A McGraw-Hill Publication 75 Cents May 11, 1962

electronics

SPECIAL REPORT *Modern Electronic Components, p 51*

Below: uncased capacitors developed for memory unit

NEW HIGH-EFFICIENCY AMPLITRON (shown actual size) permits unmatched system size and weight reduction.

25-watt, high-efficiency Amplitron* for CW space telemetry applications

New compact S-band tube is ideal for use with solid state drivers.

Forty watts of dc and 5 watts of heater power are all that is needed to operate this new high gain Raytheon Amplitron. Because of its high efficiency and modest drive requirements, the new tube offers an ideal means of producing higher powers in smaller space. Size, weight, design simplicity and ruggedness of the QKS 997 all contribute to its suitability in space, missile and airborne applications.

Write today for complete technical details on this and other Raytheon microwave tubes for missile and space applications. Address Raytheon Company, Microwave and Power Tube Division, Waltham 54, Massachusetts.

** Raytheon Trademark*

QKS 997—TYPICAL OPERATING CHARACTERISTICS

Frequency	2300±5%
Power Output	25 W min.**
Gain	20 db min.
Efficiency	60%
Weight	1 lb.
Overall size	3 in. x 1¼ in.

** Wide dynamic power range allows tube to operate as low as 10 watts without loss in efficiency.

RAYTHEON

RAYTHEON COMPANY

MICROWAVE AND POWER TUBE DIVISION

CIRCLE 202 ON READER SERVICE CARD

May 11, 1962

electronics

A McGraw-Hill Publication *75 Cents*

W. W. MacDONALD, Editor

Contents continued

electronics

May 11, 1962 Volume 35 No. 18

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

Indexed Annually in Buyers' Guide and Reference issue.

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

OFFICERS OF THE PUBLICATIONS DIVISION: Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John R. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator; Daniel F. Crowley, Vice President and Controller.

OFFICERS OF THE CORPORATION: Donald C. McGraw, President; Hugh J. Kelly, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Executive Vice President and Treasurer; John J. Cooke, Vice President and Secretary.

Subscriptions are solicited only from those actively engaged in the field of the publication. Position and company connection must be indicated on orders. Subscription rates: United States and Possessions, $6.00 one year; $9.00 two years; $12.00 three years. Canada, $10.00 one year. All other countries $20.00 one year. Single Copies, United States and Possessions and Canada 75¢. Single copies all other countries $1.50.

THE PUBLISHER, UPON WRITTEN REQUEST FROM ANY SUBSCRIBER TO OUR NEW YORK OFFICE, AGREES TO REFUND THAT PART OF THE SUBSCRIPTION PRICE APPLYING TO COPIES NOT YET MAILED.

Subscribers: Please address all correspondence, change of address notices, subscription orders or complaints to Fulfillment Manager, Electronics, at above address. Change of address notices should provide old as well as new address, including postal zone number if any. If possible, attach address label from recent issue. Allow one month for change to become effective.

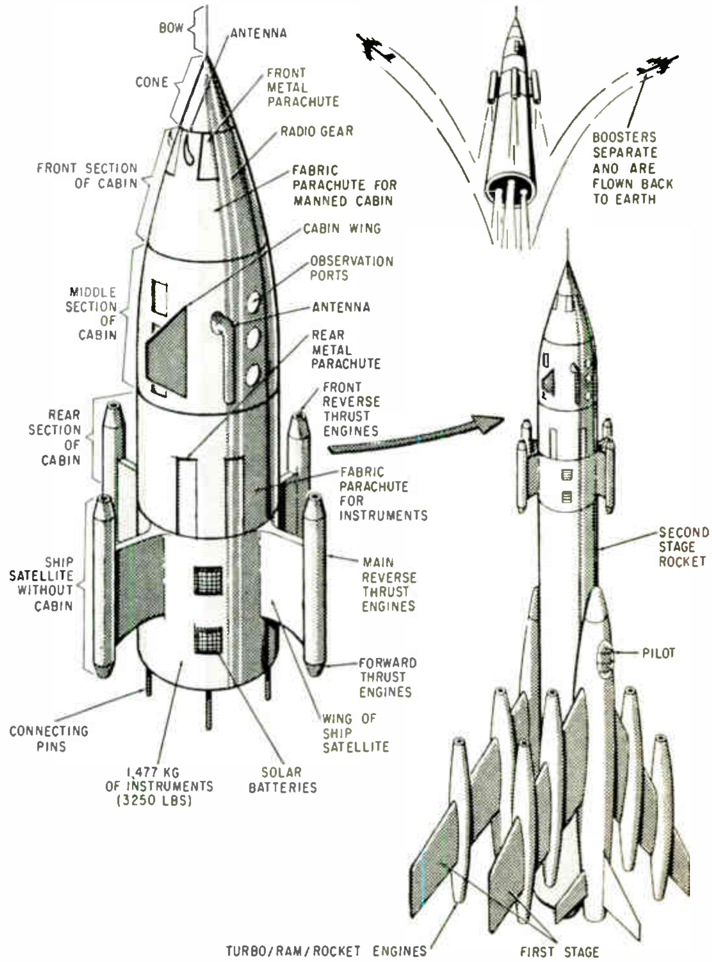
Postmaster: Please send Form 3579 to Fulfillment Manager, Electronics, 330 West 42nd Street, New York 36, New York.

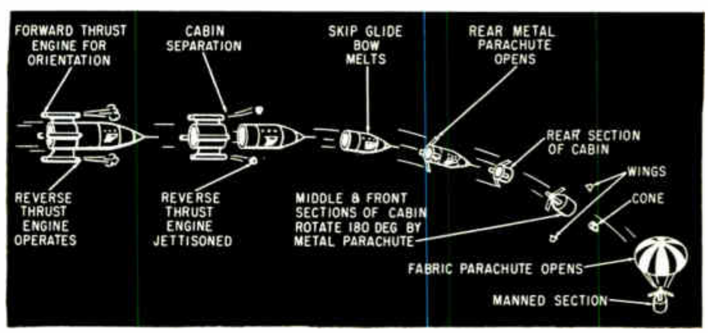
Audited Paid Circulation

CONTENTS continued

DEPARTMENTS

Russia's Spaceships





IS THIS HOW THEY DO IT? The Soviets have revealed few details on how they launch their spaceships into orbit and recover them.

Major Titov last week in Washington said that a six-engine multistage booster with a total thrust of 1,320,000 lbs was used, that the spaceship had three observation ports, that the bow of the spaceship melted on reentry, that the capsule and instrument compartments split apart when the retrorockets were fired and that after the capsule slowed down he descended by parachute.

At right is a drawing we prepared before Titov hit town. It agrees with Titov's description in some respects, notably in the general design of the spaceship and in the reentry procedure.

It does not jibe with the Rusian cosmonaut's description of the booster. But there is a question whether Titov gave a full description of the booster. He said that military rockets are used for space launchings, but it is doubtful that the USSR is building warheads weighing five tons —the weight of Titovs' spaceship.

Unless—as Khrushchev intimated recently in remarks about global missiles—the Soviets have the capability of orbiting and maneuvering their warheads. That would really be something to worry about.

Our drawing is based upon information contained in Soviet scientific literature since 1958—plus a few educated guesses. Soviet engineers, like Titov, aren't saying much about what is actually being done. But, like scientists everywhere, they like to talk about how things should be done.

One recurrent proposal has been the use of winged, multiengine boosters as a recoverable, economical first stage. This isn't too different from the proposal made in the U.S. to use the X-15 as a launch vehicle (ELECTRONICS, p. 11, Oct. 20, 1961) or Air Force plans to launch Sky Bolt missiles from jet bombers. The difference is one of size and power, not concept.

Associate Editor Solomon says the scheme jibes with the average Russian engineers' outlook on engineering problems: solve them in the simplest way (see, for example, ELECTRONICS, p 24, May 26, 1961).

Got a big spacecraft? Don't miniaturize, build a big booster. Big boosters expensive? Make them recoverable. Lift-off guidance and control problem? Put a pilot in the booster. Worried about reentry? Keep the ablative part of the cabin far away from the pilot and controls.

One last clue: we understand that the Soviet Air Force publication *Vestnik Vozdushnogo Flota* uses a booster and a winged rocket as an emblem.

So, while we can't present the drawing as more than speculation, we suspect that even if the Soviets are not doing it this way now that they will be using manned boosters in the future and that they will look like the ones you see here.

COMMENT

Indicator Tube

We read with interest the recent *Components and Materials* article, Indicator Tube for Transistor Circuits (p 646, April 6), about a Japanese indicator tube. There are somewhat similar American-made devices, notably the Tung-Sol type 7401. Unlike the Japanese tube, which is always "on" and merely switches the glow from the shaded area to the visible area, the Tung-Sol tube does not draw any current until triggered "on." For very fast response the tube is available as type 7813, which has a similar structure but employs also a very low current "keep-alive electrode." Both the 7401 and the 7813 are subminiatures designed for end-on viewing and both can be triggered by low-level, transistor-generated signals.

The Japanese tube is essentially a diode and therefore the output current (325 μa) appears in the control circuit. The Tung-Sol tubes are triodes and operate at very low control-grid currents (1 to 10 μa). This also frees the control circuit from higher anode currents (up to 7 ma) if it is desired to run the tubes this way for brighter indication, or for use as self-indicating relays.

DAVID M. SANGER
Tung-Sol Electric Inc.
Chatham Electronics Division
Livingston, New Jersey

Contents Page

Although you have been doing it for years, I would like to congratulate you on continuing to place your contents on page one. The value of this is made evident to me every week when I scan through a large number of engineering magazines. Most of them bury the contents page among the advertising pages, and I find it only after what can be an exasperating amount of time, when several dozen magazines are involved.

Your recent expansion of the contents page to two pages requires more look-up time now, but no doubt I am in a small, selfish minority in criticizing this.

Obviously, page one is, after the four cover pages, one of the most expensive advertising pages, and few publications are willing to forego the high-paying location. It is refreshing to note that ELECTRONICS, almost alone, is more interested in being of service to its readers than in making the highest possible profit.

LEE CHURCH
Chicago, Illinois

Our Binding (and Chart)

ELECTRONICS has always been a good publication. It has kept up with changing technologies in many ways, including the present weekly publication and more subtly, in the binding method.

In my opinion the adhesive, stapleless binding is the best in the industry for a technical publication. Pages fold easily and lay out flat. Most importantly, pages may be removed easily for subject matter filing. For the latter purpose the binding method is far superior to perforated pages, which I believe McGraw-Hill also pioneered.

VERNON E. BENJAMIN
Department of the Navy
David Taylor Model Basin
Washington, D. C.

About seven years ago, McGraw-Hill pioneered the use of perforated pages, which are now featured in Electrical World and in parts of Power magazine. The adhesive binding, known as Perfect binding, was first used on ELECTRONICS for the issue of Nov. 10, 1961, and is currently used on six McGraw-Hill publications.

May I offer my congratulations to your magazine and persons involved for the splendid job of design, art work, printing and concepts of the April 13th Table of Frequency Allocations chart (p 37). A very complex problem has been well done.

Another bouquet is certainly due your production departments for the new method of binding ELECTRONICS. It is much easier to leaf, and very simple to remove advertisements and articles of interest for filing. This alone has made ELECTRONICS more valuable.

ROBERT W. OLIN
Director of Planning
Potlatch Forests, Inc.
Lewiston, Idaho

For the 10TH year...

LAMBDA OFFERS THE STRONGEST PROOF OF TROUBLE-FREE POWER SUPPLY PERFORMANCE

Every Lambda power supply sold since 1953 has been backed by Lambda's 5-year guarantee, which covers workmanship and materials (except for tubes and fuses). Any Lambda power supply sold today is guaranteed to perform to specifications until 1967.

ALL-TRANSISTORIZED LA SERIES
Nine Models Available—Voltages up to 330 VDC—Currents up to 20 Amp
Convection Cooled—Short Circuit Proof

Send for Catalog on LAMBDA'S wide range line of regulated transistorized power supplies

LAMBDA ELECTRONICS CORP.

515 BROAD HOLLOW ROAD • HUNTINGTON, L.I., NEW YORK • 516 MYRTLE 4-4200

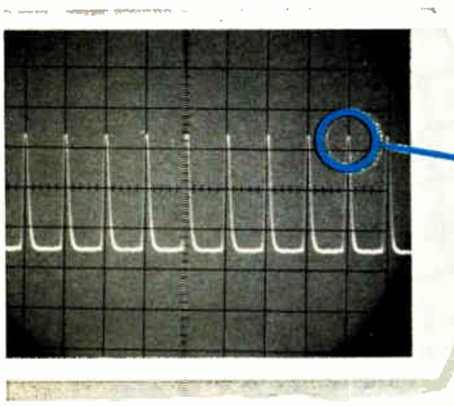
Western Regional Office: 230 North Lake Avenue, Pasadena, California • Phone: Code 213, MUrray 1-2544
New England Regional Office: 275 Boston Post Road, Marlboro, Massachusetts • Phone: Code 617, HUntley 5-7122
Middle Atlantic District Office: 515 Broad Hollow Road, Huntington, L. I., New York • Phone: Code 516, MYrtle 4-4200
Southeastern Region: W. A. Brown & Associates, Inc., Engineering Representatives

LA-128-A

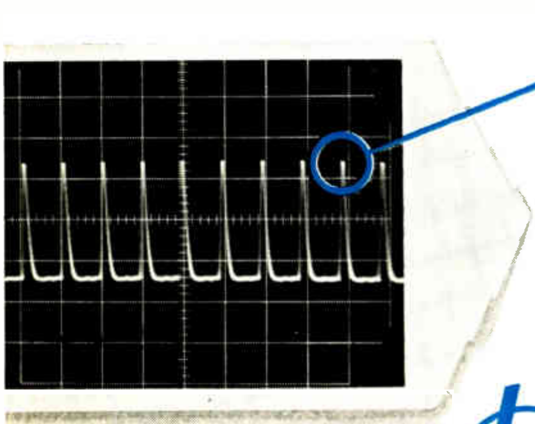
NEW, NO-PARALLAX hp 120B
easiest-to-use, surest-reading
450 KC OSCILLOSCOPE

This new hp 120B Oscilloscope combines more actual measuring help and desirable features than any 450 KC scope ever produced. Not only are reading error from parallax and distracting reflections eliminated, but you have a genuinely unique array of electrical and convenience features for measurements from dc to 450 KC.

SPECIFICATIONS: Model 120B combines minimum controls with hp automatic triggering for utmost speed, convenience. Horizontal amplifier dc to 300 KC, phase-shift within ± 2°. More X-axis information due to horizontal amplifier sensitivity control, 5% accuracy. Times-5 sweep expander, all ranges. 15 calibrated sweeps, 5 μsec/cm to 200 msec/cm. Vernier for continuous adjustment of sweep time between calibrated steps, extends slowest sweep to at least 0.5 sec/cm. 10 mv/cm sensitivity calibrated vertical amplifier, drift-free trace. Balanced input on most sensitive range for noise rejection at low levels. Model 120B in new modular design for rack or bench use, $475.00. Accessories available.



Perfectly linear signal *reads* perfectly. Exclusive hp development places calibrating graticule in identical *inside* plane with trace. Since trace and graticule are on the same plane, there is no reading error— even at wide viewing angles.



Conventional scopes have calibrating graticule a full 1/4 inch in front of trace. Note identical signal on old-type cathode ray tube. Parallax is inescapable and errors up to 5% are possible.

Many engineers who have tested the new 120B feel it is perhaps the easiest-to-use, most widely versatile, and highest value commercial 450 KC scope ever offered. Why not confirm their opinions with a test on your own bench.

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

HEWLETT-PACKARD COMPANY
1501 PAGE MILL ROAD, PALO ALTO, CALIFORNIA
AREA CODE 415, DA 6-7000
Sales and service representatives in all principal U. S. areas;
Europe, Hewlett-Packard S.A., Rue du Vieux Billard No. 1, Geneva;
Canada, Hewlett-Packard (Canada) Ltd., 8270 Mayrand St., Montreal

7658

ELECTRONICS NEWSLETTER

Conelrad Concept Changes to Communications

CONELRAD'S role is being changed from that of preventing enemy aircraft homing to an expanded government and civil defense emergency communications system. FCC and the Department of Defense have not firmed up the exact form Conelrad will take, but a-m radio will probably be the backbone of the system with little or no participation by f-m and tv.

Present frequencies, 640 and 1,240 Kc, adopted under the Control of Electromagnetic Radiation plan, may be changed since preventing aircraft homing is no longer considered important.

Stations participating in Conelrad since 1951 have done so at their own expense. Revised plans may provide federal aid. Broadcasters close to the situation say word on this may be forthcoming in three months.

In Ottawa, the Canadian Department of Transport said that almost all of the country's 290 radio stations and 110 tv stations will be hooked into an expanded emergency network. A smaller network already put together by the Army and CBC is ready for operation.

NASA's Contractors to Get More During 1963

NATIONAL AERONAUTICS and Space Administration will spend approximately 90 percent of its 1963 budget on outside contracts. This amounts to $3⅓ billion out of NASA's total budget request of $3.748 billion. The remaining 10 percent will be spent in NASA research centers. Last year, 84 percent of NASA's total budget was spent on contracts. The agency also reported that out of the 100 largest contracts placed during the first 6 months of this fiscal year, small business companies received 21.

Two-Mile Accelerator Gets AEC Go-Ahead

STANFORD UNIVERSITY is getting $114 million from the Atomic Energy Commission to design and construct a linear accelerator center as a national research facility. It will have an accelerator 10,000 ft long with an energy range of 10 to 20 Bev. R-f power will be supplied by 240 klystrons in stations spaced every 40 ft. Construction will take six years. Stanford proposed the accelerator in 1957 and got $3 million in 1960 for preliminary design.

Aging Echo Relays Direct Coast-to-Coast Television

WASHINGTON — Equipment developed for the West Ford and Dicon projects (p 20, April 13) was used for the first direct transcontinental transmission by satellite of a tv picture. The feat was reported by the Air Force last week.

Picture quality wasn't so good, but neither was the satellite—the partially deflated, wrinkled, irregularly orbiting Echo I. Although beset by weak signals and rapid, deep fading, the experiment foreshadows improved transmission by a 135-ft rigid sphere, planned by NASA, and the Bell System's Telstar.

W. E. Morrow, of MIT Lincoln Lab, told URSI that transmissions were made at 8.35 Gc with power of 20 Kw. Receiver overall noise temperature was 200 K. Double-sideband a-m was used with overall receiver video bandwidth cut to less than 2 Mc to suppress noise background. A signal-to-noise ratio of 10 db was observed.

Big, High-Purity Gallium Arsenide Crystals Pulled

PASADENA—Method for producing gallium arsenide, developed at Bell and Howell's research center, reportedly yields material with silicon impurities of less than 50 parts per billion. According to a company spokesman, commercially available crystals have averaged 5 to 20 parts per million, limiting applications in tunnel diodes, transistors, solar cells and transducers. Silicon can act as either a *p* or an *n* type impurity at these and higher levels of concentrations. B&H says that crystals weigh 200 to 300 grams. Mobilities at room temperature range from 6,000 to 7,000 cm^2/volt sec. The Czochralski technique—but not quartz crucibles—is used to pull crystals.

Large-Scale Computer System Is Introduced

SAN FRANCISCO — Philco Corp. is going more strongly after the large-scale business and scientific computer market by introducing pe-

Van Allen Doesn't Mind a Hole in His Belt

SIR BERNARD LOVELL, head of Britain's Jodrell Bank radio astronomy station, last week urged the U. S. not to go through with plans for a nuclear explosion in the earth's radiation belt. He reportedly fears the disruption of scientific studies aimed at obtaining a basic understanding of the nature of the universe.

Some scientists have been reported as believing that it might take a century for particles from space to replenish particles driven out of the belt by the blast.

In Washington, James Van Allen, for whom the belt is named, agreed the blast could rupture the belt, but according to press reports, said that it would probably heal in a few weeks. He said only a small part of the belt would be affected and that particles coming down into the atmosphere would not harm anyone ripheral equipment to step up the speed and efficiency of its 2000 Computer Series.

The system can add or subtract two million sets of four-digit numbers in one second. Higher speed is achieved with a satellite computer that handles input-output operations, tape units with transfer rates of 240,000 characters a second, a disk file storing up to 167,964,160 characters and transferring 960,000 a second, and a one-microsecond memory.

The satellite performs concurrent programs and handles two simultaneous input-output operations with up to 64 input-output devices. Tape and disk units can perform independent searches. Philco is also offering a series of programs.

Ducts Near Earth Provide Low-Frequency R-F Paths

WASHINGTON—There are a large number of radio signal conducting ducts aligned with the earth's magnetic field at altitudes averaging 1.4 kilometers, T. E. van Zandt, of NBS's Radio Propagation Lab. reported last week to the International Radio Scientific Union (URSI). Caused by stratified ionization irregularities, the ducts allow relatively loss-free propagation of l-f radio waves, he said.

In another URSI paper, R. E. Anderson and B. H. Klaxton, of GE, said the moon is not a good communications reflector. Great radar depth, many scattering surfaces and other factors contribute to multipath delay. The hidden surface of Venus may resemble the moon's, suggested G. S. Levy and D. Schuster, of Jet Propulsion Lab. Radar reflections from both bodies were found to be similar during depolarization experiments.

Ultrasonic Detectors to Report on Traffic Jams

TRAFFIC CONTROL system that uses ultrasonic detectors to check on traffic flow and a computer to analyze the information will be designed and installed by General Railway Signal Co. in Chicago. The information will be used for traffic studies along five miles of the Congress Street Expressway.

Detectors will be mounted on bridges and ramps. Reflection of ultrasonic beams from the cars provides data on traffic volume and speed. Each detector will have an individual analog computer. A master computer will prepare tapes for digital computer analysis. Traffic conditions will also be shown on a large display map.

Infrared Photos Reveal Faulty Parts or Design

WALTHAM, MASS.—Infrared techniques can be used to test rapidly and nondestructively electronic circuit assemblies or can quickly pinpoint weak spots in a breadboard.

Raytheon's equipment division reports that methods developed by Riccardo Vanzetti measure heat dissipation of components to improve equipment reliability.

An infrared photo of a complex circuit board shows which components are dissipating too much—or not enough—heat for proper operation. Recording the output of a radiometer allows an exact determination of power dissipated as radiation.

Polaris Submarines Get Better Navdac Computers

NEWEST POLARIS submarine, the *Lafayette*, which was launched in Groton, Conn., this week, carries improved versions of Sperry Gyroscope's Navdac computers. The submarine, designed to carry the 2,500-mi version of the Polaris now in development, is the first of a new class.

The Navigation Data Assimilation Computers have almost double the memory capacity of earlier Navdacs and can evaluate navigation information eight times faster, Sperry said. Memory includes both drum and cores, with total capacity of 600,000 bits. Speed is 2,000 computations a second.

Sperry is producing 48 Navdac computers. Each submarine gets two. Some will be used to replace Navdacs aboard earlier submarines. A new star-tracking periscope made by Kollmorgen Corp., will also have its initial use on the Lafayette.

In Brief . . .

HUGHES AIRCRAFT is developing a computer-based checkout system for missile guidance systems, under a $4 million Air Force contract. Among other features, system will optically project repair instructions on a screen.

DUAL electron accelerator has been built by High Voltage Engineering Corp. Single remote power supply provides 300 and 500 Kev beams.

PRELIMINARY contract negotiations for Titan III guidance will be held by Air Force with Arma division of American Bosch Arma and Space Technology Labs.

APPOINTMENTS include Col. Otto J. Glaser, a radar expert, as vice commander of Air Force Electronic Systems Division, and Raymond L. Bisplinghoff, an MIT professor, as director of NASA's Office of Advanced Research and Technology.

GLIDE PATH system, with antennas flush-mounted in airport runways, developed by Ohio State University, is being tested by FAA.

SYLVANIA will enter color-tv tube production with a 21-in., 90-deg, shadow-mask type available next year.

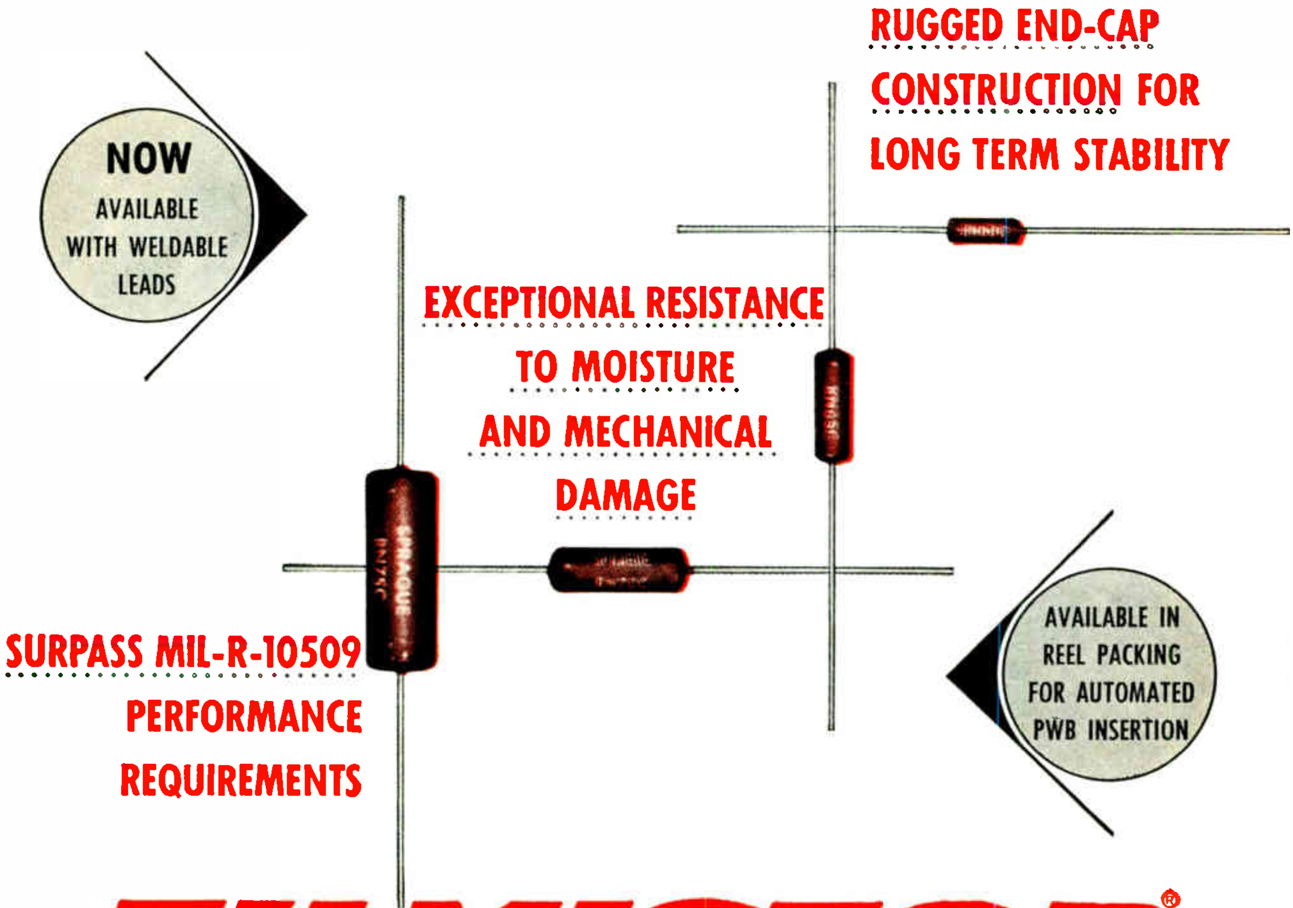
HALLICRAFTERS' contract backlog rises to $45 million with $3 million in new Air Force contracts for aerospace, reconnaissance and missile ground support gear.

CUBIC CORP. has a $3 million contract for missile tracking gear to be used by Department of Defense in experimental tests.

NAVY IS CONVERTING another ship for tracking, telemetry and data processing service on the Pacific Missile Range.

MORE TV activity in Africa: Morocco is building its first tv and electronics plant; Kenya is setting up its first transmitter near Nairobi, with Marconi equipment.

KEARFOTT is to determine feasibility of a sun/moon tracker for ships. The $225,000 contract from Navy includes design of a breadboard model.



FILMISTOR®

METAL FILM RESISTORS

OFFER 5 DISTINCT TEMPERATURE COEFFICIENTS TO MEET ALL CIRCUIT REQUIREMENTS

Providing close accuracy, reliability and stability with low controlled temperature coefficients, these molded case metal-film resistors outperform precision wirewound and carbon film resistors. Prime characteristics include minimum inherent noise level, negligible voltage coefficient of resistance and excellent long-time stability under rated load as well as under severe conditions of humidity.

Close tracking of resistance values of 2 or more resistors over a wide temperature range is another key performance characteristic of molded-case Filmistor Metal Film Resistors. This is especially important where they are used to make highly accurate ratio dividers.

Filmistor Metal Film Resistors, in ⅛, ¼, ½ and 1 watt ratings, surpass stringent performance requirements of MIL-R-10509D, Characteristics C and E. Write for Engineering Bulletin No. 7025 to: Technical Literature Section, Sprague Electric Co., 35 Marshall Street, North Adams, Mass.

For application engineering assistance write:
Resistor Division, Sprague Electric Co., Nashua, New Hampshire.

SPRAGUE COMPONENTS

RESISTORS
CAPACITORS
MAGNETIC COMPONENTS
TRANSISTORS
INTERFERENCE FILTERS
PULSE TRANSFORMERS
PIEZOELECTRIC CERAMICS
PULSE-FORMING NETWORKS
HIGH TEMPERATURE MAGNET WIRE
CERAMIC-BASE PRINTED NETWORKS
PACKAGED COMPONENT ASSEMBLIES
FUNCTIONAL DIGITAL CIRCUITS

SPRAGUE®
THE MARK OF RELIABILITY

XTK

XTL

XTM

XTV

XTH

TYPE	MAX. TEMP.	CAPACITY AND 85°C V.D.C.
XTM	175°C	4 mfd, 340 volts to 140 mfd, 8 volts
XTK	175°C	2 mfd, 340 volts to 70 mfd, 8 volts
XTH	200°C	7 mfd, 630 volts to 240 mfd, 18 volts
XTL	200°C	3.5 mfd, 630 volts to 120 mfd, 18 volts
XTV	200°C	12 mfd, 630 volts to 2200 mfd, 12 volts

P. R. MALLORY & CO. Inc.
MALLORY

Delivered from stock at factory prices by these distributors:

Baltimore, Md.
Radio Electric Service
Binghamton, N.Y.
Federal Electronics
Boston, Mass.
Cramer Electronics
DeMambro Radio Supply Co.
Lafayette Radio
Bridgeport, Conn.
Westconn Electronics
Buffalo, N.Y.
Wehle Electronics
Chicago, Ill.
Allied Electronics Corp.
Newark Electronics Corp.
Cincinnati, Ohio
United Radio
Cleveland, Ohio
Pioneer Electronics
Dallas, Texas
Engineering Supply Co.
Dayton, Ohio
Stotts-Friedman Co.
Denver, Colo.
Denver Electronics
Houston, Texas
Harrison Equipment Co., Inc.
Lenert Company
Indianapolis, Ind.
Graham Electronics
Los Angeles, Calif.
Allied Radio of California
California Electronics
Kierulff Electronics, Inc.
Lynch Electronics
Radio Product Sales
Minneapolis, Minn.
Northwest Radio
Montreal, Que.
Canadian Electrical Supply Co.
Mountainside, N.J.
Federated Purchaser, Inc.
Nashville, Tenn.
Electra Dist. Co.
Newark, N.J.
Lafayette Radio
New York, N.Y.
Harrison Radio Corp.
Harvey Radio Co., Inc.
Lafayette Radio
Milo Electronics
Terminal Hudson Electronics
Oakland, Calif.
Elmar Electronics, Inc.
Orlando, Fla.
East Coast Electronics
Ottawa, Ont.
Wackid Radio-TV Lab.
Palo Alto, Calif.
Zack Electronics
Perth Amboy, N.J.
Atlas Electronics
Philadelphia, Pa.
Herbach & Rademan
Philadelphia Electronics
Pittsburgh, Pa.
Radio Parts Co.
Salt Lake City, Utah
Kimball Electronics
St. Louis, Mo.
Olive Electronics
Seattle, Wash.
F. B. Connelly Co.
Tampa, Florida
Thurow Electronics, Inc.
Toronto, Ont.
Alpha Aracon Radio Co.
Electro Sonic Supply
Wholesale Radio & Electronics
Tulsa, Okla.
Engineering Supply Co.
Washington, D.C.
Capitol Radio Wholesalers
Electronic Industrial Sales
White Plains, N.Y.
Westchester Electronic Supply Co., Inc.
Winston-Salem, N.C.
Electronic Wholesalers Inc.

Complete line of aluminum and tantalum electrolytics, motor start and run capacitors

WASHINGTON OUTLOOK

UHF-TV BILL SEEMS SURE THING

FEDERAL COMMUNICATIONS COMMISSION'S all-channel receiver legislation cleared its major hurdle when the House of Representatives passed the bill, 279 to 90, last week. FCC officials are confident the Senate will act this year. If it does, tv manufacturers will eventually have to make sets receiving 70 uhf channels as well as the 12 vhf ones.

The measure will not become effective overnight. It will take about a year for FCC and manufacturers to work out procedures. Then there will probably be a court test of the bill's constitutionality. It will be at least three years before manufacturers shipping tv sets in interstate commerce must equip them to receive all channels. However, FCC officials expect all-channel equipment production to be stimulated before the law goes into effect.

Economists say the law will spur educational tv and probably result in one or more new national tv networks (President Kennedy last week signed the five-year $32-million educational tv grant program). The bill is designed to get more uhf stations on the air by providing enough viewers to make broadcasting worthwhile. Less than 10 percent of 1,554 uhf station assignments are in use. FCC economists figure seven years of all-channel set sales will make uhf broadcasting generally profitable.

NASA ISSUES QUALITY CONTROL REGULATION

SPACE PROGRAM CONTRACTORS now have a new set of quality control and reliability instructions—documenting NASA practices in effect for some time. No basic changes were made to the working draft of instructions issued last December.

"Few, if any, contractors will be required to make changes in practice on existing contracts," a NASA spokesman says. Instructions are consistent with Department of Defense policies.

Contractors not now working under NASA instructions will have to establish new procedures. For example, contractors must set forth specific policies and objectives of quality control programs, including written operating plans and documented means for measuring results.

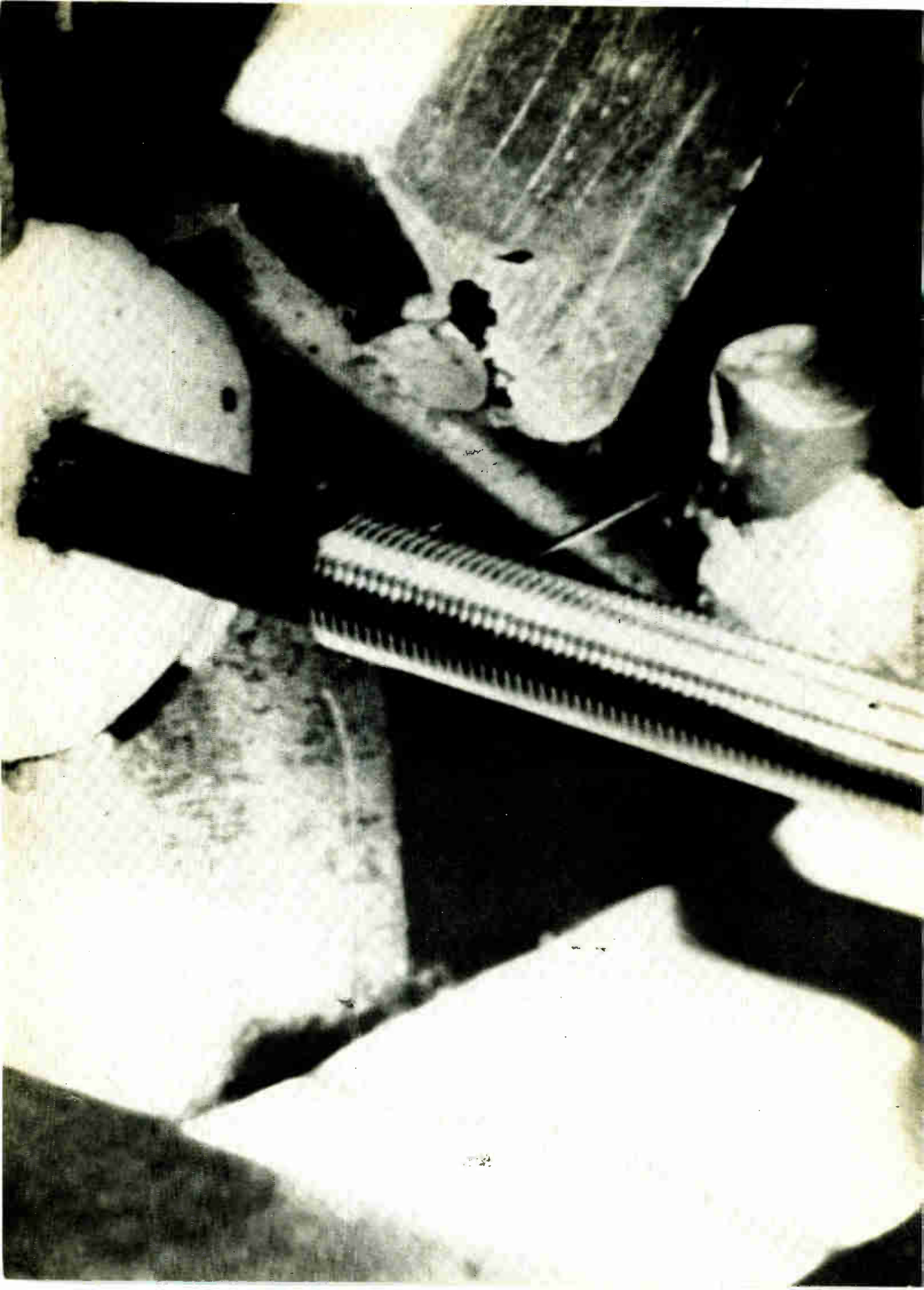
SATELLITE BILL FACES SENATE FIGHT

THE SENATE IS EXPECTED to quickly approve formation of a space communications satellite corporation, financed 50-50 by communications common carriers and the general public. In the House, this compromise plan withstood two days of attempts by House liberals to weaken the role of the carriers. Then it passed, 354 to 9.

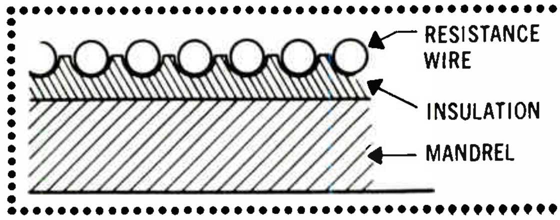
The crucial test was a voice-vote defeat of an amendment by Rep. John Moss (D.-Calif.), who claimed the bill in effect directs FCC to license the carriers to operate all ground facilities, stripping the corporation of much of its profit potential.

Chairman Oren Harris (D.-Ark.), defending the Commerce Committee bill, said that Moss' intent was to give the new corporation control of all ground stations. Both Moss and Harris professed that they want carriers and the corporation on equal footing before FCC, but the bill adopted instructs FCC to give carriers preference.

The issue of who is to control ground sending and receiving stations will be refought in the Senate, where backers of the Moss view, including FCC and the administration, are stronger.



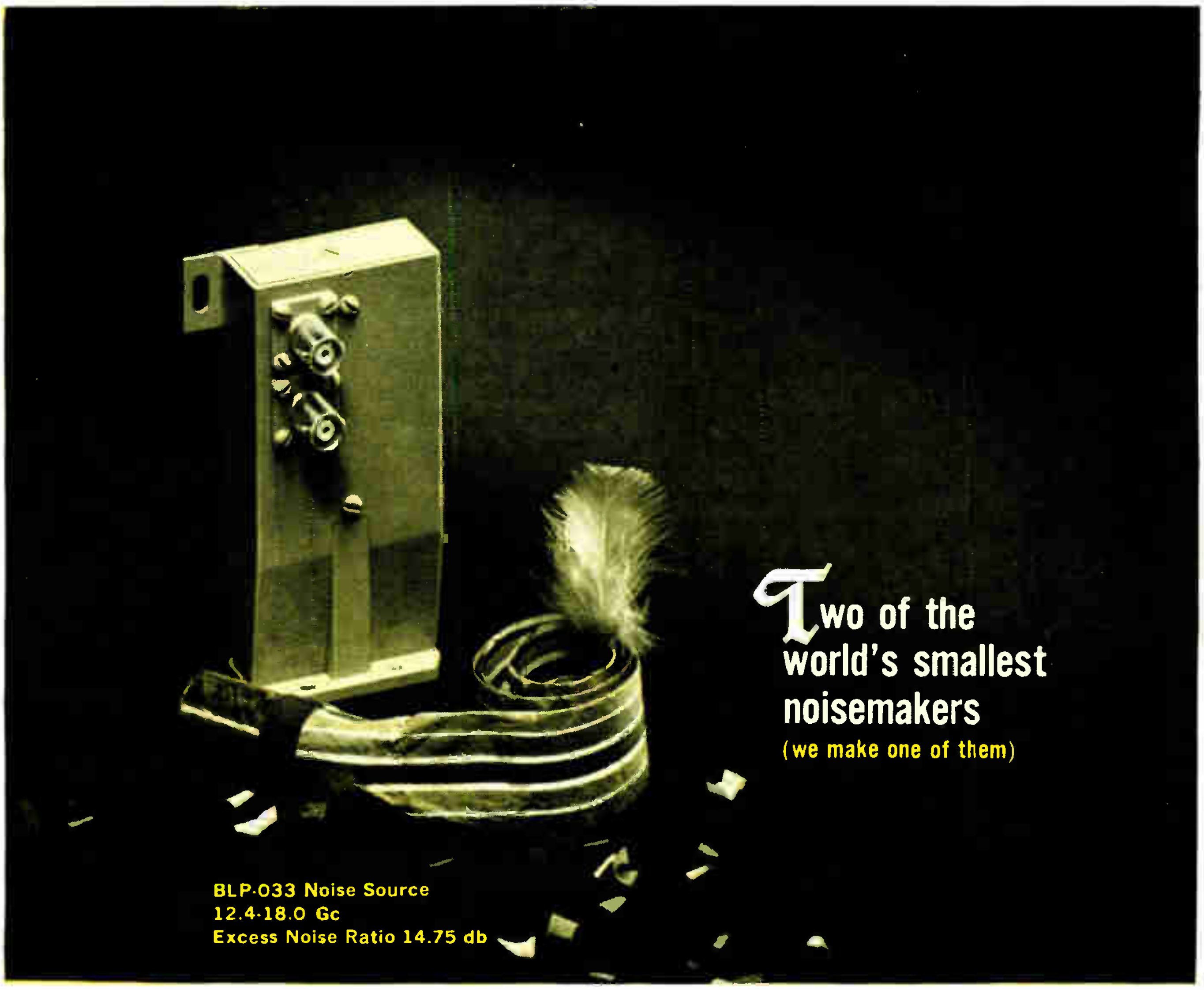
The Secret of Locked-In Linearity... AND THE High Reliability of Daystrom Squaretrims®



At left you see a photograph...magnified many times...of the unique Daystrom technique of "wire-in-the-groove" resistance winding for its famous Squaretrims. Above is a schematic drawing of the same process. An insulated mandrel is fed into a precision winding machine, where a diamond tool (shown in raised position in the photograph) cuts a shallow groove in the insulation, forming an endless grooved helix. Into this helix the un-insulated resistance element is wound tightly, using electronic controls. The result is that the resistance wire is firmly locked in place, without the use of adhesives or other problem-causing procedures. Each turn of the wire remains securely separate in its groove even under severe shock and vibration. This is why Daystrom Squaretrims possess such high reliability. Their linearity is locked in to resist the worst environmental stress. And the high reliability of Squaretrims is a prime reason they are specified by more engineers than all other square trimmers combined. Call your local distributor for off-the-shelf delivery of over 2,000 standard model Squaretrims.

All pots shown actual sizes.

DAYSTROM, INCORPORATED
POTENTIOMETER DIVISION
ARCHBALD, PENNSYLVANIA • LOS ANGELES, CALIFORNIA



Bomac Laboratories is in the noisemaker business. Our products don't exactly apply to parties, but they're ideal for small-space designs requiring good excess noise production capabilities.

The BLP-033 is one of our newest noise sources—and it's smaller than any other known conventional noise generator. Operating in K_u-band, the BLP-033 is specially designed for AC power conditions through 400 cps or higher. Cumbersome DC power supply systems are eliminated. And the BLP-033 is only 4 inches long over-all.

Excess random ("white") noise is produced in the 14.75 db region, with 0.25 db excess noise variation. Fired or unfired VSWR is 1.2 db max. Special gas fill maintains striking voltage throughout an extended life period, more uniformly than can conventional noise generators. Matched load is contained within a compact package, further reducing system design space requirements. Encapsulated waveguide and special finishes are provided for rugged airborne or extreme atmospheric conditions.

Want more technical information on this small but superior noise source? Drop us a line.

BOMAC laboratories, inc.
BEVERLY 1, MASSACHUSETTS
A Varian Subsidiary

Other Subsidiaries of Varian Associates: S-F-D LABORATORIES, INC. • VARIAN ASSOCIATES OF CANADA, LTD. SEMICON ASSOCIATES, INC. • SEMICON OF CALIFORNIA, INC. • VARIAN A. G. (SWITZERLAND)

Closer tolerances in your

PRECISION EQUIPMENT

FOR ONLY A FEW CENTS MORE

with **Wilrite Metalloy**

1%

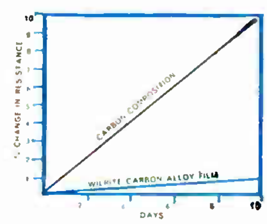
CARBON FILM RESISTORS

Greater precision and greater stability can be built into test equipment and other precision devices with the use of Wilrite's ½ watt, 1% film resistors, series CMC. These units are only slightly higher in price than 5% carbon composition resistors, but provide greatly improved performance.

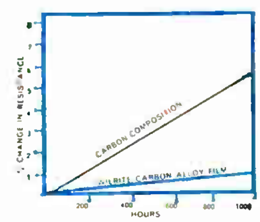
These resistors are fabricated by Wilrite's patented "Metalloy" process that deposits a hard crystalline carbon alloy film on a ceramic substrate. The film cannot scratch or rub off. This is coated with an exclusive silicone formula and cured. A resin impregnated kraft sleeve provides excellent mechanical and additional electrical protection.

The Series CMC resistors are rated at 70°C, full load, and derate to zero at 150°C. They can also be supplied to closer tolerances on special order.

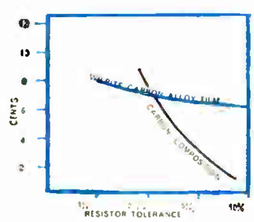
MOISTURE RESISTANCE



AGING STABILITY



COST VS. TOLERANCE



WILRITE—Film Resistors built to MIL-R-10509D

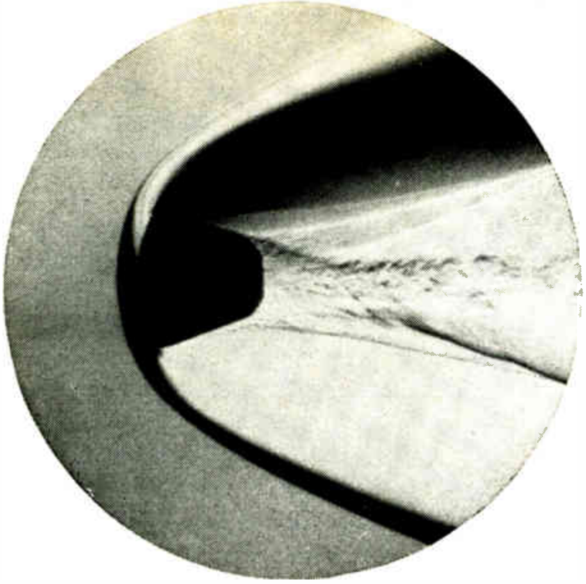
Type CMG
Hermetically Sealed—
meets MIL characteristic B
(150°C)

Type CMI
Silicone Resin Molded—
meets MIL characteristic D
(165°C)

Type CMH
Ceramic encased—
meets MIL characteristic G
(165°C)

W-6216

WILRITE PRODUCTS, INC.
A SUBSIDIARY OF GLOBE-UNION INC.
3835 West 150th Street • Cleveland 11, Ohio
in association with
Centralab, the Electronics Division of Globe-Union Inc.



Space Researchers

High or low frequencies can get through. Windows may be opened by using magnetic fields or changing plasma composition

By THOMAS MAGUIRE, New England Editor

Blunt-shaped nose cone model creates typical shock wave in air as it travels down Avco's ballistics range at speed of 5,500 ft a second. Plasma sheath results from heating of shock waves during reentry

BOSTON—Stepup in reentry physics field-test programs underscores the seriousness of the communications and telemetry blackout caused by the plasma sheath—a crucial and possibly limiting factor in military and civilian space projects.

At the Second Symposium on the Plasma Sheath, sponsored late last month by Air Force Cambridge Research Laboratories, there emerged this general appraisal:

- The sheath can be penetrated if transmission is restricted to high enough or low enough frequencies.
- Alternative approaches include the use of magnetic fields to open r-f "windows," addition of physical and chemical contaminants to nose cones or ionized gas streams to reduce electron concentration, and aerodynamic modifications to the reentry vehicle.
- Combinations of these approaches may provide solutions for specific needs.

At present, a proven technique for piercing the sheath is choice of frequency. Avco's Drets system, for example, transmits above the critical plasma frequency.

Millimeter waves can penetrate, but are unsuited to all-weather operation since atmospheric attenuation is severe. Low frequencies get through because plasma thickness is small compared to wavelengths. However, the communications or telemetry system again meets a severe problem—available bandwidth, dependent on the antenna's electrical size.

Higher or lower frequencies are not ideal solutions. It is not economical to change entire communications and telemetry systems. The military doesn't want to be barred from using any part of the spectrum.

Even so, telemetry for space projects will probably have to move up eventually to X band. An X-band telemetry system has been developed by AFCRL (ELECTRONICS, p 8, May 4). Equipment in the Asset program developed by McDonnell Aircraft for Wright Field will also test X-band and uhf transmission through the plasma sheath.

Generation of static magnetic fields adjacent to radiating antennas appears promising as a direct means of penetrating the sheath, particularly at higher frequencies. It will not be difficult to put coils around small antennas.

In one of several analyses based

Components' Future Seen Healthy

IN A KEYNOTE address this week before the Electronic Components Conference in Washington, Robert C. Sprague, of Sprague Electric Co. presented this estimate of the components market through 1972.

He saw an evolution towards the use of integrated circuits, molecular and micrologic elements and other complex components (see also p 51), but not a revolution replacing discrete components.

	1957	1962	1967	1972
		(Millions of Dollars)		
Components Markets:				
Federal Government	925	1,750	2,550	3,225
Industrial	600	975	1,550	2,150
Entertainment	925	1,025	1,300	1,500
Total	2,450	3,750	5,400	6,875
Components Sales:				
Total Tubes	753	830	980	985
Receiving	384	310	260	185
Power and spec. purpose	186	320	450	500
Tv Picture	183	200	270	300
Total Semiconductors	155	645	1,160	1,615
Transistors	68	365	770	1,125
Diodes and rectifiers	83	200	280	350
Special devices[a]	4	80	110	140
Total Passive Components	1,502	2,117	2,710	3,135
Capacitors	225	330	150	550
Resistors	195	315	115	545
Inductors	115	305	105	470
All other[b]	967	1,197	1,110	1,570
Total Complex Components	40	128	550	1,140
Nonminiaturized filters and networks	27	13	85	140
Miniaturized packaged assemblies	13	50	200	450
Planar and molecular circuits	.....	35	265	550

(a) Includes voltage-regulator diodes, microwave diodes, light-sensitive devices, tunnel diodes, thermoelectric semiconductors, etc. (b) Includes connectors, crystals, relays, microwave parts, etc.

Shed Light on Plasma Sheath

on laboratory experiments, H. S. Rothman and T. Morita, of Stanford Research Institute, reported that reentry blackout of a conventional telemetry system can be eliminated by two conditions: if a field applied in the direction of propagation produces an electron cyclotron frequency greater than the impressed angular frequency, and if the square of the collision frequency is much less than the square of the difference of the cyclotron and angular frequencies.

Wave propagation analyses indicate that static fields give significant improvements in reentry telemetry. According to H. Hodara, of Hallicrafters, models show that a magnetic field helps as long as the electrons revolve around the lines of the magnetic field, thus reducing attenuation. But if the collision frequency is higher than the cyclotron frequency, the mean free path of the electrons is too small. Hallicrafters proposes a missile test of effect of a 500-gauss field applied to a rectangular slot antenna.

Effectiveness of magnetic fields in opening windows for free-space transmission will not be known until the theory is flight-tested. Among the first field tests is an Air Force try, using a superconducting magnet to generate a field of about 10 kilogauss (ELECTRONICS, p 7, April 20).

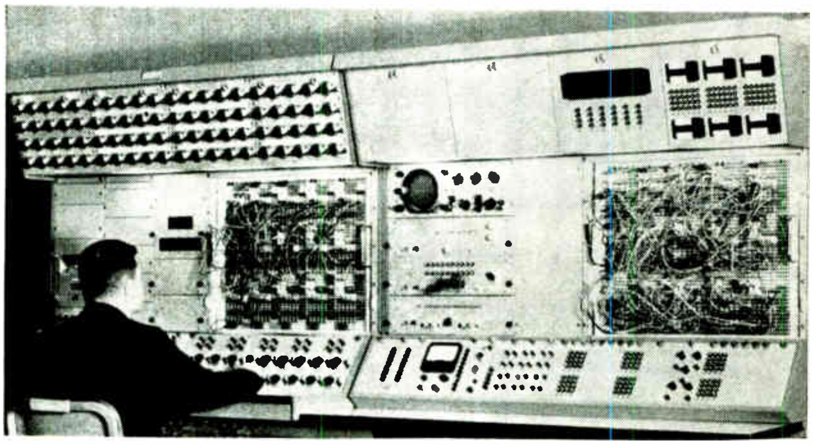
Aerodynamic modifications of the space vehicle and radiating systems is an approach that some people think will be as practical as magnetic fields. Avoiding blunt shapes, using structures that produce weaker shock waves, optimum placement of antennas, and separating the antenna from the vehicle skin to reduce thermal plasma are all under consideration.

Additives may reduce electron concentration in the ionized air layer around the nose cone. For example, fluorcarbons and electrophilic compounds squirted into the gas stream and around the antenna reduce shock heating and ionization. Water vapor has been used in laboratory experiments, but some measurements indicate little enhancement of transmission.

Research reports also indicate that plasmas can drastically change voltage breakdown characteristics of antennas even if the plasma is not dense enough to appreciably attenuate signals.

Another problem is that signals passing through rocket exhausts are strongly attenuated. Above 100,000 feet, the plume starts to envelop the vehicle. The problem gets worse with higher-energy engines, particularly solid fuel exhausts containing aluminum. Ground antennas may be relocated so the plume is not in the signal path.

Analog-Digital Computer Bows



Hydac digital console (right), has patch panel similar to analog plugboard (left)

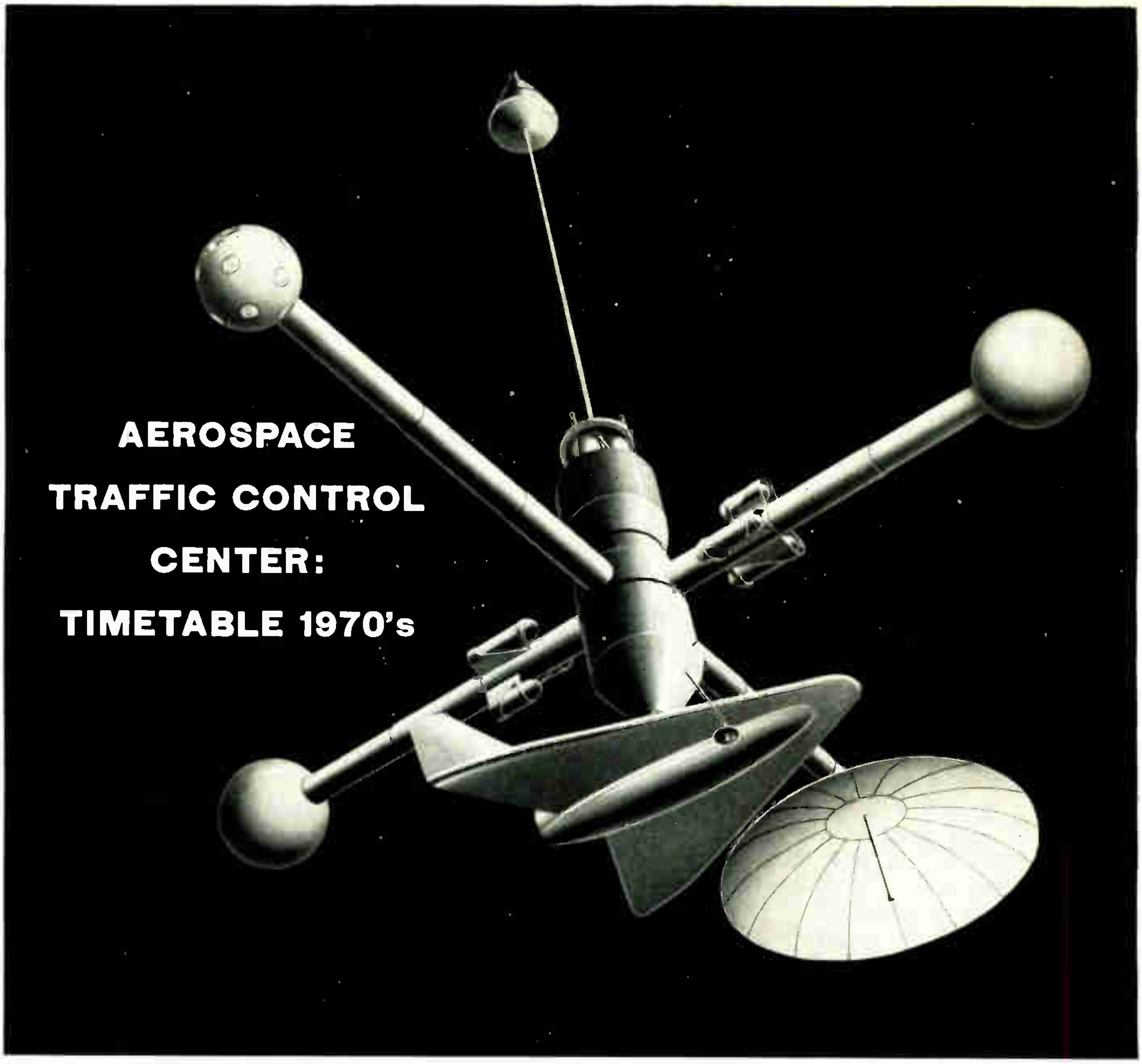
ANALOG AND DIGITAL operations are now combined in one centralized system to achieve a computational efficiency said to be better than either analog or digital computers used alone, according to Electronic Associates, Inc., builders of the recently introduced Hydac Series 2000 (hybrid digital-analog) computer.

Introduced at the Spring Joint Computer Conference, the computer is made up of a general-purpose EIA 231R analog computer plus a digital console that contains an expandable complement of logic and memory modules, depending on the application.

Lloyd F. Christianson, EAI president, said that although digital computers have been connected to analog systems by special linkage, flexibility, ease and economy are limited by features designed primarily for the general-purpose operation of the individual computers.

The hybrid computer adds to the analog functions, the digital operations of timing, selection, sequencing, memory look-up and calculation of simple functions. Some applications of the Hydac are in iteration and optimization studies, partial differential equations, simulation of logic functions, and integral equations.

Christianson said Hydac will simulate a space vehicle flight and duplicate exactly the logical decisions made by an airborne computer in controlling the flight. The first contract for the new system was from NASA for future space projects research.



A typical example of advanced design by Lockheed-California Spacecraft

Will command centers based in space be an outstanding development in the ten-year span from 1967 to 1977?

The answer at Lockheed-California Company's Spacecraft Organization is—Yes. Proof: the Spacecraft design pictured here. It reflects the maturity developed in our thinking about manned space systems.

The station—aeroscope traffic control center of the 1970's—will be assembled in orbit in a series of pieces brought together by rendezvous techniques. Included: Command center; living quarters; maintenance station; radar and infra-red sensing devices; nuclear power supply; communication links with the earth and other space vehicles. As now planned, 12 people will man the vehicle. Their tour of duty will be measured in weeks.

For four years Lockheed-California Spacecraft has concentrated on the needs of man in space. Activities embrace all fields pertaining to development of complex spacecraft as well as supporting technologies. An operation of such magnitude opens many doors of opportunity.

Scientists and Engineers of outstanding talent and training are needed to develop new Spacecraft, Aircraft, ASW concepts in: Human Factors; Physics (theoretical, plasma, high-energy, solid state, infrared, optics, nuclear); Thermodynamics; Servosystems; Reliability; Guidance and Control; Dynamics; Electronic Systems; Aerospace Ground Equipment; Bioastronautics; Systems Integration and Trade-Off; Space Mechanics; Sub-Systems Synthesis and Analysis; Nuclear, Electric and Liquid Rocket Propulsion; Electronics Research; Hydrodynamics. Send résumé to: Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 1505, 2408 N. Hollywood Way, Burbank, California. An equal opportunity employer.

LOCKHEED *CALIFORNIA COMPANY*

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

LET **Reeves** PROVEN CAPABILITIES CUT URGENT PROJECT LEAD TIME...

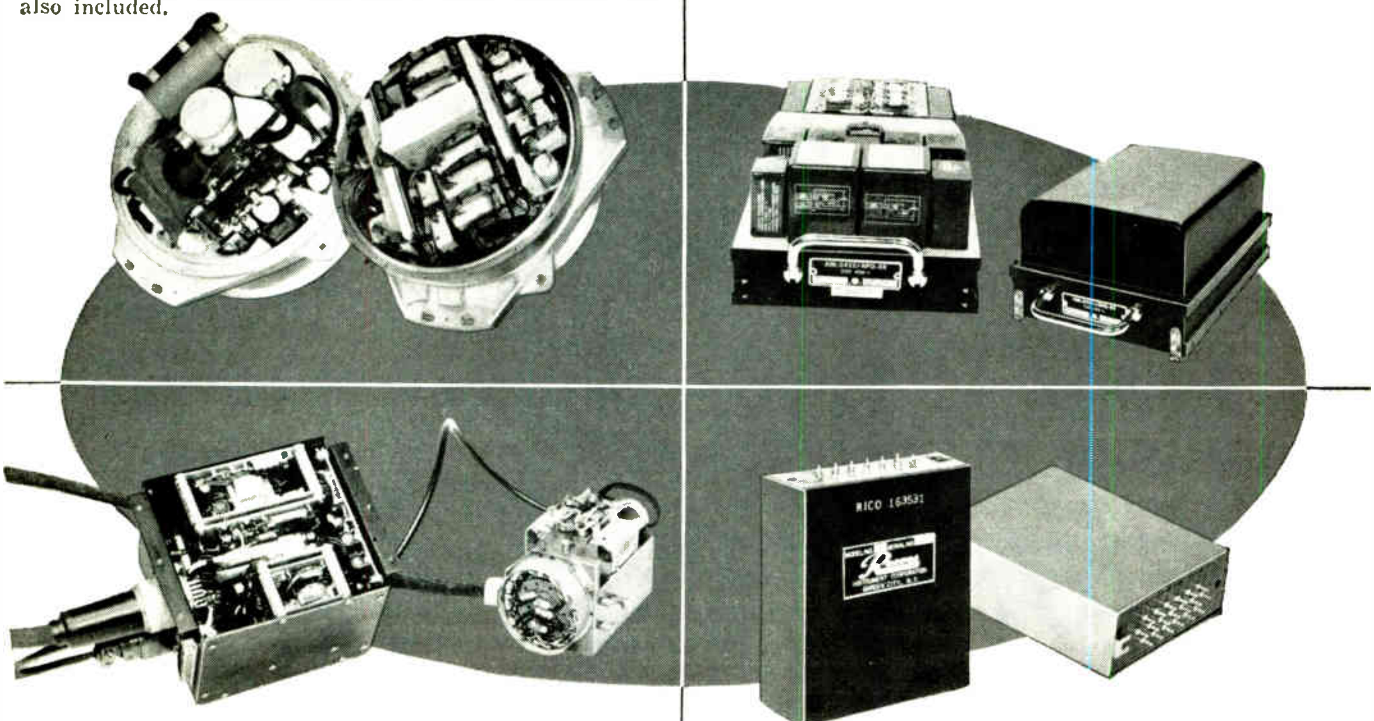
modular strap-down gyro packages

FOR GUIDANCE... STABILIZATION... CONTROL

Operational . . . producible . . . with reliabilities and performance fully demonstrated in current satellite and aircraft programs . . . Reeves Gyro Packages cover an extremely broad range of requirements. The following four representative types indicate the scope and experience of our design, engineering, and production capabilities immediately available to aid in your advanced projects.

THREE AXIS SATELLITE INERTIAL REFERENCE PACKAGE: Three single axis floated gyros and two accelerometers are employed. The gyro and accelerometer loops employ seven voltage amplifiers and five power amplifiers. All amplifiers are individually encapsulated, transistorized units. A current regulator amplifier and heater relay amplifier are also included.

TWO CHANNEL ANTENNA STABILIZATION SYSTEM: Each loop comprises a Reeves HIG-4 gyro and a voltage amplifier and power amplifier. Proportional temperature control amplifiers regulate temperature to ±0.5 degrees for each gyro.



SINGLE CHANNEL SATELLITE STABILIZATION SYSTEM: This high precision system utilizes a Reeves D30S gyro, with trimmed drift rate of 0.1°/hr. The gyro loop incorporates a voltage amplifier, a demodulator and a d.c. power amplifier for driving the gyro d.c. torque motor. Temperature regulation is effected by means of a proportional temperature control amplifier.

MODULAR AMPLIFIER COMPONENTS: Transistorized, fully encapsulated units which can be readily incorporated into any system for providing voltage and power amplification; demodulation where required, and high precision temperature control.

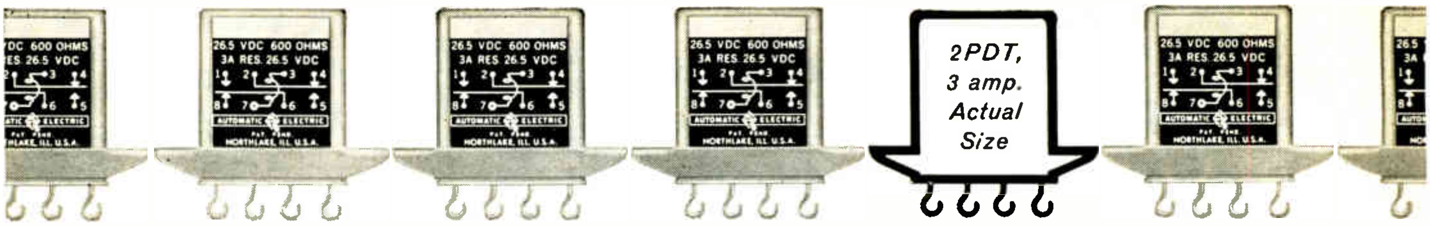
Write for data file 105

Reeves

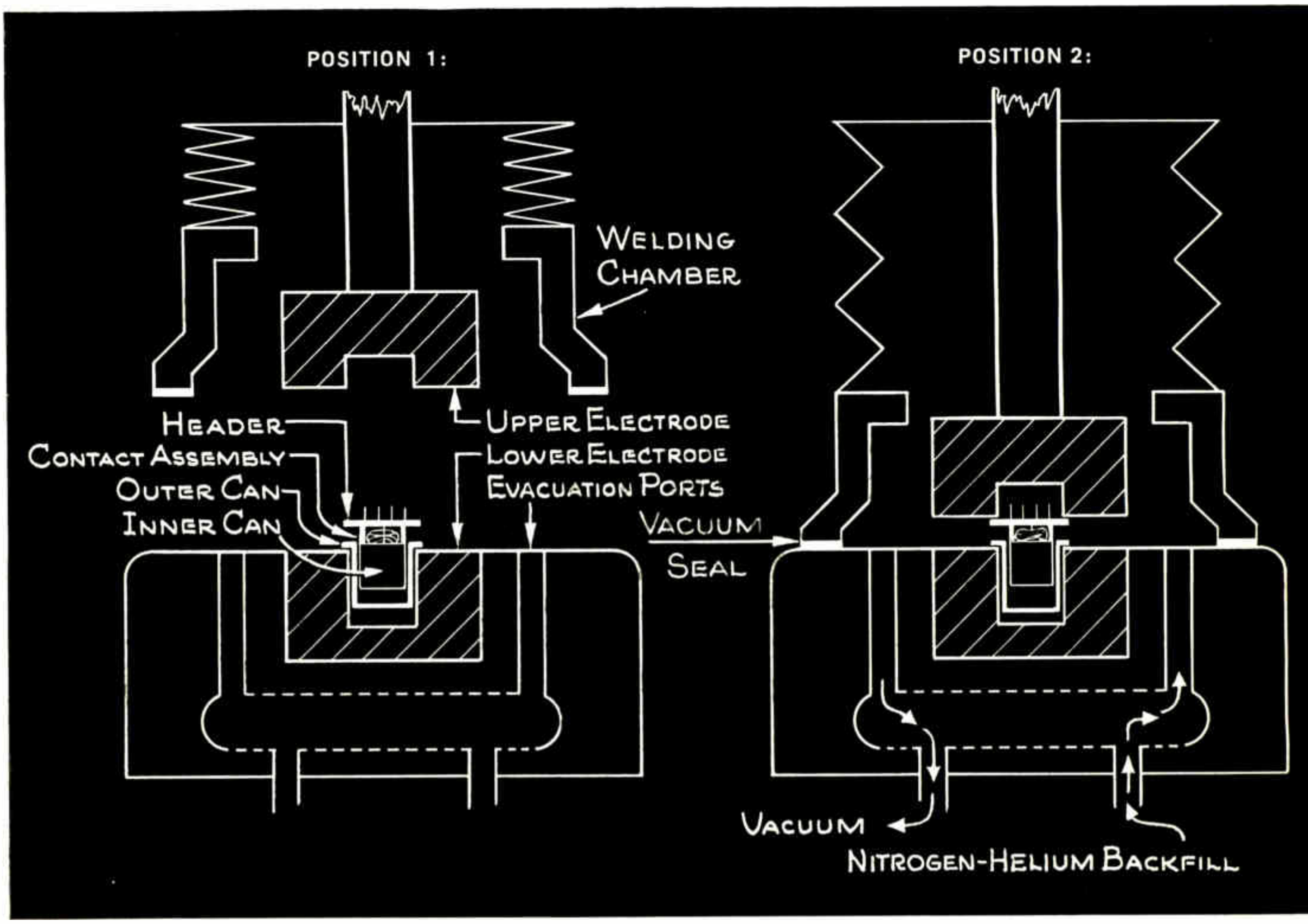
REEVES INSTRUMENT CORPORATION

A Subsidiary of Dynamics Corporation of America, Roosevelt Field, Garden City, N.Y.

CIRCLE 23 ON READER SERVICE CARD



Why AE's MM-22 military relay approaches *absolute* reliability



AE has licked the most common source of military relay failure — contact contamination.

You can run a "low level miss test" on a batch of MM-22's with certainty that the contact resistance on every one will remain remarkably low and consistent. A test at the full power rating will also demonstrate the contact reliability. As an example, MM-22's on a life test of 3 amperes 28 volts dc resistive had a contact resistance of *less than* 50 milliohms after *3½ million* operations.

One reason for this extreme reliability is found in AE's exclusive sealing method, graphically illustrated below. Note that no sealing hole or evacuation tube is used. After evacuation and backfilling of the welding chamber (including the relay), the outer can is resistance-welded to the relay and header assembly.

The final sealing operation is performed in a dry box containing the sealing chamber and the welding electrodes. A pure and dry nitrogen atmosphere is maintained in the dry box and all operations are performed through glove ports.

If your tests of microminiature sealed relays have shown an alarming probability of system failure, then the MM-22 is the answer to your problem. For more information, write for Circular 1999 to: The Director, Military Equipment Sales, Automatic Electric Sales Corporation, Northlake, Illinois.

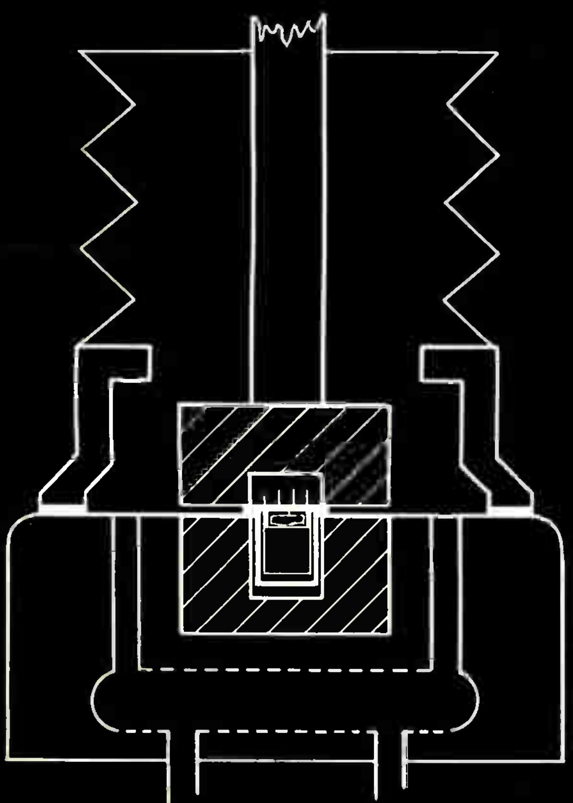
AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

POSITION 3:



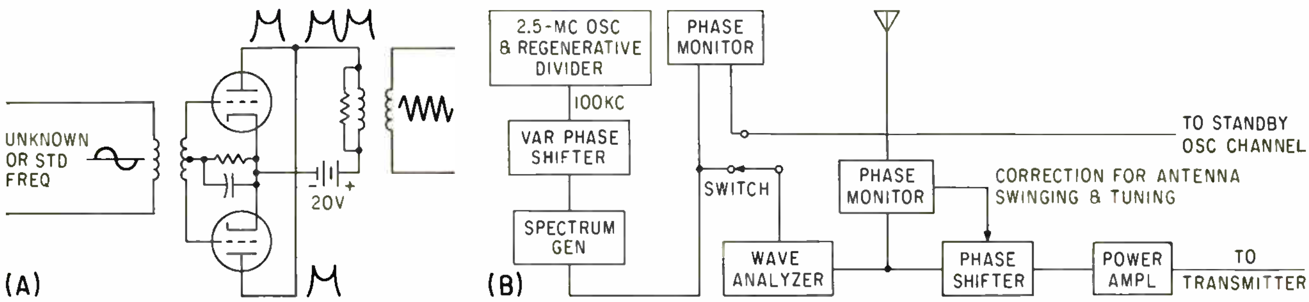
How the AE MM-22 Relay is hermetically sealed by resistance welding

POSITION 1: Relay structure and outer can are loaded into cavity in lower welding electrode. Relay structure and outer can are held partly open. Operator presses button to initiate cycle which, from then on, is completely automatic.

POSITION 2: Welding chamber closes and is evacuated and then backfilled with nitrogen containing helium tracer.

POSITION 3: Upper electrode descends, pressing relay completely into outer can and then completes the weld. Welder then reverts to Position 1 and completed relay is ejected.

CIRCLE 25 ON READER SERVICE CARD



Transformer replaces synthesizer in West German frequency printer (A). Frequency stabilizer (B) for Navy vlf transmitters uses Western Electric AT-cut 5th overtone crystal oscillators. R. R. Stone, Jr., Naval Research Lab, said system can maintain a local frequency standard to 1 part in 10^{10}

Frequency Controls Near 10^{13} Accuracy

By MICHAEL F. WOLFF
Senior Associate Editor

ATLANTIC CITY—Progress in raising stability and accuracy of frequency control devices was reported at the 16th annual Frequency Control Symposium late last month. The conference, sponsored by U. S. Army Signal Research and Development Laboratory, drew approximately 500 persons, including about 25 from Canada, Europe and Japan.

Sessions on atomic and molecular resonance indicated it may be possible to improve atomic frequency standards by one or two orders of magnitude, N. F. Ramsey, of Harvard University, hopes to demonstrate soon an accuracy of 1 part in 10^{13} by comparing frequencies of two atomic hydrogen masers having improved magnetic field and temperature control. Accuracy may ultimately reach 1 part in 10^{14}.

The masers utilize a hyperfine transition in the ground state of atomic hydrogen stored in a container for long times (order of seconds). In the discussion, R. F. C. Vessot said similar work is underway at Bomac Labs. He expects to have four masers by midsummer.

A. Javan described new experiments at MIT on stabilizing gaseous optical masers. Frequency stabilities of 1 part in 10^{13} might be obtained by observing the beat notes between two independently oscillating lasers with a multiplier phototube.

In a paper on stability of tunnel-diode oscillators, Frank Sterzer, of RCA, reported that fractional frequency shifts of less than 3×10^{-6} per deg C, 2×10^{-6} per mv, and 1×10^{-4} for a change in load vswr from 1 to 2 can be achieved by using a stabilizing resistor and choosing diodes with high peak-to-valley ratios and temperature-stable peak currents.

Carl J. G. Abom, of the Research Institute of National Defense, Stockholm, reported that drift rates in precision vacuum-tube oscillators could be reduced by two orders of magnitude by high-purity nickel cathodes. Such cathodes reduce the effect of cathode interface impedance changes with temperature.

Frequency control systems utilizing electric transitions in molecular beams also came under scrutiny. J. J. Gallagher, of Martin Co., described excitation and detection techniques for molecular millimeter-wave transitions that could be used to develop a system utilizing the 394.8-Gc transition in hydrogen sulfide.

In preliminary work, a 168-Gc absorption line has been observed with a superheterodyne receiver. Signal input power of 15 μw is obtained by multiplying from a 24.1-Gc klystron which is phase-locked to the 241,000th harmonic of a 100-Kc oscillator. Similar inputs are anticipated from mm klystrons under development for a 394.8-Gc system.

More than half the papers dealt with crystals and associated circuits and measurement techniques. A method of measuring resistance and equivalent capacity as a function of crystal unit frequency was described by F. K. Priebe, of USASRDL. A modified Boonton RX meter is used to obtain a plot of equivalent capacitance against frequency from which motional capacitance can be computed to within two percent.

On display by Rohde & Schwarz was a new test set for measuring crystals under loads from 0.001 mw to 5 mw and temperatures from −20 to 70 C. The set has a range up to 300 Mc and can measure motional resistance from 0 to 17,000 ohms with an accuracy of three significant figures, R&S said.

Possibility of frequency control in high-radiation environments with quartz crystals if they are operated at high temperatures was shown by J. C. King and D. B. Fraser, of Bell Labs. When AT-cut quartz resonators were exposed for 46 days to a high neutron flux (1.2×10^{18} nvt), resonant frequency increased by 900 parts per million and Q decreased an order of magnitude. This damage annealed out at temperatures above 300 C, however.

U. E. Adelsberger, of Physikalisch-Technische Bundesanstalt, West Germany, described a digital system for continuously printing frequencies to an accuracy of 1 part in 10^{11}. High count precision is achieved by using the frequency transformer (illustrated) at the printer input. Transformer multiplies a low input frequency by 1,000 and improves accuracy by the same factor. The battery eliminates phase shift.

Nuclear Blasts Testing R-F Blackout

DOMINIC, the U. S. nuclear test series now underway in the Pacific includes among its goals evaluating the disruptive effects of nuclear explosions on communications and radar and the ability of electronic equipment to withstand blasts and fallout, as well as tests of weapons.

In one test, for example, a bomb in the one-megaton (Mt) range will be lifted to 500 miles in space by a Thor IRBM and exploded. The explosion is expected to temporarily eliminate a portion of the Van Allen radiation belt.

High-energy particles from the belt will drop into the atmosphere. Disruption of the ionosphere will black out high-frequency communications. Ionized layers pushed down into the atmosphere will form a barrier, for a period of minutes, to frequencies slightly above 30 Mc and and for perhaps hours to the 1 to 10 Gc range.

The blackout is expected to provide information on techniques for preventing a breakdown of communications caused by enemy (or even our own) nuclear blasts during war.

Two lower-altitude H-bomb tests are also planned in this series.

Distortion of radar target returns and complete blocking of radar by nuclear blasts has been experienced in the past. Exploding enemy missiles as well as explosion of nuclear warheads on defending antimissiles such as Nike Zeus might prevent target acquisition and tracking of subsequent attacking missiles.

General effect of nuclear blasts on communications has been known for some time, and several summaries have been published, based primarily on the 1958 Argus experiments.

It has been estimated that a 50-Mt bomb exploded at an altitude of 50 mi would black out communications for about a day in a 2,500-mi radius. The radius would increase or decrease with altitude and bomb size.

The 1961 Soviet test series included a bomb of that size and there has been at least one indication it could be used for jamming (ELECTRONICS, p 9 Nov. 10, 1961). In the U. S. tests a total explosive force of roughly 20 Mt will be detonated, about 12 Mt in fusion energy and 8 Mt in fission energy.

Federal Aviation Agency has warned civilian planes of the disruptive effects of the blasts on communications and navigation equipment. Planes will be grounded up to 32 hours after each blast. Radio amateurs have been requested by government agencies to collect data on communications disturbances.

Exposure of electronic gear to effects of blasts and radiation is of major interest, with instrumentation methods and results highly classified.

Proof testing of weapons will include nuclear firings of Minuteman, Atlas and Polaris missiles, Asroc and perhaps Subroc antisubmarine rockets, and nuclear depth charges. The Nike Zeus antimissile missile will attempt to intercept an Atlas warhead. At least one new, unnamed weapon will be tested.

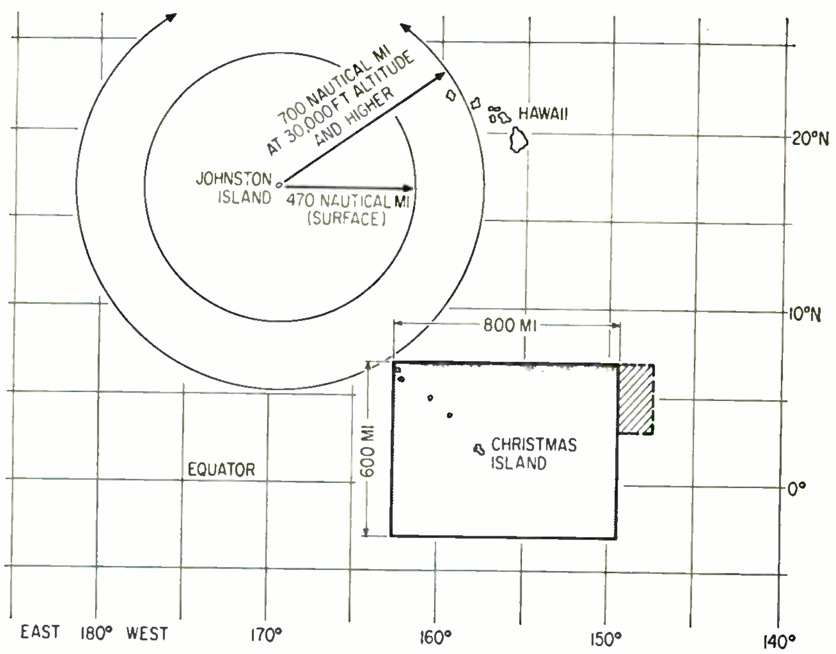
Efforts to improve weight-to-yield ratios of nuclear warheads will be evaluated. The Polaris submarine *Ethan Allen* this week fired a Polaris missile with a live nuclear warhead of reportedly ½-M-t yield. Ability of Minuteman hardened silos to withstand atomic attack will be investigated.

The White House has invoked extensive security measures. Reporters will not be allowed on the proving grounds and only brief announcements of each blast are being made.

Among top personnel are Maj. Gen. A. E. Starbird, Army, directing the test series; William Ogle, AEC, scientific director; Brig. Gen. J. Samuel, Air Force, communications and transportation, and Rear Adm. L. Mustin, experienced in antisubmarine warfare, who will direct Navy efforts.

Groups from AEC's Los Alamos Labs, Lawrence Radiation Lab and Sandia Corp., as well as other experts, will be present. Edgerton, Germeshausen and Grier is supplying much of the electronic equipment, including a countdown system, and gear for gathering blast data by measuring light, radiation, shock wave propagation and other effects.

Preparations were made on a crash basis in just four months. Roughly $100 million in equipment of all types is employed, not counting major construction.



Dominic test areas in the Pacific. Smaller rectangle is believed to be for underwater weapons tests

AT THE WORLD'S FAIR

An Electronic World of Tomorrow

By RAY BLOOMBERG
McGraw-Hill World News

SEATTLE—Electronic equipment is not only gathering crowds at industrial exhibits at the World's Fair here, it also controls two of the biggest public displays—the World of Tomorrow and the International Fountain.

In the World of Tomorrow, fairgoers pass through a fantastic arrangement of 3,700 aluminum cubes bathed in changing light and "slightly eerie" music.

Visitors are lifted to a 28-ft-high platform in a plastic-enclosed elevator, called a Bubblelator, then walk down a ramp through clusters of cubes. Dimmer-controlled lights and speakers guide the tour.

Five continuous-loop 16-mm projectors cast images on three-dimensional screens and 16 magnetic tape reproducers feed music, messages and sounds into some 100 loudspeakers in two systems. Projectors and reproducers are timed to 0.01 second, to maintain five-minute cycles over a 12-hour day. Control equipment was installed by RCA.

The fountain presents seven 20-minute water concerts daily. Nine lights and spray patterns from 117 nozzles are controlled by a tape recorder from Tally Register Co.

The 600-ft-high space needle has a 549-bell electronic carillon. It's billed as the world's largest and highest. It may also be the loudest, since it can be heard 10 miles away.

Among the exhibits is a National Cash Register preview of future electronic business systems: an on-line banking system based on a 315 computer, and a cash register that processes data for retailers. NCR also invites visitors to play black-jack with a 390 computer.

Industry contributed to the American Library Association's library of the future. When a request is dialed on a home phone, a computer will locate the document in one of the world's libraries, transmit the request by satellite and receive an image by the same route. The exhibit is based on RCA's Video File.

The library also includes a Sperry Rand Univac whose stored information is available to fairgoers, and a Mark II Auto Tutor for teaching mathematics and science.

IBM's exhibit uses visual displays and operating models to relate electronic computers to the more simple devices of the past. A children's maze gives the basic principles of today's computers.

Another device does arithmetic and prints answers to simple problems on voice command. It will recognize and respond to 16 spoken words. In the U. S. Science Exhibit, an IBM 1620 and a California Computer Products digital plotter simulate a space flight.

Pacific Northwest Telephone Co. is making use of the Bellboy personal-signaling device. Some 40 pocket-size radio receivers buzz fair officials, maintenance and medical personnel when their telephone number is dialed anywhere in the Seattle area. They then get the message by phone.

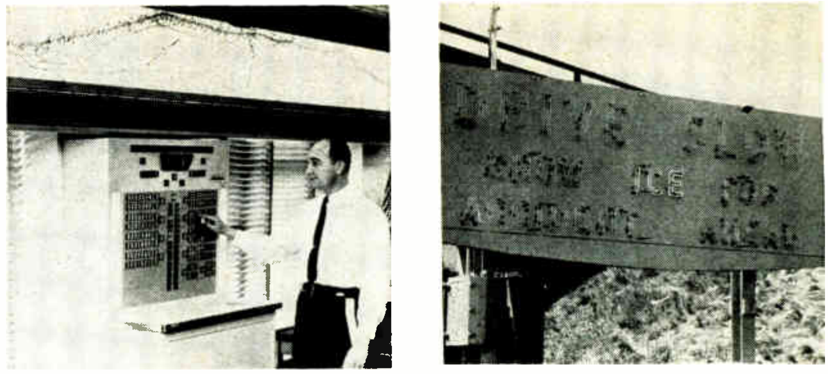
Projectors and recorders guide visitors through geometric forms representing world of tomorrow

Spoken arithmetic problems are solved by IBM device that prints the answers

NCR offers fairgoers an opportunity to play black-jack with a computer

Electronically controlled fountain presents seven water concerts a day

Transit tracking station and satellite introduces visitors to space systems



Map tells what signs are in operation. Modules above and below map indicate which messages are lit (left). Receiver-decoder and antenna are seen at left side of sign

Tones Control Highway Sign System

NEW JERSEY TURNPIKE is equipped with 67 neon signs, warning motorists to drive slow when there is snow, ice, fog or an accident ahead. Until last week, state troopers turned these signs on and off by hand. Delays of an hour or more sometimes occurred, especially when the troopers were tied up at an accident scene.

To eliminate this delay and the hazards that resulted, the Turnpike Authority had Motorola install a system which controls the signs by vhf radio tones. Signs can now be turned on seconds after a trooper radios a hazard report and can be turned off as quickly.

The dispatcher uses selector switches to operate individual signs or groups of signs. Switch positions are coded, transmitted over the turnpike's microwave relay system, received and rebroadcast by five repeater stations. A receiver-decoder at each sign actuates the neon messages. The receiver-decoders use transistor circuits. If the primary repeater station for a sign or group of signs fails, an alternate station may be used.

Status of each sign is displayed by optical projection on an 18-ft map of the 131-mi-long road. Checking circuits verify sign operation and a data logger provides a permanent record of the operation.

The system can be expanded to handle 100 signs with up to 20 messages each. The repeater system is also used for two-way radio communication with the turnpike's 80 maintenance vehicles. That system was also installed by Motorola.

Sweden Studies Plans To Build Rocket Range

STOCKHOLM—Sweden is discussing possible entry into the European Space Research Organization with construction of a rocket launch range some 45 Km east of the town of Kiruna, located at 65 deg N lat.

Tentative plans call for less than ten sounding rocket firings the first year (two-stage rockets with a payload of 50 Kg up to altitudes of 150 Km), 40 the second year and 65 in each of the following six years.

Subjects of investigation would be upper atmosphere physics in the auroral zone, upper atmosphere physics at lower altitudes, and astronomical studies.

Estimated costs for the Kiruna site are estimated about $5.44 million including $1.22 million for equipment. Included in the equipment list are: $440,000 for radar, $120,000 for telemetry, $70,000 for ionospheric sounding, $70,000 for operational control, $30,000 for meteorological sounding, $90,000 for communications and $200,000 for ramp service. Cost of operation would be about $1.06 million a year.

Sweden's plans also include—although Kiruna is not mentioned in this context—small satellites in near-earth orbits during the fourth year of the program, large stabilized astronomical satellites and lunar satellites in the sixth year.

10 TURN RESOLUTION WITH ONLY 1½ TURNS!

(ACTUAL SIZE)

SPECIFY FLUKE PRECISION POTENTIOMETERS!

THESE new time-savers combine the advantages of speed, high resolution, linearity and AC response . . . in a fraction of the space required for standard helical potentiometers . . . in fact less space than many single turn, low resolution potentiometers. The unique FLUKE patented design results in all the most looked for capabilities; for example, thin card-type windings reduce residual reactance and allow operation at much higher frequencies than other potentiometers with similar DC specifications. The 1½ turn control of the entire adjustment range allows substantial time savings in frequently adjusted or multiple potentiometer installations such as analog computors, simulators and data logging systems. For built-in dependability, precision and all around performance . . . specify FLUKE *reliable* potentiometers.

20A RESISTANCE RANGE IN OHMS: . . . . 100 to 25K
RESOLUTION: . . . . 1K and above, better than 0.02%
POWER RATING IN WATTS: . . . . 2 at 20°C
PRICE: $8.50

21A RESISTANCE RANGE IN OHMS: . . . . . 30K, 40K and 50K
RESOLUTION: . . . . . . 30K and above, better than 0.008%
POWER RATING IN WATTS: . . . . 3 at 20°C
PRICE: $10.00

22A RESISTANCE RANGE IN OHMS: . . . . 1K to 100K
RESOLUTION: . . . . 1K and above, better than 0.02%
PRICE: $15.00

30A PROVIDES 40 TURN RESOLUTION WITH ONLY 2½ TURNS
RESISTANCE RANGE IN OHMS: . . . . 1K to 100K
RESOLUTION: . . . . . 1 part in 50,000, or better than 0.002%
POWER RATING IN WATTS: . . . . 5 at 20°C
PRICE: $30.00

Available from stock. Compatible knobs and resettable dials also available. *Write, wire or phone for your nearest local stock and short form catalog F-162.*

John Fluke Mfg. Company, Inc.
Seattle 33, Wash.

FLUKE **COMPONENTS**

Box 7428 *PR. 6-1171* *TWX — Halls Lake* *TLX — 852*

LOCAL STOCKS AVAILABLE IN MOST MAJOR MARKETS

MEETINGS AHEAD

NATIONAL AEROSPACE ELECTRONICS CONFERENCE, IRE-PGANE; Biltmore Hotel, Dayton, Ohio, **May 14-16.**

AEROSPACE INSTRUMENTATION SYMPOSIUM, ISA; Marriott Motor Hotel, Washington, D. C., **May 21-23.**

ELECTRONICS PARTS DISTRIBUTORS SHOW, Electronic Ind. Show Corp.; Conrad Hilton Hotel, Chicago, **May 21-24.**

SELF-ORGANIZING INFORMATION SYSTEMS CONFERENCE, Office of Naval Research and Armour Research Foundation; Museum of Science & Industry, Chicago, **May 22-24.**

MICROWAVE THEORY & TECHNIQUES NATIONAL SYMPOSIUM, IRE-PGMTT; Boulder, Colo., **May 22-24.**

POWER SOURCES CONFERENCE, U. S. Army Signal R & D Lab., Shelbourne Hotel, Atlantic City, N. J., **May 22-24.**

TELEMETERING NATIONAL CONFERENCE, IRE-PGSET, AIEE, ISA, ARS, ISA; Sheraton Park Hotel, Washington, D. C., **May 23-25.**

IRE SEVENTH REGION CONFERENCE, Seattle IRE Section; Seattle, Wash., **May 24-26.**

NUCLEAR CONGRESS & EXHIBIT, Engineers Joint Council; Statler Hilton Hotel, New York City, **June 4-7.**

RADAR ANNUAL SYMPOSIUM, University of Michigan; Ann Arbor, **June 6-8.**

MOLECULAR BEAMS CONFERENCE, Brookhaven National Laboratory; Upton, N. Y., **June 11-13.**

ARMED FORCES COMMUNICATIONS & ELECTRONICS ASSOC. CONVENTION & SHOW; Sheraton Park and Shoreham Hotels, Washington, D. C., **June 12-14.**

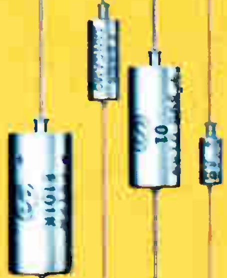
WESTERN ELECTRONICS SHOW AND CONFERENCE, WEMA, IRE; Los Angeles, California, **Aug. 21-24.**

ADVANCE REPORT

SPACE PHENOMENA & MEASUREMENTS SYMPOSIUM, IRE-PGNS, AEC, NASA: *Detroit, Mich., Oct. 15-18. July 1 is deadline for submitting 100-word abstract to: Michael Ihnat, AVCO Corp., 201 Lowell Street, Wilmington, Mass. Typical topics include: measurement in the radiation belts; solar and galactic cosmic ray behavior; electromagnetic fields in the solar system; x-ray and gamma ray astronomy.*

FALL JOINT COMPUTER CONFERENCE, IRE-PGEC, AIEE, ACM: *Sheraton Hotel, Philadelphia, Pa., Dec. 4-6. June 30 is deadline for submitting four copies of 35-word abstract, 500-word summary and complete draft of paper to: E. Gary Clark, program committee chairman, Burroughs Corp., Research Center, Box 843, Paoli, Pa. Areas of particular interest include: information processing in space technology; advanced system organizations; hardware-software relations; new applications of information processing; information communication & display; information processing as a national resource.*

NEW FROM
SANGAMO



SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO

TOUGHER TANTALUM CAPACITORS

TANTALUM CAPACITORS

These solid electrolyte capacitors, Sangamo Type 595, represent a distinct achievement in tantalum capacitors. They utilize Sangamo's exclusive "Innerseal" construction with the terminals mechanically secured to the tubular container and precisely positioned without regard to the capacitor element. The seal is produced with a minimum of solder and flux, and with minimum thermal and mechanical stress on the glass insulator. There is absolutely no reliance on solder for mechanical strength. That's why these *tougher* units give peak performance under the most drastic shock and vibration conditions.

Sangamo tantalum capacitors comply with all the electrical and mechanical requirements of Mil-C-26655A.

Basically, these tantalum capacitors provide the highest capacitance per-cubic-inch in an extremely small and strong, hermetically sealed package.

Sangamo Type 595 capacitors are designed for filter, by-pass, coupling, blocking, and low voltage applications in telemetering devices, airborne systems, computers, missiles, and transistor circuits. They have low dissipation factor, low dc leakage, and excellent shelf life. They are available in capacitance values of 0.22 to 330 mfd, and in voltages from 6 to 35 WVDC. They're suitable for operation at full-rated voltages over a temperature range of —80°C to +65°C and, when properly derated, will operate up to +125°C. Complete information is yours for the asking.

ELECTRONIC COMPONENTS

SANGAMO ELECTRIC COMPANY
SPRINGFIELD, ILLINOIS

EC62-1

SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO
SANGAMO

ELECTROLYTIC

CAPACITORS

SANGAMO

ELECTROLYTIC COMPUTER GRADE CAPACITORS

- MAXIMUM CAPACITY IN SMALLEST CASE SIZE
- HIGH RELIABILITY
- HIGH ACCEPTANCE

Sangamo Type DCM Capacitors are *computer grade*—have more capacitance per case size—operate under high ambient temperatures, are rated for high ac ripple currents, and add stability and long life to low voltage power supplies. That's why they are used by such computer makers as:

BENDIX	NATIONAL	REMINGTON RAND
BURROUGHS	PHILCO	ROYAL McBEE
GENERAL MILLS	RCA	SOROBAN
IBM	RAYTHEON	STROMBERG-CARLSON

Sangamo was the first manufacturer to produce and establish standards for high reliability, computer grade electrolytic capacitors, and can engineer and produce units to meet your most exacting specifications. Complete information is yours for the asking.

ELECTRONIC COMPONENTS

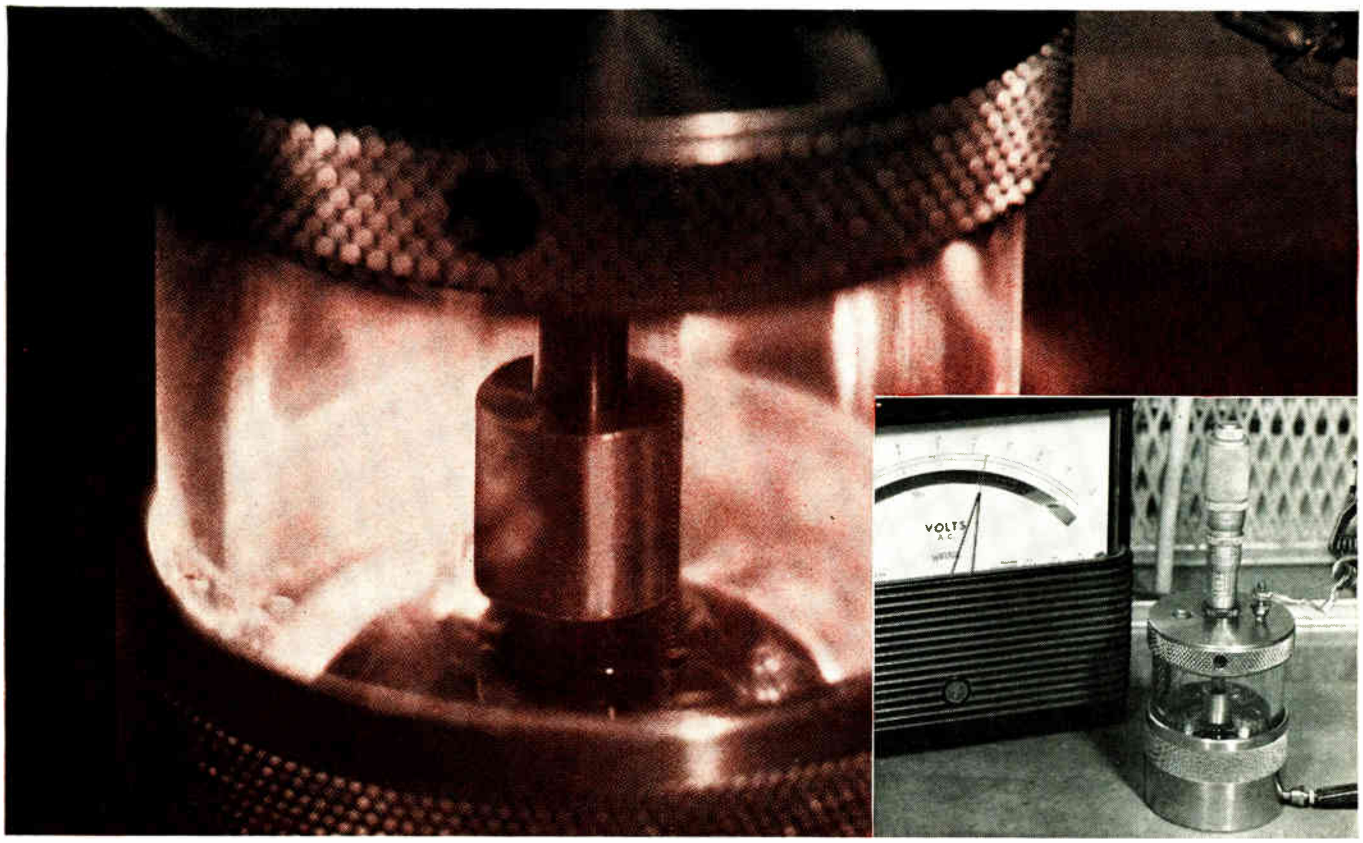
SANGAMO ELECTRIC COMPANY

SPRINGFIELD, ILLINOIS

EC62-2

SILICONE NEWS from Dow Corning

Improve product quality



Silicone fluids . . . proved by test, by performance

A part of proving silicones in the laboratory for performance in your product is the development of realistic evaluation equipment like the ball test cell shown. Developed by Dow Corning, it is used in one of the stringent quality control tests for electrical grade fluids . . . available in viscosities of 20, 50, 100, 200, 350, 500, and 1,000 centistokes.

Dow Corning silicone fluids have proved themselves outstanding performers as: 1. dielectric coolants . . . 2. surface coatings . . . 3. filling and impregnating materials for electronic components and assemblies.

As an impregnant for paper capacitors, silicone fluid decreases dielectric losses, increases permissible operating temperatures, assures uniform capacitance over a wide temperature range. In this and other filling and impregnating applications, silicone fluids add to reliability . . . often eliminate costly compensating circuits.

As dielectric coolants, Dow Corning silicone fluids can be pumped at high speed without breakdown due to shear. They maintain consistency over a range of —65 to 250 C, will not oxidize or corrode metals.

TYPICAL PROPERTIES OF DOW CORNING 200 FLUID ELECTRICAL GRADE — 100 CENTISTOKES

Nominal Viscosity at 25 C, centistokes	100
Viscosity Variation at 25 C, percent max.	5
Flash Point, degrees Fahrenheit, min.	575
Electric Strength, volts/mil, min.	350
Dielectric Constant, maximum	
at 23 C, 100 cps	2.75
at 23 C, 10^5 cps	2.75
at 150 C, 100 cps	2.45
Dissipation Factor, maximum	
at 23 C, 100 cps	0.00008
at 23 C, 10^6 cps	0.00002
at 150 C, 100 cps	0.004
Volume Resistivity, ohm-cm, minimum	
at 23 C—500 volts d-c	1.0×10^{14}
at 150 C—500 volts d-c	0.1×10^{14}
Specific Gravity 25 C	0.968
Refractive Index 25 C	1.403
Pour Point, degrees Fahrenheit	—60
Thermal Expansion Ratio†	1.12
Thermal Conductivity‡	0.00037

† $\frac{\text{Volume at 150 C}}{\text{Volume at 25 C}}$ ‡ $\frac{\text{gm-cal}}{\text{deg C cm sec}}$

ASTM D877, D924, and D1169 tests procedures used to obtain values where applicable.

CIRCLE 289 ON READER SERVICE CARD

Dow Corning is your best source of a broad line of silicone fluids, gels, elastomers and rigid forms for potting, filling, embedding and encapsulating.

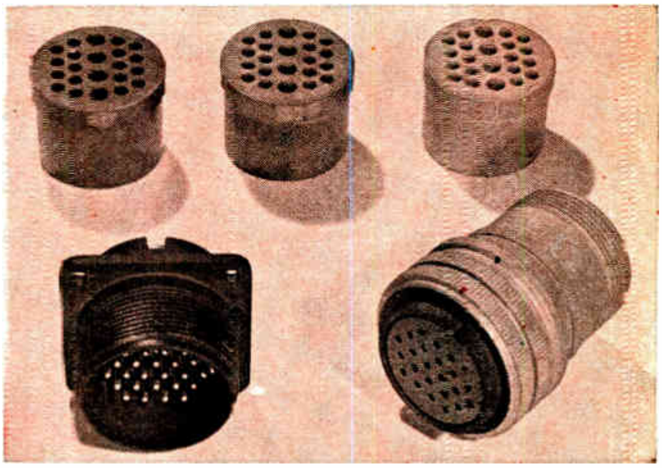
first in silicones

Dow Corning

. . . with these silicones

Molding compound for 700 F

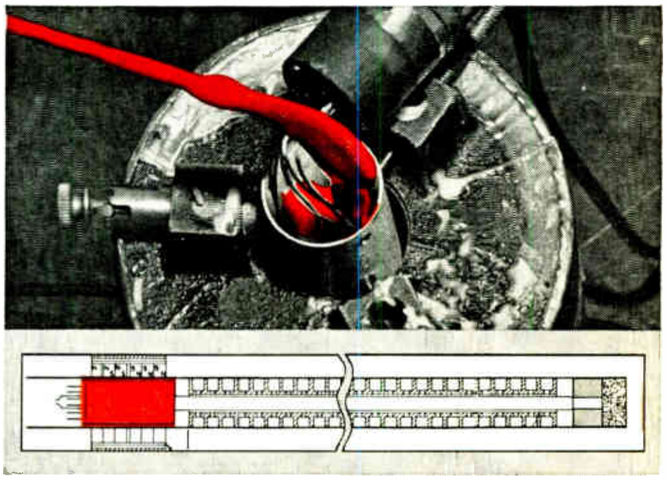
A new mineral-filled silicone molding compound developed by Dow Corning in cooperation with Amphenol-Borg Electronics Corporation's research personnel, is designed for: long-term stability at 700 F; excellent thermal shock resistance; low dissipation factor and arc resistance. Used by Amphenol to make military-type connector inserts, this compound has withstood temperatures of 700 F for several hundred hours. Other promising uses include fuses, coil forms, relay parts, tube bases, contactors, arc barriers and switch parts. This compound can be molded by compression or transfer techniques.



CIRCLE 290 ON READER SERVICE CARD

Sure fire potting of electron gun

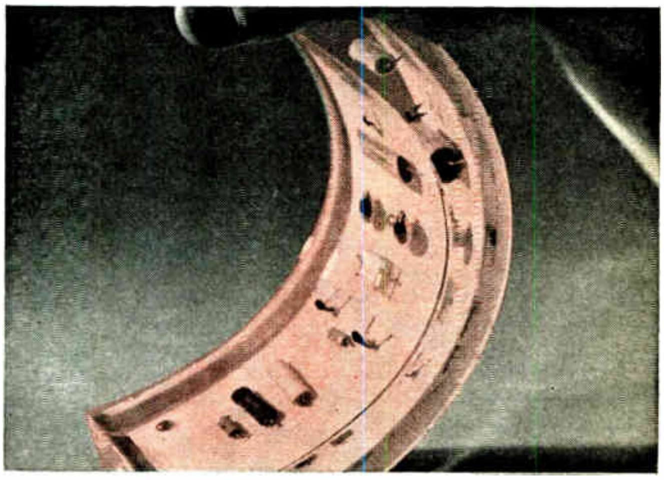
This traveling wave tube made by Huggins Laboratories, Inc., is a broad band receiving and transmitting tube used in communications, radar, missile checkout . . . other complex electronic gear. It provides: power amplification greater than 10,000 over a two-to-one frequency range; operating band widths to 7,000 megacycles. To assure this performance, precise positioning of the electron gun is vital and must be maintained under all operating conditions. Silastic® RTV, the Dow Corning liquid silicone rubber that cures at room temperature, is used to bond and cushion the gun in position within the capsule. Quick set-up time of Silastic RTV speeds production, while high dielectric strength helps assure performance.



CIRCLE 291 ON READER SERVICE CARD

New transparent embedding resin

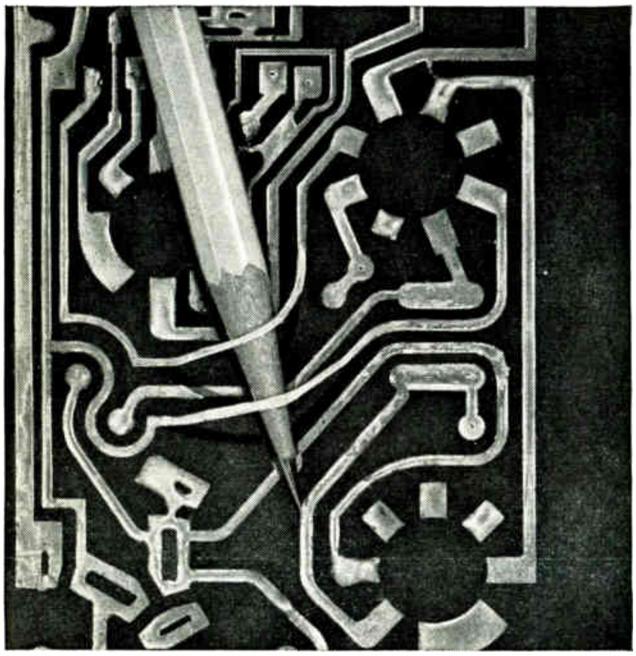
Tough, flexible, transparent and repairable, Sylgard® 182 is easy to process . . . provides excellent environmental protection. This solventless silicone casting resin cures in 4 hours at 65 C, 15 minutes at 150 C . . . cushions against shock from −70 to 225 C . . . assures constant dielectric strength . . . resists the effects of ozone, voltage stress, heat aging and thermal cycling. Faulty components can be exposed, replaced and the repair area filled with new resin. Sylgard 182 and its curing agent are not toxic to the skin, nor do they give off toxic fumes or exothermic heat during blending or cure.



CIRCLE 292 ON READER SERVICE CARD

Free 12-page manual, "Silicones for the Electronic Engineer". Write Dept. 4205, Dow Corning Corporation, Midland, Michigan.

Printed Circuit Designers! AVOID Wire Failures at Soldering Temperatures



You've never had a printed circuit fail at room temperature. But you may often have experienced loose wire trouble in the soldering pot or during solder roller coating.

Synthane G-10R, a special glass epoxy base laminate, was developed especially to eliminate wire failures during the soldering operation—approximately 500°F.

G10-R meets or beats NEMA and MIL specs for peel strength at room temperature and has a *hot* peel strength of 2 to 4 lbs. per inch of width after immersion for 15 seconds at 500°F* instead of the customary 0.1 to 0.2 lbs. per inch of width.

G-10R is available in sheets 36" x 36" or 36" x 48" and in the usual foil thicknesses. Write for new folder on all Synthane metal-clad laminates.

*Tests made on 1/16 & 1/8" wires.

SYNTHANE

CORPORATION OAKS, PENNA.
GLendale 2-2211 TWX Valley Forge 735U
Synthane-Pacific 518 W. Garfield Ave., Glendale 4, Calif. TWX GLDL 4417U

Synthane Corporation, 36 River Rd., Oaks, Pa.

Gentlemen:

Please send me your latest brochure on Synthane G-10R and other Synthane copper-clad laminates.

Name__________

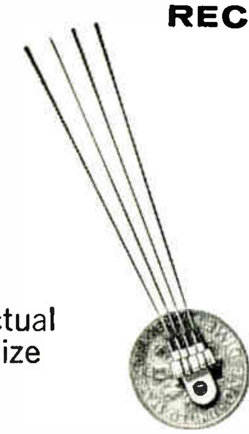
Address__________

City__________ Zone_____ State__________

CIRCLE 38 ON READER SERVICE CARD

CONANT'S Miniaturization

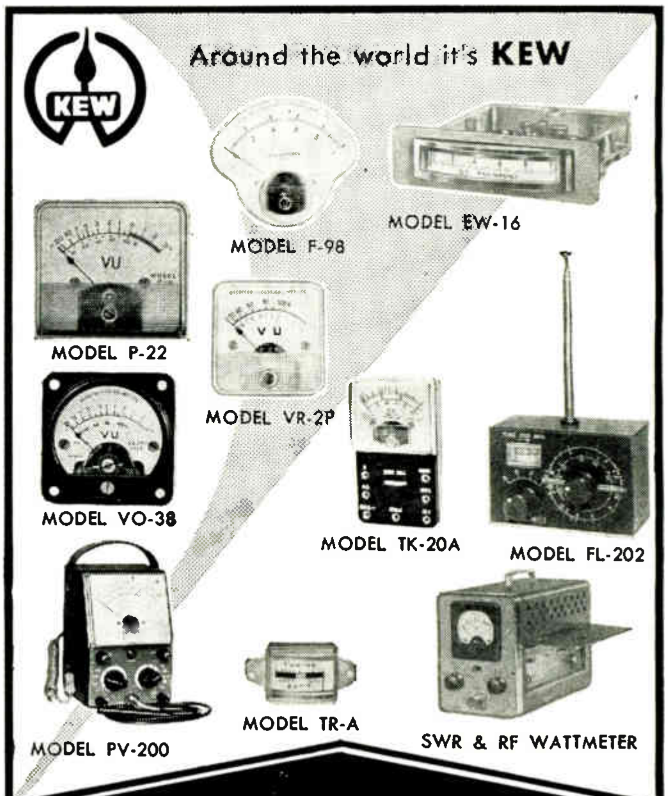
SERIES 80 INSTRUMENT RECTIFIERS



actual size

CONANT LABORATORIES
Box 3997, Bethany Station, Lincoln, Nebraska.
Write for list of types and information.

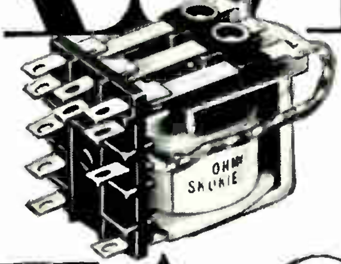
CIRCLE 200 ON READER SERVICE CARD



KYORITSU ELECTRICAL INST. WORKS, LTD.
No. 120, Nakane-cho, Meguro-ku, Tokyo, Japan
Cable Address: "KYORITSUKEIKI TOKYO"
Tel: (717) 0131 ~ 5 · 0151 ~ 3

CIRCLE 201 ON READER SERVICE CARD

10-AMP



CONTACTS

NEW INDICATOR LIGHT, TOO

now available in Ohmite GPR relays

■ Model GPR relays represent a fresh design approach in the field of good, economy-type relays. Construction is simplicity itself, and with the elimination of complexity has come compactness, versatility, and unusual ruggedness.

CONTACTS: 5 and 10 amps at 115VAC or 32VDC (non-inductive). Gold flashed, fine silver (5-amp); silver cadmium oxide (10-amp).

COILS: Up to 230VAC, 60 cycles, or 115VDC; DC, 1.4 watts; AC, 2 volt-amperes (AC latching type, 3.7 volt-amperes).

CONTACT COMBINATIONS: SPDT, DPDT, and 3PDT for single relays; 4PDT and 6PDT on latching relays.

ENCLOSURES: Clear plastic.

TERMINALS: Barrier type or octal plug.

LATCHING RELAYS: Enclosed with plug-in mounting; or unenclosed.

PLATE CIRCUIT RELAYS: Supplied in 2500, 5000 and 10,000-ohm coil resistances.

Write For Revised Stock Catalog 30

POPULAR "COST-SHAVING" FEATURES OF MODEL GPR RELAYS

CHOICE of below-chassis or above-chassis connecting in plastic enclosures.

MULTI-USE terminals allow soldering, insertion in printed circuit board, and use of AMP Style 110 push-on terminals.

ALL TERMINALS on *one* panel . . . permits insertion in printed circuit board.

OCTAL PLUG relays up to DPDT have recessed pin bases . . . meet UL spacing requirements to 150 V.

ALL ENCLOSED relays mount solidly on base . . . *not* on covers.

INTEGRAL plug-in base up to DPDT avoids wiring between contact terminals and pins.

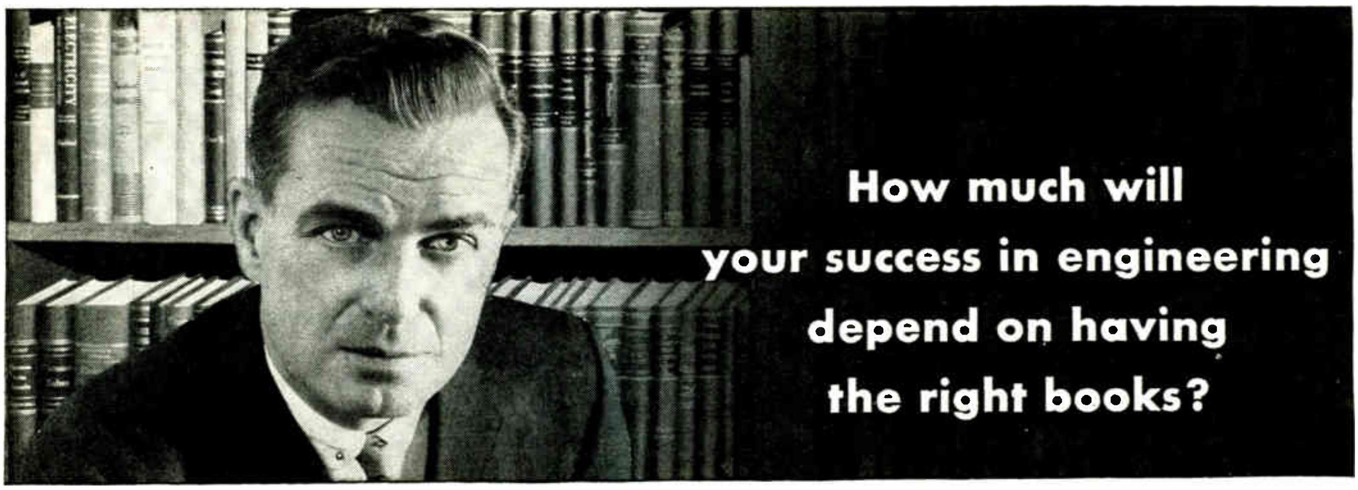
ENTIRE LINE STOCKED FOR FAST SERVICE FROM DISTRIBUTORS AND FACTORY

Rheostats • Power Resistors • Precision Resistors • Variable Transformers • Tantalum Capacitors • Tap Switches • Relays • R. F. Chokes • Germanium Diodes

OHMITE

OHMITE MANUFACTURING COMPANY
3610 Howard St., Skokie, Illinois

CIRCLE 39 ON READER SERVICE CARD



The Electronics and Control Engineers' Book Club helps you keep ahead in your field . . . *at a savings*

Start your membership with any of these selections:

Transistor Electronics by D. DeWitt and A. L. Rossoff. Full coverage from basic fundamentals to detailed mechanisms.

Publisher's Price, $9.00
Club Price, $7.65

Electronic Digital Computers by C. Smith. What they are, how they function, and their underlying principles.

Publisher's Price, $12.00
Club Price, $10.25

Control Engineers' Handbook by J. C. Truxal. A wealth of practical help on automatic feedback control systems.

Publisher's Price, $22.50
Club Price, $19.10

Mathematics for Electronics with Applications by H. M. Nodelman and F. W. Smith, Jr. Methods for solving practical problems.

Publisher's Price, $7.00
Club Price, $5.95

Epoxy Resins by H. Lee and K. Neville. Fully treats their modern applications and technology.

Publisher's Price, $9.00
Club Price, $7.65

How to Become a Professional Engineer by J. D. Constance. Authoritative guidance applicable in all states.

Publisher's Price, $6.00
Club Price, $5.10

Management for Engineers by R. C. Heimer, Practical know-how for the engineer-manager, covering every management area.

Publisher's Price, $7.50
Club Price, $6.40

Your engineering career owes a great deal to books. Why not take advantage of this convenient, economical way to have the best professional books available when you need them? THE ELECTRONICS AND CONTROL ENGINEERS' BOOK CLUB brings you the essential technical literature in your field. It also helps you overcome today's high cost of building a professional library *by saving you an average of 15% from publisher's prices.*

How the Club Operates. You regularly receive free of charge *The Electronics and Control Engineers' Book Bulletin.* This gives complete advance notice of the next selection-of-the-month, as well as many alternate selections. If you want the main selection you do nothing; the book will be mailed to you. If you want an alternate selection—or no book at all—you can notify the Club by returning the convenient card enclosed with each *Bulletin.*

Saves You Time and Money. You agree only to the purchase of three books in a year. Certainly out of the large number of books in your field offered in any twelve months there are at least three you would buy anyway. By joining the Club you save both money and the trouble of searching.

Send No Money Now. Just check the book you want as your first selection on the coupon below. With it you will be sent *Electronic Designers' Handbook* for only one dollar. Take advantage of this offer and receive two books for less than the regular price of one. (If coupon is detached, write to The Electronics and Control Engineers' Book Club, Dept. L-5-11, 330 W. 42nd St., New York 36, N.Y.)

ACCEPT THIS
$17.50 BOOK
FOR ONLY $1.00

with membership in The Electronics and Control Engineers' Book Club

ELECTRONIC DESIGNERS' HANDBOOK

By R. W. Landee, D. C. Davis, and A. P. Albrecht

Provides fundamentals and data to help you in the design of all types of electronic equipment. A large number of the circuits used in many different applications are covered, together with theoretical and technical discussions and explanations, design examples to show application of theory, and graphical and tabular data needed in day-to-day design work.

Electronic Designers' Handbook is typical of the selections of THE ELECTRONICS AND CONTROL ENGINEERS' BOOK CLUB. All books are chosen by qualified editors and consultants. Their thoroughgoing understanding of the standards and values of the literature in your field guarantees the authoritativeness of the selections.

NOTE: If you already own this volume, you may substitute any other book on this page as your DOLLAR book. Check two books below and you will receive the higher priced selection for only $1.00.

CLIP AND MAIL THIS COUPON TODAY

The Electronics and Control Engineers' Book Club, Dept. L-5-11
330 West 42nd Street, New York 36, N. Y.

Please enroll me as a member of The Electronics and Control Engineers' Book Club. You will bill me for my first selection indicated at right at the special club price and $1 for **Electronic Designers' Handbook** (or alternate choice), plus few cents delivery costs. (The Club assumes this charge on prepaid orders.) Forthcoming selections will be described in advance and I may decline any book. I need take only 3 selections or alternates in 12 months of membership. **(This offer good in U. S. only.)**

PLEASE PRINT

Name ....

Address ....

City .... Zone...... State............

Company ....

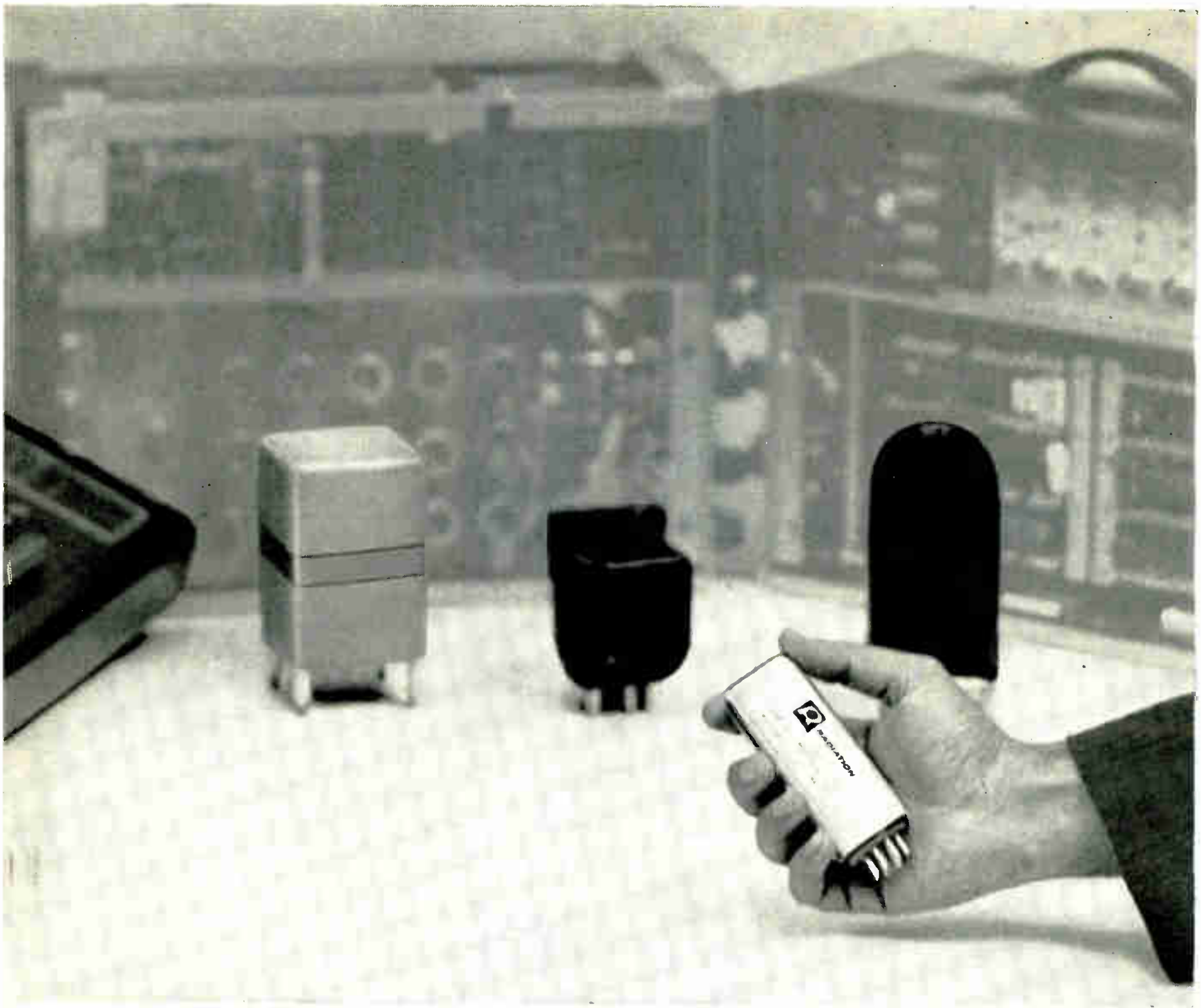
Send as my first selection: *(If more than one book is checked we will send the higher priced selection as your $1.00 book.)*

- ☐ Transistor Electronics, $7.65
- ☐ Electronics Digital Computers, $10.25
- ☐ Control Engineers' Handbook $19.10
- ☐ Mathematics for Electronics with Applications, $5.95
- ☐ Epoxy Resins, $7.65
- ☐ How to Become a Professional Engineer, $5.10
- ☐ Management for Engineers, $6.40

NO RISK GUARANTEE: If not completely satisfied, you may return your first shipment within 10 days and your membership will be canceled.

L-5-11

CIRCLE 41 ON READER SERVICE CARD→



END TELEGRAPH RELAY PROBLEMS...

Simply plug in Radiation's new Solid-State Telegraph Relays. They're designed to replace existing electro-mechanical units in standard teleprinters, telegraph and data circuits. They completely eliminate routine maintenance and tedious contact adjustment . . . eliminate costly down-time and service calls.

Radiation Solid-State Relays also offer considerable savings in new installations because bias supplies are not required for neutral operation. In addition, there's no need for expensive universal relays since *both neutral and polar* solid-state units are available. These compact relays operate at speeds up to 2,400 bauds with less than 3% bias distortion — at normal telegraph speeds with less than 1% distortion. Built-in circuitry protects against over-voltages, and Radiation's unique output bi-polar feature makes incorrect polarity connection impossible. The input impedance is essentially resistive, which permits series connection without danger of magnetic interaction.

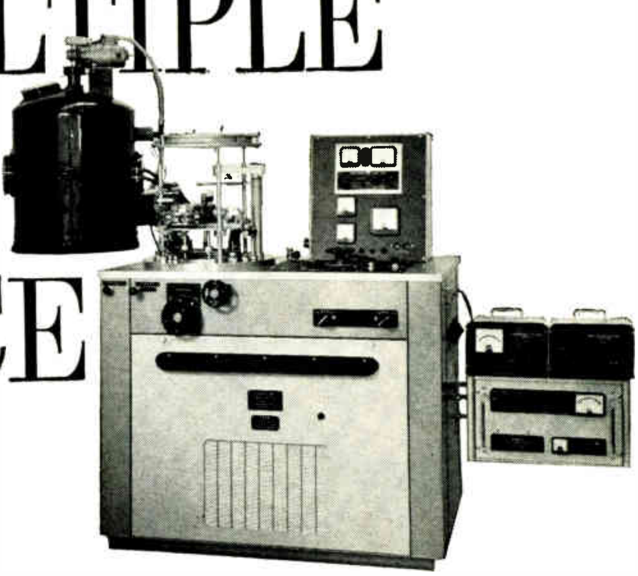
Write for our new brochure on Models 9210 (neutral) and 9211 (polar) Solid-State Telegraph Relays. If you wish, Radiation engineers will be glad to discuss application of these units in your present or planned system. Radiation Orlando, 5800 McCoy Road, Orlando, Florida.

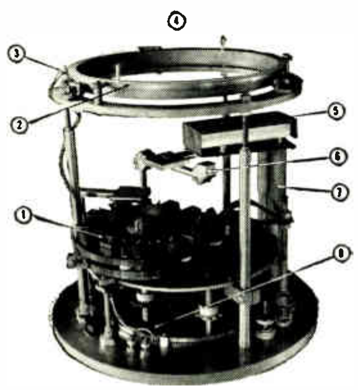
Radiation Orlando supplies the finest equipment available for commercial communication—distortion and data analyzers, test signal generators, and high-speed strip and page printers. The high efficiency of these units stems from Radiation's broad experience in research and design of advanced aerospace communication systems.

RADIATION
Orlando
A Division of Radiation Incorporated

FOR THIN FILM RESEARCH APPLICATIONS

VERSATILE MULTIPLE VAPOR SOURCE





1 MULTIPLE VAPOR SOURCES
2 ROTATING WORK HOLDER
3 SUBSTRATE TEMPERATURE THERMOCOUPLE
4 SUBSTRATE HEATER (not shown)
5 SPUTTERING CATHODES
6 FILM THICKNESS MONITOR
7 ION BOMBARDMENT CLEANING
8 CIRCULATING LIQUID NITROGEN TRAP

FOR COMPLETE INFORMATION ON EACH OF THESE SPECIFIC MODELS WRITE FOR BULLETIN E321-8.

"SPEEDIVAC"

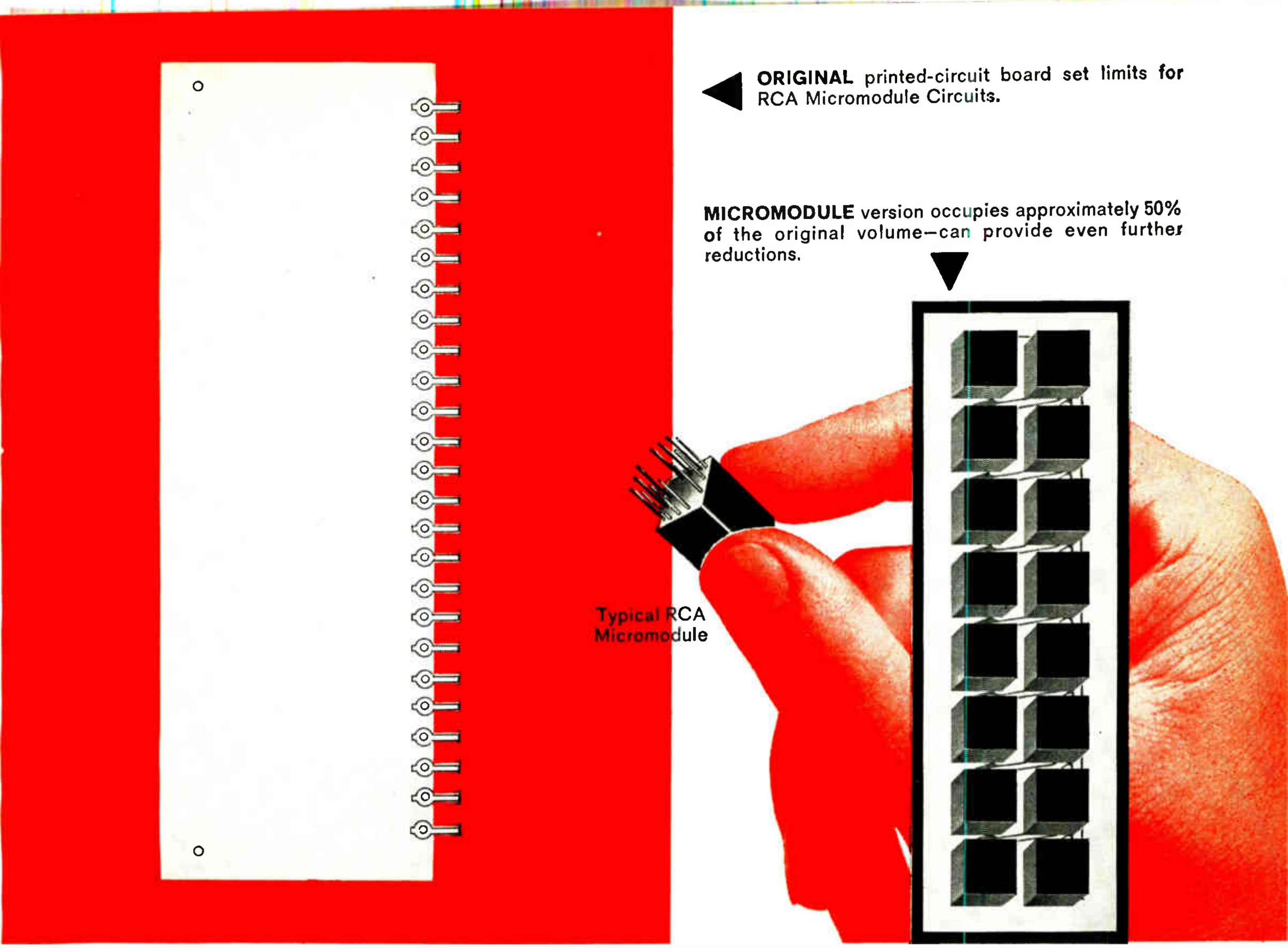
VACUUM COATING UNIT

The versatile model 19E6 production unit for evaporated micro-circuits, resistors, and capacitors features fast pump downtime and selection of accessories for almost any evaporation job. The proven Edwards design principles incorporated in this series assures fast, reliable evacuation and many years of dependable operation.

In addition to the many accessories included as standard items such as motor driven rotary work holders, multiple vapor sources, substrate heaters; optional accessories such as electron bombarded vapor sources, circulating LN^2 traps and film thickness monitoring are provided. Special jigs for the production of micro-circuitry and coated tubular resistors can also be provided to fit this highly versatile coater.

Four separate models make up the 19E series, each using a pumping system, power supply, cabinet and instrumentation common to all.

EDWARDS *HIGH VACUUM INC.* / 3279 GRAND ISLAND BLVD., GRAND ISLAND, N. Y.
MANUFACTURERS OF THE MOST COMPLETE LINE OF HIGH VACUUM COMPONENTS AND SYSTEMS



MICROMINIATURIZED IN 76 HOURS!
with RCA Micromodules
...and backed by 55,000,000 element hours of life-test experience

...THAT'S THE BREADBOARD-TO-OPERATION RECORD RCA ACHIEVED FOR THIS AVIONICS ASSEMBLY WITH RCA MICROMODULES.

In just 76 hours, RCA engineers—utilizing the broad flexibility of RCA Micromodules and the wide range of available microelements—made the complete conversion from conventional printed board construction to working Micromodule circuits. Here's the background of proof that makes RCA Micromodules today's answer to microminiaturization:

PROVED RELIABILITY: Over 55,000,000 element-hours of testing have been logged under the RCA Micromodule Reliability Program. Operating life tests demonstrate a mean time between failures for RCA Micromodules greater than 560,000 hours for a ten-part Micromodule or a failure rate per part of less than 0.018%/1,000 hours. (All modules were subjected to a series of military-grade temperature-cycling tests.)

BROAD CIRCUIT CAPABILITY: Under RCA's broad experience in Micromodule production over 200 basic circuits have been designed, built and tested. And new circuits are constantly being added. For example, five new computer Micromodules utilizing silicon transistors and diodes are now available for evaluation. The RCA Micromodule concept is highly compatible with anticipated advances in microminiaturization.

WIDE APPLICATION: RCA Micromodules have been designed into military FM receivers, a general-purpose automatic data processor, airborne digital computers, an inertial guidance platform, a digital differential analyzer, pulse-code modulation telemeter equipment and classified military applications.

LOWER COSTS: If you are looking for cost reductions as well as microminiaturization, RCA Micromodules can now show you the way.

CALL TODAY: Like to know how fast your circuits can be converted to Micromodules? Call your local RCA Office today for details on RCA Micromodules (and the RCA Micromodule Laboratory Kit for building prototype Micromodules in your own plant). For literature, write RCA Semiconductor and Materials Division, Commercial Engineering, Section E-19-NM-2, Somerville, N. J.

RCA Minimodules—miniature packaged circuits utilizing conventional components and transistors—can be supplied in large volume, in the form you need. Consider RCA your packaging headquarters for miniaturized circuits utilizing transistors, rectifiers, diodes. Practically any component you require can be packaged to your specifications by RCA Engineers.

RCA SEMICONDUCTOR & MATERIALS DIVISION FIELD OFFICES...EAST: Newark, N. J., 744 Broad St., HU 5-3900 • (Camden-Philadelphia Area) Erlton, N. J., 605 Marlton Pike, HA 8-4802 • Syracuse, N. Y., 731 James St., Rm. 402, GR 4-5591 • Baltimore, Md., EN 9-1850 • **NORTHEAST:** Needham Heights 94, Mass., 64 "A" St., HI 4-7200 • **SOUTHEAST:** Orlando, Fla., 1520 Edgewater Dr., Suite #1, GA 4-4768 • **EAST CENTRAL:** Detroit 2, Mich., 714 New Center Bldg., TR 5-5600 • **CENTRAL:** Chicago, Ill., Suite 1154, Merchandise Mart Plaza, WH 4-2900 • Indianapolis 5, Ind., 2132 East 52nd St., CL 1-1405 • Minneapolis 16, Minn., 5805 Excelsior Blvd., WE 9-0676 • Denver 11, Colorado, Continental Terrace Bldg., Suite 301, 2785 N. Speer Blvd., 477-1688 • **WEST:** Los Angeles 22, Calif., 6801 E. Washington Blvd., RA 3-8361 • (San Francisco Area) Burlingame, Calif., 1838 El Camino Real, OX 7-1620 • Seattle 4, Wash., 2250 First Ave. S., MA 2-8816 • **SOUTHWEST:** Dallas 7, Texas, 7905 Carpenter Freeway, ME 1-9720 • **GOV'T:** Dayton, Ohio, 224 N. Wilkinson St., BA 6-2366 • Washington, D. C., 1725 "K" St., N.W., FE 7-8500 • **RCA INTERNATIONAL DIVISION**, 30 Rockefeller Plaza, N.Y.20, N.Y. Cable Address: RADIOINTER, N.Y.

RCA The Most Trusted Name in Electronics

CIRCLE 45 ON READER SERVICE CARD

designers

specify crystal filters for ultra-selectivity/minimum space

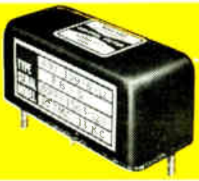
—and for your practical consideration, Midland recommends that electronic equipment be designed to incorporate a stock item wherever possible. Remember, the excellent rejection characteristics of the crystal filter, in addition to its stability and performance reliability, are achieved by many man-hours of detailed engineering and testing. Significant savings in cost and delivery time can be realized if special filters are not required. Shown below are stock items available for immediate delivery. For complete technical information, write to Midland Manufacturing Company.

TYPE NJ

Hermetically sealed, four-crystal, wide-band filters. Dimensions are 1-1/8L x 1-1/8W x 3/4H. Designed to withstand 100 g shock and 15 g to 2 KC vibration. Operating temperature range —55°C to +90°C. 40db/3db Band Width Ratio is 1.8.

TYPE	CENTER FREQ.	3db BW	40db BW	ULT. REJ.	INSERTION LOSS	INPUT-OUTPUT RES.	INBAND RIPPLE
NJ-1	7.2MC	160KC MIN.	300KC MAX.	60db MIN.	6db MAX.	13K	1db MAX.
NJ-2	7.4MC	160KC MIN.	300KC MAX.	60db MIN.	6db MAX.	13K	1db MAX.

TYPE FB

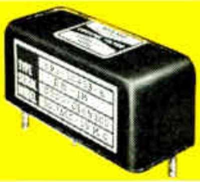


Hermetically sealed, eight-crystal, narrow-band filters. Dimensions are 2-3/8L x 1W x 1-1/32H. Designed to withstand 200 g shock and 15 g to 2 KC vibration. Operating temperature range —55°C to +90°C. 60db/6db Band Width Ratio is 1.8.

TYPE	CENTER FREQ.	6db BW	60db BW	ULT. REJ.	INSERTION LOSS	INPUT-OUTPUT RES.	INBAND RIPPLE
FB-5	10.7MC	13KC MIN.	23KC MAX.	105db MIN.	4db MAX.	1K	.8db MAX.
FB-5A	10.7MC	13KC MIN.	23KC MAX.	105db MIN.	4db MAX.	* 2K	.8db MAX.

* in parallel with 30 pf capacitor.

TYPE EB



Hermetically sealed, eight-crystal, narrow-band filters. Dimensions are 2-3/8L x 1W x 1-1/32H. Designed to withstand 200 g shock and 15 g to 2 KC vibration. Operating temperature range —55°C to +90°C. 60db/6db Band Width Ratio is 2.3.

TYPE	CENTER FREQ.	6db BW	60db BW	ULT. REJ.	NSERTION LOSS	INPUT-OUTPUT RES.	INBAND RIPPLE
EB-1B	10.7MC	15KC MIN.	37KC MAX.	70db MIN.	3db MAX.	1K	.5db MAX.
EB-2B	10.7MC	30KC MIN.	70KC MAX.	70db MIN.	3db MAX.	2K	.5db MAX.

TYPE EL-1B

Hermetically sealed, eight-crystal, narrow-band filter. Dimensions are 2-3/16L x 1W x 3/4H. Designed to withstand 200 g shock and 15 g to 2 KC vibration. Operating temperature range —55°C to +90°C. 60db/3db Band Width Ratio is 2.8.

TYPE	CENTER FREQ.	3db BW	60db BW	ULT. REJ.	INSERTION LOSS	INPUT-OUTPUT RES.	INBAND RIPPLE
EL-1B	11.5MC	32KC MIN.	90KC MAX.	90db MIN.	6db MAX.	50 OHMS	.5db MAX.

TYPE DL-1B

Hermetically sealed, four-crystal, narrow-band filter. Dimensions are 2-3/16L x 3/4W x 3/4H. Designed to withstand 200 g shock and 15 g to 2 KC vibration. 60db/3db Band Width Ratio is 6.3.

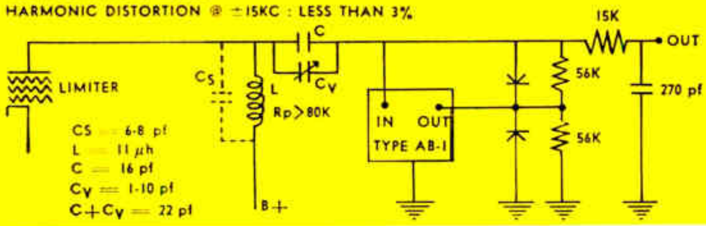
TYPE	CENTER FREQ.	3db BW	60db BW	ULT. REJ.	INSERTION LOSS	INPUT-OUTPUT RES.	INBAND RIPPLE
DL-1B	11.5MC	32KC MAX.	200KC MAX.	70db MIN.	4db MAX.	50 OHMS	.5db MAX.

TYPE AB-1 DISCRIMINATOR

Solder-sealed 1-1/8L x 1-1/8W x 3/4H case. Center frequency adjustment screw, bottom-center. Voltage output essentially linear from f_0 to ±15 KC. Recommended circuit for use with Midland Type AB-1 Discriminator is shown below.

CENTER FREQ: 10.7MC
ADJUSTABLE CENTER FREQ: ±4KC
FREQ. DEVIATION: ±20KC
HARMONIC DISTORTION @ ±15KC : LESS THAN 3%

RECOMMENDED CIRCUIT



Midland MANUFACTURING COMPANY
3155 FIBERGLAS ROAD
KANSAS CITY 15, KANSAS

world's largest producer of quartz crystals / division of Pacific Industries, Inc.

Silicon power transistors in a TO-37 package

Delco's unique new family of silicon NPN power transistors combines the benefits of miniaturization (TO-37) and light weight with the ability to withstand continuous junction temperatures of up to 175°C while operating at these absolute maximum ratings: collector diode voltage Vcb 100 volts; emitter diode voltage Vebo, 4 volts; collector current, 1 amp.; base current, .2 amp. This entire 2N2340 family is particularly useful where moderate power handling capabilities are required in a miniature package. The units have just two mounting holes and may be mounted with leads up, down or sideways on either side of the heat sink. Available in either single or matched units, they're characterized by low saturation voltage and high switching speeds. The transistors in this family are especially well suited for military or industrial applications in regulated power supplies, square wave oscillators, servo amplifiers and core driver circuitry. For complete engineering data, or applications assistance, write or call our nearest Sales Office or your nearest Delco Radio Semiconductor Distributor.

Number	IC Max.	Vcbo	Vceo	Sat. V @ IC Max.	Gain Min.—Max. @ IC	fae @ 250 ma IC (typical)
2N2340	1A	50V	40V	4V @ .75A	10— 40 @ .75A	900 kc
2N2341	1A	50V	40V	4V @ .75A	40—100 @ .75A	550 kc
2N2342	1A	100V	60V	3V @ .75A	10— 40 @ .75A	900 kc
2N2343	1A	100V	40V	2.5V @ .75A	40—100 @ .75A	550 kc

Thermal resistance of 8°C/watt max. Typical Alpha cutoff of 15 Mc

Rise Time of .2μ seconds—.75A, IB = 40 ma (Vce = 12V), Fall Time of .5μ seconds (IC = 0 Veb = 2v Reb = 37Ω)

Union, New Jersey
324 Chestnut Street
MUrdock 7-3770
AREA CODE 201

Detroit, Michigan
57 Harper Avenue
TRinity 3-6560
AREA CODE 313

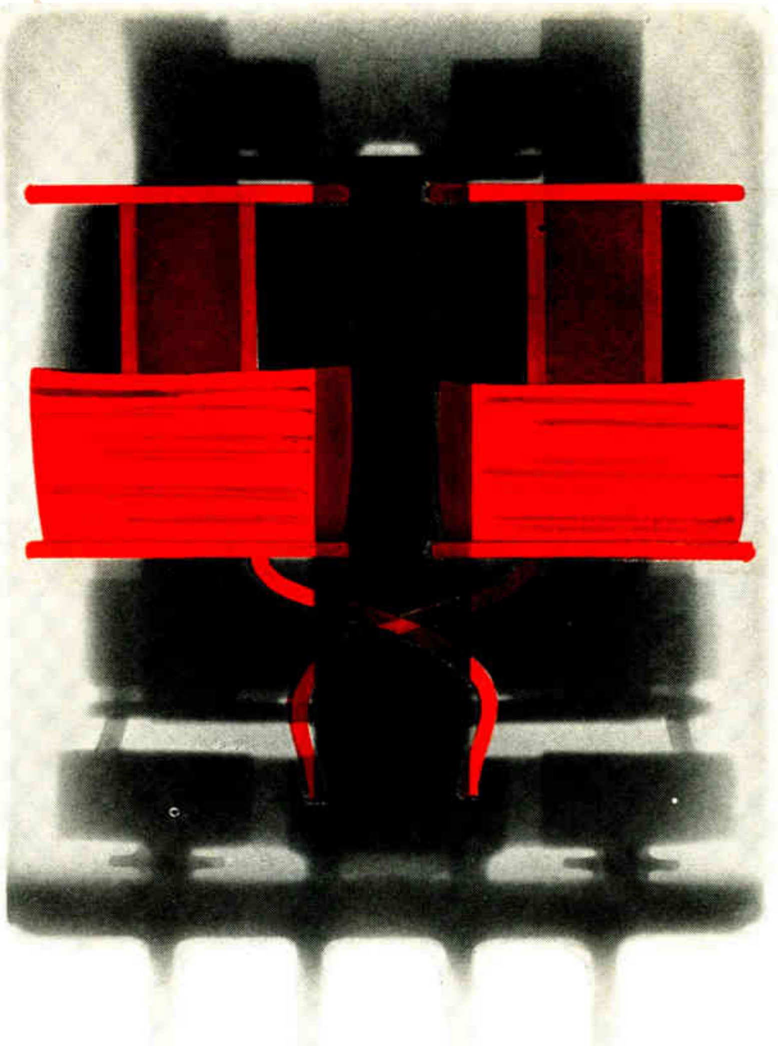
Santa Monica, California
726 Santa Monica Blvd.
UPton 0-8807
AREA CODE 213

Syracuse, New York
1054 James Street
GRanite 2-2668
AREA CODE 315

Chicago, Illinois
5750 West 51st Street
POrtsmouth 7-3500
AREA CODE 312

DELCO RADIO

General Sales Office: 700 E. Firmin, Kokomo, Indiana, GLadstone 2-8211—Ext. 500 • AREA CODE 317 • Division of General Motors



Injection-molded coil form of TEFLON® FEP helps subminiature relay meet tough specs

In this versatile subminiature relay, the coil form is molded of Du Pont TEFLON FEP-fluorocarbon resin. Because FEP resin is melt-processible, the coil form is rapidly and economically produced by injection molding. These coil forms require insulation resistance of 10,000 megohms minimum at temperatures from 65°C to 150°C. Babcock Relays Division of the Babcock Electronics Corp. found that Du Pont TEFLON FEP resin was the only practical material offering the necessary insulating characteristics over this range of temperatures. The new relay meets the rigid MIL specifications for virtually all aircraft and missile applications.

The molding of the coil form of a TEFLON FEP resin also made possible miniaturization of the relay—only 1.3″ high and slightly over one ounce in weight. And the stability of TEFLON at high temperatures eliminates the major problem of contact contamination by outgassing. The superior electrical properties of TEFLON are also utilized in tape and in lead wire in this relay.

This is another example of improved electrical design made possible by the new melt-processible FEP resins, which make TEFLON available in the form of easily molded components and in long, continuous lengths of extruded wire insulation. For more information, write: E. I. du Pont de Nemours & Co. (Inc.), Dept. E-511, Room 2526T Nemours Building, Wilmington 98, Delaware.

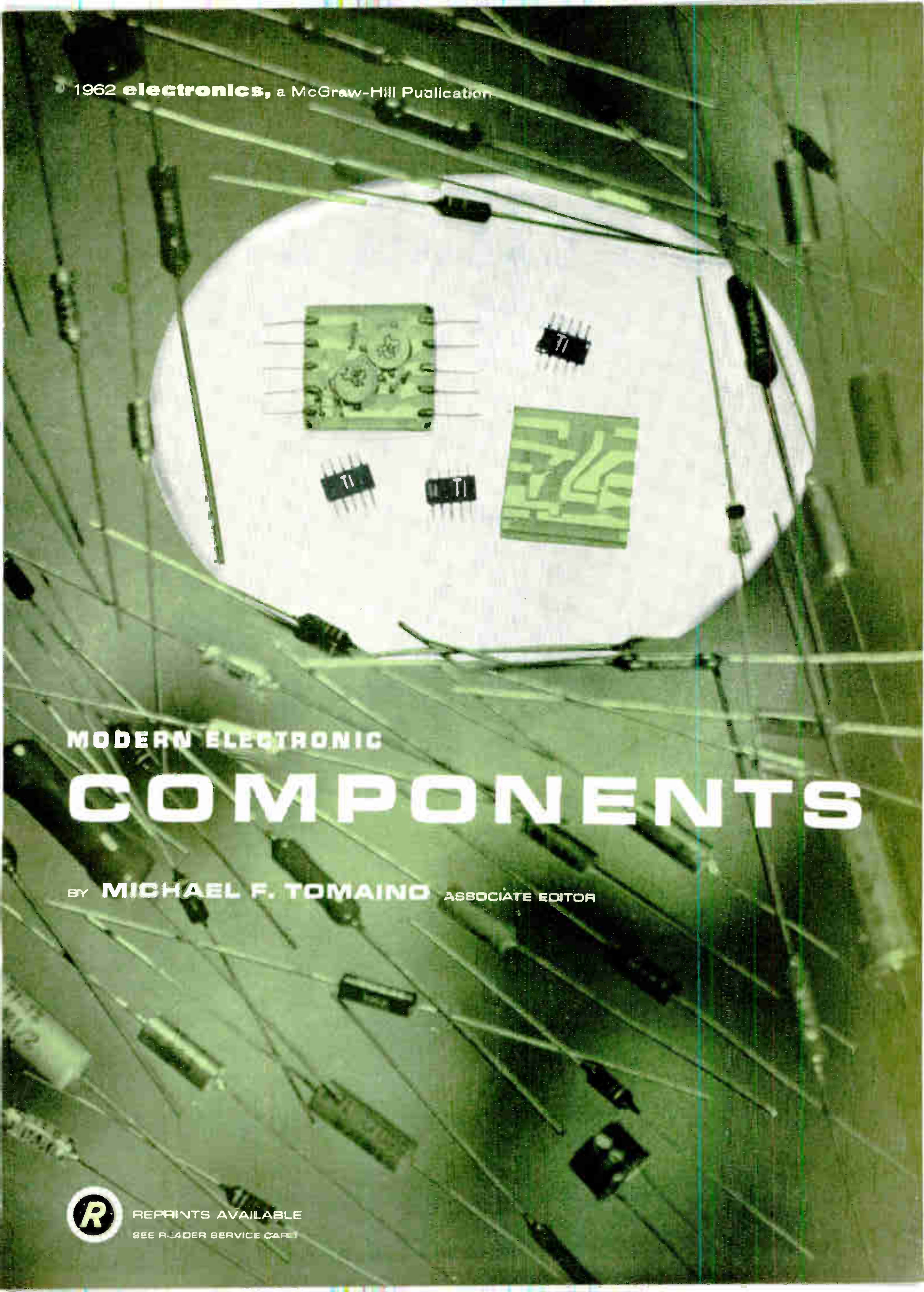
In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

DU PONT REG. U. S. PAT OFF

TEFLON® FLUOROCARBON RESINS

TEFLON *is Du Pont's registered trademark for its family of fluorocarbon resins, fibers and film, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins.*

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*



MODERN ELECTRONIC

COMPONENTS

BY MICHAEL F. TOMAINO, ASSOCIATE EDITOR

MODERN ELECTRONIC COMPONENTS

INTRODUC

DURING THE PAST DECADE, the component maker has been drawn into a materials technology that is now forged in the heat of epitaxial furnaces and vacuum-deposition chambers. He has been carried into research that now investigates over fifty important physical phenomena—from "acoustoelectric effect" to "zener effect"—covering five broad areas: electric, electromagnetic, magnetic, mechanical and thermal. And like the phoenix, (see upper right, next page) the component maker is resurrected in youthful freshness by his own action.

But unlike the phoenix, this has not been a sudden hop, it has been evolutionary. The results of this evolution are now so clearly apparent, that the change seems radical.

Most component makers have continually explored new electronic concepts, new fabrication techniques, and new disciplines. Having mastered a few of these techniques, many manufacturers now think not only of fabricating and selling individual components, but also of putting several circuit functions inside a single package.

THE INTEGRATED CIRCUIT is now important to many electronics engineers and component makers. A great deal of work in electronics today concerns techniques for putting integrated components into small encapsulated packages. And if it were now possible, some designers would wrap up the entire circuit in solid, homogenous blocks in which the individual component could not be recognized.

However clearly defined is the journey into the era of solid-state physics, improved miniature components of the electronics era may have to carry the main burden of use for many years to come, or at least until the vast scope of technical and economic problems are overcome.

While the lumped-parameter approach, and conventional circuit elements of electronics must be pushed to the limit, the functional block approach may lead to improving reliability by several orders of magnitude.

Right now, the functional block is an extension of semiconductor technology. But semiconductor effects are only a small part of the range of physical phenomena that can be put to work to perform the circuit functions of electronics.

Work also includes effects related to the dielectric properties of materials and transport phenomena for particles other than electrons or holes; and includes resonance effects described in discrete energy levels, rather than energy bands. Until recently, these effects have been applied singly or with one or two other phenomena to perform a small portion of the over-all system.

DEMAND FOR IMMEDIATE ACTION. Today, electronic technology is caught between two urgencies. The immediate need to supply electronic elements that can be incorporated into electronic systems, and the projected demand to meet space applications that may require exceedingly long mean-time-to-failure.

The latter demands will probably not be reached by

FRONTISPIECE ILLUSTRATION: From conventional components to functional blocks (Texas Instruments)

THE PHOENIX, in ancient mythology, was a gigantic bird who lived to a great old age. When he heard the rustle of death, he built a fire, hopped into it and was burned to a crisp. But rather than destroying himself, he arose from his own ashes, as good as new

Trade Sign of GoldSmith in Lombard St., London in the 17th & 18th century

TION

evolutionary improvements in existing devices.

In some applications, a departure is underway from classical components as we have known them. Functional blocks are already being offered to the electronics industry for analysis and evaluation.

The functional block is an inevitable development in the components part field, evolving from knowledge acquired in the wireless age, passing through the radio age and electronics age into the solid-state age.

Attention is now being focused on possibilities of yet undiscovered phenomena, and promising effects not yet exploited.

Significant progress has been made in surveying conventional electronic circuits to determine what basic circuit functions exist.

These functions have been analyzed and formulated into exact and workable mathematical expressions to develop future systems.

HYBRID SYSTEMS. While work towards all-solid-state systems advances, hybrid systems will be used that incorporate the most desirable features of all developments that have taken place to date.

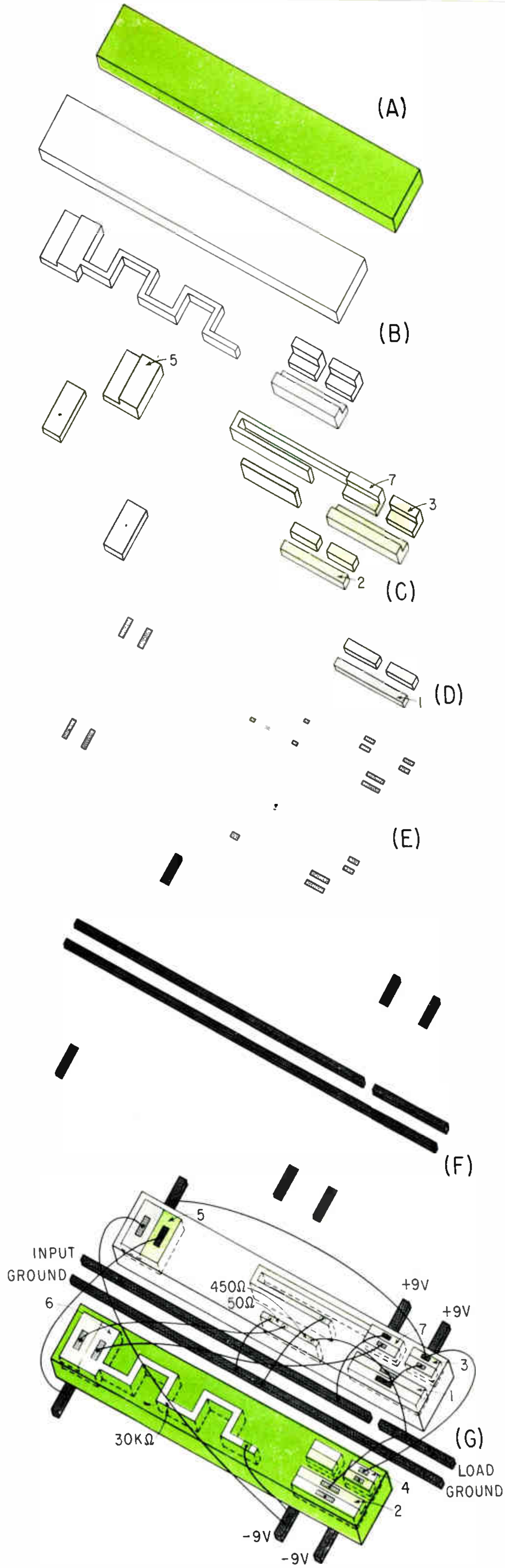
Whether integrated circuits, conventional components or both are used in a given application will depend on reliability and cost.

Whether we grow a radio in the laboratory, or whether we assemble it on the bench, will depend in the long run upon which method is the less expensive.

Given an electronic function, phenomena are explored to find the simplest possible combination in a solid block of material. After it is found, it loses its glamour and becomes just another device. As monies and man years are applied to the study of materials, new and compatible processes and techniques will be found to supplement present advances in our semiconductor materials approach.

R. D. ALBERTS, Chief
Molecular Electronics Branch
Electronic Technology Laboratory
Wright-Patterson Air Force Base, Ohio

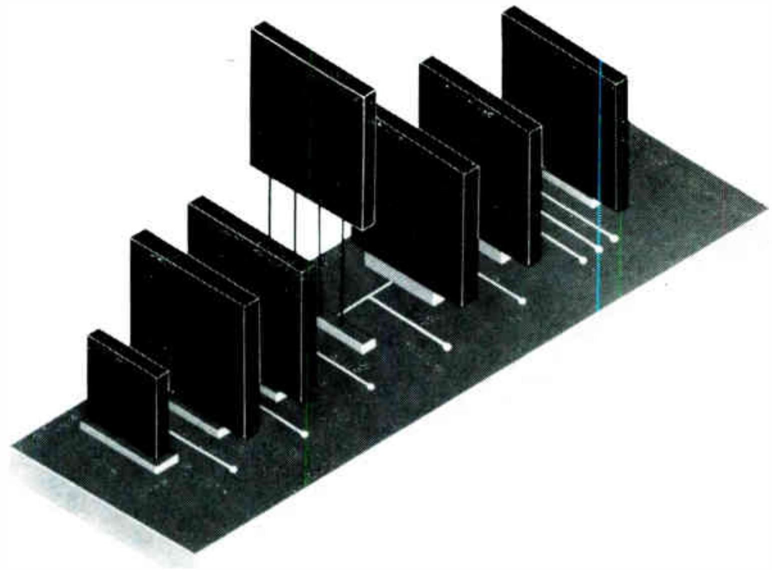
Electronic Technology Laboratory,
Wright-Patterson Air Force Base, Ohio



Steps (A) through (G) show how the functional electronic blocks for the amplifier circuit on the following page is constructed

ACTUAL SIZE

Basic components of a fixed-frequency radio receiver, in solid blocks, take up less than 1/10 the space and weight of equivalent circuits (Westinghouse)



THE SILICON BLOCK

THE SCHEMATIC (below) shows the circuit of a one-watt power amplifier that has a voltage gain of 10. It delivers full output power when driven from a high-level transducer, such as a microphone.

This amplifier has a high efficiency, since no bias current flows through the output transistors. Crossover distortion is eliminated and d-c is stabilized by output feedback to the predriver.

THE CONSTRUCTION (left) shows how the amplifier is fabricated in solid blocks. Diffused areas extend downward into the substrate.

The *p*-type silicon substrate (A) is approx 0.220 in. × 0.440 in. × 0.005 in. in size. Three *pnp* transistors in the circuit are all constructed on this basic *p*-type bar.

The *n*-type substrate and the first *n* diffusion into the *p*-substrate are shown in (B). This diffusion forms the base region for the *pnp* transistors and the 30,000-ohm resistive path used in the emitter circuit of transistor 7 in the schematic. Diffusion is down into the bar, and the diffused base regions are simplified.

In the next diffusion (C), the *P* emitters are diffused on the *p* substrate, the *p* diffused bases on the *n* substrate. The resistive path shown in the circuit diagram R_{in}, and the 50 ohm to 450-ohm voltage divider on the *n* substrate.

Diffusion (D) shows the *n* emitters on the *npn* wafer.

Gold contacts are then evaporated on all necessary areas of both bars (E).

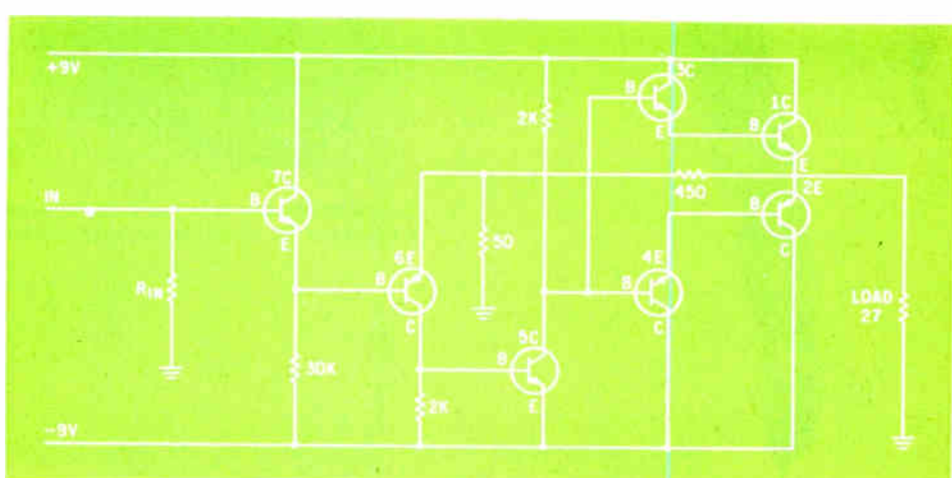
The gold bar leads are shown in (F).

Gold wire leads are then attached to the circuit by thermocompression-bonding techniques, shown in (G).

Transistors are numbered on both (G) and the circuit diagram, to simplify tracing the circuit.

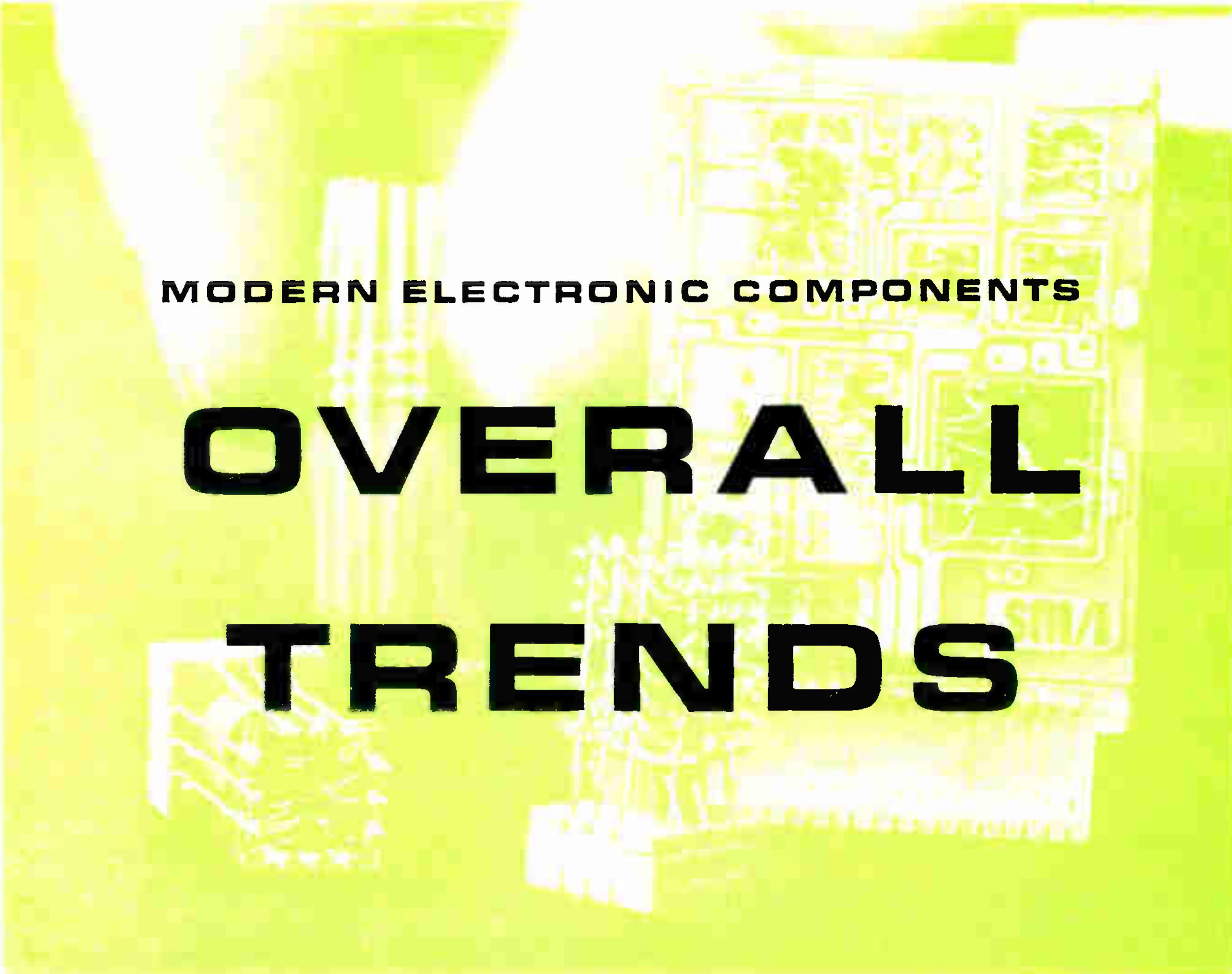
Both artist and engineer have taken liberties for clarity and simplification, and this introduction to the functional block should not be thought of as an exact reproduction of the actual power amplifier.

One-watt power amplifier

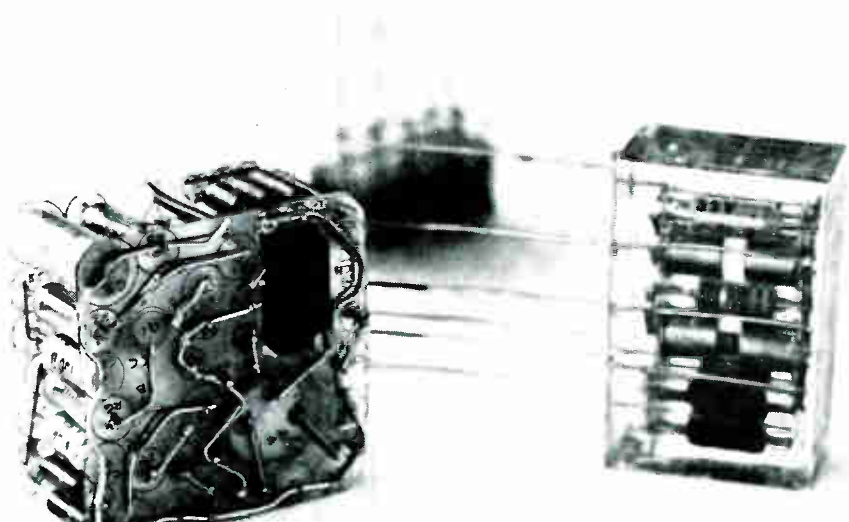


MODERN ELECTRONIC COMPONENTS

OVERALL TRENDS



Two different methods of assembling evaporated circuits. Vertical-stacking techniques (left) showing riser-wire interconnections; and planar inlaid technique (right) (Servomechanisms)



The welded module is in use in many missiles and space vehicles. Increased reliability is an advantageous aspect (Servomechanisms)

Binary divider in pea pod, showing degree of size obtainable using conventional components: 2,300,000 parts per cubic foot (Cleveland Metal Specialties)

MOST ELECTRONIC COMPONENTS used today consist of countless numbers and types of individual units, perfected and refined with technical skills and knowledge acquired over many years.

Most of these components have a documented history of circuit performance, with detailed data of failure rates. Reliability, cost, size, and weight were always considered.

The push into space emphasized construction techniques to put small circuits into limited space. A valuable lesson was learned. Saving came not only in size and weight, but in better performance. More reliable devices came in small packages.

HIGH-DENSITY PACKAGING. Several techniques emerged out of the enormous effort to 'go small'. Pack conventional components in high-density units using welding or use special modular components; print or vapor-deposit thin-films on flat insulating substrates; or form integrated circuits by borrowing semiconductor technology and diffuse or deposit elements on a semiconductor block. Call the techniques what you will, they all amount to arranging circuit elements with disciplined parts geometry that attain specific densities, with established reliability goals.

Presently, component-part densities of 2×10^8 equivalent parts per cu ft. can be considered a maximum for these microelectronic circuits or systems. Size reduction can also be established in circuit functions per cubic measurement.

Materials used in these constructions are extremely pure, immaculately assembled, and promise a high order of reliability. Use of silicon for the functional block affords thermal stability while silicon dioxide provides surface protection. Encapsulation of the package gives increased reliability, whatever the technique.

Right now, no single fabrication technique is superior in every way to any other. Nor is any one likely to be in the near future. A CTS Corporation survey revealed that each system designer must evaluate the available techniques, and choose for his own application.

The important consideration, following any approach, is to beware any technology for the sake of integration alone. Decisions should be based on expectation of improved performance and reliability. Says, J. M. Goldey of Bell Labs, "Expected benefits will come from devices that perform more complex functions." In many cases, it makes good sense to encapsulate different types of devices in a common, hermetically sealed package. More of these packages will be seen in the days ahead.

COMPONENT MAKERS PLAN AHEAD. Attitudes and plans of the component maker, as he attempts to satisfy requirements of the military, and the demands of the commercial market, are typified by comments from G. E. Pihl, Engineering Director of Miniature Electronic Components. "While hoped for potential for greatly increased reliability will come through advances in solid-state technology, miniature components will be accepted in a much wider market, and fill the gap until more solid-state devices are submitted."

These integrated circuits are used, and will be used in the future, only if they buy something, says Sprague's vice president B. R. Carlson. "We are working closely with customers for their needs now, and tomorrow, to develop what they want, not what we have to sell". Sprague sees an evolution towards the use of integrated circuits, but has increased its R & D budget to be ready for whatever happens. Their market is oriented towards large-scale use of discrete components, but with emphasis on high-density packaging, says Sprague's vice president C. G. Killen.

Even with the anticipated growth of integrated circuits, CTS Corporation does not expect demands to surpass 10 percent of their total sales within the next two years, according to their C. W. Hartman.

RELIABILITY MUST BE BUILT-IN, and must be more than a trial-and-error program that comes after the device has been developed. Reliability prediction studies should be written-in the program a priori, from knowledge or logic that deduces consequences before hand. Testing then presents factual evidence that establishes, verifies, and justifies the development.

Trends today emphasize reliability prediction at the earliest stages of design, and are normally based on knowledge of the materials used. There is a big push in programs that research the physics of failure mechanisms. In the days ahead, circuit designers will see reliability data on various high-density systems, similar to evaluation reports presented for RCA's micromodule.

Motorola, Raytheon, Clevite, General Telephone Labs, Hughes Aircraft and Sylvania are already involved in extensive government programs to test high-density systems, and establish the merits of thin-films and solid blocks. At General Electric, a long-range program is obtaining knowledge to set up systems that will generate reliability data faster, more accurately, and at a much reduced cost in dollars and man hours.

Autonetics has compiled some 521 references on reliability programs that emphasize reliability programs conducted in the past four years.

STANDARDS FOR HIGH-DENSITY CIRCUITS. There has been a lack of standardization in the approaches to high-density circuits. It is highly desirable to make a thorough study of needs for more detailed information that will guide the development and construction of devices into standardized channels, before costly equipment is set up.

Dimensional and reliability requirements fix the number of circuits that can be placed in a certain area, and each integrated circuit should be considered for cost goals.

DISTRIBUTION AND SALES. "While technology moves ahead with amazing acceleration, a big job lies ahead in providing information sources to help the design engineer ferret out new devices", says P. F. Carroll, president of Semiconductor Specialists, Inc. His firm is presently selling and stocking Fairchild's chip approach and their micrologic elements. They hope to stock Philco's thin-film circuits, and the molecular circuits of Westinghouse and Motorola. Two interesting questions face the distributor. How can he stock all the possible combinations? And how will he fit in to the process leading up to a complete integrated system?

Customers problems are: spasmodic deliveries; unkept commitments; specifying and enforcing reliability testing; and keeping up with the multiude of types available.

FIVE EXPERTS EXPRESS THEIR VIEWS ON

WHITHER ELECTRONIC COMPONENTS?

AN OLD TIMER LOOKS AT THE PAST AND POINTS

Today's wildest prediction may seem tame tomorrow. But we can forecast trends with reasonable accuracy by reviewing past experience.

Receiving tubes provide an example. In the early 1920's, tube trends demonstrated the emergence of certain objectives predominant in the minds of designers of active components: make them smaller, make them lighter, make them use less power, make them run hotter without impairing life or stability, make them so they can be produced to tighter tolerances, make them cost less, and more reliable.

Some of us remember the first pocket radio in June, 1940. It was the size of a small camera, and far ahead of anything produced up to that time. What made it possible? The design of a line of miniature button stem tubes without the old time phenolic-resin bases; the design of a line of miniature (for that time) i-f transformers; the small B battery; the miniature loud-speaker; and miniaturized two-gang tuning capacitor.

Here we see a continuation of trends apparent twenty years earlier.

Some of us, out of curiosity may have melted the wax out of a potted Radiola Semi-Portable Catacomb unit and not realized we were looking at one of the first modules.

Pressures to bring about today's components are much the same: make them smaller; make them run hotter; produce them to tighter tolerances; bring down the cost; more reliable.

Individual components will, for economic reasons, long prevail as strong leaders for the most economical circuit design in a majority of applications. They can be built to widely accepted industry standards, on highly automated production equipment and by the millions, or even billions.

But in many applications the low unit prices of standardized individual components will not in themselves spell overall economy.

Components are designed to be the servants of the apparatus of which they become a part. Electronic ap-

THE SEARCH FOR MORE RELIABLE ELECTRONICS SYSTEMS

WHERE HAS THIS TAKEN US AND WHAT WAS

In 1953, an Air Force team began a search for a new method of performing electronic functions simply and reliably. We were looking for functional components, that is, a solid block consisting of input, output and power-supply leads that would simply and directly provide a function such as oscillation, amplification, rectification and tuning.

Two people in one laboratory understood what we meant, but said that electronic technology hadn't advanced far enough to get a handhold on the problem.

Early in 1958 we placed basic research contracts with several universities, to create an environment of knowledge which would make breakthroughs more easily possible when the right gifted and talented individuals came along. A Georgia Tech contract was to catalog electronic properties of materials, and formulate these properties into mathematical equations. A University of Michigan contract examined Air Force function requirements and was to describe them by mathematical equations.

In the summer of 1958, first Westinghouse and then later Texas Instruments independently proposed methods of obtaining electronic functions by semiconductors, without using an assembly of resistors, capacitors and transistors. Silicon wafers would be processed to achieve various active and passive regions through alloying and diffusing the semiconductor surface so that the circuit function could be performed in a solid block. Each company was willing to commit a considerable portion of their resources towards the solution of the Air Force problem, and contracts were established with both companies.

During the latter part of 1958, we could not speak of the Westinghouse and Texas Instruments interests because they were proprietary. Few people were willing to accept the concept as a possibility, or if accepted, considered that it would take one or two generations to develop and make practical.

As time went on, more information was made available through scientific symposia and there was a slow but marked change in attitude.

Recently, a company who was positive that functional electronic blocks would not work assured me that their management was now behind the concept, and they were willing to commit a fair share of their resources towards applying these methods.

Last fall, Texas Instruments demonstrated a miniature computer based on the functional block, and recently Westinghouse constructed a military receiver that does utilize to a considerable extent the linear type of functional block.

While a considerable portion of the job has been accomplished, most of the pick-and-shovel work is yet to be done. To date, functional blocks have been built around semiconductor technology. This meant early, rapid progress because processing techniques were already established by transistors and diodes.

In the future we will utilize many other materials that have interesting electronic properties. Efforts have been made toward this end but we cannot delay immediate application making use of semiconductors.

First and most rapid application of functional blocks will be in computer and data-processing systems, since the non-linear type of functional block is easier to construct and stabilize than linear types.

Industrial organizations have been encouraged to introduce these concepts into consumer product lines. If they can do this, they will indeed be strongly profit motivated.

OVERALL TRENDS TO THE FUTURE

paratus is growing in variety and complexity at an extraordinary rate; it must be capable of meeting more and more rigid standards of reliability. In many applications, small size will be worth a premium.

Components may have to perform under environmental conditions beyond what presently prevail.

With components frequently representing more than half the factory cost of electronic apparatus, a large share of the burden for future improvement is on the research and design engineers in the components industry.

EDWARD W. BUTLER,
Vice President, Marketing
Speer Carbon Company, Inc.

ACCOMPLISHED?

Size was not the motivating criteria leading to this technology, it was reliability. Size reduction is immediately apparent, so perhaps it is for this reason that people have confused the functional block with microminiaturization of components.

Present trends towards Air Force Systems sophistication imply an urgent need for several orders of improvement. The reliability of conventional component parts and assembly techniques, even with marked improvements, falls far short of that required. Although the present functional block is not the ultimate, it is a big step in the direction we seek.

Today our leading universities are now participating in materials research programs that involve many millions of dollars. Scientific objectives lie in four active fields considered likely to lead to important electronic devices: magnetic and low-temperature research; semiconductors and their applications to devices; electronic materials development and preparation; and solid-state structure studies by advanced techniques.

HARRELL V. NOBLE,
Technical Director
Electronic Technology Laboratory
Wright-Patterson Air Force Base, Ohio

NEW DIRECTIONS

AT THE CROSSROADS

Today in electronics, we see the results of an evolution that has been going on for at least 20 years.

Semiconductor technology, along with other technologies yet to be developed, will be the basis for even further improvement of microminiature circuits.

However, at this time, it is not technically feasible, economically practical, or strategically advisable for the science of electronics to abandon sound evolutionary progress.

The need for a maximum miniaturization in some of today's more advanced applications is clearly understood, but extreme miniaturization is by no means a universal requirement in military electronics.

My own company, in 1954, produced a flip-flop consisting of 18 separate parts, giving a component density of 10^5 parts per cubic foot. Todays circuits, approaching 10^6 parts per cubic foot, are being produced in quantity for both military and commerical use. Recent work on planar microcircuits using ceramic substrates has made possible combinations of 14 to 22 components with densities as high as 2.6×10^6 per cu ft. This, perhaps, is only a beginning.

There is talk of molecular circuits with densities as high as 10^7. Higher densities may be obtainable because the ultimate theoretically density of these circuits is related only to the particular combination of circuit parameters desired, and not to the equivalent number of components required to perform the same functions in a conventionally assembled circuit.

As we move into the function-oriented approach, we recognize several serious difficulties. Circuits have to be operable over the whole range of component tolerances needed, but these tolerances are difficult to control in the present state of the molectronic art.

Undesirable interactions between the subfunctions of the circuit may also be a problem. Suitable values of certain parameters, such as large inductances and capacitances, are now difficult to obtain. The solid semiconductor circuit is expected to be more temperature-sensitive than other systems. We are still far from possessing the capabilities required for a large majority of the complex equipment in either military or commercial use today.

The economic aspects of integrated circuits are even more important. Cost will depend upon large production runs of identical devices. We, in the components manufacturing business, have been trying for many years, but without notable success, to bring about greater standardization of components in the interest of both economy and reliability. Is the industry now willing to standardize, in wholesale fashion? Specialized knowledge will be required to produce solid circuits.

These and other problems will, in time, yield to the scientific ingenuity and engineering skill for which the electronics industry has been famous.

We must now, as components people, make decisions as to which road we will take: miniaturized packaged circuits, the planar approach, or the use of solid block with substantial numbers of discrete parts until truly homogenous circuits.

Except for specialized applications, the miniature package will be the first widely used approach. As the planar approach is further developed, its use will be combined with packaged assembly techniques to produce circuits of even higher densities than are now possible. The functional block will be adopted in an increased variety of applications. However, the important thing is that all three approaches will develop along parallel lines, and will complement one another.

There will continue to be a place in the evolution of electronic circuits for the less spectacular, but vitally important work of the component development engineer, and the improved parts which he will make possible.

As components people, we must broaden our competence in the newer areas of thin-film and semiconductor technology. Manufacturers of components are challenged in this area. If we meet the challenge, the shape of the electronics industry as we know it today will not change dramatically during the next decade.

ROBERT C. SPRAGUE,
Chairman and Treasurer
Sprague Electric Company

a—Excerpts from a keynote address delivered at the 1962 Electronic Components Conference, Washington, D. C., May 8.

THE MICROELECTRONIC SPECTRUM

The electronic road ahead will be paved with complex miniature devices. New circuits in solid blocks will result in new families of devices that amplify, switch, conduct, store, and resist the flow of electrons by synthetization of useful elements. Much of this technology is still in research, and it may be several years before common usage in systems is possible.

Right now, the electronics engineer is offered a great variety of miniature devices that use conventional circuit functions. The welded module improves the weight factor only somewhat, but size savings of two to one are normally achieved. Direct experience indicates an increase of reliability of about ten to one over soldered circuits.

Thin-film circuits are now competitive with some welded assemblies. Statistical proof of reliability should govern a decision to use this technology in applications that require low failure rates. This information is accumulating. Fabrication is best adapted to information and data processing, with limitations in power handling capability. Right now, the thin-film approach is not adaptable for requirements of extremely tight tolerance in passive elements.

Use of a semiconductor substrate to form a conventional circuit function has similar advantages and disadvantages.

Giant steps will be taken in approaches which eliminate conventional components. A new family of thin film magnetic devices for digital components demonstrates operation by interatomic action within the material. Digital information is fed into a strip of magnetic film and moved down the film by an associated clock wiring system, and read out the end. Action is accomplished by magnetic-domain switching. These shift-register devices are in pilot production, ready for applications in systems.

An approach to analog computation makes use of an electronic amplifier driving a servo motor which drives a variable resistive element through a gear train. The solid-state approach substitutes a thin film of electroluminescent material for the motor and input voltage generates light instead of mechanical torque. At the output end, photoconductive film converts light into variable resistance as a replacement for the mechanical motion of the conventional potentiometer. This technology, just emerging from research, should be ready in about a year.

A magnetic thin-film parametron can form all common digital logic elements. It should display the same order of reliability as the shift register, but has added virtue of providing power gain so that one element may feed several others. This technology, now in research, may take several years to achieve common usage.

Longer range trends in more efficient and more reliable circuits may be reached through bionics to establish mechanisms of data sensing and data processing evolved by nature. Useful hardware can be developed within five to ten years.

Space applications requiring reliable performance of three years or about 26,000 hours (compared to 1,500 hours achieved today) will be accomplished only by radical changes in technology and break-through developments.

R. F. REDEMSKE, Vice President
Research and Development Center
Servomechanisms, Inc.

THE ROLE OF THE CIRCUIT DESIGNER

For the circuit designer, accustomed to spelling out his circuits and equipment designs in more conventional diodes, transistors, capacitors, resistors and inductors, the problem is now presented of approaching systems design from a block function viewpoint, since conventional component functions are now emerging into a single identity.

However, we have witnessed only the bare beginning of a snowballing technological change that will find an increased number of circuit functions accomplished within a single functional block.

For the component designer, traditionally concerned with only a small portion of the over-all problem of circuit interaction within a piece of equipment, the problem is now presented of analyzing and segmenting circuit functions so that functional block embraces combinations.

An attempt to draw a hard and fast line that delineates the equipment designer's role and the functional block designer's role will result only in needless conflict between the two groups. Each group will jealously guard its presumed prerogatives over its traditional sphere of influence, while at the same time attempting to extend its cognizance over a greater area of the over-all problem.

The delineation between systems designer and functional block designer will remain somewhat fluid.

With this new design dimension it becomes possible to redistribute effectively electronic functions into existing mechanical contrivances that are still a necessary part of any system.

Volume controls that incorporate preamplifiers are an excellent example of the marriage that can now take place between functional electronic blocks and other electromechanical devices (soon to be announced). This example is only one illustration of how the electronic function may be packaged with its natural mechanical partner. Many more such examples will immediately come to mind.

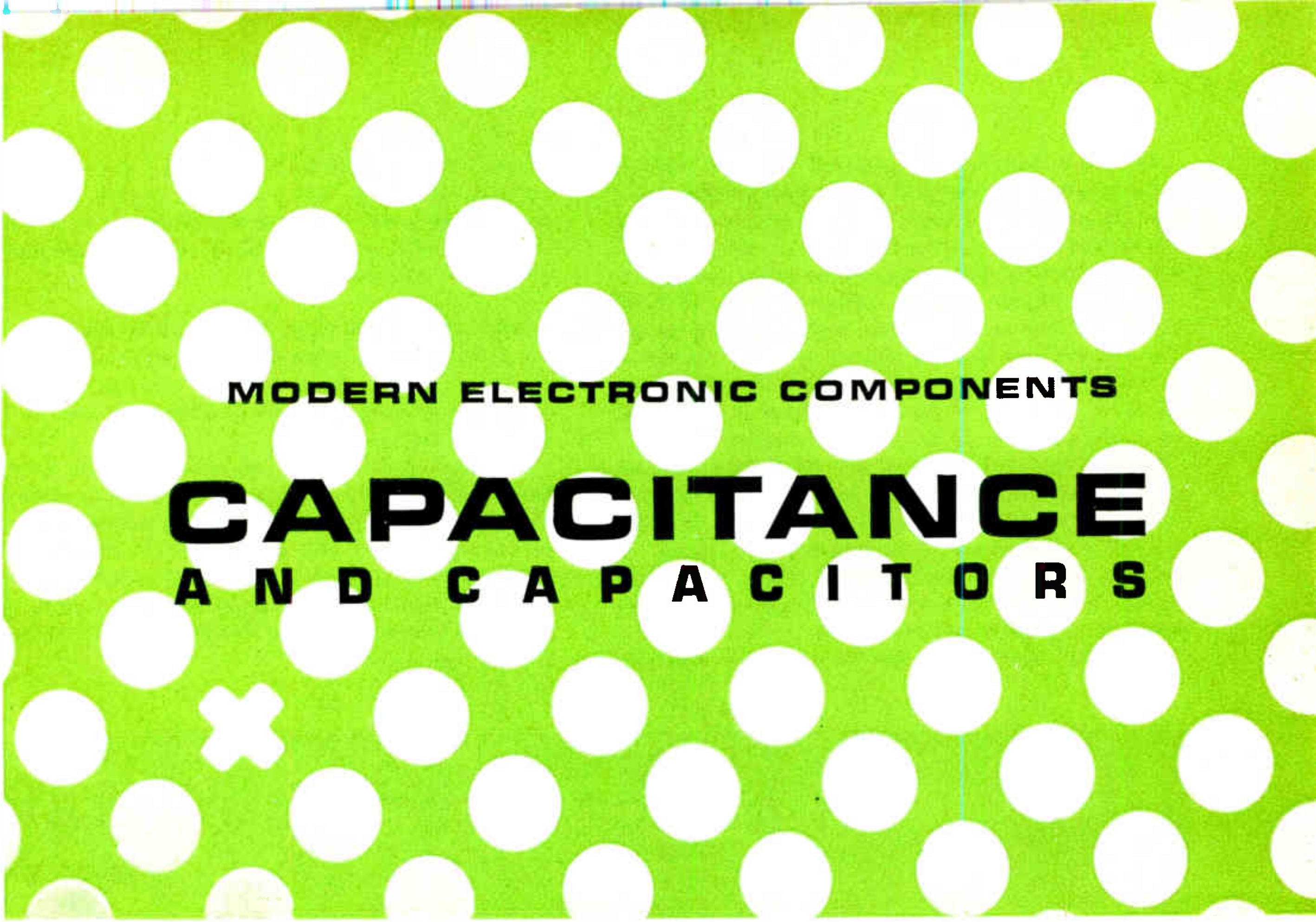
Functional electronic block kits, now available, provide the systems designer with basic functional components of a radio receiver. Intertwining of disciplines is found at MIT, in the joining together of efforts of the materials application section of the insulation research laboratory, computer components and systems group, energy conversion laboratory, and the materials application section of the electronics systems laboratory under a program entitled Molecular Science and Molecular Engineering.

One aspect is clear. There is a new interdependence between components designer and equipment designer. How complete will be the marriage of these two skills will depend to a large degree upon the specifics of a situation. One thing is sure—functional blocks are here to stay and will effect a dramatic change in the components business of the future.

F. M. HEDDINGER, Manager
Molecular Electronics Department
Westinghouse Electric Corporation

MODERN ELECTRONIC COMPONENTS

CAPACITANCE AND CAPACITORS



Enlarged portion of a slice of silicon on which an array of silicon-dioxide microcapacitors has been formed by a combination of photolithographic and diffusion techniques. Dice is sliced and individual capacitors used in microcircuits (General Instrument)

THE FIRST FACTOR to be considered in the selection of capacitance elements, is the capacitance required, and for critical work, tolerance limits for this capacitance. The rated voltage that the capacitor must take is next, and then the special electrical and environmental characteristics that apply to eventual use.

Once performance is defined and basic parameters are resolved, the final decision usually involves the acceptance of known fabricators, their materials, and data that can spell out reliability.

It is therefore important that the circuit designer understand what dielectrics can do. He must always reach a balance between overall performance requirements and cost.

Facts and data are available to enable understanding of conventional capacitors[1], and their selection (see tables pgs. 62, 63, 65). From there on, the designer should keep informed on new materials.

POLYESTER FILM introduced by Eastman Chemical (called Tenite, see p 66) makes possible the manufacture of a capacitor without casing. Since the casing represents a major part of the cost of a conventional capacitor, uncased units promise substantial savings. The polyester dielectric functions unprotected under severe as well as normal ambients. Units are small and light.

With these films, normal capacitance variation is ±2 percent, which makes them premium units without sorting. The material's 2-percent heat-distortion temperature is 170 C, which is about 10 deg greater than conventional polyester types. Dielectric constant is about 3.1 and it shows virtually no change up to 110 C. Increasing the temperature to 150 C raises the dielectric constant by only 15 percent. Dissipation factor of the film is low and shows superior uniformity over a wide range of temperatures. Dielectric strength is 8,700 volts per mil, at 60 cycles and 500-v per sec, measured on ½-mil film, and volume resistivity of 1.0×10^{17} ohm cm.

TANTALUM THIN FILMS are electrolytically oxidized to form a high-purity film of Ta_2O_5 which makes a stable, low-loss dielectric for thin-film capacitance elements. At General Instrument, the tantalum film is first deposited to leave enough tantalum behind for one electrode. Anodizing is performed in an acid bath. Areas not to be anodized are protected by a mask, and anodization is continued until the leakage current is negligible.

A capacitor is formed by depositing a counter electrode by evaporation over the Ta_2O_5 film. Electrode may be aluminum or gold, and may be extended to contact other parts of the circuit. A bridge between the Ta and Ta_2O_5 regions is preferred for small capacitance values. Values from 10 pf to 0.1 μf are manufactured to cover the useful transistor operating range, higher values are possible. Leakage currents are of the order of 10^{-8} ampere per μf volt. Capacitance is about 1.5 μf/per in^2 volt.

At Texas Instruments, sputtered tantalum resistors and capacitors are deposited and formed simultaneously from the same film. Complete passive circuits are highly reliable and readily miniaturized. The circuit is anodized to form capacitor dielectrics and to adjust resistors to value. Capacitance working voltage products of 30-40 pf-volts/mil^2 are easily obtained with dissipation factors of a few per cent and d-c leakage of 0.001 ma/per μf at 25 C. These capacitors are rated at ½ formation voltage up to 85 C and ⅓ formation voltage at 125 C and are nonpolar up to 20 percent of formation voltage.

Fansteel spokesmen believe that the tantalum capacitor will continued to play an important role in electronic circuits. Tantalum is needed for filtering, or where relatively large values of capacitance is required. In research, Fansteel is studying and testing columbium capacitors, aim to raise working voltages of solid-state capacitors and semiconductor diodes.

Deposited capacitors in the Varo microcircuits have values from 15 pf to 0.15 μf, nominal accuracy of 20 percent and voltage rating 30-v d-c typical. Miniature tantalum, ceramic, and glass capacitors can be attached to the substrate for larger values, higher voltage ratings and closer tolerances.

SOLID ELECTROLYTIC TANTALUM capacitors for the Signal Corps' micromodule perform beyond specified requirements, and will provide high values of capacitance for operation at temperatures ranging from −80 to 125 C without voltage derating.

Technical skills, production techniques and controls have been acquired at Sprague to mass produce miniature electrolytic capacitors. This program originally started as one of three parallel government efforts to prepare solid, polarized capacitors hermetically sealed in a metallic case. Units are intended for coupling, bypass, and filtering applications and in low-voltage applications requiring high stability.

CHARACTERISTICS OF CAPACI

DIELEC

Characteristic of Capacitor		Electrolytic Aluminum	Tantalum Wet Anode & Foil	Tantalum Dry Anode	Paper	Mylar	Paper-Mylar (Comb)	Polystyrene Mylar (Comb)	Metalized Paper
Cap	Capacitance Range in µf	0.5—150,000	0.2—1250	0.25—330	0.001—200	0.01—20	0.01—30	0.001—1	0.01—20
	Tolerance Standard %	+50, +100, +150 −10	+10, +20, +75 −10	±20	±20	±20	±20	±10	±20
	Tolerance Minimum %	±25	±15	±5	±2	±1	±2	±1	±5
Volts	DC Operating Volts	2.5—500	3—150	6—35	50—200,000	50—1000	100—15,000	50—1000	50—600
	AC 60 cps Operating Volts	40—320 Intermittent duty	Limited	Limited	50—75,000	Seldom used	Seldom used	Seldom used	25—250
DF	Dissipation Factor % at 60 cps	6—35, depending on voltage	(120 cps.) 10%, foil varies with C and V	At 120 cps 10% max	0.2—0.5	0.3	0.3	0.1	0.4—0.6
	% at 1,000 cps	—	—	—	0.2—0.5	0.5	0.5	0.2	0.6—0.8
	% at 1MC Low Capacitance Values	—	—	—	Higher; varies with type	Relatively high	Relatively high	0.75	Relatively high
IR	Insulation Resistance Megohm/µf at 25C	Leakage current (ma.) .006 × √CV	Leakage at 25°C .02 µa/µf/volt	Leakage at 25°C .02 µa/µf/volt	3000—20,000	50,000	20,000	>50,000	600—1,200
	Insulation Resistance at 85C compared to 25C	Leakage current 4 × 25°C value	Leakage current 4 × 25°C value	Leakage current 10 × 25°C value	1/100	1/25	1/40	1/20	1/60
TEMP	Operating Range C	−40 ±85	−55 +125	−55 +125	See Table 1	−55 +150	−55 +125	−55 +125	−55 +125
	Coefficient TC in % or ppm	Cap. drops from 30-60% at −40C	Cap. drops from 12-50% at −55C	Cap drops 12% max. at −55C	See Table 1	See Table 2	See Table 2	See Table 2	See Table 2
STABILITY	Capacitance Change With Temp Aging	Relatively large	Large ±25	Medium ±10	Medium	Medium	Medium	Medium	Medium
DA	% Dielectric Absorption at 25C	—	—	—	0.6—3, depending on impreg	0.5	0.9	0.3—0.5	—
SIZE	Size Varies as	CV approx	CV approx	CV approx	CV²	CV²	CV²	CV²	CV²
	Size for Equivalent Current-Voltage Rating	Very small	Very small	Very small	Medium Small	Small	Medium Small	Large	Small
	Per KVA 60 cps	Small for intermittent duty	Small for intermittent duty	Small for intermittent duty	Small	Seldom used	Seldom used	Seldom used	Not used
	Per KVA 1MC	Not used	Not used	Not used	Not used	Not used	Not used	Not used	Not used
COST	Relative Cost for Equiv C-V Rating	Very low	Moderate	Moderate	Low	Moderately high	Moderately high	Moderately high	Moderately high
	Relative Cost per KVA 60 cps	Low for intermittent duty	Not used	Not used	Low	Seldom used	Seldom used	Seldom used	Not used
	Relative Cost per KVA 1MC	Not used	Not used	Not used	Not used	Not used	Not used	Not used	Not used
MIL SPECS	Specs: MIL-C-	62	3965	26655	25	19978	14157	None	11693
	MIL-C-	3871			91	27287	19978		18312
	MIL-C-				11693				
	MIL-C-				12889				

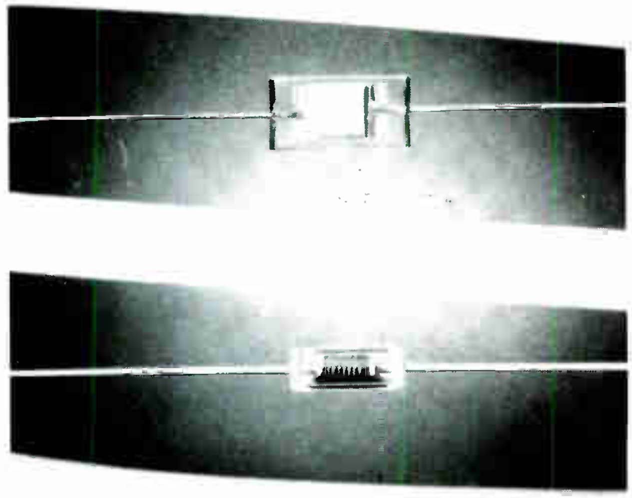
Source: Cornell-Dubilie

Values and ranges shown herein are generally typical or average. However, actual limits, in practice, may be considerably more (or less) depending on the specific application or requirements

Reliability of the solid tantalum capacitor increases with time under load, perhaps indefinitely. At Kemet, a 75-volt solid tantalum unit is available in values up to and including 15 microfarads in tolerances of 20, 10 and 5 percent. These units operate from −55 to plus 125 C.

HIGH K BARIUM TITANATE ceramics cover a capacitance range up to 1,000 picofarads. Techniques used at Chem-Electro Research, accurately cut ceramics into small pieces, maintain high percentage yields. Axial lead configurations have flat-ribbon leads, are made of gold-plated Kovar for either welded or soldered connections. The ceramic capacitor body is moisture protected, body diameter is 0.060 inch.

Philco has been working with single-crystal films of Ba-Sr titanate, formed with domains oriented perpendicularly to the interface. These high-k thin-films are being studied as coupling elements in miniature circuits and in switching.



Rectangular component is a fusion-sealed glass dielectric capacitor. Tubular component is a fusion-sealed precision tin-oxide film resistor. Background field is helix of the resistive tin-oxide film on a 1,000 watt resistor (Corning Glass)

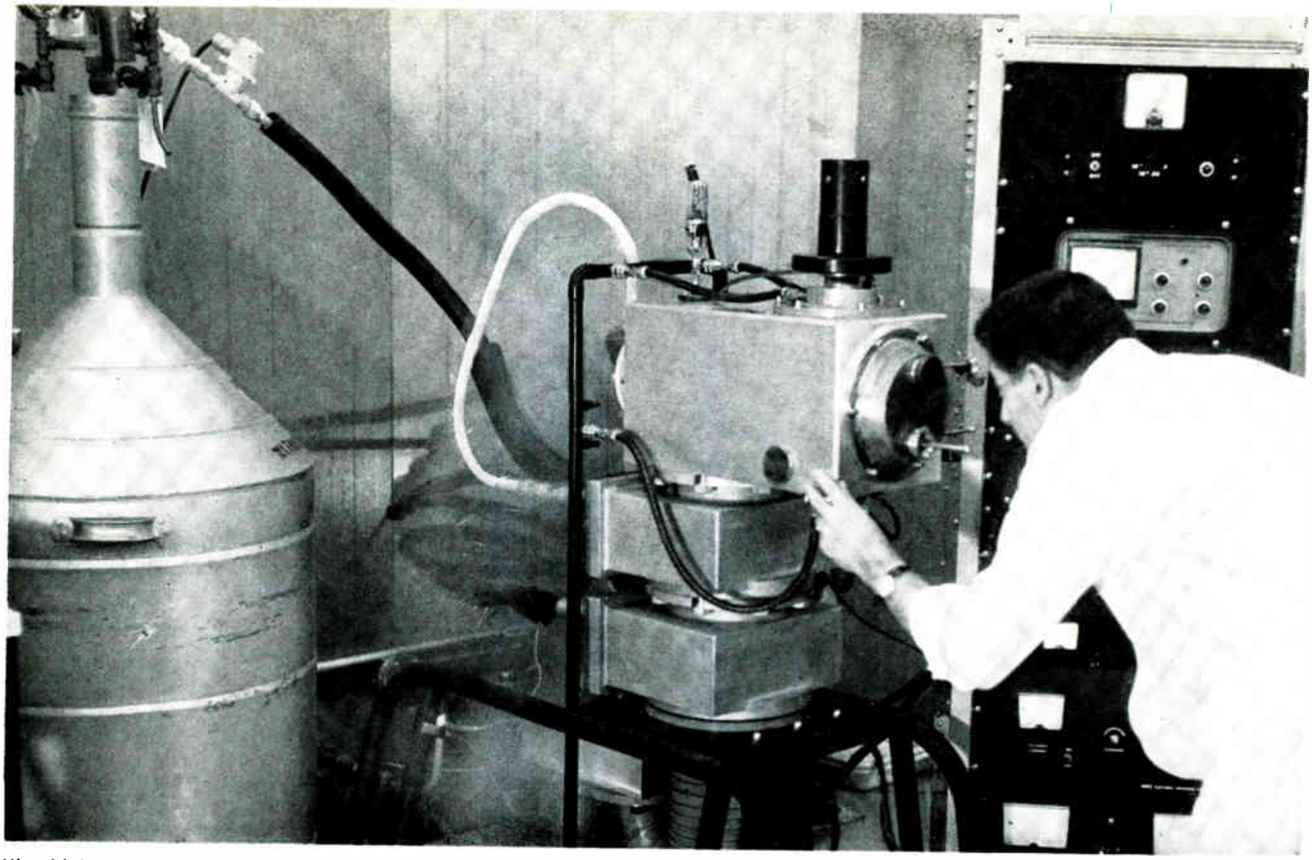
TORS AND THEIR DIELECTRIC TYPES

RICS

Metalized Mylar	Metalized Paper-Mylar (Comb)	Low Voltage Ceramic	General-Purpose Ceramic	Temperature Compensated Ceramic	Polystyrene	Teflon	Mica Receiving	Mica Transmitting	Reconstituted Mica
0.01—20	.01—12	0.005—2.2	0.000001—.02	0.000001—.0025	0.01—10	0.01—4	0.000001—.05	0.00001—1.0	0.01—4
±20	±20	±20 to GMV[a]	±5 to GMV[a]	±5 to ±20	±10	±10	±10	±5	±20
±2	±5	±20	±5	±0.25 pf	±1	±2	±1	±1	±5
50—600	200—600	3—50	500—5,000	500—5,000	100—2,000	50—1,000	50—2,500	200—50,000	200—15,000
25—250	Seldom used	Not used	Seldom used	Seldom used	50-350	Seldom used	Seldom used	R-f voltage varies with current & freq.	100—7,500
0.2—0.3	0.4—0.6	—	—	—	<0.1	<0.1	Seldom used	Seldom used	Seldom used
0.4—0.5	0.6—0.8	2.5—10	2—2.5	—	0.02—0.05	0.02—0.05	<0.1	0.04—0.07	0.5
Relatively high	Relatively high	—	—	0.05—.2	0.05—0.1	0.04—.07	<0.1	0.03—0.06	0.7—0.9
5,000—50,000	2000	Variable with voltage	>30,000 meg/unit	>50,000 meg/unit	>100,000	>100,000	20,000-50,000 meg/unit	15,000 meg/unit	10,000
1/40	1/12	1/20	1/60	1/50	1/15	1/10	1/5	1/7	1/8
−55 +125	−55 +125	−55 +85	−55 +125	−55 +125	−55 +85	−55 +250	−55 +150	−55 +70	−55 +200 −55 +315
See Table 2	See Table 2	Variable	Variable	NPO-N4700[b] ppm/°C	See Table 2	See Table 2	0 to +70 normal ppm controllable	−20 to +100, ppm controllable	+500 ppm −350 ppm
Medium	Medium	Medium	Small to Medium	Small	Small	Medium	Very small; excellent	Very small; excellent	Good
—	—	—	—	—	0.02—0.05	0.02—0.05	0.3—	0.3—	—
CV^2	CV^2	CV^2 & K	CV^2 & K	CV^2 & K	CV^2	CV^2	CV^2	CV^2	CV^2
Small	Small	Very small	Small	Small	Medium large	Large	Large	Large	Large
Not used	Not used	Not used	Not used	Not used	Medium large	Seldom used	Seldom used	Seldom used	Seldom used
Not used	Not used	Not used	Not used	Not used	Small	Small	Small	Small	Not used
Moderately high	Moderately high	Low	Low	Low	Moderately high	Very high	High	High	High
Not used	Not used	Not used	Not used	Not used	Moderately high	Seldom used	Seldom used	Seldom used	High
Not used	Not used	Not used	Not used	Not used	Low	Low	Low	Low	Medium
26487 (Proposed)	26487 (Proposed) 18312	None	11015	20	19978	19978	5	5	None

a—guaranteed min. value b—negative-positive zero (no drift)

see tables on p 65



Ultrahigh vacuum system developed for depositing films of tantalum, silicon and other refractory metals (General Instrument)

HIGH-TEMPERATURE CAPACITOR materials are investigated at Gulton to determine those best suited for stable capacitor dielectrics and electrodes over the temperature range of −50 to 750 C. Interest is in materials resistant to nuclear radiation, and formed in-place as a two-dimensional unit for the integrated circuit.

Three capacitor programs, inaugurated within the past year, reflect further interest in pursuing solid tantalum (at GE); development of capacitor impregnants (at National Research Labs); and high-temperature pulse-forming networks (at Sprague).

Preliminary investigations have been conducted on a high dielectric constant material in high-temperature thermionic circuits. At GE, a strontium oxide, tantalum oxide body, designated EL433, has an expansion match close to 430 stainless steel to allow sealing test pieces. Several ceramic compositions have been modified for a study of the high-temperature conduction process in capacitor dielectrics. Variable capacitors, with a range of 8-14 pf have been made, and life tests, low-frequency characteristics and polarization effects of ceramic capacitors have been obtained.

Aerovox is investigating subminiature, low-voltage, thin-film dielectrics using their Cerafil techniques. Multiple layers of ceramic are applied by deposition. A fabrication process uses five electrodes separated by four 0.0010-in. thick ceramic dielectric layers. Dielectrics have been fabricated to obtain capacitance values over 12 times those of conventional Cerafil units of comparable size. Alterations in the binder material may solve present firing problems.

PLANAR CAPACITOR ON SILICON. The dioxide is thermally grown onto low-resistivity silicon in oxygen or steam. The invarience of the dielectric constant of fused silicon with temperature provides a low temperature coefficient of capacitance. Further, the high stability and low losses of SiO_2 makes this material suitable for high-temperature operation. Silicon dioxide is grown onto both sides of a silicon slice, and one side is etched off to form a single capacitor with an aluminum dot on top for the contact. At General Instrument, a film thickness of 0.2 micron obtains capacitance of 33 picofarads with a contact area of 20 mils. The unit can be put onto a 30-mil square to allow for surface insulation and prevent fringing effects at the edge of the contacts. Assuming a conservative value of one million-v/cm breakdown for strength of the film, a total film thickness of 0.2 microns will have a dielectric breakdown of 100 v. The unit is called a planar cap.

Capacitor values are from 1 to 500 pf and vary in size from 0.020-in. sq. to 0.120-in. sq. Temperature coefficients as low as 5 ppm per deg. C can be provided.

As discrete dice, these components are used in nanocircuits where individual dice are preselected and thermocompression bonded into a circuit on various substrates. Dice can be encapsulated individually and sold as microcomponents. Resistors and capacitors on one substrate with deposited contacts will perform with diodes and transistors on other substrate.

SILICON-MONOXIDE FILM capacitance values remain relatively constant over the frequency range of 500 Kc to 10 Mc. Consecutive layers of aluminum and silicon monoxide form the film version of a parallel-plate capacitor. Silicon monoxide is also used for the insulating layer.

At IBM, silicon monoxide (dielectric constant of 6) was chosen in one program on the basis of previous usage. Samples with values ranging from 6 to 100 pf were measured for Q and change in capacitance over 500 Kc to 10 Mc. Value of capacitance chosen for film application approximate characteristics of bulk capacitors.

VACUUM-DEPOSITED DIELECTRIC film capacitors have been investigated for temperature dependency at Melpar. Data obtained is helpful to those active in thin-film circuits. Characteristics have been presented for silicon monoxide, zinc sulphide, ytterbium oxide, silicon nitride and cerium dioxide. Capacitors formed with cerium dioxide or silicon nitride have the best stability in the higher temperature ranges. Films thicker than one micron generally showed no change in dielectric constant with increasing thickness. Films thinner than about one micron usually exhibit variations in dielectric constant.

NUCLEAR RADIATION EFFECTS on capacitors. Mica, glass and ceramic capacitors show little change in capacitance with integrated neutron flux doses of 10^{17} to 10^{18} nvt, whereas plastic and paper capacitors show appreciable changes at doses of 10^{15} nvt. Oil-impregnated paper capacitors and tantalum electrolytic capacitors begin to show changes in capacitance at 10^{12} to 10^{18} nvt. Airborne Instruments has conducted these nuclear radiation studies.

DEGRADATION EFFECTS of high-temperature ceramic dielectrics is pursued at Linden Laboratories. These effects may be due to inhomogeneities in dielectrics, which lead to strong local fields across the layers with high resistivities and therefore breakdown of these layers by zener breakdown and by injection of anion-vacancies. Production of new anion-vacancies at the anode and their movement through the dielectric seem to be the important factors determining the life of a dielectric. Eliminating inhomogeneities by adding higher-valance cations or lower valance anions, increasing the breakdown resistance of the barriers by chemical change (fluorides or other second phases) and sealing the anode against injection of anion-vacancies are effective means to increase the high temperature life of a titanate dielectric.

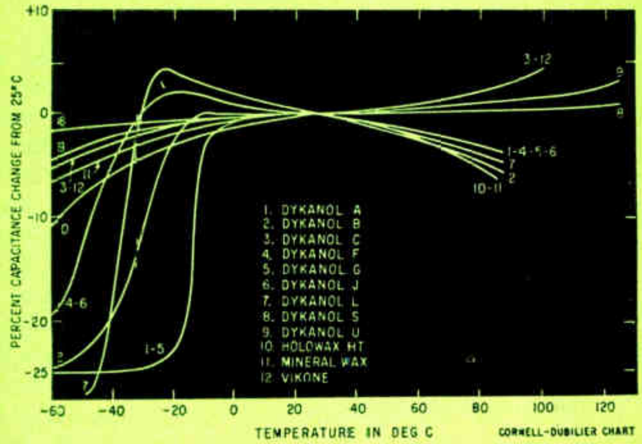
Electrolytic and ceramic capacitors have been developed for the RCA micromodule by Sprague, Centralab, Aerovox, Cornell-Dubilier, Erie Resistor and P. R. Mallory. Respective types for these modules are: general purpose B-74 multilayer ceramic capacitors, a ceramic trimmer capacitor, precision and general purpose multilayer capacitors, a single-layer ceramic capacitor and electrolytic capacitors.

GLASS DIELECTRICS have been used primarily in the military. Glass capacitors are made by stacking alternate layers of aluminum foil and glass ribbon until the desired capacitance is obtained. In the newer styles, Dumet leads are used for a true glass-to-metal seal where they enter the glass case. Miniature types have capacitance ranges of 1 to 1,000 pf with a d-c working voltage of 300. Regardless of type, Corning Glass capacitors are claimed to track accurately and predictably. Negligible hysteresis assures absolute retrace of temperature coefficient.

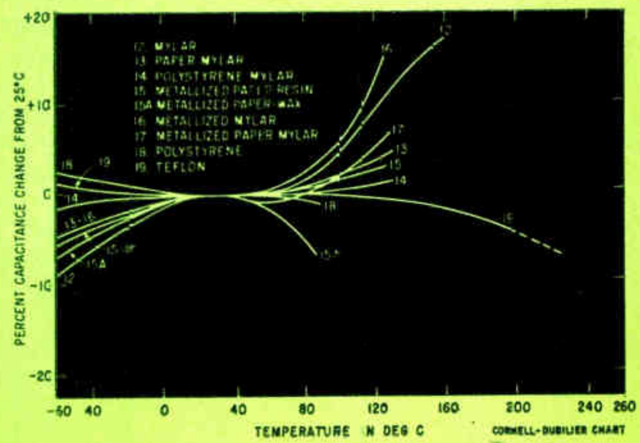
REFERENCE

(1) G. W. A. Dummer and H. M. Nordenberg, Fixed and Variable Capacitors, McGraw-Hill Book Co., Inc., 1960

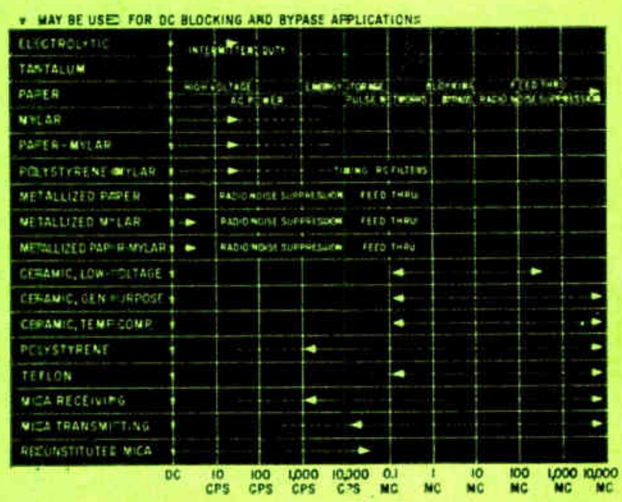
Capacitance-Temperature Characteristics of Paper Capacitors with Various Impregnants



Capacitance-Temperature Characteristics using Plastic Films and Combinations of Dielectrics



Basic Use of Various Dielectrics Over The Frequency Spectrum



CAPACITOR DEVELOPMENTS AND THE EFFECTS OF INTEGRATED CIRCUIT TECHNIQUES ON DESIGN

Design trends in new capacitors indicate immediate future developments in three basic areas: improvements in performance; continued emphasis on miniaturization; and new types and combinations for integrated circuits that will be more convenient for automatic assembly operations.

Improved capacitors and extension of their capabilities derive from new materials and processing techniques, and research in the nature of impregnants and dielectrics.

A dramatic change will be in increased reliability, higher voltage, temperature and frequency ratings, flattening of T-C (temperature-capacitance) curves, extended life and resistance to more severe environmental conditions—especially nuclear radiation.

Two outstanding new materials now coming into use in capacitors are reconstituted mica and boron nitrate. Reconstituted mica, now available in Demicon hermetically sealed tubular capacitors, provides outstanding electrical characteristics and durability in severe environmental conditions. Used with impregnants and resins, this type rates well for use in environments subject to nuclear radiation. Boron nitrate capacitors will be suitable for use up to 500 C.

Mylar and Terafilm are steadily being improved for use in dielectrics. A new 0.00015 in. film has made possible substantial size reductions in Mylar capacitors. A forthcoming capacitor development will employ Mylar and polystyrene film that will feature a T-C curve that is virtually horizontal.

Tremendous opportunities for size reduction lie in techniques for deposition of polymerized dielectric thin films on substrates.

Less dramatic, but significant improvements have been achieved in kraft paper dielectrics, now offering high dielectric strength and freedom from impurities. This is noteworthy since paper is a commonly used dielectric material.

Significant improvements have taken place in humidity-resistant paper tubulars, axial-lead tubular micas suitable for automatic production of computer circuits, stronger seals, better corrosion resistance and more reliable terminals. This trend is in line with a continuing growth of demand for high performance in consumer and less-complex industrial electronic systems.

New production methods will bring big changes in tantalum capacitors. Higher, temperatures, higher voltage ratings and smaller dimensions will be features of new designs.

Development work with evaporation of anodically formed metals will bring forth new types of capacitors much smaller than tantalum types, and equal or better in characteristics.

Both the design and the basic form of capacitors will undergo radical changes to meet requirements of integrated circuits. Forthcoming developments will be combined capacitances, inductances and resistances on a single substrate.

The increasing similarity of techniques for producing the various types of circuit elements have induced the more versatile suppliers to move into manufacture of different types of components. Experienced makers of miniature components have demonstrated both economic and technical capabilities to handle successfully the assembly of circuit packages.

Component suppliers must now maintain advanced technological capabilities in their production and engineering facilities, as well as extensive but carefully planned research and development activities.

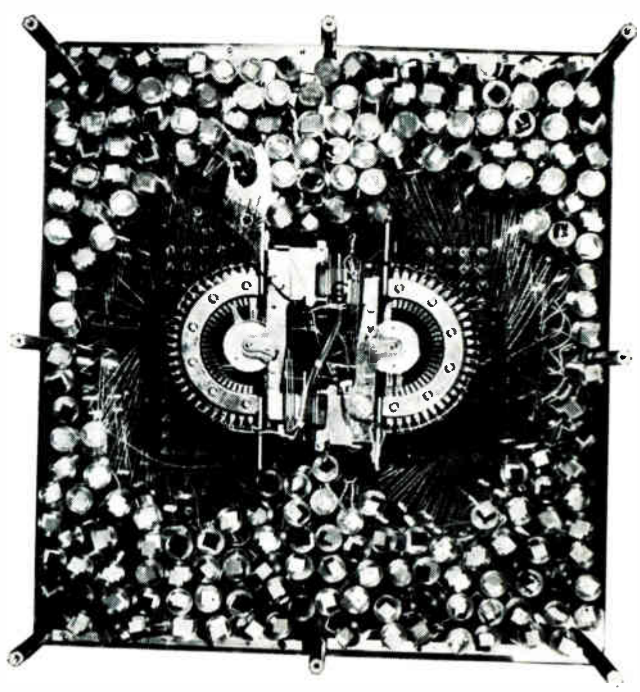
J. F. FERRANTE,
Vice President and Research Director
Cornell-Dubilier Electronics

MEMORY UNIT APPLIES UNCASED CAPACITORS

Smaller, lighter, more precise and less expensive capacitors, made from a film extruded from Eastman Chemical Products Tenite polyester film, are shown positioned around two stepper switches (right).

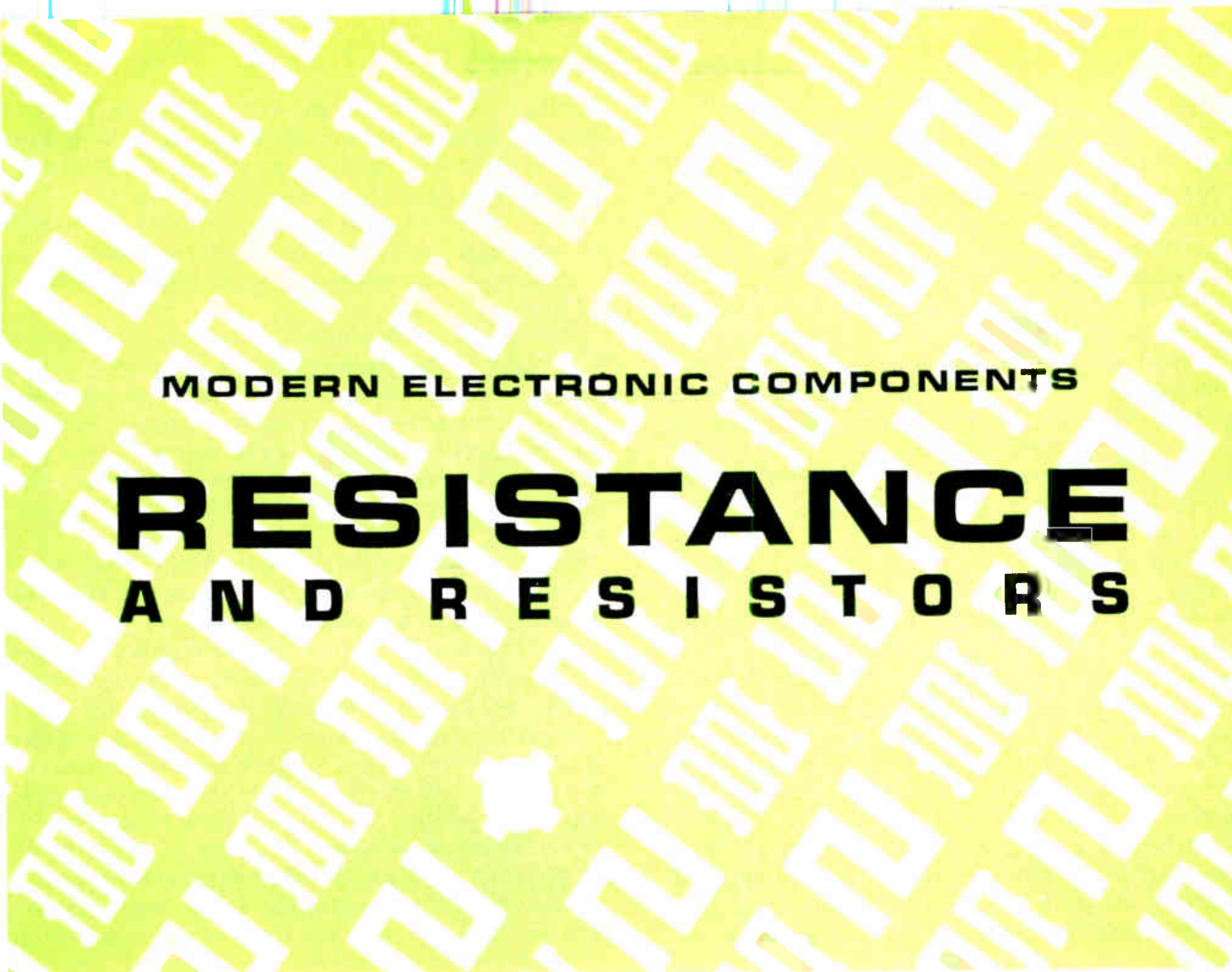
At the time the polyester material was undergoing final evaluation by one of the company's research groups, Eastman's Instrument group was developing an instrument for automating complex laboratory experiments and analyses. Chance meeting of the two interests resulted in the Instrument group finding a capacitor element that was not matched for their purposes by any other they could find. And the capacitor material gained an opportunity to demonstrate its properties in the memory unit, shown right, which is an integral part of a 100-point controller.

The improved polyester film used in the uncased capacitors is available as Terafilm, from Terafilm Corporation, Stamford, Connecticut.



MODERN ELECTRONIC COMPONENTS

RESISTANCE AND RESISTORS



Magnification of a slice of silicon on which an array of passivated silicon microresistors of three different values has been formed by photolithographic and diffusion techniques. Slice is diced and individual elements used in microcircuits (General Instrument)

BASIC ASPECTS of resistance and specific technical information on the more common types of resistors used in conventional circuits have been covered in detail[1].

Basic research in support of product development, is now being substantially increased over a year or so ago. The trend towards high-density packaging of resistive elements points to increased work in ohmic and semiconductor-type resistors. More interest is now being shown in other nonlinear resistors, such as temperature-sensitive, voltage-sensitive and light-sensitive types.

Greater emphasis, both in basic research and development and in production-development areas is being directed towards substantially increasing component reliability, proving out materials, processes, techniques, quality assurance and inspection.

TANTALUM FILM RESISTORS are extremely stable. Values are determined by thickness, length and width of the conducting path. General Instrument reports that thicknesses generally range from 200 to 5,000 angstroms. Widths as small as 0.001 inch may be used. Lengths may be extended by using a meander pattern. Resistance values may be held to closer tolerance by monitoring during evaporation or by adjusting afterwards. Electrochemical oxidation is used to reduce thickness and achieve controlled adjustment of values. Resistance ranges may extend from about 10 ohms to 1 megohm, covering the range of values useful in present transistor circuits.

Vacua of 10[illegible] mm Hg are used for tantalum and other refractory metals, and for silicon. A vacuum system used for this purpose is shown in photo on p 64.

A floating-zone-refined rod of tantalum is heated by electron bombardment for evaporation, onto specially cleaned and heated substrates of soft glass, Pyrex, quartz, MgO or ceramic, depending upon desired structure. Areas deposited are defined by shutters and photoresist etched masks. This work appears to provide a breakthrough in high-density units and permits design flexibility that has not been possible to achieve thus far by the silicon monolithic structure or deposited circuits.

Resistors for Texas Instruments tantalum film circuits are made by sputtering a tantalum film onto a substrate, etching to form a resistor path, and then anodically oxidizing part of the film. Anodization converts the outer portion of the film to a thin adherent film of oxide, which both precisely adjusts resistance values and protects the finished resistor. Sputtered tantalum resistors have temperature coefficient of ± 150 ppm/deg C and nominal resistivities of 100 ohms per square, enabling a 100,000-ohm resistor to be made in a 0.1-in. area. Typical change on load life and temperature cycling is less than one percent.

Lear uses a paralleled pattern for their thin-film resistor, rather than a meandering path. They find the former lends greater strength and rigidity to a thin-metal mask.

PROCESSING TECHNIQUES with thin-films at IBM are said to have advanced the state of the art, and they recommend further work to extend thin-film technology to electronic equipment.

Nichrome resistors have frequency stability from 50 Kc to 16 Mc, and individual film resistors have negligible shunt capacitance. On the basis of sampling in their initial hours of life, nichrome films did not drift in value, no change was detected during the first 1,600 hours of life. IBM engineers now feel that they can come up with a much better film than nichrome.

Moisture and thermal shock tests on unencapsulated substrate did not cause appreciable change in resistor values, and it may be that no encapsulant is necessary. High resistivity deposits are difficult to achieve because of suspected *p*-type impurities leaking from the quartz tubes used. With present techniques, resistivities of about 5 ohm-cm or lower are possible.

Where both resistor films and capacitor films are to be simultaneously deposited within layers, the insulation film should not simultaneously serve as the dielectric film for the capacitors. Generally, insulating films must be fairly thick, 20,000 angstroms to 30,000 angstroms, to minimize unwanted distribution capacitance. Dielectric films must be as thin as possible to maximize capacitance between plates. A film used both as an insulator and a dielectric compromises circuit fabrication. This gives either less insulation, higher distribution capacitance, and smaller plate capacitance; or better insulation, less distributed capacitance and larger plate capacitance. Freedom to adjust individually for distributed capacitance and plate capacitance, and to vary the sequence of depositing layers is lost.

VACUUM-DEPOSITED thin-film resistors, produced by Halex, are basically nickel and chromium. They are deposited with excellent control to form films having resistivities of a few ohms/sq to 500 ohms sq. Films with resistance as high as 4,000 ohms/sq are said to have excellent properties, but are more difficult to produce. Resistive films are sealed with silicon oxide while they are still in the vacuum chamber and as such are resistant to contamination or environmental corrosion.

Track widths of resistors can vary from a few mils to very wide tracks, but for most integrated circuit applications, track widths are in the order of 0.005 to 0.010 in.

Resistor films, molecularly bonded to the substrate and to the interconnecting material, result in a monolithic structure of high reliability. Temperature coefficient becomes more negative as resistance per square increases (decreasing thickness). The majority of values for a particular per square range fall within ±50 ppm. The spread is generally caused by variations in composition or structure.

Power ratings of microcircuit resistors are not based on limitation of the material, but on practical values of wafer temperature and heat dissipation.

Halex spokesmen point out that the high-vacuum thin-film process is capable of producing many other components and devices other than integrated circuits.

Deposited nichrome resistors for the Varo microcircuits have values of 100 ohms to 3,000 ohms, nominal accuracy of ±5 percent; 10 ohms to 500,000 ohms, nominal accuracy of ±20 percent. Power ratings are 0.2 milliwatt to 1 watt. Typical temperature coefficient of resistivity is 0.005 percent per deg C for 1,000 ohms/sq depositions.

Metal film resistance elements used in Varo microcircuits are rated at 4 watts per sq in. of substrate area as a normal continuous dissipation factor at 100 C ambient, with short-term overload capability of 200 percent without damage. A 0.6 by 0.6 in. substrate is used for circuits dissipating up to 1.3 watts. The primary limit considered in microcircuit systems is the transistor limit of approx 200 C maximum junction temperature. To ease this problem as much as possible, a potting compound is used for encapsulating the individual microcircuit wafer which, due to its fairly high heat transfer characteristics, distributes heat generated within the package fairly uniformly over the exposed surface of the package.

Deposited portions of the microcircuit operate successfully at temperatures far in excess of 200 C. Other substrates can be used, such as 1 × 1 in. for circuits requiring higher power dissipation, a larger number of external leads brought out, or a higher density of packaging a complex circuit.

PELLETIZED PARTS to date at Mallory are limited to passive elements. Inserted in holes in a printed circuit board, the pellets are connected in a pattern and encapsulated in epoxy. Hughes pelletized elements, smaller than Mallory's, are plugged into plate-through holes in circuit boards made of epoxy glass, or into Fotoform housings. This approach achieves an order of magnitude approximate to the RCA module and will probably find industrial applications beyond computer elements.

Evaporated resistive films of nichrome, molybdenum and tungsten have been investigated for the GE TIMMS wafers. Resistors with values ranging from 90 to 200 ohms have been produced and life tests at 580 C will prove out these units. Molybdenum film resistors have been fabricated in values from 1,000 to 5,000 ohms. Evaporated carbon-film resistors with values to two megohms have been fabricated, and GE is continuing life

CHARACTERISTICS OF THIN-FILM NICHROME RESISTORS USED IN MULTILAYER CIRCUITS

Nichrome (80% nickel, 20% chromium)	
Bulk resistivity	108×10^{-6} ohm-cm
ohms/square	200
Max. power dissipation	5 watts/in.^{2}
Resistance limited to	35,000 ohms
Minimum resistor width	10 mills
Film thickness	150 angstroms

IBM Research-Thin-Film Circuit Functions tests of pyrolytic and carbon film resistors.

COST FACTORS FOR THIN-FILMS. Electra Manufacturing Co. has established a pilot line for high stability fixed film resistors capable of full-load operation up to 150 C for nonsealed types, and up to 200 C for sealed types. Research and development was accomplished at Battelle. Electra's W. E. McLean says that cost reduction studies for the Signal Corps show that thin-film resistors can be put in the same price classification as conventional units, pointing up the economy achieved with thin-film elements.

MICROMODULE RESISTORS for RCA's program include carbon-composition resistors, tin-oxide element resistors, cermet types, noble-metal films, and resistor microelements. Aerovox, Centralab, Corning Glass Works, CTS Corp., Helipot division of Beckman Instruments, International Resistance Corp., General Instrument, and Microelectronics have developed and produced these types.

RESISTIVE ELEMENTS ON SILICON. Power dissipation for diffused resistors used in Pacific Semiconductor's tctl (transistor coupled transistor logic) circuits is 2 Kw per sq cm, compared to 10 watts per sq cm for films. Tolerances achieved with diffused resistors are ±25 percent, but are satisfactory for saturated switching circuits.

Resistors are formed in 150 ohms/sq. A typical 1,000-ohm resistor measures 0.75 mil wide, 4.5 mils in length. Trimming tabs can be employed for more precise resistance values. Temperature coefficient for diffused resistors in values from 10 ohms to 5,000 ohms is plus 0.1 percent per deg C, in the zero to 200 C range.

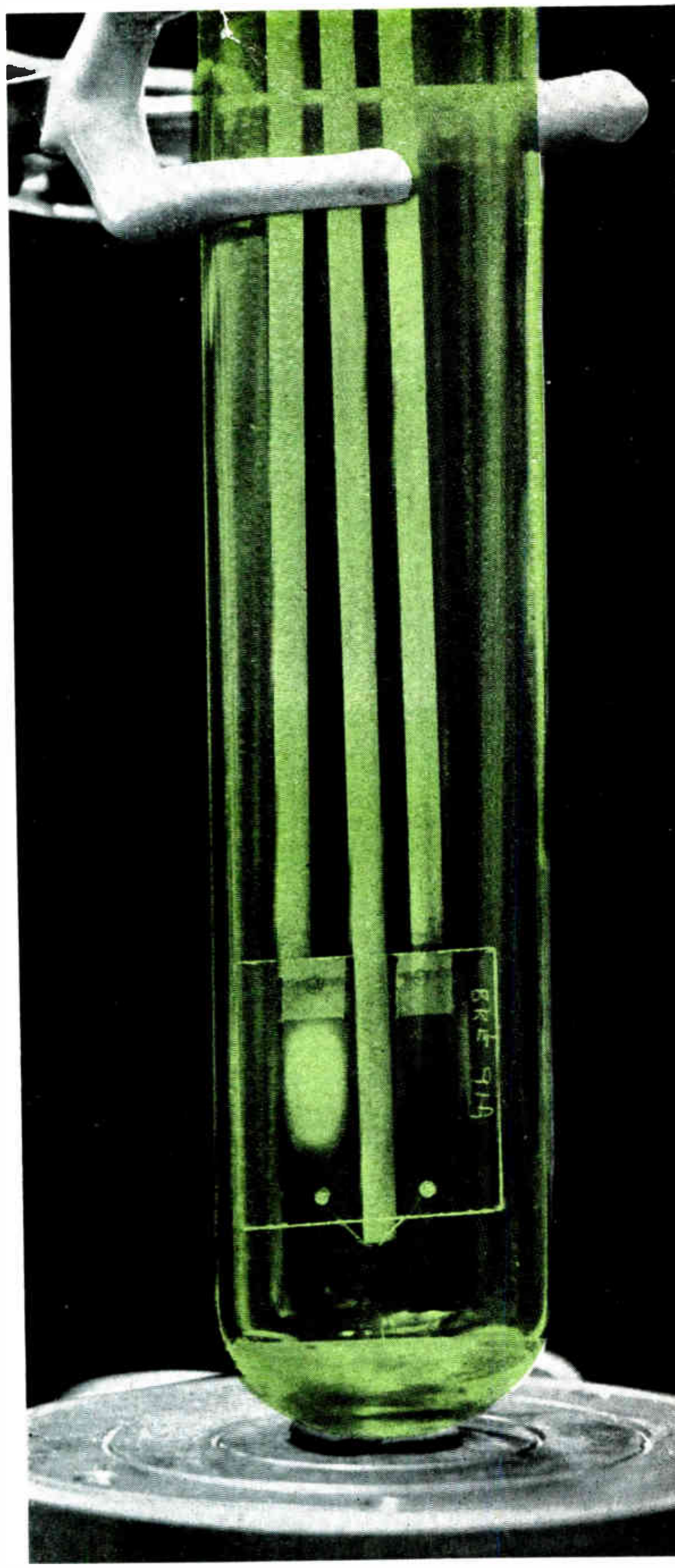
Silicon passivated resistors are fabricated at General Instrument by forming a *p-n* junction at a prescribed depth below the surface of the silicon material. The resistor is passivated by a SiO_2 layer. A *p*-type dopant is diffused into *n*-type silicon to form the junction. This junction has a high impedance to any transverse flow of current, hence the resistance obtained is essentially the sheet resistance of the diffused layer.

For a sheet resistance of 10 ohms/sq and a junction depth of 0.1 mil, a resistive element 100 mils long and 5 mils wide has a resistance of 200 ohms. The geometries of the resistance elements can be arc shaped using photolithographic techniques employed in the manufacture of passivated planar diodes and transistors.

The temperature coefficient of resistivity is determined by the temperature dependence of the number of ionized carriers and the mobility due to impurity scattering. Since each of these temperature coefficients is different, a near balance can be obtained by counter doping to give a low temperature coefficient.

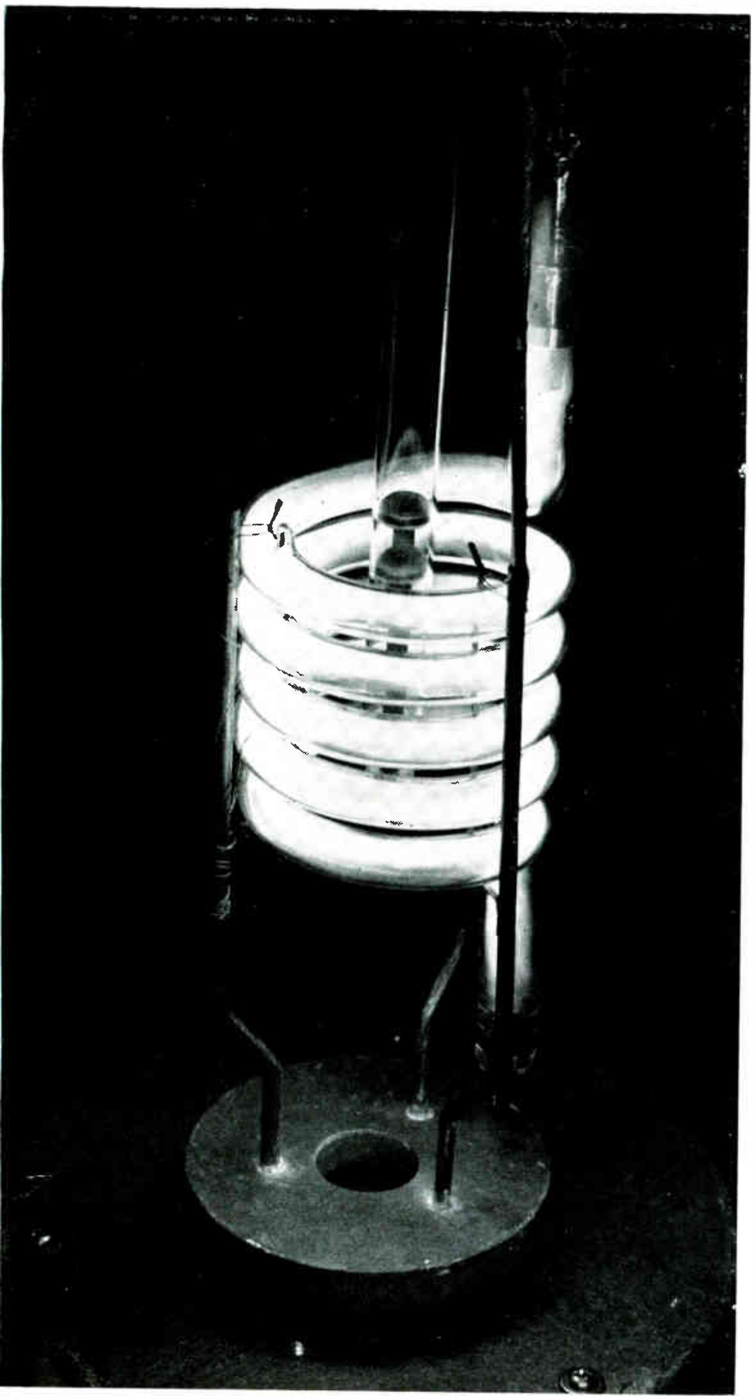
Resistors are made from 10 ohms to 50,000 ohms with temperature coefficients between 500 and 2,000 ppm. Normal tolerance is ±10 per cent but by selection, trimming or both, ±5 percent can be obtained. Dice are made in two sizes, 0.020 in. sq, and 0.040 in. sq. When mounted on a TO-5 header, the smaller units can dissipate 200 mw and the larger 600 mw.

THERMISTORS, among the most versatile of passive components, have not become standardized circuit ele-



The remarkable power dissipation properties of thin vacuum deposited metal films. Two thin film rhenium resistors have been deposited on a silica substrate. One resistor is shown under test. Arrangement will study the polarization of the emitted light (Melpar) ments. Circuits are seldom built specifically around thermistors. The result is, according to R. S. Goodyear, President of Fenwal, that an average of 1½ new types of thermistors are created daily—custom made for existing circuits.

At Fenwal, thermistor bodies have been developed which operate at 600 C. These bodies utilize chromic oxide as a chief constituent. Some hysteresis occurs in these units, but the hysteresis leads to inaccuracies of only about two percent of the resistance-temperature curve.



Techniques for rapid adjustment of resistance elements use a flash tube fired from 1,300μf capacitance at voltages up to 4,000 v. System is readily adapted to automation. Short intense pulse of light can bring about evaporations, fusions or chemical changes in small particles or thin films (Armour Research Institute)

Thermistors can give 0 to 5 volt signal without amplification, and are 10 times as sensitive as a thermocouple or resistance bulb. Engineers are looking into materials that will permit thermistor use up to 3,500 C. In field experiments, developmental probes have been used up to 1,800, but these pose production problems. Production line types have been used up to 1,200 F. For routine use, they have a maximum stability up to 300 C, have been used up to 500 C.

Thermistors are temperature sensitive only—voltage sensitivity is a fault. Varistors, on the other hand, are voltage sensitive only, temperature sensitivity is a fault. Thermistors provide an absolute correlation between absolute temperature and resistance. For telemetry, there is no cold junction involved, as with a thermocouple.

Thermistors have been used to measure the carbon-dioxide content of orbited space capsules.

Positive coefficient thermistors, made by GE and Westinghouse, operate on phase-change, and in Texas Instrument's Sensistor, a silicon crystal used as a resistance device, has a low positive temperature coefficient.

Victory Engineering has compiled a handbook containing sufficient information to enable engineers to evalute thermistors. This data book contains a comprehensive bibliography on thermistor applications.

High negative coefficient disk thermistors, developed at Carborundum within the past year have good stability. Also high power noninductive resistors are available with either a Teflon or Mylar coating to handle higher applied voltages. Conventional noninductive resistors employ Glyptal or silicone coatings for moisture protection and for improvement of dielectric strength.

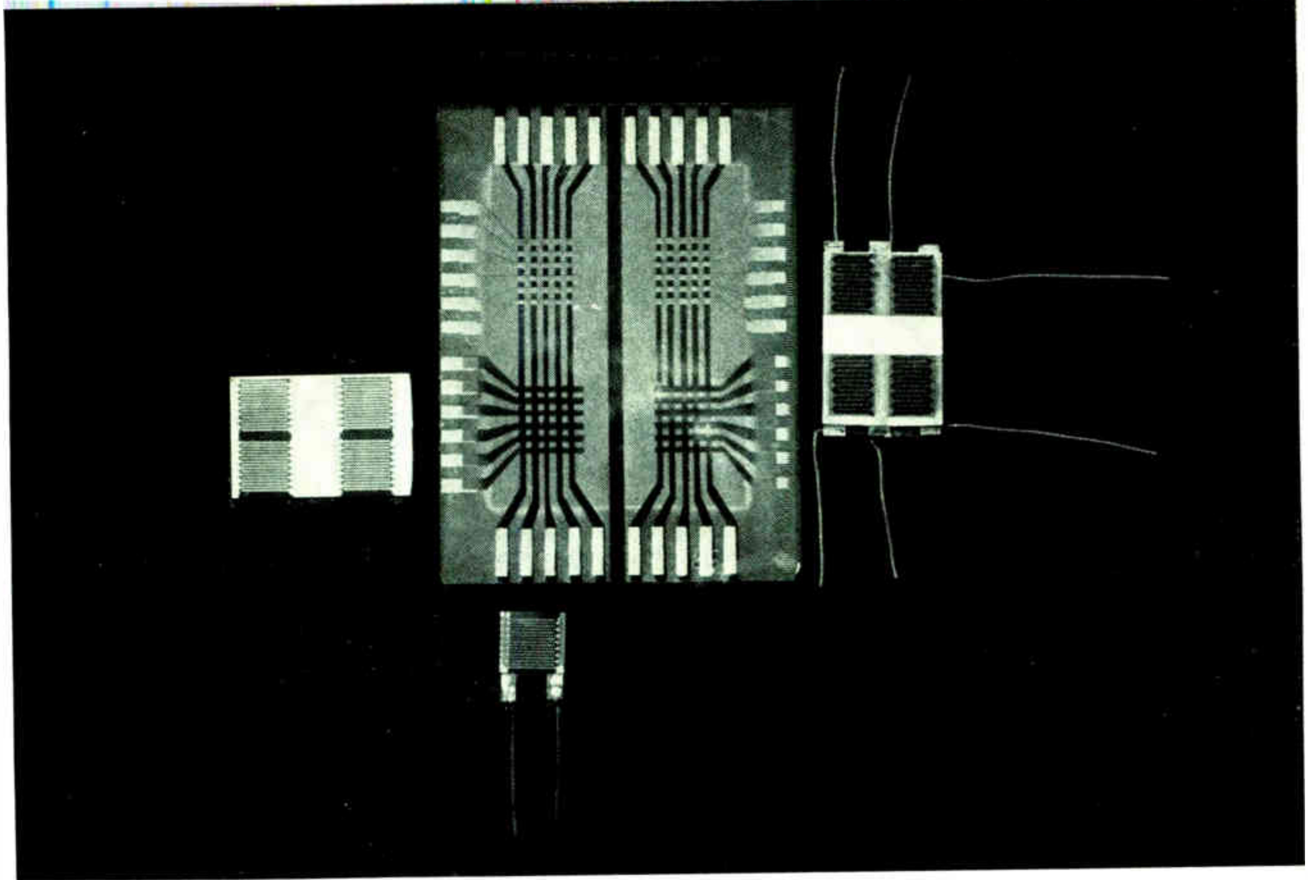
According to Carborundum spokesmen, it is doubtful that development of molecular electronics will eliminate the need for components of the types described. Increased sales of these resistive products are foreseen. To this end,

NUCLEAR RADIATION EFFECTS. Resistors are much more radiation resistant than semiconductors. Wirewound types suffer little change of resistance to a dose of 10^{18} nvt, the change being an increase in resistance.

Metal and carbon film resistors show an increase in resistance greater than wire wound types, but generally not excessive to doses of 10^{17} nvt. Carbon composition types vary little in resistance to doses of 10^{16} to 10^{17} nvt, the change being an increase in resistance.

Transient effects noted during irradiation include increased leakage currents because of ionization of the surrounding air and of insulating materials. This ionization causes units that show an increase in resistance as a permanent effect to show a decrease in resistance as a transient effect while in the radiation field. Here again, the stresses placed on the unit determine to a great extent what will take place, according to E. J. Rohrback of Airborne Instrument Labs.

RHENIUM FILM RESISTORS, possessing high stability, have been formed by vacuum deposition and annealing. Work at Melpar shows that values of resistance from ten ohms per square to several thousand ohms per sq may be successfully programmed. The films are stable to 500 C in a vacuum. With improved high temperature potting material, practical film resistors, with low temperature coefficients, may operate over 500 C. These re-



An array of deposited electroluminescent lamps and photoconductors. Photoconductive film converts light into variable resistance as the replacement for the mechanical motion of conventional potentiometer (Servomechanisms)

sistors can meet any anticipated power requirements.

A photo on p 69 shows the power dissipation properties of thin vacuum deposited metal films. This illustration shows a silica substrate, one-in. sq, on which two thin-film rhenium resistors have been deposited. It is believed that photographs and observations of an incandescent thin film have not been previously made. One resistor is shown under test. The surface area of the resistor is 0.1 sq in., the thickness less than 100 A (0.4 microinch) and the resistance, 1,000 ohms per square.

The film is shown incandescent with a power input of over 10 watts. Temperature of the film surface was about 1,500 F. Temporary atmospheric protection was provided by sealing the sample in a test tube filled with dry argon.

Studies on these films are currently being undertaken at Melpar's Physical Science Laboratory as part of their comprehensive program on thin films. The illustrated set up shown on p 69 is being used to study the polarization of the emitted light.

SUBMINIATURE POTENTIOMETERS. Performance and capabilities have been established for subminiature potentiometers used in transistor circuits. Mallory has developed a metal film, high temperature (430 C) rectilinear potentiometer for the government, and Markite has developed variable resistors and precision potentiometers that operate from 65 to 500 C, and in high nuclear flux levels.

A terminology document that will aid the designer in specifying his requirements for precision pots is available from the Precision Potentiometer Manufacturing Association in Chicago.

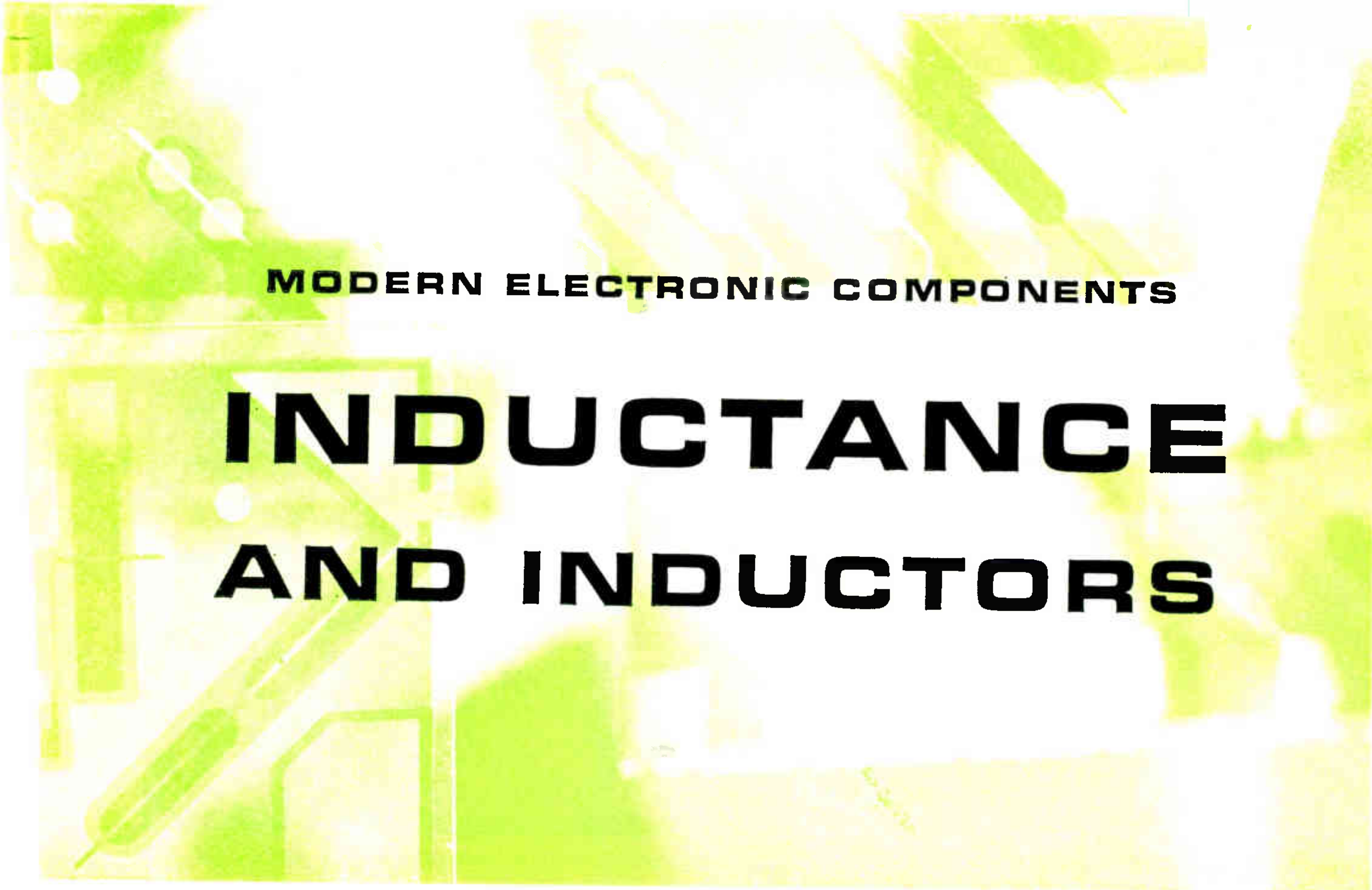
The main advantage of the precision conductive plastic potentiometers is virtually infinite resolution, long wear life, and applications involving wiper currents in the microamp region. Applications would be as a follow-up in servo systems and analog computers, and as gain controls for vacuum tubes and servo modulated telemetering transmitters. Specific military applications for plastic potentiometers developed by New England Instrument include use in Hawk, Sparrow, Nike, and other classified missiles. Although conductive plastic pots are presently limited in some applications, New England Instrument Company's Gerald Lemberg reports that research is developing new techniques that will allow higher temperature operation, lower temperature coefficient, lower contact resistances and tighter nonlinear functions.

Potentiometer engineers have been conducting continuous research aimed at investigating all the new metals. Says Daystrom's R. E. Wolin, manager of their potentiometer division, micromodule trimmers 5/16-in. sq by 0.50-in. thick will be available in the near future.

CERMET ELEMENT variable resistors, developed at Helipot, operate at full load of 2 watts up to 275 C when properly derated. Manufacturing methods, product techniques, and quality control criteria for high volume production of variable cermet element resistors has been set up at Chicago Telephone Supply. Production engineering manufacturing for 3/8-in. diameter precision potentiometers, at CTS, indicates that rotational torques will be high enough to pass stringent environmental tests.

REFERENCE

(1) C. L. Wellard, Resistance and Resistors, McGraw-Hill Book Co., Inc., 1960.



MODERN ELECTRONIC COMPONENTS

INDUCTANCE AND INDUCTORS

Magnetic film parametron will play an important part in the future of computer technology. A parametron is basically a L-C resonant circuit, tuned to a frequency f, in which one of the reactance elements is varied periodically at a frequency of 2f. Power requirements of the elements are one milliwatt per bit or less (Servomechanisms)

EMPHASIS OF PROGRAMS in inductors, coils and transformers has been mainly in product improvement through better construction techniques and designs[1]. Within the past year, interest in small inductive elements for integrated circuits has shifted into expanding research. Programs now investigate techniques that will lead to better thin-film inductive elements.

Miniature inductors, fabricated at Motorola, employ thin-film spiral conductors on ferrite substrates. They aim for inductance ranges from 38 μh with a Q value in excess of 100 at a frequency of 1 Mc. Techniques will be established for lead attachments, with a measure of the voltage and current handling capabilities of the inductors. Coils will be fabricated on Cermag 9, supplied by Stackpole Carbon. Properties of Cermag 9 include high initial permeability (190) with a Q value of 200 at 1 Mc. Surface of the material can be made smooth enough to fabricate spirals having line widths down to and including one mil. Without initial tooling, the material is available in one-quarter inch sq substrates with a thickness of 50 mils.

The spiral material is pressed on a ferrite composition, a variation of a nickel cobalt ferrite. Vacuum deposition and electroplating will be used for films on substrates. Electroless Cuposit process and electroplating will be used for depositing films in the impressed spiral configurations.

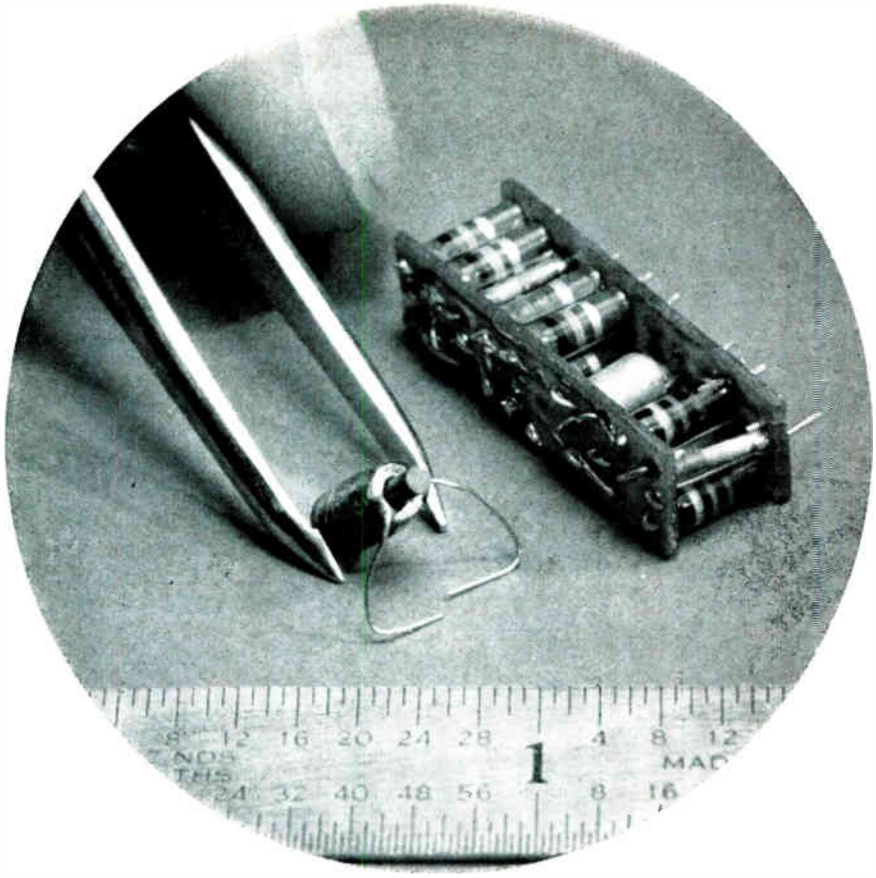
A 40-turn spiral has also been fabricated on Cermag 9 substrates. A complete knowledge of the techniques required to resolve the 1-mil lines will be determined by fabricating samples of this pattern on glass substrates. Techniques should obtain inductance values close to 254 μh.

Inductance may be increased by depositing spirals on opposite ends of the same substrate, and may also be increased through elimination of an air gap, by impressing a pattern in the ferrite. Work is also being done investigating a 20-turn, 2-mil line and space configuration.

At IBM, high resistivity magnetic materials, such as ferrites and magnetic powders suspended in plastic, have been explored as core materials to avoid distributed capacitance and insulation problems. Three types of ferrites have been investigated: sintered substrate wafers, deposited film overcoats, and powders molded in plastic suitable for overcoats and substrates. The ferrites were deposited as films by cathode sputtering and flame spraying.

A simple manganese-iron ferrite containing a small amount of zinc has been used. This material is available commercially in both substrate and powdered form as Ferroxcube 3C. With its closed B-H loop, it is reasonably free of magnetic losses. Permeability in the low megacycle frequency range is about 10. A satisfactory core material is obtained using the powder suspended in epoxy resin. This mixture provides a useful overcoat and substrate. A high-resistivity ferrite, Ferramic Q, made by General Ceramic, may simplify the problem of insulating the windings.

Three different types of inductors have been considered: a cup core, solenoid core and embedded chip inductors and transformers. The cup core consists of a ferrite substrate, onto which either a flat-spiral or a flat



Miniature tunable inductor for cordwood package. Coil is wound in epoxy, dimensions can be held to extremely close tolerances (Cleveland Electronics)

helix winding is deposited integrally with other circuit elements, and a magnetic overcoat cup added by a molding process after film deposition. In the solenoid core, a ferrite substrate, used as the sole magnetic element, provides a core for the rectangular tubular winding around it.

CONVENTIONAL CHIP inductors and transformers are embedded into the circuit substrate. Emphasis is on compatability with thin-film techniques used for the other passive elements. Inductor and transformer land areas have been made flush with the substrate surface.

All three techniques at IBM produce enhance values of inductance. Maximum values obtained on a 0.6-in. × 0.6-in. × 0.04-in. substrate are estimated as: 104 μh for a 68-turn flat spiral in a cup core; 192 μh for a 150-turn solenoid winding around a substrate. Substrate thickness required for C & I cores are 0.1-in. Millihenry range is not restricted by the number of turns.

The flat-square spiral configuration is best for a spiral inductor, but it has a low inductance and low Q.

Designing circuits around inductors may be the best way to overcome many of the problems now difficult to solve.

RADIATION RESISTANT INDUCTORS for the high-temperature GE TIMMS circuits include units fabricated with both copper and silver conductor wire windings. Data have been obtained for average values of inductance and Q.

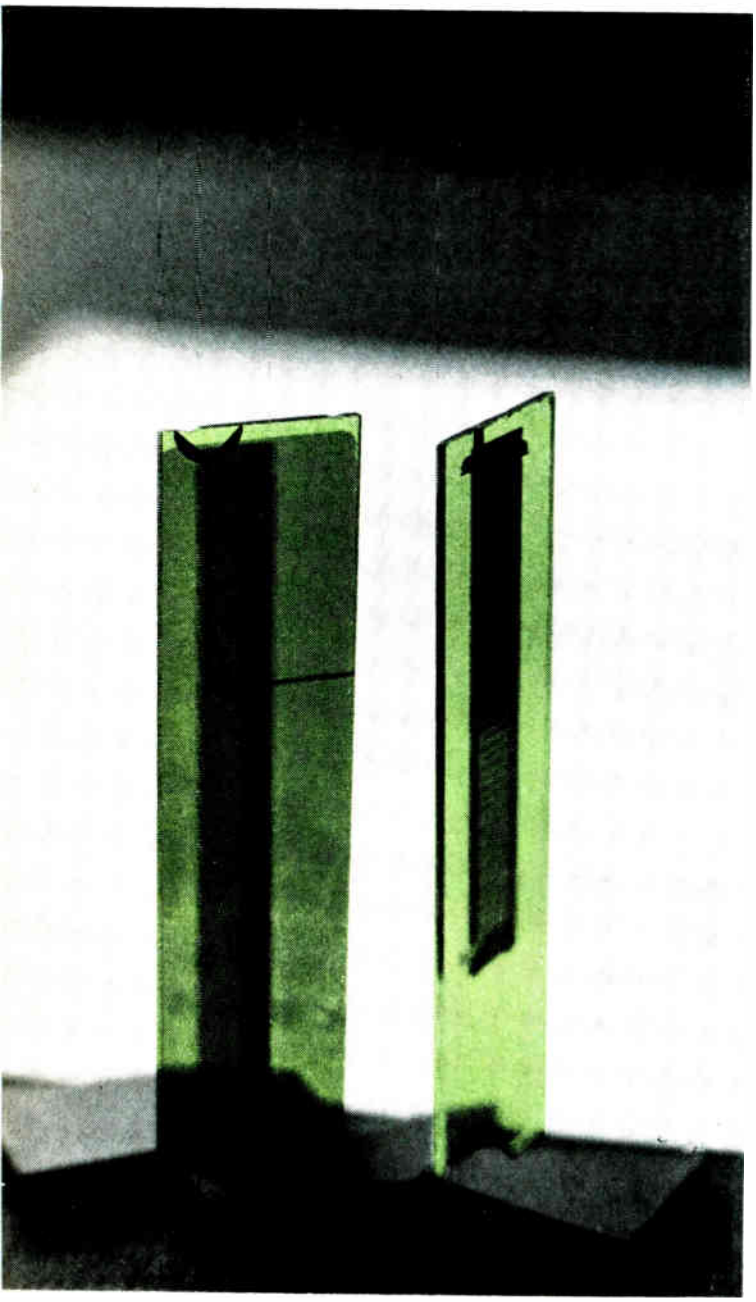
Various types of inductors have been developed for the RCA micromodule by Aladdin Electronics, United Transformer Corp., Delevan Electronics, Communication Accessories Co., and Pyro Circuits. These types include sense pulse transformer microelements, pulse transformer micromodules, audio transformer and choke micromodules, adjustable reactor modules, medium and high-frequency microelements, and printed toroids.

MAGNETIC AMPLIFIERS. Studies and experiments in the fields of magnetic amplifiers, dielectric amplifiers, and synthesis in electronic circuits are being conducted at Carnegie Institute of Technology. The work investigates characteristics of magnetic amplifiers and analytic tools useful in design and analysis. Research is primarily pursued for engineering evaluation and investigation of thermal stability, noise figure, life and efficiency.

The behavior of thin-tape ferromagnetic materials, magnetic amplifiers with counter emf loads, and self-saturating amplifiers have been analyzed also at Polytechnic Institute of Brooklyn.

HIGH TEMPERATURE MAGNETIC CORES. Westinghouse has been investigating the changes in electrical properties in transformer cores due to cycling and aging at 600 C. Cores include two sizes of punchings, EI 75 and EI 125, four types of materials (cobalt iron, non-oriented silicon steel, oriented silicon steel and low carbon steel) and both thick and thin laminations. Tests have been performed at 60, 400 and 2,000 cps and at various flux densities.

Westinghouse is also developing a high-power magnetic



Solid-state shift registers, such as this 25-bit device, utilizing molecular electronics approach of iron-atom interaction, can now be reliably produced for application (Servomechanisms)

modulator with a stable (low jitter) pulse repetition rate for radar. This includes investigation of distributed constants in lieu of lumped constants of L and C and solid-state switching. In addition to a more stable repetition rate aims are for a modulator that has a higher power output than now available.

Existing passive r-f filtering methods have been reviewed and analyzed at Illinois Institute of Technology to originate and develop a theoretical treatment of filter or network theory, and to develop and fabricate filters or circuits for advanced electronic systems.

Work at Clevite on ceramic i-f transformers will lead to improved piezoelectric band-pass filters and networks in the frequency range above 1 Mc. Objectives are reliability, miniaturization, and improved characteristics over conventional L-C filters. Ceramic filters will include multielement units with one resonator or component per body, as well as filters with more than one resonator, component or both per cubic body.

MINIATURE RESONATORS. An alternate tuning method, suitable for handling small lots of miniature ceramic radial resonators in the 1 to 6 Mc range has been developed. These have been packaged in micromodule slot packages, and have been subjected, without damage, to high-frequency vibration tests. Technique accounts for the problem of maintaining stop-band rejection when packaging five-resonator sections. Introduction of a ground plane and shielding within the module is a partial solution. Substantial increases in stop-band rejection have been obtained with resonator-capacitor filtering sections.

Clevite has developed a suitable ceramic for use in Uni-wafer filters. Dot resonators, fabricated using this material, have improved temperature and impedance characteristics over previous counterparts. A 1-Mc fundamental ladder filter is packaged in the micromodule configuration with a 9-resonator filter that occupies 0.02 cu in. New mechanical filter ceramics have over twice the mechanical Q and half the dielectric constant of any previously available.

Work on piezoelectric ceramic filters and transducers is concerned with studies for feasible operation up to 250 C.

TINY VARIABLE INDUCTORS with movable or removable cores have been developed at Cleveland Electronics. The coil is wound in epoxy and has no bobbin. Except for a film of epoxy insulation, the wire extends from the inside air core to the extreme outer diameter. Leads are made part of the coil. Flat or round wire can be used. Core material is made of Ceramag 5N and dimensions can be held to close tolerances.

STANDARDS FOR PERMANENT MAGNETS and Materials have been set up by Crucible Steel, General Electric, General Magnetic, Indiana General, Simonds Saw and Steel, Stackpole Carbon and Thomas Skinner. Specifications are advisory only and their use for adoption is entirely voluntary. General classifications come under headings of physical standards, standard magnets, standard purchasing specs and standard methods of quality determination.

PRIMARY MARKET interests of miniature products at Wabash Magnetics, aside from fine wire coils, are miniature inductors, toroidal cores and basket-weave styles. Core materials used are nickel alloys in toroids; ferrites in toroidal bobbin shapes and cup cores; and powdered iron in shapes like ferrites.

Inductor applications are for audio and low r-f using Permalloy cores on laminations; r-f and uhf (ferrites, powdered iron); pulse transformers; high-frequency transformers and hybrid transformers in the kilocycle and megacycle range; miniature magnetic amplifiers; memory elements for computers; counting and timing circuits; and d-c to d-c converters.

REFERENCE

(1) V. G. Welsby, The Theory and Design of Inductance Coils, John Wiley and Sons, 1960

PICK A PACK OF POWER

When it comes to High Voltage power packages—boosting power or shrinking size or both together—AMP's Capitron Division is completely equipped to tackle your toughest design and production problem. It has skilled personnel and research facilities—has the exclusive AMPLI-FILM dielectric for tremendous power in smaller packages—has, too, extensive production facilities to give you High Volume and complete quality control.

And, for off-the-shelf power packages, Capitron has developed keep-alive, indicator and modulator power supply packages that set new standards for high output and small cube. Whether your requirement concerns low ripple voltage, close regulation, minimum size or rugged construction, see Capitron first. Engineering facilities are also available for designing AC/DC input transistorized supplies for missile or other applications. For more information, write today.

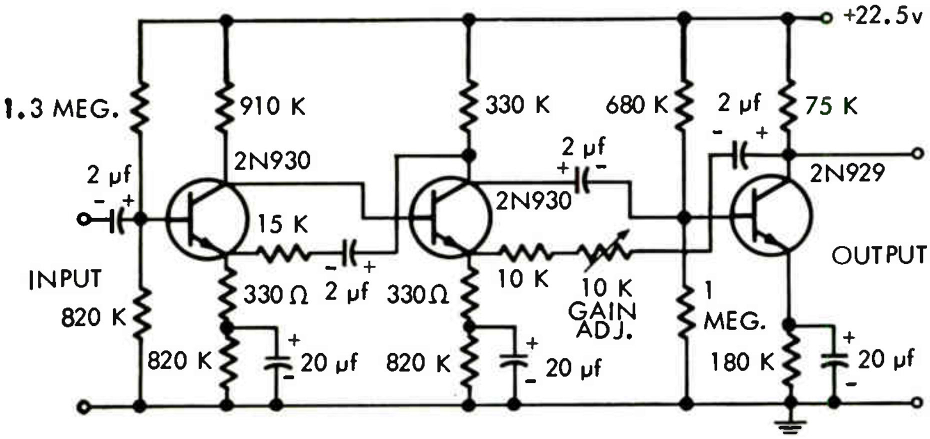
HA/HV LEADS

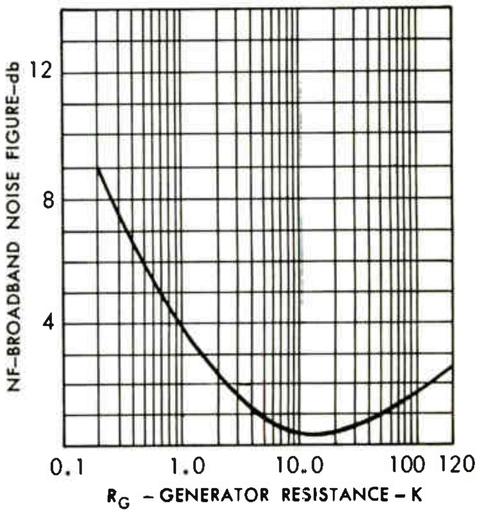
CAPITRON DIVISION
AMP INCORPORATED
Elizabethtown, Pennsylvania

Capitron products and engineering assistance are available in Canada through Aircraft-Marine Products of Canada, Ltd., Toronto, Canada

HOW TO GET MINIMUM NOISE... MAXIMUM GAIN

TYPICAL LOW-LEVEL, LOW-NOISE AMPLIFIER DEMONSTRATING LOW-NOISE CHARACTERISTICS OF TI 2N929 AND 2N930





AMPLIFIER GAIN = 1000 = 60 db
FEEDBACK = 20 db
NF (SEE GRAPH)
BW (R_G = 50 KΩ) ≅ 14 kc

INPUT IMPEDANCE = 340 KΩ @ 1 kc
OUTPUT IMPEDANCE = 12 KΩ @ 1 kc
FIRST STAGE BIASED AT 10 µa

TO-18 Case

TI 2N929
TI 2N930

low-level / low-noise / high-gain

npn SILICON

PLANAR TRANSISTORS

	TEST CONDITION	2N929		2N930	
		min	max	min	max
I_{CES}	V_{CE} = 45 v, V_{BE} = 0		0.01 µa		0.01 µa
I_{CES}	V_{CE} = 45 v, V_{BE} = 0, T_A = 170°C		10 µa		10 µa
I_{CEO}	V_{CE} = 5 v, I_B = 0		0.002 µa		0.002 µa
BV_{CEO}	I_C = 10 ma, I_B = 0	45 v		45 v	
h_{FE}	V_{CE} = 5 v, I_C = 10 µa	40	120	100	300
h_{FE}	V_{CE} = 5 v, I_C = 10 ma		350		600
h_{FE}	V_{CE} = 5 v, I_C = 10 µa, T_A = —55°C	10		20	
C_{ob}	V_{CB} = 5 v, I_E = 0, f = 1 mc		8 pf		8 pf
$\|h_{fe}\|$	V_{CE} = 5 v, I_C = 500 µa, f = 30 mc	1		1	
N. F.	V_{CE} = 5 v, I_C = 10 µa, Rg = 10 K Bandwidth 10 cps to 10 kc		4 db		3 db

Now you can design the low-level, high-gain amplifier shown above with typical noise figure as low as 1 db. Advanced low-level planar technology of Texas Instruments 2N929-2N930 series makes possible high-gain at low current levels, plus the extremely low leakage currents necessary for true low-noise performance. ■ **For high-impedance transducer applications,** the TI 2N929-2N930 permit typical 1 db noise figure at emitter currents below 1 microampere, and generator resistances over 1 megohm. These special characteristics allow direct coupling of low-level, high-impedance sources . . . advantages previously available only with vacuum tubes and field-effect transistors. ■ **For space applications,** the TI 2N929-2N930 transistors make possible low power consumption because of high gain at low levels, plus high resistance to radiation effects due to the very thin base region of the devices. ■ These TI transistors will simplify and improve the performance of your low-level circuits. They are available in production quantities from your nearest TI Sales Office or Authorized TI Distributor.

Write for TI's Technical Information Bulletin "Low-Level Operation of the TI 2N929 and 2N930"

TRANSISTOR PRODUCTS DIVISION

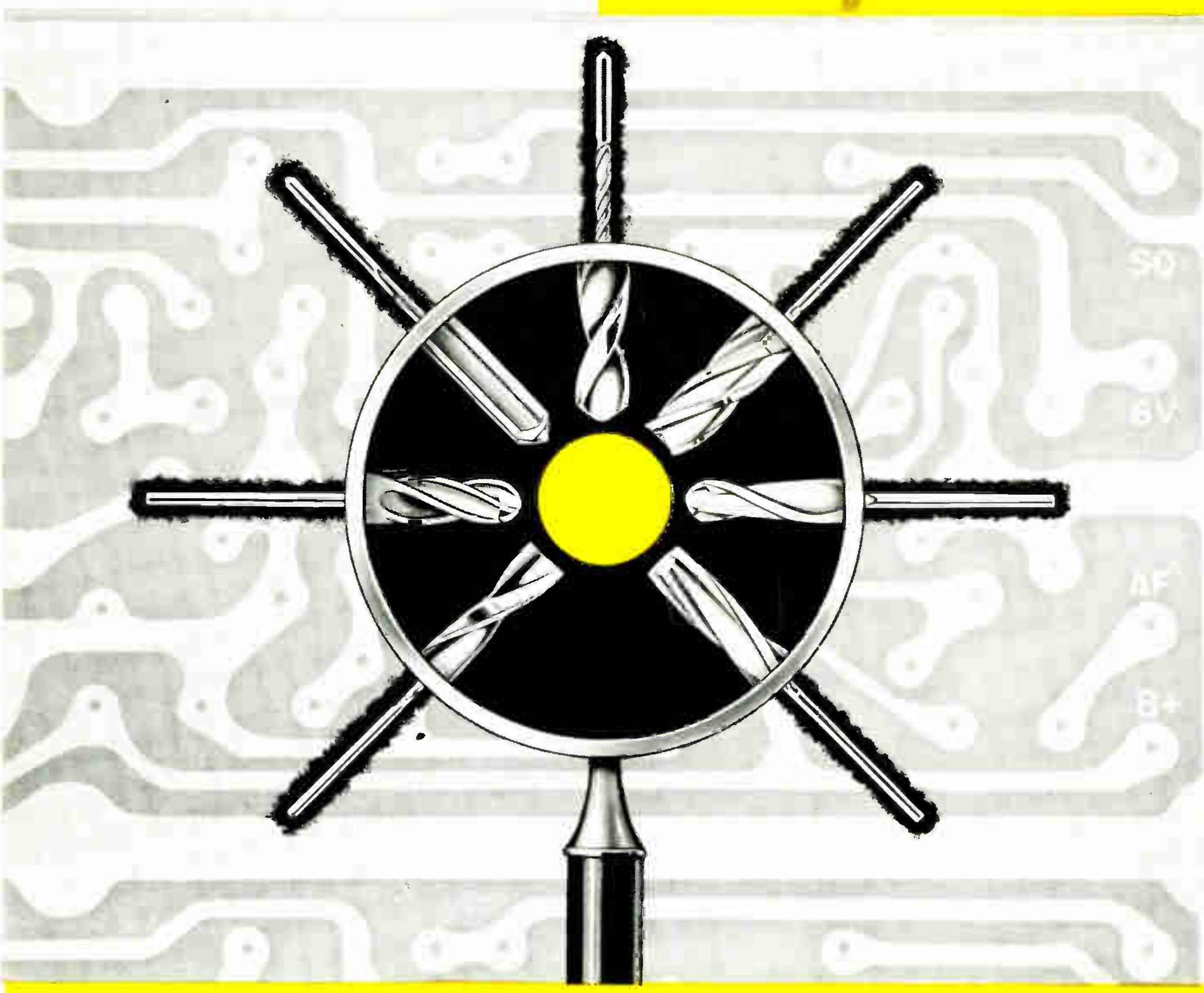
TEXAS INSTRUMENTS
INCORPORATED
13500 N. CENTRAL EXPRESSWAY
P. O BOX 5012 • DALLAS 22 TEXAS

CIRCLE 77 ON READER SERVICE CARD

SOLID CARBIDE MICRO-MINIATURE

- DRILLS
- REAMERS
- END MILLS
- ROUTERS BY.....

Super



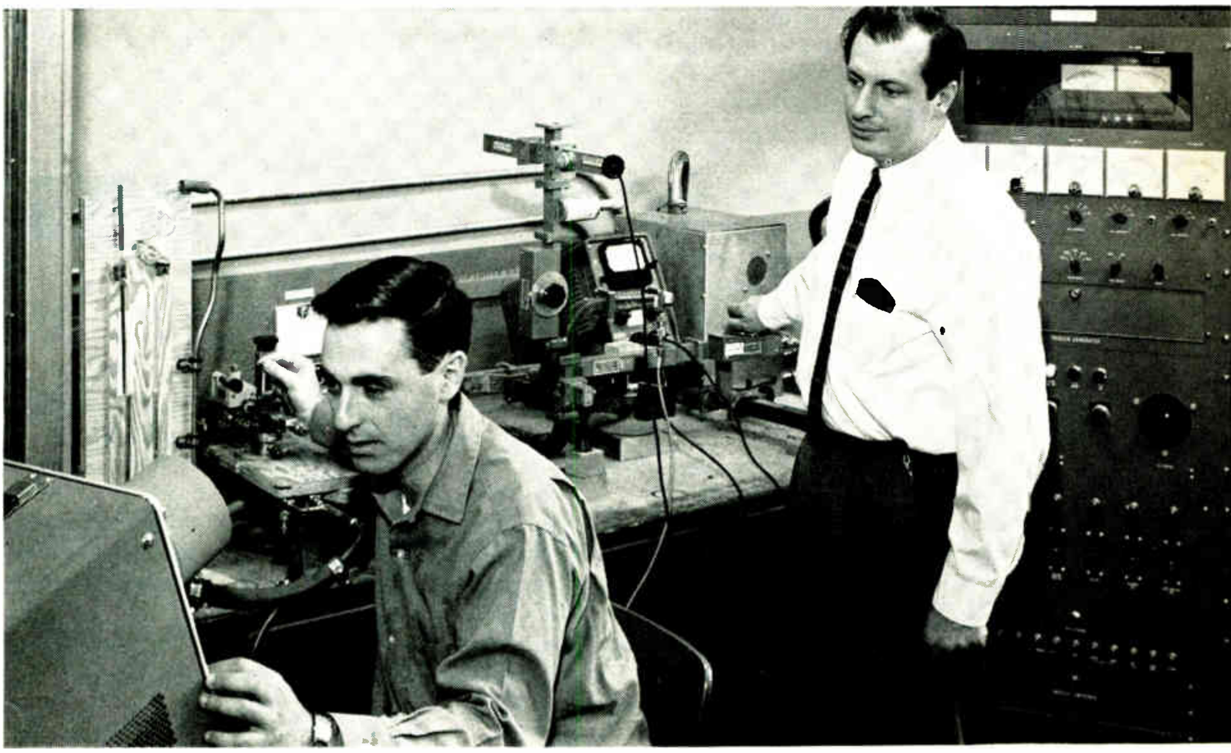
From Super Tool Company, creators of standard solid carbide miniature drills down to and including Wire size #80 (.0135") comes the most revolutionary of the Micro-Miniature tools; solid carbide, single point, gun type reamers in decimal Wire sizes from #31 (.1200") to #56 (.0465"). Special diameters, above and below these sizes are available on request.

A complete line of micro-miniature Drills, Reamers, End Mills, and Routers, especially designed for the electronics and associated industries, are available from your local Super Tool distributor.

SEND FOR CATALOG EL-62-1

SUPER TOOL COMPANY

DIVISION OF UNIVERSAL AMERICAN CORPORATION • ELK RAPIDS, MICHIGAN



Nonlinear character of microwave interactions with ammonia is demonstrated by generating third harmonic of X-band signal. Experimenter, left, is adjusting resonant cavity containing ammonia

Nonlinear Effects in Quantized Microwave Systems

Third harmonic of X-band is generated in a resonant cavity containing ammonia gas under pressure

By J. R. FONTANA
R. H. PANTELL
R. G. SMITH
Microwave Laboratory,
W. W. Hansen Laboratories of Physics,
Stanford University, Stanford, Calif.

NONLINEAR ELEMENTS have been applied to a wide variety of devices such as parametric amplifiers, harmonic generators and mixers. At microwave frequencies, the semiconductor diode is probably the most extensively used nonlinear element although ferrites, plasmas, electron beams and ferroelectrics have also been used or considered. At wavelengths shorter than a few millimeters, available nonlinear elements are not as useful. The diode, for example, is lossy and ferrites require high d-c magnetic fields.

In the optical and near infrared regions, power sources have been developed that make use of the characteristics of quantized systems. A quantized system is one in which the energy levels of the atom or molecule are discrete. If the state of the atom changes from one level to another there may be an emission or absorption of electromagnetic energy at a frequency

$$\nu = \frac{E}{h}$$

where h = Planck's constant, μ = frequency, and E = energy difference between the initial state and the final state.

The energy levels in atoms and molecules are such that the frequency may occur over an enormous frequency range, extending from microwave to optical. Since quantized systems have been successfully used for power generation at very short wavelengths, it is reasonable to consider using these systems as nonlinear elements, both for short wavelengths and for the microwave region.

If a type of atom has two possible energy levels with energy separation E, then an atom in the lower energy state can absorb one photon of energy from an electromagnetic field and jump to the upper level. The field loses an amount of energy equal to $h\mu$, the energy of a photon, which equals the energy gained by the atom. The reverse process, where an atom drops from the upper to the lower state by emitting a photon of radiation is equally probable, neglecting the effect of spontaneous emission. Therefore, to obtain a net amount of radiation from a medium, it is necessary to have more atoms in the upper state than the lower state, a condition known as population inversion. The probability of emission or absorption of a photon per unit time is linearly proportional to the energy density of the radiation field and is a linear process. In linear interaction:

(1) The frequency of the radiation field corresponds to $\mu = E/h$.

(2) Population inversion is necessary to obtain net emission of radiation.

(3) The per-unit-time probability of the process is linearly proportional to the energy density of the applied radiation. These characteristics explain the behavior of the maser or laser oscillator or amplifier.

The nonlinear quantum process does not necessarily satisfy any of these conditions. This behavior is characterized by having more than one photon involved in the interaction process. The simplest form of multiple quantum process involves two photons and satisfies the condition

$$h\mu_1 \pm h\mu_2 = E = h\mu \qquad (1)$$

where the plus sign corresponds to absorption of frequency μ_1, and the minus sign corresponds to emission at μ_2. Equation 1 expresses conservation of energy, and states that the total energy absorbed from the radiation fields equals the increase of energy of the atom. By using the plus sign in Eq. 1, absorption of energy at frequencies μ_1 and μ_2 will occur, and there will be emission at μ, the transition frequency of the atom. This corresponds to a mixing process. For the minus sign, absorption occurs at μ_1 and there is emission at μ and μ_2. This condition gives parametric amplification or oscillation, where μ_1 is the pump frequency and μ and μ_2 are the signal and idler frequencies. Harmonic generation is obtained by having $\mu_1 = \mu_2$, and using the plus sign in Eq. 1, thus resulting in second harmonic output at μ.

A paramagnetic system involving electron spin or an electric dipole transition that has a permanent dipole moment can exhibit interactions involving two photons. In a double photon interaction, the probability per unit time of occurrence is proportional to the product of the energy densities of the fields at μ_1 and μ_2. For second harmonic generation, for example, the output power at frequency μ is proportional to the square of the input power at frequency $\mu_1 = \mu_2 = \mu/2$. Population inversion is not required for emission at frequency μ for two-photon interaction, so none of the conditions that apply to the linear process is applicable to the nonlinear interaction.

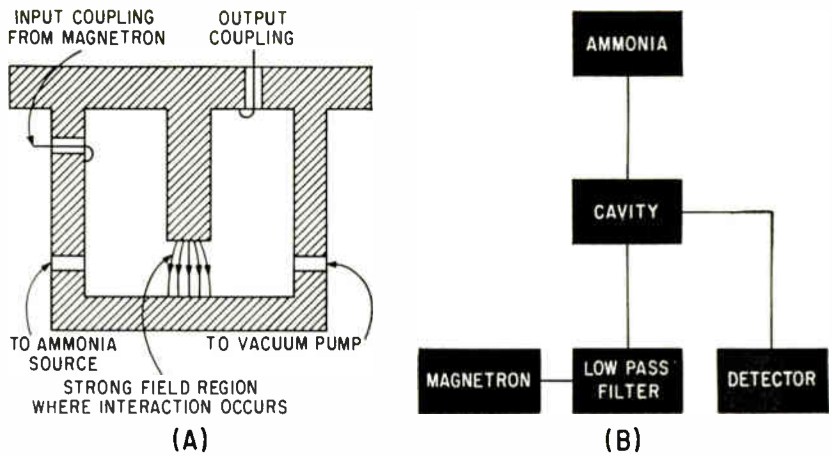


FIG. 1—Cross-section of cavity used in the harmonic generation experiment, (A); essential parts of the experimental setup, (B)

For electromagnetic interaction with an induced electric dipole transition, an odd number of photons is involved. The three-photon process is characterized by

$$h(\mu_1 \pm \mu_2 \pm \mu_3) = h\mu \qquad (2)$$

The plus signs indicate absorption and the minus signs indicate emission. By using all positive signs in Eq. 2 and by having $\mu_1 = \mu_2 = \mu_3 = \mu/3$, third harmonic generation occurs. An output signal at μ is obtained from an input signal at $\mu/3$. Mixing can occur by having three fields at different frequencies, such that the sum of these frequencies adds up to μ, the transition frequency in the atom. Second harmonic generation can be accomplished by letting $\mu_3 = 0$, corresponding to a d-c bias field, and by letting $\mu_1 = \mu_2$ with the plus sign for μ_2. The output at μ is twice the input frequency. This latter situation may be viewed alternatively as producing a permanent electric dipole moment by using a d-c bias, thereby allowing second-order processes to occur.

One possibility for parametric amplification or oscillation is indicated by $\mu_1 = \mu_2$ (using the plus sign for μ_2 and the minus for μ_3)

$$2\mu_1 = \mu + \mu_3$$

and μ_1 is the pump frequency with μ and μ_3, the signal and idler frequencies. For the three-photon process, the per unit time probability of occurrence is proportional to the product of the energy densities at the three frequencies μ_1, μ_2 and μ_3. In third harmonic generation, for example, the output power is proportional to the cube of the input power. As the power input increases, saturation effects eventually limit the output and the cube law relationship will no longer hold.

To demonstrate the feasibility of using a quantized system as a nonlinear element, a harmonic generation experiment has been performed using the transition in the ammonia molecule at 23,870 Mc, the transition used for the ammonia gas maser. This is an induced electric dipole transition, so the experiment consisted in generating third-harmonic power by applying radiation at a frequency approximately one-third the transition frequency.

It is of interest to contrast the operation of the quantum harmonic generator with the operation of the gas maser.

For harmonic generation, population inversion is not required; rather, all that is needed is an excess of molecules in the lower state. For simplicity, a gas in thermal equilibrium completely fills a reentrant cavity resonant at two frequencies, one frequency being three times the other. Figure 1A illustrates this cavity.

The ammonia maser provides an output power in the nanowatt range, whereas the experimentally obtained power output from the harmonic generator was thirty milliwatts. Theoretical calculations indicate that power output from the harmonic generator can be several watts.

The ammonia maser provides a fixed-frequency output given by the transition frequency of the ammonia molecule. The harmonic generator can provide an output power over 20 percent or more bandwidth. This broadband effect is due to alteration in transition frequency by the presence of a radiation field. In a similar way that an applied d-c field produces a Stark shift in frequency, the application of a strong r-f field also produces a frequency shift, which is proportional to the energy density of the applied radiation. Consequently, the frequency of the output radiation is still three times the frequency of the input, but the output frequency is higher than the natural transition frequency of the molecule. Another aspect of the broadbanding effect is that the gas pressure for the harmonic generator can be much higher than the pressure used in the maser, so that for the former case the spectral linewidth is broader.

Figure 1B is a block diagram of the apparatus used in the harmonic generation experiment. A pulsed magnetron was used as driver, with a low-pass filter to eliminate any third harmonic from the magnetron. The fact that the third harmonic was generated by the ammonia could be ascertained by removing the gas and noting that no output was obtained. As a consequence of the shift in frequency resulting from the presence of the radiation, the resonant cavity was tuned to 8.52 Gc and 25.56 Gc, whereas the transition frequency for ammonia is 23.870 Gc. Figure 2 shows output power versus input power for different pressures.

For high input powers the output power tends to saturate. The reason is that, as the level of applied radiation is increased, the populations of the two energy levels tend to equalize, thereby limiting the energy that can be absorbed by the dipoles and hence limiting output.

At high gas pressures, the output power versus input power curve follows the cube law predicted by the theory. At lower pressures, however, these curves follow a less than cubic relationship. This is a consequence of the spatial variation of the fields in the cavity and the frequency shift effect on the ammonia molecules. Depending on the input power level, the molecules in different portions of the cavity will have a detuned transition frequency that corresponds to the resonant frequency of the cavity. Therefore, as the power input changes, different volumes of gas are involved in the interaction, causing a deviation from a cube-law behavior. At high pressures, the spectral line is sufficiently broad so that the interaction volume does not alter appreciably as the input power is changed, and therefore the cube law is followed.

The input power levels cannot be increased appreciably beyond the level shown in Fig. 2, for at higher field strengths breakdown occurs and the gas becomes ionized. Tests to determine the presence of a plasma indicated that the onset of a plasma was readily discernible so that there was no problem in distinguishing the quantum effect from harmonic generation in a plasma.

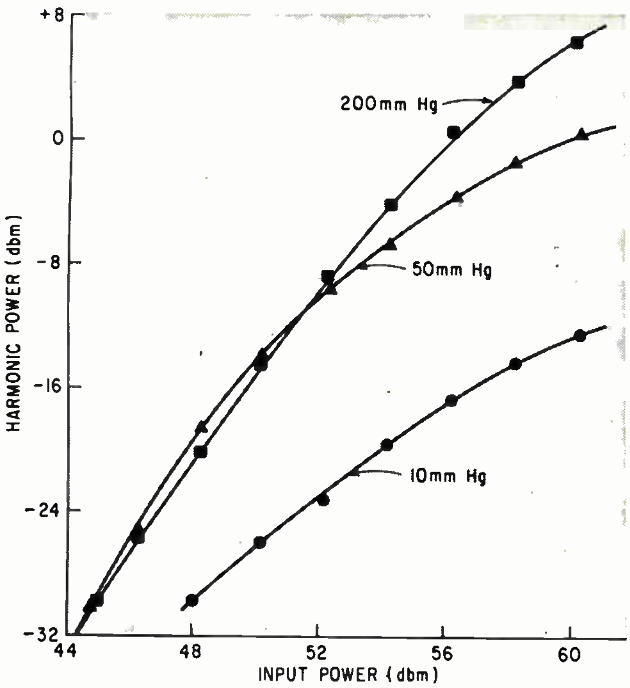
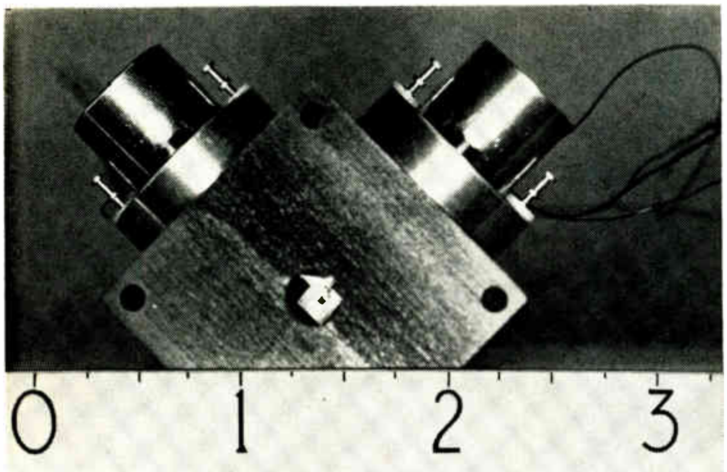
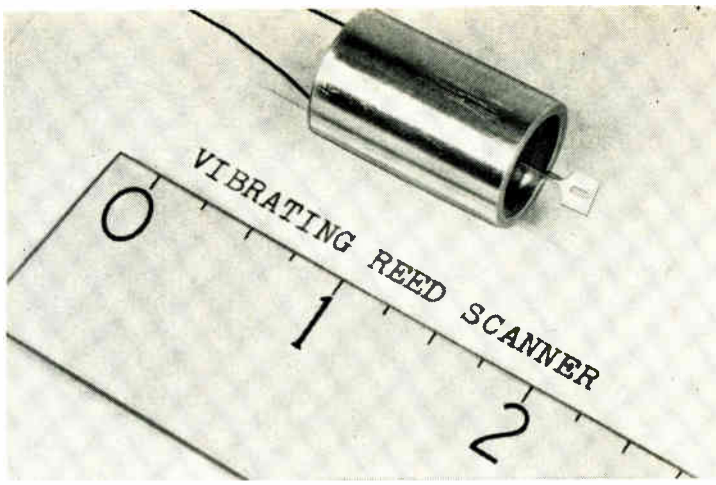


FIG. 2—Experimental curves indicate harmonic power output as a function of fundamental input power for several values of ammonia gas pressure

The research was supported jointly by the U. S. Army Signal Corps, U. S. Air Force, and U. S. Navy (Office of Naval Research).





Prototypes of the crossed reed scanner (left) and the vibrating reed scanner (right)

High-Reliability Scanners for Stellar Navigation

Originally designed for tracking stars under daylight conditions from shipboard and aircraft, this novel star tracking device will prove important in future space experiments

By JACOB S. ZUCKERBRAUN,
New York, N. Y.

A NULLING star tracker has as its main system components a telescope to collect and modulate light, and servomechanisms to position the telescope. Photoelectric signals derived from the telescope sensor supply the angular error information to the servos that drive the telescope into alignment with the star. Readout transducers transmit this information to the vehicle guidance and stabilization system.

The image scanner generates an error signal indicating the star position relative to the optic axis of the telescope and provides a recognition signal when the pointing error has been reduced to zero. In a space mission these functions must be carried out with high reliability, accuracy and minimum power drain.

These objectives are met in two scanning devices for NASA's Orbiting Astronomical Observatory. A vibrating-reed scanner will be used in the six star trackers deployed around the OAO vehicle as part of its coarse guidance system (30 sec of arc) and a tuning-fork scanner is planned for fine guidance system (0.1 sec of arc) for the Goddard ultraviolet experiment. A thin aperture plate is driven by the reed or tuning fork tine. The reed (fork) is operated as a self-excited oscillator in a transistor circuit requiring only 50 milliwatts d-c. This may be compared to motor-driven rotary scanners that usually require from 2 to 3 watts. Figure 1A shows a block diagram of a drive system that has a positive feedback loop to maintain oscillation, and a negative feedback loop for amplitude control.

While the cantilevered reed construction leads to a highly compact device in comparison to the fork scanner, the latter is a balanced structure possessing a nodal axis by which it can be mounted. Its amplitude and frequency are virtually independent of any mass and damping influences introduced by the rest of the telescope structure.

The scanning principle is shown in Fig. 1B to 1H. A slotted aperture plate is shown in Fig. 1B. Assume that the plate oscillates horizontally about the line $x = 0$ with simple harmonic motion, and with an amplitude of at least half the slot width. If a star image is on the center line of oscillation, the pulse waveform contains only even harmonics of the fundamental frequency. However, if the star appears off this null axis, to the right, an unsymmetrical waveform is generated that will contain a fundamental component. If the star appears to the left of $x = 0$ by the same amount, the amplitude of the fundamental will be as before, except that its phase will be reversed. Therefore, the requirements for error and presence signal generation are met by the sinusoidal scanning motion of the slot.

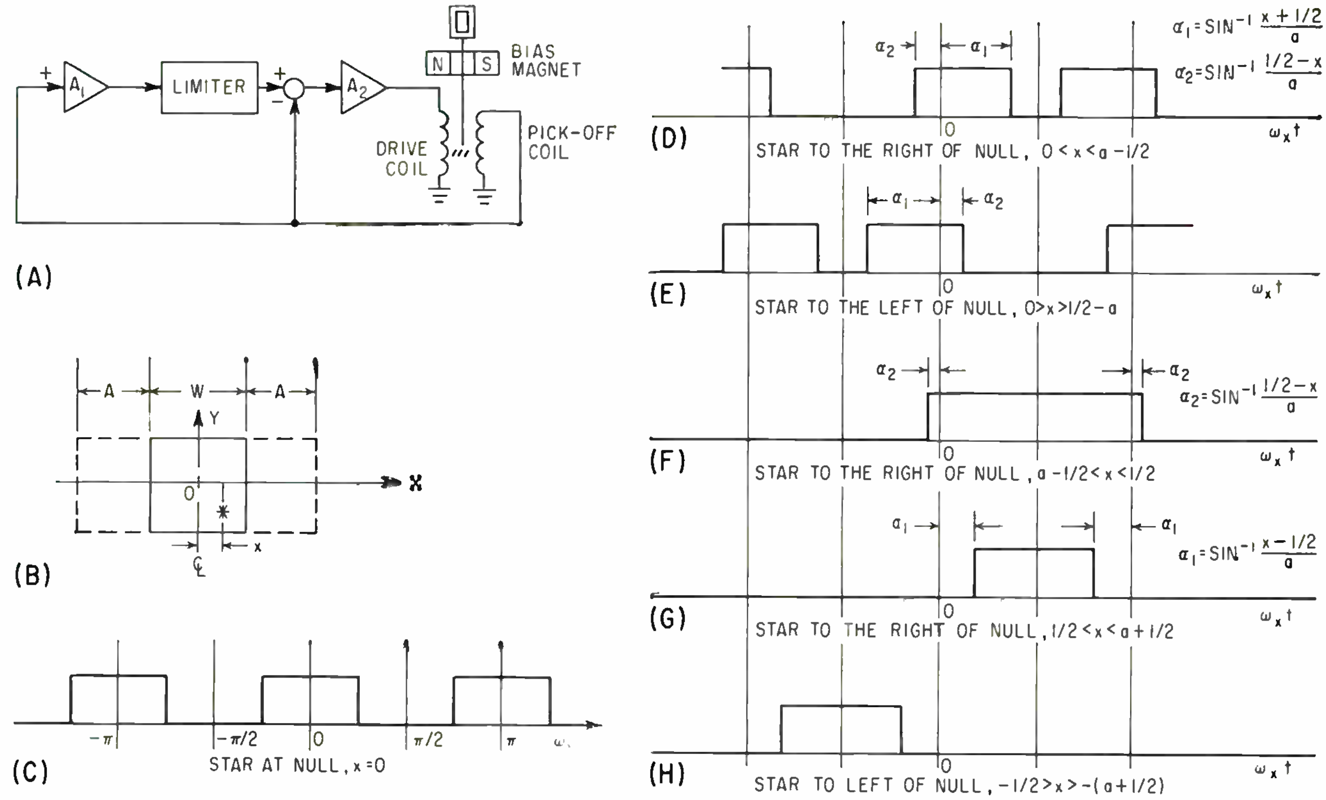


FIG. 1—Scanner drive circuit (A); slotted aperture plate (B); and illustrations for scanning principle (C to H)

The exact analysis of the waveforms yields these relations for the error and recognition coefficients, $f_1(x)$ and $f_2(x)$

$$f_1(x) = \frac{2}{\pi}\left[\sqrt{1-\left(\frac{x-\frac{1}{2}}{a}\right)^2} - \sqrt{1-\left(\frac{x+\frac{1}{2}}{a}\right)^2}\right] \quad \text{for } 0 \leqq x \leqq a - \tfrac{1}{2}$$

$$f_1(x) = \frac{2}{\pi}\sqrt{1-\left(\frac{x-\frac{1}{2}}{a}\right)^2} \quad \text{for } a - \tfrac{1}{2} \leqq x \leqq a + \tfrac{1}{2}$$

$$f_2(x) = \frac{2}{\pi}\left[\frac{x+\frac{1}{2}}{a}\sqrt{1-\left(\frac{x+\frac{1}{2}}{a}\right)^2} - \frac{x-\frac{1}{2}}{a}\sqrt{1-\left(\frac{x-\frac{1}{2}}{a}\right)^2}\right] \quad \text{for } 0 \leqq x \leqq a - \tfrac{1}{2}$$

$$f_2(x) = \frac{2}{\pi}\left[\frac{\frac{1}{2}-x}{a}\sqrt{1-\left(\frac{x-\frac{1}{2}}{a}\right)^2}\right] \quad \text{for } a - \tfrac{1}{2} \leqq x \leqq a + \tfrac{1}{2}$$

The d-c level $f_0(x)$ is

$$f_0(x) = \frac{1}{\pi}\left[\sin^{-1}\left(\frac{\frac{1}{2}-x}{a}\right) + \sin^{-1}\left(\frac{\frac{1}{2}+x}{a}\right)\right] \quad \text{for } 0 \leqq x \leqq a - \tfrac{1}{2}$$

$$f_0(x) = \frac{1}{2} + \frac{1}{\pi}\sin^{-1}\left(\frac{\frac{1}{2}-x}{a}\right) \quad \text{for } a - \tfrac{1}{2} \leqq x \leqq a + \tfrac{1}{2}$$

In the above equations, x and a are respectively the star error position X, and slot amplitude, A, both normalized to W.

A study of the waveforms produced by the scanner show that $f_0(x)$, $f_1(x)$ and $f_2(x)$ are even, odd, and even functions of x respectively.

If the excursion amplitude A is chosen to be $W/\sqrt{2}$, the recognition signal (second harmonic) at null will be a maximum. The signal coefficients (Fourier amplitude coefficients) for unit image flux are shown in Fig. 2A.

For simultaneous two axes tracking, two such scanners are used with beam-splitting optics that form independent star images. After emerging from the scanners the modulated light is recombined in a single multiplier phototube, as shown in Fig. 2C. Each scanner oscillates at a different frequency, allowing selective band-pass amplifiers to separate the position information for each axis. With dichroic optics, the ratio of the x and y recognition signals can identify the star by its color spectrum.

In another technique, the star light is passed through two parallel crossed apertures, placed close to each other on either side of the telescope focal plane. The square aperture formed by the superposition of the slots describes a lissajous pattern as the plates vibrate. The square area swept out by the instantaneous scanning aperture thus constitutes the dynamic field of view for the star tracker. As in the split-beam telescope, no critical phase or amplitude relationship need be maintained between the scanner motions. Each scanner operates as a free-running oscillator at a rate determined by the natural frequency of the reed or fork.

To appreciate the theory for the crossed reed (fork) scanner, consider the equation for the light emerging from the first vibrating slot. For a flux Φ concentrated in the star image, the modulated light at the first scanner output will be

$$\phi\,(x, t) = \Phi\,(f_0(x) + f_1(x)\sin\omega_x t + f_2(x)\cos 2\,\omega_x t + \;.\;.\;.\;+.\;.)$$

when $d = A \sin \omega_x t$ represents the slot displacement.

When the light passes through the second scanner placed at right angles to the first, multiplication occurs, yielding for light intensity as a function of time and the x, y coordinates

$$\phi(x, y, t) = \Phi[f_0(x)\,f_0(y) + f_0(y)\,f_1(x)\sin\omega_x t + f_0(y)\,f_2(x)\cos 2\omega_x t + f_0(x)\,f_1(y)\sin\omega_y t + f_0(x)\,f_2(y)\cos 2\,\omega_y t + \text{sum and difference terms}]$$

The scan frequencies ω_x and ω_y are chosen to be nonintegral multiples of each other to keep sum and difference terms outside the passbands of the follow-up amplifiers so there will not be cross-coupling between channels.

The following terms are recognized as containing the desired position and presence information

$$\Phi\,f_0(x)\,f_0(y) = \text{average flux}$$
$$\Phi\,f_0(y)\,f_1(x)\sin\omega_x t = x \text{ axis position signal}$$
$$\Phi\,f_0(y)\,f_2(x)\cos 2\,\omega_x t = x \text{ axis recognition signal}$$
$$\Phi\,f_0(x)\,f_1(y)\sin\omega_y t = y \text{ axis position signal}$$
$$\Phi\,f_0(x)\,f_2(y)\cos 2\,\omega_y t = y \text{ axis recognition signal}$$

Figure 3 shows the block diagram applicable to the split-beam and crossed-reed trackers.

The modulated light that emerges from the reed scanner is collected and imaged on the photocathode. The signal after passing through the preamplifier is fed to the tracking and recognition amplifiers for each axis, and also to a noise amplifier. Each of the signal amplifiers is connected to a detector, and their sum is fed to the star-presence detector. Under normal operating conditions with a star somewhere in the scanning field, the noise level is low, and the star presence detector is not inhibited. When this occurs, search is stopped, and the tracking loop closes. When the star reaches null, the track-null detector will no longer be inhibited by the error signals (f_1 and f_2) and a null indication appears.

The sum of the recognition signals ($2f_1$ and $2f_2$) is used as automatic gain control (agc) for the phototube power supply. This control is necessary to main-

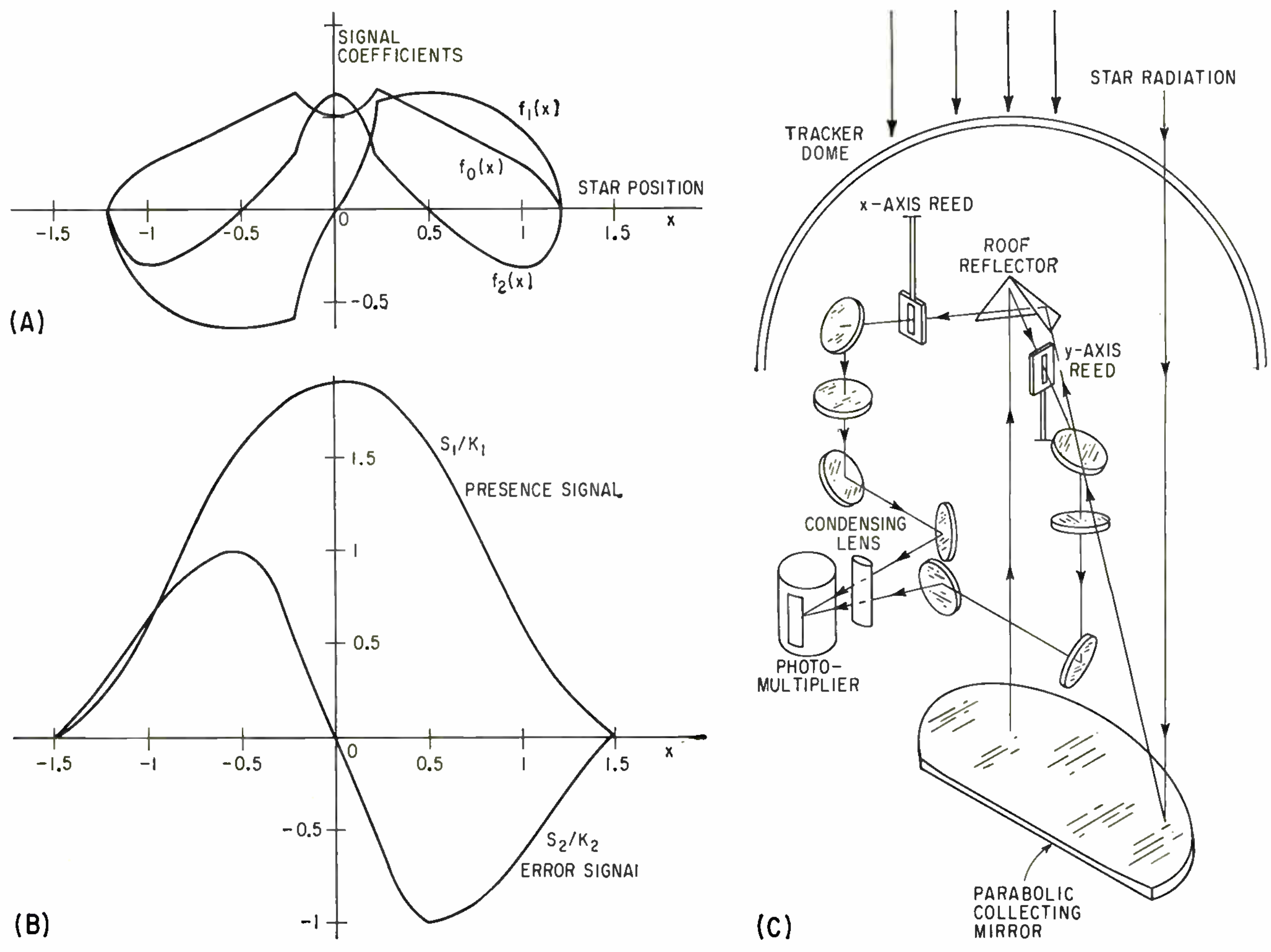


FIG. 2—Star signal coefficients (A); edge tracking signal coefficients (B); optics for split beam scanner (C)

tain tracking stability since star brightness enters into the equation for tracking loop gain. When the moon or the illuminated earth's cloud cover passes into the field of view during a search, the noise amplifier supplies an inhibiting signal to the star-presence detector, thus avoiding a false tracking signal and permitting search to continue.

The reed and fork scanners possess a number of advantages over other forms of tracking devices in daylight applications. The fundamental problem is to limit the shot noise caused by sky background illumination. The photon signal-to-noise ratio will be a maximum only if the scanning aperture is made equal to the star image (usually about 1.5 minutes of arc). The vibrating aperture scanners permit such a small aperture to be precisely manipulated. Thus the star flux can be fully and continuously modulated at some convenient frequency. If the signal is then passed through a narrow-band amplifier the signal-to-noise ratio will be raised to a usable level. By this technique, 2.5 magnitude stars such as Polaris have been tracked in a daylight sky of over 100 candles/ft².

Vidicon trackers, which are not shot noise limited and have a wider tracking field, are limited at present by target noise of the same order as the star signals under daylight conditions, and by target lag. These false star pulses cannot be eliminated by any simple electronic technique. In contrast to the vidicon systems that produce only one star pulse per frame, the reed and fork scanners produce continuous presence and tracking signals, allowing continuous averaging of star position.

The fork and reed scanners with their mechanical simplicity guarantee high system accuracy. Electron-beam devices may not compete in this area of performance for many years.

In addition to star tracking, the same scanner can also perform planetary edge tracking. This is done by interchanging the roles of the fundamental and second harmonic-signals with respect to star tracking. Thus the fundamental is the edge-recognition signal and the double frequency component yields position error. Figure 2B shows a plot of the error and presence coefficients (Fourier amplitude coefficients) for the edge mode of operation,

$$S_2(x) = K_2(1 - (x + \tfrac{1}{2})^2)^{3/2} \text{ for } -3/2 \leqq x \leqq -\tfrac{1}{2}$$

$$S_2(x) = K_2[(1 - (x + \tfrac{1}{2})^2)^{3/2} - (1 - (x - \tfrac{1}{2})^2)^{3/2}] \text{ for } -\tfrac{1}{2} \leqq x \leqq +\tfrac{1}{2}$$

$$S_2(x) = -K_2(1 - (x - \tfrac{1}{2})^2)^{3/2} \text{ for } \tfrac{1}{2} \leqq x \leqq 3/2$$

$$S_1(x) = K_1\left[(\tfrac{1}{2} - |x|)(1 - (\tfrac{1}{2} - |x|^2)^{1/2} + \sin^{-1}(\tfrac{1}{2} - |x|) + \frac{\pi}{2}\right]$$

$$\text{for } -3/2 \leqq x \leqq -\tfrac{1}{2},\ \tfrac{1}{2} \leqq x \leqq 3/2 \text{ and } -\pi/2 \leqq \sin^{-1}(\tfrac{1}{2} - |x|) \leqq \pi/2$$

$$S_1(x) = K_1[(x + \tfrac{1}{2})(1 - (x + \tfrac{1}{2})^2)^{1/2} + \sin^{-1}(x + \tfrac{1}{2}) - (x - \tfrac{1}{2})(1 - (x - \tfrac{1}{2})^2)^{1/2} - \sin^{-1}(x - \tfrac{1}{2})] \text{ for } -\tfrac{1}{2} \leqq x \leqq \tfrac{1}{2}$$

The constants K_1 and K_2 are determined by the aperture area and image brightness.

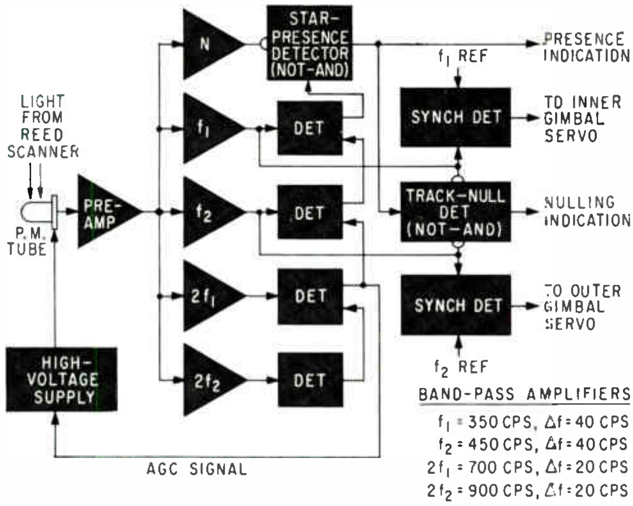


FIG. 3—Split beam and crossed-reed trackers

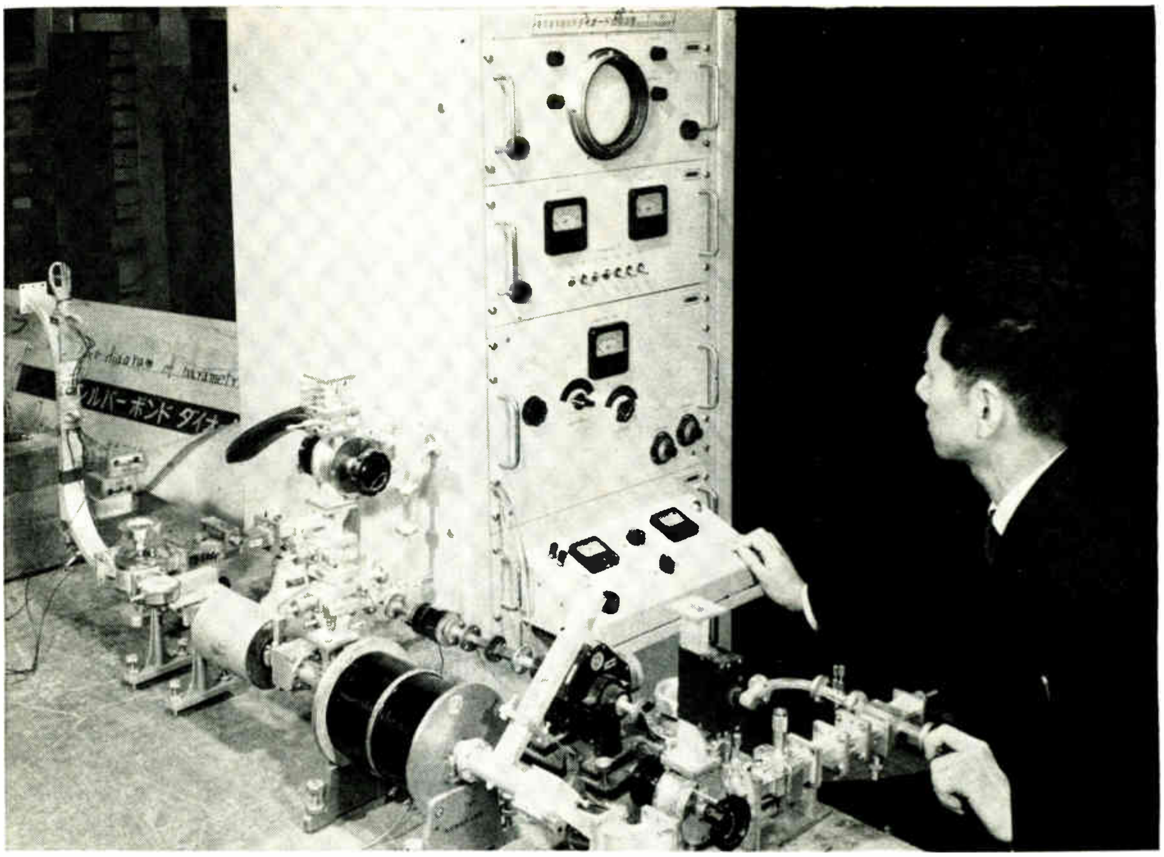
The slot displacement is given by $D = W \sin \omega x t$.

If the terminator (inner arc of the crescent) is scanned rather than the true edge of the planet, both the error and recognition signals will reverse in phase. It then becomes possible to distinguish the true edge from the inner arc of the crescent. If three points around the circumference are sampled, computation yields the coordinates of the planetary disk and range information.

Tests on the reed scanner have indicated frequency stabilities of about 0.2 percent at 400 cps and amplitude stability of 5 percent over a temperature range of −80 to 100 deg C. In applications requiring extremely narrow filter bandwidths, synchronous detection has been found to be adaptable. A reference signal is taken from the drive circuit allowing the detector to follow any frequency variations. Although the amplitude of vibration does not control the true nulling accuracy, it does influence the level of the recognition and tracking error signals. For example, an increase of A by 5 percent from the value of 0.707 W will cause a decrease of about 14 percent in the error signal gradient, and about ½ percent loss in recognition signal at null. These variations are not of great consequence to the servo tracking system. The fact that the change in recognition signal is small is most fortunate since this signal can be relied upon to give an accurate measure of star magnitude.

Stress analysis and life tests have shown no performance deterioration even after 10,000 hours of continuous operation at 400 cycles per second.

In addition to their role in stellar navigation. the trackers are finding applications to missile and satellite tracking from ground stations and to infra-red horizon sensing. One of the important reasons for the high reliability of the reed and fork scanners is the elimination of bearings and the need for lubricants. This is of even greater importance in advanced systems now in development, which will be required to function reliably even if exposed to a high-vacuum environment. The low power requirement of the scanners results in negligible self-heating, and this contributes to longevity.



Author experiments with 11-Gc parametric amplifier using silver-bonded diodes

Microwave Applications of

Low noise diode having a cutoff frequency in excess of 130 Gc, rectifying ratio of 10^6 and a junction capacitance of 0.3 pf at zero bias is suitable for parametric amplifiers, high-speed computers, harmonic generators and i-f limiters

By SHOICHI KITA, Electrical Communications Laboratory, Nippon Telegraph and Telephone Public Corp., Tokyo, Japan

SEVERAL YEARS AGO it was noticed that negative resistance could be produced at microwave frequencies by applying pump power whose frequency was higher than the signal frequency to a semiconductor diode.[1] Using this negative resistance, amplification and oscillation were obtained at microwave frequencies. This type of amplifier, now known as the parametric amplifier, has recently attracted much attention because of its low-noise characteristics.

Large variation of junction capacitance and high cutoff frequency are required of parametric amplifier diodes. Recently, the author developed the silver-bonded diode specifically for this purpose.

The silver-bonded diode is constructed by bringing the tip of a silver whisker containing gallium into contact with an *n*-type germanium wafer of about 0.02-0.2 ohm-cm resistivity where the junction is electrically formed by passing the discharge current of a capacitor through it.

The voltage-current characteristics of the silver-bonded diode and other diodes are shown in Fig. 1A. The silver-bonded diode has a larger forward current than any other point-contact diode and extremely small reverse current. Its rectifying ratio is greater than 10^6.

One feature of the silver-bonded diode that compares extremely favorably with other varactor diodes is its small junction capacitance—less than 0.3 pf at zero bias. Capacitance variations due to the bias voltage at 300K and 100K are shown in Fig. 1B.

The normalized impedance of the silver-bonded diode at 6 Gc is shown in Fig. 1C. The Q of the diode can be obtained from the figure, which shows the values of Q about 15 and

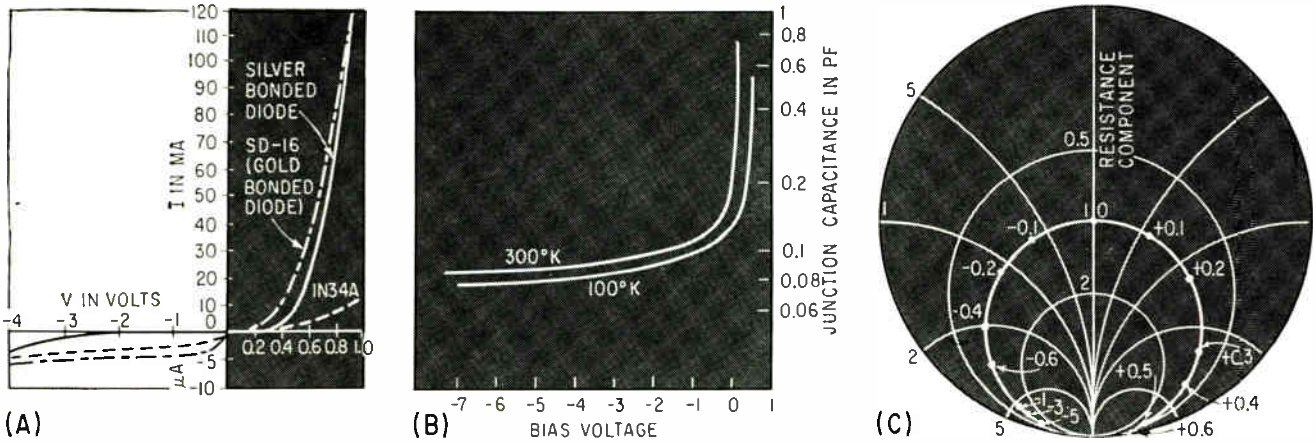


FIG. 1—Voltage-current characteristics of typical diodes (A), variation of junction capacitance with bias voltage of silver-bonded diode (B) and 6 Gc impedance normalization at zero bias as a function of bias voltage (C)

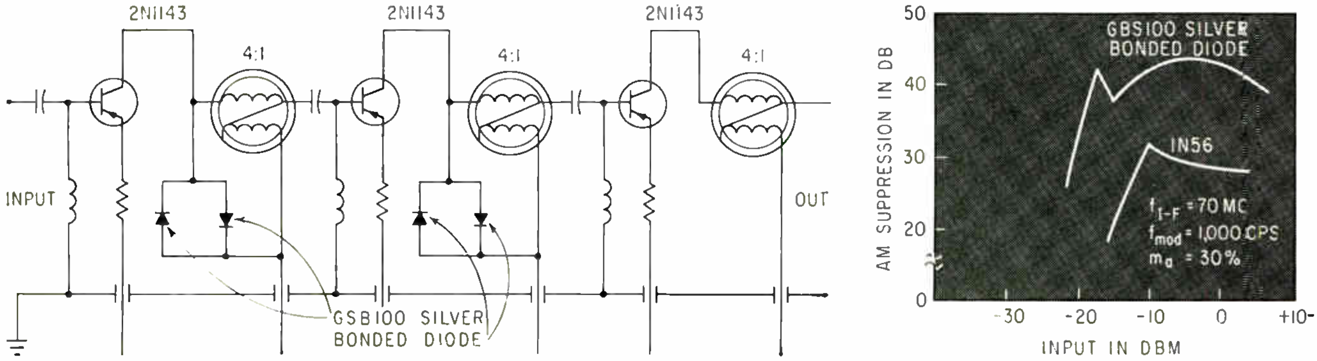


FIG. 2—Limiter circuit of a seventy-Mc i-f amplifier with limiting characteristics of silver-bonded diode compared with a conventional diode

the Silver-Bonded Diode

23 at zero bias and −5 v bias respectively. The cutoff frequency of the diode is higher than 130 Gc at −5 v. Because of small junction capacitance and high cutoff frequency, the silver-bonded diode is suitable for parametric amplifiers, frequency converters and harmonic generators. The characteristics of low forward resistance and small junction capacitance are also suitable for high-speed computer circuits. When a diode is used in computer circuits, special attention should be paid to the transient characteristics under voltage pulse conditions. The silver-bonded diode shows a fall time of less than 10 nanosec and no effects of hole storage are observed.

Using these diodes, 4 Gc, 6 Gc and 11 Gc parametric amplifiers were constructed.[2, 3] The 6 Gc signal power is supplied through a 6 Gc circulator to the diode. The pump power at 12 Gc is supplied to the diode through an X-band isolator. By adjusting the slide-screw tuner and the waveguide piston, a signal at a frequency almost one-half of the pump frequency can be amplified. Required 12 Gc pump power for amplification is 5 to 10 mw. The minimum noise figures for double sideband reception are about 2.5 db in the 4 Gc and 6 Gc bands, and about 3.5 db at 11 Gc.

The efficiency of a harmonic generator using a variable capacitance is much higher than that of a harmonic generator using variable resistance, therefore the silver bonded diode is also suitable for harmonic generator operation. A 23 Gc harmonic generator with fundamental power at 11 Gc through and X-band waveguide with the 23 Gc power produced in a K-band waveguide was built. A negative bias voltage was applied to the silver-bonded diode to obtain the best efficiency. An output of 19 mw at 22.6 Gc was obtained as the maximum output power with 300 mw input of 11.3 Gc. The best efficiency obtained was about 11 percent at 50 mw input power.

The silver-bonded diode is suitable for i-f limiter and high-speed computer use. Figure 2 shows an i-f limiter circuit using the GSB100 diode with a comparison of the limiting characteristics of GSB100 and 1N56 diodes. The value of a-m suppression of the GSB100 is 10 db higher than that of the 1N56. When the GSB100 was used in a logic circuit, the voltage drop of the diode was one-third that of the 1N34A diode.

REFERENCES

(1) S. Kita and T. Fujii, Microwave Amplification by Use of Crystal Diode, presented at Annual Convention, Inst. of Elec. Commun. Engrs. of Japan, Tokyo, Oct., 1954.

(2) S. Kita and F. Obata, An X-band Parametric Amplifier using Silver Bonded Diode, Proc IRE, 48, p 1,651, Sept 1960.

(3) S. Kita, T. Okajima and M. Chung Parametric Amplifier using a Silver Bonded Diode, IRE Trans ED-8, p 105, March 1961.

Time Compression With a

Transfluxor matrix permits real-time spectrum analysis for automatic recognition systems with minimum memory size, eliminating analog-to-digital conversion and mechanical wear points

By J. WARREN GRATIAN, General Dynamics/Electronics Research division, Rochester, New York

THE GROWING IMPORTANCE of automatic recognition, data-processing, and control systems lies in their potential for economically performing a variety of operations with speeds, accuracies and degrees of complexity beyond human capabilities. Future applications range from complex systems such as required for target classification or information retrieval to voice-operated control of machines such as typewriters and apparatus for teleprinter transmission or telephone calling. Bandwidth reduction to conserve communications space is a related application.

The first step in these processes is analysis of input stimuli and commands. Many specialized techniques are being studied in character and pattern recognition, and relatively simple laboratory equipment has demonstrated capabilities for limited voice recognition; for example, the digits zero through nine when spoken by one or a few individuals for whom the equipment was adjusted. Greater versatility in speech recognition will require more complete analysis and more complex data-processing operations on a set of parameters that adequately define speech. Typical parameters are the relative magnitudes and frequencies of speech formants.[1] Spectrum analysis identifies the location and magnitude of the various frequency components of a voice signal; recognition of an element of speech then consists of determining whether the particular combination of components which defines a set of speech parameters exists at any instant.

The major problem in spectrum analysis is the excessive cost and size of conventional equipment. This equipment consists of a parallel-channel analyzer with all channels operating continuously and a switch for sequential sampling of all channels within some short period such that no significant change in spectrum occurs. One analyzer in use for laboratory speech studies consists of a 55-channel filter system and multiplex.

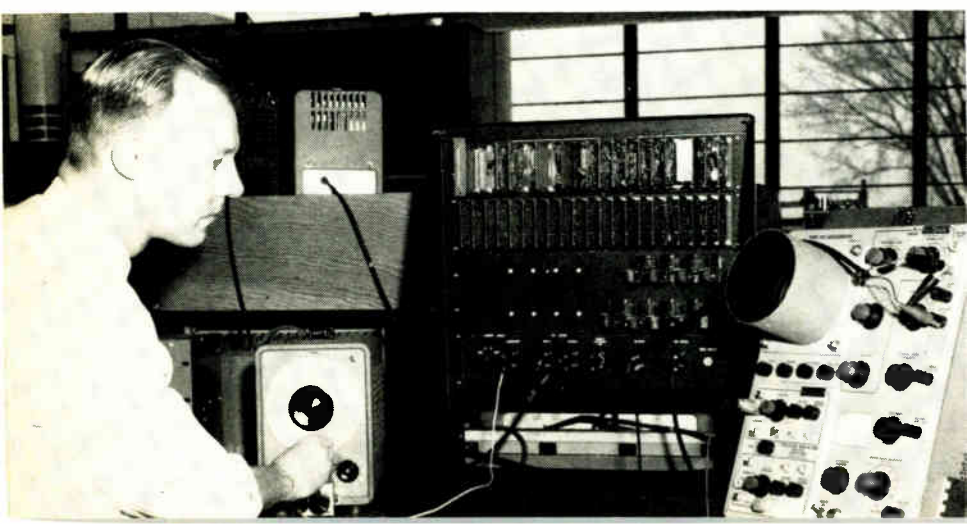
A sweep analyzer can be many times more compact because, in effect, only a single variable-frequency filter is required for scanning the complete spectrum. However this analyzer can meet conflicting requirements on frequency resolution and speed of analysis in many applications only if preceded by a time compression process that multiplies all frequencies by a given factor. Processes[2, 3] developed in the past for different spectrum analysis problems involve mechanical problems or the requirement that the spectrum be stored digitally. The process described here was conceived around two objectives:

(1) Signal storage by the analog method, which permits minimum memory size and eliminates analog-to-digital conversion.

(2) Elimination of critical mechanical wear points, such as slip-ring assemblies and contact between heads and storage media.

The representative requirements for an operational speech-analysis system are: (1) the spectral data must be produced at the same rate as the original signal, that is, real-time analysis is required; (2) the time resolution (corresponding to the period for which the signal is steady state) should be 10 to 20 msec; (3) the frequency resolution of the analysis should be comparable to the formant-frequency resolving ability of man; that is, in the range of 100 to 300 cps; and (4) the frequency range of the analysis should be approximately 200 to 4,000 cps.

A conventional sweep analyzer for spectrum analysis corresponds to the block diagram of Fig. 1A. This method requires relatively slow sweep rates if the frequency



Author tests spectrum analyzer

Solid-State Analog Memory

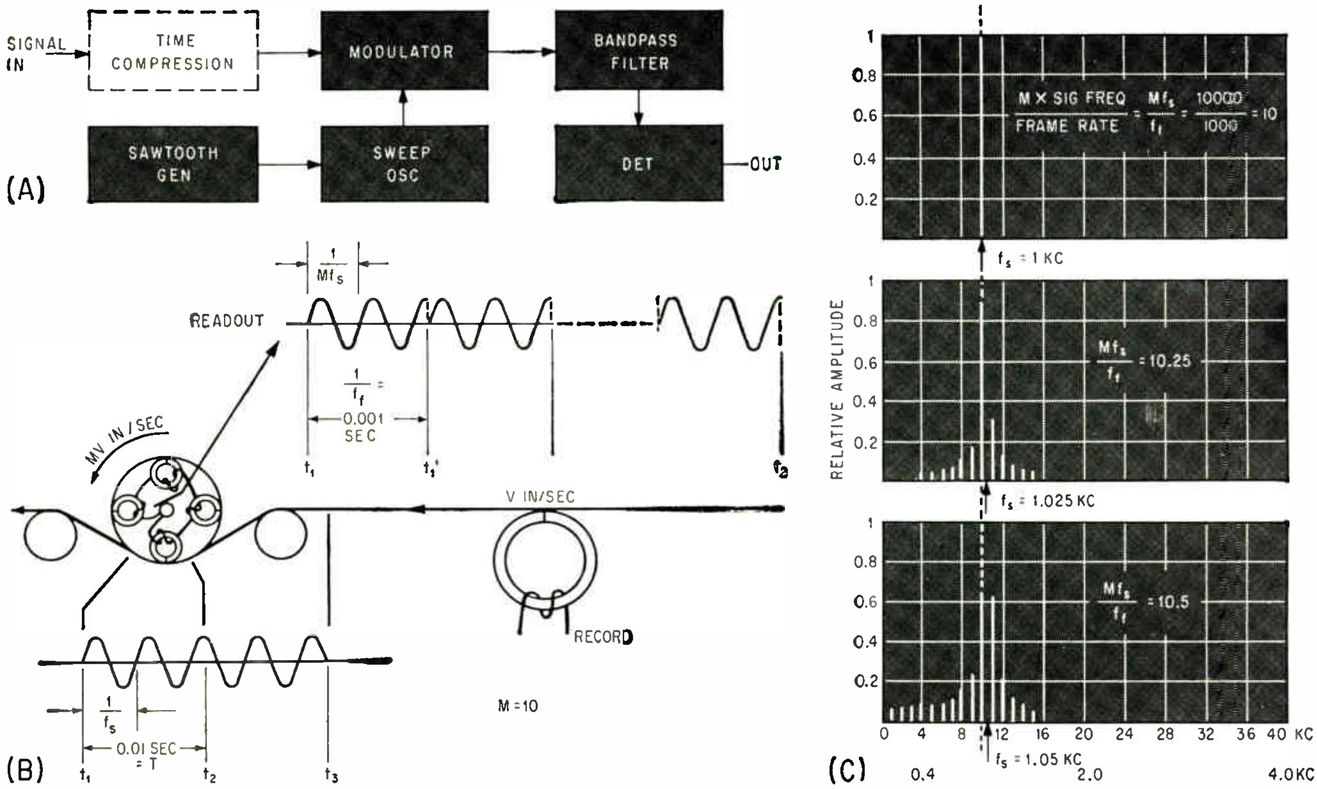


FIG. 1—Sweep spectrum analyzer (A); previous time-compression process, using magnetic tape (B); and time-compression spectra (C), in which the upper figures on the horizontal axis are the actual output frequency range, and the lower figures are the output scale calibration in terms of original signal

resolution requirements are met, and real-time analysis cannot be achieved.

Let F = total frequency band to be swept; B = filter bandwidth (the frequency resolution); T = time to sweep spectrum F (the time resolution); $t = BT/F$, time for a given component to sweep B and $t' = k/B$, time that signal must be applied to filter so that response will reach a specified fraction of maximum response. Setting $t = t'$, $T = kF/B^2$, where $k = 1$ provides 96 percent of steady-state response with a gaussian filter.[4]

Hence, with T = 0.01 sec and F = 3,800 cps, the filter bandwidth B must be greater than 616 cps, and the resolution is inadequate for speech analysis. With time compression or frequency multiplication, all frequencies in the original spectrum are multiplied by a factor M, so that $B = \sqrt{FM/T}$. For example, when M equals 10, the value of B is 1,950. Referred to the original spectrum, however, the equivalent resolution or effective bandwidth is

$$B_{eff} = \sqrt{FM/T}/M = \sqrt{F/TM} = 195 \text{ cps}$$

Table I for T = 0.01 sec shows the effectiveness of time compression.

TABLE I — PARAMETERS FOR T = 0.01 SEC AND f_p = 100

M	1	10	16		32		
FM	3,800	38,000	60,800		121,600		cps
B	617	1,950	2,470	(4,940)	3,180	(10,440)	cps
B_{eff}	617	195	154	(308)	109	(327)	cps
$t = BT/FM$	1.65	0.51	0.41	(0.81)	0.29	(0.86)	msec
f_pM	100	1,000	1,600		3,200		cps
$N = tf_pM$	0.165	0.51	0.65	(1.3)	0.92	(2.76)	cycles

where f_p = assumed minimum pitch frequency or beat frequency of adjacent components

N = number of beats during the period that a given component sweeps filter bandwidth B.

When N is less than one full cycle, the analyzer output will vary on successive sweeps in synchronism with the pitch frequency beat between adjacent harmonics of the pitch frequency. If this cannot be tolerated, the bandwidth should be increased. With several cycles of beat occuring during a sweep of

TABLE II — CYCLES PER MEMORY SEGMENT

Frame rate/$M = f_f/M$......	50				100				125				250				cps
Low-Frequency Limit	200		400		200		400		200		400		250		500		cps
L-F Cycles/Memory Segment	4		8		2		4		1.6		3.2		1		2		cycles
High-Frequency Limit	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	Kc
H-F Cycles/Memory Segment	40	80	40	80	20	40	20	40	16	32	16	32	8	16	8	16	cycles

TABLE III — FRAME RATE, FILTER AND EFFECTIVE BANDWIDTHS

f_f/M cps	50			125			250		
M	10	16	32	10	16	32	10	16	32
f_f cps	500	800	1,600	1,250	2,000	4,000	2,500	4,000	8,000
B cps	1,950	2,470	3,480	1,950	2,470	3,480	1,950	2,470	3,480
B_{eff} cps	195	154	109	195	154	109	195	154	109

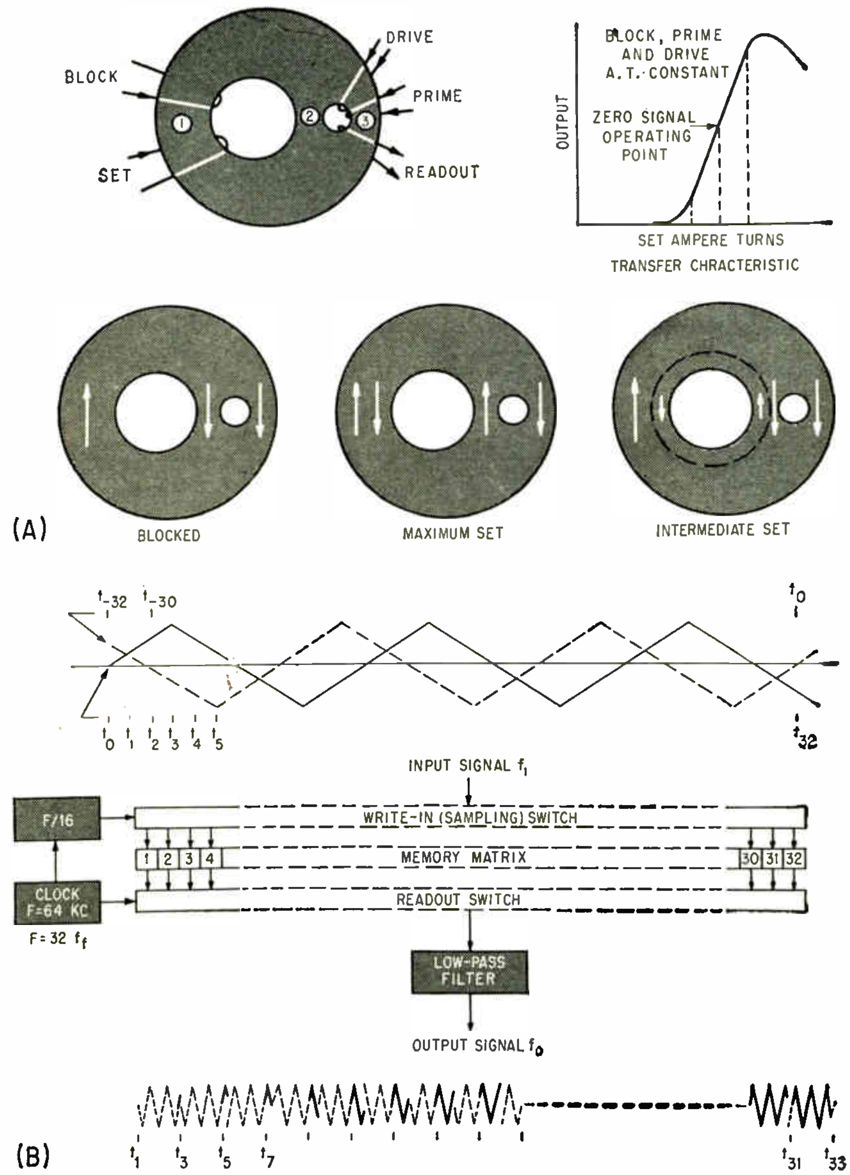


FIG. 2—Transfluxor operation (A) and solid-state time-compression process (B)

B, the demodulator time-constant can be made large enough to average over the several cycles, thus yielding uniform output on successive sweeps. The memory must be large enough to store at least one complete cycle of the beat frequency for it to be multiplied to the tabulated values of N.

Time compression requires that the signal to be analyzed must be stored so that segments of length no longer than the required time resolution can be selected in sequence and that each segment can then be scanned repeatedly for the analysis. The general process can be understood by reference to a previous method[3] shown in Fig. 1B. Since the rotating pickup scans the magnetic tape at a peripheral velocity much higher than the tape speed, the reproduced signal consists of a number of repetitions or frames of the same waveform (t_1 to t_2), where $t_2 - t_1$ = time resolution. A change in input signal may begin to occur 0.01 sec later (t_2 to t_3), but analysis of the repetitive t_1-to-t_2 sample at the multiplied output frequency can be completed by this time. The multiplied output to be analyzed has discontinuities introduced at the readout frame rate of f_f = 1000 cps; its spectrum, therefore, consists only of harmonics of 1,000 cps. The magnitude and location of these harmonics are functions of input-signal frequency.

The Fourier analyses performed in this study show that the a-c output spectrum of the time compressor for a sinusoidal input is

$$f(t) = \sum_{1}^{n \to \infty} (a_n \cos n\,\omega t + b_n \sin n\,\omega t)$$

$$a_n = \frac{2}{T}\int_0^T \sin K\,\omega t \cos n\,\omega t\,dt$$

$$b_n = \frac{2}{T}\int_0^T \sin K\,\omega t \sin n\,\omega t\,dt,$$

$$\text{where } K = \frac{M \times \text{input frequency}}{\text{frame frequency}} = \frac{M fs}{f_f} = \frac{\Omega}{\omega}$$

If $K\omega = n\omega$ and $K = n = 1, 2, 3 \ldots$ then

$$a_n = 0 \text{ and } b_n = 1$$

Hence, when the input frequency multiplied by M is an integral multiple of the frame frequency, the

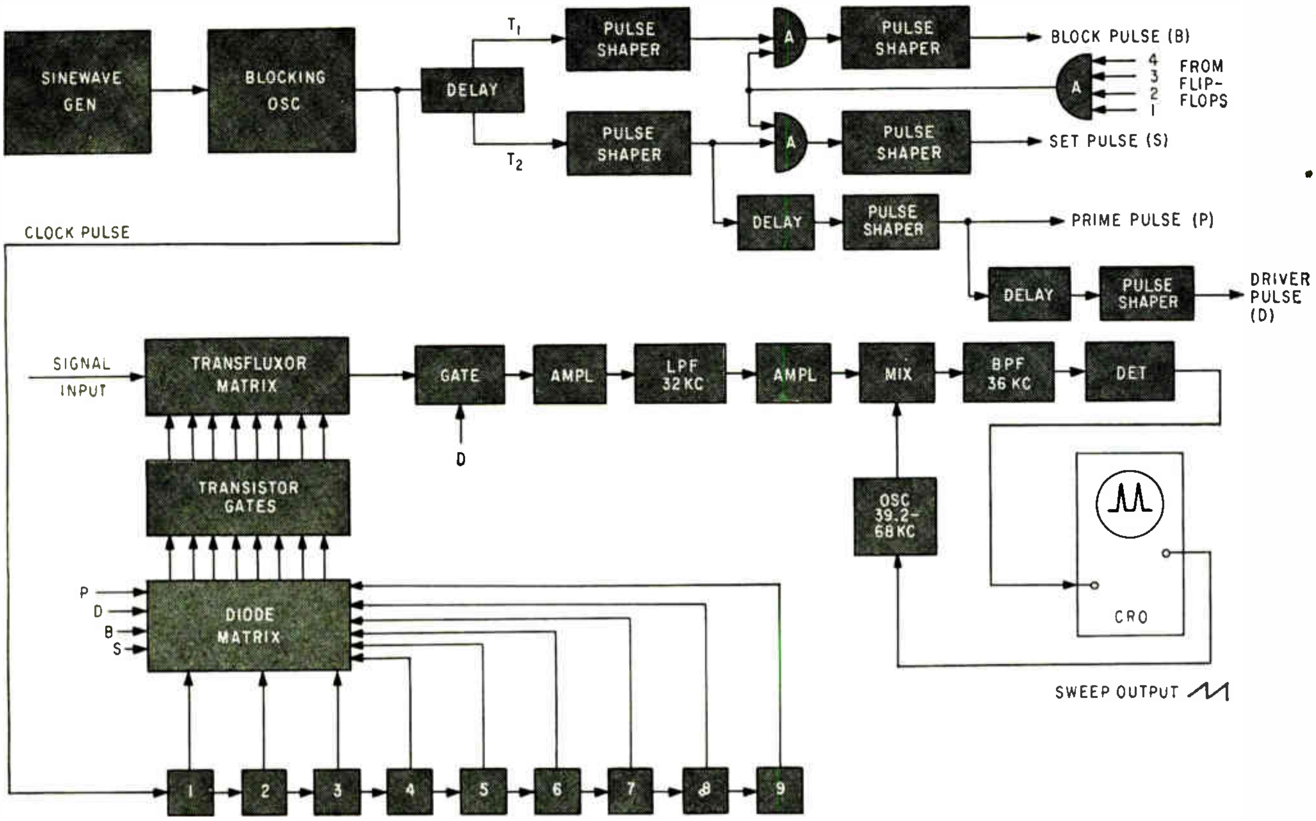


FIG. 3—Complete model of transfluxor spectrum analyzer

output is a single frequency of unity amplitude at M times the input frequency.

If $K\omega \neq n\omega$, n = 1, 2, 3 . . . and $K > 1$, then

$$a_n = \frac{K(1-\cos 2\pi K)}{\pi(K^2 - n^2)} \text{ and}$$

$$b_n = \frac{n \sin 2\pi K}{\pi(n^2 - K^2)}$$

Where Ω is not an integral multiple of ω, the output consists only of harmonics of ω, the frame rate.

Figure 1C shows representative spectra. To obtain unity response from the complex spectra, it would be necessary to sum the energy of all components, and excessive analyzer filter bandwidth would be required to span all components. However, in the worst case the energy of the two highest lines is about 90 percent of the total and may provide sufficient accuracy in some applications. Four lines constitute 95 percent of the total.

Only a relatively small change in spectra occurs as the number of stored cycles per frame approaches unity. It had been expected that it would be necessary to store a minimum of perhaps 10 cycles of the lowest signal frequency to minimize the relative effects of discontinuities at the ends of the frame. The analysis, however, shows that with $Mf_s/f_f = 1.5$, corresponding to storage of 1.5 cycles, the two major lines have normalized amplitudes of 0.76 and 0.55 as compared to 0.65 and 0.62 for a ratio of 10.5. Consequently, the memory need be long enough to store only one or two cycles of the lowest signal frequency, depending on the accuracy required. With a frequency range of 4,000/200 or 20:1. and low-frequency storage of one cycle, only 20 cycles of the top frequency must be stored, thus reducing the size of the memory and circuits.

The factors that must be considered in the choice of frame rate for analog time compressors are shown in Tables II and III.

The minimum frame rate permits the closest spacing of time-compressor spectral lines, thus allowing a summation of components with minimum analyzer bandwidth. Higher frame rates, however, reduce the number of signal cycles to be stored, thus reducing memory size. Frame rate/M is not necessarily equal to $1/T$, the analyzer sweep rate. Both must be at least 50 cps to provide the required time resolution, but the use of a higher frame rate does not require a correspondingly higher sweep rate.

If, for example, frame rate/M = 125 and M = 16, the spacing between the spectral lines, as shown in Table III, is f_f = 2,000 cps. The minimum allowable analyzer bandwidth is B = 2,170 cps, thus spanning two spectral lines as required for minimum acceptable accuracy in summing. If an effective bandwidth or resolution of 300 cps were acceptable, B could be increased to 4,800 cps, thus spanning 3 lines and providing more accurate summation.

A memory is required that permits: (1) analog sample storage, (2) nondestructive readout, and (3) repetitive address by non-mechanical means.

Various storage phenomena are being explored that may provide these characteristics in the future and, in addition, permit microelectronic construction.

At present multiapertured ferrite cores are the most suitable and 32 RCA XF-3665 transfluxors were

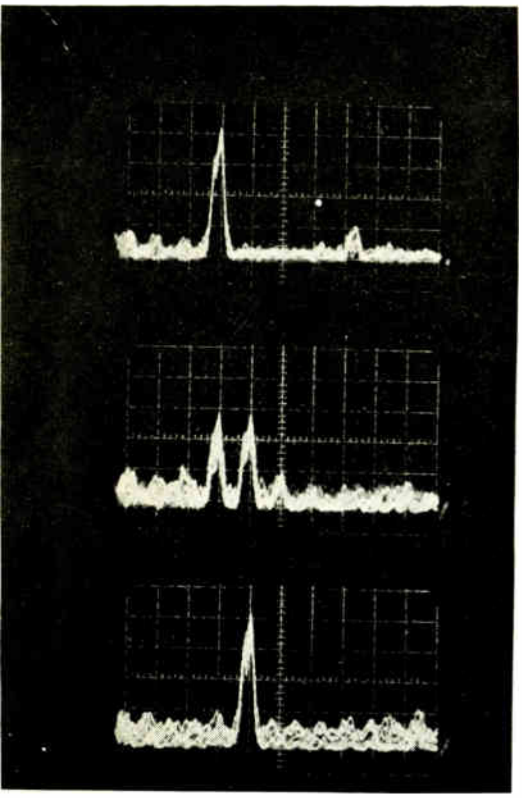


FIG. 4—Spectrum analyzer output display, with inputs of 1 Kc (top), 1.125 Kc (middle) and 1.25 Kc (bottom)

selected for the model.

The transfluxor[5] is first blocked or erased by a pulse of sufficient amplitude to saturate the complete core in one direction, as shown in Fig. 2A. A set or write-in pulse is then applied in the opposite direction to reverse the flux in a portion of the core; the amount of flux reversed, and the net flux in leg 2 depends on the pulse (signal sample) amplitude. Alternating prime and drive pulses then switch the net flux back and forth between legs 2 and 3. The voltage induced in the readout winding is gated by external circuits to pass through only at the time of the drive pulse. Thus, each transfluxor can store indefinitely an analog representation of the signal amplitude sample taken at an instant, and the magnitude of this sample can be read out repeatedly until it is desired to reset the core to a new value.

Figure 2B shows the functions of the time compressor, including the 32-core memory, when a multiplication of $M = 16$ is provided. Assume first that the 32-element memory has been filled with 32 samples of the input signal f_i during a previous time interval, t_{-32} to t_0, represented by the dotted-line function. The input signal then continues to vary as indicated by the solid-line curve during time interval t_0 to t_{32}. One readout scan of the whole memory occurs during time interval t_1 to t_3 to provide the time-compressed replica f_0 of the input signal. During that time interval, at t_1 and t_2, two new samples are placed in memory elements 1 and 2. The next readout scan during the time interval t_3 to t_5 shows two elements from the solid-line portion of the input function followed by 30 elements from the prior dotted-line portion. During that scan, two new samples are placed in cores 3 and 4 at times t_3 and t_4. The next readout scan, during time interval t_5 to t_7, shows four elements of the new input followed by 28 elements of the old. This process continues so that at t_{32} the memory holds only samples from the solid-line input curve, and readout scan t_{33} to t_{35} is a time-compressed replica of that function. Sixteen readout scans have occured while f_i progressed from t_1 to t_{33} and was sampled 32 times to refill the memory once, thus providing a multiplication of 16. If a multiplication of 32 were required, f_i would have been sampled once, instead of twice, during each readout scan.

The number of signal samples stored must satisfy the sampling theorem,[6] which requires at least two samples per cycle at the highest signal frequency. Table II shows that 32 cycles are required for an upper-frequency limit of 4 Kc when $M = 16$ and $f_r/M = 125$ cps; hence, 64 transfluxors would be required. For initial evaluations, however, it was decided that an upper limit of 2 Kc would be more appropriate since it would require only 32 transfluxors and would permit substantial circuit simplification. Or, the 32-core circuit can provide a 4-Kc upper limit when operated at a frame rate/M of 250 cps.

Binary numbers such as 16 and 32 are preferred for the multiplication factors and the number of cores so that the memory can be arranged in a 4-by-8 matrix for coincident-current address by the most economical binary techniques. Figure 3 shows a block diagram.

The spectrum analyzer portion of conventional design consists of a sweep oscillator, modulator, bandpass filter and demodulator. Signal frequencies in the range of 200 to 2,000 cps, after multiplication to the 3.2 to 32-Kc range, are hetrodyned with the sweep oscillator operating over the range of 39.2 to 68 Kc. The difference frequency is passed by a bandpass filter having a center frequency of 36 Kc and is then demodulated. The demodulated output is fed to the vertical axis of an oscilloscope producing a panoramic display by using the oscilloscope horizontal-sweep voltage to control the frequency of the analyzer sweep oscillator. The sweep is set in the range of 50 to 100 cps.

Figure 4 shows typical outputs for sinusoidal input signals when a narrow bandwidth of $B = 1{,}600$ cps ($B_{eff} = 100$) and $f_r/M = 250$ cps is used so that time compression components are resolved. Horizontal scale is 0.25 Kc per cm, centered about 1.5 Kc. Output scale calibration equals time-compressor output frequency divided by multiplication factor.

The major limitation of the present model is its saturated-signal-to-noise ratio of 15 db. This noise is believed to be due to some other than the basic memory which, theoretically, should allow a 40-db s/n to be attained.

The transfer characteristic of the cores is linearized by a zero-signal bias as indicated in Fig. 2A. This is done by setting the core with a pulse that carries the magnetization half way up the linear portion of the transfer characteristic when the input signal is zero; this value of set flux is then increased or decreased in accordance with the signal sample amplitude when the signal is not zero.

A portion of this work was sponsored under Signal Corps contract No. Da-36-039-SC-78908. Conception and an initial design are due to M. A. Stern. Stanford Goldman, C. M. Yen and A. W. LaBeouf contributed to the analysis, circuit development, construction and tests.

REFERENCES

(1) F. H. Slaymaker and R. A. House, The Speech Bandwidth Compression Problem, Fifth National Symposium on Global Communications, May 22-24, 1961.
(2) V. C. Anderson, The Deltic Correlator, Harvard Technical Memorandum, No. 37, Jan. 1956.
(3) W. S. Latham, Variable-speed Scanning of Recorded Magnetic Tapes, Jour Audio Eng Soc, **6**, No. 1, Jan. 1958.
(4) R. Saul and E. Luloff, Designing a Spectrum Analyzer, Elect Indust, April 1959.
(5) RCA Report LB-1019, The Transfluxor.
(6) Stanford Goldman, "Information Theory," p 67, Prentice Hall, New York.

INSTANTANEOUS MEASUREMENT OF

TAPE FLUTTER

Speed and speed variations of tape are determined by measuring transit time of recorded pulse as it is played back over two specially constructed heads

By ADOLPH SCHULBACH
Defense Electronics Products,
RCA, Camden, N. J.

IN DESIGNING MAGNETIC tape recording equipment it is often essential to have an instrument for the detection and measurement of flutter (percentage peak-to-peak tape speed variation or percentage frequency variation in playback). Ordinarily, devices to measure magnetic tape flutter do not provide instantaneous measurement. Furthermore, they combine the record-system flutter with the playback-system flutter so as to aid or cancel each other. An instantaneous meter, however, permits separate readings of record-system flutter and playback-system flutter.

The instantaneous measuring fluttermeter derives the speed and speed variations of the tape by measuring the time of travel of a recorded pulse from the instant of playback at one head to the instant of playback at another head. The heads are constructed to have a 0.1-in. gap to gap spacing. Pulses can be pre-recorded on the tape using either head.

It is possible but undesirable to

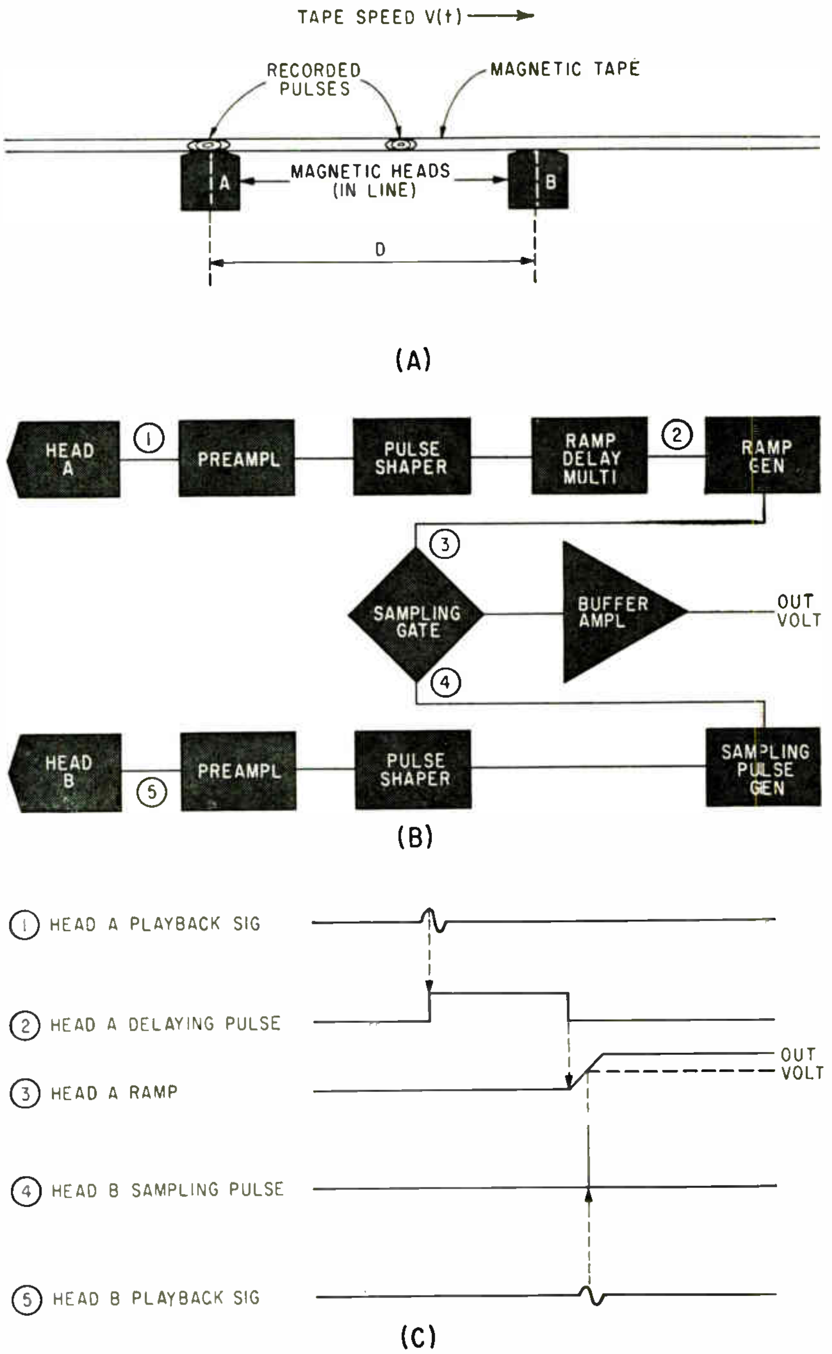


FIG. 1—Two playback heads (A) produce input signals for measuring system (B). Timing diagram (C) shows waveforms for specified locations on (B)

measure the transit time from a record head to a playback head since recorded amplitude modulation and noise can affect the instant of detection of the playback pulse. With two playback heads the instant of detection deviates an identical amount and no variation occurs in the transit time.

The derivation shows the relation of tape speed to transit time between two closely spaced playback heads *A* and *B* as in Fig. 1.

Let the head spacing be d; t_a, the average transit time; and v_a, the average velocity. Then $d = v_a t_a$, and also $d = (t_a + \Delta t)(v_a + \Delta v)$ when speed varies from average. Combining, $d = v_a t_a = (t_a + \Delta t)(v_a + \Delta v)$ which reduces to $\Delta t v_a + \Delta v t_a + \Delta t \Delta v = 0$. Term $\Delta t \Delta v$ is negligible since $\Delta t \ll t_a$ and $\Delta v \ll v_a$.

Therefore

$$\frac{\Delta v}{v_a} = -\frac{\Delta t}{t_a} = \text{flutter} \qquad (1)$$

Equation 1 shows that a circuit that can derive a voltage proportional to the time between two pulses can also measure the flutter and speed. Pulse techniques using boxcar detection circuits are ideal for this application since they can provide a high gain. With such circuits, voltages obtained can be displayed on an oscilloscope.

For maximum bandwidth, the pulse repetition rate must be high and the heads closely spaced. As in any sampled data detector, a response null will occur when the error frequency is one half of the sampling frequency. For example, the fluttermeter will have a poor response to 400 flutter if the rate is 800 cps. At a head spacing of 0.1 in., a cyclic speed variation occurring during 0.1 inch of travel of the tape is not detected since the average speed is correct. This null will limit the bandwidth to 1 v/d or 60 ips $\div$ 0.1 in. = 300 cps at 60 ips. However, even with a filter to remove sampling ripple, flutter frequencies up to 200 cps are displayed. This is usually adequate since most of the offending rotating members cause low rates of flutter.

If the bandwidth of this device is not high enough to include all of the large components of flutter, the high frequency flutter rates will beat with the null frequencies to form low-frequency noises. For example, a 790 cps flutter rate can beat with the 800 cps pulse repetition rate to give a false output at 10 cps. The design must have a bandwidth to cover all of the large amplitude flutter rates.

Figures 1B and C show the block and timing diagrams of the fluttermeter.

In the circuit (Fig. 2), the sampling gate is an electronic switch that momentarily closes when pulsed and permits holding capacitor C_1 to charge or discharge to the ramp voltage at the instant of sampling. Therefore, by varying the phasing of the two pulses, the capacitor voltage will change to correspond to the voltage of the ramp during the sampling interval.

Transistor Q_6 provides a sampling switch for this application. Output from the d-c amplifier biases the transistor off until the base is driven on by the sampling pulse. The ramp voltage on the collector of Q_6 is limited to 5 v for most reliable performance. The unity gain d-c amplifier Q_7-Q_8 is a buffer to prevent loading of the holding capacitor. Its input impedance is greater than 1 megohm if Q_7 is a high quality silicon transistor. Complementary symmetry emitter follower Q_4-Q_5 permits C_1 to be charged or discharged quickly from a low impedance source.

Although more gain can be obtained by increasing the slope of the ramp, the circuit permits measurements of flutter components as small as 0.01 percent peak-to-peak.

Equation 1 may be used to derive the calibration constant for this fluttermeter. If the ramp has a slope of 10 μsec/v and the observed or computed transit time from head to head is 1.66 msec (corresponding to a tape speed of 60 ips and 0.1-inch spacing), then 1 v of peak-to-peak error voltage represents a speed irregularity or flutter of

$$\frac{\Delta v}{v_a} = -\frac{\Delta t}{t_a} = \frac{k\,\Delta e}{t_a} = \frac{10 \times 1}{1.66}$$
$$= 0.6 \text{ percent peak-to-peak}$$

The calibration constant is then 0.6 percent peak-to-peak flutter per volt at 60 ips.

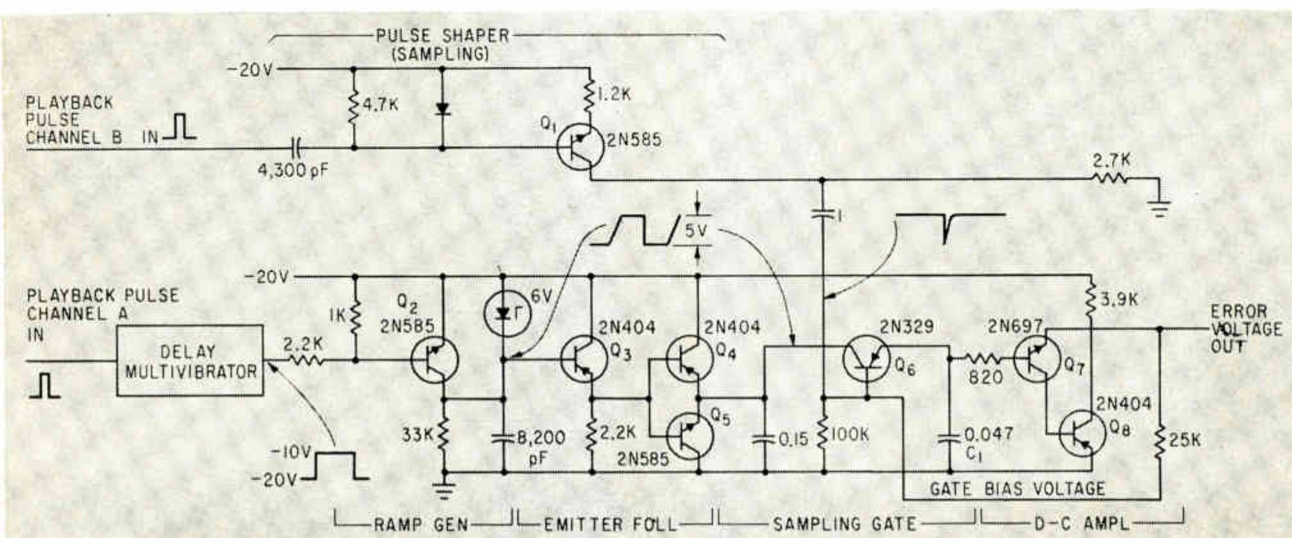


FIG. 2—Playback pulses are amplified before being fed to input of this flutter indicator

Aerovox Miniaturized Capacitors Offer Widest Selection of Case Style, Dielectric, and Application Capability

PRODUCT NEWS FROM AEROVOX

Reliability proven in demanding military, industrial and commercial installations

Type SRE* (Bulletin 201B1)
Aluminum Electrolytic Metal Case Tubular
−0°C to 65°C
3 to 150 DCWV
1 to 500 mfds
3/8" x 1" to 1/2" x 1-5/8"

Type 83Z* (Bulletin 131B2)
Metallized Paper Thermoplastic Cased Tubular
−15°C to 85°C
200, 400, 600 DCWV
.0005 to .04 mfds
3/16" x 7/16" to 1/4" x 9/16"

Type 8292ZN* (Bulletin 131B6)
Metallized Paper Plastic Cased Tubular
−30°C to 100°C
200, 400, 600 DCWV
.01 to 2.0 mfds
1/4" x 19/32" to 1" x 2-3/8"

Type V146X*—V146XR* (Bulletin 142B2)
Mylar "Wrap and Fill" Flat and Round Styles
−65°C to 85°C
150, 200, 400, 600 DCWV
.001 to 2.0 mfds
.156" x 1/2" to 1.421" x 3"

Environmental test requirements for capacitors are becoming more stringent, especially those established by the military services. In order to keep ahead of these demands, advanced research and development projects are being initiated continually at Aerovox. Entirely new design concepts have resulted from this concentrated effort. Some of the most reliable, long-life miniaturized capacitors available in the industry today are shown here. These include top-quality types ranging from low-voltage capacitors for transistorized circuits to ultra-miniature units designed to meet highly critical space requirements in such applications as computers, missiles and airborne electronic equipment.

Types P123ZN—323ZN* (Bulletin 131B8)
Metallized Paper Metal Cased Tubular
−55°C to 125°C
50, 150, 200, 400, 600 DCWV
.001 to 12.0 mfds
.175" x 7/16" to 1" x 2-9/16"

Types CRE—QRE* (Bulletins 201B6 & 201B7)
Aluminum Electrolytic Metal Cased Tubulars
−40°C to 85°C
3 to 150 DCWV
1 to 500 mfds
3/16" x 1/2" to 3/8" x 1-1/2"

Type PTT* (Bulletin 201B5)
Aluminum Electrolytic Plastic Cased Tubular
−30°C to 65°C
3 to 50 DCWV
1 to 500 mfds
1/4" to 3/4" to 3/8" x 2"

Only through the use of revolutionary design and manufacturing techniques and equipment have the greatly reduced sizes been achieved, thus permitting circuit applications previously considered impracticable or impossible. For example, a radically new etching and formation process was developed by Aerovox engineers in order to produce the unique advantages of the new QRE capacitors. As part of the automation program in the factory, a new automatic testing and sorting machine was recently installed to run more efficient tests for short circuits, opens, and grounds, while automatically sorting "ok" capacitors into specific tolerance groups. The utilization of such modern equipment by highly skilled personnel is part of the long-range program at Aerovox to advance the state of the art and to satisfy the demands of all markets.

Aerotan† Types ST12*—ST13* (Bulletin 215B2)
Solid Tantalum Electrolytic Metal Cased Tubular
−80°C to 125°C
6 to 35 DCWV   1.0 to 330 mfds
.125" x .250" to .341" x .750"

Type V84B* (Bulletin 142B5)
Mylar† Tubular with Paper-Mylar Case
−40°C to 85°C
150, 200, 400, 600 DCWV
.001 to 2.0 mfds
.156" x 1/2" to 1.421" x 3"

*Specifications listed are for standard units. If your requirements are unusual, special units can often be designed to meet your needs.
†Registered Du Pont trademark.

Yes, you can specify Aerovox with confidence. Confidence that you are buying and using the highest quality capacitors available anywhere. And, you have access to the widest selection of miniaturized capacitors in paper, metallized paper, mica, ceramic, electrolytic, solid tantalum and film types.

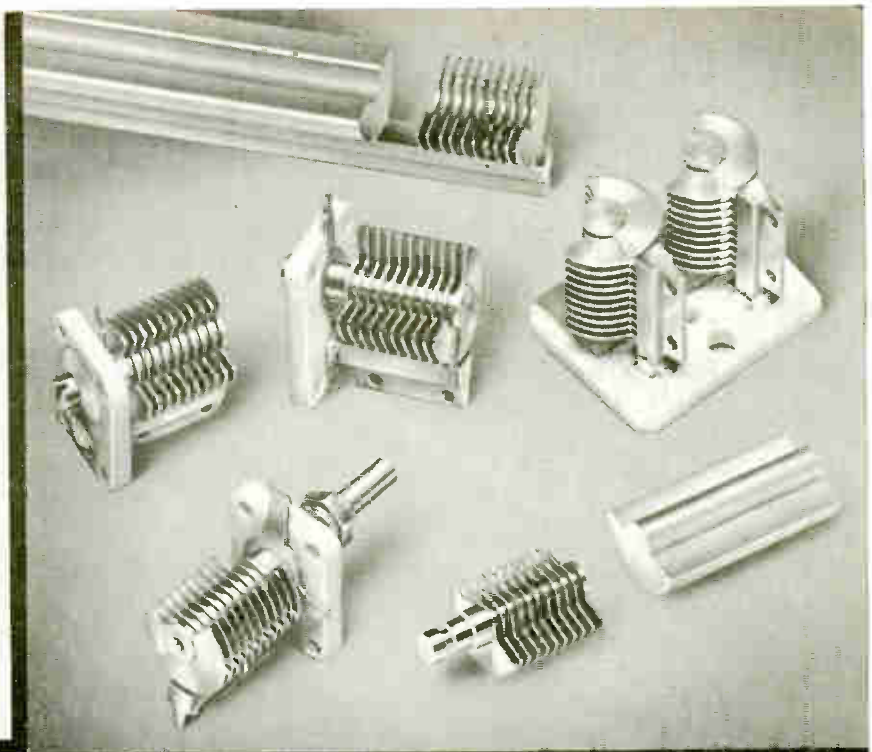
Engineering Service — If you have a special design concept, qualified engineering service is available from Aerovox at no cost or obligation. As a pioneer and leader in capacitor design and manufacture, Aerovox offers years of experience and know-how for the discussion and analysis of your specific capacitor requirements.

Technical Data — Call your Aerovox Field Representative or send today for free data sheets ... specify the capacitor types you are interested in.

AEROVOX CORPORATION
NEW BEDFORD DIVISION   NEW BEDFORD, MASS.

Technical Leadership — Manufacturing Excellence

Designed for M *Application*



NO. 25000 SERIES HIGH Q MINIATURE VARIABLE AIR CAPACITORS

High Q at high frequencies. Rotors and Stators precision machined from extruded solid brass. Terminal integral part of Stator block. Shaft an integral part of Rotor. Screw-driver slot adjustment or 1/8" extended shaft for knob. Only 6 parts to a complete Capacitor. Stock sizes 15, 25 & 35 mmfd. single or dual units.

JAMES MILLEN MFG. CO., INC.

MALDEN

MASSACHUSETTS

CIRCLE 206 ON READER SERVICE CARD

Lepel *High Frequency* INDUCTION HEATING EQUIPMENT

for

- BRAZING
- SOLDERING
- HARDENING
- ANNEALING
- MELTING
- BOMBARDING
- ZONE REFINING
- CRYSTAL GROWING
- PLASMA TORCH

ELECTRONIC TUBE GENERATORS

Sizes: 1 Kw to 100 Kw output

STANDARD UNITS
Frequencies: 180 Kc to 600 Kc

MEGACYCLE UNITS
Frequencies: 3 Mc to 50 Mc

DUAL FREQUENCY UNITS
Frequencies: 180 Kc to 600 Kc and 3 Mc to 50 Mc

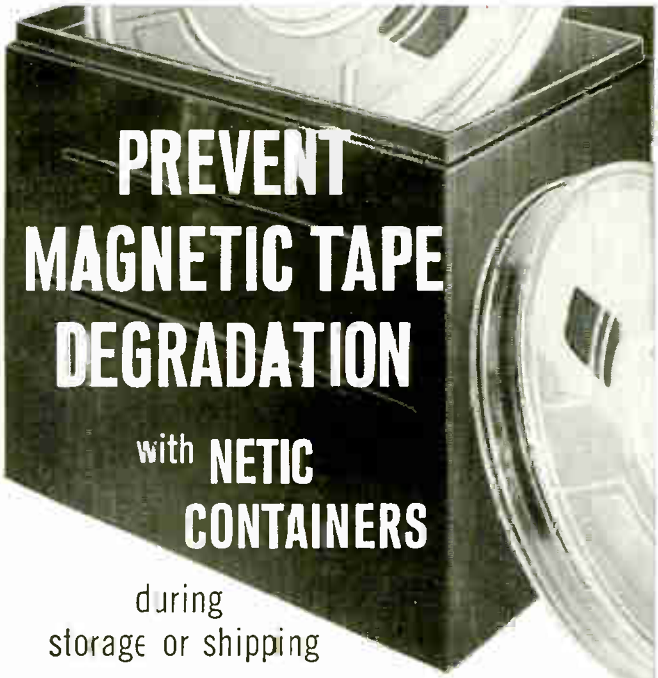
SPARK GAP CONVERTERS
Sizes: 2 Kw to 30 Kw input
Frequencies: 400 Kc to 900 Kc

LEPEL LABORATORY SERVICE is offered without charge, to process your work samples and submit recommendations.

WRITE FOR NEW LEPEL CATALOG

***Lepel* HIGH FREQUENCY LABORATORIES, Inc.**
55th St. & 37th Ave., Woodside 77, N. Y. C.
Chicago Office for Sales & Service: 6246 W. NORTH AVE.

PREVENT MAGNETIC TAPE DEGRADATION with NETIC CONTAINERS



during storage or shipping

Widely accepted since 1956 in military and industrial applications for protecting valuable tapes from detrimental magnetic environments. Long life rugged containers come in many sizes and shapes . . . are non-shock sensitive, non-retentive, require no periodic annealing. Request Data Sheet 104.

MAGNETIC SHIELD DIVISION
Perfection Mica Company / Phone EVerglade 4-2122 / 1322 No. Elston Ave., Chicago 22, Ill.

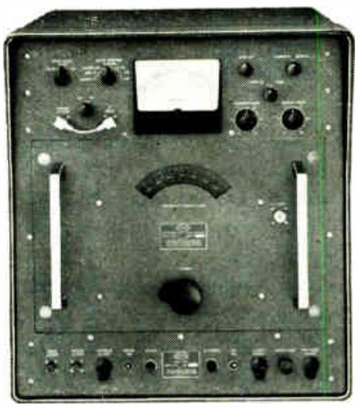
84,200 mc

is now the top frequency that can be detected by the POLARAD MODEL R

MICROWAVE RECEIVER 400 to 84,200 mc

Now the *most complete* Microwave Receiver has the *highest* frequency coverage (if we are permitted the redundant superlative).

As microwave work advances into higher and higher frequencies, the Model R keeps pace. Now Polarad has added frequency coverage from 45.3 to 84.2 gc. It's done, by the way, with a unique set of mixers incorporating integral crystals; and a local oscillator. Polarad's development engineers have designed the Model R Receiver with the most capabilities that can be put



in a single box. The Model R is an AM-FM receiver; a pulse receiver; and a sensitive microwave power meter all rolled into one. It has a direct reading frequency dial, UNIDIAL® tuning control, AGC and AFC, as well as audio, video, recorder and trigger outputs. Hundreds and hundreds of Model R users know Polarad will continue to keep their basic microwave test receivers as advanced as their own research. Have you checked the many jobs a Model R can do for you? Ask your local Polarad representative.

SPECIFICATIONS

FREQUENCY RANGE: 400 to 84,200 mc covered in 9 plug-in tuning units. A broadband tuning unit covering 2000 to 75,000 mc is available for antenna pattern measurements.
SENSITIVITY: To −85 dbm depending upon frequency range.
FREQUENCY DIAL ACCURACY: ±1%.
RANGE OF LINEARITY: 60 db with AGC.
I-F BANDWIDTH: 3 mc.
VIDEO BANDWIDTH: 2 mc.

POLARAD
ELECTRONICS CORPORATION
43-20 34TH STREET, LONG ISLAND CITY 1, NEW YORK
©PEC

POLARAD ELECTRONICS CORPORATION:
43-20 34th Street, Long Island City 1, New York

POLARAD PROVEN RELIABILITY

Gentlemen:
Please send me further information and specifications on:

A B C D E F
1 2 3 4 5 6 7 8 9 10 11 12

☐ Model R Microwave Receiver
☐ Notes On Microwave Measurements

My application is ____________

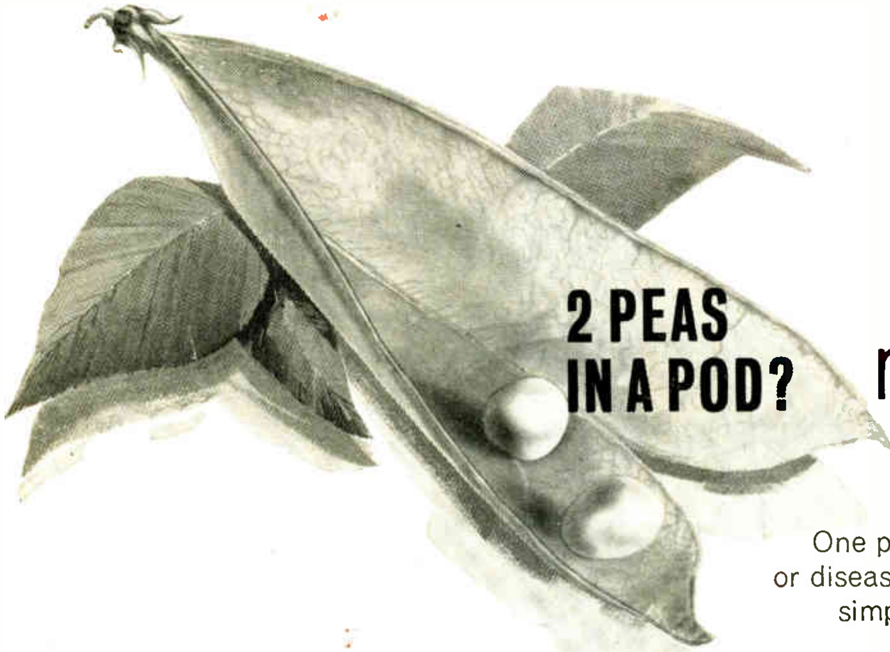
Name ____________

Title ________ Mail Station ______ Dept. ______

Company ____________

Address ____________

City ________ Zone ____ State ______



2 PEAS IN A POD? no guarantee of similarity!

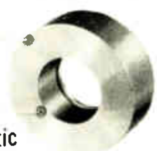
One pea may be damaged by insects or disease . . . or may be quite different simply through a caprice of nature.

THERE IS A DIFFERENCE IN DEFLECTION YOKES

TYPE Y58
Highest Resolution Stator Yoke

TYPE Y25
Compact Rotating Yoke

TYPE Y16
Low Capacity Push-Pull Yoke for Speed



TYPE F10
Precision Electro-magnetic Focus Coil

Specialists in yokes, Syntronic's team of experts knows more about yoke design, engineering and quality control than anyone else. A solid record of leadership for over 10 years—acknowledged throughout the industry.

This specialized experience means more to you than you may know. "Little" things make a big quality difference . . . like fast spot recovery time . . . smallest, roundest dots . . . geometrical precision . . . rapid settling time . . . least spot growth from center to edge . . . smallest residual magnetism. Mighty important, actually. Syntronic cares enough to make them right. You can depend on it.

Syntronic claims—and delivers—the most precise yokes that can be made. Every time. Year after year. To your exact requirement. And Syntronic's team of experts can help solve your yoke problems.

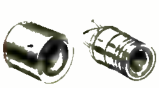
Since there is a difference, benefit from it. Get the most from your display.

TYPE Y15
Precision Low Current Yoke

TYPE Y57
1" I.D. Push-Pull Yoke

TYPE Y59
7/8" I.D. Transistor Yoke

TYPE F40
Dynamic-static Focus Coil



syntronic INSTRUMENTS, INC.
100 Industrial Road, Addison, Illinois
Phone: Kingswood 3-6444

NUMBER 23—NEW PRODUCT SERIES

Now—3-Turn, 5-Turn And 10-Turn Precision Potentiometers From The Same Reliable Source

Now Bourns gives you a choice of military-quality industrial potentiometers. In addition to the proven 10-turn Model 3500, Bourns offers you the 3-turn Model 3510 and the 5-turn Model 3520. All of these ⅞"-diameter potentiometers are shorter than comparable units available elsewhere, yet have resistance elements that are 20% longer.

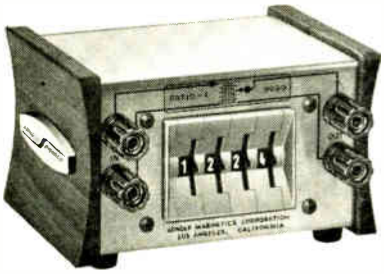
They incorporate the exclusive, indestructible Silverweld® multiwire termination, and are subjected to 100% inspection and the rigorous double-check of the Bourns Reliability Assurance Program. Write for complete data.

	3-TURN	5-TURN	10-TURN
Standard Resistances (Others available on request)	200 Ω to 50K ±3%	200 Ω to 75K ±3%	500 Ω to 125K ±3%
Meets Steady-State Humidity Requirements (Optional feature meets MIL-STD-202B, Method 106 Cycling Humidity)	Yes	Yes	Yes
Standard Linearity	±0.3%	±0.3%	±0.25%
Power Rating @ 70°C	1.0W	1.5W	2.0W
Operating Temp.	−65° to +125°C	−65° to +125°C	−65° to +125°C
Mech. Life (Shaft Revolutions)	600,000	1,000,000	2,000,000

Plants: Riverside, California; Ames, Iowa; and Toronto, Canada. Manufacturer: Trimpot® potentiometers; transducers for position, pressure, acceleration.

CIRCLE 99 ON READER SERVICE CARD

ARNOLD DIGIBOX



a complete line of versatile modules for the design or test engineer

RATIO TRANSFORMERS ▪ RESISTORS CAPACITORS ▪ INDUCTORS

Arnold digiboxes are designed as functional tools to provide direct visual presentation of component values.

These compatible laboratory-quality instruments can be quickly interconnected to provide a highly-reliable means of circuit simulation . . . digital adjustment of design parameters . . . fast evaluation of component tolerances.

Four units described below are first of a continuing line of associated devices. Future designs include: power supplies, transistor modules, meters, amplifiers, signal transformers, and voltage dividers.

Small size. All units are 4″ x 5″ x 3″ high.

Easily stacked, interconnected. All digiboxes are same size and configuration. Front panel terminals speed hook-up. You can set up an entire circuit in minutes—read off every value required directly . . . digitally.

DECADE TRANSFORMER MODEL TDA

Number of Digits:	4
Range:	0 to .9999 Ratio
Steps of:	0.0001 (Ratio)
Accuracy:	(±.008% + .00005)
Frequency:	50 cps to 10 KC

DECADE CAPACITOR MODEL CDB*

Number of Digits:	4
Range:	0 to .9999 MFD
Steps of:	100 MMFD
Accuracy:	±1%

*(Model CDA Accuracy ±3%)

DECADE RESISTOR MODEL RDC

Number of Digits:	4
Range:	0 to 99.99 K ohms
Steps of:	10 ohms
Accuracy:	±1%
Power Rating:	10 Watts Maximum

DECADE INDUCTOR MODEL IDB*

Number of Digits:	4
Range:	0 to 9.999 Henries
Steps of:	1 mh
Accuracy:	±1%
Frequency:	30 cps to 200 KC

*(This unit uses Toroidal Inductors exclusively.)

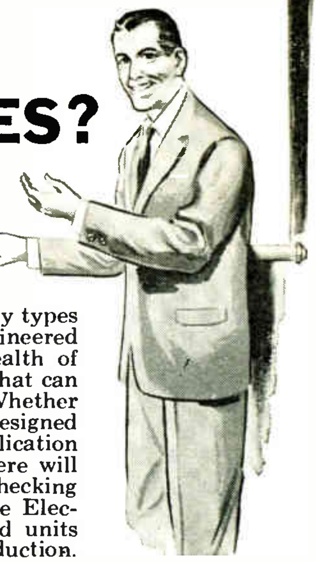
Write for complete information

ARNOLD MAGNETICS

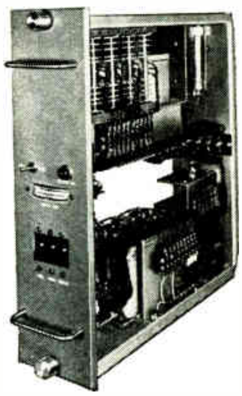
ARNOLD MAGNETICS, CORP.
6050 W. JEFFERSON BLVD., LOS ANGELES 16, CALIF.
VERMONT 7-5513 — UPTON 0-6284

 CIRCLE 100 ON READER SERVICE CARD

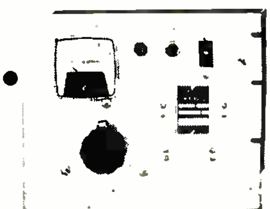
HAS ANYONE TOLD YOU ABOUT Acme Electric POWER SUPPLIES?



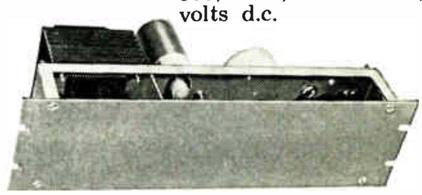
The hundreds of Power Supply types and designs that we have engineered and produced gives us a wealth of experience and "know how" that can be put to your advantage. Whether your need is for custom-designed units to meet a specific application or standard stock models, there will be a definite advantage in checking your requirements with Acme Electric. The following illustrated units indicate our wide range of production.



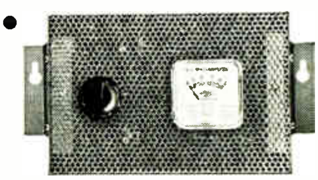
This custom designed unit, which is produced in production quantities, features modular construction and advanced circuitry.



This sturdily built design, for the manual regulation of saturable core reactors, features silicon rectifiers for full-wave d-c output. Available in 300, 500, 1000, 2000 watts; 0-100 volts d.c.



High efficiency, regulated power supply. Less than 1% ripple. Negligible thermal drift. Tubeless circuitry achieves maximum reliability. Output voltage maintained under varied conditions of input and load. Six other big features described in Bulletin 174.

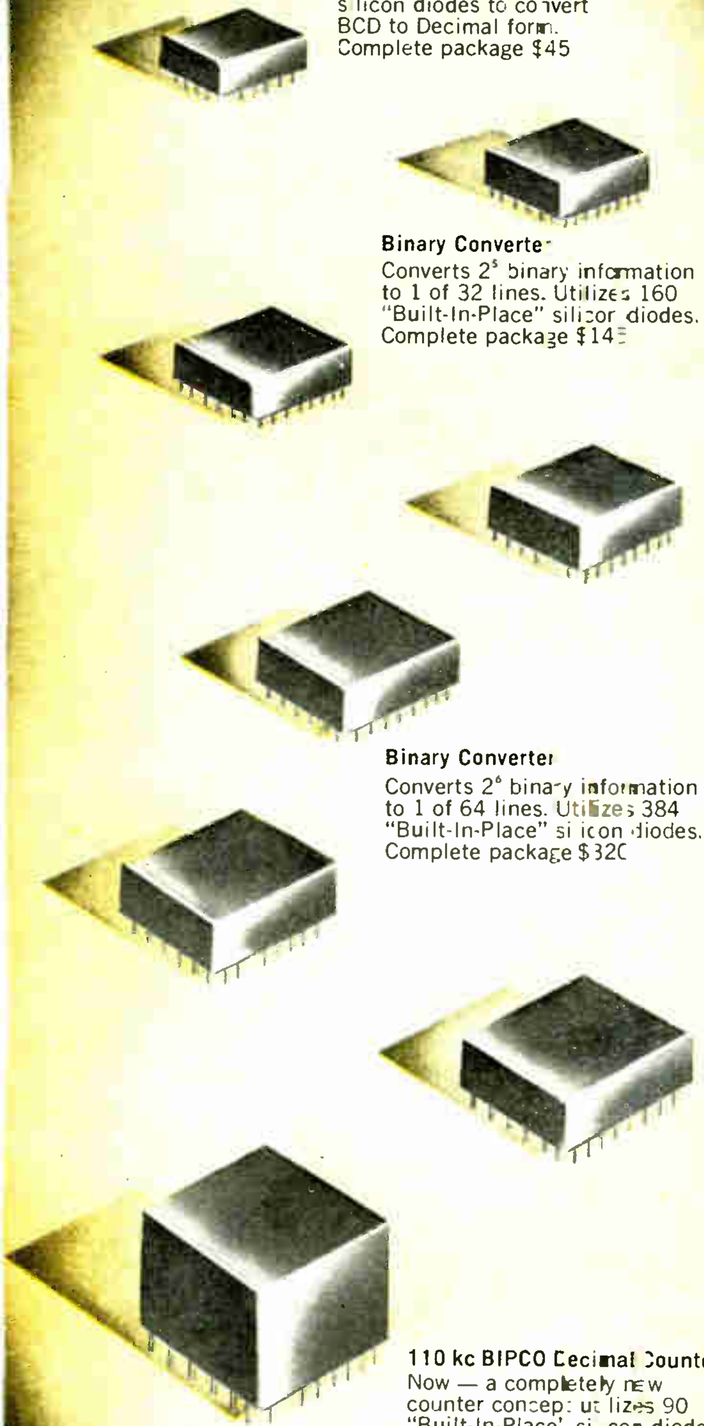


This Signal Developer Power Supply provides the necessary d-c for the signal control circuit of a magnetic amplifier. One/eighth watt, 0-25 volts.

ACME ELECTRIC CORPORATION
315 WATER STREET • CUBA, N. Y.
In Canada: Acme Electric Corp. Ltd., 50 Northline Rd., Toronto, Ont.
SAA 3574—2022

Acme Electric

CIRCLE 208 ON READER SERVICE CARD
CIRCLE 101 ON READER SERVICE CARD→



BCD Decoder
Utilizes 40 "Built-In-Place" silicon diodes to convert BCD to Decimal form. Complete package $45

Binary Converter
Converts 2^5 binary information to 1 of 32 lines. Utilizes 160 "Built-In-Place" silicon diodes. Complete package $145

Binary Converter
Converts 2^6 binary information to 1 of 64 lines. Utilizes 384 "Built-In-Place" silicon diodes. Complete package $320

110 kc BIPCO Decimal Counter
Now — a completely new counter concept utilizes 90 "Built-In-Place" silicon diodes and 12 transistors to produce individual decimal outputs. Complete package only $95

stop waiting... low cost micro packages are here...

Burroughs BIPCO™ Modules are available today and deliver what others can only promise... small size and economy.

Low cost simultaneous fabrication and connection techniques provide a whole new approach to reliable multi-element logic design.

Outline your design problem and we will show you how you can use BIPCO Modules.

WRITE TODAY **for complete technical information on the new BIPCO Module Line.**

ANOTHER ELECTRONIC CONTRIBUTION BY
Burroughs Corporation
ELECTRONIC COMPONENTS DIVISION
PLAINFIELD, NEW JERSEY

Auxiliary Memory Speeds Information Retrieval

By WILLIAM T. LENNON, JR.
WILLIAM F. JORDAN,
Senior Systems Engineers,
Computer Control Co., Inc.,
Framingham, Mass.

ONE-SECOND access is provided to 40 million bits of information stored in a mass memory. High speed is obtained using cross-referencing of addresses in an auxiliary magnetic drum that can store 5,200 36-bit words. The technique was developed for a real-time updating and transaction processing system called Tellertron. The system is being constructed under subcontract to Stone Laboratories, Inc., of which Tellertron, Inc., is a subsidiary.

Tellertron will provide a real-time link between vast customer account records and tellers, some of whom are at remote branches. It will enable tellers to obtain up-to-the-minute account information, check transactions and permit an organized input to off-line data processing system.

The account information might be stored in sequence by account number in a mass memory but only 250,000 of ten million account numbers are active and the active numbers at a given time cannot be determined. If all possible account numbers or addresses were stored, a relatively simple addressing scheme could be used. If only active account numbers are used, a time-consuming search technique would be required. Since each account requires 160 bits of data, it was concluded that complex addressing of a smaller mass memory through an auxiliary storage device would be more economical.

The mas memory is an IBM Ramac 350 disk file that provides random access to 40 million bits. The information is stored on 50 magnetic disks with 100 tracks on each side. A movable access arm with two magnetic heads searches opposing pairs of tracks simultaneously for each access arm address.

A single track can store 25 160-bit accounts so that each Ramac address could make 50 accounts available quickly. However, to provide information within one second, the track pair containing the desired account would have to be located with a single movement of the access arm. The magnetic drum in Fig. 1 can determine rapidly the one correct address of the 5,000. It has 52 tracks that are each divided into 100 sectors of 36 bits (account number length) corresponding to the 100 track pairs of a file disk.

Secondary Storage Tracks

The 50 secondary storage tracks of the drum are addressable by the numbers 00 to 49 to correspond to the 50 disks of the file. The 51st track, labelled P, is a primary address track, and only the first 50 sectors are used to correspond to the 50 file disks and 50 secondary address tracks of the drum. The 52nd track, labelled A is a prerecorded address track on which the numbers 00 to 99 are prerecorded in sequential sectors.

Account numbers presented to Tellertron in ascending order are written onto the Ramac using both ascending disk and track pair addresses. All track pairs of a disk are used before advancing to the next disk. As the first track pair (00) of the first disk (00) is loaded, the highest or last of the 50 account numbers is recorded on the drum in sector 00 and track 00.

As all track pairs of the first file disk, and thus all sectors of the drum track, are filled, the highest account number stored on disk 00 is recorded on sector 00 of track P. Loading of the second disk begins by recording the highest of 50 account numbers in a track pair in the appropriate sector of drum track 01 and then the highest account number on the second disk is recorded in sector 01 of track P. This procedure continues throughout loading.

The account number recorded in any sector X of track P is the same as that recorded in the last sector (99) of secondary address track X. Thus the drum records the ranges of account numbers that are stored on the disk track pairs.

When an account number is en-

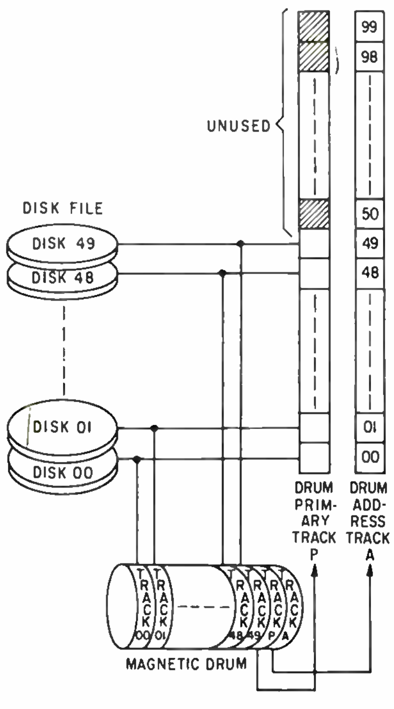


FIG. 1—Fifty secondary storage tracks on auxiliary drum correspond to 50 disks of mass memory

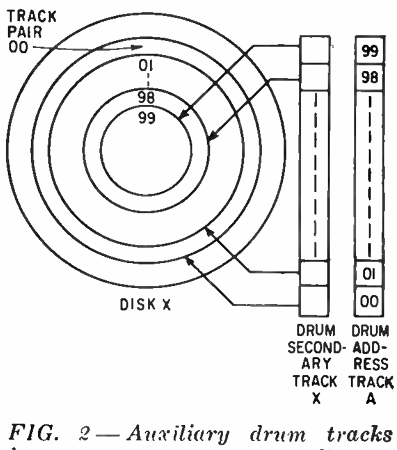


FIG. 2—Auxiliary drum tracks have 100 sectors corresponding to 100 track pairs of mass-memory disks

MEET THE WORLD'S FINEST DISTRIBUTOR TEAM

Francis R. Hine
Airwork Corporation, Miami, Fla.

Lester Avnet
Avnet Electronics Corporation,
Westbury, L.I., N.Y.

John W. Busacker
Contact Electronics, Inc.,
Dallas, Texas

Harold H. Powell
Harold H. Powell Co., Philadelphia, Pa.

Robert Avnet
Avnet Corporation, Los Angeles, Calif.

. . . serving industry with quality

BENDIX ELECTRICAL CONNECTORS

Each member of this world's finest team heads an organization having experience, ability and facilities unmatched elsewhere in the field of connector distribution. The entire team works toward the same goal—fast, efficient supply of the Bendix® Electrical Connectors best suited to *your* exact needs.

They supply to industry a nearly incredible number of connectors—running into literally tens of thousands of models—through a system pioneered by Scintilla Division in 1953. This is the *component assembly* technique, which anticipates connector needs and even permits overnight deliveries when required.

Their strategically located stocks are both broad and deep—with factory assembly and quality control standards that are extensions of those we maintain in our own manufacturing operations. Remember when you need high-quality connectors—your Bendix distributor can be an indispensable member of *your* team!

Scintilla Division THE BENDIX CORPORATION

Canadian Affiliate: Aviation Electric, Ltd., 200 Laurentien Blvd., Montreal 9, Quebec • Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

CIRCLE 103 ON READER SERVICE CARD

tered by a teller, Tellertron scans track P, comparing its contents with the number in a greater than-less than comparator until a transition indicates the correct range of account numbers. The drum sector number on prerecorded address track A is read out to external storage at the time of transition, identifying the appropriate Ramac disk. See Fig. 2.

The sector number is also used to select the corresponding secondary address track of the drum, which contains the correct set of track pair account number ranges. Contents of the selected drum track are compared with the desired account number by the same comparator and in the same way as the primary address.

A transition again identifies the correct track pair account number range. The correct sector number is then read out from track A and stored externally. Presenting this sector number to the Ramac as the track pair address completes the account number search.

BIBLIOGRAPHY

D. M. Bowers, W. T. Lennon, W. F. Jordan, Jr. and D. G. Benson, Tellertron: A Real-Time Updating and Transaction Processing System for Savings Banks, 1962 IRE International Convention Record, Session 12, Computers in Control and Simulation.

Slow-Scan Tv Vidicons Developed

By COPTHORNE MACDONALD,
Electronic Tube Div.
Westinghouse Electric Corp.,
Elmira, N. Y.

DEVELOPMENT of two vidicons could improve slow-scan tv and simplify camera design. A new photoconductive target material is used having high dark resistivity. The resulting low dark current permits very slow scan rates.

Electrostatic deflection and focusing used in one vidicon makes deflection power requirements negligible at slow scan rates and eliminates the weight of deflection and focus coils. In the other tube, either conventional or special high-impedance focus and deflection coils can be used.

The illusion of continuous motion necessary in broadcast tv is not needed in many military and industrial applications. Thus scan rates could be reduced with several advantages resulting. Required transmission bandwidth, which is proportional to the rate at which picture elements are transmitted, is reduced. Thus required transmitter power is lowered and even more important a variety of existing audio communications facilities could be used. Existing telephone lines and commercial and amateur radio facilities could transmit slow-scan tv. Images could be recorded on audio tape and might even be recorded on one stereo channel with an accompanying voice on the other.

An obstacle to slow-scan tv has been the performance of vidicons. A vidicon target might be considered to be a capacitor or array of capacitors in which dielectric resistivity varies with the amount of light falling on it. The transparent conductive coating on the inside of the glass faceplate forms on capacitor plate, the scanning beam the

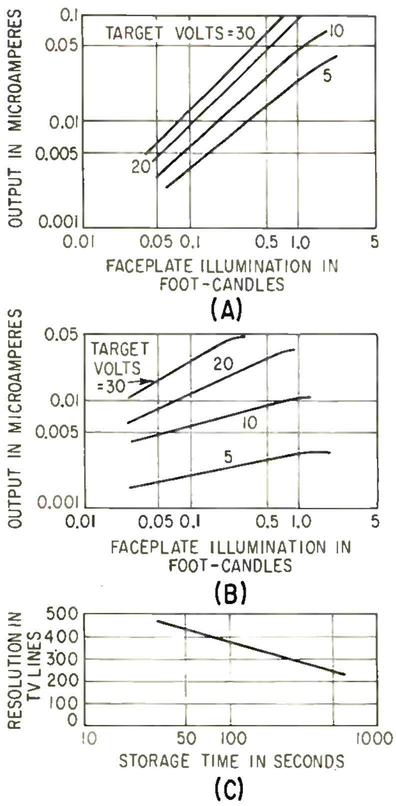


FIG. 1—Light transfer characteristics at (A) are for 30-cps frame rate for scanned area ½ by ⅜ inch using 525-line raster and (B) for 1/10 cps frame rate using 500-line raster. Resolution (C) is for same area using EIA chart

other, and the photoconductor acts as the dielectric.

Because dark resistivity of the target material is not infinite, some capacitor discharge occurs between samplings of the scanning beam. Dark current in conventional vidicons is about 1/10 illuminated current, which is acceptable at 30 frames per second but results in severe problems at slow scan rates.[1, 2] Discharge at slow scan rates occurs over much longer periods, resulting in very high dark currents.

Target Dark Current

Dark current using the new target material is low even at slow scan rates. At the standard tv scan rate, light is integrated over 1/30 second before the beam again charges the target. The time may be seconds or minutes in slow scan, and light required to change the charge is reduced proportionately. However, reading out the charge takes longer, but this can be more than compensated by a narrow-band amplifier that contributes less noise. Thus higher signal-to-noise ratios can be achieved with less light than at 30 frames per second. Transfer characteristics of the tubes are shown in Fig. 1A and B.

The new vidicons can operate at frame rates up to several minutes. Dark current change with temperature is insignificant, and the uniform low dark current gives good performance with low-contrast scenes. The tubes have low lag with only 10 percent residual signal on the second frame readout at 4-second frame time, compared to 40 percent for a conventional vidicon. Signal output at this rate is 1/5 to 1/20 of output with a standard scan, compared to 1/200 in a conventional vidicon.

Limiting center resolution of the magnetically focused and deflected WL-7920 with 300 v accelerating potential and 40 gauss focus field viewing an EIA resolution chart is at least 600 tv lines. Limiting resolution of the electrostatic WX-4384 with 250 v on grid 4 exceeds 500 tv lines. Loss of resolution from lateral charge leakage along the photoconductor is shown in Fig. 1C at long frame times.

Spectral response peaks at 4700 A with 10 percent points at about 3600 and 6400 A.

The vidicons might be operated

with an electromechanical shutter or strobe flash light to expose the tube during vertical retrace with it scanned in the dark. The high resistivity target would retain the charge pattern until scanning removed it.

For a 4 by 3 aspect ratio, only 14 v p-p on each vertical and 17 v p-p on each horizontal deflection plate is needed so that transistor drive

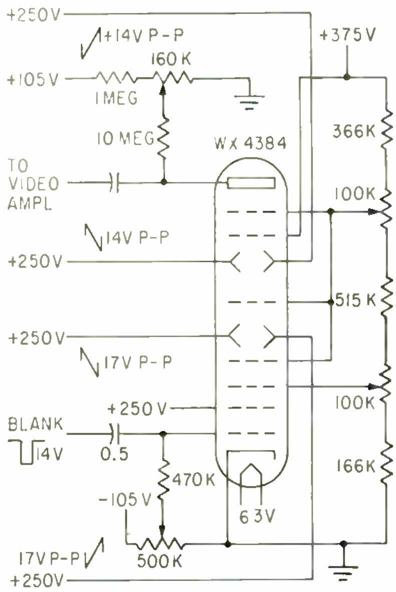


FIG. 2—Grid 2 of electrostatic vidicon draws most current and is normally less than 1 ma

can be used. Since grid 2 of the WX-4384 draws most current and it is normally less than 1 ma, a transistor supply can be used for other potentials.

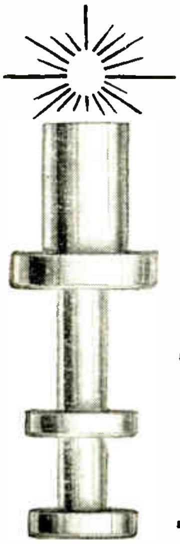
Added circuits in slow-scan tv cameras to compensate the effects of dark current and its variations with time and temperature are not needed with the new vidicons. Control circuits for the WX-4384 are shown in Fig. 2. In a complete slow-scan camera using the WL-7290, 12 miniature tubes (plus voltage regulators) are needed to provide a modulated subcarrier output for telephone line feed and to operate an electromechanical shutter.

The author acknowledges the contributions to the program of J. Nicholson, K. Simpson, R. Clayton and R. Doyle.

REFERENCES

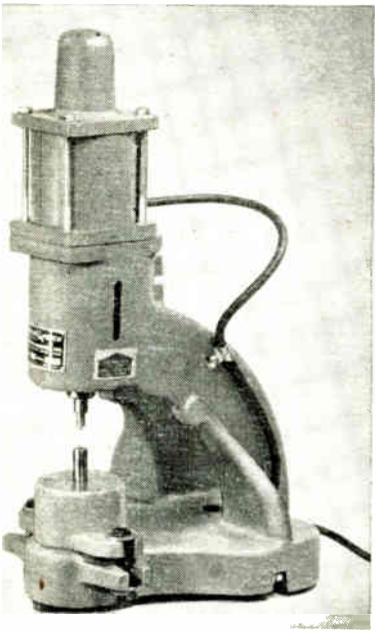
(1) C. T. Shelton and H. W. Stewart, Pick-up Tube Performance With Slow Scanning Rates, J Soc Mot Pic and Tel Engrs, 67, July 1958.

(2) F. F. Martin and C. T. Shelton, Modifying Vidicon Camera Chain for Slow-Scan Television Systems, Electronics, June 9, 1961.



LOOKING FOR THE IDEAL TERMINAL SETTER?

STOP. *You've found it. A Black & Webster Electropunch or full automatic Electroset can solve your terminal setting problems —for as little as* **$163.00**



SHORT RUNS: Electropunch — *sets hand fed terminals twice as fast as conventional methods. All electric. Foot switch operated.*

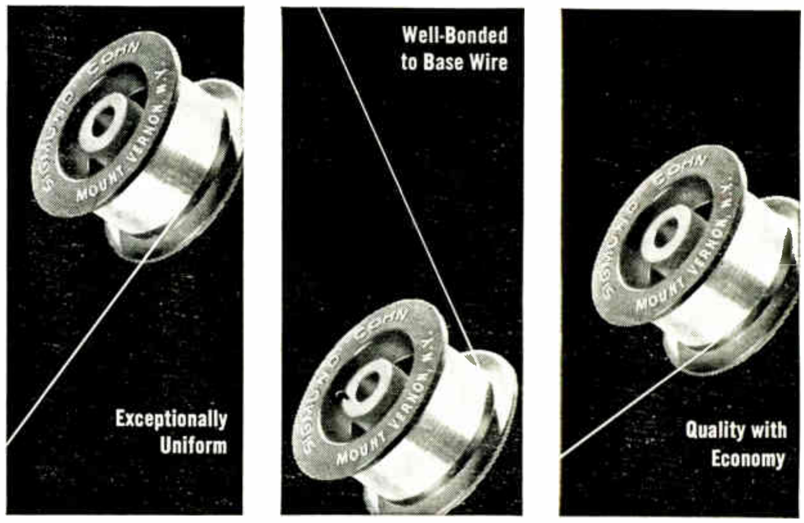
LONG RUNS: Electroset — *automatically feeds and sets terminals up to 3600 per hour. All electric. Customized to your needs.*

WHAT'S YOUR PROBLEM?
Black & Webster can help. Send sample terminal and requirements.

Write today for free 14-page catalog describing our complete line of production tools.

BLACK & WEBSTER, INC.
Dept. E, 570 Pleasant Street
Watertown 72, Mass.

CIRCLE 108 ON READER SERVICE CARD



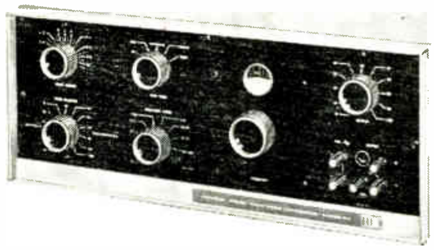
Electroplated Wires

For many years we have specialized in the continuous electroplating of wires...Gold, Silver, Nickel, Rhodium, Indium, Tin and many other metals, or combinations, can be plated onto wires of Tungsten, Molybdenum, Nickel, Bronze, Copper, Silver, etc.... Purity of the metals and quantity deposited are precisely controlled. Send us your specific requirements.

SIGMUND COHN Mfg. Co., Inc., 121 So. Columbus Ave.
Mount Vernon, N.Y.
Since 1901

SIGMUND COHN CORP. OF CALIFORNIA • 151C NORTH MAPLE STREET, BURBANK, CALIFORNIA

CIRCLE 209 ON READER SERVICE CARD



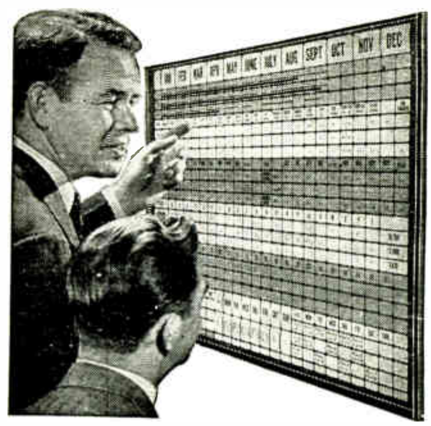
pulse waveform generator

Pulse, sine, triangular and square wave output of high order of purity . . . remarkably free of transients. For medical and biological research; precision testing of servo systems, computers, input/output devices, flight test and geophysical equipment. Frequency from .01 to 2000 cps. Compact versatility at a reasonable price. Ask for Tech Bul. 660-6.

PARABAM
DIVISION OF HF HOUSTON FEARLESS CORPORATION
12822 Yukon Ave., Hawthorne, Calif. / OSborne 9-3393

CIRCLE 210 ON READER SERVICE CARD

How To Get Things Done Better And Faster



BOARDMASTER VISUAL CONTROL

☆ Gives Graphic Picture—Saves Time, Saves Money, Prevents Errors
☆ Simple to operate—Type or Write on Cards, Snap in Grooves
☆ Ideal for Production, Traffic, Inventory Scheduling, Sales, Etc.
☆ Made of Metal, Compact and Attractive. Over 750,000 in Use

Full price $49.50 with cards

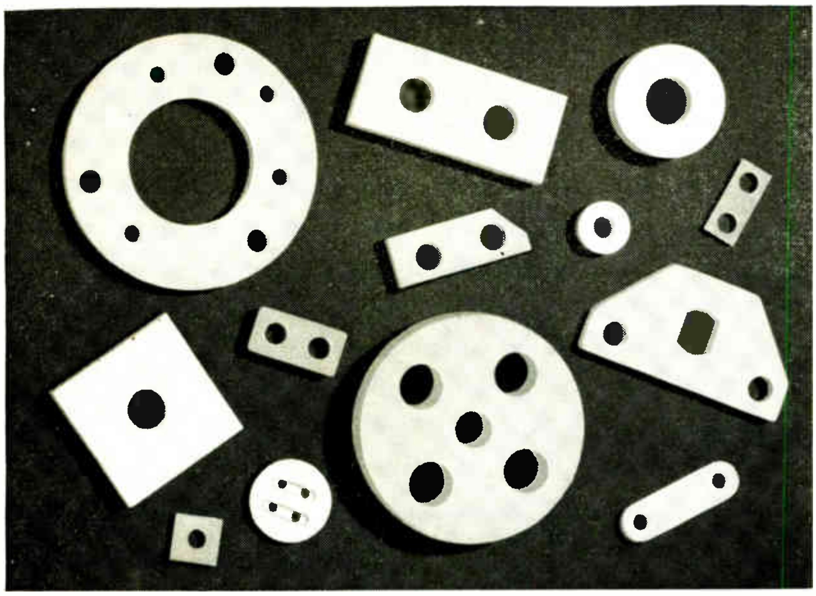
FREE 24-PAGE BOOKLET NO. C-50
Without Obligation

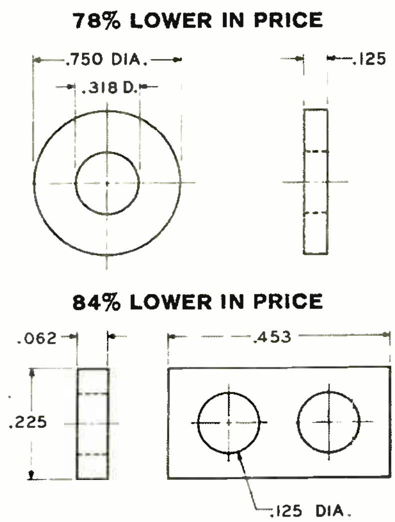
Write for Your Copy Today

GRAPHIC SYSTEMS
YANCEYVILLE, NORTH CAROLINA

CIRCLE 211 ON READER SERVICE CARD

New cost savings for users of dielectric materials





. . . a progress report on the MYCALEX METHOD
from Jerome Taishoff, President, Mycalex Corporation of America

"We're proud to announce the MYCALEX METHOD: a unique molding and finishing technique that delivers higher-performance parts at lower cost. In line with our policy, we pass all savings on to our customers.

"The diagram above outlines typical savings –78% and 84%–both in addition to the temperature endurance, total dimensional stability, dielectric strength and low-loss SUPRAMICA® and MYCALEX® have delivered for years."

Your choice of SUPRAMICA 620 "BB", 560 and 555 ceramoplastics, as well as MYCALEX 410 glass-bonded mica.

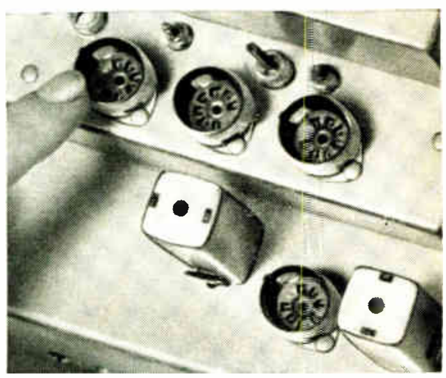
So to ease your profit squeeze . . . get top-grade electronic-insulation materials for less than ever . . . look into the new MYCALEX METHOD. Send blueprints and drawings for specifics.

IN SUPPLY

Sockets of MYCALEX glass-bonded mica are yours in standard or custom-designed types. Also supplied in SUPRAMICA ceramoplastics on special order . . . sockets illustrate the complex configurations in which these versatile materials can be produced.

IN SERVICE

For 11 years, MYCALEX tube sockets in important AM, FM and low-level audio circuits have helped to make this custom-made Fisher TRI 6G the superb radio-phono-TV instrument it is.



General Offices and Plant:
120 Clifton Boulevard
Clifton, N. J.

MYCALEX
CORPORATION OF AMERICA

Executive Offices:
30 Rockefeller Plaza
New York 20, N. Y.

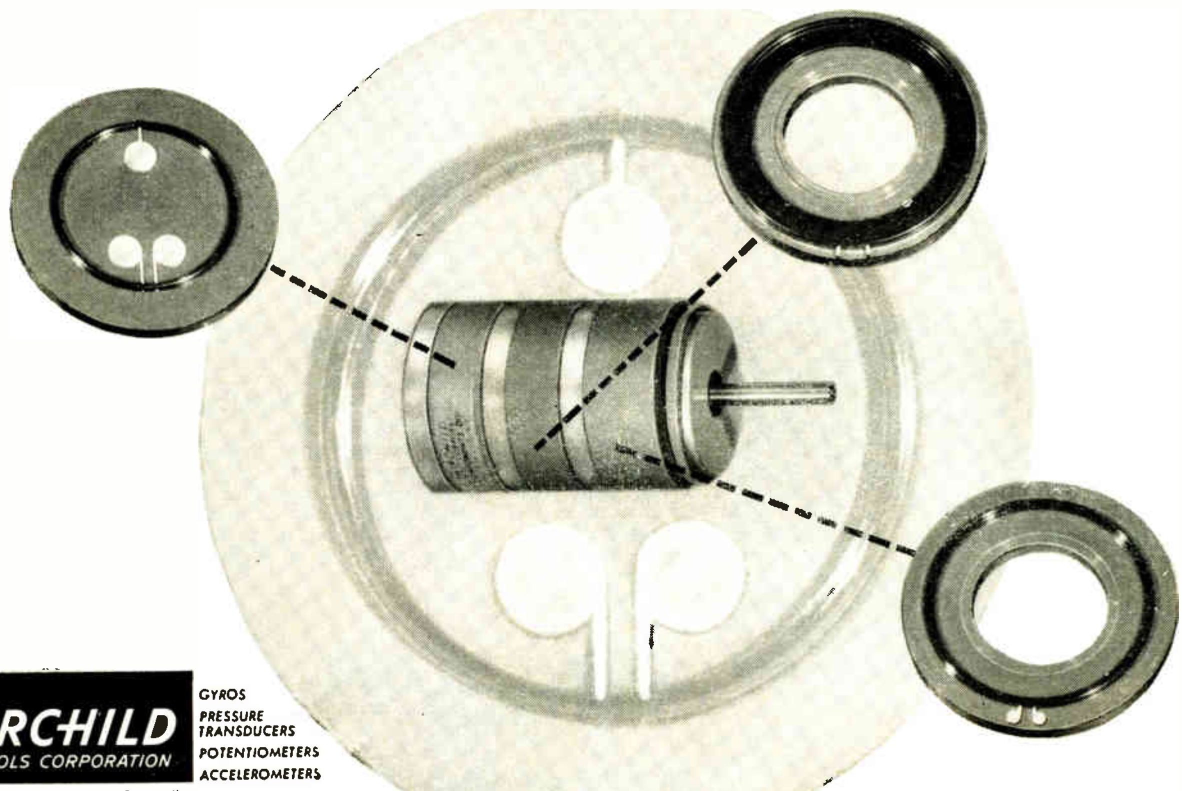
World's largest manufacturer of ceramoplastics, glass-bonded mica and synthetic mica products

FĀRITE CONDUCTIVE PLASTIC POTENTIOMETERS

Fairchild, the leader in precision potentiometers, takes another giant stride in technological progress with infinite-resolution, conductive plastic potentiometers having Fairchild reliability "built-in" ■ Fāritc potentiometers utilize a continuous track of specially prepared, conductive, high impact plastic co-molded with an insulating base of the same heat-resistant material to provide superior performance under temperature and humidity extremes ■ Temperature cycling tests of this advanced Fairchild design shows that resistance values are consistently reproduced ■ Resistance stability is maintained by Fairchild's unexcelled production skills which assure sufficient conductor bulk to virtually eliminate effects of wear ■ Low end-loss positive connections are achieved through co-molding of silver terminations with the conductive track. In addition, track geometry can be varied to obtain optimum functional conformity ■ Reliable operating life of many millions of cycles is assured through the resistance stability of Fairchild's Fārite conductive plastic potentiometers. For more information, write Dept. 53E.

FEATURES: INFINITE RESOLUTION/UNSURPASSED RELIABILITY/RESISTANCE STABILITY/CONSTANT RESISTANCE VALUES/LOW END-LOSS/LONG LIFE/COMPLETE RANGE OF SIZES

ELECTRICAL		ENVIRONMENTAL	
Resistance Range, ohms	2K — 50K ± 10%	Temperature Range	—65°C to + 150°C
Ind. Linearity	0.5% standard	Humidity	95% to 100% RH at 71°C
Resolution	Virtually infinite (less than .005°)	Vibration	10 G's to 2000 cps
Temperature Coefficient	Negative 3-400 ppm	Life	Over 10 million cycles at 600 rpm
Power Rating	2 watts at 20°C		



FAIRCHILD CONTROLS CORPORATION

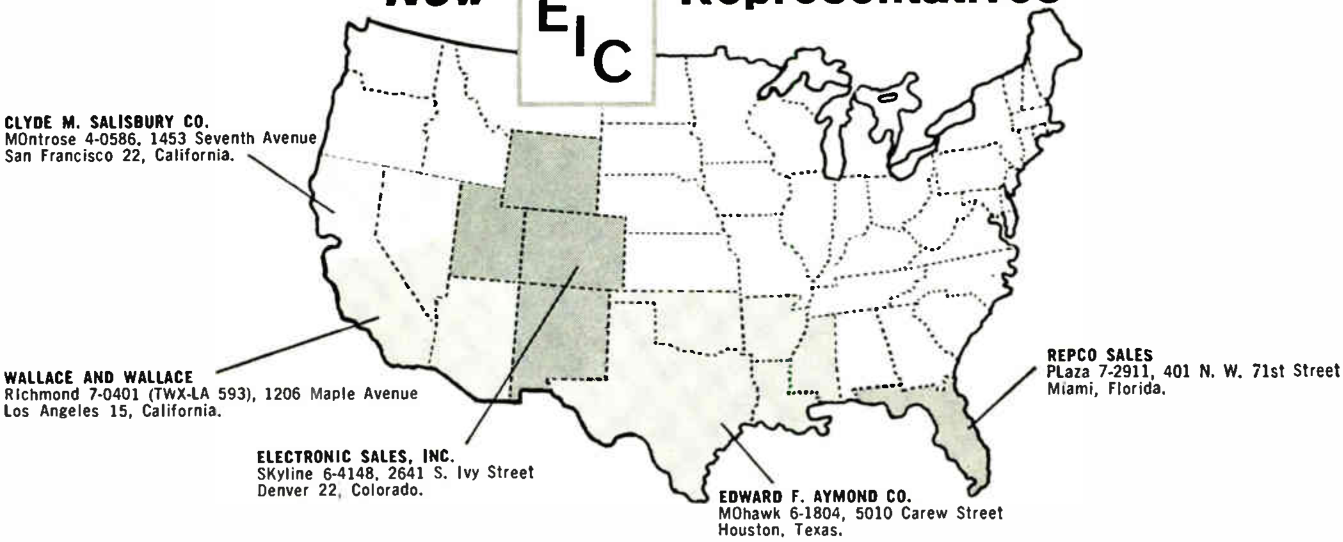
GYROS
PRESSURE TRANSDUCERS
POTENTIOMETERS
ACCELEROMETERS

A Subsidiary of Fairchild Camera and Instrument Corporation

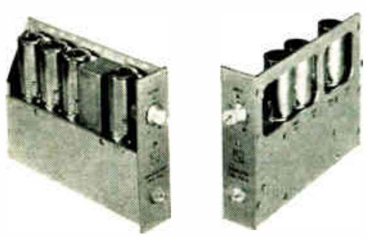
225 Park Ave., Hicksville, L. I., N. Y.
6111 E. Washington Blvd., Los Angeles, Cal.

ANNOUNCING

New EIC Representatives



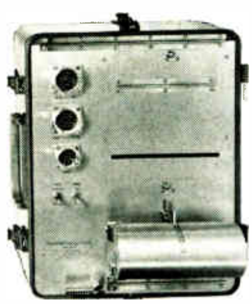
These distributors can handle your needs for standard off-the-shelf or custom solid state power supplies, transformers, modulators, demodulators, and recording oscillographs. They can also give you quotations on top-quality EIC printed circuits.



Modulators and demodulators

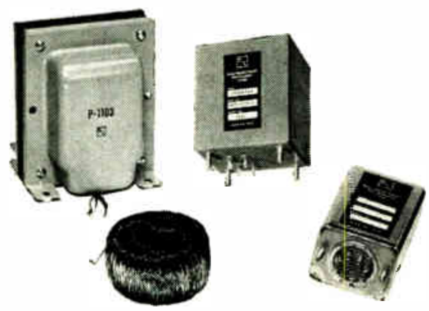
Solid state power supplies

Magnetic recording heads



Recording oscillographs

Recording interval timers



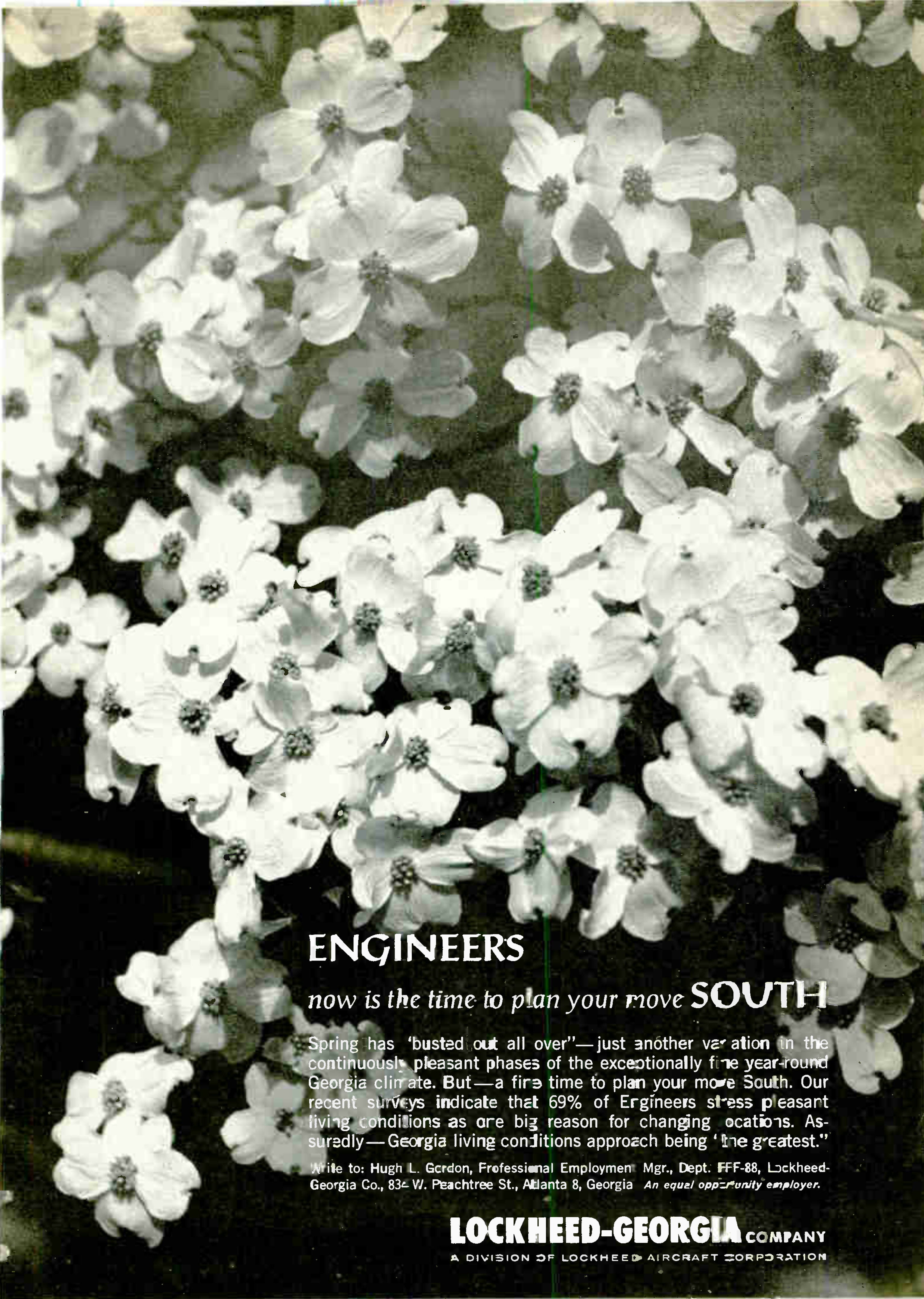
Transformers and chokes

EIC

ELECTRODYNAMIC INSTRUMENT CORPORATION

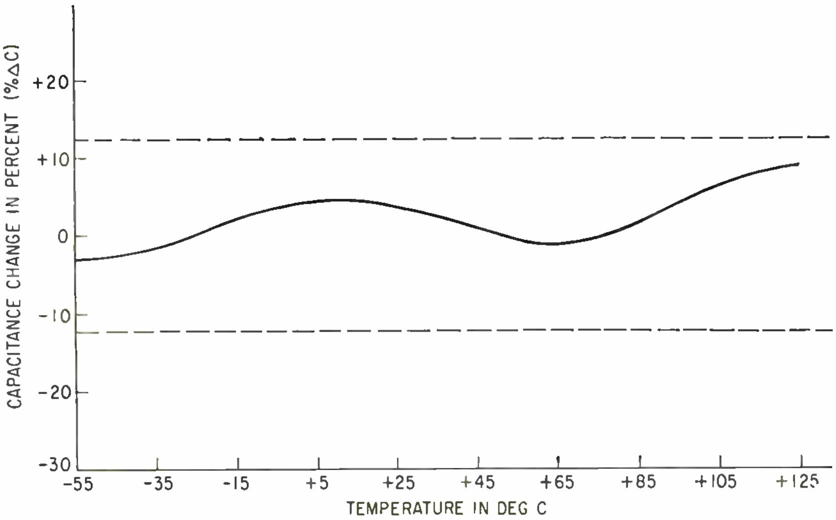
Subsidiary of Reed Roller Bit Company

TWX HO-1147 / JA 6-3761 • 1841 Old Spanish Trail • Houston 25, Texas



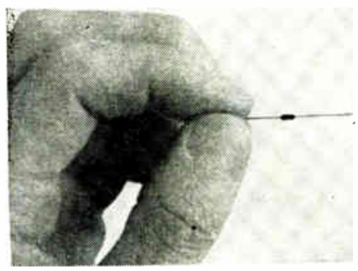
ENGINEERS
now is the time to plan your move SOUTH
Spring has 'busted out all over"—just another variation in the continuously pleasant phases of the exceptionally fine year-round Georgia climate. But—a fine time to plan your move South. Our recent surveys indicate that 69% of Engineers stress pleasant living conditions as one big reason for changing locations. Assuredly—Georgia living conditions approach being 'the greatest."
Write to: Hugh L. Gordon, Professional Employment Mgr., Dept. FFF-88, Lockheed-Georgia Co., 834 W. Peachtree St., Atlanta 8, Georgia An equal opportunity employer.
LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

Microminiature Capacitor for Modular Circuits



Capacitance change vs temperature for microminiature capacitor series, initial value at 25 deg C equals 129pf

By R. D. DUNWELL
Chief Engineer
Chem-Electro Research, Inc.,
Van Nuys, California



Reduced size of microminiature capacitor

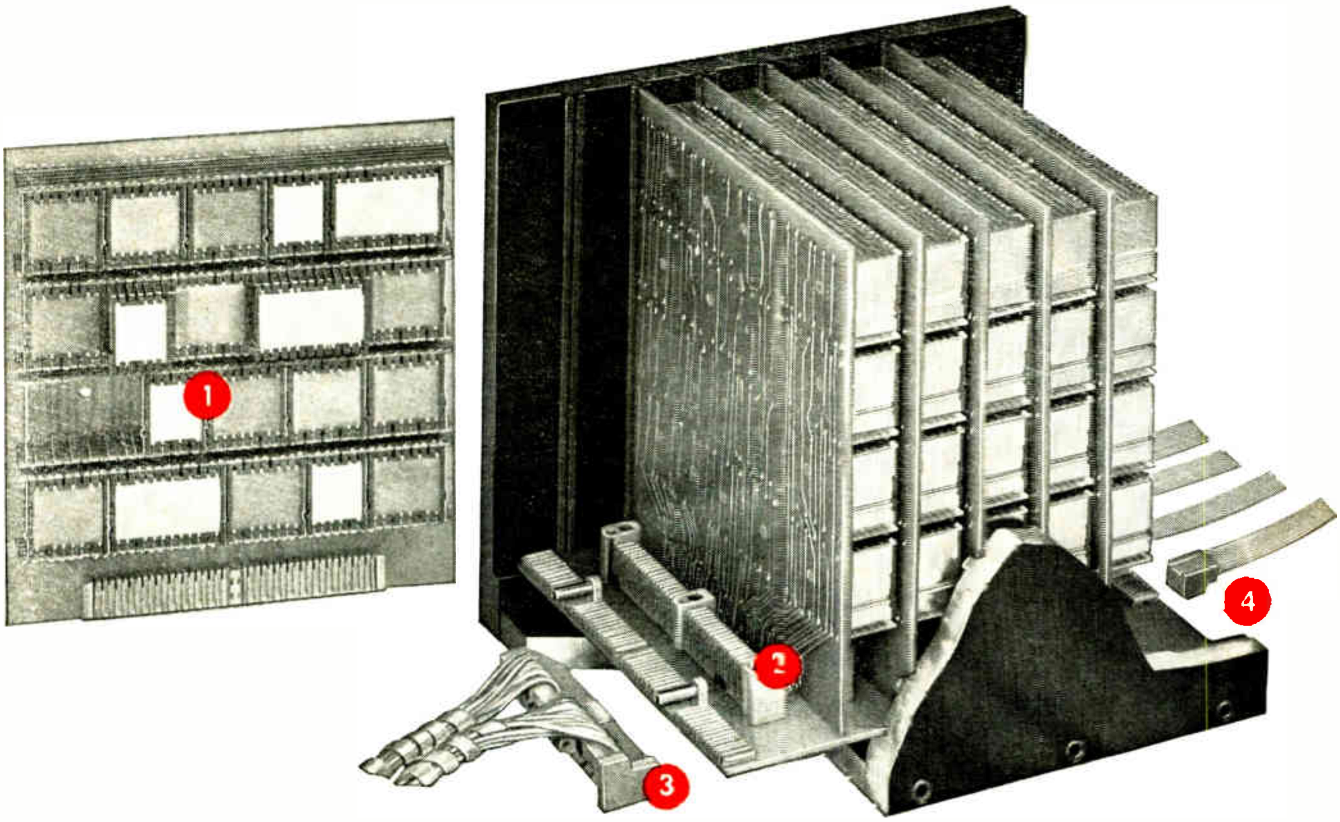
EVER-INCREASING DEMAND for smaller high-reliability electronic packages for underwater, airborne and space applications has stimulated activity along several different paths. While most industrial equipment, including computers, does not normally require the miniaturization aimed for in military equipment, manufacturers will be quick to capitalize upon the advances realized from work on military and space programs. Among the current approaches to miniaturized circuitry are deposited circuits, circuits utilizing "dot" components, i.e. the "swiss cheese" approach, and encapsulated circuits utilizing "cordwood" stacking of components and low temperature welding techniques. Great progress is being made in the field of deposited circuits, but much remains to be done in developing techniques and reducing costs. It appears certain that deposited circuitry and molecular electronics will assume a significant position in the microminiature circuits field within the next two to five years. Meanwhile, the high cost and lack of availability of dot components makes the cordwood stacking technique attractive. Somewhat of a stalemate appears to exist between the possible manufacturer of dot components and those who would conceivably be large users of these components, with both being unwilling to make major commitments until a reasonable market is established on the one hand, and an adequate supply of components on the other.

Cordwood packaging permits high component density as well as avoiding the possibility of decreased component life due to stresses introduced by bending component leads and using high temperatures during fabrication. The results which can be achieved by using these techniques are illustrated by the fact that at least one leading manufacturer of encapsulated circuits currently markets flip-flops, etc. in a package consisting of a ½-inch cube, and confidently expects to achieve the same results in a ¼-inch cube in the near future. Size reductions of this magnitude are made possible only as a result of the development of microminiaturized electronic components. Significant reductions in size have been achieved in transistors, diodes and resistors which, until recently, left capacitors as the largest single circuit element.

Barium Titanate Ceramics

Chem-Electro Research, Inc. of Van Nuys, California, in conjunction with the research laboratories of its parent corporation, Products Research Company of Burbank, California, has achieved a major reduction in the physical size of capacitors covering a range of standard values up to 1,000 picofarads. This has been made possible as a result of extensive background in the production of capacitors using high K barium titanate ceramic dielectrics, plus the development of improved techniques for accurately cutting ceramic wafers into very small pieces while maintaining a high percentage yield.

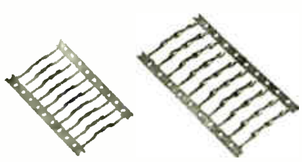
Chem-Electro Research is currently manufacturing a line of microminiature weldable-lead ceramic capacitors designated as the CK1MW series. These capacitors are available in standard values up to 1,000 picofarads, with non-standard values available on special order. They are of axial lead configuration with flat ribbon leads made of gold plated kovar for convenience in making either welded or soldered connections. The ceramic capacitor body is epoxy coated to provide protection against contamination and moisture absorption, and the entire range of values up to 1,000 picofarads is covered in

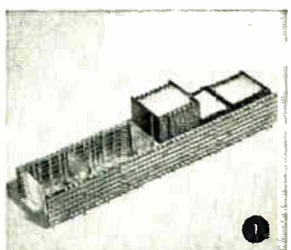


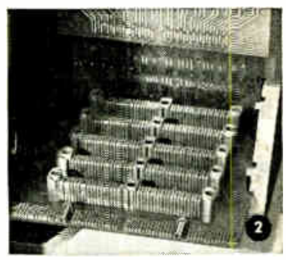
THE AMP-MECA* SYSTEMS APPROACH TO INTERCONNECTIONS

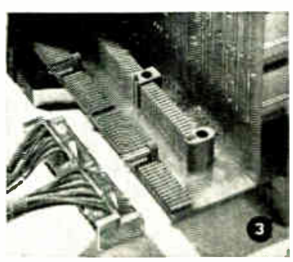
AMP-MECA assemblies, first with three-dimensional interconnections for pluggable sub-module circuits, gets down to specifics when it comes to interconnections for all your electronic systems requirements. Your systems no longer need to be interconnected using connectors which are not uniform in design and reliability.

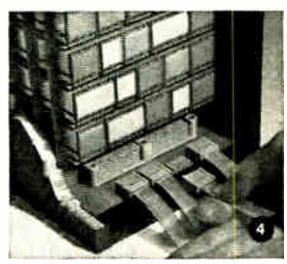
From individual sub-module circuit (1), to plug-in module boards (2) to base plane wired inputs (3), or using the increasingly popular tape cable (4), the AMP-MECA Systems Approach to interconnections provides, throughout, performance of maximum reliability because contacts of all the systems connectors are uniform in design, and incorporate a redundant 4 point contact.











In addition, the AMP-MECA Systems Approach starts with the layout of circuit interconnections. Through the use of AMP-MECA graph layout charts, time to layout each plug-in board can easily be reduced from the normal three to five weeks to less than one week.

Send today for complete information on how the AMP-MECA Systems Approach can apply to your interconnection problems.

*Trademark of AMP INCORPORATED

AMP
INCORPORATED
Harrisburg, Pennsylvania

AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • Mexico • West Germany a maximum body diameter of 0.060 in. Graph indicates the capacitor capacitance change with temperature for the series. Capacitance values through 180 picofarads are available in a maximum body length of 0.075 in.; 220 through 470 picofarads in a maximum body length of 0.150 in.; and 560 through 1,000 picofarads in a maximum body length of 0.200 in. The capacitors are rated at 100 wvdc and are available in ±5, ±10 and ±20 percent tolerances. Power factor is rated at 2.5 per cent maximum, measured at 1 volt rms at 1,000 cycles per sec. The operating temperature range is from −55°C to +125°C and the capacitance change with reference to the 25 deg C value is within ±12½% over the entire temperature range (see graph).

Dicing Wafers Accurately

While the desirable characteristics of high K barium titanate ceramic materials have long been known and utilized in capacitors featuring high capacitance per unit volume, a size reduction of this magnitude necessarily depends heavily upon techniques for accurately dicing ceramic wafers and assemblying microminiature parts. The techniques must also result in a high percentage yield to keep the selling price down to a level which does not preclude the use of the finished components in any significant portion of the potential market. An indication of company's success in this respect is that the ceramic wafers used in manufacturing the smaller values of the CK1MW series are approximately 0.040 in. square and range downward from 0.012 in. thick, while the yield of saleable parts exceeds 80 per cent of those manufactured. The techniques used are quite naturally held to be proprietary information since they include the use of special assembly fixtures and proprietary methods for accurately cutting ceramic; however, the process flow is as follows:

Grading of raw ceramic wafers; preliminary cutting of ceramic wafers; assembly of leads and ceramic dielectric; finish cutting of ceramic; cleaning and coating of capacitor body; testing; aging, to stabilize temperature characteristics; and grading and packaging.

Testing includes both in-process testing to insure that physical size and construction are correct, and electrical testing to establish that quality levels are maintained. All capacitors are subjected to a high-potential test at 400 per cent of rated voltage, followed by a 24-hour "burn-in" period during which the capacitors are continuously operated at 200 per cent of rated voltage, followed in turn by a second high potential test at 400 per cent of rated voltage. All capacitors which survive the testing are subjected to an aging cycle of approximately two weeks duration to permit their temperature characteristics to stabilize, following which they are graded for capacitance value and packaged for shipment.

The extremely small size of the CK1MW capacitors requires that they be handled carefully in order to avoid losing them. Consequently, the standard packages are individual clear plastic tubes with removable end plugs. The tubes are clearly and permanently marked with the part number, which indicates the capacitance value and tolerance of the part.

Widespread Use Seen

Response to the series has been very strong and company anticipates these parts will find wide usage among the manufacturers of modular circuits.

A line of microminiature resistors having the same form factor as the CK1MW capacitor series is planned in the near future. These microminiature resistors are being developed utilizing the chemical technology inherent within Products Research Company in conjunction with the electronic components technology existing within its wholly owned subsidiary, Chem-Electro Research, Inc.

Uses Rise For Precious Metals

RIGHT NOW in Washington, congressional decisions are being formed on the future of silver. With significance for our industry, the deliberations are also reminders of the growing use of other precious metals in electronics.

Present electronics requirements for silver run to about 50 million

Smaller diameter for complex hook-ups with Beldfoil* shielded cables

Where shielding is required you can reduce the size and weight of your cable with Beldfoil shielding. This new development can greatly reduce the diameter of multi-conductor cables.

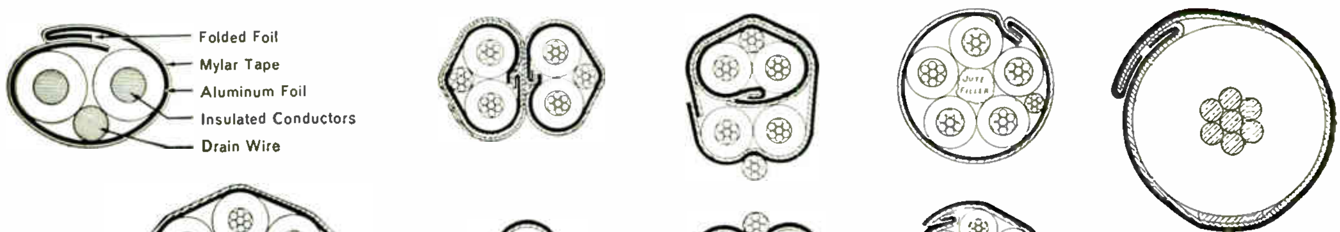
Multi-cable hook-ups can also be confined to less area. In many applications Beldfoil shielded cables can replace combined and complex hook-ups of twisted pairs and individual conductors laced together.

Beldfoil is a lamination of aluminum foil with Mylar† which provides a high dielectric strength insulation that is small in diameter, light in weight and low in cost. Its superior characteristics give 100% isolation between shields and adjacent pairs.

For audio and radio frequency applications, it eliminates cross-talk and is ideal for stationary or limited flexing.

The cable cross sections shown below (outer jacket not shown) are just a few of the many intricate and diverse ways Beldfoil has been used to solve a specific shielding problem for a customer.

If you have a space or design problem on shielded cables Belden engineering can help you.



Belden
WIREMAKER FOR INDUSTRY
SINCE 1902 — CHICAGO

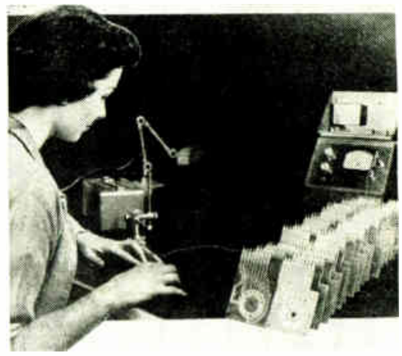
power supply cords • cord set and portable cordage • electrical household cords • magnet wire • lead wire • welding cable • automotive wire and cable

*Belden Trademark Reg. U. S. Pat. Off. †du Pont Trademark

8-1-2

ounces a year, gold is being used at the rate of about 2½ million ounces and platinum applications account for some 200,000 ounces annually. Close to forty companies are now supplying gold, silver and platinum for electronics uses. Most of these say the proportion of their income from electronics oriented products is rising with silver in the lead.

Most commonly given reasons for this center about the role of electronics in space-age technology. Wider ranges of environmental conditions, the constant push for miniaturization and growing applications in semiconductor technology are some of the prime factors for the increase.



Conductivity tests for gold plated printed circuits

Gold and platinum prices are now subject to free market conditions. This means that electronics users and others can take advantage of market fluctuations in determining when and how much of these metals to buy. If the present administration plans go through, to "get the U. S. Treasury out of the silver business" the same free trade conditions will prevail for silver.

Use in Batteries

One major user group that could benefit from this would be battery manufacturers. It is estimated that silver now being consumed for battery manufacture is beginning to approach the amounts used by the photography industry which is now the largest user of silver. Connector and relay manufacturers are also major users of silver as well as gold and platinum. In semiconductor manufacture all three precious metals are used for coating layers, joining different materials and as headers and casings. Silver use in electronics over the past ten years

RESISTIVITIES OF PRECIOUS AND OTHER METALS

Metal	*Deg. C.*	*Resistivity in ohms/cm* $\times 10^{-6}$
Aluminum	20	2.828
Brass (various) ..	0	6.4—8.4
Copper	20	1.72
German Silver ..	20	33.0
Iron	20	10.0
Nickel	20	7.8
Gold	20	2.44
Platinum	20	10.0
Silver	18	1.629
Palladium	20	11.0
Rhodium	0	4.69

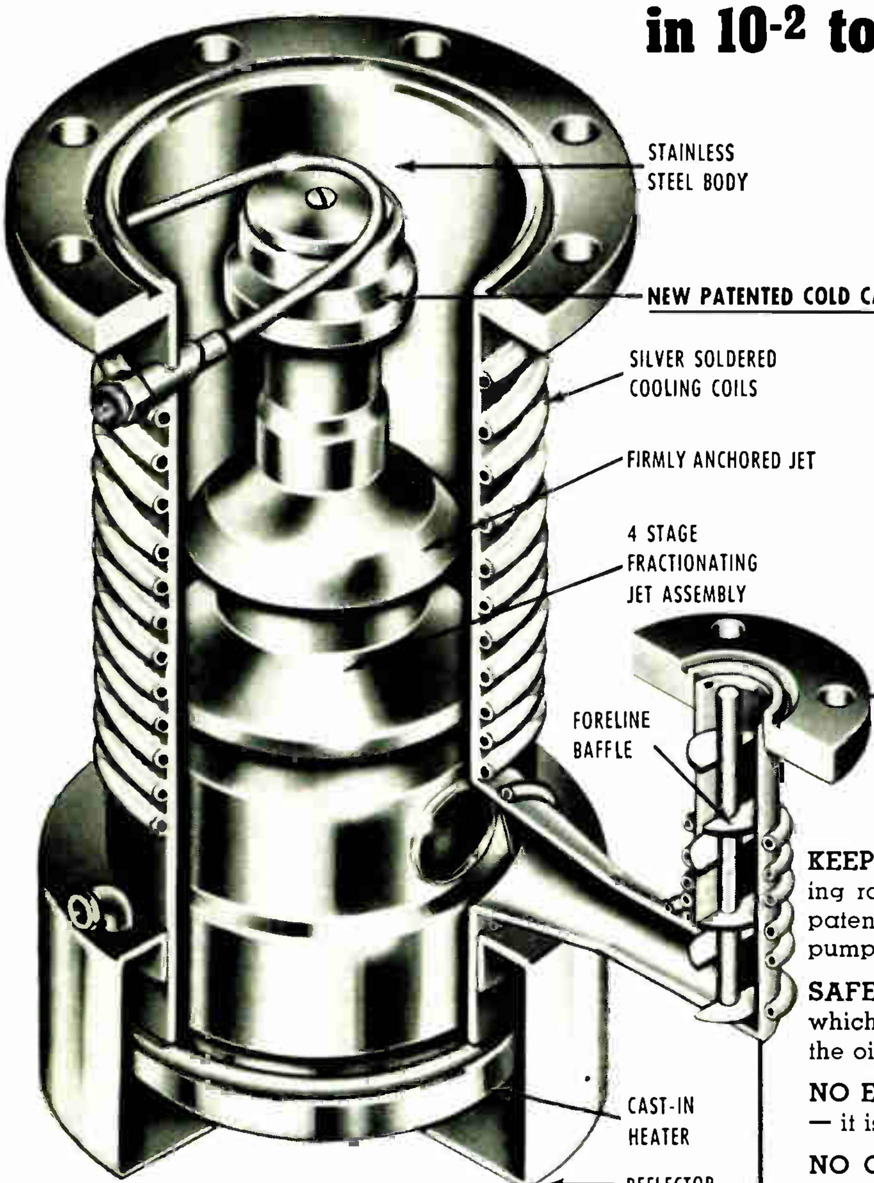
has increased by almost fifteen percent and shows promise of continuing to climb.

Gold use has also risen. Estimates are that ten percent more gold is being used in electronics now than was used in 1951. The main advantage of gold in electronics is its resistance to corrosion. A drawback, however, is its extreme softness in comparison with other metals. For this reason a major portion of the gold found in electronic devices is in alloy form. One such form, made by Sel-Rex Corp. is being used now to plate waveguide components including pressure windows and contact pins. This harder form, called bright gold is twice as hard as 24 karat gold plate and is also used for semiconductor housings. The company, a leading supplier of electroplating solutions in the precious metals field, also produces bright silver and bright platinum.

Platinum in electronic applications goes back some 50 years when researchers discovered that platinum coated with certain oxides heated in a vacuum would emit large quantities fo electrons. According to International Nickel Co., a major free-world supplier of platinum metals, the present use of platinum in electrical and electronic applications accounts for slightly more than half of all other uses which include dental, chemical and jewelry. Certain types of x-ray tube anodes are made from platinum. Other long-life cathodes including those of a newly designed amplifier tube for the transatlantic cable are also made of platinum. A number of radar tubes employ grids made from platinum alloys.

CLEANEST VACUUM

in 10^{-2} to 10^{-10} torr range



Other "HS Series" pumps to 32", peak speeds to 52,000 liters per second. Cold Cap standard on 10" pump, optional on 4" and 6" sizes.

THESE ADVANTAGES GIVE MORE DEPENDABILITY

KEEPS VACUUM CLEAN—backstreaming rate only 0.0005 mg/cm²/min., with patented cold cap on the 4" and 6" pumps.

SAFER OPERATION — no superheaters which operate above the flash point of the oil — no explosion risk.

NO EXTRA COST for all stainless body — it is standard equipment.

NO OIL LOSS — fluid retaining foreline baffle keeps oil in pump even if incorrectly air released.

QUICK HEAT UP AND COOL DOWN—cuts operating time and power cost.

NEW COLD CAP DESIGN

cuts backstreaming 99%

Get speeds of 750, 1500 and 4200 liters per second with these new "HS Series" 4", 6" or 10" diffusion pumps. Each pump is shorter, more efficient, and attains higher speeds than all previous models. Smaller, lower-cost back-up pumps can be used because of high forepressure limits of new jet design.

Water temperature is not critical and, therefore, greater latitude of pumping oils is possible. These are the pumps to buy for the cleanest, fastest, low cost, most dependable vacuum system. Call or write for more details now on the new "HS Series" Diffusion Pumps.

* Licensed exclusively from Edwords High Vacuum Limited U. S. Pat. No. 2919061

Manufacturing Plants at Newton, Mass. and Palo Alto, Cal.

NRC EQUIPMENT CORPORATION

A Subsidiary of National Research Corp.

160 Charlemont Street, Dept. 4E
Newton 61, Massachusetts

CIRCLE 123 ON READER SERVICE CARD

Microminiature Multi-pin Connectors

Only one-quarter the size of current "miniature" types, Microdot Multi-pins are available in three shell sizes to contain up to 61 power or 19 coaxial contacts in a 1¼" shell. Interchangeability of parts is featured with inserts available in a variety of straight power, straight coaxial, and combination power-coaxial contacts. Power contacts are interchangeable without changing inserts, allowing hermaphroditic contact arrangements to be set up. Microdot Multi-pins are available completely assembled with Microdot cable, or in unassembled kit form.

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California

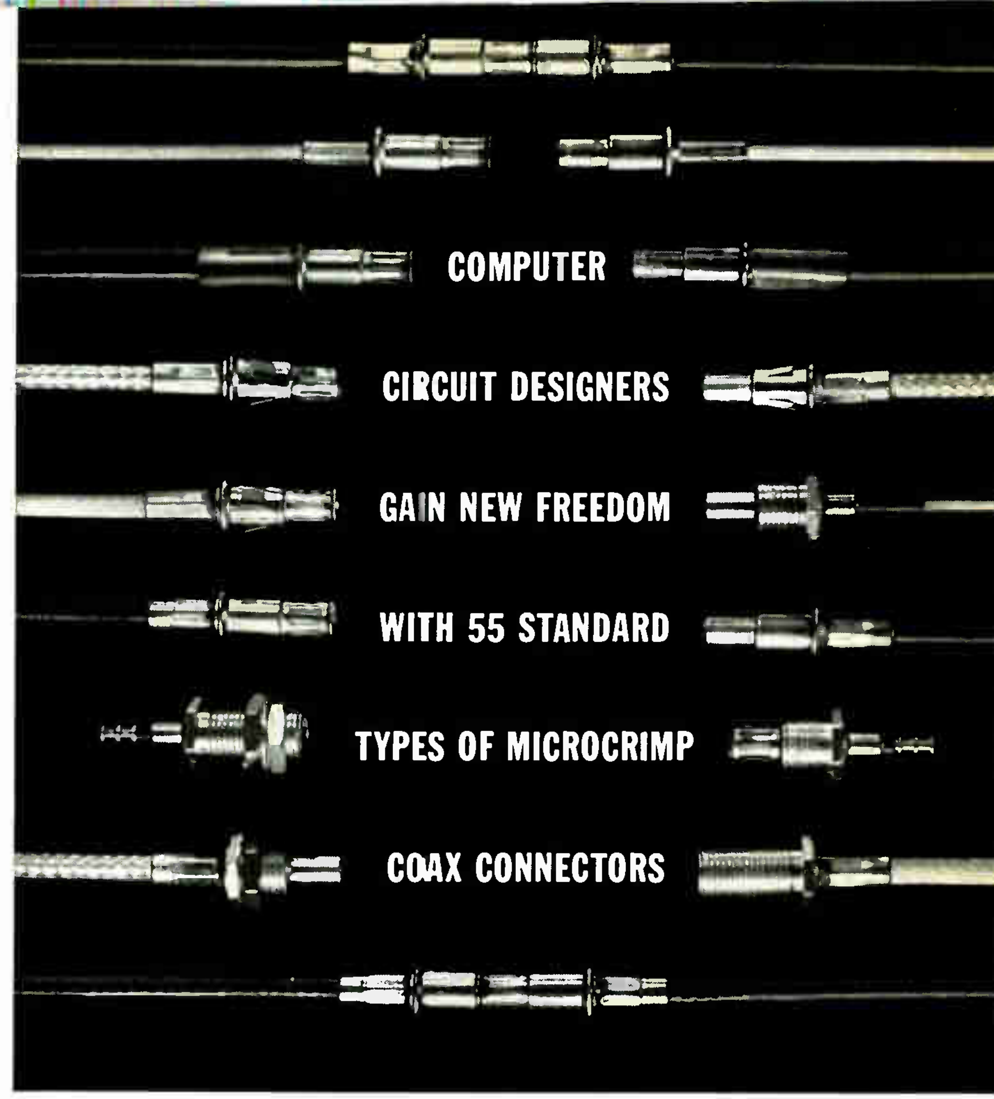
CIRCLE 215 ON READER SERVICE CARD

Microminiature Coaxial Connectors

Microdot's microminiature connectors—including the world's smallest 50-ohm coax connectors—are available in over one million combinations. Plugs are available in straight or angle screw types and slide-on versions. Receptacles include printed circuit and bulkhead feed-thru types. Only highest quality materials are used. Conductors are of silver-plated copperweld or cadmium bronze, center contacts are of gold-plated coin silver. Housings are silver-plated brass to assure minimum electrolysis with aluminum panels. "Teflon," "Kel-F," polyethylene, and neoprene are used as dielectrics, jackets, bend relief caps, and pin protectors.

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California

CIRCLE 216 ON READER SERVICE CARD



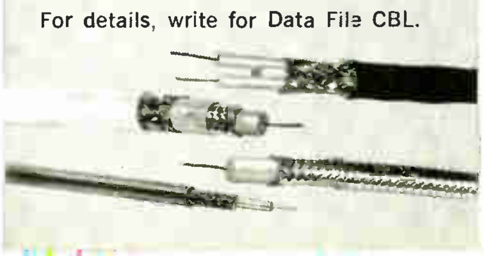
Specifically designed for application to modern digital computer circuitry, Microdot's wide variety of 55 standard MICROCRIMP coaxial connectors offers design freedom previously available only with solder-type connectors. Yet you get crimp-type ease-of-use and reliability assured by the highest specifications available from any standard crimp-type coax connector line. And, with MICROCRIMP, you also get two-step inspection — of both crimped center contact and of crimped shield. Available off-the-shelf in 55 types, these connectors have standardized parts that easily and economically make up into specials.

MICROCRIMP connectors offer the closest impedance match available in a miniature crimp connector—VSWR of 1.01 to 1.1 between .4 and 2.0 kMc. They come in four sizes (for cable from .085 to .163 O.D.), four mounting configurations (cable; short threaded; long threaded; and snap-lock), and two mating configurations (low and high retention). Mated length is only 1-13/16" and males and females are interchangeable. These connectors handle higher working voltages, to 1,000 V maximum at sea level, and 500 V maximum at 60,000 feet, thanks to their longer leakage path and the use of Teflon* dielectrics. Mated pairs of high retention connectors will withstand a 15g vibrational environment for 12 hours per MIL-E-202. Life is 5,000 matings, minimum, without electrical deterioration.

*Du Pont trademark.

For full details, see your Microdot sales representative, or write for Bulletin CTC.

Microdot Microminiature Cables are available in coax, twinax and triax constructions to meet MIL-C-17C. For details, write for Data File CBL.

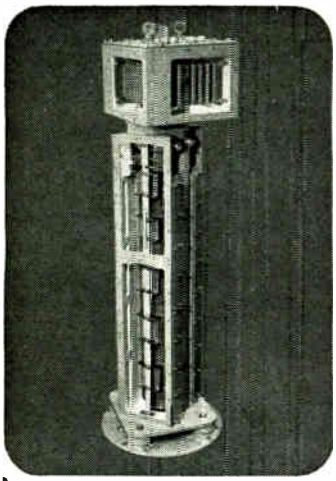


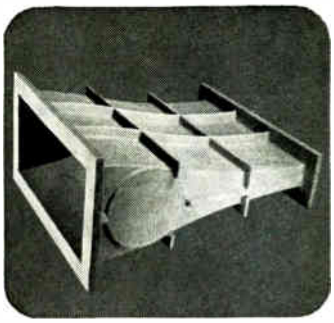
MICRODOT INC.

220 Pasadena Ave./South Pasadena, Calif.

MUrray 2-3351 SYcamore 9-9171

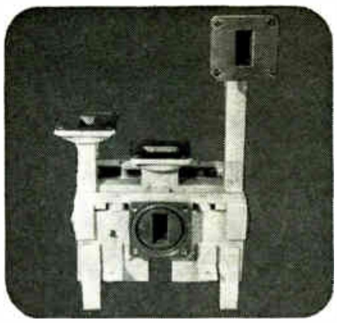
CIRCLE 125 ON READER SERVICE CARD →





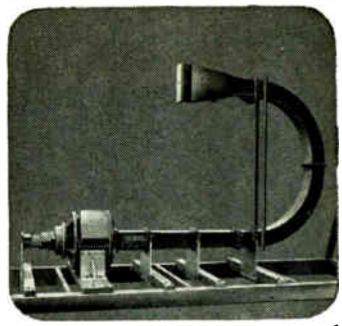
PRECISION CAST HORN

Precision Microwave Castings — We pour aluminum, magnesium and copper base alloys. Precision sand, plaster and investment castings complete with metallurgical tests are processed at our foundry.



WAVEGUIDE ASSEMBLY

Microwave Devices — Typical microwave devices ranging between L and KU Band include duplexers, switches, phase shifters, power dividers, horns, directional couplers and mixers. We test to your specifications.



CIRCULAR LINEAR POLARIZER

Antenna Assemblies — Complex assemblies in the L through KU Band frequency ranges for ground, shipboard, airborne and missile applications are available.

360 RING SLIP RING ASSEMBLY

Slip Ring Assemblies—Our new concept of button type spacing eliminates moisture and dust traps, gives maximum ring capacity within minimum space requirements. Dynamic characteristics are improved because of lower torque, heat dissipation is better and capacitance is reduced. Cost is lower.

PRODUCTS OF PROVEN RELIABILITY

Gorham Electronics has established a reputation of supplying complex precision castings, microwave devices and slip ring assemblies of proven reliability to the country's major contractors. Completely integrated facilities covering design, precision casting, close tolerance machining and assembly, plus final electrical test — all at one location—are your assurance of a quality product, at lowest cost.

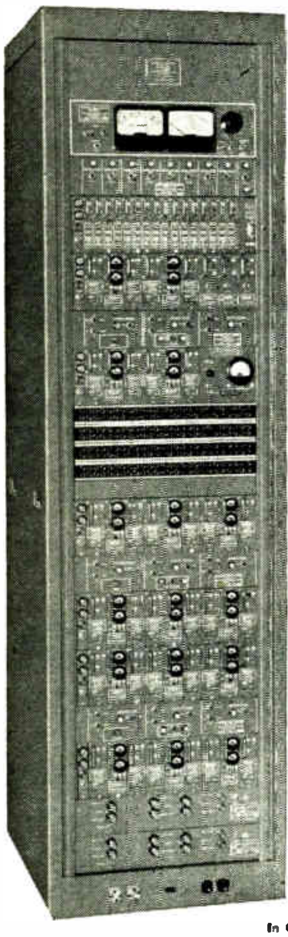
Hidden costs associated with vendor liaison, incoming inspection, divided technical responsibilities, and multiple profits are eliminated by placing a single order for timely delivery of a final tested product with an "Integrated Facility of Proven Reliability"—Gorham Electronics. Write today for our brochure.

GORHAM ELECTRONICS

DIVISION OF GORHAM CORPORATION
333 ADELAIDE AVENUE, PROVIDENCE 7, RHODE ISLAND
Tel. Area Code 401 Williams 1-1000

ENGINEERING DESIGN • FOUNDRY • MODEL SHOP • MACHINE SHOP • PLATING & PAINTING • ASSEMBLY • TEST

CIRCLE 217 ON READER SERVICE CARD



NEW BETTER-THAN-EVER

RELIABILITY

for long-distance point-to-point communications

NORTHERN RADIO

NEW 16-CHANNEL TRANSISTORIZED VOICE FREQUENCY DIVERSITY CARRIER TELEGRAPH TERMINAL TYPE 235 MODEL 3

MIL DESIGNATION AN/FGC-61A

NEW

. . . **All units militarized:** components and design approved by U.S. Military.

. . . **Converters** have equalized gain and adjustable time delay in each channel for better diversity performance and interchangeability.

. . . **Switching Panels** provide "local" or "remote" selection of 2-channel or 4-channel diversity modes.

. . . **Combiners** have adjustable gains in each channel, for complete switching flexibility, and the combining follows an ideally modified square law function for both 2-channel space or frequency and 4-channel space plus frequency diversity.

. . . **Keyers** have adjustable "threshold" sensitivity control and simplified input circuit selection.

. . . **Dotter and Delay Indicator** provides test keying signal source for keyers and delay equalizers in all channels.

Write for complete literature.

Pace-Setters in Quality Communication Equipment.

NORTHERN RADIO COMPANY, inc.
147 WEST 22nd ST., NEW YORK 11, NEW YORK
In Canada: Northern Radio Mfg. Co., Ltd., 1950 Bank St., Billings Bridge, Ottawa, Ontario.

WESTERN ASSOCIATES

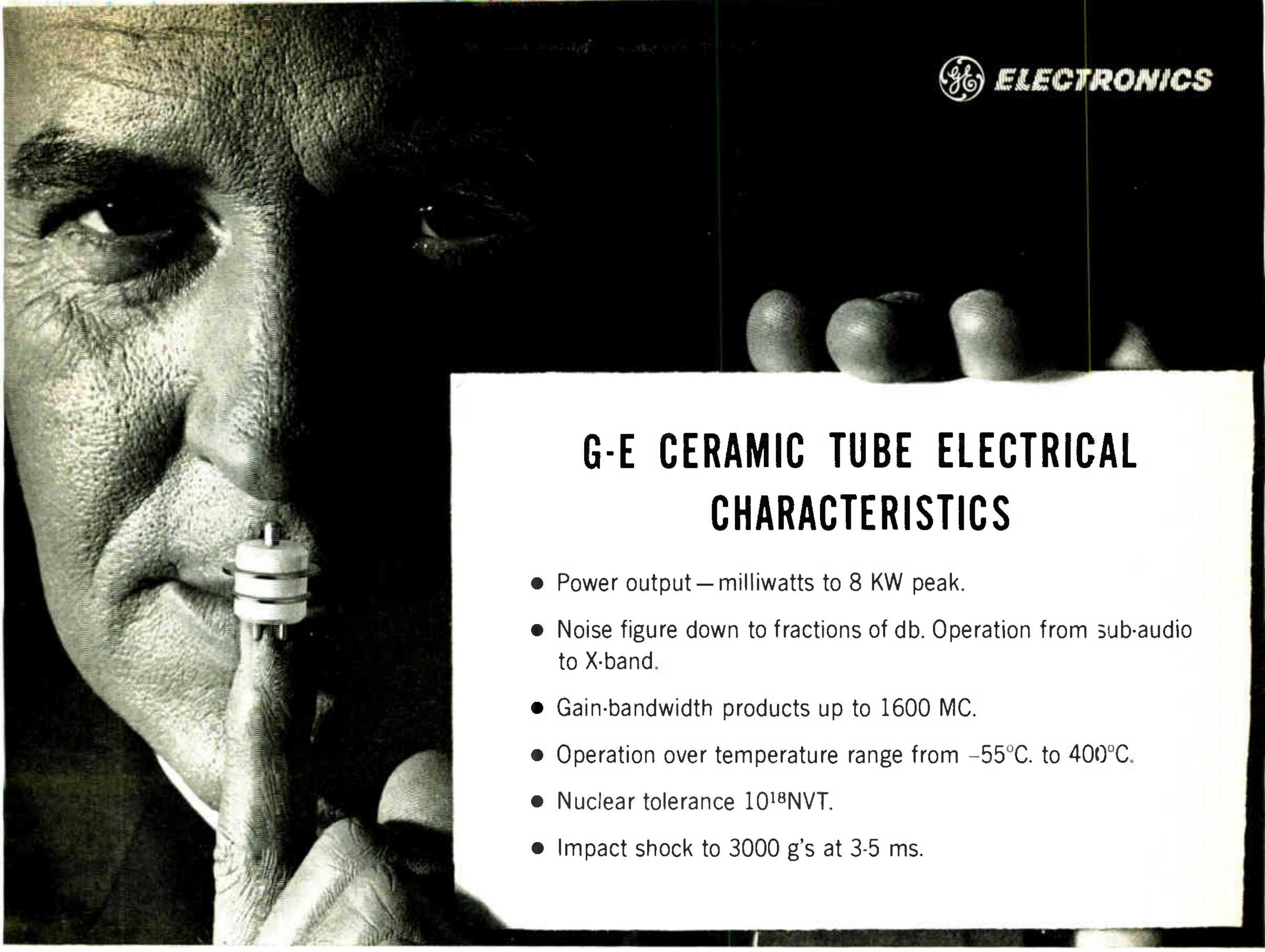
- Merchandising & Sales Promotion
- Campaigns
- Marketing
- Manufacturers' Representatives
- Consumer Technical Industrial

607 MARKET ST.
SUITE 201
SAN FRANCISCO 5, CALIF.
GA 1-8145

9735 WILSHIRE BLVD.
SUITE 129
BEVERLY HILLS, CALIF.
CR 5-5397

 CIRCLE 126 ON READER SERVICE CARD

CIRCLE 127 ON READER SERVICE CARD→



New General Electric ceramic tubes give high-gain, low-noise microwave performance for as low as 1/94 the price and 1/40 the size

Detailed value-analysis chart shows how size, cost and performance advantages can be yours. Clip coupon, or circle reader service number, for free copy.

No other microwave device can match the electrical performance of G-E ceramic tubes without sacrificing either small size, low cost, high-temperature tolerance, or radiation resistance. In many UHF applications up to 10 Gc (KMC), General Electric ceramic tubes can perform functions which now use TWT's, klystrons, magnetrons or parametric amplifiers. The result: component size-and-weight reductions up to 40:1, component cost reductions as high as $1,400.

High-gain, low-noise G-E ceramic tubes simplify circuitry and lower power requirements in such microwave applications as: power amplifiers, oscillators, or frequency multipliers. Planar construction of ceramic tubes, with the terminals as integral parts of the structure, results in low lead inductance, low interelectrode capacitances and good isolation between input and output circuits. Solid brazing of the integral parts gives an extremely tight tube structure and virtually eliminates tube element vibration. This also results in excellent thermal coupling which allows unsurpassed tube-performance at temperatures as high as 400°C. Most G-E ceramic tubes are on approved MIL-spec lists and are available "off-the-shelf" from your local G-E Receiving Tube Sales Representative. For more information, clip coupon below.

Progress Is Our Most Important Product

GENERAL ELECTRIC

G-E TIPS (Technical Information & Product Service)
General Electric Receiving Tube Department
Room 1731A, Owensboro, Ky.

CERAMIC TUBE VALUE ANALYSIS DATA

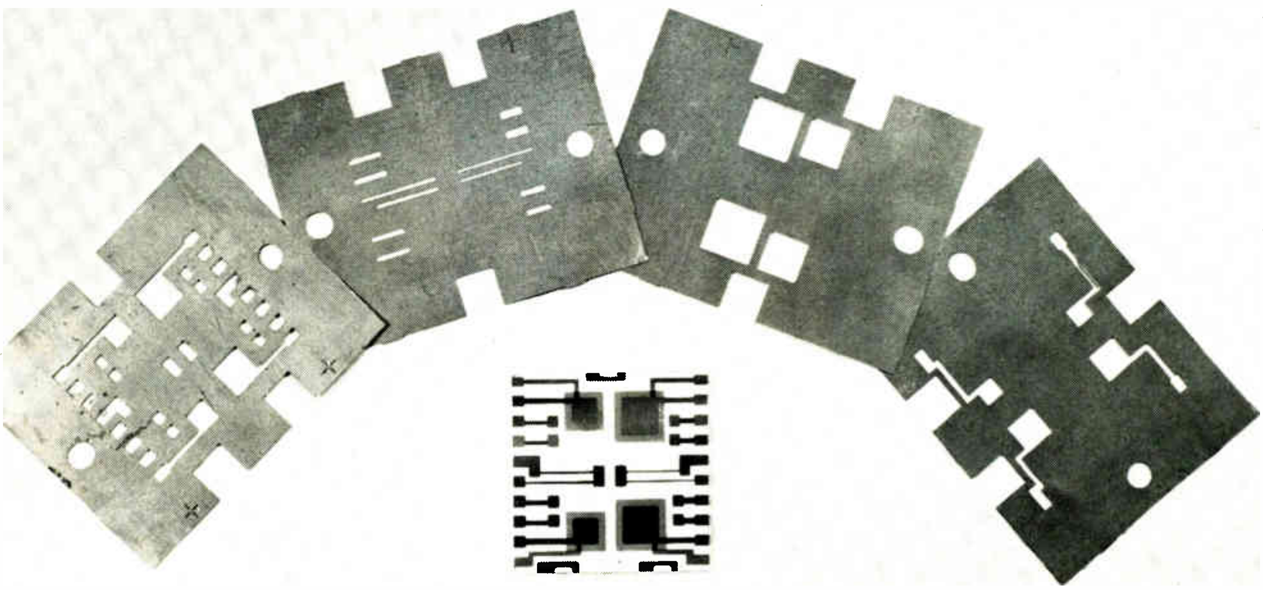
Please rush my free copy of "Ceramic Tube Value-Analysis Data."

Name .... *Title* ....

Company ....

Address ....

City .... *Zone* ...... *State* ....



Thin film circuit, center, and the precision metal masks used in making the circuit: from left, conductor and capacitor plates, resistor runs, silicon monoxide dielectric, top capacitor plates

Etching Precision Masks for Thin Film Circuits

By J. W. DILLON
J. C. GIOIA
Light Military Electronics Dept.
General Electric Co., Utica, N. Y.

TO MEET THE EXACTING requirements of thin film circuits, precise photoetched masks are essential. If a vapor deposited resistor, for example, is to be within five percent of desired value, and if the width of the resistor is 0.010 inch, then a simple calculation—0.010 inch times 0.05—shows that the 0.010 inch opening in the mask cannot vary more than ± 0.0005 inch.

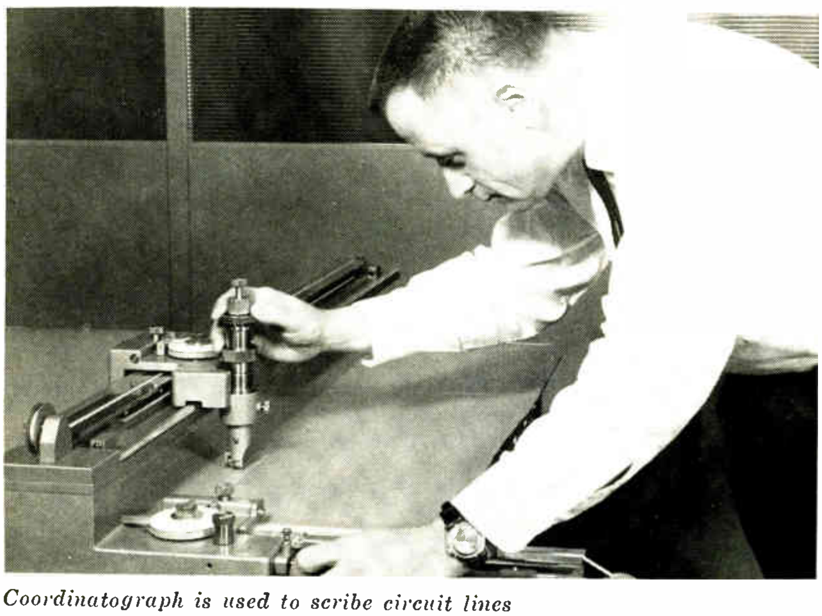
The 0.0005 inch figure is based on the premise that no other errors will occur during deposition. Actually, the resistance monitoring process must be given a margin of error, and drift in film resistivity will also cause error. For these reasons it is necessary to reduce the tolerance on masks to at least ±0.0002 inch and preferably to ±0.0001 inch. Preliminary information pointed to the mask specifications given in the table.

A program at LMED has led to a repeatable precision mask-etching process with control of etching to within ±0.0002 inch on 0.003 inch stock. The control is obtained by a four-step, relatively simple laboratory procedure.

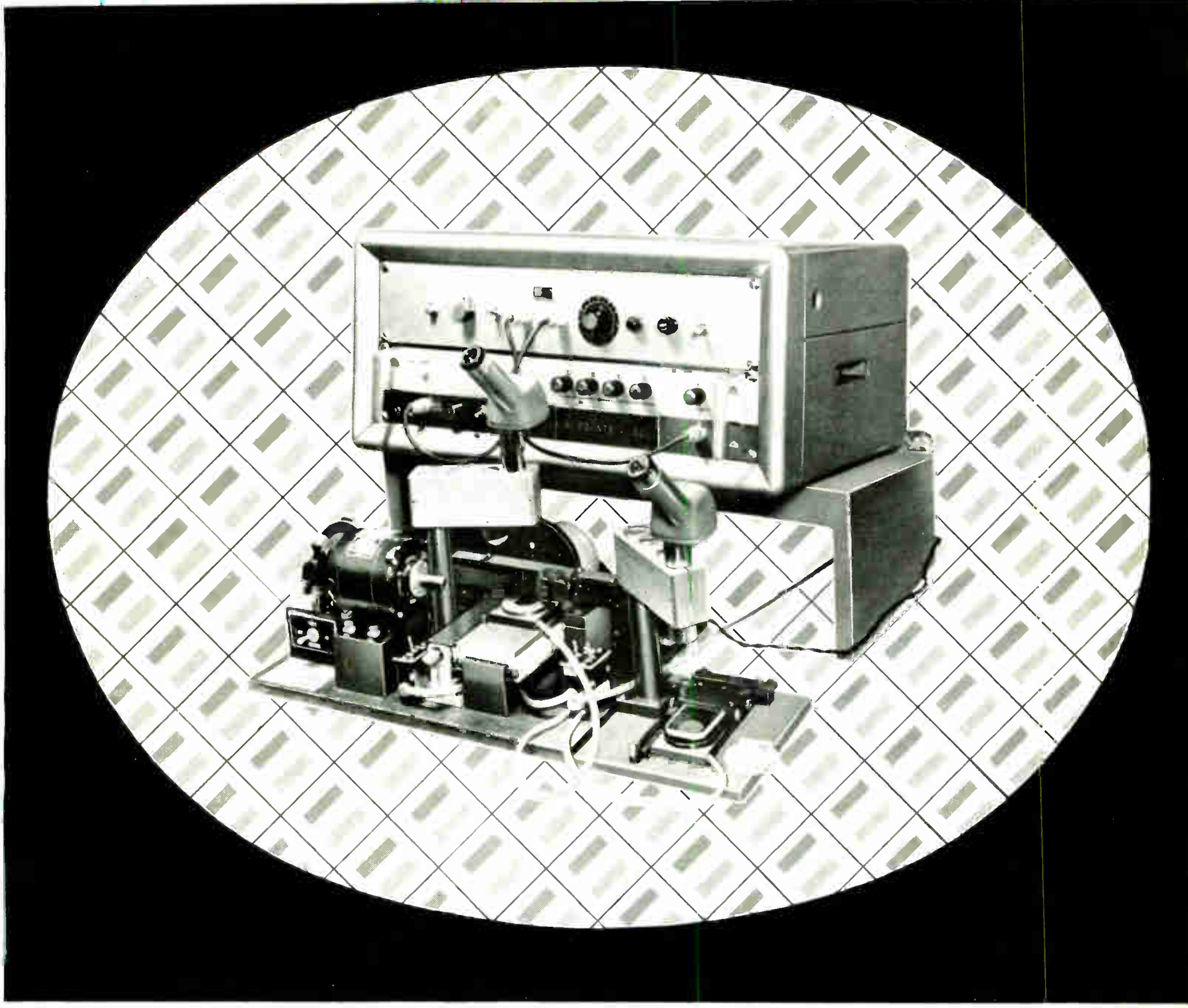
To keep the size of the art work to manageable limits, 40 times scale is used for magnification for average mask areas of one square inch. The circuit pattern is scribed on Mylar Scribe-Coat film using a coordinatograph. Hand scribing is not suitable.

Sidewise etching is a phenomenon inherent in chemical etching. As a result, a line will be wider in the mask than it is on the art work and compensation has to be made in the original art work.

The principal reason for multi-



Coordinatograph is used to scribe circuit lines



SCRIBES SMALLEST SEMICONDUCTORS—AUTOMATICALLY

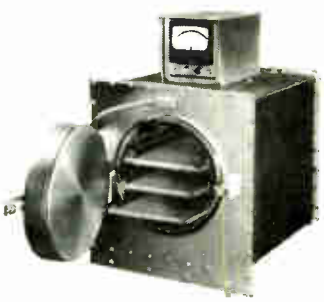
New Philco Controlled Index Scriber embodies a host of new semiconductor scribing capabilities ■ Automatically scribes blanks as small as .010″ x .010″ ■ Vacuum hold-down ■ Separate alignment and scribing stations ■ Electronic Indexing ■ Speed of 20 scribing cycles per minute ■ Dial Indexing adjustment in quarter-thousandth increments from .00025″ to 2.5″ ■ Ideal for new mesa and planar devices.

NEW METERED CLEAN-UP ETCHING

New Philco Modular Chemical Pumping System assures critically uniform clean-up etching of all components. Dispenses metered quantities of the most highly corrosive etchants, with rapid cycling, low pressure and clean cut-off. System No. 8-0306.

NEW LOW-COST 250°C. VACUUM OVEN

Outstanding quality at a budget price. All stainless steel. Hard vacuum—down to the 10^{-5} Torr range. Adjustable shelves. Includes vacuum valve, vent valve, and foot switch. Cylindrical muffle dimensions: 10″ diameter, 18″ depth. Model No. HB-1.



Get complete specifications. Write Dept. E51162.

EQUIPMENT DEVELOPMENT & MANUFACTURING OPERATION

PHILCO®

A SUBSIDIARY OF *Ford Motor Company*,

LANSDALE DIVISION, LANSDALE, PENNSYLVANIA

CIRCLE 129 ON READER SERVICE CARD

scaling original art work is to obtain final, single-scale art work with a minimum of error. Good process cameras and films are a must.

Using green-blue filters to limit chromatic aberration, only using five degrees of the lens center for the field, and limiting field area to one-fifth or one-sixth the focal length of the lens, the average process camera will give resolutions of 100 to 300 lines per millimeter. Reducing this lens resolving power to tolerances on line patterns, errors of plus or minus 0.00013 inch are introduced; the resolution available from mylar-supported emulsions produces another error of similar magnitude. The error exceeds that allowable for five percent resistors.

Improved Cameras

T. C. Hellmers and J. R. Nall have designed and built two precision cameras for use with spectroscopic plates that have a resolving power of 2000 lines per mm.[1] A special high-resolution camera using an apochromatic lens (corrected for both spherical and chromatic aberration) with a resolution of 1800 lines per mm has been built by Burke and James. Such precision cameras when used with new commercially developed spectrographic plates having emulsions capable of 2000 lines per mm make possible a heretofore unknown clarity of photographic images.

Two single-scale positives—one front and one back—are produced on these glass spectroscopic plates. Extreme care is necessary to keep the images of the front and back plates in exact juxtaposition relative to points on the edges of the glass.

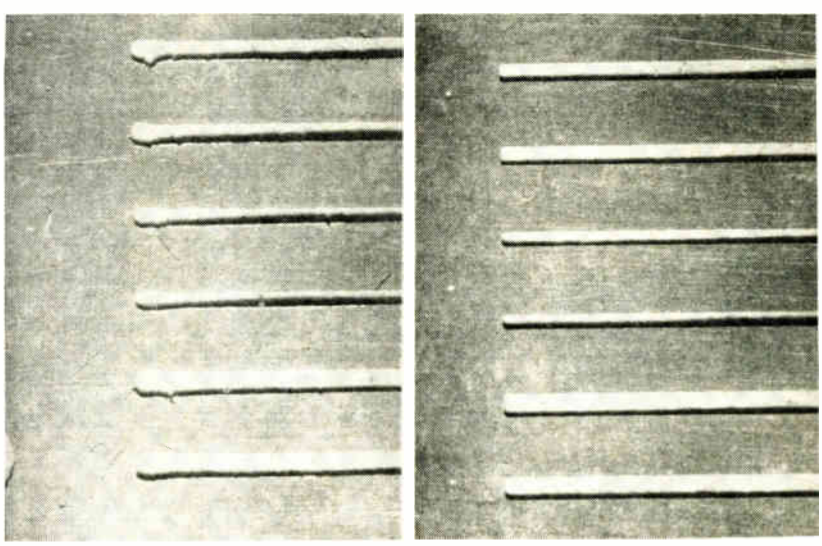
The metallic mask blanks are cleaned to remove organic and inorganic contaminants and oxidation. Kodak Photo Resist (KPR) is applied to the clean mask material. Copper, brass, and stainless steel are good choices.

The KPR is applied in a controlled atmosphere room or work chamber with gold fluorescent lights. Pure, freshly filtered KPR is applied by dipping the metal until the film is 0.001 inch thick; spraying or whirl-coating are also effective coating techniques.

The resist should be air dried for at least 24 hours; accelerated heat drying should be avoided.

The coated metal is mounted between the spectrographic plates, with accurate registration of the front and back plates, and exposed to ultraviolet light tubes. (Arc lights are not good for this purpose because they are not clean enough.) Both sides of the work should be exposed simultaneously and light scatter should be minimized. Exposure time is determined from a Kodak step table.

The work is developed by soaking it in KPR developer for two minutes with no stirring. It is spray-rinsed immediately with three or four passes of a one to one solution of KPR developer and denatured al-



Resistor runs reproduced here about 20 times actual size. Tear drops and line roughness are apparent on sample at left, which was made with usual techniques. Sample at right does not have these defects

cohol. Then it is soaked in this solution for 15 seconds and sprayed with aerated water. Where there is considerable developing to be done, two developer solutions may be desirable: one for the initial rinse and one for final clean developing. The image can be hardened further if the next etching step requires by baking it at 450 F or exposing it to more ultraviolet light. The harder the KPR, the more difficult it is to strip from the finished

TABLE—PRELIMINARY SPECIFICATIONS FOR THIN FILM MASKS

1. Accuracy sufficient to etch 0.005-inch wide resistors to within ± 0.0002 inch.
2. Mask to have sharp definitions and no ragged edges when viewed at 50× magnification.
3. Minimization of wedge shape to etched lines as well as tear drop appearance at end of lines.
4. Mask to be sufficiently rigid to avoid distortion in handling and to lie flat against substrate material; maximum flatness variation to be limited to ± .002 inch.
5. Material selected for masks to withstand 250 C temperatures in vacuum of 10^{-6} mm of Hg.
6. Mask material to have sufficiently low vapor pressure not to outgas during deposition.

mask. Thus, hardening the image more than is necessary complicates the task.

Controlling all variables in the process produces highly accurate masks but the etching requires extreme precision in front-to-rear alignment of the photographic emulsion plates. This precision has been attained with fixturing techniques that limit misalignment to ±0.00005 inch.

In the etching step the mask is dipped in a flat position into a beaker of etchant. The work remains stationary in the solution for ½ of etch time. It is then removed and given a light water-spray rinse. Finally, it is returned to the beaker, and the procedure is repeated for the reverse side until etch is complete. Eetching through both sides in this fashion reduces undercutting by one-half.

Control charts predict the accuracy of the etching process to within ±0.0002 inch and the results

are verified with a 50× microscope. Once the etching time in minutes and seconds has been established, a batch of five masks are etched at the same time. The process is easily mechanized once the effect of etchant life, temperature, specific gravity, and milligrams of metal in solution have been plotted on control charts.

Upon completion of etch, the KPR should be removed so that it will not interfere with the vapor deposition process. Several proprietary KPR strippers that produce good results are available.

Process Variables

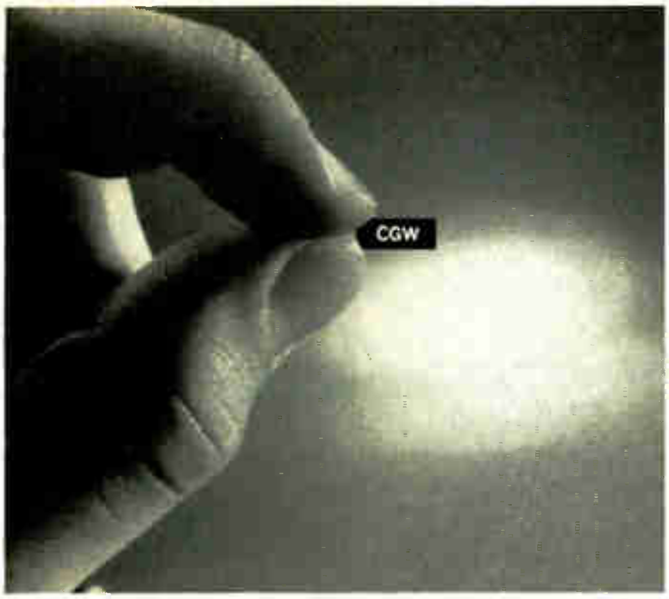
Among the principal variables in making resistor masks are tear drop effects on the ends of resistors, line roughness, protrusions, and variations in line width. The tear drop effects are caused chiefly by uneven run-off of etchant solution. Line roughness and variations in line width can be attributed to loss of acid-resistant coating. Metal protrusions on the etched circuit are usually caused by the minute pieces of dust that normally float in the air. These dust particles adhere to the protective acid resist and become a part of the coating. Dust particles as small as two microns can be the nuclei of metallic protrusions, especially if they fall across a narrow resistor run. Improved reliability and elimination of protrusions have been obtained by using clean-room techniques.

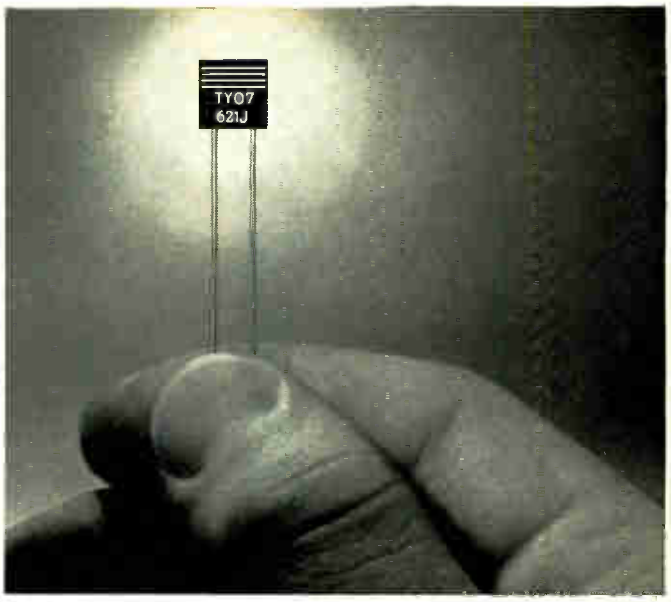
The science of mask preparation has progressed to the point where metals of higher purity and closer tolerances are required. The accuracy and control of line width can now be directly related to the crystal size of the metal, grain orientation and variations in surface thickness. On 0.003 inch thick stock, thickness variations greater than ±0.0001 inch will definitely influence results.

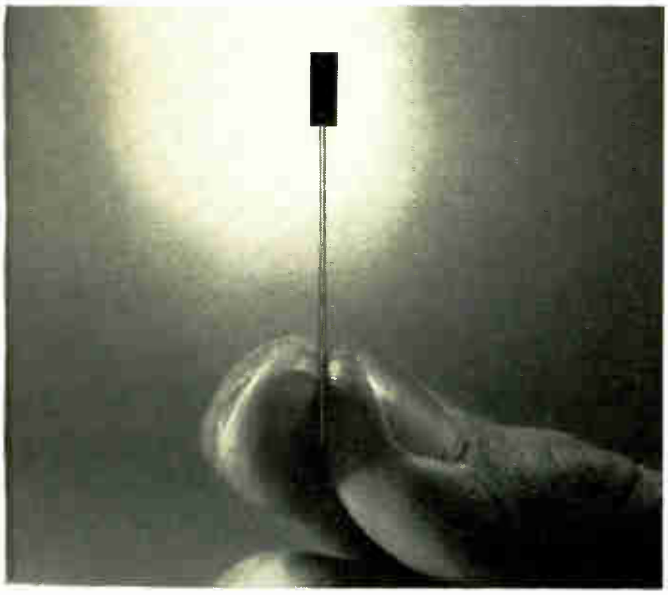
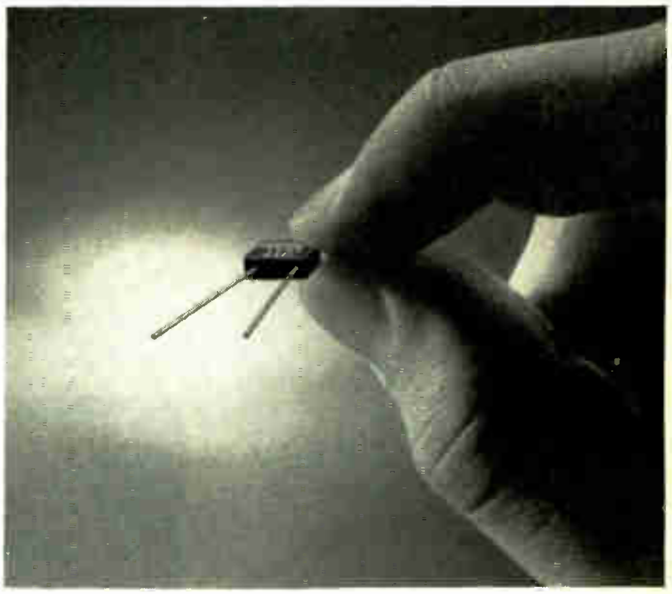
Unfortunately, high-density metals (with low vapor pressure and resistance to thermal sagging) resist normal etching techniques and better equipment is needed for these metals.

REFERENCES

1. T. C. Helmers, Jr., and J. R. Nall, Micrographs for Electronics, Semiconductor Products, 4, p 37, Jan. 1961.





New
Corning TY capacitor

gives you glass stability in a new package

Check the TY from every angle against what you need in a printed circuit capacitor:

High stability—You get the same type basic capacitive element of fused glass and foil that we put in the hi rel Minuteman and all other Corning capacitors.

Small size—The "T" in TY is for tiny. See the table.

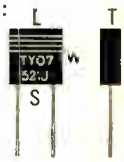
No shorts—The case and potting compound prevent inter-component, wire, or chassis short circuits.

Easy mounting—Parallel leads are symmetrical with the case, spaced uniformly on 1/10" grids. The standard gold-flashed Dumet leads are *welded* to the conductive plates for greater strength, and are easier for you to weld or solder. No "pants" on the TY—it sits flat on your board—and its dimensions are stable.

Try the TY06 now, with a capacitance range of 1 to 560 *pf*, and the TY07, with a range of 560 to 1000 *pf*. These values hold at 300 volts from −55°C. to +125°C. with no derating. Corning TY capacitors retain the electrical performance inherent in glass capacitor construction as evidenced by their stability, life performance, and TC.

Check these TY dimensions for your application:

	L±.005"	W±.010"	S±.020"	T±.005"
TY06	.300"	.200"	.200"	.115"
TY07	.300"	.300"	.200"	.115"
Lead diameter 0.020"±.002				



For more information, write Corning Glass Works, 539 High St., Bradford, Pa.

CORNING
Electronic Components

NEW

WIDE RANGE R-C OSCILLATOR

TUNES 10 CPS TO 10MC
•
BUILT-IN VOLTMETER AND ATTENUATOR CONTROLS OUTPUT, 1MV TO 3.16V
•
SOURCE IMPEDANCE SWITCH SELECTED, 75, 100, 600 Ω
•
HIGH OUTPUT TO 31.6V (BELOW 100KC)
•
PLUS FEATURE: SQUAREWAVES TO 100KC
•
PRICE: $770

New RC Oscillator Model 1370 tests AF/Video Amplifiers, wide band systems, networks, and telephone circuits with ease. Output impedance may be set at 75, 100 and 600 ohms (or 5 ohms using accessory pad TM6454) to exactly suit the system under test. Six decade bands effectively expand the tuning dial to 105 inches; dual ratio drive enables any frequency to be set with precision.

A modified Wien Bridge circuit gives exceptional stability and low, low distortion. Circuit also generates squarewaves to 100Kc for transient analysis and rapid bandwith determination.

Write For Complete Technical Literature

MARCONI INSTRUMENTS
DIVISION OF ENGLISH ELECTRIC CORPORATION
111 CEDAR LANE • ENGLEWOOD • NEW JERSEY
Main Plant: St. Albans, England

CIRCLE 136 ON READER SERVICE CARD

AIRFRAME CABLE MIL-W-7139 TEFLON INSULATED

A DISTRIBUTION LEAD WIRE with superior solvent resistance
FOR AIRCRAFT AND MISSILES

from Super-Temp

QUALITY ASSURANCE PLUS RELIABILITY are the all-important factors that have made Super-Temp your most dependable source for specialized wire and cable . . . Especially in missiles and aircraft that cost millions to build and whose operation depends on the perfect function of every delicate component. No other manufacturer offers the experience and facilities immediately available to you from Super-Temp. Why not discuss your particular requirements with one of our engineers now? For further information on our full line of wire or cable, send for new data folder. Address Dept. E-25,

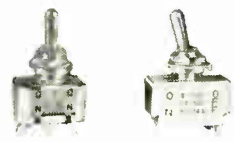
AMERICAN SUPER-TEMPERATURE WIRES, INC.
A Subsidiary of Haveg Industries, Inc.
8 West Canal Street, Winooski, Vt.
13151 Sherman Way, N. Hollywood, Cal

CIRCLE 219 ON READER SERVICE CARD

PS Type Rotary Switch
125V, 30A. A.C.

Each main switch has from 1 to 5 circuits, from 2 to 11 contacts, and has been designed so that the member of contacts can be altered to suit your purpose.

Sub-miniature Toggle Switches
125V 15A., 250V 10A. A.C.



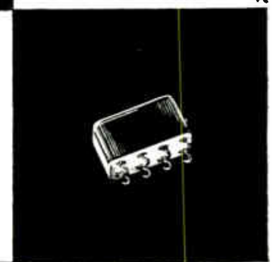
Miniature Switches
Toggle Switches 125V 10A. A.C.
S-2012 (SP. DT)
S-2022 (DP. DT)
S-2025 (DP. DT) (momentary)

Push-Button Switch
125V 6A. A.C.
SB-2061 (DP. DT)

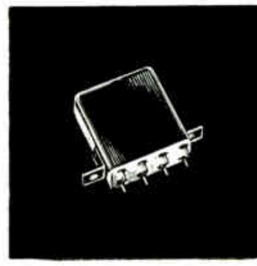
We will send a catalog immediately upon inquiry.

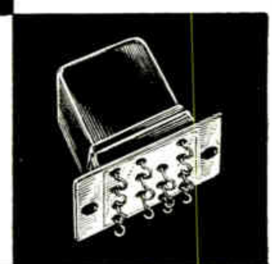
NIHON KAIHEIKI IND. CO., LTD.
644, 3-chome, Higoshi, Mogome-cho, Oto-ku, Tokyo, Jopon Tel: Tokyo (772) 3181/5

CIRCLE 220 ON READER SERVICE CARD

★


when thinking small becomes a BIG problem





★★


Hi-G Inc. makes the only complete line of microminiature relays . . . and our continuous research and development is producing new products geared to the requirements of the most technical and advanced electronic thinking.
But every Hi-G made relay, whether on the shelf or on the boards, is created for RELIABILITY above and beyond the requirements of normal performance.

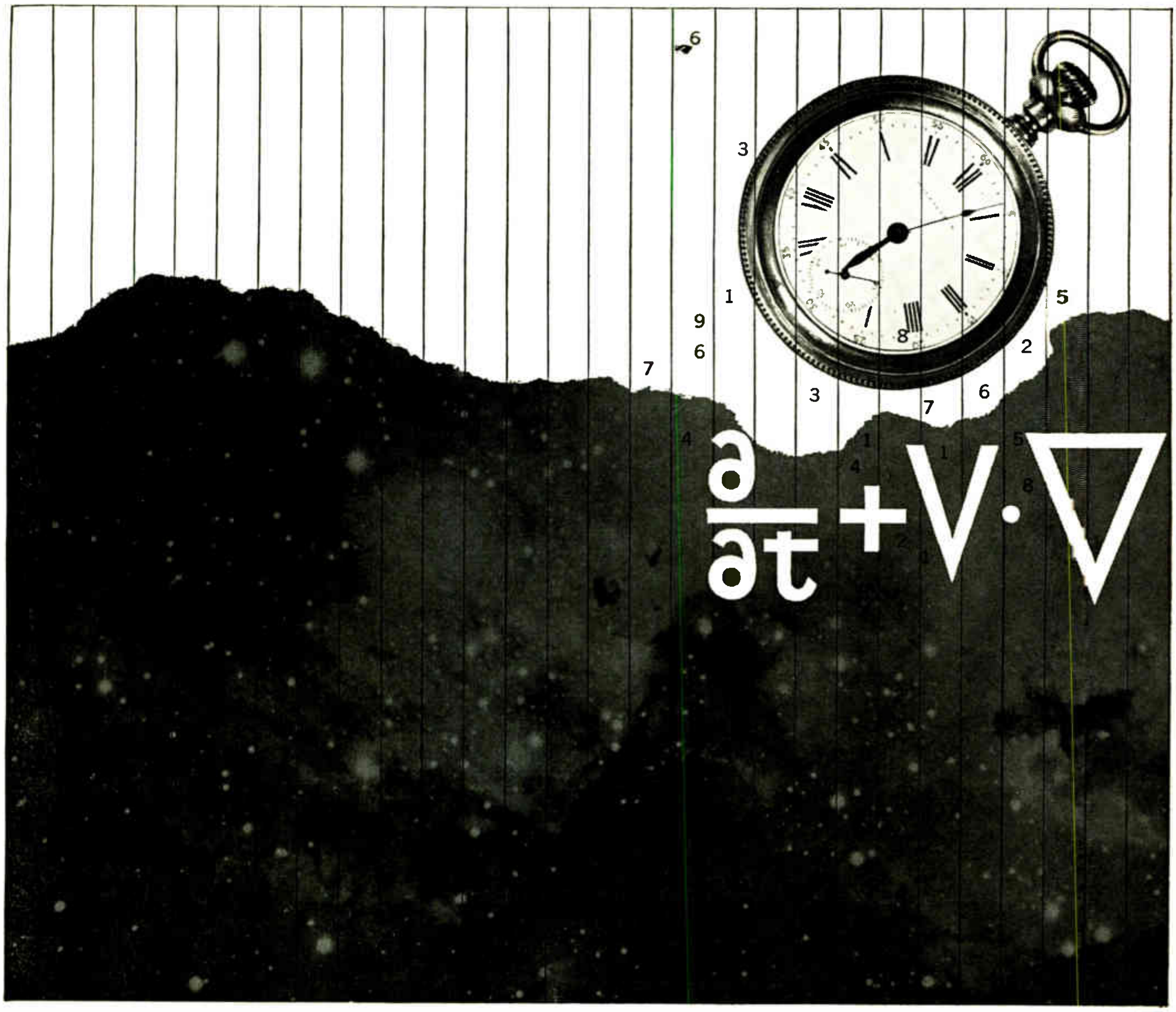
Hi-G
INC.

WINDSOR LOCKS, CONN.

☆ NEW—TYPE H (HALF PINT) half size crystal can
☆☆ NEW—TYPE T—10 AMP crystal can

CIRCLE 137 ON READER SERVICE CARD

 CIRCLE 138 ON READER SERVICE CARD

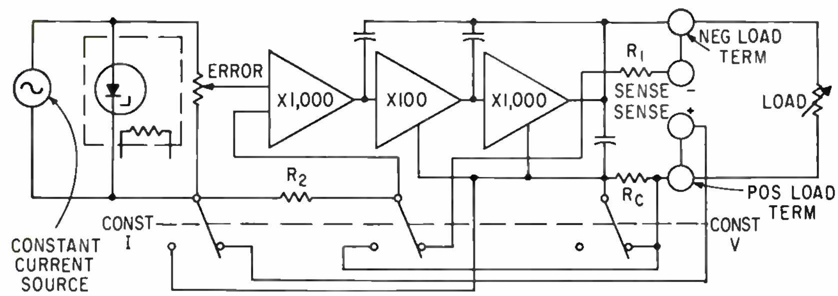


purposeful imagination....in time

The men of Aerospace apply the full resources of modern science and technology in a timely manner to achieve the continued advances in ballistic missile and space systems basic to national security. Their mission includes stimulating the flow of the most advanced scientific information and objectively planning the technical management programs necessary to generate superior systems in the shortest possible time. □ Chartered exclusively to serve the United States Government in this effort and acting in partnership with the Air Force-science-industry team, the men of Aerospace contribute: advanced systems analysis and planning; theoretical and experimental research; general systems engineering and corresponding technical direction of programs. □ To aid in reducing the timetable of advanced systems, from concept through completed mission, more men with advanced degrees are needed at Aerospace Corporation, an equal opportunity employer. Dedicated interdisciplinary scientists and engineers who can contribute effectively are invited to contact Mr. George Herndon, Room 110, Aerospace Corporation, P. O. Box 95081, Los Angeles 45, California. □ Organized in the public interest and dedicated to providing objective leadership in the advancement and application of science and technology for the United States Government.

AEROSPACE CORPORATION

DESIGN AND APPLICATION

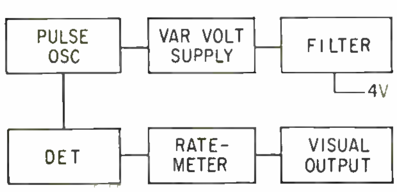


Voltage-Current Reference Source

± 0.001% STABILITY, ± 0.0001% REGULATION

ANNOUNCED by Princeton Applied Research Corp., POB 565, Princeton, N. J., are the models TC-100.2 and TC-100.2R voltage-current reference sources. Constant output voltage is adjustable by thumb-wheel switches between zero and 99.999 v with a resolution of 1 mv. Output current is 100 ma. Output impedance is less than 10 μohms at d-c and less than 0.1 ohm at 100 Kc. Combined ripple, hum and noise are less than 50 μv rms. Output current is also adjustable with thumb-wheel switches between zero and 99.999 ma. Resolution is 1 μamp. Compliance voltage is zero to 100 v. Combined ripple, hum, noise and spikes are less than 600 namp independent of current level. Output impedance is approximately 1,000 megohms at d-c. Eight hour stability is ±0.001 percent or ±250 μv/namp while long-term stability is ±0.01 percent or ±2.5 mv/μamp. Transient response is less than 25 μsec to within 10 mv. As shown in the sketch, a temperature compensated Zener diode is placed in a constant-temperature oven. A five digit Kelvin-Varley voltage divider, adjusted by five decade thumb-wheel switches, is across the diode developing variable compensating voltages. Error signal is amplified yielding a total d-c loop gain of almost 10^7. Output voltage is divided by a factor or 12 by matched precision resistors R_1 and R_2 and compared with the reference voltage. Separate sense terminals allow output voltage to be sensed and controlled at point desired, cancelling effects of lead resistance. In constant-current mode, sense terminals are connected across series resistor R_c.

CIRCLE 301 ON READER SERVICE CARD

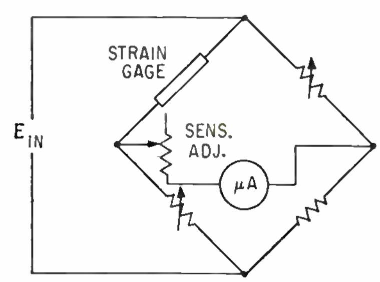


Fallout Detector

POCKET SIZE

NEW on the market from Nuclear Corp. of America, 2 Richwood Place, Denville, N. J., is the NU-TEC RM-100 pocket size radiation detector. Used for field survey and industrial or medical monitoring applications, the device covers the range from 0 to 10 mr/hr, 100 mr/hr, 1,000 mr/hr and 100 r/hr. The device has a flat response for gamma energies over range of 80 KEV to 1.2 KEV and will not saturate in any field. For field intensities up to 1,000 mr/hr, the G-M tube is operated under d-c conditions and an oscillator is used to maintain off-scale readings at field intensities normally sufficient to produce detector saturation. For 0 to 100 r/hr field, range extension is accomplished through statistical sampling. D-c voltage bias to G-M tube is reduced below threshold voltage and a low duty cycle voltage step is superimposed on the tube bias and raises the tube to a proper operating voltage. The tube duty cycle is 0.3 percent. If an ionizing event occurs simultaneously with a voltage pulse, an output is produced, otherwise no output from the G-M tube is coupled to the ratemeter circuit. This superimposed voltage pulse also eliminates saturation effects normally encountered at high field levels. Calibration is by external Cobalt 60 or Cesium 137 sources.

CIRCLE 302 ON READER SERVICE CARD



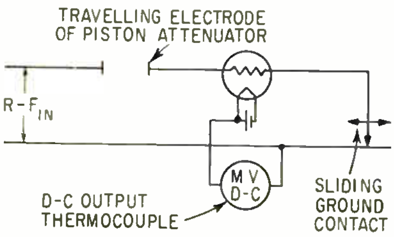
Silicon Strain Gage

GAGE FACTOR OF 130

RECENTLY announced by the General Diode Corp., P.O. Box 172, Framingham Center, Mass., is a practical semiconductor strain gage for small area measurements. The strain sensitive element is a filament sliced from a silicon single crystal, provided with high purity gold wires. The device has a gage factor of 130—approximately 65 times that of metallic strain gages. The units are up to 1 in. length, resistance of 350, 1,000, or 2,000 ohms ±10 percent, temperature range from 320 to 650 F, temperature sensitivity of 0.016 percent/degree F, 0.125 inch minimum radius of curvature and a maximum

operating strain of over 3,000 μstrains. The simple Wheatstone bridge shown (sketch p 140), uses a strain gage bonded to an aluminum channel. The bridge is balanced by adjustment of the two variable resistors and a zero center 100 μa meter is used as readout. When sensitivity is set at zero, an apparent strain of less than 100 μstrain will deflect meter to full scale.

CIRCLE 303 ON READER SERVICE CARD



Voltmeter Standard

ACCURACY ±1 PERCENT

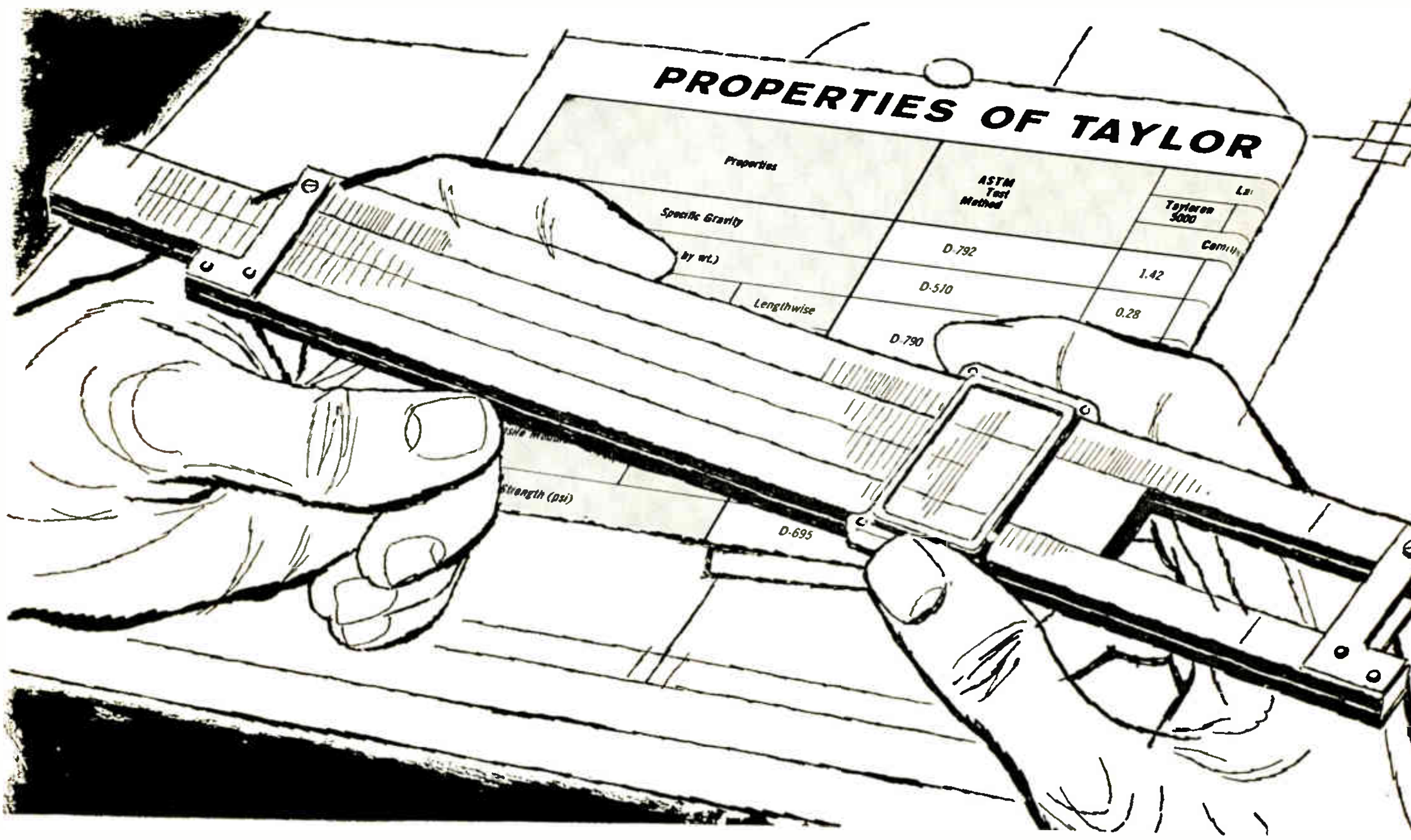
MANUFACTURED by General Microwave Corp., 155 Marine St., Farmingdale, N. Y., the model 350 A-T voltmeter operates between 10 and 1,000 Mc measuring between 0.2 and 500 v (depending on frequency) with an accuracy within ±1 percent of NBS calibration for at least one year. Input capacitance is nominally 4.2 pF, reference d-c output of calibration thermocouple is nominally 0.1 mv and the d-c output resistance of the thermocouple is 8 ohms ±10 percent. As shown in the sketch, the device is an adjustable waveguide-below-cut-off attenuator operating in the TM_{01} mode in combination with a uhf vacuum thermocouple. The carriage is driven by a special 2-inch micrometer, calibrated in ten-thousandths of an inch. The unknown voltage signal at predetermined frequency is connected to the attenuator input. Attenuation is adjusted with the micrometer to produce standard reading, as specified on NBS calibration charts, on the millivoltmeter. Because input frequency and micrometer setting are known, r-f voltage can be derived from NBS charts of voltage versus frequency as a function of micrometer setting, or voltage versus micrometer setting as a function of frequency.

CIRCLE 304 ON READER SERVICE CARD

Source & Meter

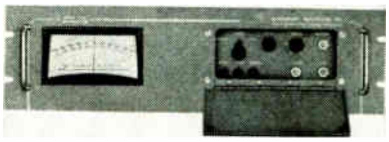
HIGH ACCURACY

ABBEY ELECTRONICS CORP., 143 Old Country Road, Carle Place, L. I., N. Y. Dual-purpose instrument combines the functions of a high-



resolution d-c voltage and current source with a precision nulling-type voltmeter. Operating as either a source or a meter, the SM-4 has an absolute accuracy of 0.025 percent of reading ± 500 μv from 0 to 1 v, and 0.025 percent of reading ±5 mv from 1 to 10 v. In either mode, resolution is better than 500 μv on the 1 v range, and better than 5 mv on the 10 v range. Price is approximately $300.

CIRCLE 305 ON READER SERVICE CARD



Servoamplifier

ALL SOLID-STATE

BOONSHAFT AND FUCHS INC., Hatboro Industrial Park, Hatboro, Pa. Model 471 is of all solid-state design, including solid-state chopper stabilization. It is used for direct operation of servomechanisms of all types. It utilizes a model TR-1 operational amplifier. This amplifier, with a drift of less than 10 μv in 24 hr, has a gain of 10^7 and lends great flexibility to the servoamplifier.

CIRCLE 306 ON READER SERVICE CARD

Coaxial Switch

WITH INDICATORS

TRANSCO PRODUCTS, INC., 12210 Nebraska Ave., Los Angeles 25, Calif. A new indicator circuit switch option is now available for the spdt type-Y coaxial switch. Indicator switch contact ratings: 28 v d-c, 7 amp resistive, 4 amp inductive. The coax switch with indicators weighs 8 oz and is available with 6 different r-f connector types, various solenoid configurations and voltages. R-F characteristics are good to 11 Gc. Designed to meet MIL specs.

CIRCLE 307 ON READER SERVICE CARD

Circulators

RANTEC CORP., Calabasas, Calif. Three new three-port, Y-junction coaxial ferrite circulators cover a frequency range from 0.9 Gc to 2.15 Gc.

CIRCLE 308 ON READER SERVICE CARD

VHF Receiver

3 I-F BANDWIDTHS

COMMUNICATION ELECTRONICS, INC., 4900 Hampden Lane, Bethesda 14, Md. Providing a-m, f-m and c-w reception, type 960 vhf receiver covers the range of 30 to 300 Mc. With special applications in monitoring, telemetry, and surveillance fields, the instrument is designed with three i-f bandwidths, 20 Kc, 200 Kc, and 500 Kc. A feature is the simultaneous operation of the narrow-band i-f in the a-m or f-m position and the wide band i-f in a-m and f-m. Price is $2,400.

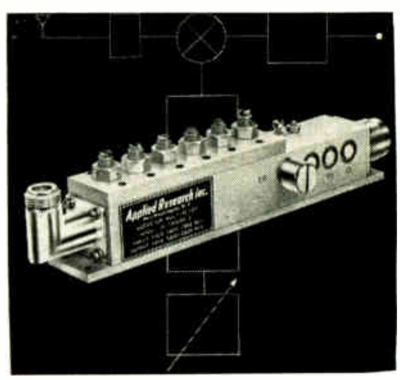
CIRCLE 309 ON READER SERVICE CARD

Potting Forms

FOR CABLE CONNECTORS

STEVENS TUBING CORP., 86-88 Main St., East Orange, N. J., announces inexpensive potting forms made by cutting short pieces from lengths of glass laminated epoxy or silicone tubing, molded with tight tolerances to snap fit over the connector receptacle. The form, when filled with RTV Silastic compound, encapsulates the wire connections. The resulting cable assembly features high resistance to moisture, temperature, and shock.

CIRCLE 310 ON READER SERVICE CARD



C-Band Tripler

500 MC WIDE

APPLIED RESEARCH, INC., 76 South Bayles Ave., Port Washington, N. Y. Output of 20 mw over the entire 500 Mc wide region between 5,400 and 5,900 Mc is delivered by the VM-5625/500-3 passive Varactor tripler. Spurious content is held 60 db or more below the desired output. Price of unit depends upon center frequency, bandwidth and power output requirements.

CIRCLE 311 ON READER SERVICE CARD

Pressure Transducer

LUNAR ENGINEERING CORP., 1501 Calle Valle, San Clemente, Calif., has available model DSST high-line, low-differential silicon-semiconductor strain-gage pressure transducer.

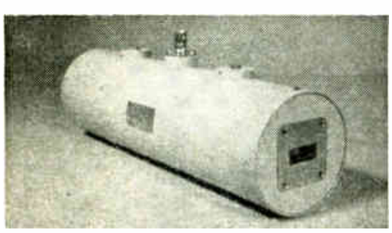
CIRCLE 312 ON READER SERVICE CARD

Time Display Unit

SELF-CONTAINED

METRIC SYSTEMS CORP., 736 N. Beale St., Fort Walton Beach, Fla. Series 8729 time display unit is a digital code format translator and visual indicator, designed to accept one of several standard time codes and present a visual indication of the time-of-day. It is completely self-contained, including power supply and removable indicator section. Unit is of solid state modular design.

CIRCLE 313 ON READER SERVICE CARD

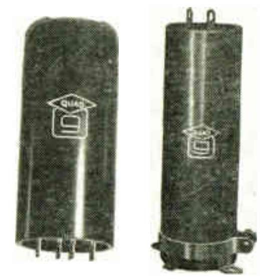


Ferrite Switch

X-BAND

HYLETRONICS CORP., Burlington, Mass. Model SX1, an X-band ferrite switch, exhibits greater than 100 db isolation in the "off" state and only 0.2 db loss in the "on" state over a 100 Mc band centered at 9.375 Mc. It has a switching time of less than 50 μsec. Designed for maser protection, the switch also has applications in duplexing, power dividing, standby transmitter switching and modulation techniques.

CIRCLE 314 ON READER SERVICE CARD



Capacitors

DRY ELECTROLYTIC

SYNCRO CORP., Hicksville, O., announces types MSP and MSM series of dry electrolytic rotor starter capacitors. Ratings are available up to 708 μf for 110 v a-c operation, and up to 77 μf for 320 v a-c operation, with capacitors also for 125, 160 and 220 v a-c.

CIRCLE 315 ON READER SERVICE CARD

Power Supply

KUPFRIAN MFG. DIV., Robinson Technical Products Inc., 374 State St., Binghamton, N. Y., offers frequency regulated transistorized power supplies that will convert 12, 24, or 32 v d-c power sources to 400 cps 117 v a-c square wave; inverters regulated to ± 0.7 cps are included in the group.

CIRCLE 316 ON READER SERVICE CARD

Oscillators

ADJUSTABLE FREQUENCY

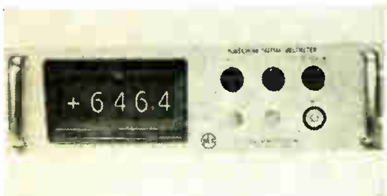
GREENRAY INDUSTRIES, INC., 5281 E. Simpson Road, Mechanicsburg, Pa. Model 61,000 transistorized oscillators are adjustable over a narrow frequency range of ±10 percent of any center frequency specified. Available at any specified center frequency in the range of 400 cps to 10 Mc. Applications: scr's, power supplies, transmitters, receivers, missile control systems, telemetry systems.

CIRCLE 317 ON READER SERVICE CARD

Trimming Pot

SPECTROL ELECTRONICS CORP., 1704 South Del Mar Ave., San Gabriel, Calif. Measuring just ¼ in. in diameter and weighing only 1 gram, the model 80, with single turn adjustment from the top, is suited for printed circuit application.

CIRCLE 318 ON READER SERVICE CARD

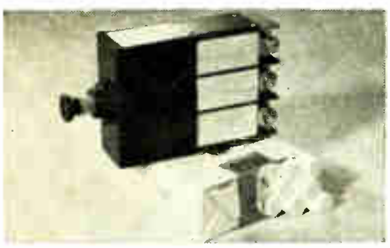


Digital Voltmeter

ONE READING PER SEC

NON-LINEAR SYSTEMS, INC., Del Mar, Calif., announces the V64B, a low-cost, full four-digit, digital voltmeter. It measures from ±0.001 to ±9.999 v d-c as is, and can measure ranges of ±99.99 and ±999.9 with an accessory input voltage divider. Accuracy is ±0.01 percent of full scale. Special heavy-duty stepping switches in the unit are mounted on individual plug-in boards for ease of servicing.

CIRCLE 319 ON READER SERVICE CARD

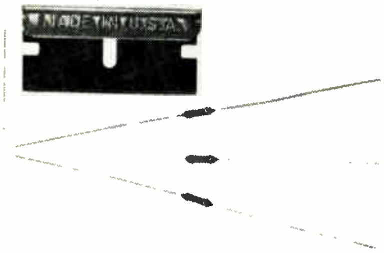


Circuit Breaker

THREE-PHASE

METALS & CONTROLS INC., 34 Forest St., Attleboro, Mass. The Klixon 7276-1 is designed for use in aerospace and electronic applications for low-amp, three-phase circuit protection. An overload on any one phase trips all three breakers and releases the single indicating button. Unit has fast tripping response —2 to 20 sec at 200 percent rating. Ratings of $\frac{1}{2}$ to 10 amp are available.

CIRCLE 320 ON READER SERVICE CARD



Miniature Resistors

SILICONE COATED

DALE ELECTRONICS, INC., Columbus, Neb. Type RS-$\frac{1}{4}$ has a power rating of $\frac{1}{4}$ w at 50 C ambient temperature. Maximum continuous operating temperature is 275 C. Maximum continuous working voltage is 12 v d-c. Resistance range is from 1 ohm to 3,000 ohms, depending on tolerance. Tolerances: 0.5 percent and 1 percent. Temperature coefficient 20 ppm/deg C.

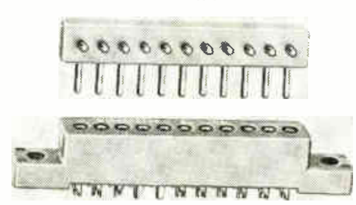
CIRCLE 321 ON READER SERVICE CARD

Temperature Recorder

ULTRASENSITIVE

ASSEMBLY PRODUCTS INC., Chesterland, O. The compact Temprint recorder features: no amplification, no drift, frictionless movement, no ink to spill or refill, and control or alarm contacts. Prices range from $165 to $185.

CIRCLE 322 ON READER SERVICE CARD



P-C Board Connector

MICROMINIATURE

WINCHESTER ELECTRONICS INC., 19 Willard Road, Norwalk, Conn. The WD series consists of a tiny right angle dip solder type plug for board thicknesses up to $\frac{1}{16}$ in. for use with two boards, or a single board along with a mating receptacle. It is available in 11 and 22 contact configurations. Terminal types are: pin, dip solder; socket, solder cup. Contacts are: phosphor bronze, gold plated over silver. Contact spacing is 0.100.

CIRCLE 323 ON READER SERVICE CARD

Adapter

SANDERS ASSOCIATES, INC., 95 Canal St., Nashua, N. H., announces model SK20, an adapter that permits all octal base klystrons to be plugged into coaxial circuits.

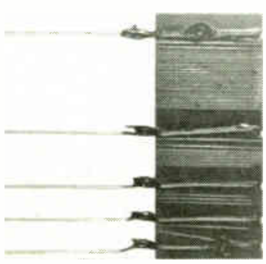
CIRCLE 324 ON READER SERVICE CARD

Transformers

SUBMINIATURIZED

TOROTEL, INC., 5512 E. 110th St., Kansas City 37, Mo., announces transformers that meet the specifications of class R, grade 5, MIL-T-27A. Units exhibit excellent response, load distortion and power capabilities and mounting is by 1 in. leads for direct printed circuit application.

CIRCLE 325 ON READER SERVICE CARD



Strip Resistors

PRECISION-WOUND

ORION ELECTRIC CORP., 108 Columbus Ave., Tuckahoe, N. Y., announces precision-wound strip resistors up to 1/10th of 1 percent accuracy. These epoxy-impregnated wire wound items are noninductive and are designed for applications from d-c to above 10 Mc. They can be custom-made in any shape or size.

CIRCLE 326 ON READER SERVICE CARD

Solid State Choppers

RAWCO INSTRUMENTS INC., 1400 Riverside Drive, Fort Worth 11, Texas. Type 100 solid state choppers have a noise level of 3 to 10 μv at 1,000 ohms impedance and a noise level of 20 to 150 μv at 10,000 ohms impedance.

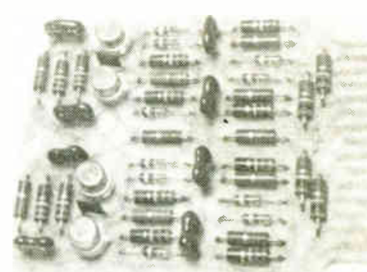
CIRCLE 327 ON READER SERVICE CARD

Connectors

MINIATURIZED

AMP INC., Elizabethtown, Pa. Versatile line of high altitude/high voltage electrical connectors are available in T, L and Y configurations and mate with their existing HA/HV-1 systems. Operating specifications are 12 Kv d-c at 5 amp, with a temperature range of −55 C to + 140 C at altitudes up to 70,000 ft above sea level.

CIRCLE 328 ON READER SERVICE CARD

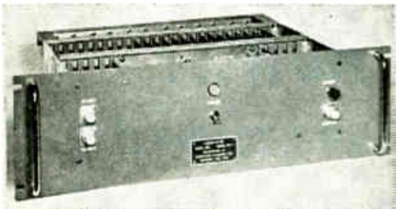


Flip-Flop Module

FOR DIGITAL SYSTEMS

CONTROL EQUIPMENT CORP., 19 Kearney Road, Needham Heights 94, Mass. FF-521 consists of two independent transistor flip-flops which operate from d-c to 250 Kc. Each circuit has a-c coupled "set" and "reset" inputs and a d-c reset input. The flip-flops may be used as counters by connecting the set and reset inputs together externally. New module is available from stock at less than $15 per circuit.

CIRCLE 329 ON READER SERVICE CARD



Multiplexer

ALL SOLID-STATE

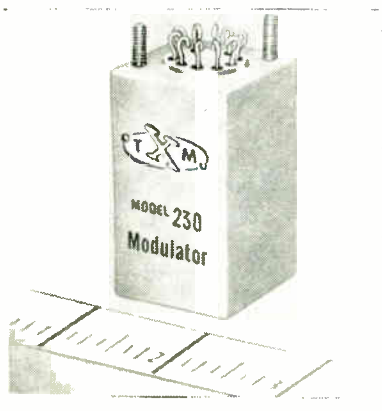
COMPUTER SCIENCES, INC., 603 Main St., Westbury, N. Y. Model 428 is designed for automatic commutation of up to 100 input channels. High-speed solid-state switches accept both positive and negative signals with levels up to 10 v. Max offset signal is 200 μv. Operating speed exceeds 20 Kc with each channel duty cycle up to 80 percent. Multiplexing can be controlled through an internal oscillator-counter or by external means.

CIRCLE 330 ON READER SERVICE CARD

Winding Machine

GEO. STEVENS MFG. CO., INC., Pulaski Road at Peterson, Chicago 46, Ill. Precision potentiometer winding machine winds tapered flat cards up to 1 in. wide to 0.0005 accuracy per ¼ in. length at speeds up to 1800 rpm.

CIRCLE 331 ON READER SERVICE CARD



Magnetic Modulator

HERMETICALLY SEALED

TRANSMAGNETICS INC., 40-66 Lawrence St., Flushing 54, N. Y. Model

230 magnetic modulator converts thermocouple output to 400 cps phase sensitive a-c featuring a gain of 400 into 10,000 load, drift less than 100 μv over −55 to +105 C, and very long life, without moving parts. Applications include temperature feedback control systems and linear signal conditioning and data amplifiers.

CIRCLE 332 ON READER SERVICE CARD

Wideband TWT

ALL METAL-CERAMIC

LITTON INDUSTRIES, San Carlos, Calif., has developed a 21-oz. rugged wideband twt providing 1 w c-w power in the range 4,000-8,000 Mc. The L-3711 features 36 db minimum small signal gain and excellent linear saturation characteristics. It is operational after 50 g shock, 60 g vibration and at an altitude of 100,000 ft.

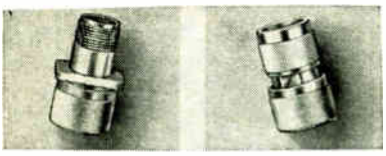
CIRCLE 333 ON READER SERVICE CARD

Commutator

MINIATURIZED

COMPUTER INSTRUMENTS CORP., 92 Madison Ave., Hempstead, L. I., N. Y. Model 5015 is an extremely low noise, miniaturized commutator designed for high speed switching applications. Only 0.530 in. in diameter, it has a max starting torque of 0.015 oz in. and will operate to speeds of 3,000 rpm. It is available with up to 3 poles, with ±2 deg tolerance on the conductive segments. Operating temperature range is from −55 C to +150 C.

CIRCLE 334 ON READER SERVICE CARD

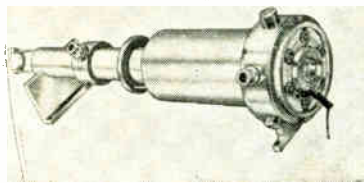


R-F Connectors

TRIAXIAL

GREMAR MFG. CO., INC., 7 North Ave., Wakefield, Mass. Designed for use with triaxial r-f cables, these connectors solve ground loop problems by providing a double shielding and prevent random r-f noise in electronic equipment.

CIRCLE 335 ON READER SERVICE CARD

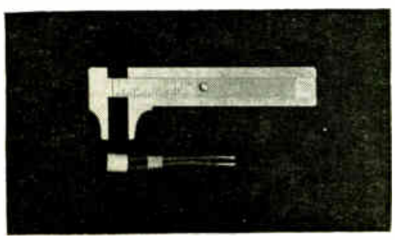


Pulse Amplifier

GAIN IS 8 DB

TRAK MICROWAVE CORP., Tampa, Fla. Type 9183 pulse amplifier is capable of 15 Kw peak power output at 1,030 Mc; gain is 8 db; isolation between input and output, greater than 50 db in the OFF condition. There is negligible deterioration of pulse characteristics. The amplifier will handle a 1 μsec pulse at prf of 1000.

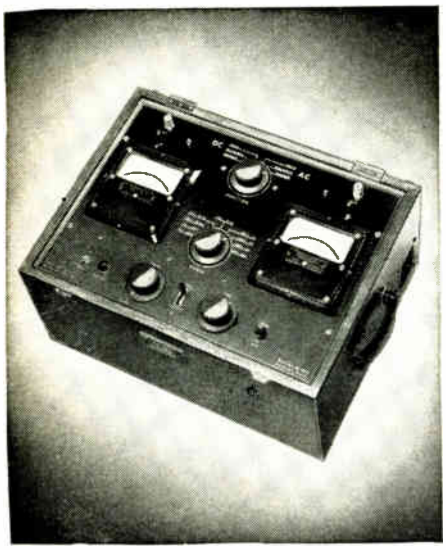
CIRCLE 336 ON READER SERVICE CARD



Cooling Modules

THERMOELECTRIC

SEMITRONICS, INC., 63 Swanton St., Winchester, Mass. Models SMT-42S and SMT42E are miniature single and multijunction thermoelectric cooling modules. They are suited for applications which re-



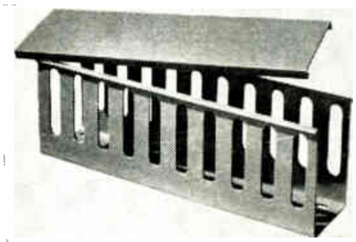
quire cooling of temperature-sensitive electronic components, such as transistors and memory cores where the spatial requirements are a major consideration. Temperature differential attained at 60 C is 25 C.

CIRCLE 337 ON READER SERVICE CARD

R-F Calorimeter

ELECTRO IMPULSE LABORATORY INC., 208 River St., Red Bank, N. J. Compact, lightweight calorimeter that gives an accuracy rated at better than 5 percent has a frequency range of d-c to 2,500 Mc.

CIRCLE 338 ON READER SERVICE CARD

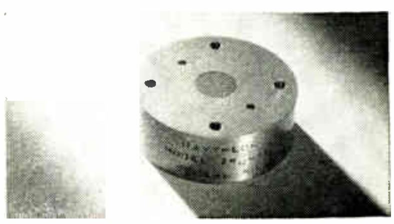


Wiring Duct

SLOTTED DESIGN

TAYLOR ELECTRIC INC., Howell, Mich. Type V wiring raceway is available. Slots offer the benefits of easy slip-through of large lugged wires, while the closed top surface above the slots affords necessary rigidity not found in open slot ducts. Type V is extruded from high-impact rigid vinyl plastic material that will not support combustion and is self-extinguishing. Available in sizes from 1 in. to 4 in., lengths to 12 ft.

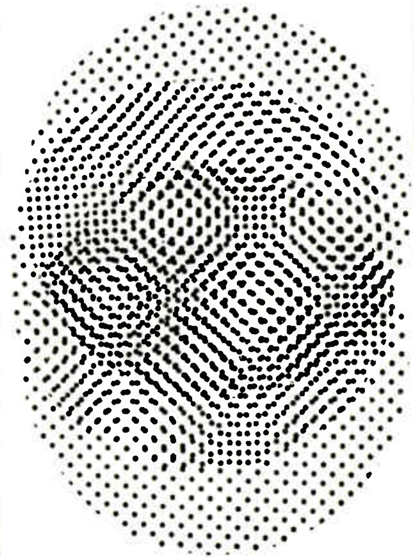
CIRCLE 339 ON READER SERVICE CARD



Ku-Band Isolator

HANDLES 1 KW PEAK

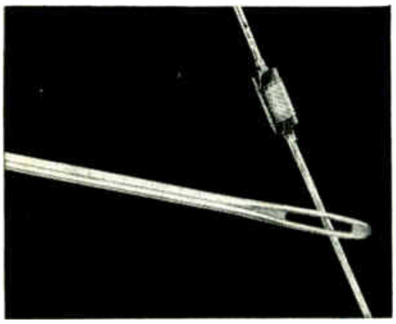
RAYTHEON CO., Foundry Ave., Waltham 54, Mass., Model IKuL10 is based on the Faraday rotation principle and operates at 15.5-16.5 Gc. It handles 1 Kw peak and 5 w average power, and provides 18 db minimum isolation with less than 0.5 db insertion loss. Vswr is 1.25



 CIRCLE 154 ON READER SERVICE CARD **CIRCLE 227 ON READER SERVICE CARD**

max across the band. Mechanical rotation is 45 deg between input and output flanges. Price is $175 for single units or $75 in quantities of 100.

CIRCLE 340 ON READER SERVICE CARD



R-F Chokes

SUBMINIATURE

DELTA COILS, INC., 1128 Madison Ave., Paterson 3, N. J. The 1900 series r-f Miniachokes includes 39 coils covering a complete range of useful inductances—1.0 μh to 10.0 mhy. Coils have a 50 ma max d-c current rating. They are wound on 0.107 in. by [illegible] in. long iron forms except Nos. 1935-1939 which are wound on 0.10 7-in. by [illegible] in. long iron forms. Miniachokes feature high permeability, high Q, easily formed tarnish-free axial leads.

CIRCLE 341 ON READER SERVICE CARD

Switching Diodes

WESTERN SEMICONDUCTORS, INC., Santa Ana, Calif., announces GaAs switching diodes that provide 0.2 nsec recovery time, 0.5 nsec switching speed, and high reliability at well above 400 C.

CIRCLE 342 ON READER SERVICE CARD

Log I-F Amplifier

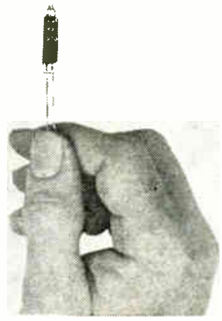
ACCURATE UNIT

LEL, INC., 75 Akron St., Copiague, N. Y. Model IF2309 has a log characteristic accurate to ±1 db for a 60 db signal range and ±2 db for 80 db range. It is useful in instrumentation for antenna ranges, panoramic receivers, radar

CIRCLE 155 ON READER SERVICE CARD

and countermeasures systems. Center frequency is 30 Mc and available bandwidths are 4 and 7 Mc. Price $675.

CIRCLE 343 ON READER SERVICE CARD

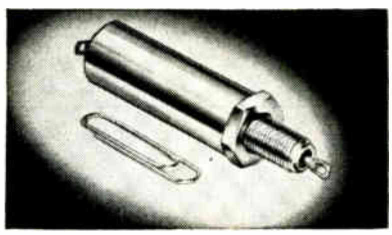


Reference Tube

SUBMINIATURE

AMPEREX ELECTRONIC CORP., 230 Duffy Ave., Hicksville, L. I., N. Y. Types 8228/ZZ1000 stable subminiature voltage reference tube has a temperature coefficient of 3 mv/deg C over a temperature range of −55 to 70 C. Nominal reference voltage is 82 v at an average current of 2 ma. Variation in regulating voltage is less than 100 mv. Tube is guaranteed for 30,000 hr.

CIRCLE 344 ON READER SERVICE CARD



R-F Filter

MINIATURIZED

STANDARD ELECTRONICS CO., 1611 W. 63rd St., Chicago, Ill. Series 1100 filter features hermetic seal, low pass, high attenuation and simplified panel mounting. Filters conform to MIL-S-15773D and are rated at ¼ amp 220 v a-c/400 v d-c 60 db attenuation 0.150 to 1,000 Mc. Units also available up to 5 amp ratings and 110 db.

CIRCLE 345 ON READER SERVICE CARD

Beryllia Ceramic Disks

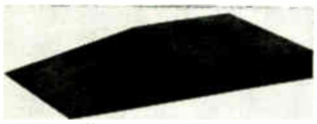
ELECTRONIC MATERIALS CORP., 131 Lexington St., Waltham 54, Mass. Beryllia ceramic disks are available

CIRCLE 228 ON READER SERVICE CARD

CIRCLE 229 ON READER SERVICE CARD

metallized on both sides for easy soldering or high temperature brazing. They can be used as heat sinks.

CIRCLE 346 ON READER SERVICE CARD

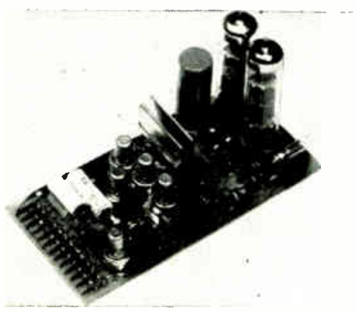


Termination

25 WATT, COMPACT

COAX DEVICES, Box V, Chelsea 50, Mass., offers a 25 w microwave termination made of Microloss, a lossy microwave plastic. Geometric shape is in the form of a slide which has a total length of 5 in. and fits inside 3 in. by 1½ in. waveguide tubing. Over the 2.7-4.0 Gc region, it produces a max vswr of 1.15. Price is $45.

CIRCLE 347 ON READER SERVICE CARD

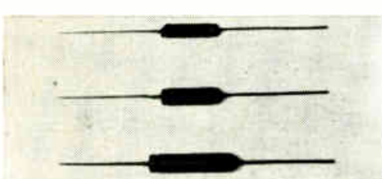


Plug-In Amplifier

CHOPPER-STABILIZED

EMBREE ELECTRONICS CORP., 993 Farmington Ave., West Hartford, Conn. Model 1502 NUVAMP is designed with 5 Nuvistors, has a d-c gain of over 50 million, and delivers 15 ma at ±100 v to 50 Kc without distortion. Open-loop gain drops linearly from 160 db at d-c to 0 db at 6 Mc, with noise down to 200 μv rms.

CIRCLE 348 ON READER SERVICE CARD

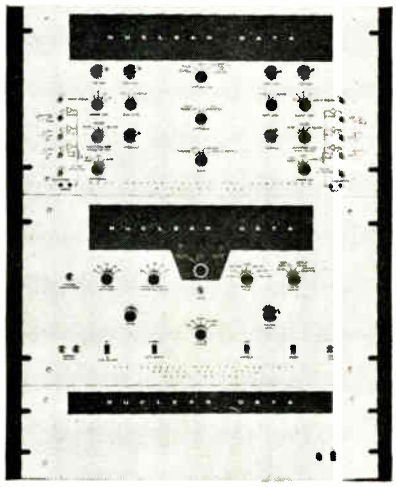


Precision Resistors

WIRE WOUND

CANADIAN RESEARCH INSTITUTE, 85 Curlew Drive, Don Mills, Ontario, Canada. These resistors are wound on phenolic forms from selected manganin and Evanohm wire in three wattage sizes: model P-4 conservatively rated at ¼ w, 7/16 in. long by ⅛ in. diameter; model P-2, ½ w, ½ in. by 5/32 in.; model P-1, 1 w, ¾ in. by 3/16 in. Resistors are available in accuracies of ±1, ±0.5, ±0.2 percent in values from 1 ohm up to 5,000 ohms for the P-4; 7,000 ohms for the P-2; and 20,000 ohms for the P-1.

CIRCLE 349 ON READER SERVICE CARD

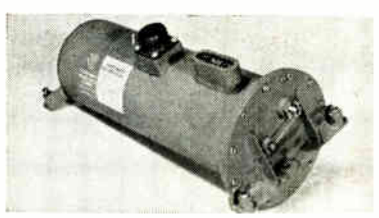


Radiation Analyzer

HIGH VERSATILITY

NUCLEAR DATA INC., 3833 West Beltine Hy., Madison 5, Wisc. Model ND150FM 1024 channel radiation analyzer provides two-parameter analysis, time analysis, high resolution pulse-height analysis, scattering measurements, and Mossbauer-effect measurements.

CIRCLE 350 ON READER SERVICE CARD



Missile Battery

AUTOMATIC ACTIVATION

YARDNEY ELECTRIC CORP., 40-50 Leonard St., New York 13, N. Y. Silvercel silver-zinc primary battery consist of 4 separate units capable of independent or simultaneous discharge. The 4 battery units, and the single automatic-activation system that makes their

CIRCLE 230 ON READER SERVICE CARD

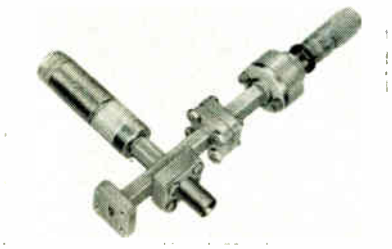
energy available instantly, are contained in a metal cylinder 6 in. in diameter by 16 in. long. Battery is maintenance-free and absence of moving parts within activation system makes possible very high efficiency and dependability.

CIRCLE 351 ON READER SERVICE CARD

Precision Capacitors

BALCO RESEARCH LABORATORIES, 49-53 Edison Place, Newark, N. J., announces precision standard capacitors available in 37 individual values ranging from 100 $\mu\mu$f through 1.0 μf. Tolerance is $\pm$0.05 percent.

CIRCLE 352 ON READER SERVICE CARD

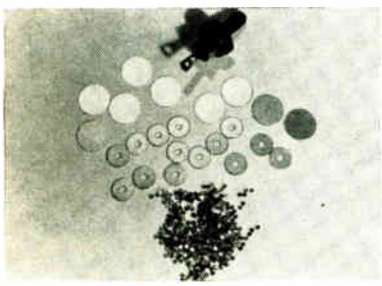


Harmonic Generators

USE VARACTORS

PRD ELECTRONICS, INC., 202 Tillary St., Brooklyn 1, N. Y. The 6611 series of varactor harmonic generators are tuned fundamental and tuned harmonic type devices. Input frequency range is 2.0 to 4.2 Gc/sec and input power range is 60 to 100 mw. Harmonic power output ranges from 0 dbm to -40 dbm. A type BNC jack is provided to monitor the varactor bias voltage of 6 to approximately 8 v d-c, 22 ma maximum current.

CIRCLE 353 ON READER SERVICE CARD



Substrates

GOLD PLATED

ALPHA METALS, INC., 56 Water St., Jersey City 4, N. J. Disks, squares, washers and special configurations of gold plated molybdenum, tungsten, Kovar, nickel and nickel/iron are available. Parts may be supplied fully plated on both sides, or on one side and edges as required, in thicknesses up to 0.001 in. Plating process produces parts which are non-porous and resistant to etchants such as CP4. The gold plated parts will withstand extremely high temperatures without discoloration or blistering.

CIRCLE 354 ON READER SERVICE CARD

Coaxial Isolator

EXTENDED BANDWIDTH

E & M LABORATORIES, 15145 Califa St., Van Nuys, Calif. Model CX101LCI measures 7⅝ in long. Over the frequency range of 4.0 Gc to 11.0 Gc, this coaxial isolator provides a minimum of 10 db isolation, a maximum insertion loss of 1.3 and a maximum vswr of 1.25:1. Unit has application in many microwave areas, such as laboratory use, and for systems and test equipment where sweep sources are being used. Price is $325.

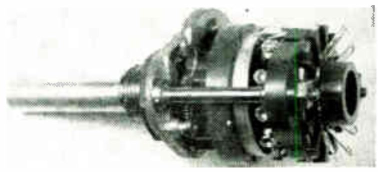
CIRCLE 355 ON READER SERVICE CARD

Oscillator

VOLTAGE CONTROLLED

SOLID STATE ELECTRONICS CORP., 15321 Rayen St., Sepulveda, Calif. Model V-510 voltage controlled oscillator is designed for accurate conversion or varying analog d-c voltage to a linearly proportional sine wave frequency. Standard units are calibrated for operation over a frequency range extending from 400 cps to 70 Kc within IRIG bands 1 to 18 and A to E. Stability of the V-510 provides data accuracies within 1 percent.

CIRCLE 356 ON READER SERVICE CARD



Rotary Switches

MINIATURIZED

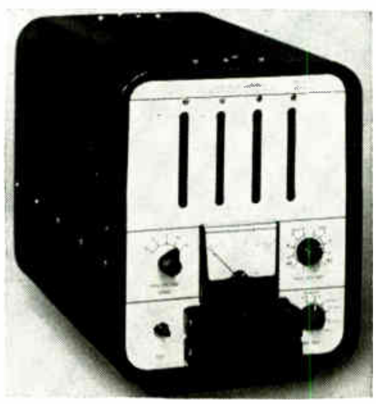
TRUCO ENGINEERING CO., 195 W. Main St., Avon, Conn., offers rotary switches that require less than 1 in. of panel space. They are rated at 5 amp or 125 w and have an insulation resistance of over 1 million megohms even after long exposure to extreme conditions of humidity. The switches have excellent characteristics as far as up to 10 Mc. Available up to 6 decks, solid or concentric shafts, they can be supplied with as many as 5 poles per deck.

CIRCLE 357 ON READER SERVICE CARD

Ceramic Headers

CFI CORP., Mineola, N. Y. Vacuum tight multiterminal ceramic-to-metal headers with as many as 14 leads are available for high temperature applications.

CIRCLE 358 ON READER SERVICE CARD

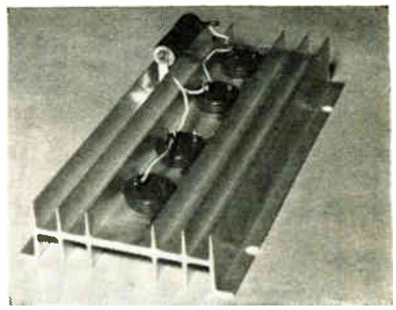


Digital Relay Timer

ACCURATE UNIT

SCHMELING ELECTRONICS, 20 First St., Keyport, N. J. Model 150 provides accurate measurements of relay timing without being subject to operator interpretation. Incorporates metering and regulated power supplies to provide relay coil voltage up to 120 v d-c and contact loading up to 1 amp. Price $2,090.

CIRCLE 359 ON READER SERVICE CARD



Heat Sinks

FOR SEMICONDUCTORS

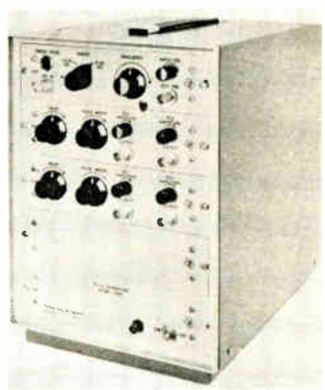
ANDERSON MACHINE, INC., 50 Brook Road, Needham Heights 94, Mass. Models 10106 and 20107 are natural convection coolers which lend themselves equally well to forced convection requirements. Natural convection thermal resistance as low as 1.5 deg C/w. Thermal resistance as low as 0.3 deg C/w, with moderate air flow.

CIRCLE 360 ON READER SERVICE CARD

Foil Capacitor

GENERAL ELECTRIC CO., Schenectady 5, N. Y. Tantalum electrolytic capacitor, measuring 0.438 in. long with a 0.175 in. diameter, has ratings from 6 v, 47 μf to 150 v, 1 μf at 85 C.

CIRCLE 361 ON READER SERVICE CARD



Pulse Generator

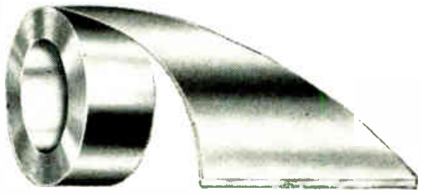
PLUS/MINUS

TEXAS INSTRUMENTS INC., 3609 Buffalo Speedway, Houston, Texas. Pulse generator incorporates two independent pairs of plus/minus

TWO AFFILIATED COMPANIES PROVIDE A SINGLE SOURCE FOR

SEMICONDUCTOR CLAD METALS & PARTS

Clad Metal Combinations



- Tin Clad Nickel
- Lead-Tin-Antimony Clad Nickel Iron
- Tin-Lead Clad Nickel
- Gold-Antimony Clad Molybdenum
- Gold-Antimony Clad Nickel Iron

Single or Double clad in continuous coils

NEW COMBINATIONS BEING DEVELOPED DAILY

Precision Parts Fabrication

Long experience with the electronics and allied industries plus exceptional tooling facilities qualify to meet semiconductor parts requirements at low cost with complete conformity.

SPECIFY BOTH L & G AND G F

For Alloys and Clad Metals — For Precision Parts

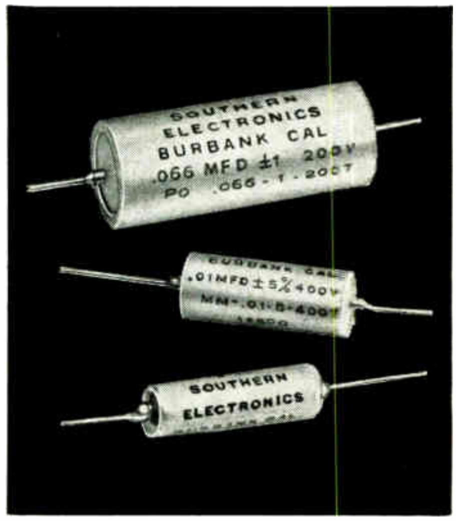
LEACH & GARNER COMPANY / GENERAL FINDINGS INC.

For complete information on materials and parts write 52 Pearl Street, Attleboro, Massachusetts

SALES OFFICES: NEW YORK • CHICAGO • LOS ANGELES

CIRCLE 234 ON READER SERVICE CARD

ULTRA HIGH RELIABILITY tubular capacitors



WITH A NEW DEGREE OF PRECISION

SOUTHERN ELECTRONICS CORP. has long been a leader in the design and manufacture of **high-precision** tubular capacitors, and has pioneered in supplying them for critical applications in computers, missiles, communications and other high-grade military and commercial equipment. They are made to the same standards as our high precision polystrene capacitors so widely accepted for military applications.

SEC tubular capacitors are manufactured under unusually critical quality control standards, resulting in tolerances as low as 0.5% in most values, and hermetic sealing guarantees accuracy over wide environmental changes.

SEC tubulars are available in a wide range of tolerances to meet your needs, from 100 mmfd. to any higher value, in polystrene, mylar, metallized mylar, teflon and dual-dielectrics.

All SEC tubular capacitors meet or exceed the most rigid MIL-SPECS.

In addition, we manufacture a complete line of tubular capacitors for commercial applications. Let us know your requirements.

Write today for detailed technical data and general catalog.

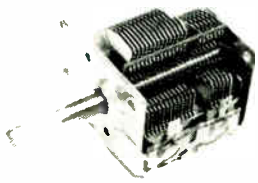
POLYCON SEC MYCON

SOUTHERN ELECTRONICS *Corporation*

150 West Cypress Ave., Burbank, California

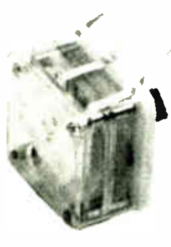
CIRCLE 163 ON READER SERVICE CARD

VARIABLE CONDENSER



3 types; AM, AM-FM, FM.
2 gang, 3 gang, 4 gang.

PLASTIC INSULATED VARIABLE CONDENSER



Square Sizes:
15mm., 17mm., 20mm., 21mm., 24mm.,
Single band, 2 band, 3 band and for FM only.

SANKAISHA CO., LTD.

Cable address, SANESVARICON TOKYO
1425. 4-chome. Higashinakanobu,
Shinagawa-Ku, Tokyo, Japan.

CIRCLE 235 ON READER SERVICE CARD

MICO

DESK AND DOOR PLATE ENGRAVER

FOR

Engraving most sizes of Desk and Door Plates in a single set-up.

FEATURES

1. Six pantograph ratios—from 1.5:1 to 4:1.
2. Spindle has integral micrometer depth control of .250".
3. Uses standard tapered-shank engraving cutters.
4. New 19" Copy carriers hold 17" of master copy: Permits engraving about 11" line of characters in one set-up at the 1.5:1 ratio.
5. Three sizes of copy carriers available. Each positioned separately.
6. Work-holding fence speeds set-up and engraving time.

Send for illustrated Catalog

MICO INSTRUMENT CO.

77 Trowbridge St. Cambridge 38, Mass.

CIRCLE 236 ON READER SERVICE CARD

outputs. Model 6507 offers high repetition rates plus fast rise and fall time. Width and delay of each pair of outputs are coincidentally variable—the width from 20 to 1,000 nsec and the delay from 20 to 1,000 nsec with respect to the clock. Amplitudes are independently variable from 0 to + 5 v and 0 to −5 v. Rise time is 6 nsec.

CIRCLE 362 ON READER SERVICE CARD

Time Delay Relay

JORDAN ELECTRONICS, 121 So. Palm Ave., Alhambra, Calif., is marketing an all-purpose time delay relay with an externally adjustable delay time ranging from 50 millisec to 180 sec.

CIRCLE 363 ON READER SERVICE CARD

Universal Counter

SOLID STATE

SYSTRON DIVISION, Systron-Donner Corp., 950 Galindo St., Concord, Calif. Model 1038 is a basic 25 Mc counter designed to meet the demands of ground support consoles for reduced power consumption, rugged construction and remote controlled operation. Features: multiple period averaging up to 10,000 periods, solid-state heterodyne plug-in for frequency measurements to 222 Mc, remote programming for all functions.

CIRCLE 364 ON READER SERVICE CARD

Variable Delay Line

MINIATURIZED

COMPUTER DEVICES CORP., 6 West 18th St., Huntington Station, N. Y. Model DV252 has a delay range from 0 to 65 nsec with a resolution of 0.1 nsec. Rise time is approximately 15 nsec at maximum delay. Housed in a metal, hermetically sealed case 1½ in. o-d by ¾ in. thickness with an "O" ring shaft gasket. Characteristic impedance is 330 ohms. Applicable as a delay trim adjustment for computer, radar and other wide band pulse delay networks, as well as an r-f phase shifter or trimmers for fine phase adjustment.

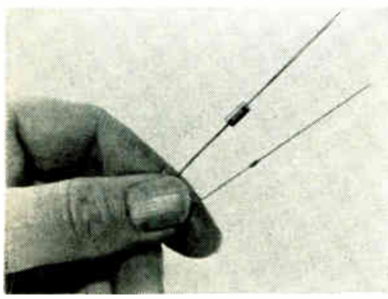
CIRCLE 365 ON READER SERVICE CARD

Reference Elements

MINIATURE, 10.5 V

HENRY ENGINEERING CO., 3625 W. Pacific Ave., Burbank, Calif., has in production temperature compensated 10.5 v miniature Zener reference elements with temperature coefficients as low as ± 0.00025 percent/deg C over a range of 0 to + 50 C. Typical dynamic resistance is 15 ohms with an operation current of 10 ma. Noise is less than 10 μv rms.

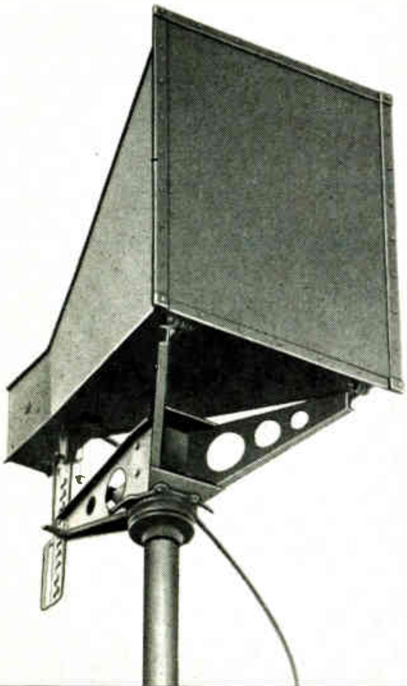
CIRCLE 366 ON READER SERVICE CARD



Miniature Resistors

METAL FILM

WESTON INSTRUMENTS DIV., Daystrom, Inc., 614 Frelinghuysen Ave., Newark 14, N. J., announces 1/10 w and 1/20 w Vamistors. They feature Vamalloy (a low temperature coefficient alloy), deposited



ANTENNA CAPABILITIES

The advanced design and precision construction of Ainslie antenna systems and associated equipment bear testimony to nearly two decades of microwave communication, detection and identification experience. By virtue of complete design-to-delivery capabilities and facilities, Ainslie Corporation offers its customers not only comprehensive standard lines of mesh, spun and horn antennas, but also the flexibility required to develop custom designed prototypes for on-schedule delivery.

We invite your inquiry.

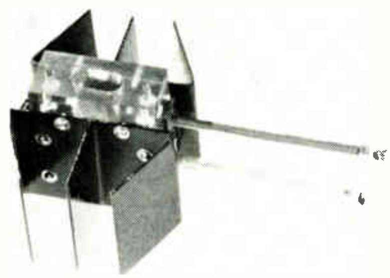
Ainslie CORPORATION

531 Pond Street
Braintree 85, Massachusetts

CIRCLE 166 ON READER SERVICE CARD

and fused to the glazed surface of a ceramic tube and helically grooved to resistance value. Fire-bonded silver conducting bands and epoxy resin encapsulation are added to make a resistor which is compact, highly accurate, and virtually impervious to weather, humidity, and salt spray conditions.

CIRCLE 367 ON READER SERVICE CARD

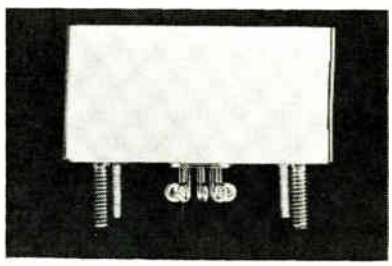


Oscillator Oven

SMALL, COMPACT

SUMITOMO ELECTRIC INDUSTRIES, LTD., 60 Okijima Minamino-cho, Konohana-ku, Osaka, Japan. Thermoelectrically controlled oven accurately maintains the temperature of quartz oscillators at their optimum operating temperature. Absence of moving parts results in noiseless operation. Temperature is maintained at 20 C ±0.5 deg in ambients of 5 to 40 C. Max operating current at the greatest differential temperature is 25 amp at 0.1 v d-c.

CIRCLE 368 ON READER SERVICE CARD



Delay Line

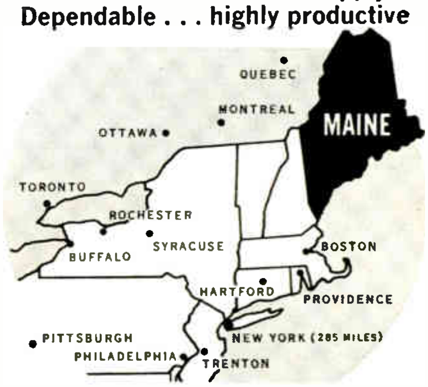
LUMPED CONSTANT

ESC ELECTRONICS CORP., 534 Bergen Blvd., Palisades Park, N. J., offers a transponder delay line, with 40 to 1 delay/rise time ratio in a 6 cu in. case. Designed to meet critical weight and space requirements in air traffic controls, radar, and airborne equipment, model 52-44 provides a 50 percent savings in space and a 35 percent savings in weight over conventional designs.

CIRCLE 369 ON READER SERVICE CARD

ELECTRONICS IN MAINE

Excellent female labor supply
Dependable . . . highly productive



Near major research centers, markets and sources of supply

Modern Plants
Lease-purchase for as little as 55¢ per sq. ft. per year

An independent research organization reports that lower overall operating costs contribute to maintaining firms in a competitive industry position. Raytheon, Dielectric, Sylvania and other firms have large facilities in Maine. May we give you more facts on electronics in Maine?

Write for electronic facts:

Lloyd K. Allen, Commissioner
Maine Dept. of Economic Development
State Capitol Room 211H Augusta, Maine

CIRCLE 238 ON READER SERVICE CARD

PRODUCT BRIEFS

WAVEGUIDE CARTRIDGE DEHYDRATOR silica gel-filled. Belz Industries, Div. of El-Tronics, Inc., 89 Union St., Mineola, L. I., N. Y. (370)

GENERAL PURPOSE OSCILLOSCOPE popular-priced. Lavoie Laboratories, Inc., Morganville, N. J. (371)

MICROWAVE AMPLIFIER tunnel diode. Sylvania Electric Products Inc., Mountain View, Calif. (372)

TWO-PART EPOXY CEMENT easy to mix. Epoxy Products Div., Joseph Waldman & Sons, 137 Coit St., Irvington 11, N. J. (373)

SPECTRUM ANALYZERS 480-filter. Spectran Electronics Corp., 146 Main St., Maynard, Mass. (374)

TEMPERATURE PROBE fast response. Giannini Controls Corp., 1600 S. Mtn. Ave., Duarte, Calif. (375)

TRANSISTORIZED AUDIOMETER portable. Zenith Radio Corp., 6001 W. Dickens, Chicago, Ill. (376)

ACCELEROMETER CALIBRATOR 100 g 10 Kc. Unholtz-Dickie Corp., 2994 Whitney, Hamden, Conn. (377)

QUICK-DISCOUNT PLUG for cryogenic use. The Deutsch Co., Municipal Airport, Banning, Calif. (378)

POWER SUPPLY universal point source. PEK Labs Inc., 4024 Transport St., Palo Alto, Calif. (379)

RATIO COMPUTER for industrial use. Navigation Computer Corp., Valley Forge Industrial Park, Norristown, Pa. (380)

STEREOSTETHOSCOPE transistorized. MED Electronics Inc., 1200 First St., Alexandria, Va. (381)

SERIAL MEMORIES high-speed. Computer Control Co., Inc., 983 Concord St., Framingham, Mass. (382)

PRESET VOLTMETER 1/5 sec response. J-Omega Co., 323 First St., Los Altos, Calif. (383)

TINY NUVISTOR TUBE for satellite tv cameras. Radio Corp. of America, Harrison, N. J. (384)

TRANSFORMER-RECTIFIER self-cooled, solid state. Airborne Accessories

Corp., 1414 Chestnut Ave., Hillside 5, N. J. **(385)**

SILICONE-EPOXY COATING POWDER for resistors. Dow Corning Corp., Midland, Mich. **(386)**

DECADE COUNTER MODULE low cost, small size. Anadex Instruments Inc., 7617 Hayvenhurst Ave., Van Nuys, Calif. **(387)**

C-BAND DIPLEXER tunable, high power. Antenna Systems, Inc., Hingham, Mass. **(388)**

PUSH-PULL POT space saving. Carter Mfg. Corp., 23 Washington St., Hudson, Mass. **(389)**

CRYSTAL FILTERS high stability. Ortho Industries Inc., 7 Paterson St., Paterson 1, N. J. **(390)**

SYNCHRO POSITIONER for quality control tests. Theta Instrument Corp., 520 Victor St., Saddle Brook, N. J. **(391)**

LOG-PERIODIC ANTENNA for h-f communications. Granger Associates, 974 Commercial St., Palo Alto, Calif. **(392)**

PULSE MAGNETRON high temperature. Litton Industries, 960 Industrial Rd., San Carlos, Calif. **(393)**

COMPONENT TEST MODULES for 2 or 3 lead devices. Gruenberg Electric Co., Inc., 9 Commercial Ave., Garden City, N. Y. **(394)**

HEAT SINK high volumetric efficiency. Astro Dynamics, Inc., Second Ave., Northwest Industrial Park, Burlington, Mass. **(395)**

CURRENT REGULATORS low voltage, high temperature. CircuitDyne Corp., 480 Mermaid St., Laguna Beach, Calif. **(396)**

T-W PREAMPLIFIERS for the 1 to 10.75 Gc range. Applied Technology Inc., 930 Industrial Ave., Palo Alto, Calif. **(397)**

PULSE DISCHARGE SYSTEMS ultra-high-power. Technical Operations Inc., Burlington, Mass. **(398)**

TRANSLATOR and calculator system. Picker X-Ray Corp., White Plains, N. Y. **(399)**

RECTIFIERS Kilo-Potential devices. Rectifier Division, General Instrument Corp., 65 Gouverneur St., Newark, N. J. **(400)**

Literature of the Week

R-F INDUCTORS Nytronics, Inc., 550 Springfield Ave., Berkeley Heights, N. J. Catalog sheet covers Essex Wee-Wee Ductors, a line of subminiature r-f inductors. (401)

QUALITY CONTROL Micro Switch, Freeport, Ill. A 20-page booklet contains descriptions and pictures of the company's quality control organization. (402)

MICROWAVE POWER GENERATORS Raytheon Co., 225 Crescent St., Waltham 54, Mass. Microwave power generators and accessories for a variety of laboratory applications are described in an 8-page brochure. (403)

D-C POWER SUPPLIES Kepco Inc., 131-38 Sanford Ave., Flushing 52, N. Y., has available literature on the ABC series, low cost, voltage and current regulated, d-c power supplies. (404)

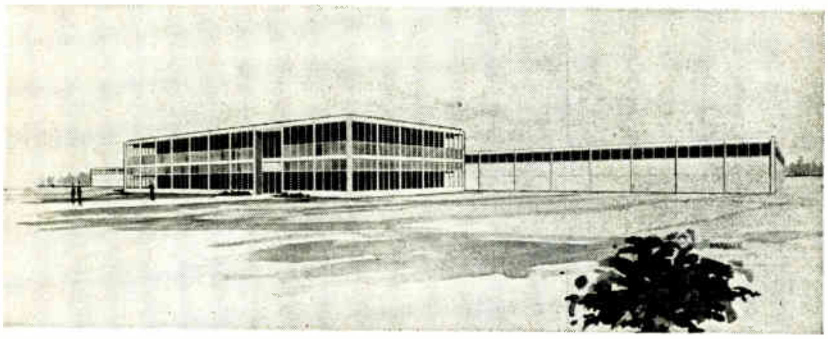
TERMINAL BLOCKS Curtis Development & Mfg. Co., 3203 N. 33rd St., Milwaukee 16, Wisc. A 16-page catalog describes a line of more than 373 terminal blocks. (405)

DATA PROCESSING DEVICE Digi-Data Corp., 4908 46th Ave., Hyattsville, Md., has published a catalog sheet containing specifications and applications for the model 1250 digital stepping recorder. (406)

SILICON ZENER DIODES International Rectifier Corp., El Segundo, Calif. Bulletin SR-260 covers 152 standard silicon voltage reference diodes now in EIA 5, 10 and 20 percent preferred value series. (407)

CAPILLARY TUBES Tempress Research Co., Inc., 566 San Xavier Ave., Sunnyvale, Calif., offers a 4-page engineering bulletin on tungsten carbide semiconductor lead bonding capillary tubes. (408)

COMPUTER PROGRAMMING Auerbach Corp., 1634 Arch St., Philadelphia 3, Pa. A complete description of computer programming is given in a 4-page folder. (51)



Webcor To Build $1 Million Facility

CONSTRUCTION will begin early this summer on a $1 million plant to house the expanded Government Electronics division of Webcor, Inc., Chicago, Ill.

Titus Haffa, board chairman of the diversified manufacturing firm, said that a new 125,000-sq-ft facility is planned for construction on a 23-acre property in Berkeley, a western suburb of Chicago.

The new structure will house all administration, engineering, research and development and production departments of the Webcor Electronics division, presently located in Chicago proper, Haffa said. The plans also provide for facilities such as an expanded environmental testing laboratory, cafeteria and other features including an antenna range for testing radar and navigation equipment.

Haffa stated that the move reflects the growth achieved by the Electronics division during the past few years. A producer of timing controls, airborne data recorder-reproducers, electronic countermeasure systems, and related equipment, the division had sales of approximately $4.5 million during the last fiscal year. Sales of more than $8 million are anticipated for the year ending May 31, Haffa said.

The new facility will represent the 11th plant operated by Webcor, Inc., in the Chicago area.

Babcock Electronics Names Braverman

RALPH BRAVERMAN was recently named engineering manager of Babcock Electronics Corp., Costa Mesa., Calif.

Braverman, who has served as technical assistant to president Stuart K. Babcock since joining the firm in June of last year, will direct the activities of the company's 250-man engineering division.

Instrument Systems Moving to New Site

GROUND was recently broken in Hicksville, N. Y., for the new electronics manufacturing facility of Instrument Systems Corp. The company, less than three years old, is presently headquartered in College Point, N. Y., and will move into the new building late this summer.

The 44,000 sq ft building will contain 20,000 sq ft of air conditioned space for offices, engineering laboratories and dust-controlled precision assembly rooms as well as 24,000 sq ft of machine shop and electronic manufacturing area. Expansion to approximately 70,000 sq ft will be possible at a later date.

Fairchild to Open Plant in Maine

FAIRCHILD SEMICONDUCTOR, a division of Fairchild Camera and Instrument Corp., will soon open a new transistor production facility in South Portland, Maine.

The new building, now in the final stages of construction, will provide the firm with an additional 48,000 sq ft of manufacturing space. The company expects to be in pilot production by early Fall and should employ approximately 250 persons by the end of the year.

Robert N. Noyce, general manager of Fairchild Semiconductor, said the decision to open this plant will in no way reduce the activity of the division's operations in Mountain View, San Rafael, or Palo Alto, Calif., but will in fact supplement that activity.

Jones Joins Ortronix As Production Mgr.

ROBERT A. JONES has been appointed production manager at Ortronix, Inc., Orlando, Fla.

Formerly manager of manufacturing at Radiation-Orlando, he will be in charge of all assembly work for electronic and electromechanical devices as well as production engineering.

Ceramaseal Opens Plant Addition

CERAMASEAL, INC., recently opened a $200,000 addition to its plant in

IS YOUR FILE COMPLETE?

If it contains all you need to know about every kind of Crystal Can Relay, it is. As you know, these Leach specification sheets are essential if you use relays in electronic control systems, aircraft, missiles, ground support equipment, data handling equipment, printed circuit or high environmental applications. If your file doesn't look like this, it should. And can. All it takes is just one phone call to your nearby Leach sales office or distributor. Or you can send a postcard to the address below.

LOOK TO LEACH *CORPORATION* 18435 Susana Road, Compton, California

New Lebanon Center, N. Y.

The new section produces wet-process porcelain insulating bushings, high-alumina ceramic-to-metal seals, and sapphire-to-metal seals. Output from the addition multiplies manufacturing capacity nearly four times, company says.

Borg-Warner Corp. Elevates Executives

E. SWAIN RUSSEY, president of Warner Gear division and chairman of Borg-Warner Ltd., has been elected a group vice president of Borg-Warner Corp., Chicago, Ill.

Alonzo B. Kight, president of Borg-Warner International, was elected a vice president of the corporation.

GI Rectifier Div. Names Heflin V-P

APPOINTMENT of Paul S. Heflin as vice president-Newark operations of General Instrument Corporation's recently enlarged Rectifier division has been announced. He will report directly to Arno Nash, vice president and general manager of the division.

Heflin was formerly vice president-engineering of the GI Semiconductor division.

Ray Smith Joins Mallory Electronics

RAY Z. SMITH has joined the West Coast Laboratories of the Mallory Electronics Co. in Lakewood, Calif., as application engineering section head. The division of P. R. Mallory & Co. Inc. specializes in the development and manufacture of power conversion equipment and solid state timing, sensing and switching devices for the aerospace industry.

Smith was previously with Christie Electric Corp., American Electronics Inc., and U. S. Electrical Motors Inc.

Rhodes Assumes Alphomega Post

ROBERT RHODES, formerly with General Bronze Corp., is appointed manager of the microwave department of the recently formed Alphomega Research Laboratories, Inc., Carle Place, N. Y. The organization is currently engaged in the basic design of a new concept in end-fire antennas.

Packard Bell Computer Appoints Frady

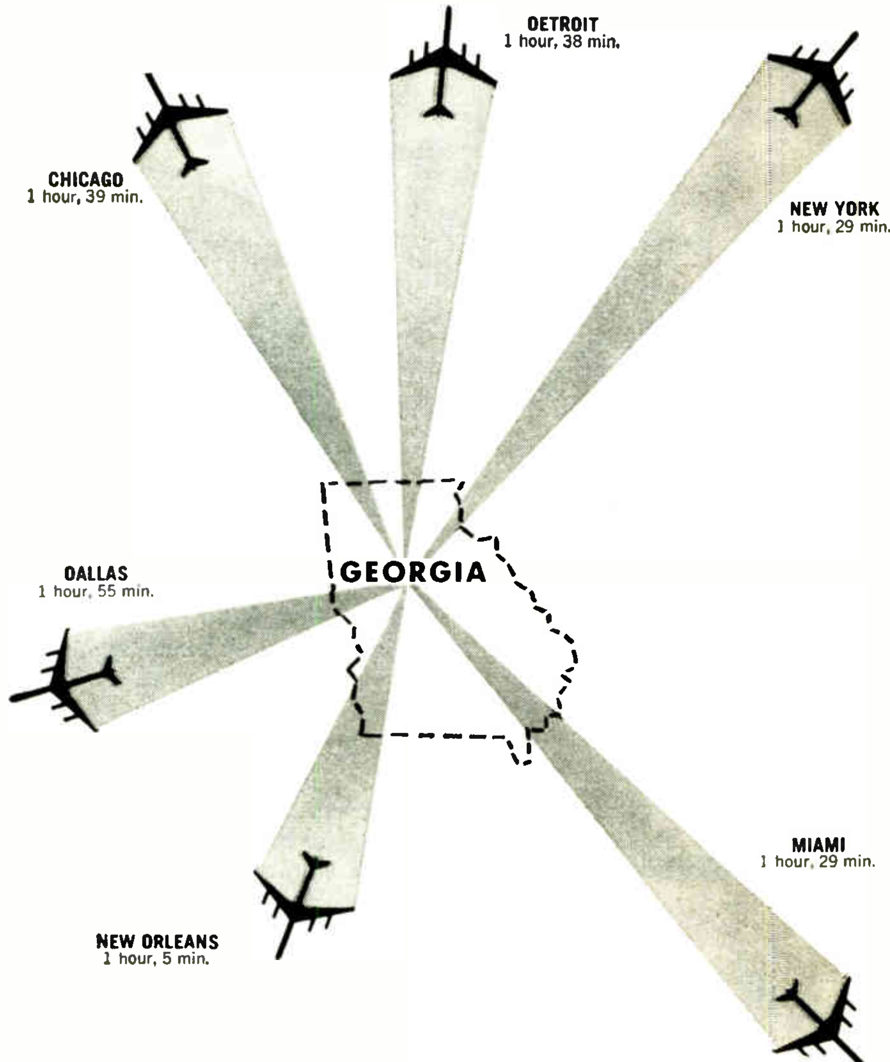
WILLIAM E. FRADY has been appointed vice president and director of data and industrial systems for the Packard Bell Computer Corp. He will direct the company's growing penetration into the field of computer controlled and data acquisition systems, and will be headquartered in Anaheim, Calif.

Frady came to PBC from the Aeronutronic Division of Ford Motor Co.

Rauland Launches Expansion Program

ZENITH RADIO CORP. has announced the start of a $4 million expansion program for its wholly-owned subsidiary, The Rauland Corp.

Construction has begun on a 50,000 sq ft addition to Rauland's Chicago plant, which will be equipped with highly mechanized facilities for the mass production of color tv tubes. The building extension is scheduled for completion



late this summer, with installation of machinery to begin in September.

A second phase in the program began with the purchase of 18.1 acres of land in Niles, Ill. Initial construction here will be a 55,000 sq ft research and administration building scheduled for completion by the end of the year.

Third phase is the purchase of a 45,000 sq ft building in Chicago, to be used for storage and warehousing. Occupancy is scheduled for July.

Elect Gamson Ampex V-P

EDWIN R. GAMSON, general manager of Ampex Corporation's Computer Products Co. in Culver City, Calif., has been elected vice president of the corporation.

Gamson has been with Ampex since 1960 and has managed several product divisions. Before joining Ampex, he was vice president of Telemeter Magnetics, Inc., which merged into Ampex in 1960.

Gaither Takes New Sylvania Post

APPOINTMENT of Loren F. Gaither as assistant program manager for the AN/MPQ-32 weapons-locating radar program now being carried out at the eastern operation of Sylvania Electronic Systems, Waltham, Mass., is announced.

Gaither has been senior staff specialist-systems since joining Sylvania Electronic Systems in June, 1961. Prior to joining the company, he was affiliated with the Philco Corp., as director of communications engineering for Philco's government and industrial division.

Alto Scientific Appoints Derus V-P

RICHARD A. DERUS has been appointed vice president of Alto Scientific Co., a Palo Alto, Calif., electronic systems manufacturer.

Derus was previously associated with Lockheed Missiles and Space Co., Sunnyvale, Calif., for four years in research and product planning.

PEOPLE IN BRIEF

Dan A. Kimball, president of Aerojet-General, elected to board of Hycon Mfg. **Edwin F. Hall** leaves Diehl Mfg. to become mgr., application engineering, Daystrom Transicoil. **Eugene J. Martin** from Epsco, Inc. to Silicon Transistor Corp. as production engineering mgr. **Guy W. Numann,** ex-General Dynamics/Electronics, has joined the engineering staff of RF Communications Associates, Inc. Three promotions at Adler Electronics, Inc.: **Abraham Rubenstein** raised to principal engineer and **Olaf Blomgren** to senior engineer in the Military Products div., and **Joseph Coleman** named provisioning editor in the Operations div. **Linder C. Hobbs** has left Aeronutronic to form the consulting firm of Hobbs Associates. **Philip R. Vance** moves up to head of the tactical systems dept. of Mitre Corp. **Gary D. Hainey** advances to quality control mgr. at Duncan Electronics, Inc. **Earl J. Seely,** formerly with GE, now an applications engineer with Rixon Electronics, Inc. **John T. Williams** and **Bernard S. Parmet** elevated to director of engineering and technical director, respectively, at The Hallicrafters Co. **Leonard Feldman,** ex-Crosby Electronics Inc., now director of engineering at Datom Industries' Madison Fielding 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, Pennsylvania	180	1
BOEING COMPANY New Orleans, Louisiana	19*	2
COLLINS RADIO COMPANY Dallas, Texas	63*	3
DOUGLAS AIRCRAFT CO. Missiles & Space Systems Div. Santa Monica, California	119	4
EITEL-McCULLOUGH INC. San Carlos, California	73*	5
ESQUIRE PERSONNEL SERVICE INC. Chicago, Illinois	180	6
FAIRCHILD STRATOS Aircraft-Missiles Div. Hagerstown, Maryland	67*	7
GENERAL DYNAMICS/ELECTRONICS Div. of General Dynamics Corp. Rochester, New York	178	8
GENERAL ELECTRIC CO. Defense Systems Dept. Syracuse, New York	179	9
INTERNATIONAL BUSINESS MACHINES CORP. Owego, New York	180	10
INTERNATIONAL BUSINESS MACHINES CORP. Poughkeepsie, New York	77*	11
LOCKHEED CALIFORNIA CO. Div. of Lockheed Aircraft Corp. Burbank, California	22	12
LOCKHEED-GEORGIA CO. Div. of Lockheed Aircraft Corp. Atlanta, Georgia	113	13
MARTIN ORLANDO Div. of Martin Marietta Orlando, Florida	180	14
McDONNELL AIRCRAFT St. Louis, Missouri	177	15
MICROWAVE SERVICES INTERNATIONAL, INC. Denville, New Jersey	77*	16

CONTINUED ON PAGE 180

(cut here) (cut here)

electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME ....

HOME ADDRESS ....

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

HOME TELEPHONE ....

Education

PROFESSIONAL DEGREE(S) ....

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check)

51162

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

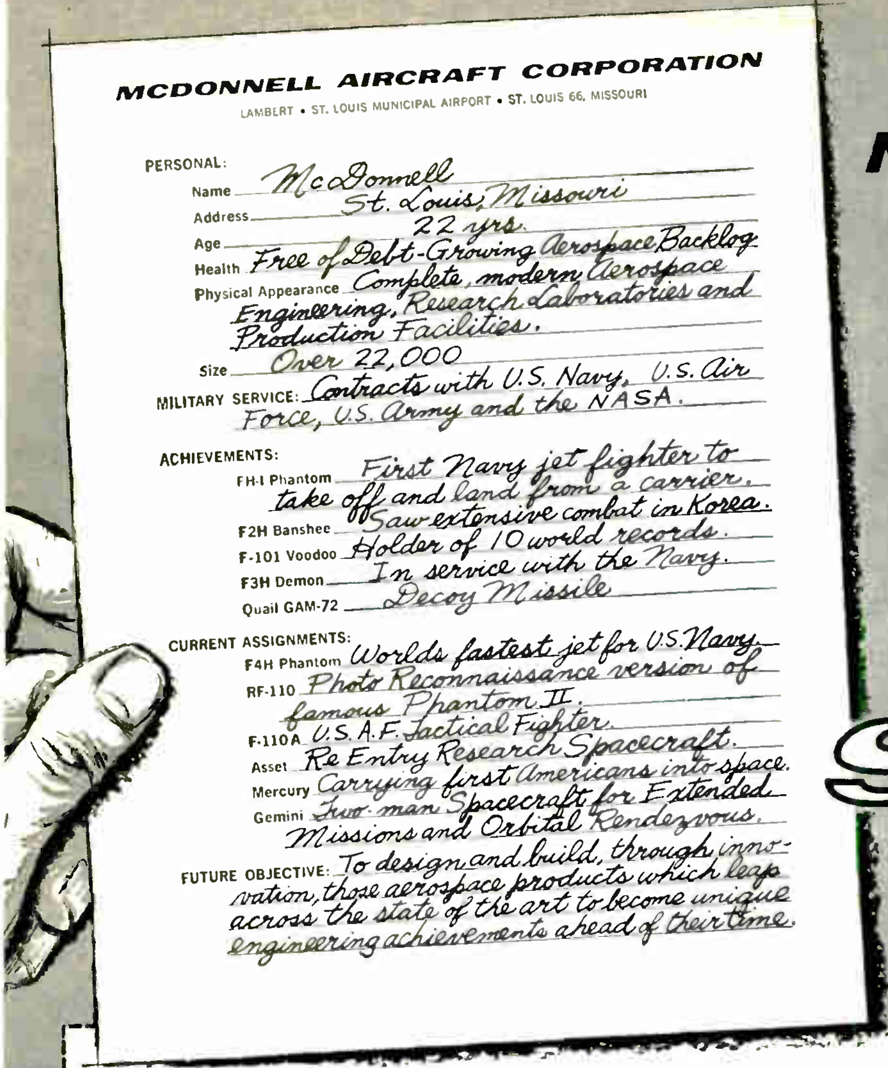
CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines.

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

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

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



THE FUTURE IS AT MCDONNELL

WHERE ENGINEERING CONCEPTS ARE MOVING...

...Men into Space
...Aircraft to New Records
...Design Beyond the State of the Art

LET'S SWAP RESUMES

Please complete this form and forward to: Mr. D. F. Waters, Professional Placement, Dept. 62, McDonnell Aircraft, St. Louis 66, Missouri. *This is not an application for employment.* Your qualifications will be reviewed by our placement staff and you will be advised of positions at McDonnell for which you qualify. You may then make application if you wish. All replies confidential.

Name________ Home Address________

City & State________ Phone________ Age____

Present Position________

Primary Experience Area________ Number of Years____

Secondary Experience________ Number of Years____

Additional Comments________

Education: AE____ ME____ Math____ Physics____ Chemistry____ EE____ Astronomy____ Other____

Degree: BS____ Date MS____ Date PHD____ Date

I would like to receive application form ☐

I would like to receive literature about professional opportunities at McDonnell ☐

My primary interest is:

- ☐ Airborne Communications
- ☐ Antenna and Microwave Techniques
- ☐ Automatic Test Equipment
- ☐ Computer Development
- ☐ Thin Film Techniques
- ☐ Military Airborne and Solid State Electronics
- ☐ Research
- ☐ Digital Technique and Logic Design
- ☐ Weapons Systems Analysis

MCDONNELL An equal opportunity employer.

F4H and F-110A Fighter and Attack Aircraft • RF-110 Photo Reconnaissance Aircraft • Mercury, Gemini, Asset and Aeroballistic Spacecraft • Talos and Typhon Missile Airframes and Engines • Quail Decoy Missiles • Rotorcraft • Electronic Systems • Automation

MCDONNELL AIRCRAFT • ST. LOUIS

Space Guidance Systems

- Solid State Physicists (Radiation Effects Studies)
- Reliability Statisticians
- Logic Designers
- Circuit Designers
- Programmers
- Quality Engineers
- Control Systems Engineers
- Mechanical Engineers (Heat Transfer/Stress Analyst)

IBM SPACE GUIDANCE CENTER

At its Space Guidance Center in Owego, New York, IBM is responsible for vehicle guidance and control systems for manned aircraft, satellites, space craft, submarines, and other vehicles. Accomplishments include: successful test flights of the rugged IBM computer used in the all-inertial AChiever guidance system that directs the TITAN intercontinental ballistic missile to its target; an advanced memory system for the NASA Orbiting Astronomical Observatory; guidance computers for flight testing with the SATURN space vehicles.

The IBM Space Guidance Center is situated in pleasant surroundings with ample housing, good schools, and fine recreational facilities. The company-paid benefit program features broad educational opportunities. Relocation expenses are paid. IBM is an Equal Opportunity Employer.

For full details on career opportunities, please write, outlining your interests and background, to:

Fred Guth, Dept. 554 R2
Space Guidance Center
IBM Corporation
Owego, New York

IBM®

INTERNATIONAL BUSINESS MACHINES CORPORATION

Communications

Systems Scientists For Advanced Programs

Staff level openings in Orlando, Florida, are available for outstanding technical contributors in communications systems technology.

Assignments require communications systems engineers who are experienced in circuit design and analysis, information theory, or probability theory. Applications include airborne and ground digital data transmission, analog and digital computer systems, pulsed RF/IF amplifiers, and command and control display systems.

Work with the team who developed Pershing, Bullpup, GAM-83, Lacrosse, Racep, Missile Master and BIRDiE! Join them as they constantly advance the state-of-the-art in missile and electronic systems. Investigate these opportunities by sending your resume, in confidence, to Mr. P. A. Miller, Martin Company, Orlando Division, Sec. 376, Orlando, Florida. (An equal opportunity employer.)

MARTIN
ORLANDO
A Division of Martin Marietta

COMPUTER APPLICATIONS SPECIALIST
$12,000 Per Year

Will investigate application for special purpose analog and digital computers and data processing equipment. Analyze requirements and prepare proposals and estimates. Staff opportunity. Company assumes all expenses.

ESQUIRE PERSONNEL
202 South State St., Chicago 4, Illinois

E. E.'s

For professional, individualized fee-paid service write for confidential application.

A national employment agency for the Nuclear & Scientific Fields.

ATOMIC PERSONNEL, INC.
Suite 1207L, 1518 Walnut St., Phila. 2, Pa.

Engineering or Science Graduates to be trained as

INSTRUMENT SALES ENGINEERS
with
The Bristol Company

Leading manufacturer of automation equipment and control systems requires men, preferably 25 to 35 years old, to sell high quality, nationally accepted products to wide variety of industrial markets

Openings in various areas of the country. Successful applicants take comprehensive three-months course at headquarters. Salary and expenses

All replies confidential; every inquiry answered.

Write: Charles F. Johnson, Mgr. of Sales Training

The Bristol Company
Waterbury 20, Conn.

MANUFACTURERS' REPRESENTATIVES

IN THE ELECTRONIC INDUSTRY

SAMUEL K. MACDONALD, INC.
manufacturers representatives over 25 years
1531 SPRUCE STREET, PHILA. 2, PA.

Territory: Pennsylvania • New Jersey • Delaware • Maryland • Virginia • West Virginia • District of Columbia

Other Offices: Pittsburgh, Baltimore, Washington, D.C.

electronics

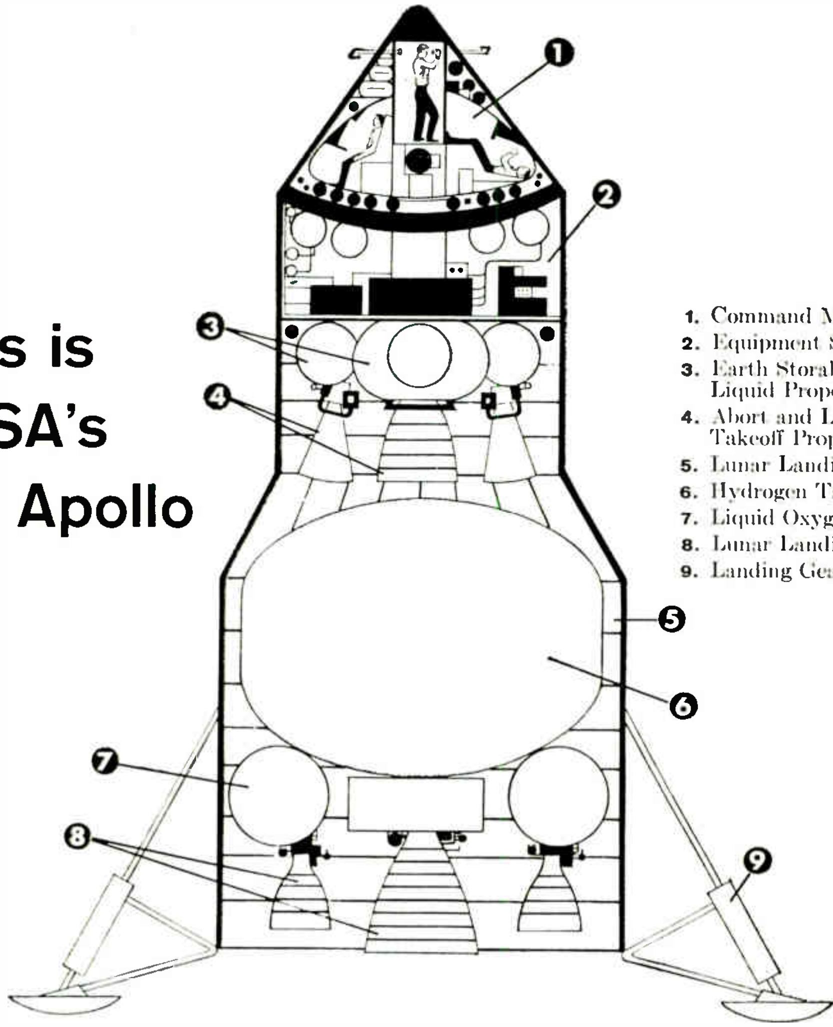
WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

(Continued from page 176)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION Washington, D.C.	181	17
NATIONAL CASH REGISTER CO. Dayton, Ohio	178	18
PHILCO WESTERN DEVELOPMENT LABS. Palo Alto, California	79*	19
SPACE TECHNOLOGY LABORATORIES, INC. Sub. of Thompson Ramo Wooldridge Inc. Redondo Beach, California	13	20

*These advertisements appeared in the 5/4/62 issue.

This is NASA's Project Apollo



1. Command Module
2. Equipment Storage
3. Earth Storable Liquid Propellants
4. Abort and Lunar Takeoff Propulsion
5. Lunar Landing Module
6. Hydrogen Tank
7. Liquid Oxygen Tank
8. Lunar Landing Propulsion
9. Landing Gear

The men of NASA are readying for a journey that will surely be one of the most significant achievements of this century—Project Apollo, the landing of men on the moon and their safe return to earth. It will happen before this decade is over.

The project will proceed in three stages. Before the culminating voyages to the moon, three-man Apollo spacecraft will first orbit the earth for as long as two weeks. Next, spacecraft will head out toward the moon, circle it and return to earth.

The end product of Project Apollo and NASA's other space programs is not just placing a man on the moon, but the release of a flood of knowledge and benefits for mankind through research and development. We will chart the last unexplored sea on the map—the great void of space; we will improve weather forecasting (where even a 10 per cent gain in accuracy would save the nation billions of dollars every year); we have already taken the first steps in establishing a global system of communications satellites; and we may expect new products and new techniques that will stimulate the entire industrial spectrum.

Still, the advances in scientific knowledge hold the exciting promise of much greater returns, far beyond what earthbound man can possibly envision.

SEND JUST ONE RESUME TO NASA

. . . it will be reproduced and distributed to all appropriate NASA facilities for consideration. You can be sure to play an important role in America's space achievements when you join NASA. Outstanding career opportunities are available in these locales: Washington, D. C. area; Mountain View and Edwards, Calif.; Hampton and Wallops Island, Va.; Cleveland, Ohio; Huntsville, Ala.; Cape Canaveral, Fla.; and Houston, Texas.

Write to: Director, Professional Staffing, Dept. 106, NASA Headquarters, Washington 25, D. C.

AN EQUAL OPPORTUNITY EMPLOYER. POSITIONS ARE FILLED IN ACCORDANCE WITH AERO-SPACE TECHNOLOGY ANNOUNCEMENT 252-B.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Advertisement

INTERESTING TO NOTE . . .

NEW YORK, N. Y. Feb. 1962:—

Universal Relay Corp., 42 White St., New York 13, N. Y. announces the publication of their 52 page Spring 1962 catalog. With publication of the catalog, they inform their customers that "normal inventory includes over 1,500,000 relays in approximately 30,000 types. In most cases stock is sufficient to give immediate delivery of production quantities.

This catalog is, therefore, not just a listing of items available 'on order' but, by and large, it is an indication of in-stock items (either as complete units or as ready to assembly components).

The average shipment is made within 48 hours. Where coils and frames require assembly, or relays require special testing or adjustment, shipments are made within one week to ten days.

Universal is completely equipped to assemble, adjust and thoroughly test any type of relay. Assembly and test facilities have been imitated by some relay manufacturers.

A personal interest is taken in every order. This interest is maintained as the order is processed. And, it continues even after the customer receives the merchandise until he makes sure that it satisfies his needs.

All merchandise is guaranteed, subject to customers' inspection and approval, and may be returned within 30 days for replacement or credit.

The catalog is full of items to fill everyday relay requirements".

Catalog E-162 may be obtained by writing directly to:

UNIVERSAL RELAY CORP.

42 White Street, New York 13, N. Y.

WAlker 5-6900

CIRCLE 460 ON READER SERVICE CARD

SEARCHLIGHT SECTION

Classified Advertising

BUSINESS OPPORTUNITIES — EQUIPMENT - USED or RESALE

—RATES—

DISPLAYED

The advertising is $27.25 per inch for all advertising other than on a contract basis. AN ADVERTISING INCH is measured 7/8" vert. on a column, 3 cols.—30 inches—to a page. EQUIPMENT WANTED or FOR SALE ADVERTISEMENTS acceptable only in Displayed Style.

UNDISPLAYED

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

BOX NUMBERS count as one line additional.

DISCOUNT of 10% if full payment is made in advance for four consecutive insertions.

Send NEW ADVERTISEMENTS or Inquiries to Classified Adv. Div. of Electronics, P. O. Box 12, N. Y. 36, N. Y.

ANTENNA PEDESTAL SCR 584-MP 61B

Full azimuth and elevation sweeps 360 degrees in azimuth, 210 degrees in elevation. Accurate to 1 mil. or better over system. Complete for full tracking response. Angle acceleration rate: AZ, 9 degrees per second squared EL, 4 degrees per second squared. Angle slewing rate: AZ 20 degrees per sec. EL. 10 degrees per sec. Can mount up to a 20 ft. dish. Angle tracking rate: 10 degrees per sec. Includes pedestal drives, selsyns, potentiometers, drive motors, control ampildynes. Excellent condition. Quantity in stock for immediate shipment. Ideal for missile & satellite tracking, antenna pattern ranges, radar system, radio astronomy, any project requiring accurate response in elevation and azimuth.
Complete description in McGrow-Hill Radiation Laboratory Series, Volume 1, page 284 and page 209, and Volume 26, page 233.

2 MEGAWATT PULSERS

(A) 31 KV at 60 amps .002 Duty Cycle Ideal for 5J26 at 500 KW $950.

(B) 30 KV at 70 amps .001 Duty Cycle. $1250 w/pulse output trans.

MIT MODEL 9 PULSER 1 MEGAWATT—HARD TUBE

Output pulse power 25KV at 40 amp. Max. duty ratio: .002. Uses 6C21 pulse tube. Pulse duration .25 to 2 microsec. Input 115 volts 60 cycles AC. Includes power supply in separate cabinet and driver. Fully guaranteed as new condition. Full Desc. MIT. Rad. Lab. Series "Pulse Generators."

500 KW PULSER

5C22 Hyd. Thyr. Modulator. 22KV at 28 Amps. W/HV & Fil Supplies. 3 pulse length rep rates: 2.25 usec 300 pps. 1.75 usec 550 pps. .4 usec 2500 pps. 115V 60 cy. Will deliver nominal 225 KW X Band using 4J50 magnetron.

L BAND RF PKG.

20KW peak 990 to 104MC. Pulse width .7 to 1.2 micro sec. Rep rate 180 to 420 pps. Input 115 vac. Incl. Receiver $1200.

SCR 584 RADAR AUTO-TRACK

3 CM & 10 CM. Our 584s in like new condition, ready to go, and in stock for immediate delivery. Used on Atlantic Missile Range, Pacific Missile Range, NASA Wallops Island, A.B.M.A. Write us. Fully Desc. MIT Rad. Lab. Series, Vol 1, pps. 207-210, 228, 284-286.

300 TO 2400MC RF PKG.

300 to 2400MC CW, Tuneable, Transmitter 10 to 50 Watts. Output. As new $575.

AN/TPS—1D RADAR

500 kw. 1220-1359 mcs. 160 nautical mile search range P.P.I. and A. Scopes. MTI. thyratron mod. 5J26 magnetron. Complete system.

AN/TPS 10D HEIGHT FINDER

250 KW X-Band. 60 & 120 mile ranges to 60,000 feet. Complete.

AN/APS—15B 3 CM RADAR

Airborne radar. 40kw output using 725A magnetron. Model 3 pulser. 30 in. parabola stabilized antenna. PPI scope. Complete system. $1200 each. New.

10 KW 3 CM. X BAND RADAR

Complete RF head including transmitter, receiver, modulator. Uses 2J42 magnetron. Fully described in MIT Rad. Lab. Series Vol. I, pps. 616-625 and Vol. II, pps. 171-185 $375. Complete Radar System $750.

PHILCO MICROWAVE LINK

7KMC System Type CLR-6. Also in stock: Repeaters. 12 and 24 Channel Multiplex. Large Quantity. Exce. Cond.

CARCINOTRON

Type CM 706A Freq. 3000 to 4000 mcs. CW. Output 200 Watts minimum. New, with full guarantee.

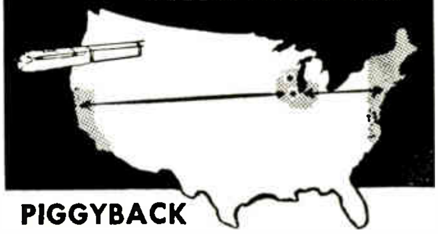
VA-800 KLYSTRON

1.7 to 2.4 KMC. (continuously tunable). 10 KW. CW. 50 db Gain output UG-435 A/U Flange $975 each.

RADIO RESEARCH INSTRUMENT CO.
550 FIFTH AVE., NEW YORK
JUDSON 6-4691

CIRCLE 461 ON READER SERVICE CARD

LIFSCHULTZ FAST FREIGHT



PIGGYBACK TO BOTH COASTS

TRUCKLOAD RATES TO BOTH COASTS

PROMPT DAILY PICKUP and DELIVERY

• *We welcome your inquiry.*

FASTEST TO BOTH COASTS!

CIRCLE 462 ON READER SERVICE CARD

Dividend Notice From Waters Manufacturing, Inc.

An initial cash dividend of five cents per share has been declared payable June 1, 1962 to stockholders of record May 15 1962

Robert A. Waters, President

CIRCLE 463 ON READER SERVICE CARD

SCHOOLS

LEARN MATHEMATICS

Today, to get ahead as a technical man, you must understand basic mathematics—logarithms, slide rule, algebraic notation and laws, various equations, progressions and series, etc. Grantham School has just recently developed an unusual home study course which can bring you up to date in these subjects. Don't let inadequacy in math hold you back. Write today.
GRANTHAM SCHOOLS, INC., Dept. 272-A
1505 N. Western Ave. Los Angeles 27, Calif.

CIRCLE 464 ON READER SERVICE CARD

Wilgreen

can deliver Amphenol Bendix Cannon

CONNECTORS FITTINGS & CLAMPS

We stock more than 5,000,000 MS/AN CONNECTORS . . . of 50,000 variations! In PRODUCTION QUANTITIES . . . we sell BELOW "O.E.M." PRICE . . . and offer IMMEDIATE "OFF-THE-SHELF" DELIVERY!

FREE . . . Send for latest brochure and list price chart

WILGREEN INDUSTRIES, Inc.
102 Warren Street, New York 7, N. Y.
WOrth 4-2490-1-2 Wire: FXK

CIRCLE 465 ON READER SERVICE CARD

FOR RESEARCH—DEVELOPMENT & EXPERIMENTAL WORK

Over 10,000 different electronic parts: waveguide, radar components and parts, test sets, pulsers, antennas, pulse xmfrs, magnetrons, IF and pulse amplifiers, dynamotors, 400 cycle xmfrs, 584 ant. pedestals, etc.

PRICES AT A FRACTION OF ORIGINAL COST!

Visit or Phone—

COMMUNICATIONS EQUIP CO.

343 CANAL ST., N. Y. 13, N. Y.
(Formerly at 131 Liberty St.)
CHAS. ROSEN, WOrth 6-4045

CIRCLE 466 ON READER SERVICE CARD

SMALL AD but BIG STOCK

of choice test equipment and surplus electronics

Higher Quality—Lower Costs
Get our advice on your problem

ENGINEERING ASSOCIATES
434 Patterson Road — Dayton 19, Ohio

CIRCLE 467 ON READER SERVICE CARD

MICROWAVE ANTENNAS

6' Spun aluminum dish, Parabolic, Andrews #2006 W/T4 Mounting brackets, de-icer and dipole radiator. New crated for export. $100.00 complete. One hundred available. Also Rigid Line, Hangers & Fittings.

SIERRA WESTERN ELECTRIC
1401 Middle Harbor Road Oakland 20, Calif.
TE-2-3527

CIRCLE 468 ON READER SERVICE CARD

TUBE & COMPONENT

FREE...CATALOG BARRY ELECTRONICS

512 BROADWAY NEW YORK 12, N.Y.
WAlker 5-7000 TWX: NY 1-3731

CIRCLE 469 ON READER SERVICE CARD

"SEARCHLIGHT" IS Opportunity Advertising

—to help you get what you want—to help you sell what you no longer need.

Take Advantage Of It

For Every Business Want
"THINK SEARCHLIGHT FIRST"

SPECIAL PURPOSE TUBES

OA2	.80	4-65A	10.00	25Z6WGT	1.50	725A	10.00	5751A	W 2.00
OA2WA	2.00	4-125A	20.00	26Z5W	1.50	726A	5.00	5763	1.75
OA3	.85	4-250A	32.50	FG-27A	20.00	726B	5.00	5777	150.00
OB2	.60	4-400A	30.00	28D7W	3.50	726C	8.50	5778	150.00
OB2WA	2.00	4-1000A	80.00	FG-32	6.50	802	5.00	5783	2.25
OB3	.70	4AP10	10.00	35T	10.00	803	3.50	5784	2.50
OC3	.50	4B31	12.50	35TG	2.50	804	15.00	5787	2.50
OD3	.30	4C35	15.00	FP-54	100.00	805	7.50	5796	8.00
C1A	8.50	4CX250B	30.00	FG-57	6.00	807	1.35	5800/VX-41	7.50
1AD4	1.50	4D32	15.00	RK-60/1641	1.50	807W	1.75	5803/VX-55	5.00
1B24	7.50	4E27	10.00	HY-69	3.00	808	2.50	5814A	1.35
1B24A	12.50	4J32	100.00	BL-75	3.00	809	5.00	5829	1.00
1B35A	3.00	4J34	100.00	TG-77	7.50	810	15.00	5830/FG41	100.00
1B63A	10.00	4J50	100.00	HF-100	10.00	811	2.50	5836	50.00
1C/3B22	5.00	4J52	35.00	100TH	12.00	811A	4.00	5837	50.00
C1K	7.50	4PR60A	50.00	100TL	12.00	812A	4.75	5840	2.50
1P21	32.50	4X150A	15.00	FG-105	25.00	813	12.50	5845	6.00
1P22	8.00	4X150D	15.00	F-123A	5.00	814	3.50	5852	5.00
1P25	10.00	4X150G	25.00	FG-172	25.00	815	3.75	5876	8.50
1P28	15.00	4X250B	25.00	211	2.50	816	2.25	5879	1.25
1Z2	1.50	4X250F	30.00	212E	25.00	826	3.50	5881/6L6WGB	2.50
2-01C	12.50	5BP1A	9.50	FG-235	40.00	828	12.50	5886	4.00
2AP1A	7.50	5C22	17.50	242C	10.00	829B	9.50	5894	18.85
2B23	20.00	5CP1A	9.50	244A	3.50	832	2.50	5915	1.00
2BP1	8.50	5CP7A	9.50	245A	3.50	832A	7.50	5931/5U4WG	4.00
2C36	22.50	5D21	7.50	249B	10.00	833A	37.50	5933/807W	2.50
2C39A	9.75	5J26	50.00	249C	5.00	834	7.50	5948/1754	100.00
2C39B	15.00	5JP1	7.50	250R	10.00	836	2.50	5949/1907	50.00
2C40	7.50	5LP1	7.50	250TH	25.00	837	1.00	5963	1.10
2C42	3.00	5R4GY	1.10	251A	50.00	838	1.00	5964	.85
2C43	7.50	5R4WGA	5.00	254A	3.50	842	7.50	5965	.85
2C46	5.00	5R4WGB	6.00	FG-258A	75.00	845	7.50	5976	50.00
2C50	4.00	5R4WGY	2.25	259A	3.50	849	75.00	5992	5.00
2C51	1.50	5RP1A	9.50	262B	3.50	851	50.00	5993	5.00
2C52	1.50	5Y3WGT	1.25	267B	5.00	866A	1.90	6002/QK221	250.00
2C53	7.50	5Y3WGTB	3.00	271A	12.50	869B	50.00	6005/6AQ5W	1.50
2D21	.50	6AC7W	.50	274A	3.50	872A	5.00	6012	4.00
2D21W	1.00	6AC7WA	2.00	283A	3.50	874	.75	6021A	2.00
2E24	2.25	6AG5WA	1.50	287A	3.50	884	1.25	6027/2J42A	100.00
2E26	2.50	6AG7Y	1.00	QK-288	250.00	885	.85	6032	10.00
2J42	75.00	6AK5W	1.25	HF-300	35.00	889RA	150.00	6037/QK243	50.00
2J51	50.00	6AK5 (WE)	.75	300B	5.00	891R	200.00	6045	1.15
2J55	90.00	6AL5W	.60	304TH	35.00	913	9.50	6072	1.50
2K22	25.00	6AN5	1.75	304TL	35.00	920	2.50	6073	1.50
2K25	8.50	6AN5WA	3.50	307A	.50	927	1.50	6074	1.75
2K26	35.00	6AQ5W	1.00	310A	3.50	931A	3.50	6080	3.35
2K28	30.00	6AR6	.75	311A	3.50	1000T	80.00	6080WA	5.00
2K29	25.00	6AS6	.85	313C	1.50	R1130B	10.00	6080WB	12.50
2K30	50.00	6AS6W	1.00	323A	6.00	1500T	150.00	6082	2.50
2K33A	200.00	6AS7G	2.50	328A	3.50	1611	2.00	6087/5Y3WGTB	3.00
2K34	75.00	6AU6WA	1.25	329A	4.50	1614	2.75	6101/6J6WA	1.50
2K35	200.00	6B4G	3.35	336A	2.50	1616	1.00	6106	1.50
2K39	150.00	6BA6W	.75	337A	3.50	1620	4.00	6115/QK351	50.00
2K41	50.00	6BE6W	1.50	347A	1.00	1624	1.00	6130/3C45	6.50
2K42	125.00	6BH6W	2.75	348A	4.50	1625	.50	6136/6AU6WA	1.25
2K43	175.00	6BL6	20.00	349A	3.50	1635	2.00	6146	3.00
2K44	125.00	6BM6	25.00	350A	3.50	1846	50.00	6159	3.50
2K45	20.00	6BM6A	30.00	350B	2.50	1855	250.00	6161	35.00
2K47	150.00	6C4W	2.50	352A	8.50	2050	1.25	6186/6AG5WA	1.50
2K48	50.00	6C4WA	1.00	354A	12.50	ZB-3200	100.00	6189/12AU7WA	1.50
2K50	100.00	6C21	17.50	355A	12.50	5528/C6L	3.50	6197	1.75
2K54	10.00	6D4	1.50	371B	2.50	5545	20.00	6201/12AT7WA	1.85
2K55	15.00	6F4	3.50	388A	2.00	5550	30.00	6202/6X4WA	1.50
2K56	50.00	C6J	10.00	393A	5.00	5552/FG235	50.00	6216	3.00
2P21	40.00	C6J/A	15.00	394A	3.00	5553/FG258	75.00	6233	100.00
2X2A	1.00	C6J/K	20.00	395A	2.25	5557/FG17	5.00	6236	125.00
3A5	.75	6J4	1.50	396A/2C51	1.50	5558/FG32	6.50	6248	500.00
3AP1	3.50	6J4WA	2.50	398A/5603	3.00	5559/FG57	6.00	6263	9.00
3B24W	3.00	6J6W	.60	401A/5590	1.00	5560/FG95	20.00	6265/6BH6W	2.75
3B24WA	5.00	6J6WA	1.00	403B/5591	3.00	5561/FG104	40.00	6299	37.50
3B25	2.50	6K4	2.00	404A/5847	7.50	5586	150.00	6316/BL800A	100.00
3B26	2.25	6L6GAY	.75	407A	3.75	5636	2.25	6322/BL25	15.00
3B28	3.00	6L6WGA	1.50	408A/6028	2.75	5642	2.00	6336	8.75
3B29	5.00	6L6WGB	2.50	409A/6AS6	1.00	5643	3.00	6336A	12.75
3BP1A	5.00	6Q5G	2.50	410R	75.00	5647	3.50	6344/QK235	500.00
3C/4B24	4.00	6SJ7WGT	1.25	416B/6280	30.00	5651	.75	6352	7.50
3C22	25.00	6SK7W	.75	417A/5842	9.50	5654/6AK5W	1.50	6385	6.00
3C23	4.00	6SK7WA	2.00	418A	9.50	5656	5.00	6390	125.00
3C24/24G	7.50	6SL7WGT	1.00	420A/5755	5.00	5663	1.00	6394	10.00
3C33	7.50	6SN7W	.50	421A/5998	7.50	5665/C16J	35.00	6438	5.00
3C45	3.50	6SN7WGT	1.00	429A	6.50	5667	125.00	6463	1.00
3CX100A5	17.50	6SN7WGTA	2.50	GL-434A	10.00	5670	1.00	6485	1.50
3D21A	2.50	6SU7GTY	.85	450TH	40.00	5672	1.35	6517/QK358	500.00
3D22	8.00	6V6GTY	1.00	450TL	40.00	5675	8.50	6533	5.00
3DP1A	5.00	6X4W	.75	575A	15.00	5678	1.25	6542	5.75
3E29	7.50	6X4WA	1.50	578	5.00	5686	2.25	6550	3.00
3GP1	1.50	6X5WGT	1.00	KU-610	5.00	5687	1.50	6807	20.00
C3J	7.50	5RL7F	100.00	NL-623	8.50	5691	5.00	6883	3.50
C3J/A	9.50	5RL7H	100.00	631-P1	5.00	5692	2.50	7034/4X150A	15.00
3J21	35.00	7AK7	2.50	673	15.00	5693	3.50	7044	1.50
3J31	100.00	7MP7	22.50	676	30.00	5696	.75	7580	35.00
3JP1	5.00	10KP7	15.00	677	40.00	5720/FG33	17.50	8002R	25.00
3K21	125.00	12AT7WA	1.50	701A	5.00	5721	110.00	8005	7.50
3K22	125.00	12AU7WA	1.50	703A	1.50	5725/6AS6W	1.50	8008	7.75
3K23	200.00	12AX7W	1.35	707B	2.50	5726/6AL5W	.75	8013A	5.00
3K27	150.00	12AY7	1.00	NL-710	9.75	5727/2D21W	1.25	8014A	30.00
3K30	100.00	C16J	25.00	715C	15.00	5728/FG67	10.00	8020	4.50
3KP1	9.75	FG-17	5.00	719A	12.50	5749/6BA6W	.75	8025A	7.50
3RP1	7.50	HK-24	5.00	721B	5.00	5750/6BE6W	1.50	9003	2.00
3WP1	12.50	25T	10.00	723A/B	3.50	5751/12AX7W	1.35	9005	3.00

ALL TUBES ARE NEW, INDIVIDUALLY CARTONED, FULLY GUARANTEED

western engineers

ELK GROVE, CALIFORNIA

SUPPLIERS OF ELECTRON TUBES SINCE 1932

TWX: ELK GR CAL 123
TEL: 916—685—9582
Mail: Box 520

Prices FOB shipping point

Min. order $10.00

CIRCLE 470 ON READER SERVICE CARD

INDEX TO ADVERTISERS

Audited Paid Circulation

• See advertisement in the July 20, 1961 issue of Electronics Buyers' Guide for complete line of products or services.

MANUFACTURERS REPRESENTATIVES

CLASSIFIED ADVERTISING

F. J. Eberle, Business Mgr.

INDEX TO CLASSIFIED ADVERTISERS

• See advertisement in the July 20, 1961 issue of Electronics Buyers' Guide for complete line of products or services.

This Index and our Reader Service Numbers are published as a service. Every precaution is taken to make them accurate, but ELECTRONICS assumes no responsibilities for errors or omissions.

electronics

Audit Bureau of Circulations

Associated Business Publications

Audited Paid Circulation

JAMES T. HAUPTLI

Advertising Sales Manager

R. S. QUINT:
Assistant Publisher Buyers' Guide and Business Manager
FRED STEWART:
Promotion Manager
B. ANELLO:
Market Services Manager

RICHARD J. TOMLINSON:
Production Manager
GEORGE E. POMEROY:
Classified Manager
HUGH J. QUINN:
Circulation Manager

ADVERTISING REPRESENTATIVES

NEW YORK (36):
Donald H. Miller, Henry M. Shaw, George F. Werner
500 Fifth Avenue, LO-4-3000 (area code 212)

BOSTON (16):
William S. Hodgkinson, Donald R. Furth
McGraw-Hill Building, Copley Square, Congress 2-1160 (area code 617)

PHILADELPHIA (3):
Warren H. Gardner, William J. Boyle
6 Penn Center Plaza, LOcust 8-4330 (area code 215)

CHICAGO (11):
Harvey W. Wernecke, Robert M. Denmead
645 North Michigan Avenue, Mohawk 4-5800 (area code 312)

CLEVELAND (13):
Paul T. Fegley
55 Public Square, Superior 1-7000 (area code 216)

SAN FRANCISCO (11):
R. C. Alcorn
255 California Street, Douglas 2-4600 (area code 415)

LOS ANGELES (17):
Peter S. Carberry, Ashley P. Hartman
1125 W. 6th St., Huntley 2-5450 (area code 213)

DENVER (2):
J. W. Patten
Tower Bldg., 1700 Broadway, Alpine 5-2981 (area code 303)

ATLANTA (9):
Michael H. Miller, Robert C. Johnson
1375 Peachtree St. N.E., Trinity 5-0523 (area code 404)

HOUSTON (25):
Joseph C. Page, Jr.
Prudential Bldg., Holcomb Blvd., Jackson 6-1281 (area code 713)

DALLAS (1):
Frank Le Beau
The Vaughn Bldg., 1712 Commerce St. Riverside 7-9721 (area code 214)

LONDON W1:
Dennis McDonald
34 Dover St.

FRANKFURT/Main:
Matthee Herfurth
85 Westendstrasse

GENEVA:
Michael R. Zeynel
2 Place du Port

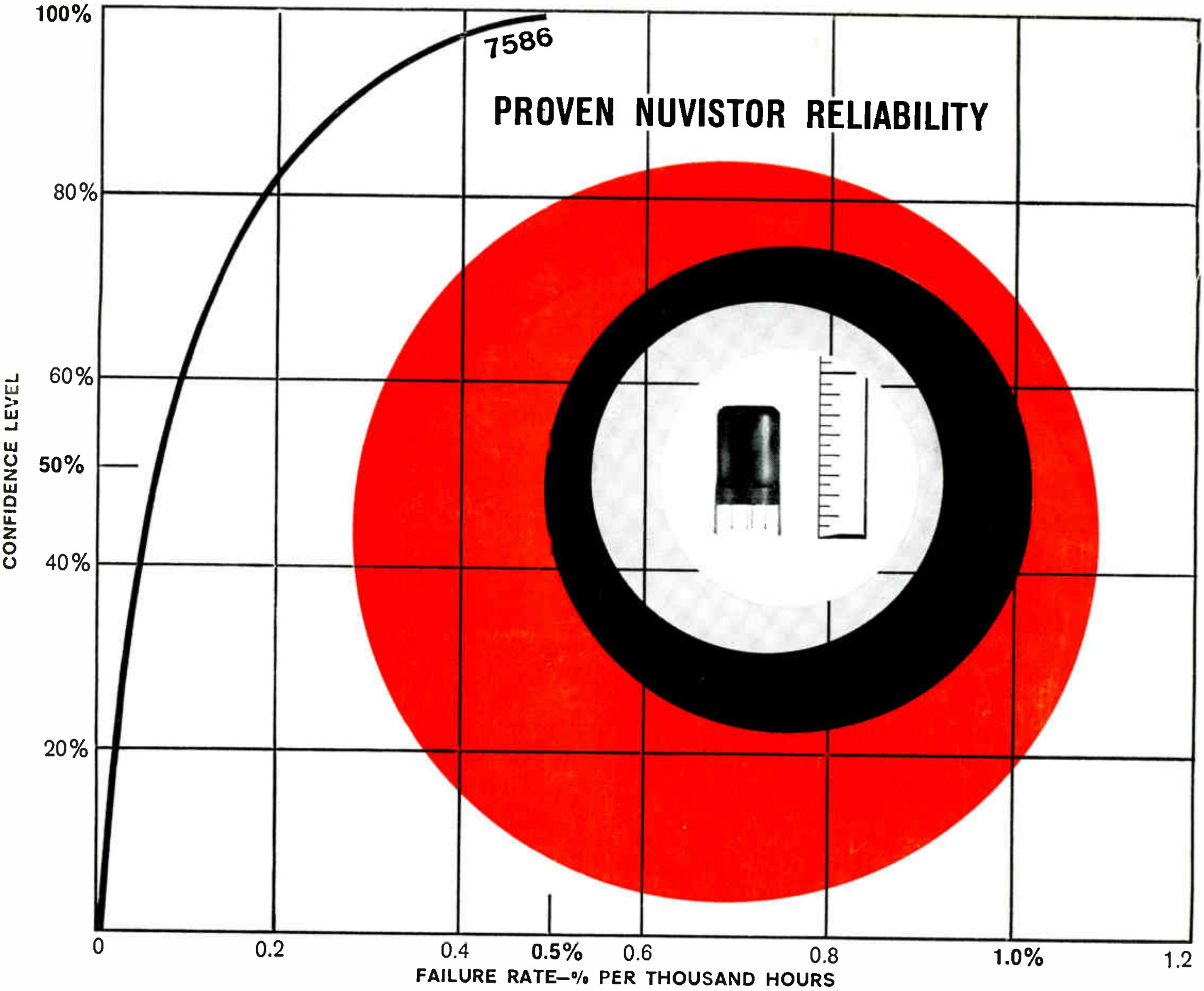
"Headquarters for Business Information"

McGraw-Hill Technical and Business Publications

American Machinist/Metalworking Manufacturing
Aviation Week and Space Technology
Business Week
Chemical Engineering
Chemical Week
Coal Age
Construction Methods and Equipment
Construction Daily
Control Engineering
Electrical Construction and Maintenance
Electrical Merchandising Week
Electrical Newsletter
Electrical West
Electrical Wholesaling
Electrical World
Electronics
Engineering Digest
Engineering and Mining Journal
E & MJ Metal and Mineral Markets
Engineering News-Record
Factory
Fleet Owner
Industrial Distribution
National Petroleum News
Nucleonics
Nucleonics Week
Platt's Oilgram News
Platt's Oilgram Price Service
Power
Product Engineering
Purchasing Week
Science Week
Textile World

Overseas only:
Automobile International (English, Spanish)
Ingenieria Internacional Construccion (Spanish)
International Management (English, Spanish Portuguese editions)
Metalworking Production (Great Britain)

Available by subscription only—to qualified persons actively engaged in the field of the publication. For subscription rates and information describing the editorial coverage of any of the above publications, write to: *Subscription Manager, Circulation Department, McGraw-Hill Publishing Company, 330 West 42nd Street, New York 36, N. Y.*



RCA-7586 FAILURE RATE IS:

0.36% OR LESS PER THOUSAND HOURS WITH A 95% CONFIDENCE LEVEL

...and at a 50% confidence level, the failure rate is only 0.084% or less per 1,000 hours. These extremely low failure rates shown with corresponding confidence levels on the chart above, are based on more than 1,000,000 tube hours of *actual* life testing. Many of the life tests have been run beyond 5000 hours with no sustained downward trend in transconductance observable in the distribution.

This data indicates you can be 95% sure that RCA-7586 nuvistor triodes, operated under conditions equivalent to those described, would have less than 4 failures out of each 100 tubes after 10,000 hours of operation.

These life test results demonstrate conclusively the *extra* reliability the tiny nuvistor tube brings to your electronic systems.

FIELD OFFICES:

EAST: 744 Broad St., Newark 2, New Jersey
HUmboldt 5-3900

MIDWEST: Suite 1154, Merchandise Mart Plaza
Chicago 54, Illinois
WHitehall 4-2900

WEST: 6801 E. Washington Blvd.
Los Angeles 22, Calif.
RAymond 3-8361

1838 El Camino Real, Burlingame, Calif.
OXford 7-1620

Tests were conducted under two sets of field conditions as shown:

NUVISTOR LIFE TEST CONDITIONS

	Test Conditions #1	*Test Conditions* #2
Heater Volts	6.3	6.3
Heater-Cathode Volts	100	0
Plate Volts	100	–
Plate-Supply Volts	–	75
Grid Volts	−1.85	–
Cathode Resistor—Ohms	–	100
Grid-Circuit Resistance—Megohm	0.5	0.5
Metal-Shell Temperature—°C	150	150
Plate Dissipation—Watts	1	0.75

Start now to give your circuits the extra advantage of nuvistor reliability and performance. For technical data on the 7586, get in touch with your RCA Field Representative or write Commercial Engineering, Section E-19-DE-2, RCA Electron Tube Division, Harrison, N.J.

RCA® **The Most Trusted Name in Electronics**