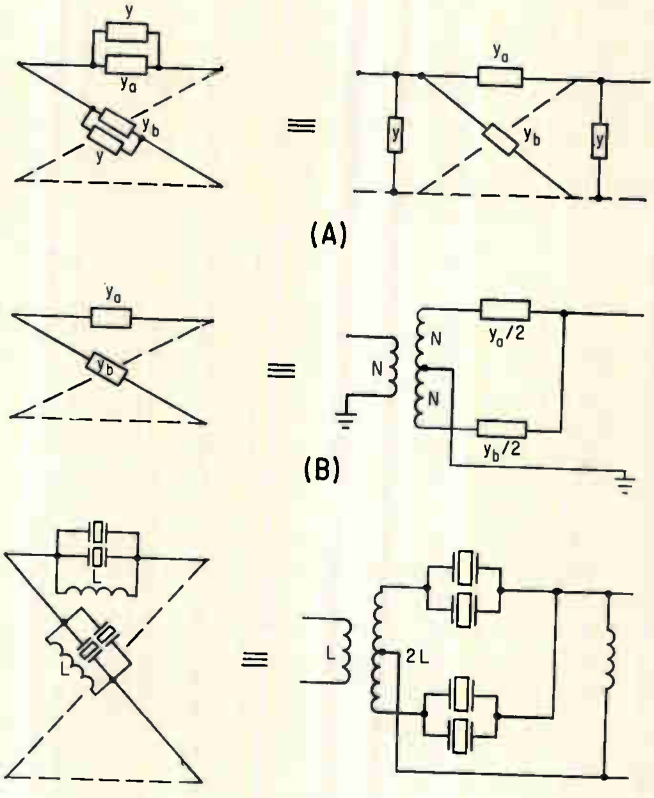
These are well within the limits of available ceramic resonator parameter values.

Step 8. Convert the lattice into a more convenient form.

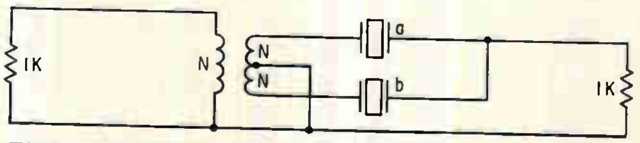
Equivalences, Fig. 3A and 3B, are used to derive the more convenient form, Fig. 3C. The form of the filter realizing the specifications of the example is shown in Fig. 4. Although the resonators are not very lossy, a critical design could take this loss into account by the usual predistortion schemes.

CERAMIC RESONATOR PARAMETERS

Parameter	Range	Typical Values for 455 Kc Resonator
Shunt Capacitance	8:1	75 pf → 600 pf
Q	3.5:1	100 → 1,400
$\Delta f/f_r$	24:1	0.3 → 8 percent
f_r	150-6,000 Kc	———



EQUIVALENTS *of various lattice circuits. Forms (A) and (B) can be used to derive a more convenient form (C)—Fig. 3*



FINAL FORM *of the design example realized from the specifications—Fig. 4*

Getting Rid of Transients In

Major problem eliminated in frequency-shift-keyed oscillator circuit by keeping frequency-shifting reactance and oscillator tank at the same potential

By N. C. HEKIMIAN, Page Communications Engineers, Inc., Washington, D.C.

WHEN AN OSCILLATOR is shifted in frequency by inserting a series impedance or shunt admittance, a severe transient is created. This is due to instantaneous voltages and currents within the oscillator that differ from those during steady-state operation with the new component. A capacitor keyed across an L-C oscillator tank usually has no inital charge. There is then an abrupt redistribution of charge between the new capacitor and the tank capacitor that causes large transients to develop. These transients must be removed by signal processing with filters and clippers. By eliminating transients, shaping, filtering and clipping circuits can be simplified, resulting in greater reliability and economy. Also, the necessity of taking corrective steps is eliminated by preventing transients from occurring at all.

Here is a way to eliminate transients by causing the voltage across a frequency-shifting reactance to be essentially the same as the tank voltage at all times; even when that reactance is not used to cause a frequency shift.

RELIABILITY AND ECONOMY

Here is a circuit that offers a high degree of reliability and simplifies design of frequency-shift keying generators by eliminating the need for clipping and filtering circuits following the oscillator.

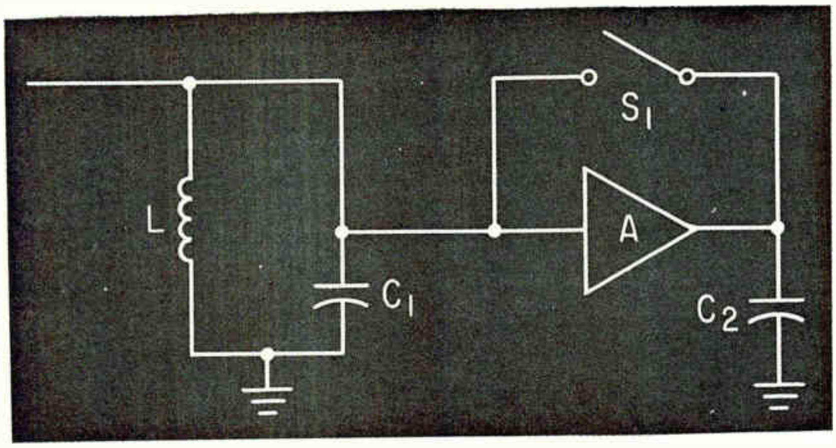
This approach shows how to remove transients in an oscillator rather than suggesting preventive measures to be added after transients have been generated

CIRCUIT OPERATION—A typical circuit in which the frequency-shifting reactance is a capacitor is shown in Fig. 1. Inductor L and capacitor C_1 resonate at the higher of two operating frequencies. Capacitor C_2 is in parallel with C_1 through the action of switch S_1, causing a shift to the lower operating frequency. Amplifier A has a gain near unity, high input impedance and low output impedance. It provides ample current gain but unity voltage gain. With current gain β, the effective capacitance of the combination of amplifier A and capacitor C_2 is C_2/β, which is much smaller than the capacitance of C_2 itself. When switch S_1 is closed, the amplifier is disabled and the capacitance across the tank is C_2 itself; thus, the capacitance across the tank is greatly increased. There is no significant switching transient since capacitor C_2 has the same voltage as the tank at all times.

In a transistor circuit, a push-pull complementary emitter-follower can be used as amplifier A as shown in Fig. 2. The current gain is designated either β_2 or β_3, depending on which of the transistors is conducting. When the tank swings negative, Q_2 conducts and when it is positive Q_3 takes over. In either case, the peak current is about ±1 ma. No d-c return is ever required for a push-pull emitter-follower output; hence, there is little degradation of the Q of the tank.

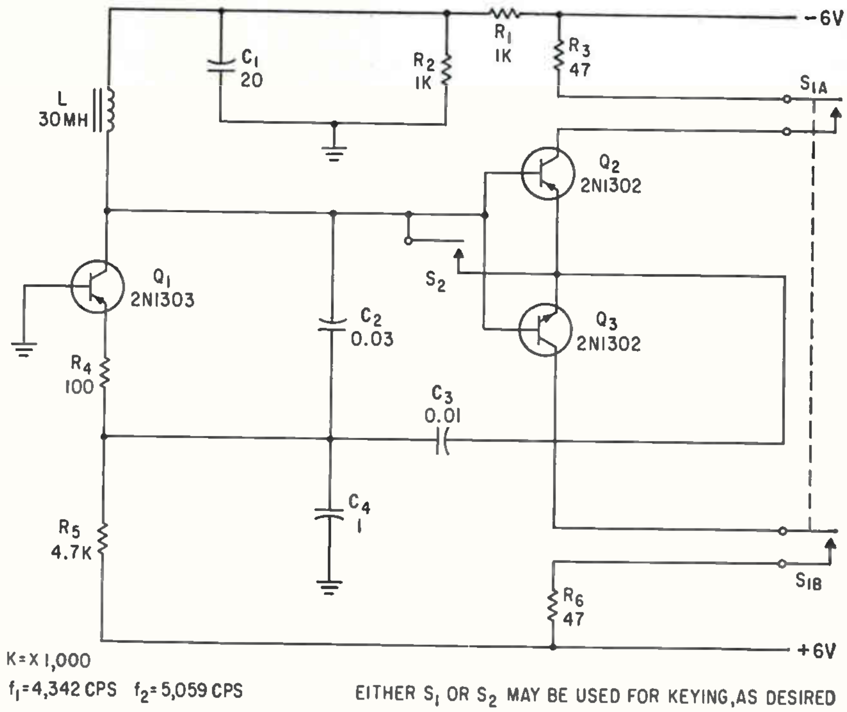
Only one switch pole is needed, since shorting the emitter to the base of either transistor completely disables it. Keying can also be accomplished electronically by gating the collector supplies of the transistors. This can easily be done due to the low peak collector currents of ±1 ma.

It is possible to introduce variations of the circuit that will improve its operation even more. Transistors Q_2 and Q_3 can be replaced by Darlington compounded emitter-followers to attain gains closer to unity. There are several other types of amplifiers and oscillator variations that are possible. However, if the amplifier output

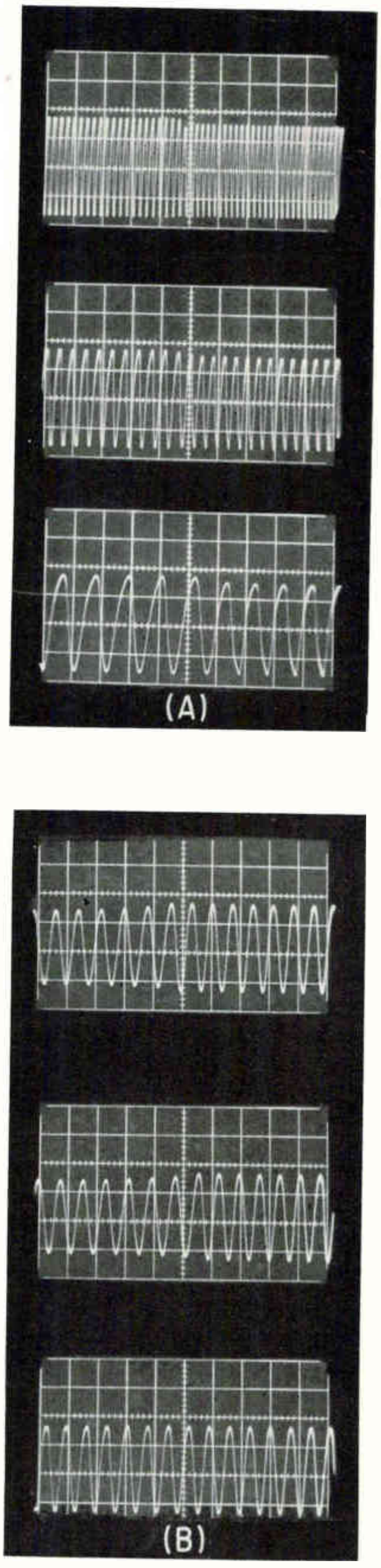


CAPACITOR *is frequency-shift reactance in typical circuit—Fig. 1*

Frequency-Shift Keying



PUSH-PULL *emitter-follower used as amplifier—Fig. 2*



OSCILLOSCOPE PRESENTATIONS *of voltage waveforms for circuit in Fig. 2 (A) and waveforms for a higher frequency circuit (B)—Fig. 3*

impedance is not greatly increased by switching capacitor C_3 directly across the tank, heavy damping and reduced oscillator feedback will occur. As a result, the oscillations can stop. If the effective series resistance of the amplifier is too high, the series combination of this resistance and capacitor C_3 will lower the effective Q of the tank.

Figures 3A and 3B show the absence of transients during keying. The slight steps in amplitude are desirable to identify the keying apparatus. If otherwise objectionable, these can be eliminated by balancing the impedances of the tank at the two resonant frequencies. Figure 3A shows the waveforms of voltages in the circuit of Fig. 2. The voltage waveforms of a circuit that operates at a considerably higher frequency are shown in Fig. 3B. The advantages of the technique are even more evident for the higher frequency circuit.

TYPICAL DESIGN PROCEDURE —With a Q of 10 and a resonant impedance of 10,000 ohms at about 5 Kc, $X_L = 10,000/Q = 1,000$ ohms; $L \cong 24$ mh. For resonance $C \cong 0.027\ \mu f = C_2$. Since the shift has been chosen as 1 Kc, the shifting capacitance is $\Delta C/C = 2\Delta f/f = 2\ (1/3)\ \therefore \Delta C \cong 0.01\ \mu f = C_3$. For a feedback ratio of 5:1 use $C_4 = 1.0$. The collector supply for the Colpitts oscillator transistor Q_1 is set to half or less of the supply for the pair Q_2, Q_3. This is done to limit the input swing to emitter-followers Q_2 and Q_3. Emitter resistor R_4 is added to the oscillator to improve the waveform.

Switching can be accomplished as shown or by gating the collector supplies of transistors Q_2 and Q_3. Since the peak collector currents are simply the peak currents through C_3, these currents are given by $i_{peak} = 3V/XC_3 = 2\pi\ fC \times 3 = 2\pi \times 6 \times 10^3 \times 0.01 \times 10^{-6} \times 3$. The keying can be accomplished electronically if desired.

This work was begun while the author was employed by the Department of Defense and the initial development was sponsored by that agency.

GLASS DIGITAL Delay Lines: New

Delay lines using time-invariant glass as the delay medium combine the high-frequency

ULTRASONIC lines, the delay medium used in early computers, were generally mercury lines and the information bits consisted of r-f bursts between 10 to 30 Mc. Transducers were usually quartz crystals. These lines had a time-delay variation with temperature and needed complicated driving and detection circuits.

The use of mercury lines was abandoned after the development of the core memory. Recently, work in delay-line memories has concentrated on magnetostrictive lines. These devices operate with short video pulses, eliminating the need for a carrier. The delay medium is a metal wire that can be made almost time invariant with temperature. But the upper frequency of operation is generally limited to about 2 Mc in the nrz (non-return to zero) mode and the lines are sensitive to vibration and moisture.

A new generation of delay lines has been developed combining the high-frequency action of the mercury line with the video response and time stability of the wire lines. These devices use time-invariant glass as a delay medium and either quartz or ceramic transducers.

DIGITAL ULTRASONIC LINES—Glass digital delay lines can be operated at frequencies from 2.5 to 30 Mc or higher. Due to this high-frequency operation, access time of an ultrasonic line is up to 15 times smaller than a high-speed magnetostrictive line of comparable storage. Maximum bit storage in the rz (return to zero) mode is presently 4,000 bits for lines using zero-temperature-coefficient glass. Larger bit capacities are possible on lines using fused silica as the delay medium. The acoustic attenuation coefficient of fused silica is 1/20 to 1/40 that of zero-temperature-coefficient glass, allowing faster data rates and longer time delays. Delay lines storing as high as 20,000 bits have been made in the laboratory.

Digital delay lines usually take one of two forms, a flat plate of glass packaged in a metallic or epoxy case, or a rod of glass with mounting brackets and coated for physical protection.

Rod lines are limited in time delay because the velocity of sound in zero-temperature-coefficient glass is approximately 0.1 inch per 1 μsec. Any line above 100 μsec is inconveniently long. Temperature-invariant lines of the plate type with delays up to 200 μsec are generally packaged in cases approximately 4 inches square or smaller

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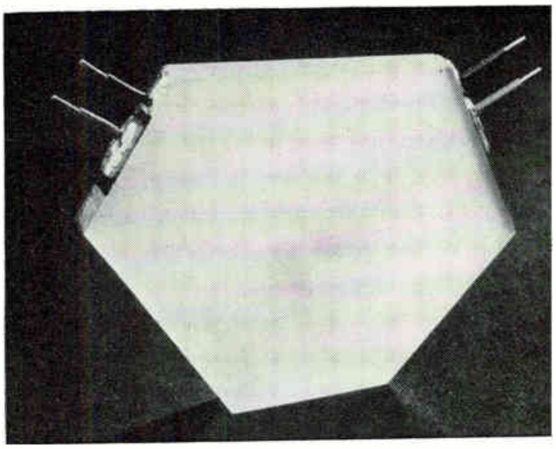
WHAT IS A DIGITAL DELAY LINE?

Digital delay lines operate on d-c pulses, while delay lines designed for r-f applications are excited with either r-f pulses or c-w signals. Because of the much greater percentage bandwidth required to transmit d-c pulses faithfully, phase and amplitude distortion of digital delay lines are held to a minimum. Digital delay lines are used as storage devices in memories and buffers by feeding back the electrical signal from the output of the delay line to its input. Any pulse or train of pulses can be recirculated until the data is required elsewhere in the computer system.



TYPICAL *delay line is fused silica or glass with zero nominal temperature coefficient of time delay. Waveforms show storage capacity of 250 bits at 2.5 Mc*

Computer Component

By DELAY LINE ENGINEERING GROUP
Corning Glass Works, Bradford Pa.

action of a mercury line with the video response and time stability of wire lines

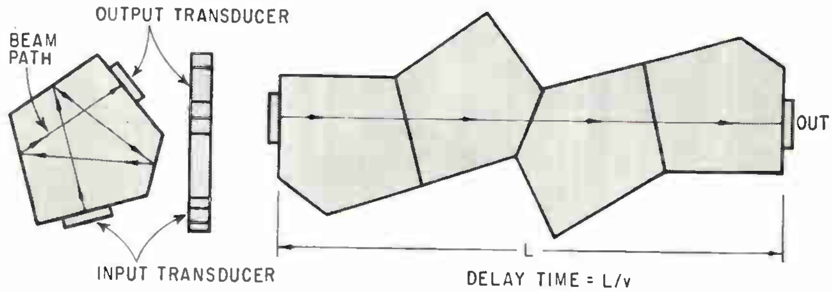
and 0.5-inch thick. Fused silica lines are usually much larger because of the greater bit storage and the possible requirement for temperature control.

In general, solid ultrasonic delay lines have an extremely simple construction and can be produced very economically.

APPLICATIONS — Digital delay lines can be used either for main memories or as buffers. Their resistance to vibration makes them ideal for military applications, especially as memories in guidance computers. Other applications include deltic data processors and one-word memories. Glass digital delay lines have been used successfully as replacements for cores, drums and magnetostrictive lines.

DEFINITIONS—

Delay time: Delay time of a digital delay line is equal to the total path or length of the beam divided by the velocity of sound in the delay line blank. Figure 1 shows the configuration of a typical delay line while Table I gives velocities for three glass delay media.



DELAY TIME *is equal to total path or length of beam divided by the velocity of sound in the media—Fig. 1*

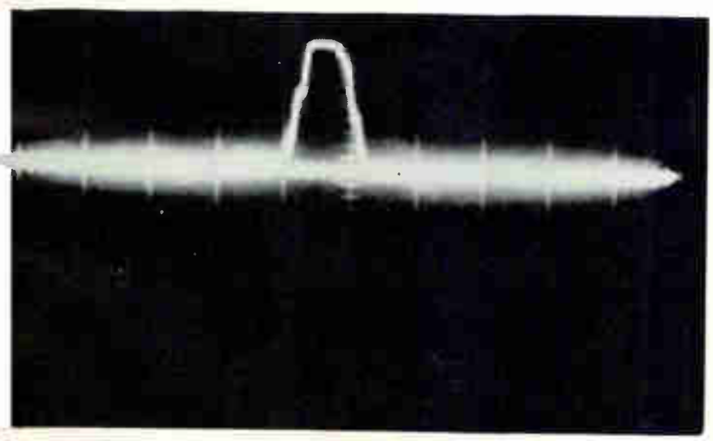
Delay time tolerance: Table II illustrates the grinding tolerance required to achieve a given delay-time tolerance on fused silica and zero t-c (temperature-coefficient) blanks of various reflection schemes. In addition to grinding tolerances, time delay tolerance is affected by velocity variation in the zero t-c glasses. Velocity variation in fused silica is also present but to a lesser degree.

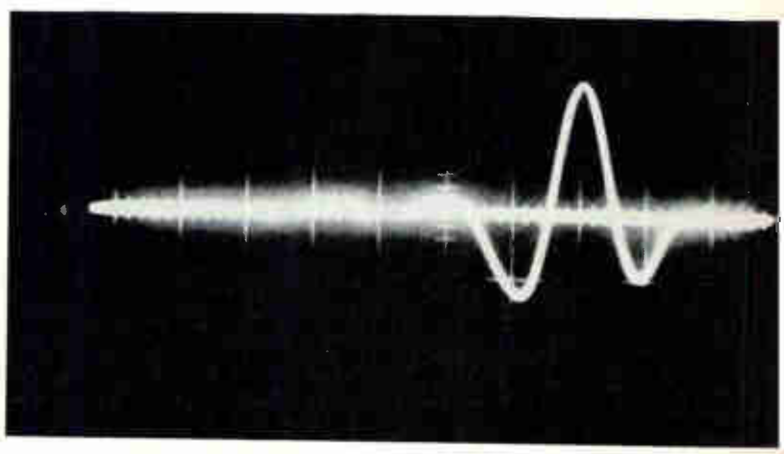
Time delay stability: Plots of the variation of t-c and time delay for 100-μsec lines made from code 8875 and code 8877 glasses are given in Fig. 2A. A plot of a line made from code 7940 fused silica is shown for comparison. The equations for the calculation of delay-time change with temperature are Code 8875—delay variation (μsec) $= (3 \times 10^{-5})$ (delay time) $(T - 25C)^2$. Code 8877—delay variation (μsec) $= (5.5 \times 10^{-5})$ (delay time) $(T - 25C)^2$.

The coefficients important to delay-time stability of digital delay lines are listed in Table III.

Figure 2B shows the temperature control required to hold a fused silica line to within $\pm\frac{1}{4}$ bit at various delay times and frequencies.

BIT FREQUENCY—The bit capacity of a digital delay line is the





product of the delay time and the data rate. Generally, the maximum data rate is considered to be equal to the peak frequency of the line when the line is operated in the rz mode. The peak frequency of the line is the frequency at which the attenuation in the line is minimum. This peak is determined by the frequency response of the transducer pair and the medium loss variation with frequency. Since the medium loss increases with frequency, peak frequency of a delay line is below the resonant frequency of the transducer pair. The lines can be used in nrz systems if conversion circuits at the output are employed. This effect doubles the bit capacity of the delay line.

Most of the signal loss in the medium is due to absorption of the signal by the glass. A smaller amount of the loss is due to spreading of the acoustic beam. The loss constants for absorption in the glass are given in Table IV. The loss constant for fused silica is so low that it rarely is the limiting factor in the maximum capacity of a digital line. The maximum frequency as a function of delay time for the two zero t-c glasses is given in Fig. 2C.

DESIGN EXAMPLE—Given the value of the time delay, a graph such as Fig. 2A shows whether the change in time delay over the operating temperature range is within some acceptable amount. Often a change is permissible up to ¼ pulse width or ¼ bit. For example, a 200 μsec line made of code 8875 glass experiences a nominal change in delay of four nanoseconds (4 × 10^{-9} seconds) over commercial temperature ambients of 0 to 50C. Therefore, if a ¼ bit change can be permitted, pulse widths of 16 μsec can be handled. This is comparable to a square-wave frequency of 30 Mc.

However, Fig. 2C shows that the maximum possible operating frequency for a 200 μsec line is only about 15 Mc. A practical maximum is 10 Mc when the effect of transducer capacitance and terminal impedance is taken into account. This means that the duration of the input pulse should be approximately 50 μsec to obtain the performance indicated in Fig. 5. A 4-μsec change with temperature is then considerably less than ¼ bit.

Figure 2C is based on 60-Mc transducer, and if the line must run at 5 Mc (100-μsec pulse width) then lower frequency transducers would have to be used to reduce the peak frequency of the delay line if time delay is to be the same. The crystal frequency is chosen primarily from experience, but it is possible to repeat Fig. 2C for lower-frequency transducers and refer to each graph for combinations of pulse width and time delay.

Minimum size of transducer is usually determined by beam spreading. Experiments indicate the size, but rules of thumb are helpful such as $L^2 = [(TD)\ V_s^2]/[10^{12}f]$ where L is the width of the transducer, f is the operating frequency in Mc, TD is the time delay in μsec, and V_s is the velocity of sound in the glass.

Choosing the minimum size transducer reduces the overall size of the delay line and reduces the transducer capacitance that loads the driver and post-amplifier. For a particular size, the capacitance can be computed and the attenuation of the transducer pair can be obtained from Fig. 3A. A 200 μsec line operating at 10 Mc uses 60 Mc transducers approximately 0.23-inch square in area. For AC-cut transducers, the attenuation is approximately 57 db as determined by the intersection of the horizontal line marked 100 pF with the vertical line marked 10 Mc.

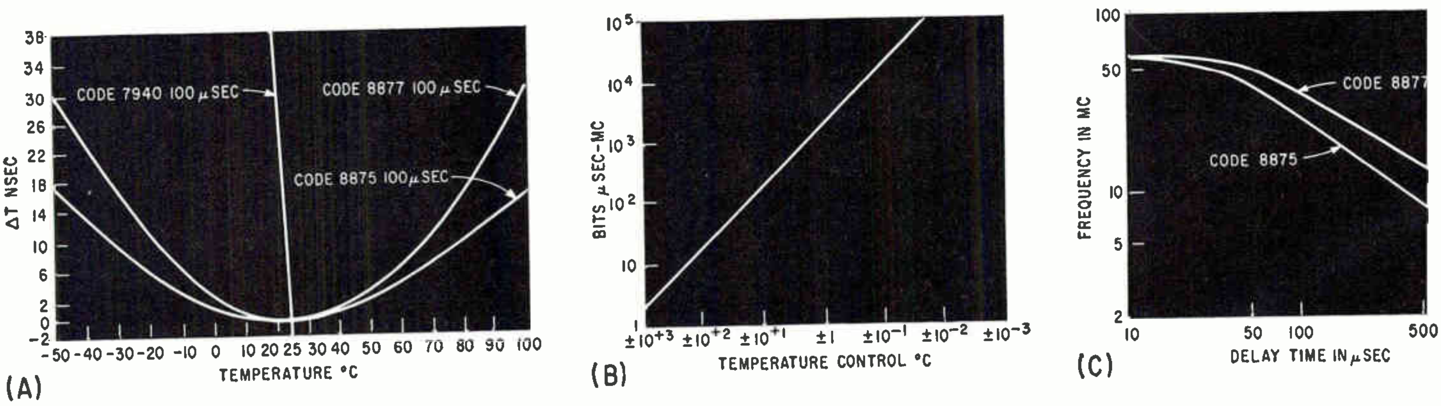
Accounting for glass loss—using the constants in Table IV—the attenuation is 57 + 6 × 10^{-3} × 200 ×10 = 69 db.

If any single characteristic is objectionable, changes can be made in the transducer area and frequency.

ATTENUATION — Figure 3A shows the digital attenuation of a quartz crystal transducer pair as a function of end cell capacitance, transducer frequency and crystal cut. A fourth variable, terminal resistance, is not included.

The attenuation of a digital delay line cannot be determined directly from this graph because it does not take into consideration losses due to signal absorption in the glass, beam spread and operation off crystal resonant frequency.

Losses due to absorption by the delay medium can be calculated from the loss constants given in Table IV. This loss varies with temperature as listed in Table V. The loss due to the spreading of the



DELAY *time change with temperature (A), temperature control against bit capactity for fused silica to keep time delay variation at ¼ bit (B) and maximum frequency against delay time and glass type (C)—Fig. 2* acoustic beam is difficult to calculate since it is a complex function of the length of the line, the length of the transducer and the frequency. However, this loss will be less than 6 db. For lines operated above 10 Mc the loss amounts to only one or two db.

The shape of the frequency response of a transducer pair is drawn in Fig. 3B. The increasing loss with frequency due to signal loss in the glass will bring the peak response of the line below the resonant frequency of the transducer pair. The loss due to operation off the resonant point of the transducer pair can be found directly from the graph if the ratio of the peak frequency to the transducer resonant frequency is known. A line will peak at the frequency at which the glass-loss slope is equal and opposite to the transducer response slope as illustrated in Fig. 3C.

The main signal attenuation of a digital delay line into a resistive load of 50 ohms can be calculated from the graphs and formulas. This is based on a known equivalent circuit for quartz transducer. The equivalent circuit of a delay line with matched input and output transducer is shown in Fig. 4.

Typical values might be $C = 65 \pm 5$ pf, $R_a = 10{,}000$ ohms, $R_g = R_L = 50$ ohms and frequency = 20 Mc.

At the output, this delay line looks like a constant-current generator, so increasing R increases the voltage output of the line until $X_c << R_L$. The attenuation of a digital line with a quartz trans-

TABLE I—VELOCITIES OF DELAY LINE GLASSES

v = 0.0985 in./µsec for code 8875 zero t-c glass
v = 0.1080 in./µsec for code 8877 zero t-c glass
v = 0.1182 in./µsec for code 7940 fused silica

TABLE II—GRINDING TOLERANCE VS DELAY TIME TOLERANCE

Grinding Tolerance Each Facet in Mils, Disregarding Tolerance on Transducer Facets

Time Delay Tolerance in nsec	Fused Silica No. of Reflections				Zero T-C Glass (8875) No. of Reflections			
	1	5	10	20	1	5	10	20
±1	±0.075	±0.014	±0.0075	±0.0037	±0.05	±0.01	±0.005	±0.0025
±5	±0.37	±0.075	±0.037	±0.0185	±0.25	±0.05	±0.025	±0.0125
±10	±0.75	±0.14	±0.075	±0.037	±0.5	±0.1	±0.05	±0.025
±20	±1.5	±0.295	±0.15	±0.075	±1.0	±0.2	±0.10	±0.05
±30	±2.2	±0.445	±0.22	±0.11	±1.5	±0.3	±0.15	±0.075
±50	±3.7	±0.75	±0.37	±0.185	±2.5	±0.5	±0.25	±0.125
±100	±7.5	±1.4	±0.75	±0.37	±5.0	±1.0	±0.5	±0.25

TABLE III—DELAY TIME STABILITY COEFFICIENTS

	Code 8875	Code 8877	Code 7940
Temp Coeff of Time Delay	0 ± 1.0 ppm/°C at 25°C	0 ± 1.0 ppm/°C at 25°C	−81.5 ± 1.5 ppm/°C
Temp Coeff Variation of Time Delay with Temp	+0.06 ppm/°C²	+0.11 ppm/°C²	+0.07 ppm/°C² approximately
Delay Time Aging	−1 part in 30,000 for life, 15 day half life, −1 part in 120,000 from time of grinding	−1 part in 15,000 for life, 15 day half life, −1 part in 60,000 from time of grinding	None ever measured

TABLE IV—ACOUSTIC LOSS CONSTANTS FOR DELAY LINE GLASSES

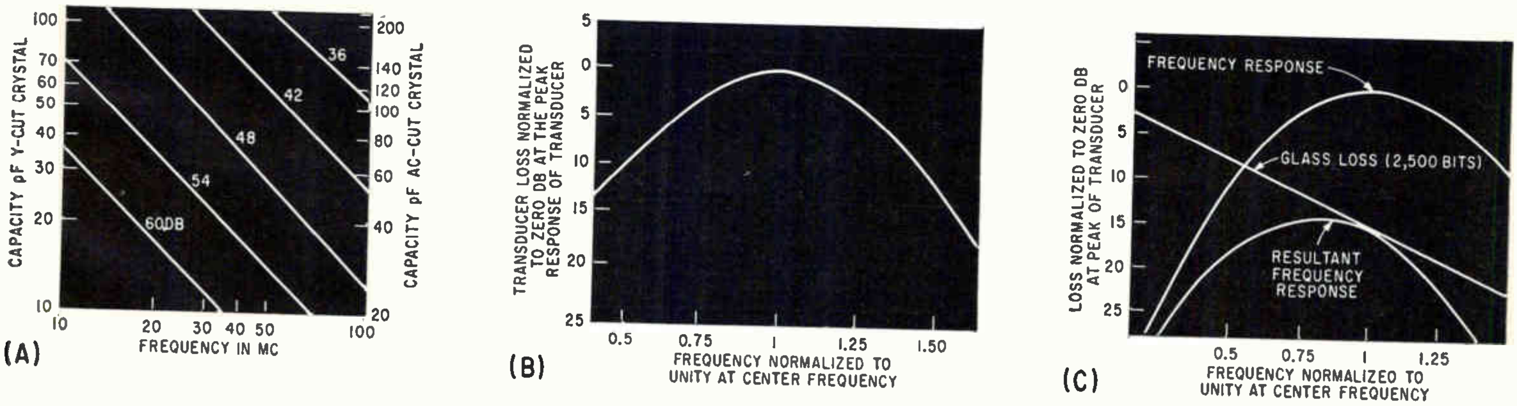
Code 8875	6.0×10^{-3} db/µsec-Mc
Code 8877	4.0×10^{-3} db/µsec-Mc
Code 7940	0.15×10^{-3} db/µsec-Mc

TABLE V—VARIATION OF GLASS LOSS WITH CHANGE IN TEMPERATURE

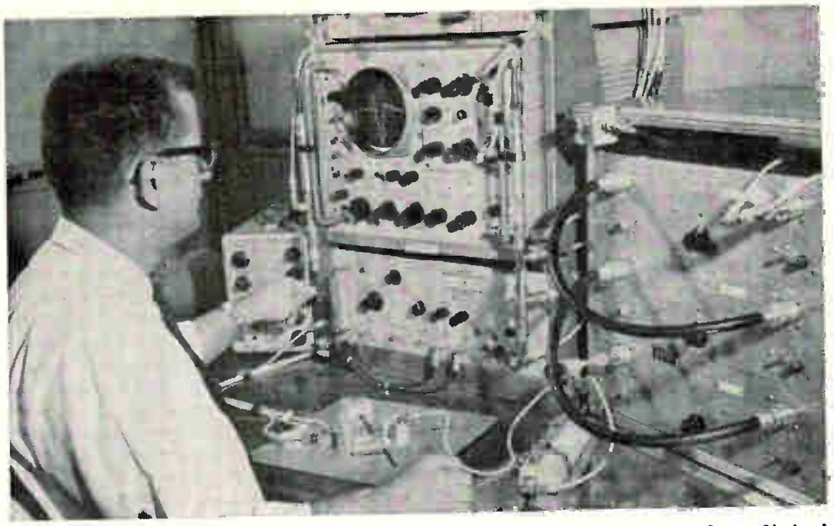
Code 8875	−0.3%/°C approx.
Code 8877	−0.3%/°C approx.
Code 7940	−5 to −10%/°C

TABLE VI DELAY LINE TRANSDUCER MATERIAL CHARACTERISTICS

Material	Coupling Coefficient	Dielectric Constant
Ceramic	0.66	870
Quartz, Y cut	0.142	4.58



MAIN signal attenuation into 50 ohms of a transducer pair as a function of capacitance and frequency (A), transducer pair frequency response shape (B) and typical delay line frequency response (C)—Fig. 3



LABORATORY *equipment checks output pulse response of a glass digital delay line. Tripolar waveform on cro is typical of good delay line response*

ducer at the output can be reduced by operating it into a higher resistance than the conventional 50 ohms. However, this gain is offset by a loss of electrical bandwidth and an increase in the R-C time constant. An optimum R_L exists for each delay line and pulse requirement.

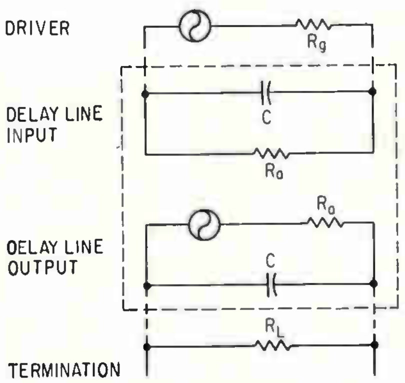
Attenuation in lines using ceramic transducers is much less than those using quartz transducers. The ceramic transducer differs from the quartz transducer in coupling coefficient and dielectric constant. A comparison is shown in Table VI for transducers operating in the thickness shear mode.

Since the efficiency of a transducer varies as the square of the coupling coefficient and directly as the dielectric constant, the ceramic transducer is more efficient than the quartz transducer. However, the large dielectric constant of the ceramic yields a transducer with an extremely high capacitance. In addition, the terminal resistance R_a, a measure of the energy put into the delay medium and backing material, will be several orders of magnitude lower than that of comparable quartz transducers. Typical values for a 20 Mc transducer are $C = 4{,}000$ pf and $R_a = 1.5$ ohms.

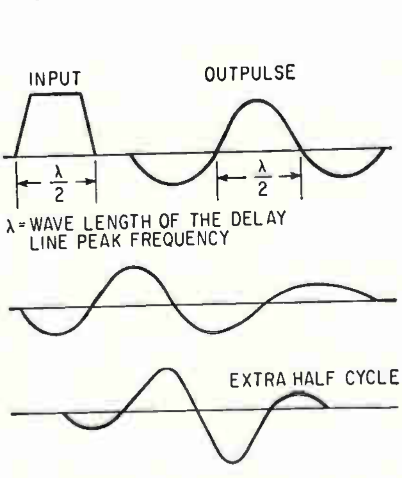
If the size of the transducer required is known, $C = 2{,}000\ (Af)$ pf and $R_a = 60$ to $150/Af^2$ ohms where A is the area in square inches and f is the transducer resonant frequency in megacycles.

An average transducer might be 0.1 in^2. Lines with high frequency ceramic transducers will have intolerable transducer capacitances. Proper engineering design can produce more desirable values of C and R.

Attenuation produced by a ceramic transducer delay line results from a combination of the same factors as that of the quartz line — transducer, glass, beam spread and off-transducer resonance operation. If a transducer pair is properly terminated, its contribution to the loss of the line will be 15 to 25 db for practical lines regardless of the size or frequency of the transducer. For calculation of the loss due to operation off crystal resonance, the curve for the quartz transducer can be used to a good approximation. Actually the bandwidth runs between 50 and 65 percent of the center frequency and the curve is flatter in the center than for quartz.



DELAY LINE *equivalent circuit at transducer resonant frequency—Fig. 4*



TRIPOLAR *response has negative area approximately equal to positive area—Fig. 5*

RESPONSE—Response of a delay line to a unipolar pulse is a function of how well the acoustic impedances of the transducer materials and delay medium match and how well the electrical impedances of the input and output transducers match the driving and detection circuits. In general, a good digital line will have a tripolar response with the negative area of the pulse approximately equal to the positive area of the pulse as shown in Fig. 5. Pulse distortion can be experienced if the transducer materials are improperly chosen. If phase dispersion occurs in the line, pulse distortion takes the form of the middle wave. In most digital delay lines, pulse distortion takes the form of an extra half cycle on the end or beginning of the pulse or both, as shown in the bottom wave. This extra half cycle is generally the most serious spurious signal in the line and the ratio of its amplitude to the desired pulse normally defines the signal to noise ratio of the delay line.

Several glass digital ultrasonic delay lines are available each with various ranges of delay time. They use a zero t-c glass or fused silica as delay media and are equipped with ceramic or quartz transducers. One of these devices is a low-capacitance 2.5 Mc line, which is used primarily for serial arithmetics in military applications such as missile and satellite guidance systems. Another line operates at 20 Mc with a delay time as high as 167 μsec. It is the memory in real-time controls that feature high speed logic.

Characteristics of other lines will be published.

NEW USES FOR MICROPHONES

Traditionally, microphones have been used to pick up speech or music. The missile industry, however, uses them as pressure gages as well. Here a problem has appeared: what is the reference level for gain calculations? Everyone uses decibels, but there are at least two reference levels in common use. This chart helps the engineer carry out calculations at different levels easily and rapidly

Microphone Calculations for the Space Age

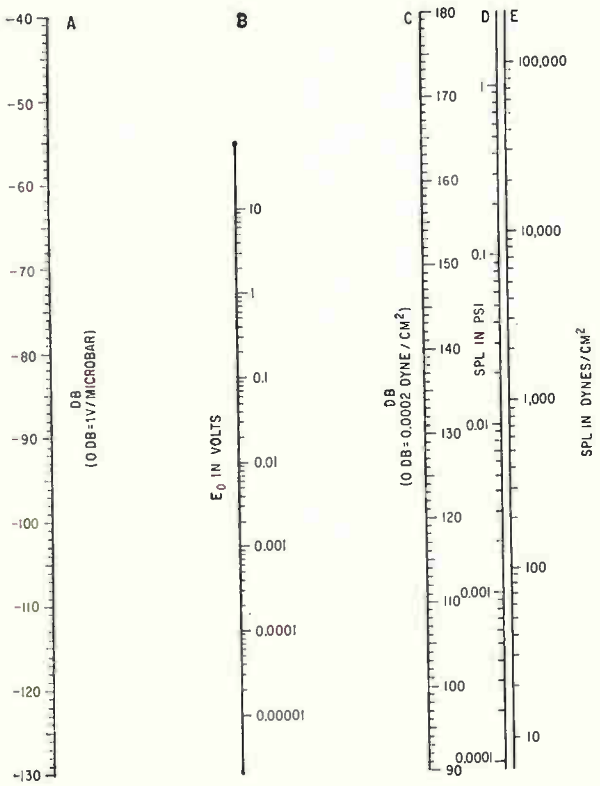
By D. ABRAMS, Chief Engineer, Instrumentation Division, Gulton Industries, Inc., Metuchen, New Jersey

MICROPHONE sensitivities are usually specified in db below 1 v/μbar, while sound pressures levels (spl) are specified in db above 0.0002 dyne/cm². The equations relating sound level, sensitivity, and output voltage are simple; the calculations, however, are time consuming.

This nomograph helps to determine quickly the output voltage from sensitivity and spl. Also included is a chart of sound pressure in db reference (ref) 0.0002 dyne/cm² and pressure in dynes/cm² and psi.

Example 1. Microphone sensitivity, −95 db (ref: 1 v/μbar). Determine output voltage at spl of 130 db (ref: 0.0002 dyne/cm²).

Solution: draw a line between −95 in column *A* and 130 in column *C* and read microphone output voltage in column *B* or 12 mv.



Example 2. Microphone output 2.5 mv at spl of 120 db (ref: 0.0002 dyne/cm²). Determine microphone sensitivity (ref: 1 v/μbar).

Solution: draw a line between 0.0025 in column *B* and 120 in column *C* and extend the line to column *A*; read the microphone sensitivity in column *A* or −99 db (ref: 1 v/μbar).

Example 3. A minimum signal of 0.01 volt is required from a microphone at 140 db spl (ref: 0.0002 dyne/cm²). Determine the minimum sensitivity in db (ref: 1 v/μbar) that can be used.

Solution: (1) draw a line between 0.01 in column *B* and 140 in column *C* and extend the line to column *A*; (2) read the minimum microphone sensitivity in column *A* or −106 db (ref: 1 v/μbar).

The actual spl in psi or dynes/cm² is determined by reading the psi value, in column *D*, or the dynes/cm², in column *E*, directly opposite the db value in column *C*.

USEFUL HINTS—For microphone sensitivities given in db below 1 v/μbar the output voltage will be *x*-db below 1 volt when the microphone is subjected to a 1-μbar spl. Since 1 μbar is equal to 1 dyne/cm² (74 db above 0.0002 dyne/cm²) the output voltage will be *x*-db below 1 volt when the microphone is subjected to spl of 74 db (ref: 0.0002 dyne/cm²).

The spl at which the output of any microphone is 1 volt can then be readily determined by arithmetically adding 74 to its sensitivity in db (ref: 1 v/μbar). For example, a microphone having a sensitivity of −60 db will produce a 1-volt output at a sound level of 60 + 74 = 134 db (ref: 0.0002 dyne/cm²). This can be checked by drawing a line between −60 in column *A* and 1 in column *B* and extending it to column *C*. The value read in column *C* is 134.

The units for voltages and sound levels must be of the same order—that is, rms, peak or peak-to-peak.

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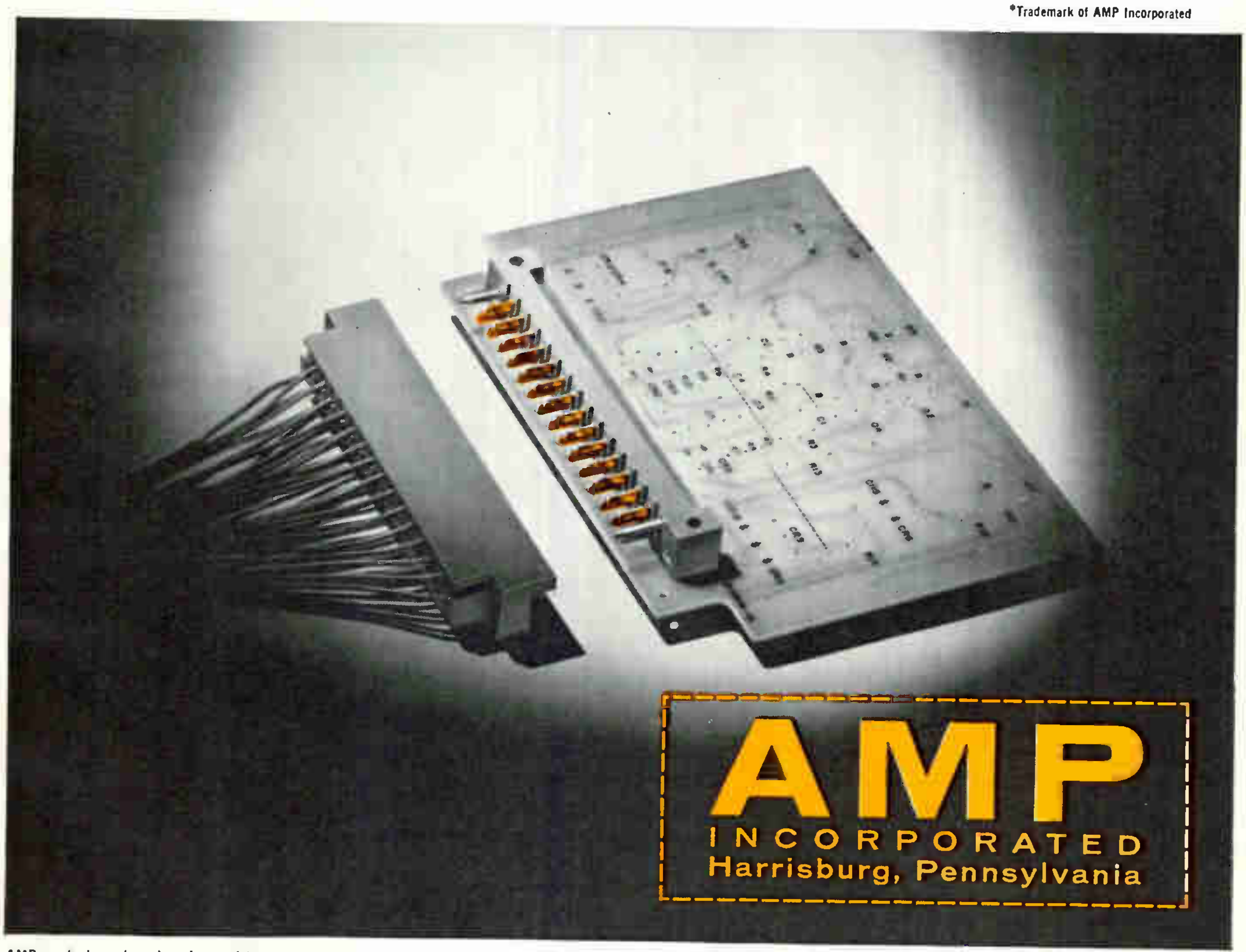

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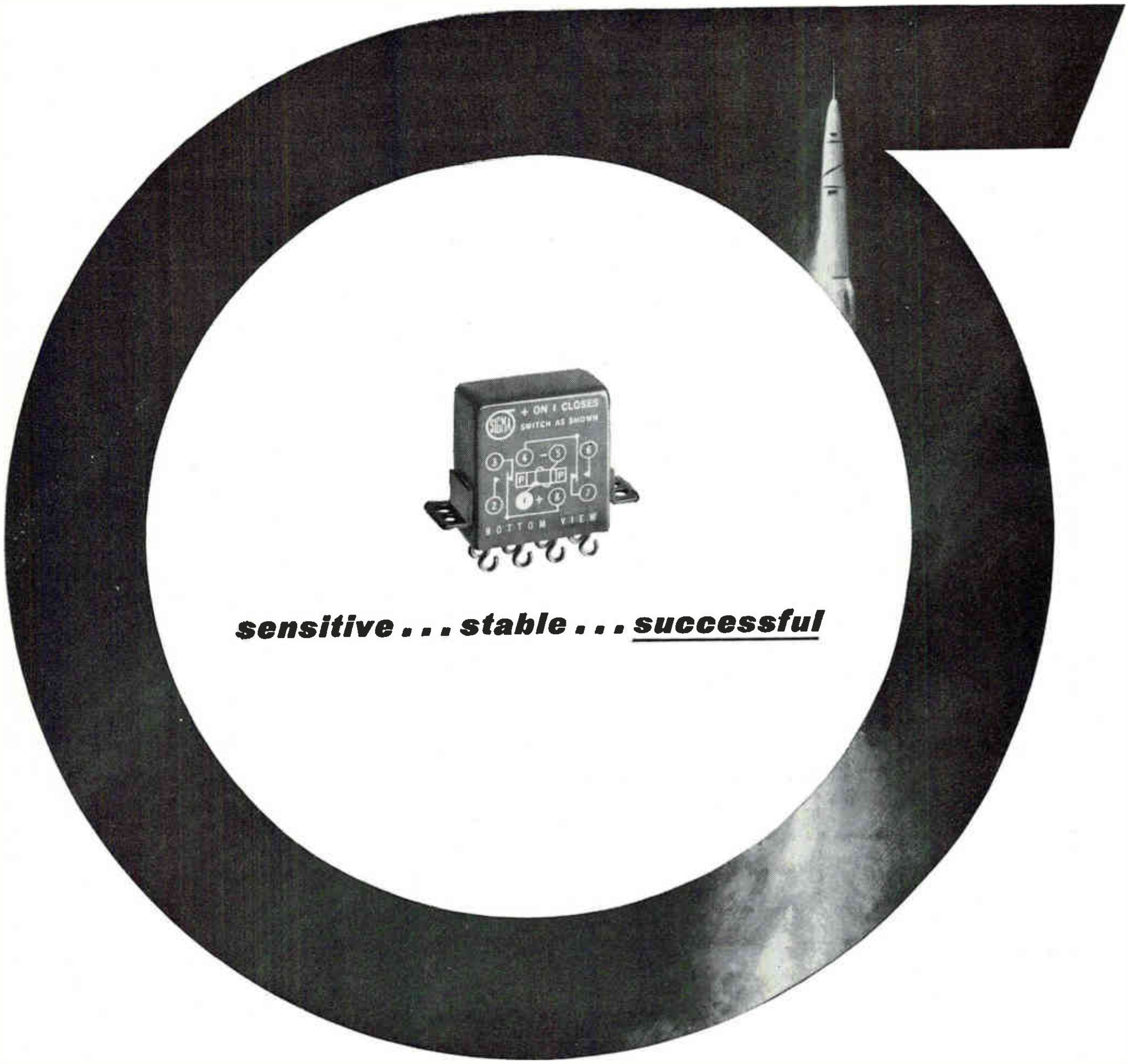


TARZIAN DESIGN IDEAS

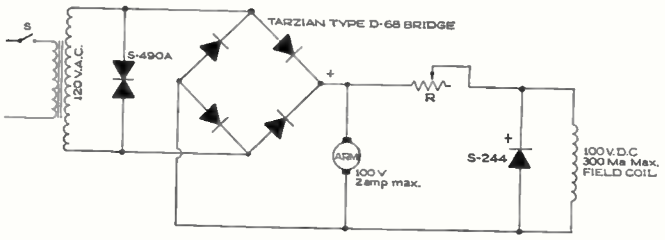
How to stop voltage transients and diode failures

■ Any circuit that is switched can generate high voltage spikes of harmful amplitude to semiconductor devices. Sarkes Tarzian voltage transient suppressors (Klipvolts) offer an economical, efficient solution.

One recurrent problem that suppressors solve is encountered when switching is at the primary of a transformer. Magnetizing currents are interrupted, causing a voltage spike many times the steady state value of secondary voltage. The result is failure of voltage sensitive devices in the circuit.

Transient voltage spikes of very short time duration often escape detection by instruments of normal sensitivity. Spikes occurring in control circuits where oscillation or "ringing" can occur are also hard to find. These transients can often be the reason for circuit problems that seem to have no obvious cause.

Standard Tarzian suppressors can handle discharge currents as high as 430 amperes (43,000 ampere load current in a three-phase circuit). Special types can be custom-designed for any practical rating. The diagrams shown here represent actual applications in which Klipvolt suppressors have been used. Your circuit is probably well within their wide range of application.

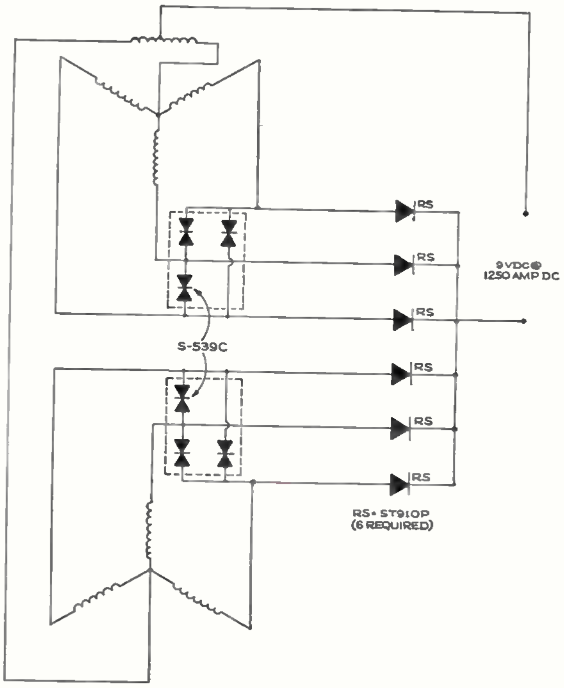


Transient Voltages in Motor Speed Control Rectifier (Fig. 1)

Problem: D-68 bridge rectifier assembly with 400V diodes is used to supply DC to controlled speed DC motor. Switching is accomplished at primary of an isolation transformer. Random switching causes intermittent rectifier failures. Tests show transients to 600V without suppression.

Solution: Use S-490A non-polarized Klipvolt across transformer secondary. Use S-244 Klipvolt across the motor field coil to limit transient spikes to less than 150V.

Result: Rectifier failure eliminated.



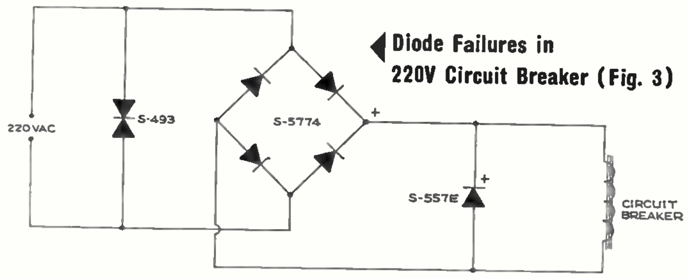
Voltage Transients in Electroplater (Fig. 2)

Problem: Three-phase center tap and six-phase star connections causing transient voltages several times the steady state peak value at the secondary...in excess of 200V.

Solution: Connect an S-539C suppressor across the secondary to reduce transients to below 100V. Use 100 PIV rated diodes instead of 300 PIV ratings.

Result: Substantial cost saving on heavy current diodes.

Diode Failures in 220V Circuit Breaker (Fig. 3)



Problem: Failures reported even though all operating parameters are well within the rating of S-5774 rectifier assembly. Laboratory investigation discloses voltage spikes in excess of 3000V, peak to peak, above steady state value...an oscillatory transient set up by the inductance and inter-turn capacity of the circuit breaker.

Solution: Use S557E Klipvolt suppressor to dampen the superimposed peak to 35V above steady state values. Place type S-493 Klipvolt across line to protect against random input transient voltages.

Result: "Mystery" failures eliminated.

TYPICAL TARZIAN KLIPVOLT SUPPRESSORS

POLARIZED

Type	Max DC Volts	Max PIV	Peak Dischg. Amperes
S-550	27	45	5.5
S-550L	27	45	430
S-554	135	225	5.5
S-554L	135	225	430
S-556	189	315	5.5
S-556L	189	315	430
S-557E	216	360	65

NON-POLARIZED

Type	Max RMS Volts	Max PIV	Peak Dischg. Amperes
Single Phase			
S-487	35	50	2.5
S-490A	140	200	4.5
S-492L	210	300	180
S-493	400	280	2.5
Three Phase			
S-539C	50	35	13.5
S-544L	210	300	180

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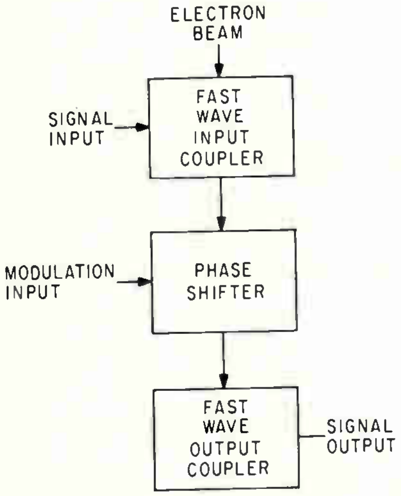
New Tube Shifts Phase Linearly With Current

Insertion losses in tube are low and are constant with phase shift

PHASE can be shifted linearly in either direction with an applied current in an experimental phase-shifting tube. The device, which has constant insertion loss for phase changes of more than 360 degrees, is expected to be useful in phased-array radar systems. The cyclotron-wave phase shifter was described at the National Electronics Conference in a paper by George Ryan and William Sackinger of Zenith Radio Corp.

THEORY—Structure and operating principle are similar to a low-noise, electron-beam parametric amplifier. However, the quadrupole gain section between the input and output is replaced by a phase-shifting section. The electron beam from the gun in the phase shifter in Fig. 1 passes successively through an input coupler, the phase-shifting section and an output coupling region. The parallel-plate Cuccia-type input and output couplers produce a transverse field at signal frequency.



PHASE-SHIFTING *region replaces quadrupole gain section of electron-beam parametric amplifier —Fig. 1*

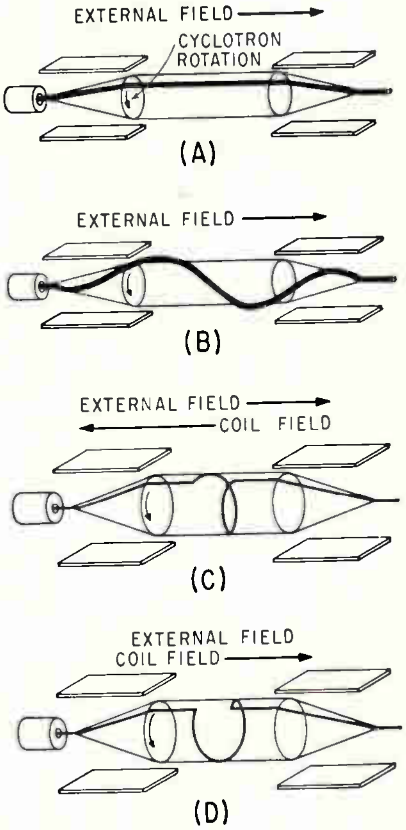
Applying an r-f signal at cyclotron frequency to the input coupler causes the electrons in the beam to rotate at cyclotron frequency, as shown in Fig. 2A. Because of the transverse velocities of the orbiting electrons, in the output coupler they induce currents in the load and give up their rotational energy. In this case, the electrons in the input and output couplers are in phase.

If input and cyclotron rotation frequencies are not exactly equal, electrons entering the input coupler may start synchronously with the r-f field but then rotate at cyclotron frequency. Because each electron is slightly displaced in phase from those immediately in front of or behind it, the beam pattern becomes slightly twisted as in Fig. 2B. The beam remains twisted after leaving the coupler because there are not r-f fields in the drift space. Thus phase of input and output signals are different when signal frequency differs from cyclotron frequency.

To change relative phase between the input and output signals, pitch of the spiraling beam must be changed. This pitch is linearly dependent on the difference between signal and cyclotron frequencies, and cyclotron frequency is proportional to magnetic field.

Although changing cyclotron frequency produces a phase shift, it also changes impedance of the input and output couplers. However, if a drift space is provided between the couplers, the magnetic field can be modulated only in the drift space with the couplers left in a constant field.

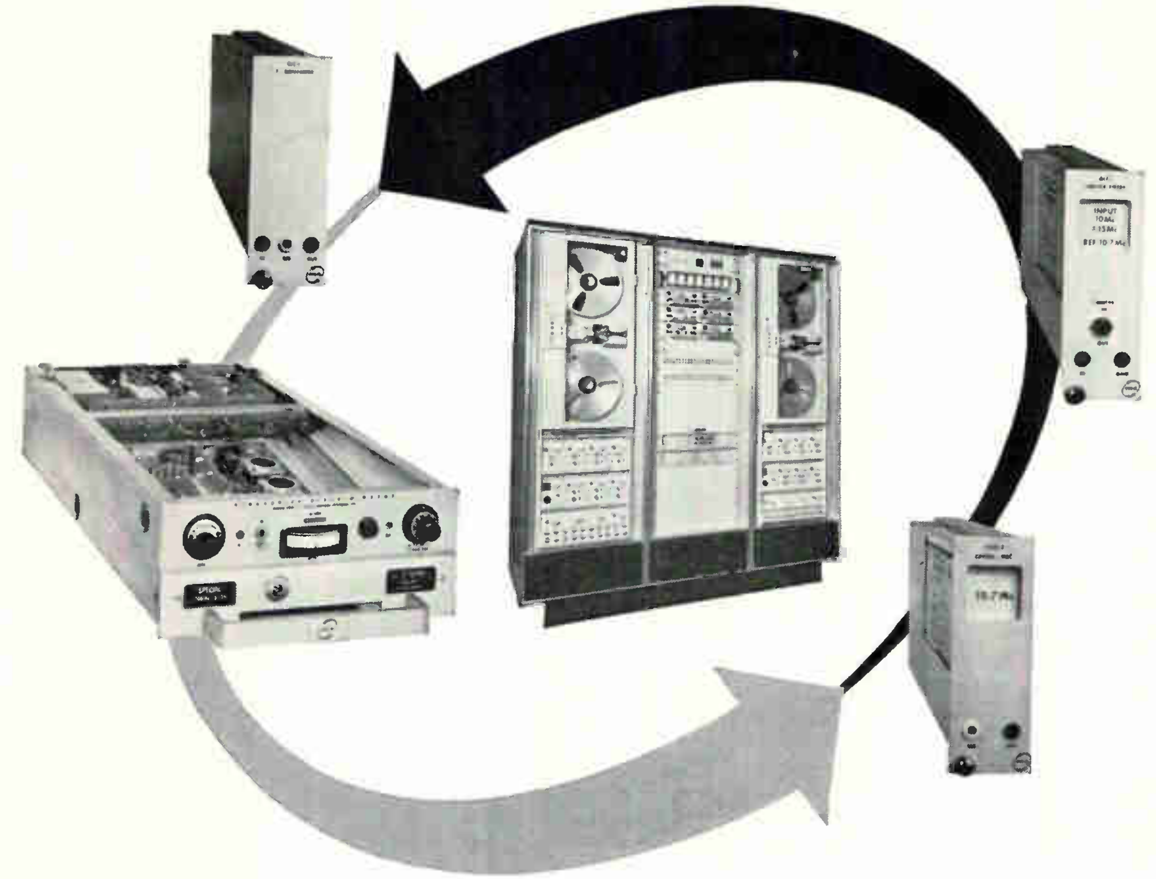
CONTROL COIL—In practice, a single-layer solenoid between the input and output couplers changes cyclotron frequency. The solenoid field adds to or subtracts from the uniform externally imposed magnetic field. The change in magnetic field is directly proportional to solenoid current.



INPUT *and output signals are in phase (A) when signal and cyclotron frequencies are equal, but beam is twisted (B) when they are not equal. Coil current that produces field opposite to external field (C) delays phase while current in opposite direction (D) advances phase—Fig. 2*

Current in the solenoid twists the center section of the beam, as in Fig. 2C and D. Polarity of the current determines whether the solenoid field is in the opposite direction from the externally applied field producing a phase delay or in the same direction producing a phase advance.

An experimental tube was made to operate at 1,300 Mc and provide



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±180 degrees phase shift. The phase-shift coil between the two couplers is made of thin copper wire wound into a 20-turn helix with an inside diameter of 0.05 inch and about ⅜ inch long.

In measuring phase shift using the setup in Fig. 3, the 1,300-Mc signal from the generator was split to provide one channel to the phase-shift tube and the other to a coaxial slotted line. Output of the phase-shift tube was connected to the opposite end of the slotted line. A well-defined null was found in the standing wave on the slotted line, and its position was found from the electrical length of the two signal channels. A phase change was clearly indicated by a change in the null position on the slotted line.

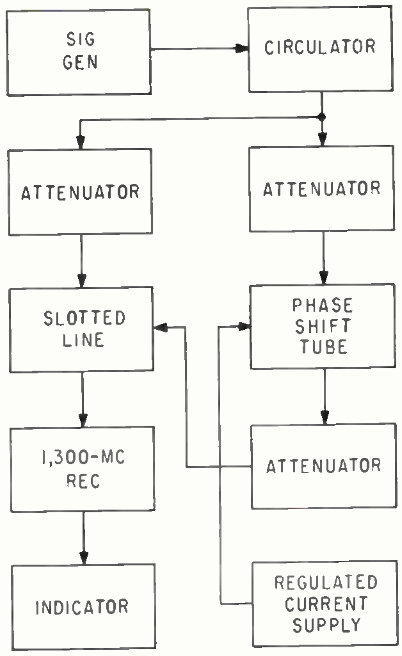
PERFORMANCE—Using a regulated current supply, phase shift through the tube was determined at different levels of solenoid current. In this experiment, phase shifts of ±180 degrees were obtained with coil currents of ±1.5 amperes, and the predicted linear relationship between current and phase shift was demonstrated. Greater phase shifts were also possible with a practical limit of 4 amperes coil current because magnetic field in the drift space was too low to keep the beam focused. Phase shift at 4 amperes was 470 degrees.

The measurement method used was sufficiently accurate to demonstrate the linearity of phase shift with control current from zero through more than 360 degrees.

Attenuation of signals passed through the tube was only about 1.8 db. Apparently, there is no attenuation of the signal when it has been impressed on the beam, and insertion loss results from resistance in the input and output couplers. Insertion loss in parametric amplifiers using the same type couplers is about 1 db, which can also be expected in phase shift tubes constructed in the future.

Phase shift is independent of insertion loss, and no changes in amplitude were observed even at phase shifts of 360 degrees.

Current in the small phase-shift coil can be changed quickly, and some measurements were made using a 600-Kc modulating signal applied to the coil. The 1,300-Mc signal frequency was phase modulated ±1.5 Mc. Higher modulating frequencies are now being used in additional experiments to determine optimum design of future phase-shifts tubes.



TEST *setup verified that phase shift and control coil current are linearly related—Fig. 3*

Providing Thermocouple Compensation at Low Cost

By PAUL J. BOUDREAUX
Physics Dept., Loyola Univ.
New Orleons, Louisiana

THERMOCOUPLE compensating circuit using a thermistor features simplicity and low cost. Mean percentage error throughout its operating range is less than 0.1 percent.

The thermocouple-compensation circuit was required for a crystal furnace being used in an undergraduate research participation program being conducted under a National Science Foundation grant. Since the furnace is operated over extended periods, use of an ice-bath to maintain a cold-junction reference temperature was inconvenient.

Basic requirements for the compensating circuit were reasonable precision and low cost. The most common of the various circuits proposed for thermocouple compensation is the Wheatstone-bridge type. However, this circuit requires materials that are relatively difficult to procure, such as pure annealed nickel wire and precision components.

The principle used in the newly designed circuit is the same as that used in compensating circuits now being produced by Consolidated Ohmic Devices, Inc. The circuit, which is shown in Fig. 1, provides compensation by adding a potential in series with thermocouple output that is a function of ambient temperature.

The values of all components except thermistor R_t do not vary appreciably with changes in ambient temperature T_o. Thus, when the circuit operates into a potentiometer, current i is directly proportional to T_o. For accurate compensation, the circuit must satisfy two conditions. Potential drop E_r across resistor R must equal potential E_t of a thermocouple at all temperatures from 0 to T_o degrees C. Also, the rate of change of these two voltages must always be equal.

Under these conditions and with no current flowing in the compensating circuit except i,

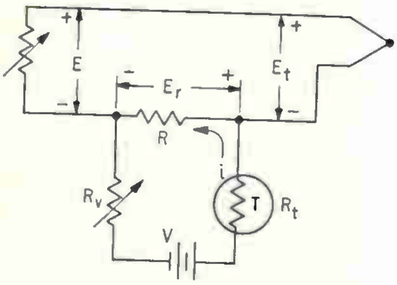
$$E_t = E_r = VR\,(R_t + R_v + R)^{-1} \text{ and} \quad (1)$$

$$dE_r/dT = dE_t/dT = -VR\,(R_t + R_v + R)^{-2}\, dR_t/dT, \quad (2)$$

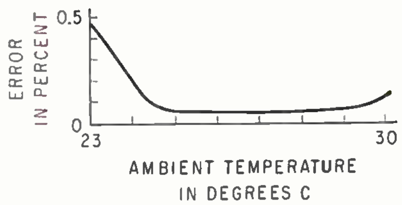
where V is battery voltage.

Within a specified temperature range, a thermocouple can be chosen having a linear output within the range. For example, Chromel-Alumel has a potential of 0.04 millivolt per degree C between 15 and 30 degrees C. Within this range, therefore, dE_t/dT is constant, and dR/dT is also constant for common thermistors.

The values of R and R_v are found



THERMISTOR *varies current through resistor in series with thermocouple output to compensate ambient temperature variations—Fig. 1*



MEAN *percentage error over operating range is less than 0.1 percent —Fig. 2*

by solving Eq. 1 and 2, since E_r, E_t, V, R_t, dE_t/dT and dR_t/dT can be found for any particular value of T_o.

In the present operating model, a thermistor is used having 5,000 ohms resistance at 25 degrees C and a dissipation constant of 0.7 milliwatt per degree C. The value of R_t must fulfill the requirements of Eq. 1 and 2. Current i must not have an appreciable affect of temperature of the thermistor, and the thermistor time constant should be as small as possible.

The value of R_v was calculated to be 546 ohms, so a 1,000-ohm carbon potentiometer was used. The value of R was found to be 4.14 ohms and a resistor was wound to this value using Chromel wire. A mercury cell was selected as the power source because of its long life and constant output.

Mean percentage error achieved using the parameters indicated was less than 0.1 percent over the operating range, as shown in Fig. 2.

REFERENCE

(1) J. Bruce Brownwood, Thermocouple Compensating Circuit Design, ELECTRONICS, p 98, January 5.

Fiber Optics Provides High-Speed X-Ray Photos

FIBER OPTICS image-dissection camera can take a sequence of 75 x-ray pictures at 40,000 frames per second. Good resolution was claimed for the pictures, which were made in recent experiments at Bell Telephone Laboratories.

The camera was described at the 6th International Conference on High-Speed Photography at The Hague by J. S. Courtney-Pratt. The glass fibers, phosphor-coated at one end to convert x-rays to visible light, are embedded in a matrix to

conduct light to a photographic plate. The matrix and the rapidly moving plate beneath it act as a high-speed recorder.

High-speed cinematography is an important tool for research into many physical phenomena. X-ray pictures are particularly useful for studying actions like that of a melting fuse or of an electrical contact inside a sealed relay system. In rocket propulsion, such x-ray pictures can be useful in determining mass and velocity distribution of particles in the combustion process.

In the camera, the fiber-filled matrix is about 3 inches square and 1 inch thick. Each 1-inch long fiber is a rod of flintglass 0.001 inch in diameter. The rod is surrounded by a thin sheath of crown glass having a lower index of refraction that provides total internal reflection. The crown glass sheath is coated with a second sheath of opaque glass. The closely packed matrix of 32,000 fibers is held together by an opaque epoxy resin.

OPERATION—Light from the image is transmitted efficiently by the fiber assembly to the photographic emulsion, which is positioned close to the opposite side of the matrix. With the image continuously illuminated, each fiber produces a line varying in intensity with the light reflected by the image. Subsequent exposure of an entirely new pattern of light and dark areas requires that the film be displaced only the width of one fiber. This displacement of only about 1 mil combined with the rapid movement (36 feet per second maximum) of the film plate results in the extremely high speed capability of the arrangement.

The film plate is mounted in a trolley that moves in a track by compressed air. Despite acceleration and deceleration exceeding 100 g's, the plates do not break.

The pictures from the composite plate must be decoded to get recognizable pictures. This reconstruction is accomplished by aligning the plate in accordance with a recognizable pattern originally exposed on the plate. The plate is slowly pulled through the same physical sequence resulting in a slow-motion reproduction that can be directly observed or copied using conventional photographic techniques.

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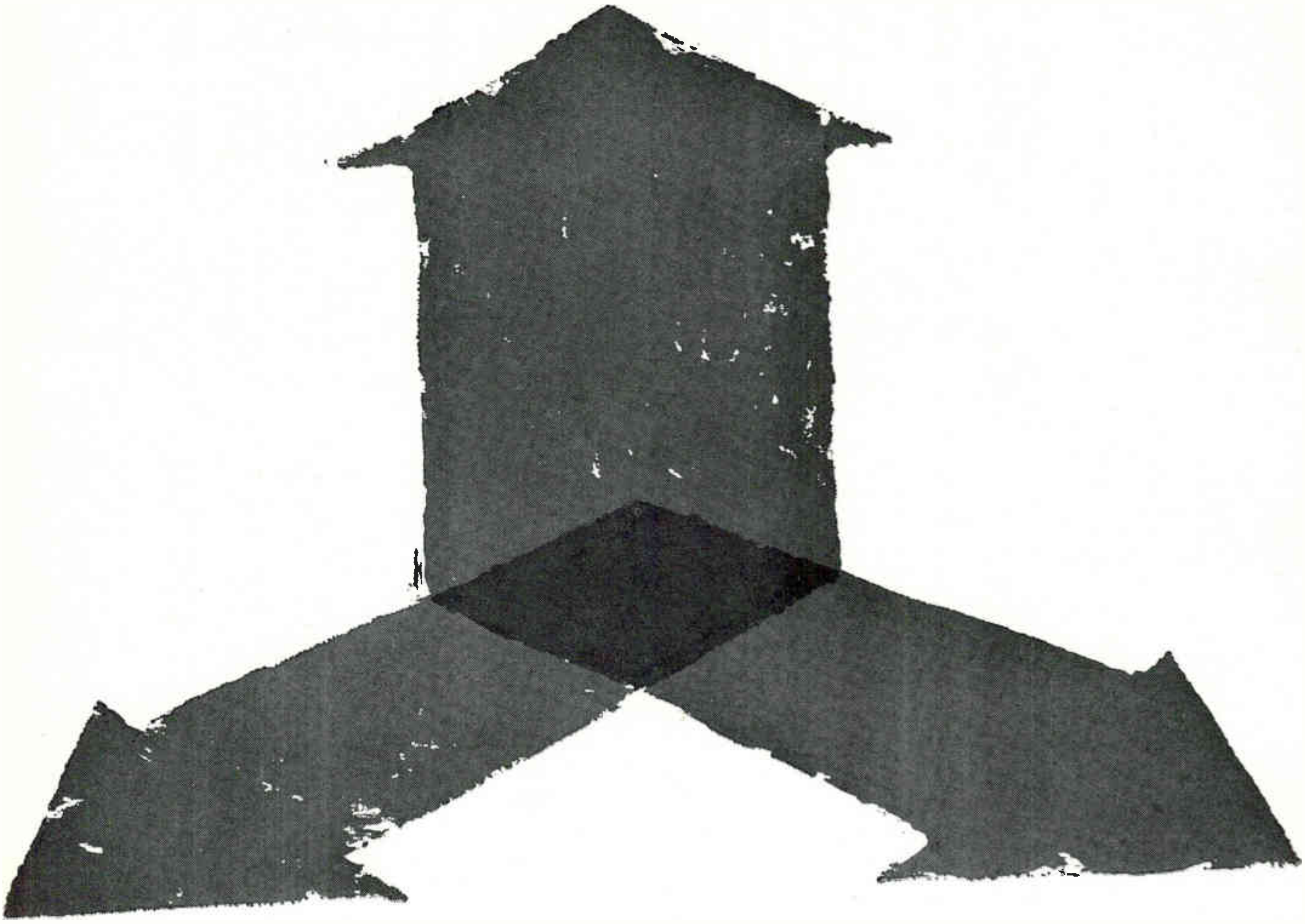

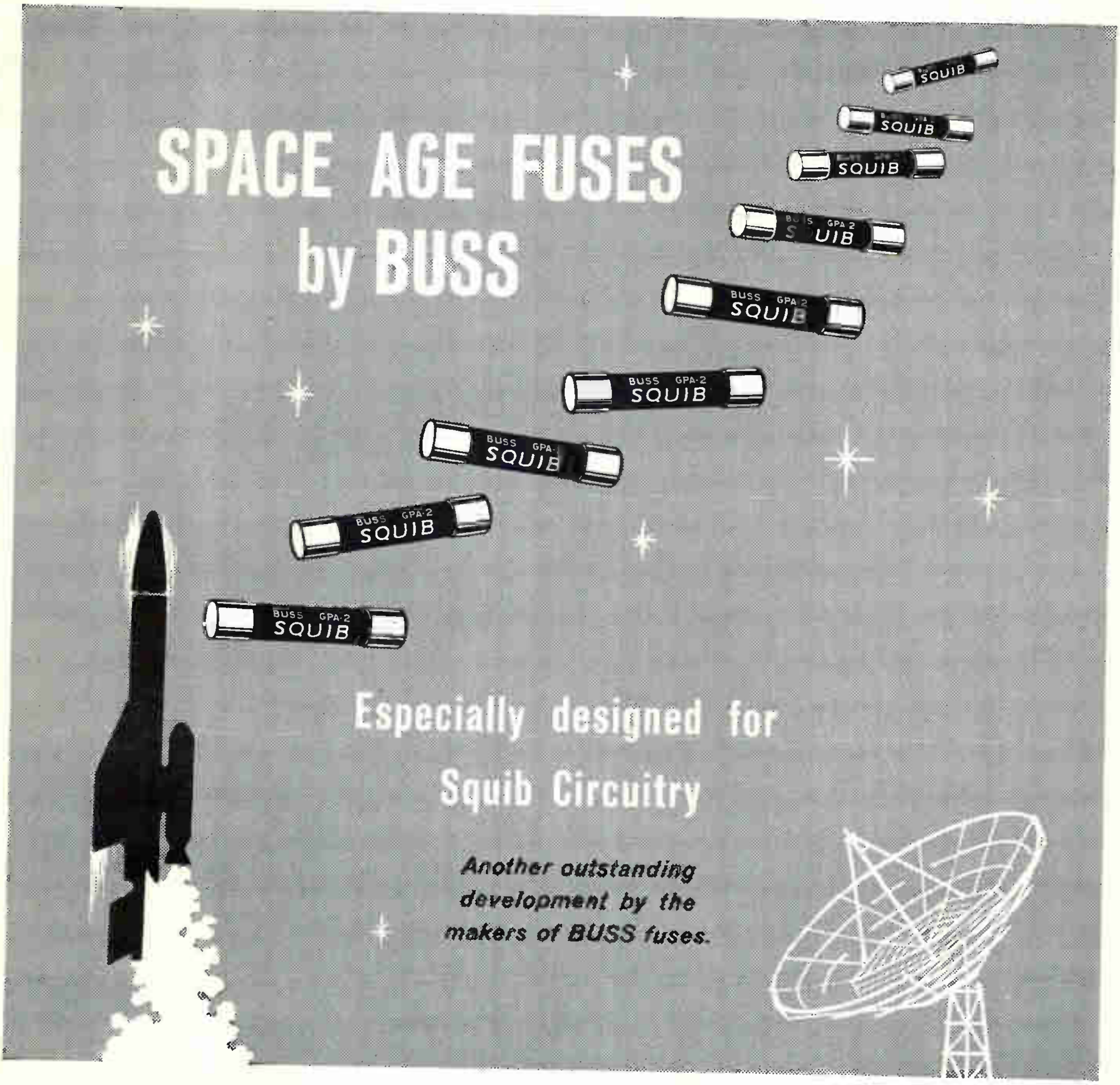

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Increasing Corona Thresholds in Dielectrics

Metallized coating of dielectric films raises a-c corona levels

By R. A. SAMODEN
Film Department,
E. I. du Pont de Nemours and Co.
Wilmington, Delaware

UNTIL recently, the high dielectric strengths of polymeric films could not be utilized fully in many a-c power applications because of low corona levels of these films. Studies towards improving corona levels have been conducted with capacitors made from Mylar polyester film. Same techniques are applicable for other electrical apparatus where corona can occur.

Initial effort to improve corona levels of conventional film foil capacitors was by liquid impregnation. Units were subjected to a vacuum and heat treating cycle for eight to twenty hours, the end point being determined by the corona level of the unit.

Corona was observed with a narrow band detector, Addison Model AC2.

No difference was observed in corona starting levels when metalized film was used in place of ordinary film of comparable gauge.

Corona threshold level of a capacitor made from three-mil Mylar is 3,600 volts. However, subjecting such film-foil capacitors to voltages ranging from 2,400 to 3,000 volts resulted in early failures. Inspections invariably indicated failure at the foil edges with pits in the film, erosion of the foil edges and x-waxing.

Transients incurred during switching, one to two times the rms voltages, were sufficient to ignite corona and cause dielectric breakdown.

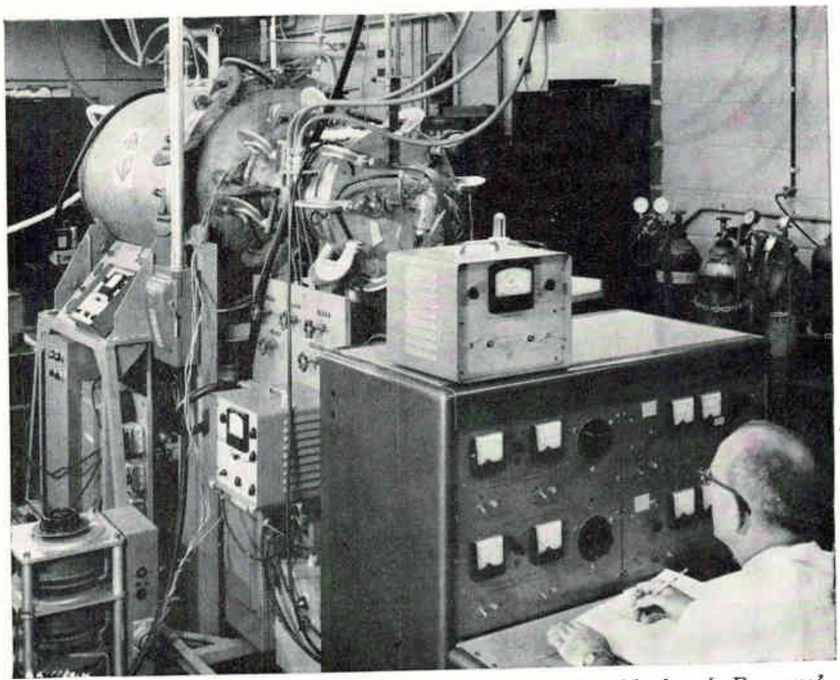
Stress distribution across the capacitor imposed a stress on the liquid which exceeded breakdown strength. This stress possibly caused local heating followed by bubble formation and corona which ultimately brokedown the dielectric film. Castor oil, polybutenes, askarels, and fluorinated liquids would not withstand stress levels incurred during these switching transients.

REDUCING STRESS — Two-side metallize film was tried in conjunction with foil to conduct the current. This construction reduced the stress on the oil between the two electrodes. Also, the effect of the switching transients may be minimized by the increased impedance of the extended metalized electrode. Using a metalized film-foil construction, two-mil capacitors have operated at 2,000 volts as long as 18 months while subjecting the units to on-off switching transients three times per day.

Dielectric gases at pressures of 50 to 100 psi have been used to suppress corona in plastic films. Nominal pressures of 5 to 10 psi increased significantly the corona threshold level of light gauge film. Use of a gas resulted in a lighter unit with much less process time. Corona threshold level and extinction level are almost the same. Although transient overvoltages produce corona for a fraction of a second, corona disappears on return to operating voltage.

Corona threshold levels of 0.75-mil film capacitors in Freon C-318, Freon F-115, and nitrogen show that increases with Freon are significant and sufficient to utilize high inherent dielectric strength

Vacuum in a Vacuum Simulates Deep Space



DOUBLE-WALLED *vacuum chamber developed by National Research Corp. has reached pressures as low as 10^{-15} torr—equivalent to interplanetary space, NRC says. The test chamber is surrounded by a second high-vacuum chamber, to minimize leaks, and is made of polished stainless steel to limit gas absorption. NRC will use the chamber in tests of space components and materials and other high-vacuum work. Vacuums are checked with Redhead cold-cathode gage and mass spectrometer*

NEW G-E CERAMIC TUBES REDUCE MICROWAVE COMPONENT SIZE* UP TO 40 TIMES

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In many UHF applications, up to 10 Gc (KMC), microminiature G-E ceramic tubes can replace TWT's, magnetrons, klystrons, and parametric amplifiers with no sacrifice in performance. G-E ceramic tubes are up to 40 times smaller and 20 times lighter than most UHF devices. Often, ceramic tubes can effect component cost reductions as high as $1,400.

To determine the specific reductions G-E ceramic tubes can make in your equipment, check these 6 size- and weight-saving features:

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2. High-gain, low-noise ceramic tubes eliminate components, require less complex circuitry. Useful to "C" and "X" band frequencies.
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Most G-E ceramic tubes are on approved MIL-spec lists and are available "off-the-shelf" from your local General Electric Receiving Tube Sales Representative. Send today for your free value-analysis chart which lists all the size, cost and performance advantages that can be yours with G-E ceramic tubes.

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CERAMIC TUBE VALUE ANALYSIS DATA

*Name*____________________ *Title*__________

*Company*____________________________

*Address*____________________________

*City*______________ *Zone*____ *State*________

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of the films to advantage, with no need of pressure vessels. No differences in corona threshold levels were noted between metalized and plain films.

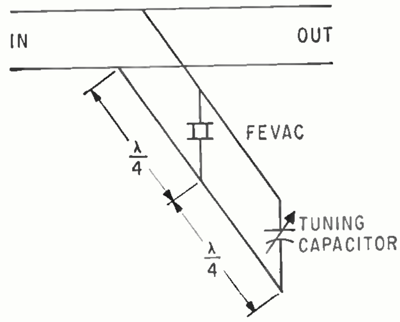
Subjecting a metalized film capacitor to corona discharge in the presence of a fluorinated gas resulted in an increase in its corona threshold. Amount of increase depends upon time of exposure, applied voltage, gas pressure, type of gas, resistivity of metalized coating and alignment of metalized coatings.

Samples tested for various gases showed Freon F-115 to exhibit greatest increase in corona threshold, with Freon C-318 and SF_6 following.

Switching High Microwave Power

Active ceramic material in low-loss switch is not susceptable to burnout

By A. L. STANFORD, Jr.
R. T. ARNOLD
Sperry Microwave Electronics Co., Clearwater, Florida



CAPACITANCE *is varied rapidly by applying voltage across terminals—Fig. 1*

FAST ferroelectric microwave switch has been developed recently to operate at L-band frequencies. Device is a transmission-reflection type used in conjunction with a circulator to perform as a spdt switch. Constructed in a strip transmission line, unit exhibits low insertion loss and high isolation.

Low-loss characteristics of the switch are attribute to a new microwave encapsulation of ferromagnetic material into a cartridge which has been termed a FEVAC (ferroelectric variable capacitor).

Capacitance is varied rapidly by application of voltage across its terminals. It has been incorporated into a device shown schematically in Fig. 1.

Tuning capacitor transforms sufficient inductance to the position of the variable capacitor to resonate it when no bias voltage is applied to the ferroelectric, resulting in a high impedance point which is further transformed to appear as a low impedance across the main line.

Under these conditions, microwave energy incident to the device is reflected. When voltage is applied to the variable capacitor, the resonance is destroyed and a high impedance is effected at the main line, so that incident microwave energy is transmitted through the device.

Isolation in the *off* condition was measured to be greater than 20 db, while insertion loss in the *on* condition was less than 0.5 db. Switch is capable of operation in less than 0.1 μsec, though the limit of switching speed has not been determined.

Subsequent improvements in the switch have been made by incorporating a second ferroelectric variable capacitor on an identical stub a quarter wavelength down the main line. This has resulted in a single device with isolation in excess of 40 db and insertion loss of 0.8 db.

Since the material is ceramic, it is not susceptable to burnout, and it is expected that this type device will be able to accomplish fast

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Polaris has a new nose-cone configuration and a new extended capability. And extended capability is also the phrase for Daystrom Transicoil, supplier of servo components for both generations of Polaris. Our extended capability stems from newly increased plant area (now 65,000 square feet) backed by strengthened facilities for engineering and production. Result: still greater prowess for design and delivery.

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AND THIS IS A LOOK AT THE COMPONENTS THAT UNITE THEM

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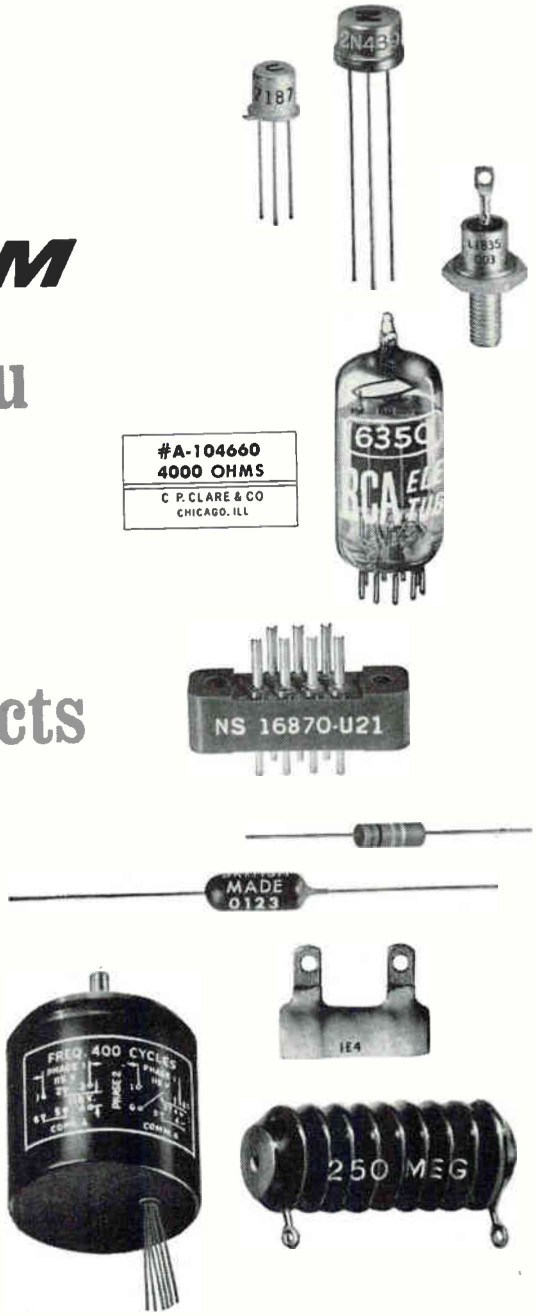


switching of high microwave power with low insertion loss.

New Alloy Solves Brazing Problems

FURNACE BRAZING of electronic components that require extremely low dew point atmospheres presents many metallurgical and furnace control problems. Such problems have been eliminated by an unusual approach. Instead of experiments in controlling furnace atmosphere to enhance the brazeability of an existing alloy, a special alloy has been developed that can be brazed in higher dew point atmospheres.

According to Huntington Alloys' J. L. Shaw and C. L. Ramsey, difficulty in making successive brazes of certain nickel-copper and copper-nickel alloys during the manufacture of large power tubes of the klystron and magnetron types led to the development of the alloy, tailored specifically for the electronics industry.

Alloy is particularly suitable for electronic parts since its low magnetic permeability is not significantly affected by processing and fabrication. Thermal expansion characteristics of the material (Monel alloy 401) developed enable the firing of the composite metal tubes with negligible distortion.

The material can be brazed in wet hydrogen. Furnace leakage and inability to maintain a good purge become less significant, and maintenance is reduced, they said.

Other prime requirements considered in the development of the alloy were nonmagnetic properties, strength and low content of voltatile elements. The 55 percent nickel, 45 percent copper alloy has a strength at least comparable to an alloy of slightly higher nickel (57.5 percent) and lower copper (40 percent).

MAGNETIC PERMEABILITY—Because manganese is not desirable in vacuum tubes, this element was omitted from its composition. To compensate for the effect of manganese on magnetic permeability, copper content of the alloy ensures a low magnetic permeability.

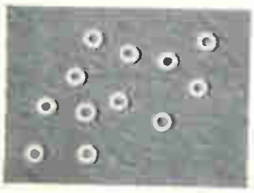
Magnetic transformation of fer-

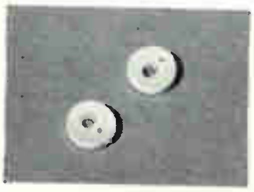
Progress Report on ALSIMAG® Ceramics
TO CLOSE TOLERANCES WITHOUT GRINDING


O.D. .350 ± .003


Thickness .040 ± .001


O.D. .133 ± .0005


Hole .042 ± .001


Holes ± .002
Thickness .062 ± .002


O.D. .6345 ± .0025
Holes .041 $^{+.001}_{-.0005}$

Precision technical ceramics are usually produced by grinding to final dimension. This is not always satisfactory or practical. Surface characteristics of ground ceramics may be unsuited for substrates. There is also a greatly increased demand for large quantities of miniature ceramics, thin, flat ceramics and ceramics with complicated contours — all to close tolerances.

Users of technical ceramics will be interested in American Lava progress in close tolerance production in four areas:

1. AlSiBase process produces a wide range of thinner and flatter ceramics.

2. Injection molding of AlSiMag ceramics permits complex contours.

3. Isostatic pressing gives precise control over certain critical internal dimensions and shapes.

4. New dry pressing techniques and equipment permit new tolerances in certain AlSiMag ceramics.

Unless otherwise specified, the AlSiMag parts shown here are from present volume production by the new pressing techniques. Significant dimensions and tolerances are indicated.

Outline your requirements and let our engineers make suggestions. Though your tolerance requirements may be met, please bear in mind that the largest tolerances permit the lowest costs.

Parts illustrated approximately actual size. A wide range of parts too small to illustrate is regularly processed with tolerances on the order of those shown here.


Holes .064 $^{+.002}_{-.000}$


Length .850 ± .005


Hole .050 ± .002

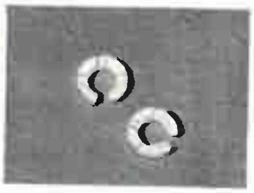

O.D. .588 ± .0025

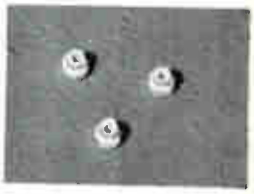

Length .906 ± .005

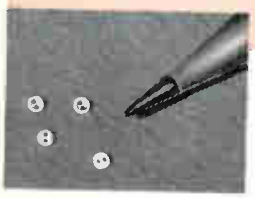

Hole Centers 1.000 ± .005


Holes .0185 ± .002
Height .235 ± .002


Hole .010 ± .001

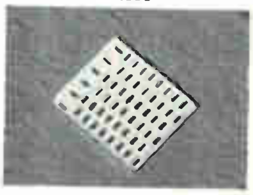

O.D. .251 ± .003
Wall Thickness .053 ± .002


O.D. .140 ± .002
Hole .048 $^{+.002}_{-.000}$


O.D. .0815 ± .0015
Holes .017 ± .001
Thickness .016 ± .001


O.D. .590 ± .003
O.D. .182 ± .002
Thickness .125 ± .002


O.D. .2695 $^{+.000}_{-.001}$
Thickness ± .0015


54 Holes, Each Held to ± .002
Spacings to ± .002
Thickness to ±.0005
Tape, Ground After Firing

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romagnetic nickel takes place with no alteration of crystal structure. On heating above the magnetic transformation temperature (Curie point), the alloy (low temperature magnetic phase) loses its magnetism. Magnetic characteristic is regained on cooling below this point. The Curie point is lowered or raised by alloying elements that form solid solutions, to an extent which varies greatly with the different elements. Curie point decreases with increasing percentages of copper. For example, Curie point decreases from 360 deg C at zero percent copper to −90 deg C with 45 percent copper.

Once the basic nickel-copper ratio was set, elements were selected for deoxidizing and desulfurizing the melt. Elements selected establish optimum composition for the braizing applications, and two types of braze tests were conducted to make a comparison of 21 different laboratory melt compositions.

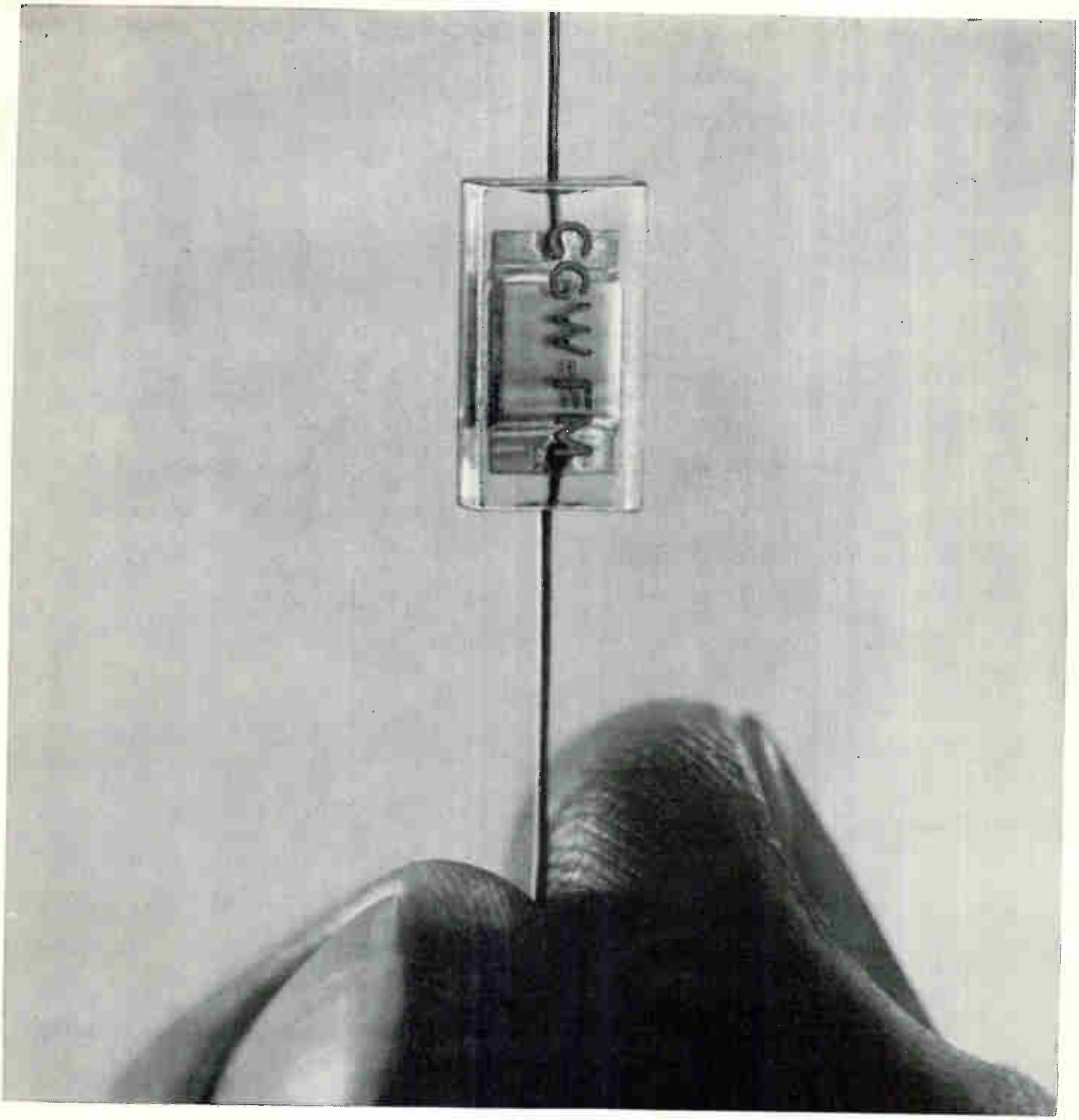
Tables have been worked out for brazing results at various dew points; room temperature mechanical properties; and short time, high temperature, tensile properties.

Diode Makes Accurate Cryogenic Thermometer

LINEAR variations of the voltage-temperature characteristics in a gallium arsenide *pn* diode makes generally useful device for low-temperature measuring. Voltage varies nearly linearly with temperatures over the entire range from room temperature down to 1.4 deg K. Temperature is read as voltage taken from a potentiometer connected across diode.

Zinc-diffused gallium arsenide diodes have a sensitivity of 3.5 millivolts per deg K at room temperature, and 1.5 millivolts per deg K at around 1.4 deg K. In this area, a resolution of ±0.01 deg K is possible when current is held steady to ±0.02 percent.

Diode is tiny, uses only 10 microwatts, and has little effect on temperature of area it measures. Bell Laboratories reports use as a temperature monitor in masers and parametric amplifiers.


CGW-FM

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Company and Div. ....

Product or Service .... Approx. No. of Employees ....

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City .... Zone ..... State or Prov. ....

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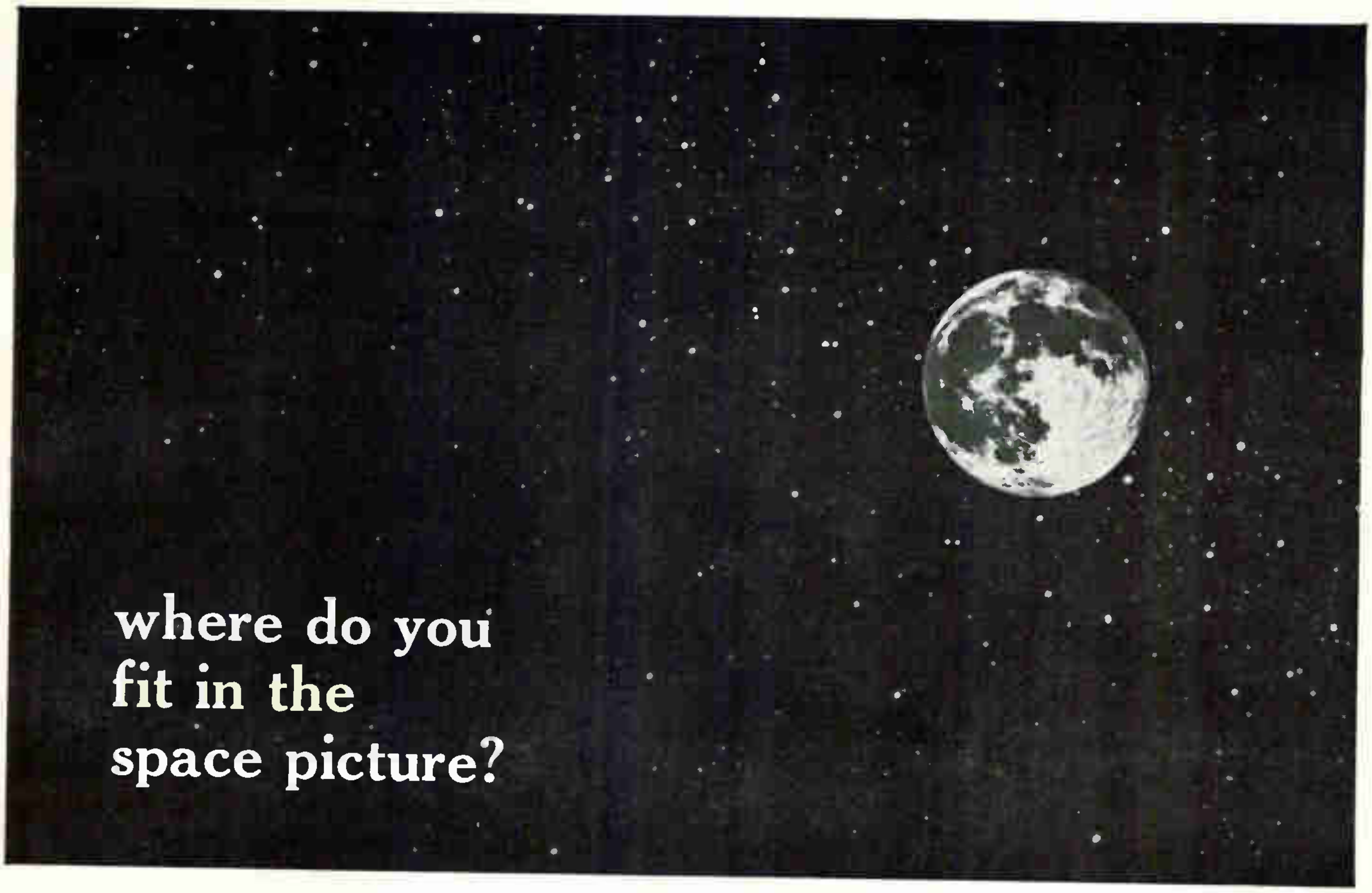
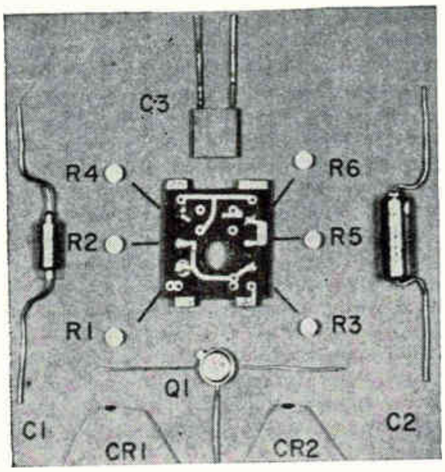
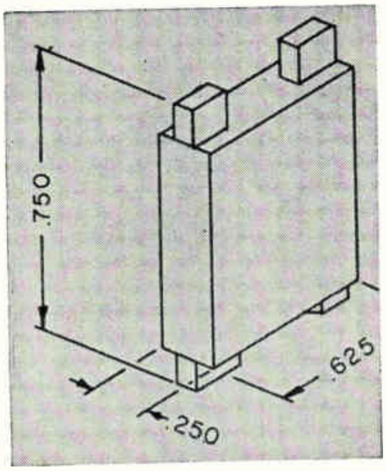
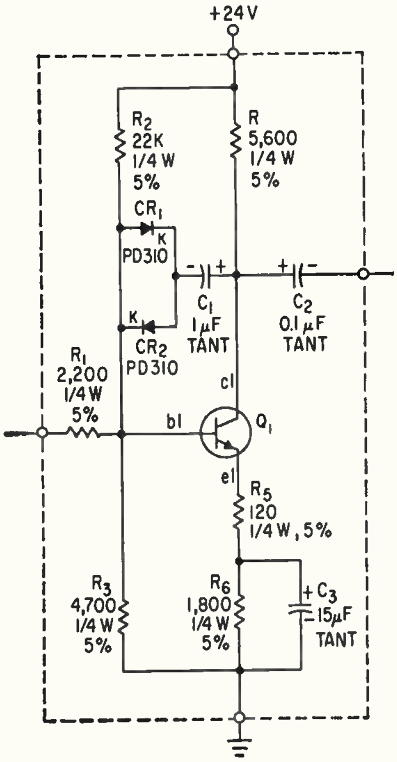

where do you
fit in the
space picture?







COMPONENTS *of amplifier stage are pellet and axial lead type. Pellet type transistors and capacitors can be used as soon as they become available in a sufficient range of ratings. Volume of this module after encapsulation is 0.117 cubic inch. Schematic is at right*

Wiring Patterns Bonded to Pellet Modules

Soldering occurs simultaneously with circuit transfer

By FRANKLIN T. JARVIS
Raytheon Co., Missile and Space Div., Bedford Mass.

COPPER CIRCUITS are being transferred from thin Teflon film to substrates in a circuit packaging technique developed by this division.

The major objective of the packaging method was to apply miniaturization techniques to analog type circuits, and to use readily available components of known reliability.

Other aspects of the technique are listed in the table; the ultimate in miniaturization was not an objective.

In the first stage of the process, copper is bonded with a special resin to 0.01 inch thick film. Wiring patterns are then etched in the copper using conventional techniques, and the copper wiring remaining on the film is then plated. Meanwhile, the substrate is prepared, first by coating it with another resin. Holes are punched in the coated substrate such that registration is obtained between the etched wiring pattern on the film and the required circuit components. Pellet components with pretinned conducting end caps are then inserted in the substrate.

The film with etched wiring pattern is then placed on the component-loaded substrate and heat and pressure are applied. The two resins—the one holding the copper to the film and the one on the substrate—have been carefully selected; the resin holding the copper to the film releases, and the resin on the substrate kicks over and bonds the wiring pattern to the substrate. At the same time, soldering occurs simultaneously between pellet components and copper wiring takes place.

Critical temperature for the three stage process is approximately 400 F, since solders of the type used fuse in this range and since higher temperature can cause excessive resistance changes in the pellet resistors used. (Other techniques of applying the bonding epoxy between

OBJECTIVES OF TRANSFER CIRCUIT PROCESS

(1) Use smallest size components presently available and of known reliability

(2) A composite design concept using various conventional techniques to best advantage

(3) Modularize to a cost, complexity, and minimum interconnection level consistent with economic throwaway. So far as possible, modules should coincide with natural circuit boundaries

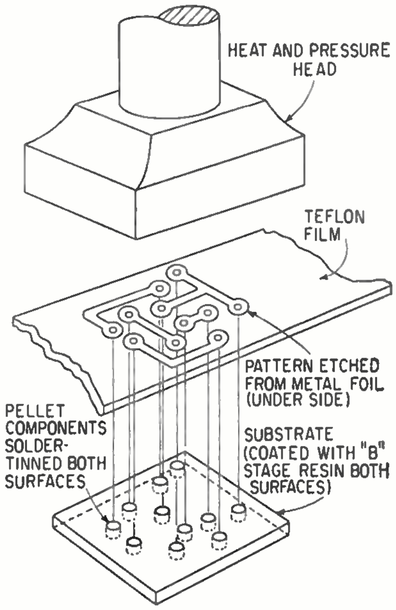
(4) Where possible, each module is to be a functional entity, capable of separate testing

(5) Design concept should permit incorporation of evolutional circuit changes without requiring radical changes, or extreme expense resulting from scrapped tooling.

(6) The construction techniques to be capable of being automated

(7) Applicability to a variety of end usages (submarine, surface, airborne, space, etc.)

(8) Technique to be practical, reliable and capable of future improvement.



CIRCUIT *is transferred from film to substrate when heat and pressure are applied; soldering occurs at the same time*

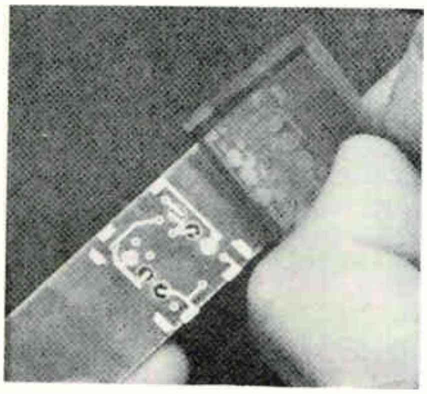
substrate and copper wiring are feasible.)

APPLICATIONS—One of the photographs shows how the packaging method was used for an amplifier stage. Pellet components were used for resistors but not for capacitors because of non-availability of pellet type units of the desired value and rating. After wiring and pellet components are connected, capacitors are wired in. After all circuit connections are complete, the module is

EXPERIMENTAL, *hand operated, two-surface transfer machine is being used with prototype work with the modules* encapsulated, using material selected either for minimum weight or for high thermal conductivity. Shielding is easily applied by overplating. Modules are keyed by tab locations or by thickness—which is the only dimension that varies—so that interconnection errors are minimized when the modules are installed in their parent interconnecting boards.

The film on which the copper is bonded and the circuit etched can be processed in long strips, with the same width as 35 mm photographic film and with sprocket holes. Sprocket drive is suitable for automating the process.

A plated copper platten is used to effect the transfer operation. It



AFTER CIRCUIT *has been transferred to substrate, film is peeled off*

is square and flat and has a thermocouple, which is inserted near its face through a drilled hole. In an automated production set up, an extra heating pulse would be used to prevent a rapid temperature drop when the platten contacts the substrate. The platten applies force and heat to the Teflon film and substrate for about 15 seconds, then the heat input is terminated but pressure is maintained until the temperature drops below the solidification point of the solder. The heater platten is then withdrawn.

Initially, circuits will be applied to one side of a substrate at a time, but the technique can easily be modified to apply circuits to both sides of a substrate simultaneously.

The first assemblies made with the process have used both pellet and axial lead type components, chiefly because an adequate range of proven pellet type components are not available. As more types of pellet components become available, the amount of automation possible increases. Certain types of components used in analog circuits are too bulky for pellet type construction, especially at low frequencies; these include some transformers, large value capacitors, etc. It is not intended to make these items integral parts of the modules.

Massive Shake Table Tests Radar Sets

ONE OF THE largest vibration testing machines in the world has been installed in the environmental

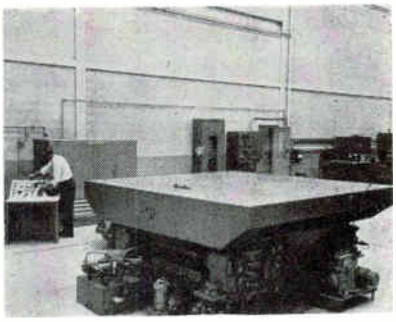


TABLE *can vibrate a 10,000 lb. fixture at 3 g's from 1 to 35 cps*

test facilities of General Electric Company's Heavy Military Electronics Department at Syracuse, N.Y.

The table, built to specifications by the L. A. B. Corp. of Skaneateles, N.Y., will be used to test large radar antennas and electronic system components. It has a 10,000 lb. dead-weight load capacity and a 10-foot square top. Vibration can be produced either vertically or horizontally at a maximum force of 3 g's, from 1 to 35 cps.

Tests of large and partially flexible structures on reaction type vibration machines have been difficult to control. This is due to an unfavorable mass ratio between the test load with its high center of gravity and the compact, freely suspended reaction table. Frequently, this type of load condition causes a shift in table amplitude or a rocketing motion.

The new machine operates on brute force and is rigidly attached to a 500,000 lb concrete block in the floor. It can resist massive force couples produced by vibrating

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test specimens that have a center of gravity as high as 10 feet above the table. Selected input amplitudes at the table are maintained even under conditions of severe load resonance.

The table can produce peak-to-peak displacements to 1 inch at low frequencies. It can also produce linear, and circular and elliptical motions, and tipping, to simulate of ship and other transportation motions.

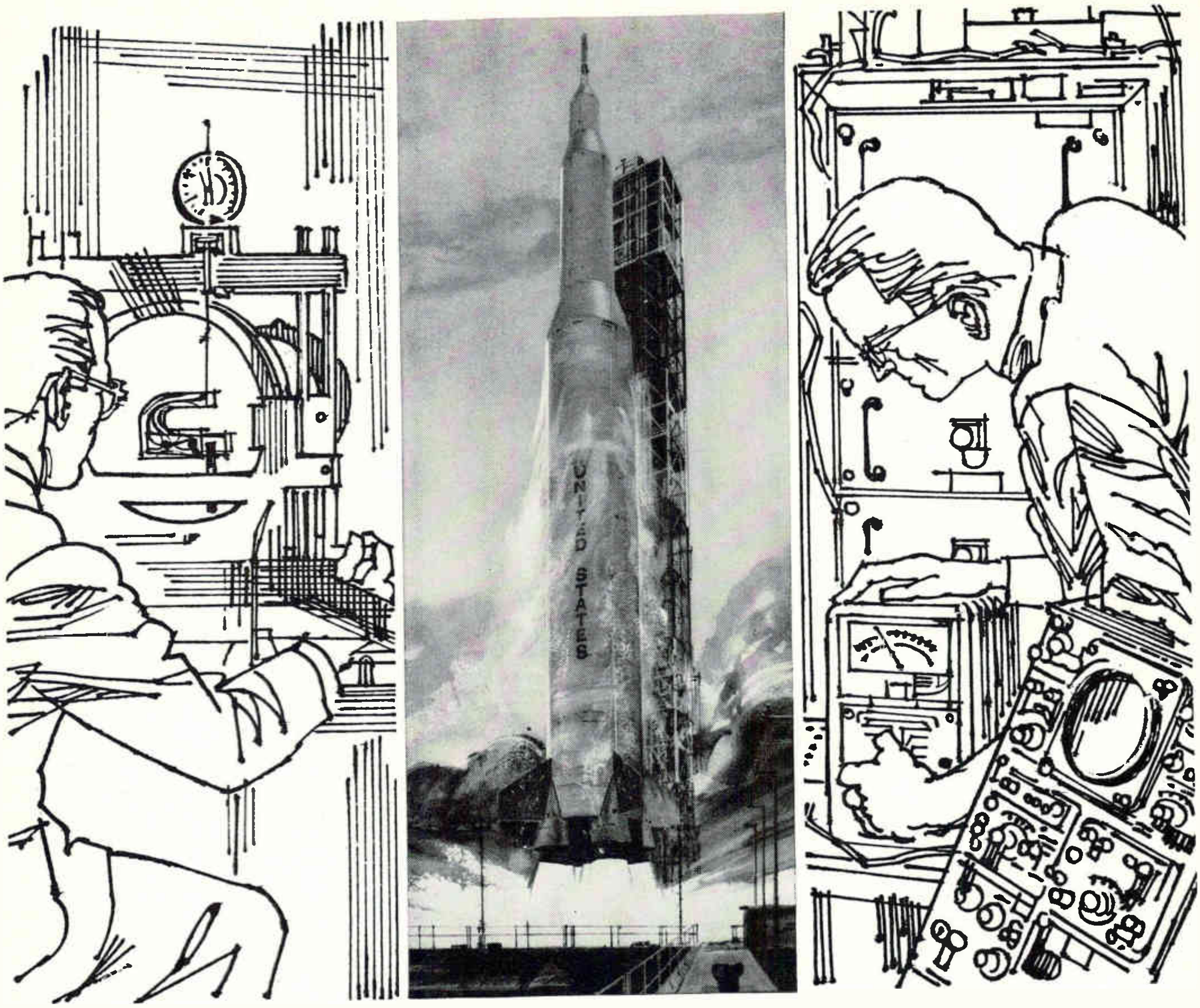
Solder Ingots Hold Component Leads

HOLDING device for lead wires during assembly of thermistors and resistors is lead ingots in a production method used by Carborundum Company, Niagara Falls, New York. First the lead wires are placed on end in small troughs containing molten lead. The lead is allowed to harden and forms an ingot, with the wires held firmly in place.

LEAD INGOTS *are used to hold components during manufacture*

Thermistor disks and resistor blanks are attached to wires in a conventional production operation and are then spray-coated or encapsulated as the process requires. When this part of the operation is complete, the wires of all units held by the ingot are sheared off simultaneously.

The ingots are melted down for reuse. Besides providing firm support for the components during manufacture, the technique clears up small wire ends from the working area and is compatible with any scrap recovery program.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Low Power Consumption
Frequency Coverage 30-1000mc

Type 901 RECEIVER
Frequency range 30-300mc
IF Bandwidth 20kc-300kc
Noise figure ....4db(30-60mc)
6.5db(60-300 mc)
Power consumption 40w
Weight ....18 lbs

Type 702 RECEIVER
Frequency range ....235-1000 mc
IF bandwidths ....50 kc-300 kc, 2 mc
Noise figure ....10 db 235-500 mc
12 db 490-1000 mc
Power consumption ....60 w
Weight ....21 lbs

Type 501 RECEIVER
Frequency range ....54-260 mc
IF bandwidth, ...300kc (AM-FM, CW)
10kc (AM-CW)
Noise figure 6db
Power consumption 35w
Weight ....18 lbs

Type SM-9310A SIGNAL MONITOR
This unit is used to provide a visual display of signal in a band around the received signal. Sweep width is continuously adjustable 0 to 3 mc.

Type FE-25-1 FREQUENCY EXTENDER
When used with any receiver tuning to 60mc, this unit gives additional frequency coverage from 235 to 1000 mc.

CIRCLE 202 ON READER SERVICE CARD

TKK

TKK INDUSTRIAL MOTORS

Lowest Drain, Minimum Noise, Longest Life — at Low Cost

RM-170 T FM-250 R FM-250 N

APPLICATIONS
* Tape-recorders
* Record-players
* Clocks
* Shavers
* Music Boxes
* Cinecameras
* Turntables
* Automations
* Other Appliances

type	voltage (D.C.)
RM-170 T models	1.5 ~ 3.0 V
RM-170 S models	1.5 ~ 6.0 V
RM-170 SC models	3.0 ~ 12 V
FM-250 N models	1.5 ~ 4.5 V
FM-250 R models	1.5 ~ 6.0 V

Large orders executed reliably and on schedule by the world's largest factory specializing in D.C. magnetic low current motors (Output: up to 2½ million units per month!) Your detailed inquiry is invited — your satisfaction guaranteed.

MABUCHI SHOJI K.K.
37, Kabuto-cho 2-chome, Nihonbashi, Chuo-ku, Tokyo, Japan
C.P.O. Box 1084, Tokyo Cables: "NIHONKAKOCO TOKYO"

CIRCLE 203 ON READER SERVICE CARD

Now, KWIK-TRIM
THE POTENTIOMETER WITH THE
VISUAL INDICATOR

IMPROVED RESOLUTION APPROX. 10% TO 25% OVER MANY COMPARABLE TYPES.

Designed for the ultimate in reliability and performance and to meet applicable military specifications for shock, temperature cycling, vibration, altitude, fungus, humidity, immersion, salt spray, sand and dust.

MULTIPLE ADJUSTMENT

A KWIK-TRIM one to one nominal adjustment . . . A vernier 45:1 ratio for precise setting . . . Shaft is journaled at each end with precision bearing fit . . . These precision features are your assurance for ease of setability and the stability of setting.

Please Write for ELECTRICAL, MECHANICAL AND ENVIRONMENTAL SPECIFICATION CATALOG.

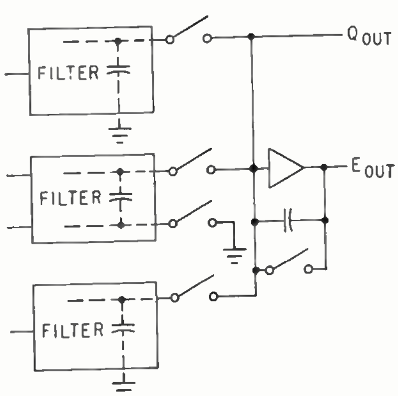
GS *General Scientific* CORP.
A SUBSIDIARY OF SAN FERNANDO ELECTRIC MFG. CO.
1535 FIRST ST. SAN FERNANDO, CALIF.
EM 1-1193 . . . TWX S.F. CAL 9900

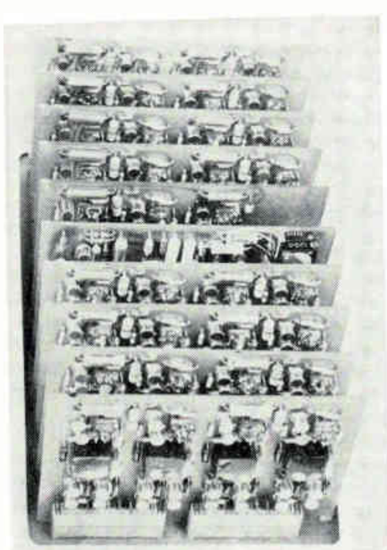
CIRCLE 99 ON READER SERVICE CARD

DESIGN AND APPLICATION

Multiplexer Uses Capacitive Charge Transfer

Sampling aperture is 0.25 μsec, rate is 200 Kc and error less than 0.5 mv



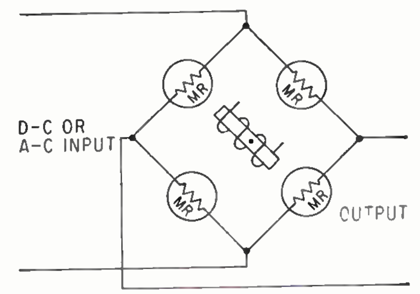


ANNOUNCED by Towson Labs., Inc., 200 E. Joppa Rd., Baltimore 4, Md., the Caplexer device handles analog inputs in the range from 0 to ± 10 v with effective sampling aperture of 0.25 μsec or less at rates as high as 200 Kc. Sampling errors of less than 0.5 mv are available. Single ended or balanced inputs are provided. Each plug-in board accommodates 4 channels of analog information. A 32 channel unit at maximum sampling consumes less than 1 watt. The unit uses low-pass sampling filters ranging from simple RC types to elaborate RLC combinations. One is an active low-pass filter using little power and complete freedom from d-c amplifier drift. Each channel uses a sampling capacitor that charges proportional to analog input signal (see sketch). The charges are sequentially transferred into an a/d converter. Both grounded and floating inputs can be used. Sampling switch closes for 1 μs or less so operating duty cycle is low. Series input impedance is high to prevent appreciable charge flow from the analog source thus negligible transient is reflected to sampled source. Voltage gain is obtainable by making sampling capacitance larger than capacitor across charge transfer amplifier. Device is useful in PCM telemetry, data logging and communications systems.

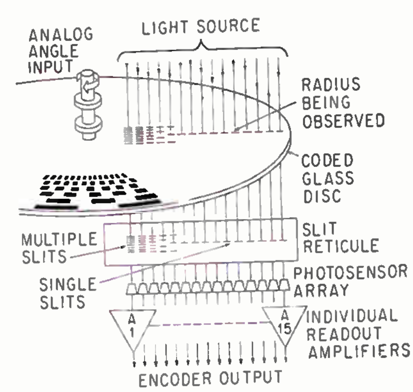
CIRCLE 301, READER SERVICE CARD

Magnetoresistive Element Has Many Functions

RECENTLY announced by American Aerospace Controls, Inc., 123 Milbar Blvd., Farmingdale, N. Y., the Mistor device is a high-impedance, thin-film, solid-state magnetoresistive element whose electrical resistance changes directly as a function of applied magnetic flux density. Resistance change as a function of magnetic field is linear from 1,000 to over 30,000 Gauss. Nominal resistance values extend to 10,000 ohms. Sensitivity increases as temperature decreases so device may find use in cryogenic areas. The device has no junction noise and thermal noise is approximately several μv. Response is almost instantaneous and time lag of

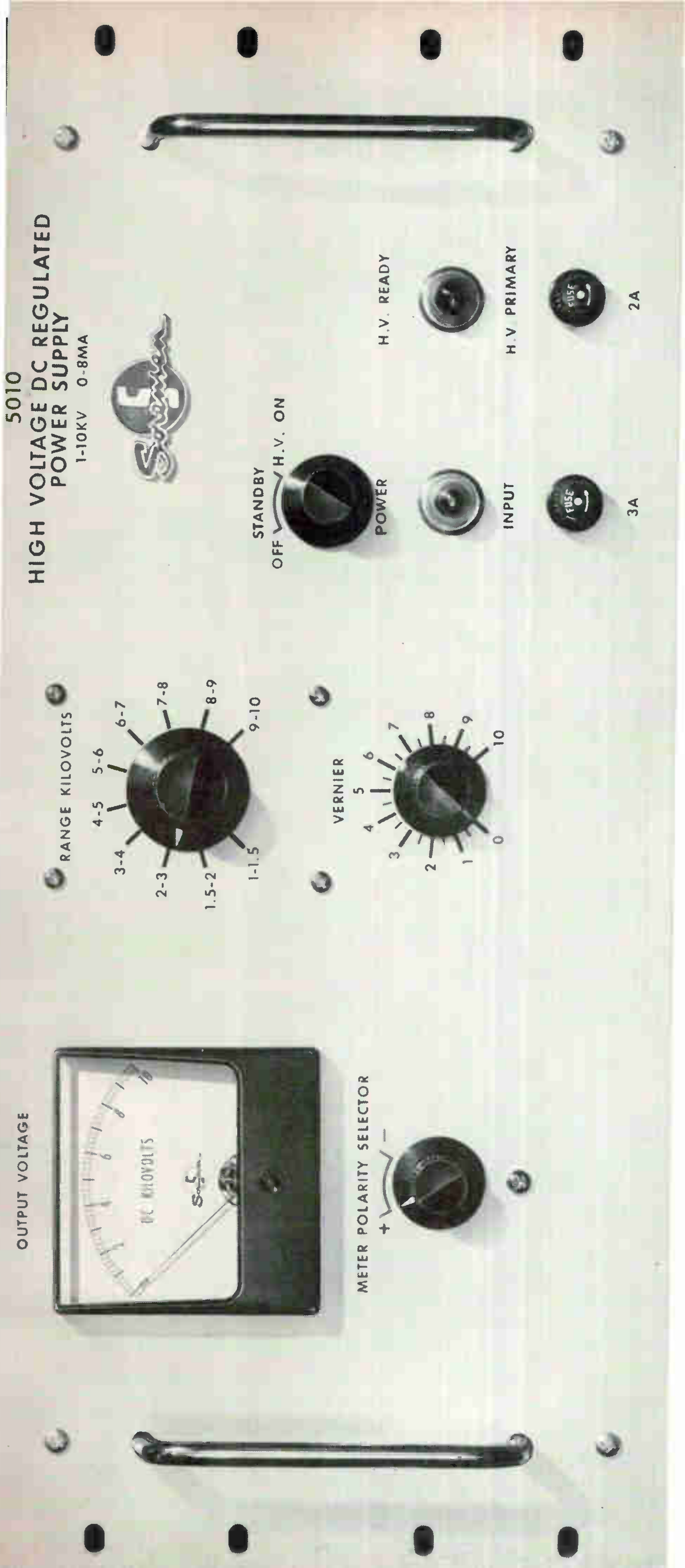


magnetic circuit is usually maximum frequency limitation. The unit is purely resistive (non-inductive) and can be used in either a-c or d-c circuits, without phase shifts, harmonics, quadrature or other influences. The sketch shows application as waveform generator or servo positioner. When the magnet is rotated so that its field acts on alternate legs of the 4-arm bridge, output is a-c whose frequency varies as a function of magnet speed of rotation. The output waveshape depends on the physical relationship between the magnetoresistive element arrangement and the magnet arrangement. **(302)**



Optical Encoder Uses Multiple Slit Technique

DEVELOPED by Computer Control Co., Old Connecticut Path, Framingham, Massachusetts, the model



TODAY'S BIGGEST VALUE IN REGULATED HIGH VOLTAGE DC POWER

In many applications your high-voltage power supply dollar will go twice as far with a Sorensen 5010-8. This high-performance DC supply (1,000 to 10,000 V DC; 8 MA continuous current) offers:

1. Precise output voltage regulation (±0.05% for line voltage changes of ±10%, and ±0.05% for load changes from no load to full load. 2. Low ripple . . . less than 300 millivolts RMS. 3. Easily reversible polarity. 4. Variable output (coarse and fine controls). 5. Ease of operation (all controls on front panel). 6. Maximum protection for personnel and equipment. 7. Panel height 8¾ inches. 8. Removable end bells (optional) for quick conversion from cabinet to rack mount.

Price? $750.

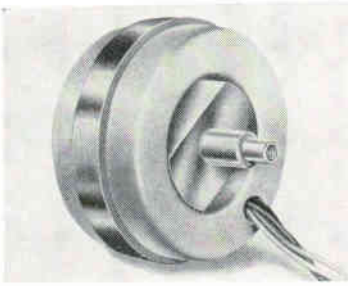
Interested in biggest value in high-performance, high-voltage DC supplies? Get more information on Sorensen's 5000 series. Contact factory or use reader service card number **256.**

Sorensen

A UNIT OF
RAYTHEON COMPANY
RICHARDS AVE., SO. NORWALK, CONN.

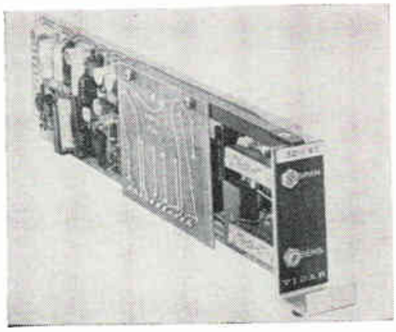
3C Dicotron encoder package is a series of optical shaft angle encoders using multiple slit techniques. Models come with parallel cyclic binary (Gray) code and binary coded decimal. The device involves an increase in the number of slits in the stationary reticule that admits light to the encoders photosensors. Conventional optical encoders now use one reticule slit for each track on the code disc. This new device uses a number of slits for each of the finer, more densely packed (least significant bit) tracks. As more light reaches the photosensors, the increased intensity permits several additional code tracks to be built in yielding a 2X increase in resolution and accuracy. Also, additional light can increase reliability as output is higher and signal-to-noise ratio is improved. Multiple slits also average out small imperfections (foreign matter) on the disk. By using an inside-out code disk (least significant bit code track is on the inner track), the device produces uniform transition slopes and uniform signal levels.

CIRCLE 303, READER SERVICE CARD



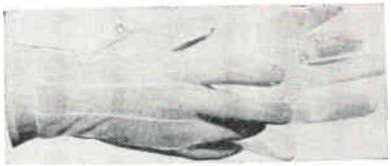
New Shape in High Sensitivity Transducer

MANUFACTURED by Pickering and Co., Inc., Sunnyside Blvd., Plainview, L. I., New York, the model 7056 linear variable differential transformer has its armature and stator constructed using stacked laminations. Coils are epoxy encapsulated and covered with a protective cap. High sensitivity of 2 w at 4,800 cps is not obtained at the expense of input power. Low source impedance of 200 ohms at 4,800 cps does not impose a loading problem. Output is 12 v at 0.040-inch displacement from the null position. Range is 0.040-in axially from null, output is 0.3 v per 0.001-in displacement, linearity is ±0.5 percent, phase shift is +5 degrees, null output is 60 mv, voltage input is 26 v at 4,800 cps and source impedance is 200 ohms. (304)



Converters Feature High Output Level

VIDAR CORP., 2296 Mora Drive, Mountain View, Calif. An all solid state frequency-to-voltage converter designed for high accuracy multichannel data acquisition features 0.1 percent stability and linearity. Ten standard full scale frequencies are available, ranging from 500 cps to 100 Kc. High output level (10 v) allows direct use with magnetic recorders, digitizers, computers, oscilloscope monitors and other data processing equipment. (305)



Clean-Room Gloves Are Lint-Free

CLEAN ROOM SPECIALTIES, 511 Victor St., Saddle Brook, N.J. Clean room gloves are manufactured by a special process where the edges are neatly trimmed and sealed to prevent fraying. This permits the hand to be removed from the glove without carrying lint into the area from within the glove. The gloves, lint free inside and outside, are made of a vinyl laminated Nylon cloth palm with a clear monofilament Nylon-back that permits the hand to breathe. They are skin fit, static free and washable. (306)

Antenna Multiplexers

ALLEN-BRADLEY CO., 102-N West Greenfield Ave., Milwaukee 4, Wisc.,

An idea grows from one mind to another.

It may begin with nothing important. Just a word. Or a notion. But as each succeeding mind brings a fresh viewpoint, the idea begins to grow and mature.

If you like working in an atmosphere that breeds ideas, you'll like working at Northrop. Stimulating minds and stimulating projects are all a part of the climate here. We have more than 70 active projects in work, and we're constantly evaluating new lines of inquiry. Projects range from space guidance and navigation to automatic checkout equipment, from computer design and world-wide communications to laminar flow control.

On the following pages you'll find some specific positions available now at Northrop Space Laboratories and Northrop Norair. Look them over. One may be just the spot for you.

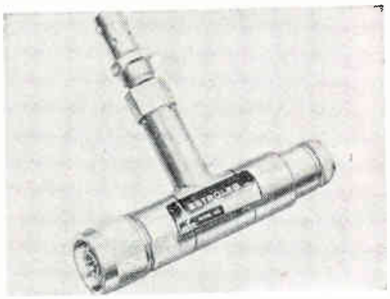
But even if you don't find your specialty listed — don't go away. We simply don't have room to mention all the opportunities to be found throughout Northrop's several divisions. For more specific information, write to Dr. Alexander Weir at Northrop Corp., Box 1525, Beverly Hills, Calif. You'll receive a prompt reply.

NORTHROP

AN EQUAL OPPORTUNITY EMPLOYER

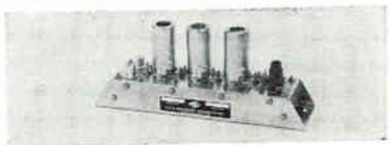
offers antenna multiplexers, designed to permit two or more simultaneous telemetry signals to be transmitted or received from one antenna without mutual interference, and intended for use in extreme conditions encountered in second generation missiles.

CIRCLE 307, READER SERVICE CARD



Signal Sampler Uses Ferromagnetic Material

ASTROLAB INC., 120 Morris Ave., Springfield, N. J. Signal sampler, using ferromagnetic material to give broader bandwidth and lower vswr, is an adjustable 50 ohm line coupled with coil type loop to monitor the level of magnetic r-f energy on the main transmission line. (A safety device is incorporated to prevent damage to loop). This adjustable line can be positive locked in any position. Electrical characteristics optimized to your specific frequency band. (308)

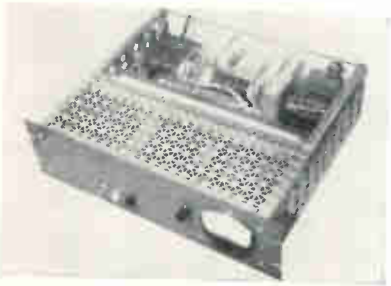


Wideband Preamplifier Has 40 Db Gain

RHG ELECTRONICS LABORATORY, INC., 94 Milbar Blvd., Farmingdale, N. Y. Preamplifier series are centered at 30 and 60 Mc with noise figures of 2.0 and 3.5 db respectively. Bandwidth is 10 Mc at 1 db down. Gain is 40 db minimum with 50 db typical. Balanced and unbalanced inputs are available for any type of crystal mixer. Units are priced at $140. (309)

Delay Line

ESC ELECTRONICS, Palisades Park, N.J. A 20 μsec, 500 ohm delay line with 200 equally spaced taps located to a tolerance of ± 30 nsec, the model 53-13 has a pulse rise time of 0.2 μsec maximum and a pulse attenuation of 3 db max. (310)



H-V Power Supply Offers High Stability

WALDEN ELECTRONICS CORP., 85 Mystic St., Arlington, Mass. Model 538 series of power supplies is designed for high resolution crt's (accelerating voltage). Specifications include all-semiconductor circuitry, output voltage from 15 Kv to 27 Kv. Output current 0 to 0.5 ma. Regulation 0.1 percent line and load combined. Ripple is 0.1 percent. (311)

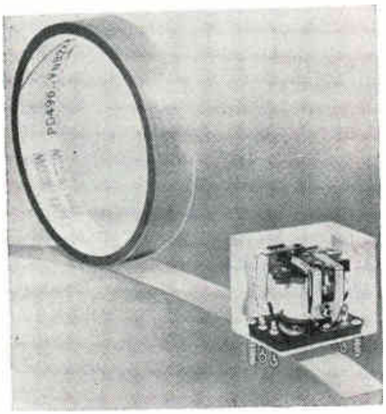
Pulse Generators Require No Oven

SOLID STATE ELECTRONICS CO., 15321 Rayen St., Sepulveda, Calif., announces models PG111 and PG112 silicon transistorized crystal controlled pulse generators for 2 Kc to 20 Mc. The encapsulated units were designed to provide a precision pulse or square wave output having high reliability over temperatures from − 55 C to + 85 C. Temperature stability is achieved without the use of an oven. (312)

Epoxy Molding Powder Has Room Stability

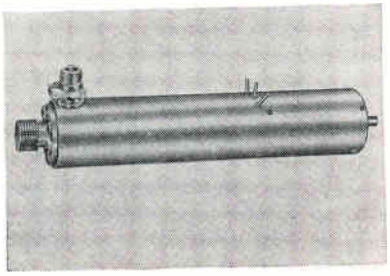
EPOXY PRODUCTS DIVISION, Waldman, 133 Coit St., Irvington, N. J., has developed a line of epoxy molding and encapsulating powders which are stable at room temperatures. The formulations can be stored for one year or longer at 75 F and are usable after storage for three months at 95 F. Curing time has been greatly reduced and molded parts are hard on ejection from the mold. For some grades curing time is as fast as 15 sec.

CIRCLE 313, READER SERVICE CARD



Pressure-Sensitive Tape Prevents Corrosion

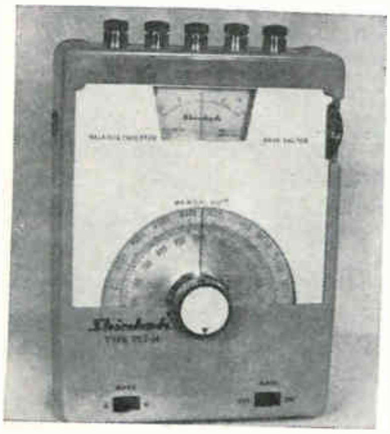
MYSTIC ADHESIVE PRODUCTS, INC., 2635 N. Kildare Ave., Chicago 39, Ill., has announced a non-gassing pressure-sensitive tape that prevents corrosion and pitting in electronic components. Known as PD-496, it has a three-mil Teflon backing and a thermostetting rubber-based adhesive. It is especially designed for insulating the coil windings of Class F hermetically-sealed components. The tape is available from stock in 36-yard rolls and in a broad range of width. (314)



C-W Oscillator Tunes From 2.0 to 4.1 Gc

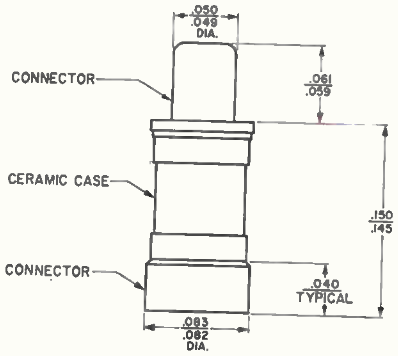
TRAK MICROWAVE CORP., Tampa, Fla., has developed a c-w oscillator with a continuous manual tuning range from 2.0 to 4.1 Gc. Type 2982 has a power output of 1 w, with a frequency stability of 25 ppm/deg. C. Power input requirements are 325 v d-c at 60 ma; 6.0 v at 0.9 amp.

The oscillator is 2 in. in diameter and 11 in. long including projections. The tuning mechanism is of the non-contacting type, resulting in a tuning resolution of better than 40 Kc, with the discontinuities or reversals. (315)



Strain Indicator Used in Lab and Field

METRIX, INC., P.O. Box 683, Walnut Creek, Calif. Model PS7-H miniature portable strain indicator features transistor circuit design. Single dial control permits strain measurement over a wide range. Other controls are for gage factor setting, 2 or 4 gage selector and on-off. Unit is powered by self contained flashlight cells which provide approximately 60 hr of operating life. (316)



Varactor Diodes Are Ruggedized Units

AIRTRON, a division of Litton Industries, 200 E. Hanover Ave., Morris Plains, N. J., has available point-contact gallium arsenide varactor diodes with nominal cutoff frequencies of 150 Gc at zero bias, and guaranteed minimum of 100 Gc. Other nominal specifications include: non-linearity, 0.4-0.55 from

0 to −5 v; junction capacitance at zero bias, 0.1-0.4 pf ± 0.02 pf; case capacitance, 0.06 pf; reverse breakdown voltage, 6 v min (2 μa reverse current).

CIRCLE 317, READER SERVICE CARD

Germanium Transistors For High Power Uses

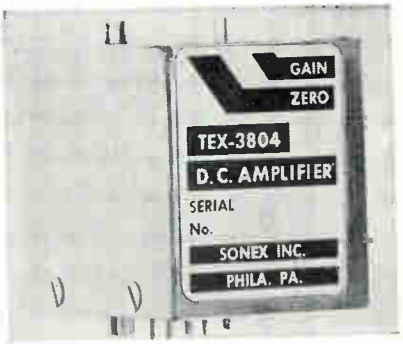
TUNG-SOL ELECTRIC INC., One Summer Ave., Newark 4, N. J., has added five new transistor types to its high power germanium devices. They have a collector current rating of 5 amp and were designed with low leakage current and high voltage protection which suits them for use in applications such as high power amplifiers, motor controls, d-c to d-c converters, relay drivers and high power switches. Max collector dissipation is 106 w. Derating factor is 0.8 C/w and max junction temperature 100 C. (318)

Trimmer Capacitors

JFD ELECTRONICS CORP., 6101 Sixteenth Ave., Brooklyn 4, N.Y. Four new Hi-Life precision trimmer capacitor series exceed MIL-C-14409A adjustment life requirements by more than 600 percent. (319)

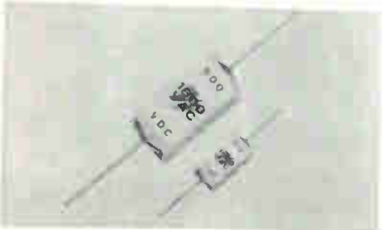
Null Detector Has Extended Range

WEINSCHEL ENGINNEERING, 10503 Metropolitan Ave., Kensington, Md. With the model ND-2, a 1000 cps differential null detector, the dynamic range of the Weinschel dual channel insertion loss test set is extended to 35 db as compared to the 20 db formerly obtainable. The improvement results from the synchronous detector and associated meter which have been introduced to permit finer resolution of the null. An external control is provided to permit selecting the sensitivity over a wide range. For measurements up to 20 db, a typical half-scale sensitivity of the meter is 0.01 db. (320)



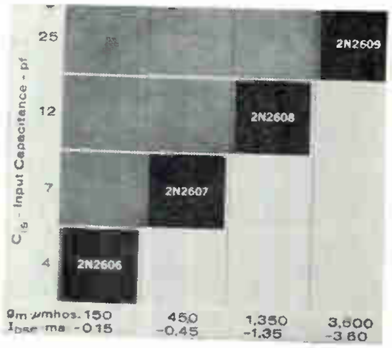
D-C Amplifier Provides Gain of 250

SONEX, INC., 20 E. Herman St., Philadelphia 44, Pa. The TEX-3804 is an all solid-state high environmental d-c amplifier, designed for aircraft and missile use where minimal size is vital. Characteristics include airborne ruggedness, differential input, gain 250, 5 v p-p output, and an output impedance of 3000 ohms max. It features adaptability to combination form. Piggybacked with the TEX-3007 high-level voltage controlled oscillator, the d-c amplifier achieves low cost flexibility as a new low-level voltage controlled oscillator. (321)



Porcelain Capacitors Handle up to 14 Amp

VITRAMON, INC., P.O. Box 544, Bridgeport 1, Conn. Miniature solid state porcelain capacitors will handle up to 14 amp of current and range from 1 to 2.000 pf. They permit drastic reduction in the size of equipment, such as transmitters and other applications requiring high current operation. Operating range is from −55 through 125 C and from 2-30 Mc the units will operate at 1,500 v a-c rms. (322)



Field-Effect Transistors Have Low Pinch-Off

SILICONIX INC., 1140 W. Evelyn Ave., Sunnyvale, Calif., announces four new P-channel planar silicon unipolar field-effect transistors in the TO-18 package. They offer individual geometries and corresponding tightly controlled ranges of g_m, I_{DSS}, and C_{is}. All have typical pinch-off of 2 v at $I_{DS} = -1$ µa. Minimum gate-drain breakage voltage of 30 v is guaranteed at $I_G = 1$ µa. Typical small signal input resistance exceeds 100 megohms suiting them for high input impedance amplifiers, analog multipliers and analog function generators. (323)

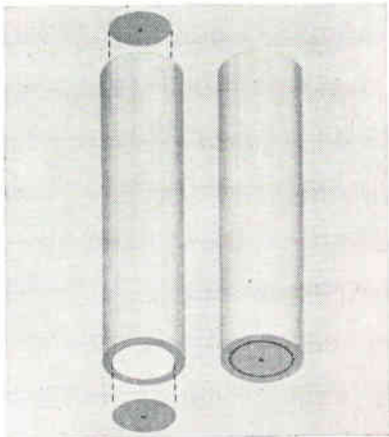
Tachometer Generator Needs No Maintenance

VIBRAC CORP., 281 Billerica Road, Chelmsford, Mass. Unit consists of a precision wound stator and p-m rotor. Since it uses no bearings or brushes, it requires no maintenance and less than 2 cu in. of space. An encapsulation process and a molded epoxy case make it essentially impervious to oil, grease, moisture and corrosive solvents. The Vibratac is easily installed on any rotating device. Its output voltage at a given rpm is proportional to its speed and is readily measured by an inexpensive voltmeter. It can be supplied with a voltage output from 1 to 6 v/1,000 rpm.

CIRCLE **324**, READER SERVICE CARD

Choppers Feature Low Noise Level

CAMBRIDGE SCIENTIFIC INDUSTRIES, INC., 18 Poplar St., Cambridge, Md. Series of 60 cycle choppers are available in both make before break, and break before make contact action. They feature a noise level of less than 0.5 μv into a 1,000 ohm load, and less than 5 μv into a 1 megohm load. Standard plug-in models are conservatively priced at $36.90 each in sample quantities. Flange and strap mounted units are priced slightly higher. (325)



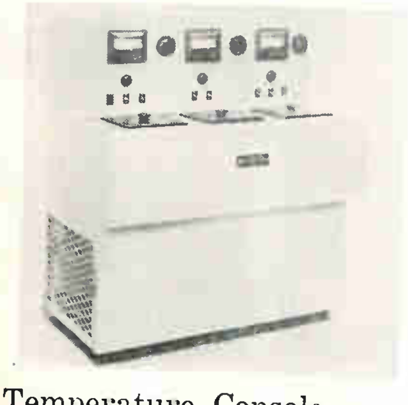
Hermetic Seal Made of Ceramic

ADERHOLD ELECTRONICS & CERAMIC SPECIALTIES, INC., Saxonburg, Pa. The Aderseal is made from an epoxy-impregnated ceramic tube with matching caps that has a coefficient of expansion halfway between the ceramic and the epoxy.

When the element to be sealed is encased in the tube, the ends are closed with the caps and coated with additional Aderseal material. A simple curing procedure completes the seal and makes it hermetic, as determined by a helium leak detector mass spectrometer apparatus. (326)

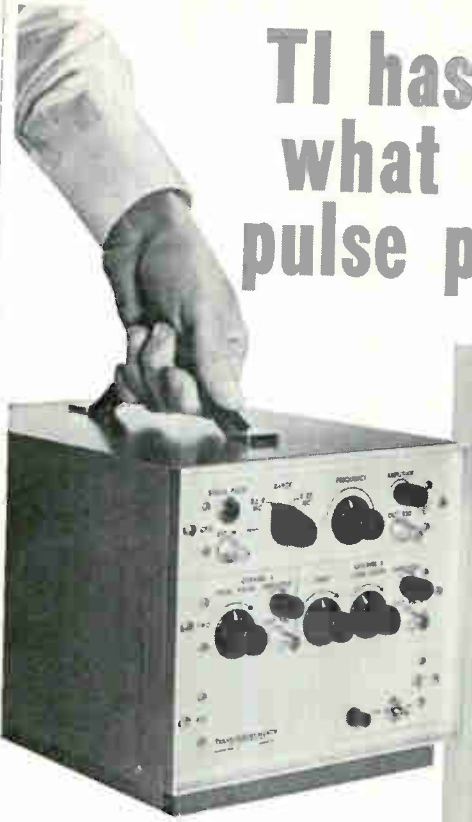
Phase Meter Provides High Resolution

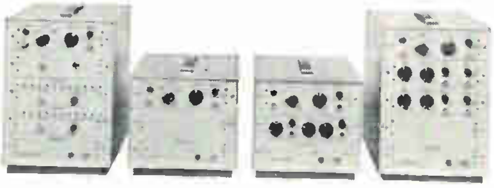
INDUSTRIAL TEST EQUIPMENT CO., 55 E. 11th St., New York 3, N.Y., announces the model 210AB direct reading Phazor phase meter. A projection read-out device is utilized to display the quadrant of the phase angle. The number of degrees within that quadrant is read directly on the meter. This arrangement coupled with utilization of the full meter scale length to read an angle of 45 deg provides a high degree of phase resolution. (327)



Temperature Console Has Three Chambers

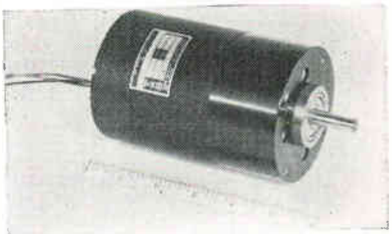
CINCINNATI SUB ZERO PRODUCTS, 3932 Reading Road, Cincinnati 29, O. Three individually controlled chambers provide comparative temperature testing facilities, or instrument calibrating media, over a temperature range from −65 to +300 F. Immersion heaters equalize the temperature during the refrigeration cycle resulting in





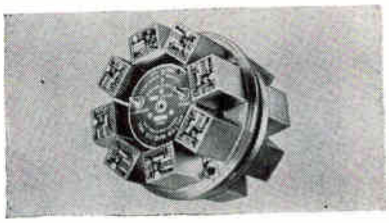
accuracy of ±1 F. Temperature stratification is minimized through the use of agitated convection fluid in the liquid tight chambers. Console type cabinet is 44 in. long, 31 in. wide and 50 in. high.

CIRCLE 328, READER SERVICE CARD



A-C Gear Motor Weighs About 5 Lb

GLOBE INDUSTRIES, INC., 1784 Stanley Ave., Dayton 4, O. Gearmotor combines the type LC motor with the 1½ in. planetary gear box to produce 75 in. lb of torque from a low speed a-c motor. The drive motor is a 2 pole, 115 v, 60 cycle, single phase LC type which will draw 2 amp and 120 w of power when running at full load. Qualified to MIL-E-5272B, life of gearmotor is in excess of 1,000 hr when run at intermittent duty. (329)



Telemetry System Fits in Small Space

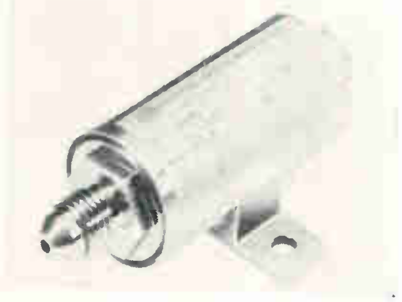
VECTOR MFG. CO., INC., Southampton, Pa. This specially packaged system is designed for the nose of a small missile and consists of seven TS-54 oscillators and a TA-58 mixer amplifier on one side of a 5-in. plate; on the other side are TV-56 and TV-53 voltage regulators, six TLA-55 low level amplifiers, and a TRPT-2V transmitter. (330)

Millivoltmeter

DAWE INSTRUMENTS, LTD., Western Ave., Acton, London W. 3, England. Type 616A transistor millivoltmeter is a portable battery operated instrument which measures alternating voltages from less than 1 mv to 300 v over a frequency range of 2 cps to 100 Kc. (331)

Vacuum Phototube Measures Laser Pulses

CETRON ELECTRONIC CORP., 715 Hamilton St., Geneva, Ill. The XR-798 phototube, because of its close spaced anode-cathode configuration, has found application in measurement of high intensity, short duration light flashes. Minimum sensitivity is 25 μa per lumen; max sensitivity, 70 μa per lumen. Max recommended anode voltage, d-c or peak a-c, is 250; max dark current at 200 v d-c, 25 C is 0.1 μa. (332)



Pot Type Transducer Weighs 4 Ounces

SERVONIC INSTRUMENTS, INC., 1644 Whittier Ave., Costa Mesa, Calif. Model 3021 miniature low pressure transducer withstands 35 g vibration with less than 1.0 percent error. Featuring a new pressure-sensing concept, the unit has two separate sets of aneroid capsules attached to opposite ends of a driving frame. One set is connected to a pressure fitting and the other is evacuated for an absolute pressure reference. The second can be vented to the atmosphere for gage pressure measurement. (333)

PRODUCT BRIEFS

SUBMINIATURE R-F CHOKES are magnetically shielded. Inductance range is from 0.1 μh to 180 mh. Vanguard Electronics Co., 3384 Motor Ave., Los Angeles 34, Calif.
CIRCLE **334**, READER SERVICE CARD

RACK AND PANEL CONNECTORS designed for use with MIL-C-26636 type contacts. They are available in six insert arrangements and three shell sizes. The Deutsch Co., Municipal Airport, Banning, Calif. (335)

BREADBOARDING MODULES designed for building semiconductor circuits. Each of the 35 solderless connectors accepts up to four leads. Vari-L Co., Inc., 207 Greenwich Ave., Stamford, Conn. (336)

DUAL TWO-INPUT GATE MODULES permit cost and space savings. They have standard seven-pin miniature base configurations. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass. (337)

FIXED NEON INDICATOR LIGHTS are all plastic, subminiature. Lenses are available in colors of red, white, amber, or clear. The Solan Co., Box 367, Sun Valley, Calif. (338)

COAXIAL R-F CONNECTORS accept microminiature RG cables from 50 to 95 ohms. They feature crimp type, captive contact. Tamar Electronics Division, 2045 West Rosecrans Ave., Gardena, Calif. (339)

SELENIUM RECTIFIERS packaged in Mylar film. They are available in ratings of 2-30 Kv prv at 5 ma average d-c. Bradley Semiconductor Corp., 275 Welton St., New Haven 11, Conn. (340)

TEFLON FLAT CABLE has construction that permits almost unlimited design possibilities. It is available in temperature requirements up to 200 C. Hitemp Wires Co., 1200 Shames Drive, Westbury, N.Y. (341)

PHOTOELECTRIC TAPE READER has varied applications. It is bidirectional, with a 28-v d-c control signal to reverse tape motion. Seattle Development Laboratory, Honeywell Ordnance Division, 5303 Shilsole Ave. N.W., Seattle 7, Wash. (342)

MINIATURE MULTI-GANG POT has linearity better than $\pm$ 0.3 percent. Standard resistances are 10 to 20,000 ohms. The Gamewell Co., Newton Upper Falls, Mass. (343)

VARIABLE POWER DIVIDER has a frequency range of 400 to 6,000 Mc, with tuning range of 15 percent. Max vswr is 1.5. Microlab, Livingston, N.J. (344)

ELECTRICAL CONNECTORS offer quick connect and disconnect. They are designed with field indexable keying for application in control, power, and communication circuits. The

Pyle-National Co., 1334 N. Kostner, Chicago 51, Ill. (345)

SILICONE DIELECTRIC COMPOUND designed for use as a general purpose protective coating. It features ease of application. General Electric Co., Waterford, N.Y. (346)

ELECTRONIC PEGBOARD KITS aid in circuit design and instruction. Pegs may serve both as solder points and as temporary circuit junctions. Laguna Labs, 2419 S. Coast Blvd., Laguna Beach, Calif. (347)

DIVIDING HEAD for both automatic and semiautomatic operation. Accuracy is 10 sec-of-arc. Gertsch Products, Inc., 3211 S. LaCienega Blvd., Los Angeles 16, Calif. (348)

SOLID STATE CONTACTORS with extremely low noise. They are designed for use in computer power circuit switching where transients developed would be troublesome in the computer. LJ Products, 7450 Girard Ave., LaJolla, Calif. (349)

SOLID-STATE INVERTER is a low-cost unit. It offers reliability, frequency stability and small size. Humphrey, Inc., 2116 E. Central Ave., Wichita, Kansas. (350)

SPECTRUM RESOLVER/INTEGRATOR requires no tape, either perforated or magnetic, to resolve information. It operates with the 400 series pulse height analyzers. Technical Measurement Corp., 441 Washington Ave., North Haven, Conn. (351)

TRANSISTOR PROTECTOR safeguards circuitry against overload and overvoltage. It is a three terminal device suitable for mounting in p-c boards or used with standard wire connections. Littelfuse, Inc., Des Plaines, Ill. (352)

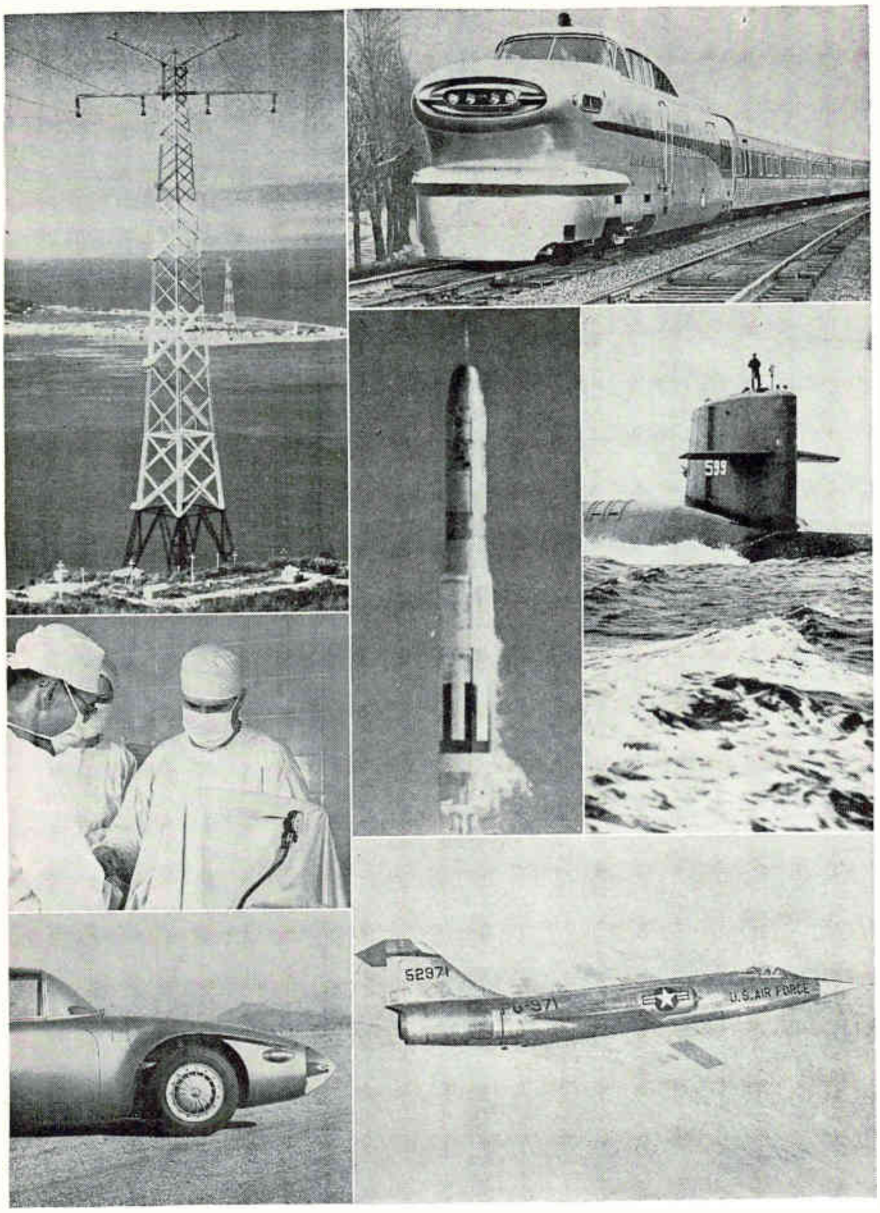
COAXIAL DIRECTIONAL COUPLERS provide octave coverage, 2.0-8.0 Gc, at coupling values of 10, 20 or 30 db. They weigh only 2 ounces. Omni Spectra, Inc., 8844 Puritan Ave., Detroit 38, Mich. (353)

AUTOMATIC MACHINE welds headed leads to transistor bases. It produces from 4,000 to 6,000 welds per hour. Mann-Made Enterprises, Addison, Ill. (354)

SNAP-ACTION ACCELERATION SWITCH operates between 2.5 g and 50 g. Unit measures 2 by 2⅜ by ⅞ in. and weighs 4 oz. Maxson Electronics Corp., 475 Tenth Ave., New York 18, N.Y. (355)

PRESSURE TRANSDUCER is small and hermetically sealed. Pressure ranges are 0-10 to 0-100 psia. Servonic Instruments, Inc., 1644 Whittier Ave., Costa Mesa, Calif. (356)

MOTOR GENERATOR is temperature and frequency compensated. Model CR4 0860 014 is designed for high response systems. Kearfott Division, General Precision, Inc., Little Falls, N.J. (357)



Literature of the Week

SILICON CONTROLLED RECTIFIERS Semicon, Inc., 200 Sweetwater Ave., Bedford, Mass., has available a silicon controlled rectifier interchangeability guide.
CIRCLE 358, READER SERVICE CARD

GLIDE SLOPE ANTENNA Sparton Electronics, division of Sparton Corp., Jackson, Mich. Product data sheet No. 6 covers the AT-983/ARN glide slope receiving antenna. (359)

EXPANDED CURRENT METER Paulte Mfg. Co., P. O. Box 85, Merrick, L. I., N. Y., has published a technical bulletin on the model 101 expanded current meter. (360)

COMPUTER INDICATOR POWER SUPPLY Power Devices, Inc., 8710 Darby Ave., Northridge, Calif., offers a technical data sheet on the PS50/1-.15 computer indicator power supply. (361)

INTEGRATED CIRCUITS Signetics Integrated Circuits, 680 W. Maude Ave., Sunnyvale, Calif., has published two brochures detailing characteristics and specifications of integrated circuits and the step-by-step manufacturing process. (362)

RECORDING OSCILLOGRAPH Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. Capabilities and specifications of the type 5-123 recording oscillograph are given in a bulletin. (363)

LASER SYSTEMS Trion Instruments, Inc., 2320 Washtenaw Ave., Ann Arbor, Mich., has available a bulletin describing the research, development and production of laser systems. (364)

TRACKING AND RANGE DATA EQUIPMENT Resdel Engineering Corp., 990 South Fair Oaks Ave., Pasadena, Calif., offers a brochure on equipment used in acquisition and reduction of track and range data. (365)

METALLIZED PAPER CAPACITORS Aerovox Corp., New Bedford, Mass. A revised bulletin gives complete technical data on microminiature Aerolite molded metallized paper capacitors. (366)

MAGNETIC TAPE DATA RECORDERS Precision Instrument Co., 1011 Commercial St., San Carlos, Calif. A series of compact data recorders are described in an illustrated 12-page technical brochure. (367)

SOLDERING TIPS Hexacon Electric Co., 130 W. Clay Ave., Roselle Park, N. J. Catalog 651 shows the Durotherm line of non-freezing soldering tips. (368)

SYNCHROS John Oster Mfg. Co., Racine, Wis. A 16-page catalog describes electrical parameters and mechanical characteristics of more than 175 basic synchros and variations. (369)

SENSITIVE RELAYS Babcock Electronics Corp., 3501 Harbor Blvd., Costa Mesa, Calif. Bulletin describes the BR-13 all-welded sensitive relay series. (370)

PROGRAMMER Trio Laboratories, Inc., Dupont St., Plainview, L. I., N. Y. Technical bulletin describes a self-powered relay-type programmer compatible with 4-bit binary-coded digital equipment. (371)

POWER TRANSISTOR Tung-Sol Electric Inc., One Summer Ave., Newark 4, N. J. Product bulletin describes a power transistor with a 15 amp collector current. (372)

SILICONE DIELECTRIC COMPOUND Dow Corning Corp., Midland, Mich. Technical data sheet describes a grease-like, non-melting silicone dielectric material. (373)

AIRBORNE PRESSURE TRANSDUCER Taber Instrument Corp., 107 Goundry St., North Tonawanda, N. Y. Bulletin gives specifications and prices on a lightweight pressure sensing unit for space vehicle and rocket applications. (374)

HEAT DISSIPATION Astro Dynamics, Inc., Second Ave., Northwest Industrial Park, Burlington, Mass., offers an 18-page application manual for heat sinks. (375)

METALLIZED MYLAR CAPACITORS San Fernando Electric Mfg. Co., 1509 First St., San Francisco, Calif. Bulletin 71662 contains complete information on West-Cap Midget metallized Mylar capacitors. (376)

MEASUREMENT INSTRUMENTS Power Instruments, Inc., 7352 North Lawndale Ave., Skokie, Ill., has published a condensed catalog illustrating and describing its line of instruments. (377)

MAGNETORESISTIVE ELEMENTS American Aerospace Controls, Inc., 123 Milbar Blvd., Farmingdale, N.Y. Product data bulletin describes Mistor thin-film, solid-state magnetoresistive elements. (378)

ENCODER PACKAGE Computer Control Co., Inc., Old Connecticut Path, Framingham, Mass., offers a portfolio of Dicotron optical shaft angle encoders incorporating Multiple Slit Technique. (379)

MINIATURE PREAMPLIFIER Ad-Yu Electronics Lab., Inc., 249 Terhune Ave., Passaic, N.J. Data sheet contains description and specifications for type A102 miniature nonmicrophonic preamplifier. (380)

CROSSBAR SCANNER James Cunningham, Son & Co., Inc., 10 Carriage St., Honeoye Falls, N.Y., offers a bulletin on a transistor driven crossbar scanner with remote decimal readout. (381)

HIGH-Q FIXED INDUCTOR Nytronics, Inc., 550 Springfield Ave., Berkeley Heights, N.J. Therm-L inductor for temperature applications is covered in a data sheet. (382)

Thomas H. Rogers

Howard D. Doolittle

Announce Two Promotions at Machlett

THOMAS H. ROGERS director of engineering for The Machlett Laboratories, Inc., Springdale, Conn., has been elected vice president and x-ray product line manager of the Raytheon subsidiary. At the same time it was announced that Howard D. Doolittle, associate director of engineering, has been named to the new post of technical director for the firm.

Machlett president Joseph W. Skehan said that Rogers, who joined the company 28 years ago, will be responsible for the design and manufacture of x-ray products. His experience in the x-ray tube field includes many important contributions to the development of Dynamax rotating anode tubes.

Doolittle, in his new position, will be responsible for overseeing the technological advancement of the company across its whole area of interests including x-ray tubes, large power tubes, high power radar tubes, small power tubes, tv camera tubes, x-ray image intensifiers, and solid state rectifiers. He joined the firm in 1945 and was named associate director of engineering 10 years later.

Leesona Moos Labs Advances Mezzina

ALESSIO MEZZINA has moved up to director of physical and electronic research for Leesona Moos Laboratories, Jamaica, N.Y., a division of the Leesona Corp.

Founded in 1948, and formerly known as Patterson Moos Research, the Laboratories are engaged in basic and applied research.

Engelmann Sets Up New Company

HERBERT F. ENGLEMANN has formed a new company, Engelmann Microwave, Mountain Lakes, N.J., for the design, development and manufacture of coaxial components and subassemblies. The company will specialize in the development of highly reliable microwave hardware for space communications and military defense systems.

Engelmann was formerly vice president and technical director of Microlab, Livingston, N.J.

Hewlett-Packard Forms Two New Divisions

HEWLETT-PACKARD CO., Palo Alto, Calif., has converted two of its wholly-owned subsidiaries, Boonton Radio Corp. and Palo Alto Engineering Co., into divisions of the company. Both new divisions produce instrumentation equipment complementary to the H-P product line.

The establishment of Boonton Radio and PAECO as divisions is part of the parent company's program of gradually divisionalizing its corporate structure, according to president David Packard.

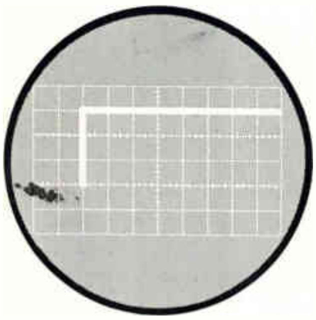
Packard pointed out that the new divisions will retain present policies and product lines. He announced that John C. Beckett, now president and general manager of PAECO, will continue as general manager of that division.

He also said that William D. Myers has been named general manager of the Boonton Radio division. He succeeds George A. Downsborough who recently resigned the presidency of Boonton Radio. Myers was formerly manufacturing manager of H-P's Microwave division in Palo Alto.

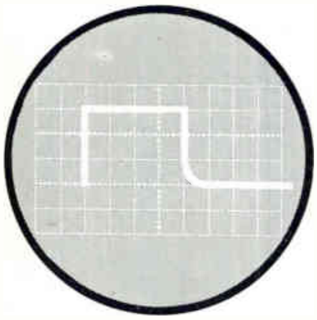
Singer Metrics Names Wu to Direct R&D

WILLIAM I. L. WU, formerly chief engineer of Panoramic Electronics,

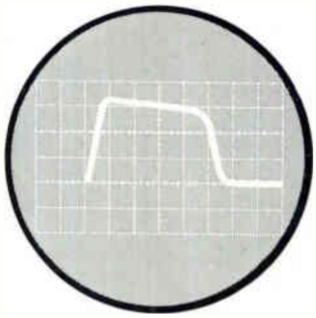
"Bounce-Free" for pulse and digital systems that operate in less than a microsecond. *Data Sheet 177.*



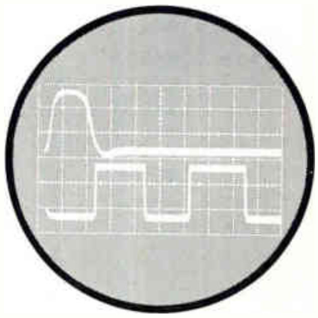
"DC Pulse Circuit" produces square wave millisecond pulse for high speed devices. *Data Sheet 194.*



"One-Shot" produces one square wave of 0.1 to 10.0 microseconds regardless of actuation speed. *Data Sheet 150.*



Synchronized "One-Shot" generates single square wave output pulse in synchronism with external clock pulse. *Data Sheet 172.*



PACKAGED PULSE CIRCUITS

save circuit development time

MICRO SWITCH pre-engineered electronic circuit "packages" help speed equipment design by eliminating the need for custom circuit development. These compact packages save space in equipment racks and control consoles. Four Data Sheets on MICRO SWITCH circuit packages are available. Write for them . . . or contact our nearest Branch Office (See Yellow Pages) for expert engineering assistance.

MICRO SWITCH
FREEPORT, ILLINOIS
A DIVISION OF HONEYWELL

IN CANADA: HONEYWELL CONTROLS LIMITED, TORONTO 17, ONTARIO

HONEYWELL INTERNATIONAL SALES AND SERVICE OFFICES IN ALL PRINCIPAL CITIES OF THE WORLD. MANUFACTURING IN UNITED STATES, UNITED KINGDOM, CANADA, NETHERLANDS, GERMANY, FRANCE, JAPAN

CIRCLE 121 ON READER SERVICE CARD

has been appointed director of R&D at Singer Metrics division of The Singer Mfg. Co., Bridgeport, Conn.

Singer Metrics is engaged in research and production of electronic laboratory instruments for precise measurement, calibration and spectrum analysis—subsonic through microwave; and precision electromechanical systems and components.

PRD Electronics Appoints Prager

PRD ELECTRONICS, INC., Brooklyn, N. Y., manufacturer of microwave and electronic test equipment, has announced the appointment of Jerome Prager as applications engineer.

Prior to joining PRD, Prager was with the communications and electronics department of ITT's Federal Electric Corp. as a systems and installation engineer.

Anderson Accepts USI Position

APPOINTMENT of David Anderson, Col. USAF Ret., as director of engineering for the United States Instrument Corp. has been announced by William A. Rockwood, president.

USI produces telecommunications systems and equipment for private commercial and military use, as well as for the independent telephone industry. In his new post, Anderson will play a primary role in the company's current product diversification and expansion program, Rockwood said.

Anderson's last military assignment was with the electronic systems division of the USAF Systems Command at Hanscom Field, Bedford, Mass.

Martin Company Appoints Bender

WELCOME W. BENDER, director of Martin Company's Research Institute for Advanced Study, Baltimore, Md., has been appointed director of research for the company.

Bender will have overall responsibility for the programming, integration and quality of Martin's research effort in the company's six operating divisions located in Maryland, Florida and Colorado.

He will also continue as director of the Research Institute for Advanced Study.

Trask to Direct BMEWS Office

AIR FORCE Col. John A. Trask has been named director of BMEWS System Program Office at Electronic Systems Division, Bedford, Mass.

SPO is managing construction of the third BMEWS site at Flyingsdale Moor, Yorkshire, England.

Barnes Engineering Expands in Florida

BARNES ENGINEERING CO., Stamford, Conn., a firm engaged in infrared and electrooptical instrumentation, has acquired the assets of the Versatronics Corp., Fort Walton

Beach, Fla. All Versatronics personnel have been retained.

According to Eric M. Wormser, vice president in charge of Barnes' defense and space activities, the purchase extends the company's capability to provide complete systems for missile range applications.

Sonex Appoints Porst To Vice Presidency

LEE PORST, western regional manager of Sonex, Inc., Philadelphia, Pa., has been promoted to vice president of the firm.

Sonex produces a diversified line of airborne telemetry components, power supplies, printed circuit boards and component assemblies.

Porst, with Sonex for the past 1½ years, had previously been associated with Tele-Dynamics, Inc., and with North American Aviation's engineering department.

REL Names Burrows Senior Scientist

CHARLES R. BURROWS has been appointed to the post of senior scientist of Radio Engineering Laboratories, Inc., Long Island City, N. Y. He will be based at the Bethesda, Maryland, division. REL, the communications subsidiary of Dynamics Corp. of America, manufactures tropospheric scatter radio communications equipment.

Burrows joined REL in the spring of this year. His industrial experience includes a vice presidency of Ford Instrument Co., where he was responsible for the long range planning of R&D projects. He has also been associated with Radiation, Inc., and Page Communications, Inc.

PEOPLE IN BRIEF

Dutch Grimm, formerly with Transformer Engineers, joins Monitor Products Co., Inc., as electronic assembly mgr. **David Kramer,** previously with Minneapolis-Honeywell Regulator Co., now an applied scientist at MB Electronics. **D. T. Latimer, Jr.,** leaves Hoffman Electronics Corp. to join ITT Federal Laboratories as director of the Airways Aids lab. **Evan Ragland** of Motorola's Chicago Military Center advances to mgr. of its Teledata Laboratory. **Joseph B. Merrill** moves up to v-p, production, at High Vacuum Equipment Corp. **Daniel G. Dow** promoted to mgr. of tube research for Varian Associates' Tube div. **Milton J. McNeal,** ex-Stewart Engineering Co., appointed director of mfg. at Warnecke Electron Tubes, Inc. **Paul S. Collins** from Hughes Aircraft Co. to The Electrada Corp. as v-p, corporate planning and product development. Computer Control Co., Inc., elevates **Franklin R. Dean** to v-p for operations. **Sidney A. Greenberg,** formerly with the Portland Cement Association, named staff scientist at Ampex Corp.'s magnetic tape lab. **Henry K. Kindig** promoted to general mfg. mgr., black and white tv picture tubes, for Sylvania's Electronic Tube div. Bourns, Inc., ups **M. E. Harrison** to director of engineering of the Trimpot div. **Richard M. Bloch** named asst. v-p of Honeywell Electronics Data Processing. He is succeeded as director of product planning by **J. Chuan Chu,** previously associate director. Beckman Instruments, Inc., advances **James L. Donahoe** to quality control mgr. for its Offner div.

EMPLOYMENT OPPORTUNITIES

electronics

WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

This Qualification Form is designed to help you advance in the electronics industry. It is unique and compact. Designed with the assistance of professional personnel management, it isolates specific experience in electronics and deals only in essential background information.

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

STRICTLY CONFIDENTIAL

Your Qualification form will be handled as "Strictly Confidential" by ELECTRONICS. Our processing system is such that your form will be forwarded within 24 hours to the proper executives in the companies you select. You will be contacted at your home by the interested companies.

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).

COMPANY	SEE PAGE	KEY #
ATOMIC PERSONNEL INC. Philadelphia, Penna.	126	1
BELL AEROSYSTEMS COMPANY Div. of Bell Aerospace Corp., A Textron Company Buffalo, New York	84*	2
BRISTOL COMPANY Waterbury, Conn.	84*	3
CURTISS WRIGHT CORPORATION Electronics Div. E. Paterson, N. J.	110, 111	4
DOUGLAS AIRCRAFT CO. Missile and Space Systems Division Santa Monica, Calif.	53*	5
GENERAL DYNAMICS/ASTRONAUTICS San Diego, California	126	6
HIGH VOLTAGE ENGINEERING CORPORATION Burlington, Massachusetts	79*	7
INTERNATIONAL BUSINESS MACHINES New York, N. Y.	127	8
LOCKHEED MISSILES AND SPACE COMPANY Sunnyvale, California	78	9
NATIONAL CASH REGISTER CO. Dayton, Ohio	85*	10
NORTHROP CORPORATION Norair Div. Hawthorne, California	105, 109	11
NORTHROP CORPORATION Space Laboratories Hawthorne, California	105, 107	12
PHILCO WESTERN DEVELOPMENT Sub. of Ford Motor Co., Palo Alto, California	83*	13
REPUBLIC AVIATION CORPORATION Farmingdale, L. I., New York	84*	14
REPUBLIC AVIATION CORPORATION Mineola, L.I., New York	128	15

* These advertisements appeared in the Nov. 2nd issue.

(cut here) **electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE** (cut here)

(Please type or print clearly. Necessary for reproduction.)

Personal Background

NAME ....

HOME ADDRESS ....

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

HOME TELEPHONE ....

Education

PROFESSIONAL DEGREE(S) ....

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check) 11962

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

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

EMPLOYMENT OPPORTUNITIES

The advertisements in this section include all employment opportunities — executive, management, technical, selling, office, skilled, manual, etc.

Look in the forward section of the magazine for additional Employment Opportunities advertising.

— RATES —

DISPLAYED: The advertising rate is $40.17 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured ⅞" vertically on a column—3 columns—30 inches to a page.

Subject to Agency Commission.

UNDISPLAYED: $2.70 per line, minimum 3 lines. To figure advance payment count 5 average words as a line.

Box numbers—count as 1 line.

Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Not subject to Agency Commission.

FOR INFORMATION

About Classified Advertising

Contact The McGraw-Hill Office Nearest You

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1375 Peachtree St. N. E. — TRinity 5-0523
D. HICKS

BOSTON, 16
Copley Square — COngress 2-1160
O. DAVIS

CHICAGO, 11
645 No. Michigan Ave. — MOhawk 4-5800
W. J. HIGGENS—D. BERAN

CLEVELAND, 13
1164 Illuminating Bldg. — SUperior 1-7000
I. C. HILL

DALLAS, 2
1712 Commerce St., Vaughn Bldg. — RIverside 7-9721
F. LE BEAU

DENVER, 2
1700 Broadway, Tower Bldg. — ALpine 5-2981
J. PATTEN

DETROIT, 26
856 Penobscot Bldg. — WOodward 2-1793

HOUSTON, 25
Prudential Bldg., Room W-724
Holcombe Blvd. — JAckson 6-1281
J. PAGE

LOS ANGELES, 17
1125 W. 6th St. — HUntley 2-5450
B. McGINNIS

NEW YORK, 36
500 Fifth Ave. — LOngacre 4-3000
H. T. BUCHANAN

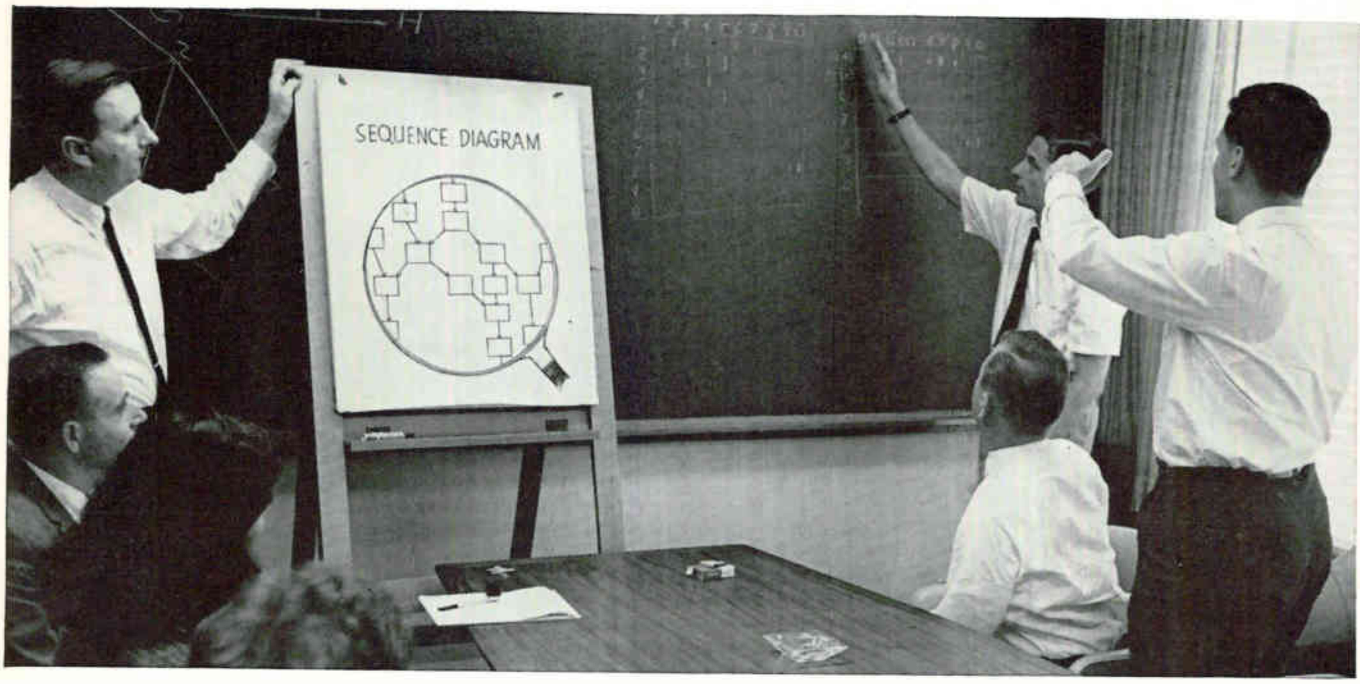
PHILADELPHIA, 3
Six Penn Center Plaza — LOcust 8-4330
W. B. SULLIVAN—R. LEWIS

PITTSBURGH, 22
4 Gateway Center — EXpress 1-1314
J. WILLIAMS

ST. LOUIS, 3
7751 Carondelet Ave. — PArkview 5-7285

SAN FRANCISCO, 11
255 California St. — DOuglas 2-4600
J. A. HARTLEY

at IBM®



PROGRAMMERS shape the future of a new technology

IBM programmers, working with professional associates in research, development and manufacturing, are contributing expert knowledge and ideas in the creation of future computing systems.

This teamwork represents a striking advance in the role of the programmer and dramatizes the important part being played by this young but rapidly growing profession. At IBM, programmers are creating new concepts in software, and contributing to the design of new systems for virtually every phase of business, science and industry.

In response to the vastly increasing versatility of computers and their widespread applications, IBM programmers at all levels of endeavor are establishing new standards of achievement. They are designing programs that will simulate business and industrial operations. They are developing systems for government projects in space, defense and communications, where their data processing skills will help produce significant advances in tomorrow's computer technology. They are also studying the complex programs for . . . information-handling systems . . . scheduling methodology . . . information-retrieval studies.

IBM programmers also face challenging tasks in developing new programming systems. For example, they are devising programs that in turn use machine capability for formulating new programs. They are creating programs that enable computers to diagnose their own faults through self-checking. And they are helping to design the systems that will let scientists and engineers "talk" to machines in the everyday language of science and engineering.

Programmers at IBM take pride in their professional status and enjoy the unusual opportunities offered by a leader of the computer industry. In an atmosphere so receptive to new ideas, their concepts flourish. They find that their keen interest in exploring the capabilities of electronic computing is supported by IBM's full resources. This combination results in significant accomplishments recognized throughout the field.

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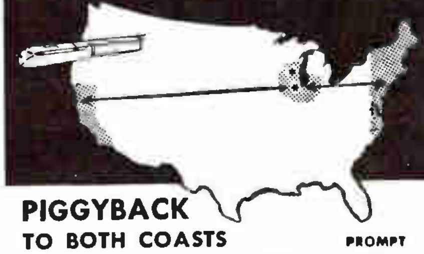

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SS111 is designed to serve as a reliable local oscillator in most applications demanding moderate rf power output. SS504 is a tunnel-diode device well-suited for radar and telemetry applications—or wherever low-noise (5.5 db max.), low-power converters are required.

Opening up new areas of design and application, the SS111 and SS504 incorporate the latest advances in solid-state technology. Both of these compact, efficient, low-cost units are now ready for sampling.

Announcements of other new solid-state products will be made soon. For specifications of SS111 and SS504, see accompanying chart. For additional technical information, consult your RCA Industrial Tube Representative or write: Section K-19-Q-2 Commercial Engineering, RCA Electron Tube Division, Harrison, N.J.

Typical Operating Conditions

SS504 ELECTRICAL	
Input Frequency (4)	1250 Mc
Output Frequency	30 Mc
Input Impedance	50 ohms
Noise Figure (1)	5.5 db max.
Bandwidth	3 Mc
Tuning Range (2)	± 20 Mc
Isolator	None required
R.F. Input Power	
Dynamic Range (3)	Up to 0.1 mw
CW	1.0 watt max.
Maximum Input Pulse Energy	80 ergs
Local Oscillator Power	5.0 mw
MECHANICAL	
Weight	7 oz.
Size	2″ diam. x 1½″
SS111 ELECTRICAL	
Ebb	0.4 to 0.6 volt
Ibb	0.5 to 0.8 amp
Frequency	1600 Mc
Power Output	6.0 mw min.
MECHANICAL	
Size (5)	
(excluding connectors)	2½″ diam. x ¾″
Weight	5 oz.

NOTE 1
This is a double sideband noise figure based on employing a 30-Mc, 300-ohm input impedance intermediate-frequency amplifier with a noise figure of 1.7 db, and a bandwidth of 3 Mc.

NOTE 2
By varying the frequency of the local oscillator

NOTE 3
Minimum power input at which the gain is reduced by 3.0 db from its small-signal value

NOTE 4
Units having similar performance can be supplied in the frequency range of 800 to 1500 Mc.

NOTE 5
Units can be supplied with type N, BNC, or TNC connectors

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