ELECTRONIC INDUSTRIES

A CHILTON PUBLICATION

Reliability

$$P = e^{-\frac{t}{\mu}}$$

- MINUTEMAN Reliability (See page 89)
- Compact Traveling Wave Tubes
- Using Transient Testing Techniques

December
1960

No space too tight for RMC "SM" DISCAPS

When your product design requires ceramic capacitors in sizes that squeeze into the tightest places it's wise to specify RMC Type SM DISCAPS.

Type SM DISCAPS show a minimum capacity change between +10°C and +85°C and meet the specifications of EIA-RS-198 for Z5U capacitors. Their miniature size and high quality are combined with low cost for production savings.

DISCAP CERAMIC CAPACITORS

RMC

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A DIVISION OF P. R. MALLORY & CO., INC.
GENERAL OFFICE: 4242 W. Bryn Mawr Ave., Chicago 46, Ill.
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Circle 1 on Inquiry Card

ELECTRONIC INDUSTRIES

ROBERT E. McKENNA, Publisher • BERNARD F. OSBAHR, Editor

RELIABILITY —A KEY

NEXT year the military will invoke a new specification which will specify the minimum requirements for "white rooms." This will be a step by the government to gradually require component manufacturers to guarantee reliability to degrees heretofore thought impossible. The spec is already in draft form.

We have heard and seen much recently with regard to the "white room." Preliminary reports of tests performed on equipments made on these conditions are very impressive. But is it the best that we can do? Really, the best?

We think not. Sure, we are on the right path, but is everyone going in the same direction? What good does it do for a component manufacturer to practice all of the known and new reliability techniques if the assembly manufacturer does not practice them to a greater degree? Or, at least, to a similar degree. To achieve true reliability, it must be a completely integrated program—practicing prescribed methods right from the raw material, through component assembly, and equipment manufacture.

One of the first such programs is that being practiced for MINUTEMAN guidance and control system. (See story on page 89). Here the equipment manufacturer prescribes steps to be taken to achieve reliability and then monitors the supplier to insure that the requirements are being fulfilled.

It is almost unanimously agreed that the "white room" is the basic ingredient for achieving the desired results. Second to it, perhaps, is worker motivation. "White Rooms," no matter how small, do not come cheap. Many small manufacturers say that they cannot possibly afford them. But actually they are the ones that must do their utmost to produce reliable units. In an industry gradually awakening to the cold facts of reliability, the small manufacturer may find himself without a market if his products are not of the high reliability type.

Even in the larger firms it is often more than difficult to get management to go along with an expenditure for which they cannot see an immediate return on their investment. But those firms which have already gone the route have not regretted it for a minute.

To accomplish such a sudden upgrading in reliability requirements, the military must, and is, footing the major part of the bill. And why not? They are the first customers. They are the ones that really need it now. In many instances, though, the manufacturer is putting up a goodly share of his own funds. And, again—why not? His proprietary rights are being respected and so he will be one of the first manufacturers in the industry to be able to offer to the market ultra-high reliability units. This alone will help offset much of his investment.

A hint for the small manufacturer: The government has not exactly been refusing contracts to small business, lately, either!

MORE IN '61

We have just had a preview of our 1961 Calendar of Coming Events for the Electronic Industries. It will come as no surprise that there will be more events to go to in 1961 than there were in 1960.

In spite of the undercurrent so frequently encountered in attending these events, . . . that there are just too many symposiums, conventions, and shows . . . there has been an increase of about 20% in these activities. Of the 221 events reported, 86 will take place in the East, 60 in the Midwest, 40 in the West and 25 are Foreign. In terms of time, the days to be taken by these activities already greatly exceeds the total number of working days in the year! And still, an end to this upward trend does not appear to be in sight. As the industry expands, more and more specialized or vertical groups are formed. Each of these, in turn, naturally hopes for an event of its own.

Some years ago we advocated three major exhibit shows a year. We believe that this idea is still very valid, although, again, because of growth and the nature of the industry this might now be expanded to four or five. The additions would be technical conferences only.

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ELECTRONIC INDUSTRIES

Vol. 19, No. 12 December, 1960

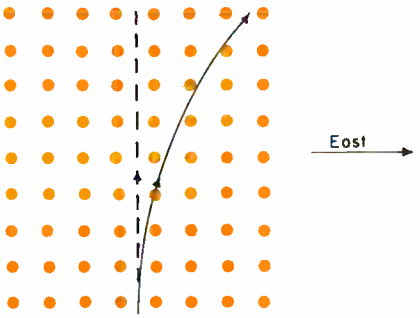
MONTHLY NEWS ROUND-UP

NEW PRODUCTS & TECH DATA

DEPARTMENTS

FRONT COVER: These two small expressions describe a multi-million dollar project currently under way in the electronic industries. Military equipment has always demanded a high degree of reliability, but the tremendous cost of a missile has even advanced this degree. Over a dozen component manufacturers in the electronic industry are working under contract with Autonetics, a Div. of North American Aviation, Inc., to increase reliability by one-hundred fold. The equation $P = e^{-t/\mu}$ simply indicates the probability of success of a system where t equals the required period of operation and μ is the mean-time-between-failure of the system. The complete story begins on Page 89.

Highlights of this issue



Shielding CRT's

Compact Traveling Wave Tube Design page 74

These small S-band tubes use a permanent magnet focus structure that is miniaturized along with other tube structures. The result is ruggedized, light weight, wideband 10 milliwatt and one watt tubes well suited for confined spaces such as in airborne vehicles.

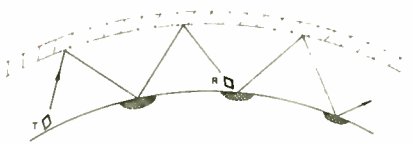
Propagation Considerations in RFI page 80

The electromagnetic field generated by a radiating antenna is quite complex. This complex field is the result of the simultaneous propagation of the energy by several modes. These modes are used for desired transmissions and, unfortunately, are also available for undesired signals. The characteristics of these modes are described.

Minuteman Reliability

Minuteman Reliability . . . Guide for Future Component Manufacturing page 89

Out of a $115-million Research and Development contract for Minuteman guidance and control systems will come new standards of reliability which will affect the design and manufacture of electronic equipment for years to come. Soon the military will invoke a new specification which will give minimum requirements for "white rooms." Reliability will be specified to degrees heretofore thought impossible. The spec is already in draft form.



Propagation & RFI

Using Transient-Testing Techniques page 106

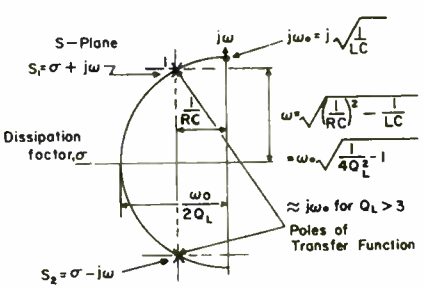
Transient testing of linear networks has certain desirable features over steady-state techniques. Before considering transient methods, however, a rough idea of the network to be tested should be had. This article gives some simple tools for making a good choice.

Psychological Research

Shielding CRT's from Magnetic Fields page 112

The field of magnetic shielding is notable for its lack of numerical values. While the subject of how to achieve good quality shielding is not emphasized, a significant contribution is made in that the article indicates how to establish the shielding objective.

Transient Testing



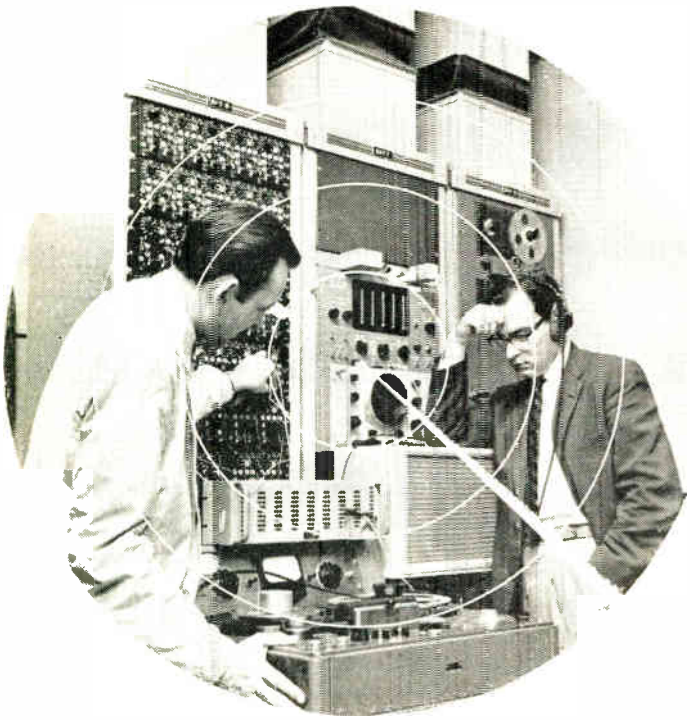
Put Hi-Fi into Your Broadcast System page 198

Today hi-fi is very popular in many homes and offices. This interest is growing. With a few changes and about $100 existing and new AM Broadcast equipment can be made to meet the general public's hi-fi requirements.

Applied Psychological Research page 208

Twenty years ago psychology was considered an academic science of interest only to college professors. But, now it has come out of the classroom and into the factory, improving products, reducing costs, solving complex man-machine relationships and even helping to decide who the next "boss" may be. The research psychologist is a scientist with sometimes limited tools but he can often provide valuable help.

RADARSCOPE



ARTIFICIAL REVERBERATOR

At Bell Labs F. F. Logan, (l) adjusts artificial reverberation filter to obtain an all-pass characteristic—equal response for all frequencies. Dr. M. R. Schroeder is evaluating the quality of the reverberated sound. The aim is to produce a "colorless" reverberation that will improve auditorium concert-hall acoustics.

UNIQUE MAGNETIC MATERIAL discovered by DuPont becomes magnetic as temperature rises above a certain point; then becomes non-magnetic as the temperature drops. It is a compound of manganese.

SIMPLIFIED COMPUTER SERVICING. Daystrom's Control Systems Div. makes a unique service available to buyers of their computers. The user places a telephone call to a central computer base at Daystrom's LaJolla, Calif., plant laboratory. The instrument's readout is transmitted over the phone line and appears on the LaJolla console, which is identical in function to that used in connection with every Daystrom installation in the country. When it is connected to the console in the customer's plant it can supervise and control the functioning of the customer's system exactly as though Daystrom's servicing personnel were in the customer's plant. The new service has been thoroughly investigated for over a year and is now being offered at a nominal fee. Daystrom people estimated it will give the system's user command of talent worth more than $100,000 a year. It marks one great step forward in solving the massive maintenance problem.

VALUE ENGINEERING is in for a re-evaluation by the Navy. Some significantly high Navy personnel feel that the concept of value engineering is little more than a license to kibitz with the design engineer's work. This second look will tell them whether the money saved warrants jeopardizing the original design.

SMALL FIRMS are getting an increasing share of prime Government contracts. Their piece of the Government's spending increased by 13.6% during the first half of the fiscal year 1961, compared to the same period of 1960. And the value of the awards increased by 37.7%.

SHIPMENTS OF COMPONENTS by U. S. electronic manufacturers is increasing sharply. Output of tubes, semiconductors and other major components during the first three months of 1960 increased 8% over the preceding six month rate more than 20% above the first half of 1959. The sharpest increases were in quartz crystals, transformers, and transistors.

EIA HAS BEGUN A SURVEY to determine the number of scientists and engineers in the electronics industry. The survey has been urged by the Office of the Secretary of Defense for Research & Engineering. Preliminary findings indicate that there are about 140,000 electronic engineers and scientists in the U. S. with 110,000 in industry. From 80 to 90% of them are believed working in defense supported programs. Much more precise

MISSILE BOMBER SYSTEMS

Part of the complete AC and DC electrical power distribution system mockups for the B-52G and the new B-52H missile bombers is shown here in the Electrical and Electronic Design Lab at Boeing's Wichita, Kans. division. Present work is concentrated on evaluation of the 120 KVA system for the B-52H bomber.

figures are expected to be available when the survey is completed. All EIA member companies and most non-member electronic manufacturers have been asked to participate in the survey.

HOW DO YOU MEASURE the importance of a scientific paper?—that problem will be investigated by a team of scientists at Case Institute of Technology, in Cleveland. The researchers will cover all fields of science, analyzing articles published since 1900. The aim is to identify the distinguishing characteristics of the quality article.

MAN-TO-COMPUTER LINK is getting increased attention, with efforts directed at matching the logic and speed requirements of the system and the human operator. Electrada Datacom, announced last month, accepts digital information at line speed, automatically translates it to ordinary alphanumeric characters and presents a clear display on the screen of cathode ray tube. As the information is being displayed, the operator may approve its contents, or alter them in part or in total by striking a standard typewriter keyboard. The Datacom reportedly greatly increases the flexibility of the computers and communications systems.

NO MORE TUBES will be exported to Canada by Japan through the balance of 1960, "or until such time as satisfactory quotas can be arranged." Japanese shipments of tubes to Canada during the first seven months of this year were almost double that of a year ago, and there was open speculation that the Canadian tube industry would collapse. Consultations are continuing between the two Governments with a view to controlling shipments to Canada on a more orderly basis in the future.

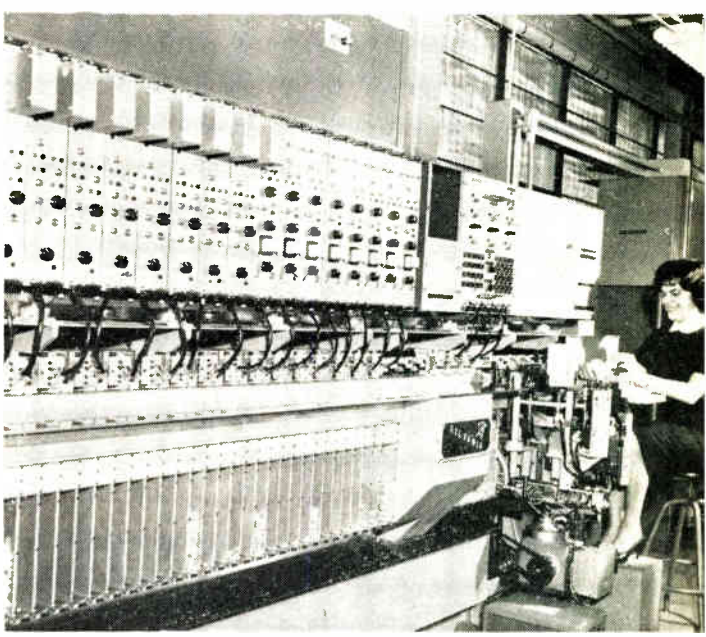
LONG AWAITED FM STEREO seems to be headed for additional delays, even though the fields tests conducted by the National Stereophonic Radio Committee have been completed and the report filed with the FCC. The difficulty is that no one system showed any marks of superiority over the others in all respects. On the basis of quality alone, the system proposed by Crosby is way out in front, but the system leaves no room for the other Subsidiary Communications Authorization (SCA) services. Its adoption would require FM broadcasters to choose between stereo and other multiplex services. All five of the other systems tested let broadcasters transmit stereo simultaneously with regular point to point multiplex services. More than 200 FM's are now authorized to conduct SCA services. The best guess is that stereo standards won't be out until the middle of next year and then it will comprise features from virtually all of the systems tested.

THE U. S. GOVERNMENT is the largest user of electronic data processing machines. In view of the rapid expansion in Government usage of computers, many Washington people are recommending that there be established a central system of control over the allocation and use of EDP equipment for the entire Government. Improved scheduling of equipment usage, including interchange and loan arrangements, would be possible among large departments and agencies during peak and slack work periods. 85% of the 524 electronic computers now operating in the Goverment (excluding those for tactical and classified uses in the defense establishment) are rented from manufacturers.

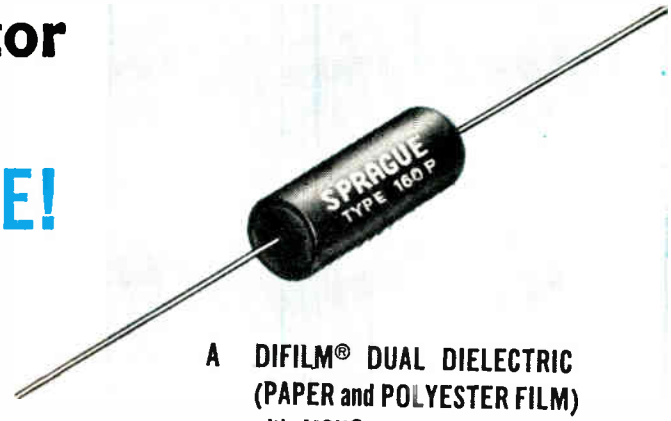
RACE TO DEVELOP a computer language that would translate numerical programming instructions into simple English saw its first practical equipment last month, introduced by RCA. It is a result of a request from the Defense Dept., largest user of computers in the country, that all computer manufacturers collaborate on COBOL (Common Business Oriented Language) system that would simplify computer programming. Active in the development, with RCA, are Remington Rand, Sylvania, and to a lesser extent, IBM. The latter firm does not feel that COBOL is fully ready as a complete substitute for numerical computer programming, but they said that as soon as COBOL is universally acknowledged as a complete substitute for numerical coding, IBM will have a programming system ready.

TRANSISTOR PRODUCTION

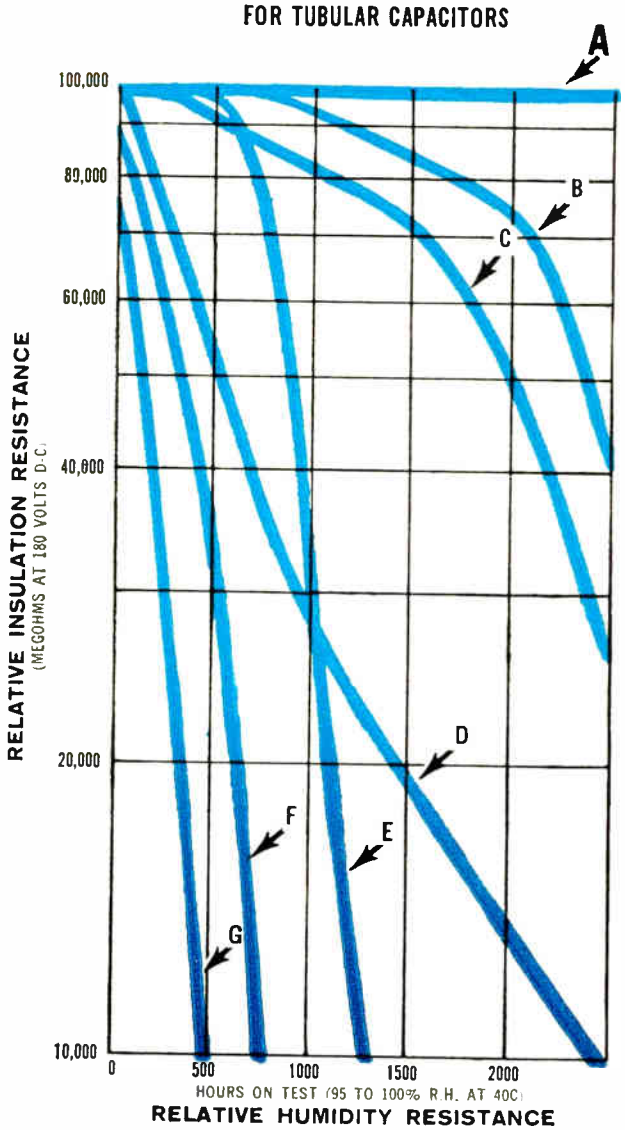
New high speed machine electrically tests and classifies transistors at Semiconductor Division, Sylvania Electric Products, Inc., Woburn, Mass. Sylvania, last month, received the Signal Corps' RIQAP Award for "consistent production of high quality germanium transistors."



See Which Tubular Capacitor leads all others in MOISTURE RESISTANCE!



MOISTURE RESISTANCE COMPARISON CHART
FOR TUBULAR CAPACITORS



A DIFILM® DUAL DIELECTRIC (PAPER and POLYESTER FILM) with HCX® solid impregnant and molded phenolic case

B PAPER DIELECTRIC with HCX solid impregnant and molded phenolic case

C DIFILM DUAL DIELECTRIC (PAPER and POLYESTER FILM) with HCX solid impregnant and dipped epoxy resin coating

D PAPER DIELECTRIC with wax or oil impregnant and molded phenolic case

E POLYESTER FILM DIELECTRIC with molded case

F PAPER DIELECTRIC with HCX solid impregnant and waxed cardboard jacket

G PAPER DIELECTRIC with wax or oil impregnant and waxed cardboard jacket

The graph tells the story simply and to the point!

DIFILM® BLACK BEAUTY® MOLDED TUBULAR CAPACITORS withstand more than 2500 hours (95 to 100% R.H. at 40 C) *with no change in humidity resistance!*

No other tubular comes even close to this performance. Difilm Capacitors are the *true* answer to moisture problems in entertainment and commercial electronics.

For complete technical data on Difilm Black Beauty Capacitors, write for Engineering Bulletin 2025 to Technical Literature Section, Sprague Electric Co., 233 Marshall St., North Adams, Mass.

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As We Go To Press...

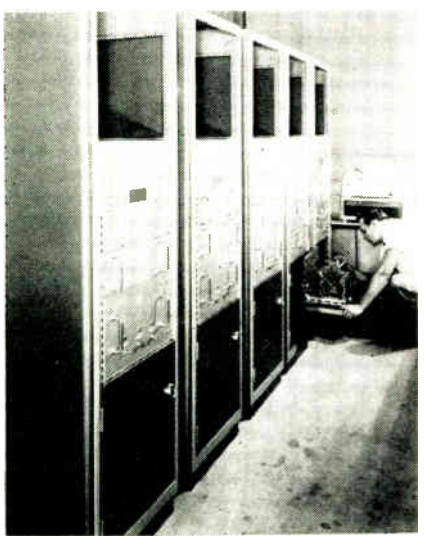
Study Generation of High-Powered Fields

Low-temperature studies at CEL (Cryogenic Engineering Labs.) of NAB (National Bureau of Standards) are exploring several methods of producing a low-power, steady-state electromagnet with a 100,000-gauss field intensity. (The earth's magnetic field is about ½ gauss.) If successful, this magnet will serve as a pilot model in the design of electromagnets with field intensities great enough to contain the temperatures generated by a nuclear fusion reaction, 350 million degrees Fahrenheit.

Feasibility Studies For Project Apollo

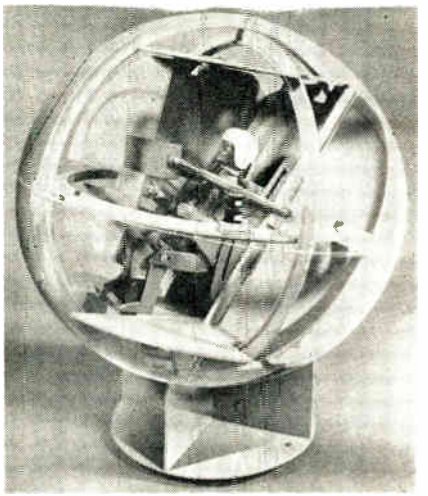
NASA has awarded several feasibility study contracts costing about $250,000 each for Project Apollo. The project looks toward the development of a 3-man space ship that could orbit the earth and make a circumlunar flight. USAF had awarded a $161,000 study contract to Ford Motor Company's Aeronutronic Div., now nearing completion. This concerns the structure of a three-man vehicle which would remain in orbit around the earth for extended periods of time. These studies are under surveillance by the Air Force and Civilian Space Agency, so that there is no duplication of efforts by either.

TELEMETERING SYSTEM



Five remote telemetering station units are part of a digital data system built by Datex Corp., Monrovia, Calif., for Milwaukee Gas Light Company. System automatically records gas flow from each station. Commercial telephone lines are used.

ROTATIONAL SIMULATOR



A one-man Space Flight Rotational Simulator, designed and under construction at Northrop Corp's. Norair Div., Hawthorne, Calif., gives Space Bound Astronauts more realistic exposure to tumbling and spinning effects of satellite flight. Motor-powered inertia rings, mounted on the axes of roll, pitch and yaw, control and rotate the 10-ft. fiberglass, honeycomb shell up to as many as 70 revolutions per minute.

Management Methods In Pace With Weaponry?

Dudley C. Sharp, Secretary of the Air Force, has directed a survey of management practices employed by the Air Force and its major contractors. Objective is to determine whether present management methods will keep pace with the rapidly advancing technology of modern weaponry. Initial survey will cover Martin Company's TITAN program because of its tremendous importance to national defense and because its complex nature generates problems common to most advanced weapon systems.

The Inspector General's office, traditionally the impartial review agency for the Air Force Chief of Staff, has responsibility for the survey.

$9,800,000 In Grants By NSF To 43 Colleges

The National Science Foundation has granted $9,800,000 to 43 colleges and universities to support Academic Year Institutes for science and mathematics teachers. The program's purpose is to help teachers improve their subject-matter knowledge through a year's advanced study on a full-time basis.

New Tunnel Effect Discovered At G.E.

The tunneling effect has been achieved at GE's Research Lab using two metal films separated by a thin insulating layer, with one or both of the metal films in the superconducting stage.

The discovery, made by Physicist Ivar Giaever, opens a new approach to the construction of versatile, microminiature electronic components.

In Giaever's discovery, tunneling occurs through the barrier of an insulating film, rather than through the charge depletion region of a semiconductor p-n junction, as in the case of the tunnel diode.

This unpredicted finding has important implications for theories about superconductivity and about tunneling. From the practical standpoint, the discovery may become important by making possible a new family of devices unequalled for their small size, and versatility.

Most of Giaever's experiments have been with films of aluminum, lead, indium and tin, all of which become superconductive at near liquid helium temperatures. A considerable number of other metals are expected to exhibit the same effect. In almost all of the experiments, aluminum oxide was the insulating layer, although proof has been obtained of tunneling through tantalum oxide, niobium oxide and nickel oxide as well.

One of the primary advantages of any device incorporating this effect is the possibility of changing the device's characteristics with a magnetic field. This is the result of a well-known property of superconductors. They can be changed to the normal state—i.e., made non-superconducting—by a sufficiently strong magnetic field. Thus by varying a magnetic field, one or both of the superconducting films can be changed to the normal state, with a consequent change in operating characteristics of the device. This is why it may be possible for the device to function as a switch, diode, negative-resistance diode, triode, resistor or capacitor.

More News on Page 8

Electronic SHORTS

▶ **FAA has endorsed the new British Red-White System for visual landings at U. S. airports to enable pilots to descend along the optimum glide path, without under-or-over-shooting a runway.**

▶ Navy's Bureau of Yards and Docks has been forced to restudy the structural design and cost of its 30,000-ton rotating radiotelescope at Sugar Grove, W. Va. Completion of the 600-foot diameter dish is now expected in 1964 at a cost exceeding $100 million.

▶ **"Project Rover"—AEC and NASA's Nuclear Rocket Program will bypass the customary feasibility design study and move directly into the industrial R&D phase to speed development. First nuclear rocket is expected to be flight-tested by 1965.**

▶ Goodyear Aircraft Corp.'s Arizona Div. (Litchfield Park, Arizona) proposal on the development of an experimental Radar Data Computer, has been selected as a basis for contract negotiations by the Maritime Administration, U. S. Dept. of Commerce. Computer will plot projected courses of ten ships simultaneously.

▶ **AMRI (Association of Missile & Rocket Industries) has counted over 337 U. S. missile projects since World War II. Count includes 11 intercontinental, 5 intermediate, 16 long range, 13 medium range, 27 short range and 16 antisubmarine. Total includes discontinued types, smaller experimental rockets and globe-girdlers, but not secret projects. The AMRI Index includes 313 other projects such as satellites, space vehicles, space power, new propellants and new methods of guidance.**

▶ FAA has concluded performance testing of the Sperry SP-30 Automatic Flight Control System and "ticketed" it for everyday use on the Convair 880 Jetliner. System provides electronic "brains and muscles" freeing the pilot from a host of manual flying tasks and enabling him to concentrate on navigation, communications, and maintaining a steady watch for other aircraft.

▶ **Westinghouse Electric Corp. V. P. John W. Simpson predicts the U. S. can have Atomic Rocket Propulsion and Auxiliary Power Systems, capable of launching a 35-ton payload in space by 1967. "Within this payload," he said, "electrical power systems of over 100 kilowatts could be carried." Present military space efforts are being achieved with chemical rocket propellants.**

▶ ITT Labs, Nutley, N. J., with a 1-lb. transmitter, an ultra-violet light bulb, and a 2-lb. transistorized receiver, have developed a high-frequency Communications System using a beam of ultra-violet light. It can handle 100 messages simultaneously.

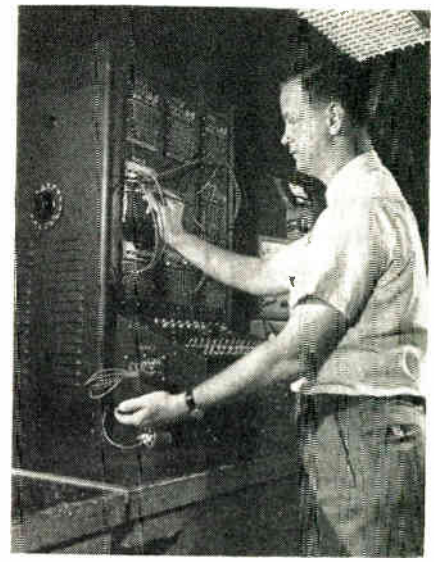
▶ **FBI Inspector Ivan W. Conrad has patented a high-speed Telegraphy System, primarily for "reading out" the results of high-speed computer operations. A passage of current or a magnetic field, instead of hammer blows, enables pulses to form letters, by changing the color of treated papers; thus speeding up the printing process.**

▶ National Bureau of Standards, U. S. Dept. of Commerce, has established two new Technical Advisory Committees; one on Calibration and Measurements Services, and the other on Engineering and Related Standards. Purpose of these committees is to aid the Bureau in the fields of precision measurement, calibration, and standard practices.

▶ Aerojet-General Corp., Azusa, Calif., has been awarded a contract by the AF Ballistic Missile Center for Ablestar second-stage boosters. They will be used in future launchings of Transit and Courier satellites. Aerojet has teamed with Space Electronics Corp., Glendale, Calif., in this project.

▶ **A directory listing 22,671 small businesses qualified to do R & D work in 33 major categories as prime or sub-contractors has been issued by the Small Business Administration. Copies are available for public inspection at all SBA field offices. Small firms, not listed in the directory, interested in performing research and development work, should get in touch with their local SBA office.**

UNIVERSAL TEST PANEL



"Home-made" Electronics Tester, made of spare parts in part time by Ernie Sweeney of North American Aviation's Los Angeles Div. will save hundreds of man hours in development of 2000-mph B-70 Cabinet is three-foot-high with over 1500 wires and 3000 soldered points. The panel tests electronic parts such as regulators, sensors, controllers, amplifiers, and other systems.

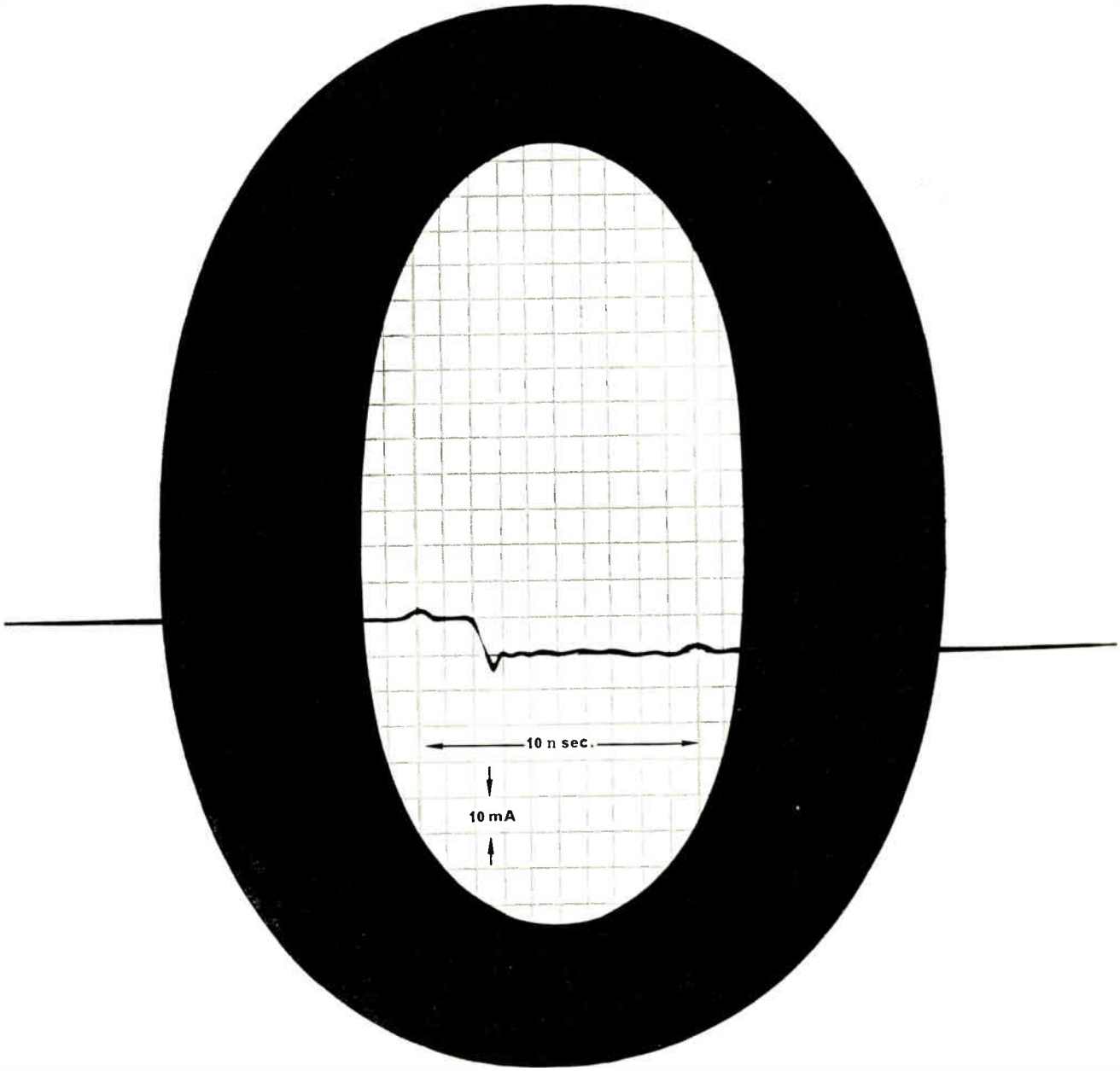
FAA To Get Computer For Air Traffic Control

Developed for the FAA Bureau of Research and Development by the Librascope Div. of General Precision, Inc., N. Y., a specifically designed computer will be installed early next year for Air Traffic Control. It will help automate the routine work of the Air Traffic Controller, now facing future demands for speed and handwork beyond human abilities.

It prints flight progress information, updates, changes and stores this information, exchanges it with other control facilities concerned with the flight, warns the Controller of impending conflicts of air traffic, and generally assists him in controlling traffic from airport to airport. It eliminates the necessity of many aircraft awaiting their turn to approach and land. The computer is part of the DPC (Data Processing Central) which FAA has under development at its National Aviation Facilities Experimental Center at Atlantic City, N. J. The DPC is a semi-automatic system for automatic air traffic control.

More News
On Page 14

STORAGE TIME:



RECOVERY TIME, GUARANTEED LESS THAN A HALF A NANOSECOND!

The new HUGHES® HD-5000 diodes are the fastest switching devices commercially available today. They are so fast, in fact, that storage time can't even be measured. ■ Think what this means. Now computer circuits can be designed that work 10 times faster than ever before. ■ This important speed breakthrough was made possible through an exclusive bonding process developed by Hughes research. The result is a low-capacity diode that completely solves the storage-time problem. ■ The HD-5000 Diode Series is available now from Hughes. Call your local Hughes Semiconductor sales engineer or distributor. Or write Hughes Semiconductor Division, Marketing Department, 500 Superior Avenue, Newport Beach, California. For export write: Hughes International, Culver City 5, California

Type	I_F @ 1V (mA)	E_S @ 100μA (volts)	I_B (μA) @ −5V @ 25°C	I_B (μA) @ −5V @ 100°C	Recovery n sec.
HD 5000	5	20	0.2	2.0	<0.5
HD 5001	5	20	1.0	10.0	<0.5
HD 5002	2	20	0.2	2.0	<0.5
HD 5003	2	20	1.0	10.0	<0.5
HD 5004	2	15	1.0	20.0	<0.5

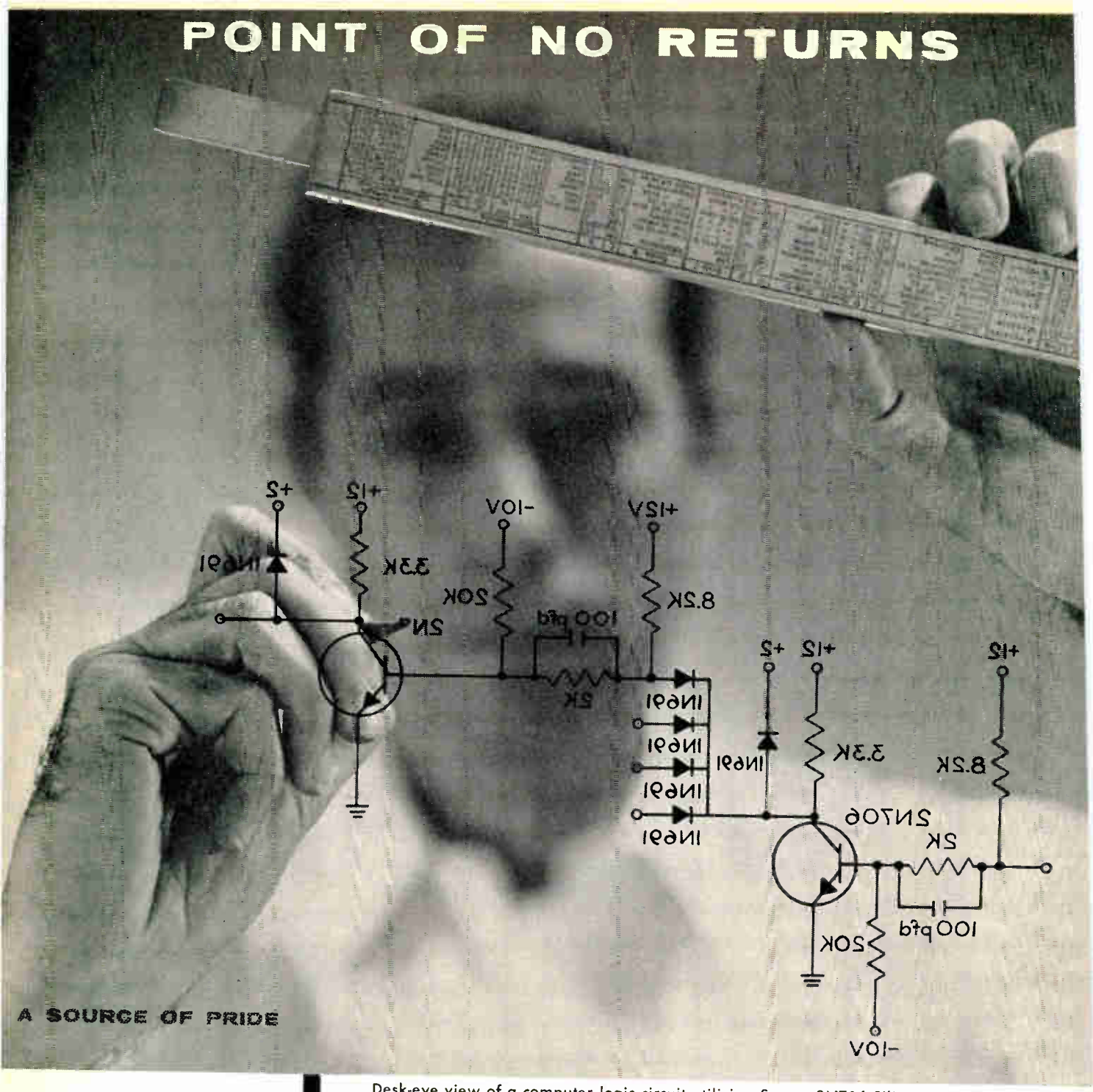
The recovery circuit uses a high-speed sampling scope and attachments. The switching is 10 mA forward to 6V reverse; recovery to 1mA reverse. Loop impedance is 100 ohms. Typical capacitance: 0.8 pf. Typical rectification efficiency 60% at 100 Mc.

Creating a new world with ELECTRONICS

HUGHES

SEMICONDUCTOR DIVISION
HUGHES AIRCRAFT COMPANY

Circle 3 on Inquiry Card



Desk-eye view of a computer logic circuit utilizing Sperry 2N706 Silicon Mesa Transistors.

SPERRY

SPERRY SEMICONDUCTOR DIVISION

OF

SPERRY RAND CORPORATION

NORWALK, CONNECTICUT

Here's where you put your experience on the line.

Will the vendor you select confirm the confidence of your decision . . . or will the transistors he delivers return to haunt him — and you?

63 QC checks before and during mechanized manufacture. Our way of trying to make your confidence our **only** return!

Circle 81 on Inquiry Card

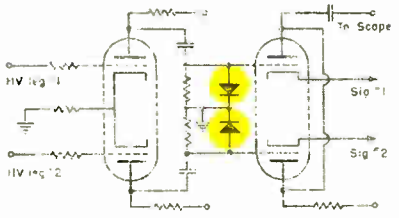
SEMICONDUCTOR IS OUR MIDDLE NAME . . . SEMICONDUCTOR INTEGRATED NETWORKS (SEMI-NETS*), TUNNEL DIODES, MESA AND ALLOY SILICON TRANSISTORS AND DIODES. SALES OFFICES: CHICAGO, ILLINOIS; EL SEGUNDO, CALIFORNIA; WESTWOOD, NEW JERSEY; TEWKSBURY, MASSACHUSETTS; STAMFORD, CONNECTICUT; TOWSON, MARYLAND; MASSAPEQUA PARK, NEW YORK.

SEMICONDUCTOR OPPORTUNITIES AVAILABLE TO QUALIFIED ENGINEERS

*Trade Mark, Sperry Rand Corporation

GENERAL INSTRUMENT SEMICONDUCTOR REPORT

Design Notes...

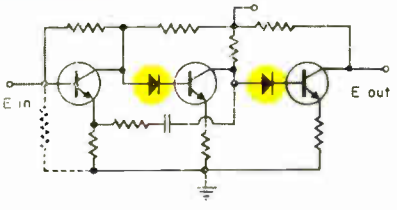


DIODE CLAMPS PREVENT DRIFT IN HIGH SPEED ELECTRONIC SWITCHES The problem of drift in high speed electronic switches has been solved through the use of clamp diodes. This application is especially useful for stabilizing the operation of go, no-go oscilloscopic testing of dynamic parameters in a variety of electronic components.

In the circuit, General Instrument MP-300 silicon diode rectifiers may be used because of their superior stability and low reverse leakage (only .05 μa @ 25°C).

Changing from vacuum tube to silicon clamp diodes minimizes problems associated with varying contact potentials. Equipment reliability is improved since total thermal dissipation is reduced. Further, equipment does not have to be reset in case of power line failure.

The small physical size of General Instrument diode rectifiers is important where a large number of switches are to be used in a single piece of equipment.



NOVEL CIRCUIT USES DIODES FOR AUDIO COUPLING There are many benefits to be gained through *diode coupling* of audio amplifiers. The simplified three-stage transistorized audio amplifier shown above uses General Instrument IN645 subminiature silicon diodes.

Since the diodes are forward biased, ac is virtually direct coupled—resulting in a flat frequency response limited only by transistor parameters. Need for large coupling capacitors is eliminated. Virtually lossless ac coupling is obtained. And, temperature stability is improved because of low external base resistance.

Complete schematics of above circuits are available upon request.

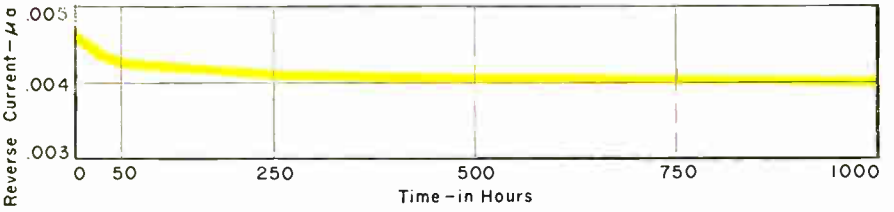
Proved Reliability: ZERO FAILURES after 11,000 hours operation at 150° C!

1N645-1N649 DIODE/RECTIFIERS AVAILABLE IN PRODUCTION QUANTITIES... EXCEED USAF STANDARDS

General Instrument 1N645 through 1N649 subminiature rectifiers are ideally suited for applications requiring small size and very high reliability. These hermetically sealed glass units are designed to operate over an ambient range from −65° to 150°C . . . pass MIL-E-1 1143 specifications for breakdown voltage . . . offer superior life test performance. This series covers the range of 225 to 600 PIV, with maximum average rectified current of 400 ma @ 25°C. Maximum reverse current @ PIV is only 0.2 μa.

These diode rectifiers are subjected to 100% environmental testing and dynamic oscilloscopic tests to assure high electrical and mechanical uniformity, surpassing the most stringent military specifications.

■ **LIFE TESTS** indicate outstanding stability of the General Instrument 1N645 series subminiature rectifiers under load. Graph shows results of a 1,000-hour test of 231 units from a normal production run. (Conditions: VRMS 160 V ac; Io 400 ma dc.)



NEW MP SERIES DESIGNED FOR 200°C OPERATION!

General Instrument has achieved an outstanding power-to-size relationship in the high quality MP silicon diode rectifier series. Parameters for these subminiature glass units are suitable for a wide range of applications under high-temperature conditions:

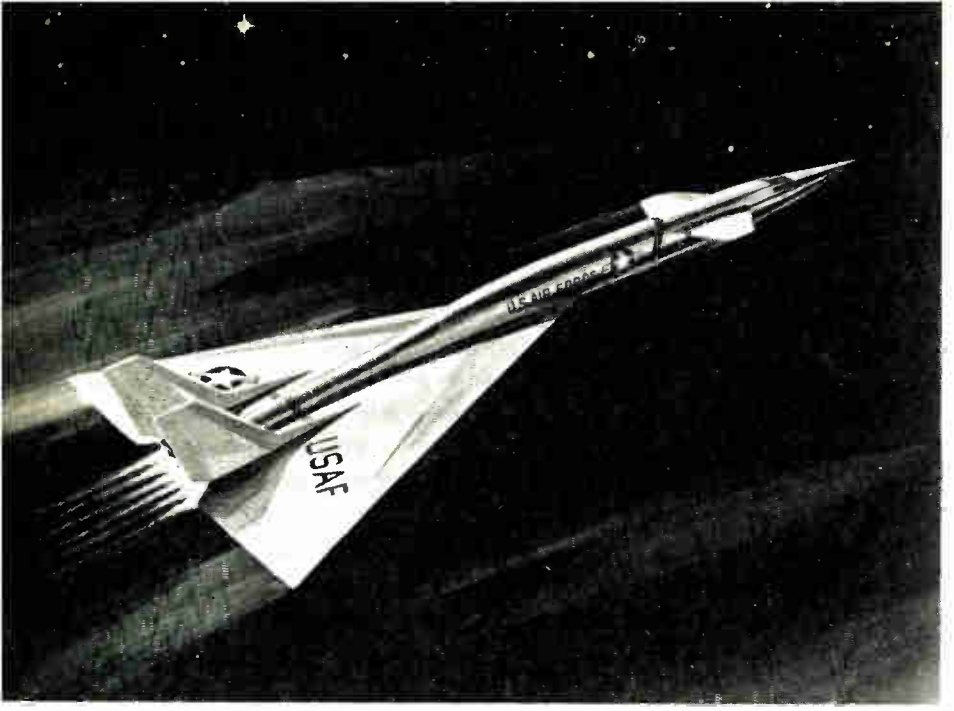
TYPE	PIV	DC OUTPUT CURRENT (Ma)		REVERSE LEAKAGE (μa) @ PIV		FORWARD DROP @ 400 Ma @ 25°C
		25°C	200°C	25°C	200°C	
MP 100	100	400	50	.05	75	1.0
MP 225	225	400	50	.05	75	1.0
MP 300	300	400	40	.05	75	1.0
MP 400	400	400	35	.05	75	1.0
MP 500	500	400	25	.05	75	1.0
MP 600	600	400	20	.05	75	1.0

CALL ON GENERAL INSTRUMENT for technical data and applications assistance on the complete line of General Instrument high reliability silicon diodes.

SEMICONDUCTOR DIVISION
GENERAL INSTRUMENT CORPORATION
65 Gouverneur Street, Newark 4, New Jersey

4448

IN CANADA: General Instrument—F. W. Sickles of Canada Ltd., P.O. Box 408, 151 S. Weber Street, Waterloo, Ontario, Canada. Sherwood 4-8101.



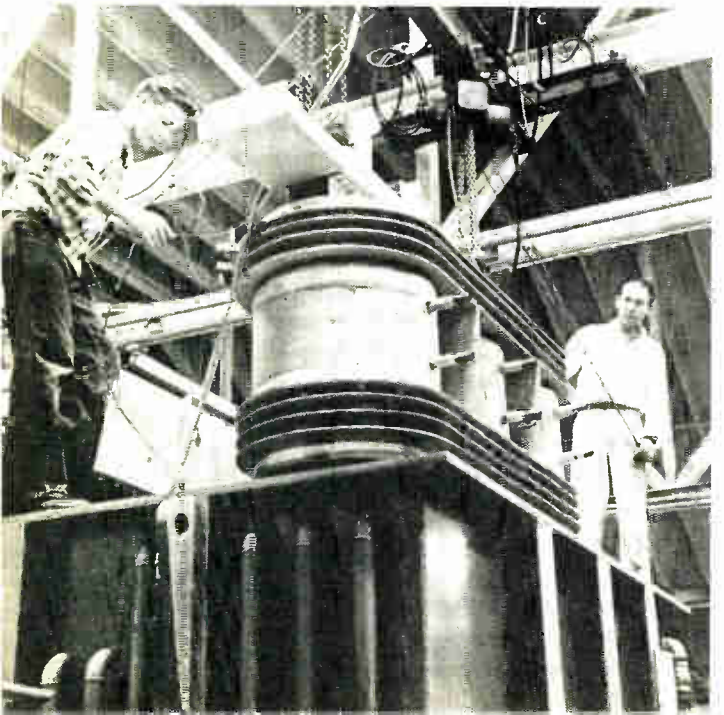
ANTENNAS FOR B-70

Transco Products, Inc., Los Angeles, will design and develop antennas for the B-70. These will include three L-Band IFF-TACAN units, two UHF communications antennas and one for Marker Receiver. Company will also do the environmental testing.

Snapshots . . . of the Electronic Industries

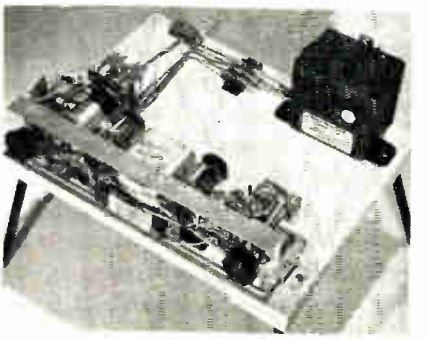
FOR KLYSTRON TESTING

This power supply (274,000 volts; 1 ampere, DC) will be used in processing and testing high power klystron tubes for the missile tracking radar system of Nike-Zeus. Electro Engineering Works, San Leandro, Calif., developed the power supply. Levinthal Electronic Products, Inc., Palo Alto, Calif., will use it. Total power supply weighs over 75 tons.



LOOP ANTENNAS

Dr. Raymond A. Santirocco, astrophysicist at Stromberg-Carlson's Research Div., examines arrangement of loop antennas to be used in study of variations of earth's magnetic field. Each of 10 loops has approx. 12 miles of wire.

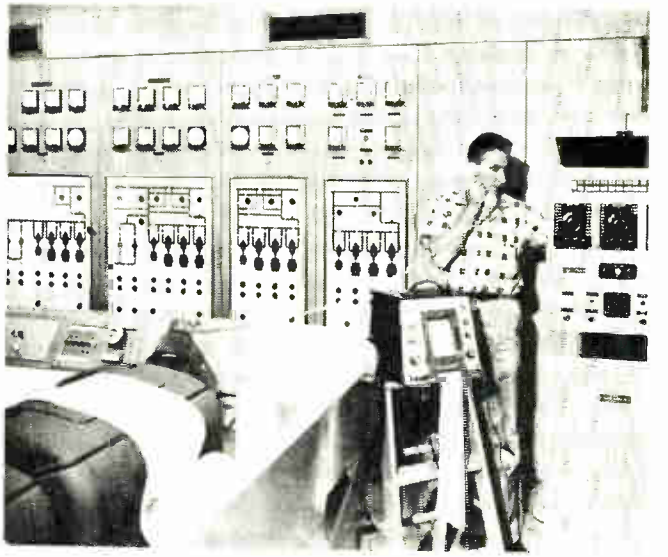


NEAR ALARM SYSTEM

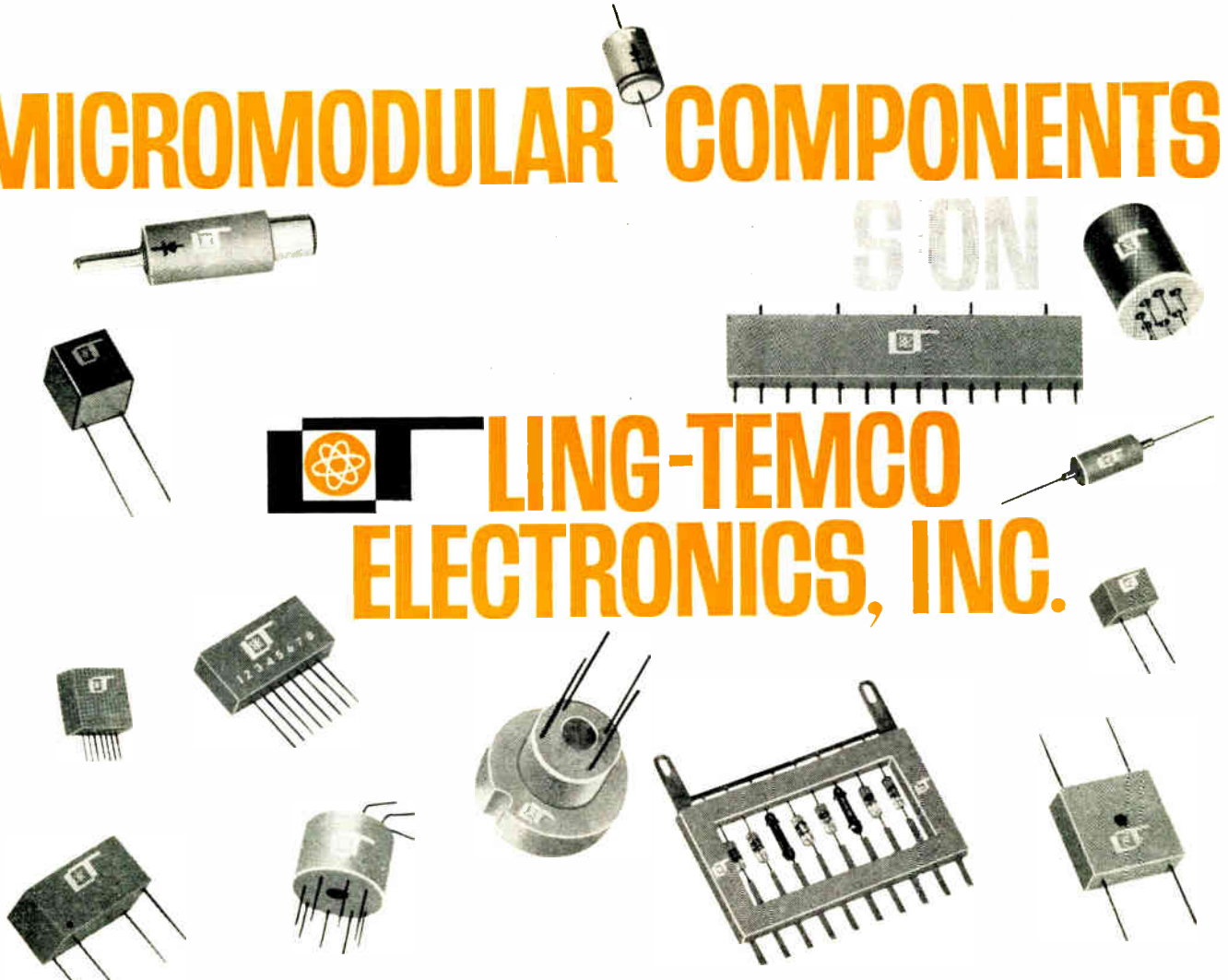
"Breadboard" hook-up of a "Compactron" table radio with a NEAR (National Emergency Alarm Repeater) receiver. 240 cycle alarm pulse turns on receiver. Office of Civil and Defense Mobilization tested alarm system developed by Midwest Research Institute recently in Charlotte, Mich. G.E. radio contains two "Compactrons," in lieu of tubes or transistors.

CONTROL OIL FLOW

Brush Instruments' Mark II recorders check out and maintain, continuously, code systems for controlling, selecting, and measuring storage tank levels at unattended pumping stations for moving crude oil from West Texas to Houston. Recorders also keep records for reference.



MICROMODULAR COMPONENTS



LING-TEMCO ELECTRONICS, INC.

Ling-Temco Electronics, Inc., is pleased to announce the establishment of a new Micromodular Components Division. This complete new division is housed in a new 22,000 square foot modern plant at Anaheim, California. The staff comprises a corps of industry-qualified, applications-minded engineer-scientists intimately familiar with the stringent performance and high reliability requirements imposed by today's "Electronic Systems Manufacturers." This newest Division will specialize in the manufacture of subminiaturized high and low-voltage rectifiers, semi-conductor logic circuits and custom miniaturized modular packaging. Design counseling, relative to circuit configuration, choice of component, subminiaturization and reliability problems, will be provided at no additional cost.

The Micromodular Components Division welcomes your inquiries and assures you immediate response to any requests. Write or phone for prices, product data sheets, quotations or deliveries. MICROMODULAR COMPONENTS, a Division of Temco Electronics & Missiles Co., P. O. Box S-1, Phone JEfferson 4-6000, Anaheim, California.

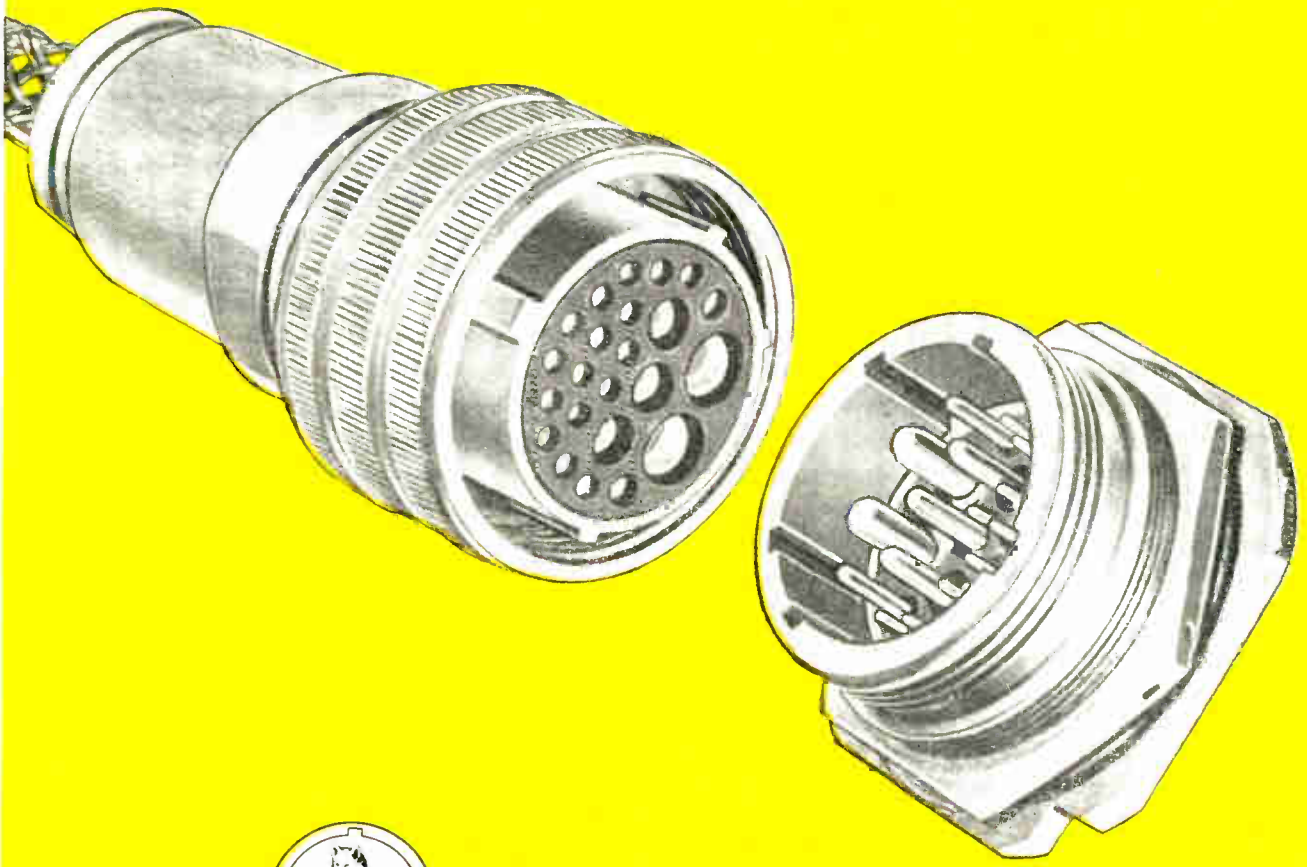
LING-TEMCO ELECTRONICS, INC.

The Ling-Temco Group • Widening Circles of Influence in Electronics

Altec Lansing Corporation, Subsidiary • Altec Service Company, Subsidiary • The Calidyne Company, Inc., Division • Continental Electronics Manufacturing Company, Subsidiary • The Electron Corporation, Subsidiary • Fenske, Fedrick & Miller, Inc., Subsidiary • Ling Electronics Division • Peerless Electrical Products Division • Temco Electronics & Missiles Company, Subsidiary • Micromodular Components Division • Temco Overhaul & Aerosystems Division • Temco Electronics Division • Temco Missiles Division • Temco Industrial Division • United Electronics Company, Subsidiary • University Loudspeakers, Inc., Division.

Circle 360 on Inquiry Card

NEW FROM BENDIX



QWLD ELECTRICAL CONNECTORS

FOR MISSILE GROUND SUPPORT EQUIPMENT

WITH SUCH OUTSTANDING ADVANTAGES AS:

FIVE INTEGRAL KEYS AND KEYWAYS that provide for positive polarization and positive mating—even in blind locations. ***No possible contact damage.*** QWLD connectors can be fully mated and unmated by hand.

HEAVY-DUTY CONSTRUCTION through use of extra-heavy machined or forged aluminum shell components, resilient inserts, silver-plated copper alloy contacts, and rugged cable accessories with new superior gasket design.

TWO NEW SERIES AVAILABLE with the QWLD having standard solder or solderless contacts and the QWLG having provisions for grounding one contact to the shell.

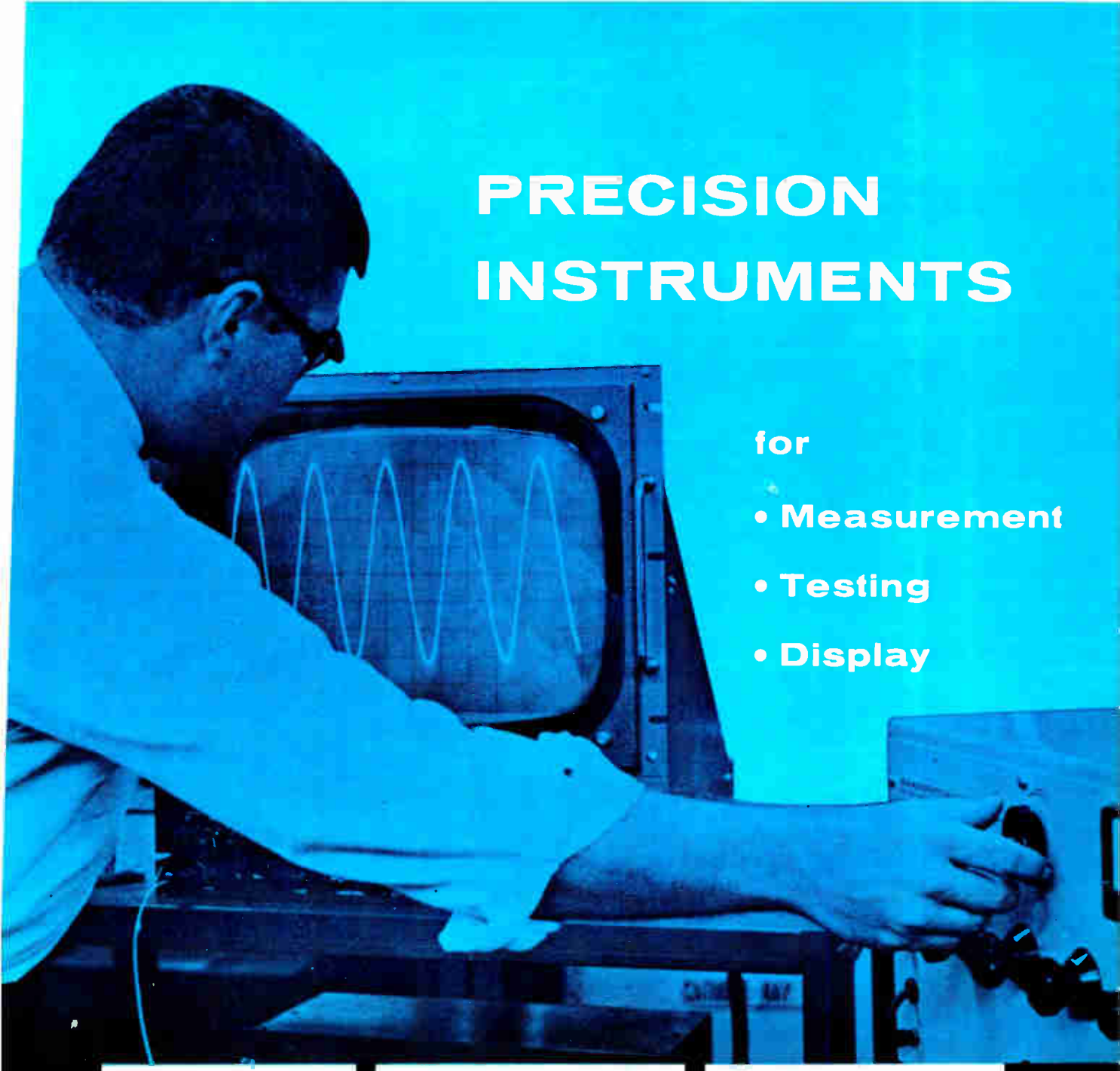
PLUS . . . IMPROVED WATERPROOFING • CLOSED ENTRY SOCKET CONTACTS • SELF-EJECTING COUPLING ACTION • DESIGNED TO MEET MILITARY SPECIFICATIONS • WIDEST RANGE OF CABLE ACCESSORIES.

QWLD is the latest development in Scintilla's long line of multiple conductor cable connectors—and is specially designed to meet the rugged environmental conditions of missile launching equipment, ground radar, or power and control circuits—and heavy-duty industrial applications such as are found in oil fields or mining. Be sure to investigate the new QWLD HUS-KEY* Connectors from Scintilla.

*TRADEMARK

Scintilla Division
SIDNEY, NEW YORK

THE Bendix CORPORATION



PRECISION INSTRUMENTS

for

- Measurement
- Testing
- Display

IIPD

Industrial Products Division

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

15191 Bledsoe Street • San Fernando, California • EMpire 7-6161

Industrial Products Division

HIGH STABILITY OSCILLATOR

MODEL 810

FEATURES

- Stability—4 parts in 10^{10}/day
- Long Term Reliability
- Small Size
- Rugged Construction
- Modular Design
- Low Weight
- Low Power Consumption

FREQUENCY SYNTHESIZERS

Crystal Accuracy 0.1 cps to 30 KMC

FEATURES

- Decade calibration
- Measures or generates to crystal accuracy
- Extreme versatility
- All components available separately
- Simple operation
- Applications: frequency drift recording... crystal control of klystrons... equipment calibration

STORASCOPE®

new high speed electronic recorder

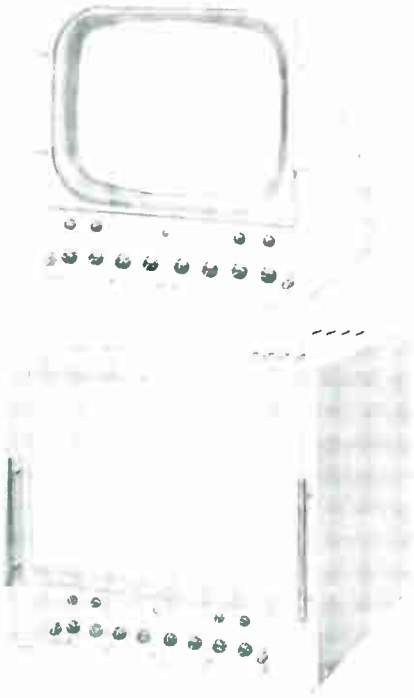
FEATURES

- 1 through 10 channel display
- Useful to 10 KC
- Automatic consecutive trace positioning
- Easily photographed trace
- Unlimited storage time
- Short erase time
- Instantaneous recording
- Automatic protection against CRT burns
- Simple operation

MODEL ST-100 AIR-SUSPENDED VIBRATION EXCITER

FEATURES:

- No measurable distortion to 10 KC
- First major resonance above 12 KC
- Shock testing to over 3,000 g
- Useful frequency range exceeds 50 KC
- 50 force-pound rated output
- Handles test samples up to 5 lbs.
- Simple to operate—even by unskilled personnel

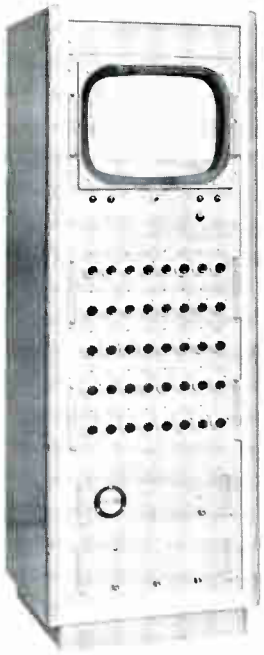


LARGE SCREEN OSCILLOSCOPES

MODELS 1735D, 1740D, 2135D, and 2140D

FEATURES

- High Resolution
- 1% Linearity
- Calibrated Time Base — 10 microseconds/inch to 1 second inch
- Driven or recurrent sweeps
- Stable DC Amplifiers
- Gain controls calibrated directly in volts inch
- Sensitivity: 10 millivolts inch or 1 millivolt inch
- Equivalent to 50 inches undistorted deflection and positioning on both X and Y axes for low-frequency signals
- Dependability guaranteed through careful workmanship and design
- Performance unaffected by line voltage changes from 105-125 volts
- Ideal for Telemetering, Production Testing, Waveform Analysis, Computer Readout, X-Y Plotting with identical calibrated high-gain amplifiers and similar applications
- Oscilloscope screens available in all standard phosphors



BAR-GRAPH OSCILLOSCOPES

DC-40BG & AC-40BG

FEATURES

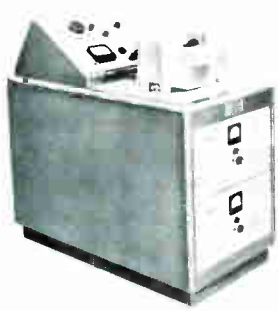
- Provides "quick-look" display of up to 40 variables for continuous monitoring, measurement and observation of drift and changes.
- Floating inputs with excellent common mode rejection provide a high degree of flexibility.
- Human error and fatigue are minimized by means of large, accurate display.
- Ultra-stable circuits provide high accuracy. Performance is unaffected by line voltage variations.
- Provides unexcelled display for production control, research and engineering, teaching and graphic demonstrations.
- Provides sensitivity in the millivolt range.
- The output of each of the 40 channels is scanned ten times per second by means of a synchronous motor-driven switch.
- Individual channel ON-OFF switches provide convenience in setting up special displays and for positive identification of channels. Individual channel attenuators facilitate sensitivity control.
- Unit is completely self-contained and caster-mounted.

MONITOR OSCILLOSCOPES

MODELS 1770A and 1770H

- High Resolution
- 1% Linearity
- Stable DC Amplifiers
- Sensitivity continuously variable from 0 to 1 inch per volt
- Performance unaffected by line voltage changes from 105-125 volts
- Ideal for Telemetering, Production Testing, Waveform Analysis, Computer Readout, X-Y Plotting with identical calibrated amplifiers and similar applications
- Oscilloscope screens available in all standard phosphors

• WITH INTEGRATED SYSTEMS FOR SHOCK AND VIBRATION TESTING



Model 1201

For vibration testing, the ITT Model 1201 is a completely self-contained console built around the ST-100 fifty force-pound Vibration Exciter.

Model 1205

For vibration and shock testing, the ITT Model 1205 offers all the features of the vibration console, plus shock test facilities.

For complete technical data and applications information on any ITT Instrument, contact your ITT Instruments representative or write directly to the factory.

ITT

Industrial Products Division

INTERNATIONAL TELEPHONE & TELEGRAPH CORPORATION

15191 BLEDSOE STREET • SAN FERNANDO, CALIFORNIA

TELEPHONE EMPIRE 7-6161

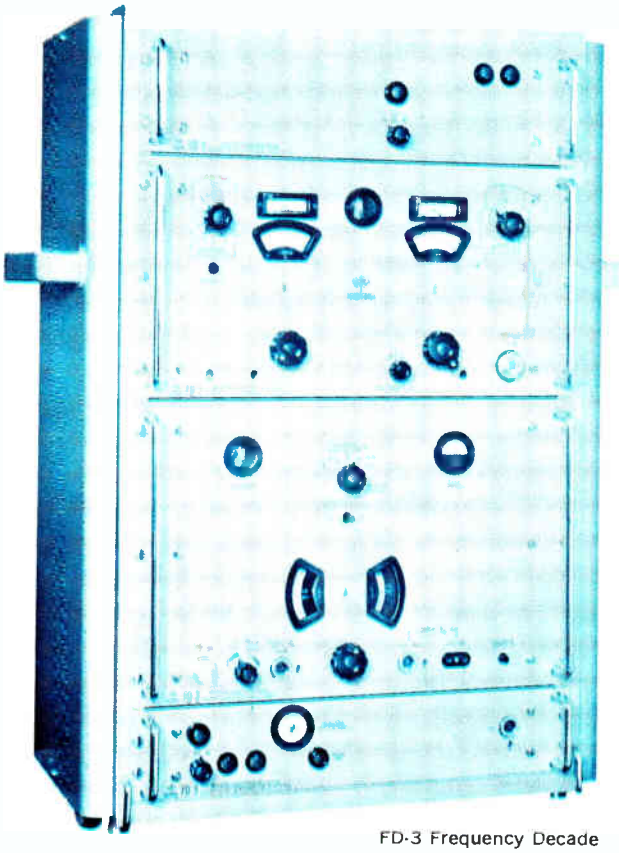
WITH ITT DECADE FREQUENCY SYNTHESIZER*

MICROWAVE FREQUENCY SYNTHESIS TO 30 KMC

WITH CRYSTAL SOURCE ACCURACY AND STABILITY

- Output frequency phase locked to reference source
- Generates fundamental frequency from 300 to 1000 mc
- Referenced from internal or external frequency standard
- Simple operation and rugged construction

The FD-3 Frequency Decade measures or generates frequencies from 300 mc to 12.6 K mc with the accuracy and stability of the self-contained 100 KC crystal source to which the output frequency is phase locked. Fundamental output of the FD-3 is from 300 to 1000 mc. A mixer unit is supplied which extends the range to 12.6 K mc. Other mixers are available to further extend the range up to 30 K mc.



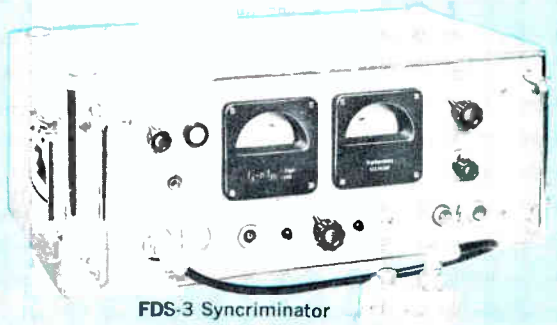
FD-3 Frequency Decade

- Telemetry
- Microwave spectroscopy
- Manufacture and test of microwave frequency meters
- Calibration of microwave signal generators
- High precision research on substance characteristics in microwave region (permability curves, dielectric constants, loss factors, etc.)

Frequency Range:	
Fundamental	300-1000 mc
Harmonic (with mixer supplied)	600 mc to 12.6 K mc
Harmonic (with additional mixers)	up to 30 K mc
Accuracy and Stability	equals that of 100 Kc standard
Stability (internal crystal standard)	2 x 10^{-8}/day
Output (fundamental)	approx. 1 milliwatt

PLUS FREQUENCY CONTROLLED POWER OUTPUT

The FDS-3 Syncriminator permits phase locking of klystrons and backward wave oscillators to the crystal accuracy of the FD-3 Synthesizer. This is accomplished by automatic control of reflector voltage through the Syncriminator. Hence, by cascading one or more klystrons — frequency-controlled by a like number of FDS-3 Syncriminators — stabilized power output can be generated up to the ultimate frequency range of available klystrons.



FDS-3 Syncriminator

Synthesizers for other frequency ranges and a wide variety of accessory units are also available. For complete data and specifications, contact your ITT Instruments representative, or write directly to the factory.

ITT Industrial Products Division
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION
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* DESIGNED AND MANUFACTURED FOR ITT BY SCHOMANDL OF MUNICH, GERMANY

A HISTORIC TELEPHONE EXPERIMENT BEGINS IN AN ILLINOIS TOWN

New technology brings the dream of an electronic central office to reality . . . foreshadows new kinds of telephone service.

Today, the science of communications reaches dramatically into space, bouncing messages off satellites. But an equally exciting frontier lies closer to home. Bell Telephone Laboratories engineers have created a revolutionary new central office. At Morris, Illinois, an experimental model of it has been linked to the Bell System communications network and is being tried out in actual service with a small group of customers.

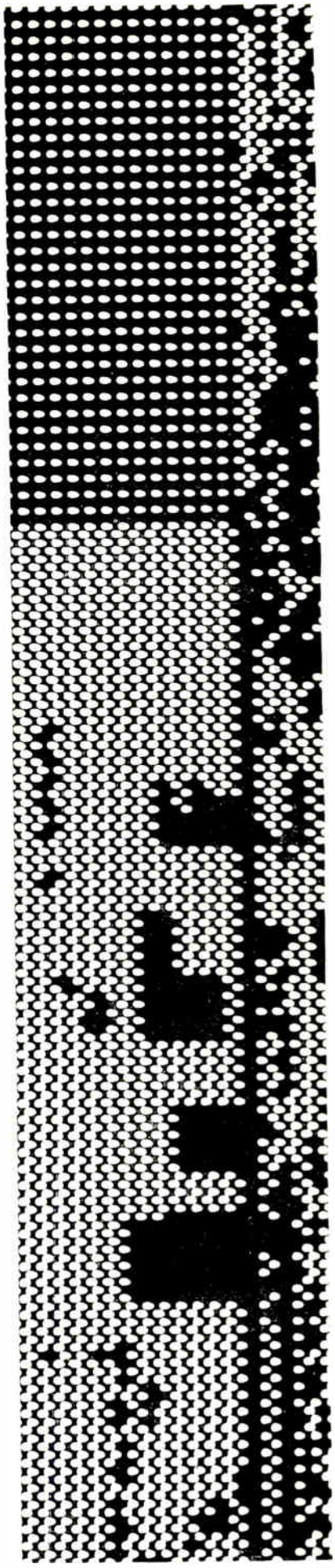
This is a special electronic central office which does not depend on mechanical relays or electromagnets. A photographic plate is its permanent memory. Its "scratch pad," or temporary memory, is a barrier grid storage tube. Gas-filled tubes make all connections. Transistor circuits provide the logic.

The new central office is versatile, fast and compact. Because it can store and use enormous amounts of information, it makes possible new kinds of services that will be explored in Morris. For example, some day it may be feasible for you to ring other extensions in your home . . . to dial people you frequently call merely by dialing two digits . . . to have your calls transferred to a friend's house where you are spending the evening . . . to have other numbers called in sequence when a particular phone is busy.

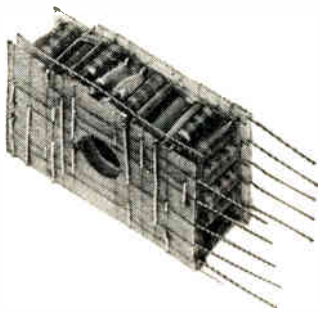
The idea behind the new central office was understood 20 years ago, but first Bell Laboratories engineers had to create new technology and devices to bring it into being. A Bell Laboratories invention, the transistor, is indispensable to its economy and reliability.

This new experiment in switching technology is another example of how Bell Telephone Laboratories works to improve your Bell communications services.

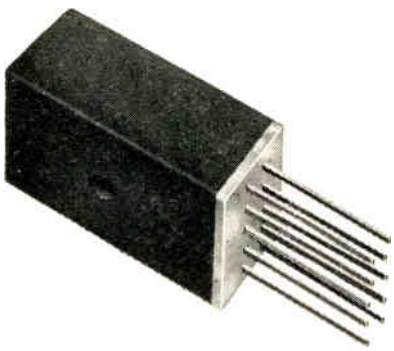
BELL TELEPHONE LABORATORIES
World center of communications research and development



Part of a memory plate of the new electronic central office is shown at right (enlarged 8 times). Spots are coded instructions which guide the system in handling calls and keeping itself in top operating form. Over two million spots are required. Logic and memory are physically separated in the machine, so new functions can be easily added. The experiment is being conducted in co-operation with the Illinois Bell Telephone Company and the Western Electric Company.



how do you play the numbers game?



The current numbers game consists of seeing how many components you can wedge into a small space. But there's a catch to it.

Some circuit modules may seem small until you string them together and find that interconnections and supporting structure take more space than the modules themselves. That's why it's important, in evaluating miniaturization, not to consider the module size alone, but to be concerned with the over-all size, including module, interconnections, and supporting structure.

New **EECO MINIWELD** circuit modules are designed with over-all system size in mind. They offer optimum miniaturization not only of modules, but also of interconnections and supporting structure. Add to this the reliability of proven circuits incorporating readily available standard catalog components rather than hard-to-get specials, the superior strength of welded rather than soldered connections, and you have an unbeatable combination of advantages.

ENGINEERED ELECTRONICS Company

Write, wire, or 'phone today for detailed information on the revolutionary new MINIWELD space-saving package.

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Coming Events in the electronic industry

Dec. 1-2: 11th Nat'l PGVC Annual Meeting Conf., IRE (PGVC); Sheraton Hotel, Phila., Pa.

Dec 3-6: 4th Annual Int'l Visual Communications Congress, Assoc. of Prof. Draftsmen, Amer. Inst. for Design and Drafting & Soc. of Reproduction Engrs Co-Sponsors; Hotel Sherman, Chicago, Ill.

Dec. 4-7: Annual Meeting of the Amer. Inst. of Chemical Engrs., incl. sections on Nuclear Reactor Operations & Nuclear Chemical Plant Safety, AIChE; Washington, D. C.

Dec. 4-9: Annual Meeting of the Radiological Soc. of North America, RSNA; Cincinnati, Ohio.

Dec. 5-7: 3rd EIA Conf. on Maintainability of Electronic Eqpt., EIA w/ Coop. DOD; Granada Hotel, San Antonio, Tex.

Dec. 5-8: 3rd Nat'l Conf. on the Application of Electrical Insul., AIEE, NEMA; Conrad-Hilton, Hotel, Chicago, Ill.

Dec. 5-9: Pest Control by Radiation Symp., Int'l Atomic Energy Agency; India.

Dec. 5-9: Symp. on Radioisotopes & Radiation in Entomology. Int'l Atomic Energy Agency; Trombay, India.

Dec. 7: 1st Annual Insul. Progress Dinner (in conj. with 1960 Nat'l Conf. on Application of Electrical Insul., NEMA; Conrad-Hilton Hotel, Chicago, Ill.

Dec. 7-9: 65th Annual Congress of American Industry, Nat'l Assoc. of Mfrs; Waldorf-Astoria Hotel, New York, N. Y.

Dec. 10: Electronic Industry Social Committee Christmas Party, EP & EM, Inc.; Chicago, Ill.

Dec. 11-14: Joint Industry M'tgs of the Material Handling Inst., College Industry Committee on Material Handling Education, The Industrial Truck Assoc., Assoc. of Lift Truck & Portable Elevator M'frs, Monorail M'ftrs Assoc.; Savoy Hilton Hotel, New York, N. Y.

Dec. 12: Annual M'tg., Metal Cutting Knife Assoc.; Pittsburgh Hilton Hotel, Pittsburgh, Pa.

Dec. 12-14: Int'l Scientific Radio Union URSI-IRE Fall M'tg., URSI, PGAP, PGI, PGCT, PGIT, PGMTT; NBS Boulder Labs, Boulder, Colo.

Dec. 12-15: Winter M'tg. of American Nuclear Soc., incl. 8th Conf. on Hot Labs & Eqpt., ANS; Mark Hopkins Hotel, San Francisco, Calif.

Dec. 12-15: ATOMFAIR - WEST — Atomic Industrial Forum; Masonic Memorial Bldg., San Francisco, Calif.

"CALL FOR PAPERS"

American Mathematical Soc., Jan. 24-27, 1961, Wash., D. C. Deadline date for scientific papers and exhibits: Dec. 9, 1960; Feb. 22, 1961, Yeshiva Univ., N. Y. Deadline date: Jan. 10, 1961; Aug., 1961, Stillwater, Okla. Deadline date: Jan. 10, 1961; Nov. 17-18, Milwaukee, Wisc. Deadline date: Jan. 10, 1961. Contact: Mrs. Robert Drew-Bear, Head, Special Project Dept., AMS, 190 Hope St., Providence, 6, R. I.

Symp. on Materials and Electron Device Processing, Apr. 10-12, 1961, Franklin Institute, Phila., Pa. Submit title and 200-word abstract to Dr. D. E. Koontz, Bell Tel. Labs., Murray Hill, N. J. no later than Jan. 2, 1961. Manuscripts by Feb. 15, 1961.

7th Region, IRE Annual Tech. Mtg., Apr. 26-28, 1961, Westward Ho Hotel, Phoenix, Ariz. Final abstracts deadline: Jan. 1, 1961. Forward to: H. W. Welch, Jr., Motorola, Inc., 8201 E. McDowell Rd., Scottsdale, Ariz.

The Electrochemical Society, Inc., Apr. 30, May 1-4, 1961. Claypool Hotel, Indianapolis, Ind.; Abstracts, not to exceed 75 words in length. Submit in triplicate to Society Hdqs. not later than Jan. 2, 1961. Indicate Symp. and author's name. Send complete manuscripts to Mgt. Editor of Journal, same address.

Plastics for Tooling, Reg. Tech. Conf., April 25, 1961, Indianapolis, Ind. Deadline date for proposal to present papers—Jan. 1, 1961. For info. write to: Milton Brummer, Sect. Pres., 4241 Marrison Place, Indianapolis, Ind. **Plastics in Automotive Industry, Reg. Tech. Conf., May 9, 1961, Detroit, Mich.** Deadline date for proposal to present papers—Jan. 15, 1961. For info. write to: John D. Young, Sect. Pres., 13000 W. Mile Rd., Detroit 35, Mich.

39th Annual Conv. of Nat'l Assoc. of Broadcasters & Broadcast Engineering Conf., May 7-11, 1961, Shoreham & Sheraton Park Hotels, Wash., D. C. Deadline for submission of topics for engineering papers is 15 Dec. 1960. Contact A. Prose Walker, Mgr. of Engineering, NAB, 1771 N St. N. W. Wash., D. C. for more info.

(*Continued on page* 24)

Dec. 12-16: Use of Radioisotopes in the Study of Endemic & Tropical Medicine Reg. Symp., Int'l Atomic Energy Agency, WHO; Bangkok, Thailand.

Dec. 13-15: 10th Annual Eastern Joint Computer Conf. (EJCC), Nat'l Joint Computer Comm: PGEC, ACM, IRE, AIEE; Hotel New Yorker & Manhattan Center, N. Y.

Dec. 14-16: 1960 Annual Conf. of the Atomic Indust. Forum, AIF, ANS; Fairmont Hotel, San Francisco, Calif.

Dec. 16-17: Combined Analog Digital Computer Systems Symp., Simulation Councils, Inc. and Missile & Space Vehicle Dept., G.E. Co., Phila., Pa.; Sheraton Hotel, Penn Center Plaza, Phila., Pa.

Dec. 17: Wright Bros. Lecture, IAS; Natural History Bldg.-Audit. Smithsonian Inst., Washington, D. C.

Dec. 19: Purchasing Agents of the Radio, TV & Electronics Industry; Gov. Clinton Hotel, New York, N. Y.

Dec. 26-30: AAAS Annual Expos. of Science & Industry (127th Meeting); Biltmore Hotel, New York, N. Y.

Dec. 29-31: Amer. Physical Soc. M'tg., APS; Berkeley, Calif.

Dec. 29-31: Symp. on Strong Interactions, AFOSR. Nuclear Physics, Amer. Instit. of Physics & AEC; Univ. of Calif., Berkeley, Calif.

ABBREVIATIONS

ACM: Assoc. for Computing Machinery
AEC: Atomic Energy Commission
AFOSR: Air Force Office of Scientific Research
AIChE: American Institute of Chemical Engineers
AIEE: American Institute of Electrical Engineers
AIF: Atomic Industrial Forum
ANS: American Nuclear Society
APS: American Physical Society
ARS: American Rocket Society
ASME: American Society for Mechanical Engineers
ASQC: American Society for Quality Control
DOD: Department of Defense
EIA: Electronic Industries Association
EJCC: Eastern Joint Computer Conference
IAS: Institute of Aeronautical Sciences
IRE: Institute of Radio Engineers
ISA: Instrument Society of America
NEC: National Electronics Conference
NEMA: National Electrical Manufacturer's Association
PGANE: Prof. Group on Aeronautical & Navigational Electronics
PGAP: Prof. Group on Antennas & Propagation
PGCS: Prof. Group on Communications Systems
PGEC: Prof. Group on Electronic Computers
PGI: Prof. Group of Instrumentation
PGIT: Prof. Group on Information Theory
PGMTT: Prof. Group on Microwave Theory and Techniques
PGVC: Prof. Group on Vehicular Communications
SMPTE: Society of Motion Picture and TV Engineers
WEMA: Western Electronic Manufacturer's Association
WHO: World Health Organization

Coming Events

"CALL FOR PAPERS"

(*Continued from page 23*)

1961 Western Joint Computer Conf., May 9-11. The Ambassador Hotel, Los Angeles, Calif. Detailed summaries of papers by Dec. 15 to C. T. Leondes, Assoc. Prof. of Eng'g, Dept. of Eng'g, Univ. of Calif., Los Angeles 24, Calif. Final papers due on March 15, 1961.

1961 Nat'l Symp. of Prof. Group on Microwave Theory and Techniques, IRE, May 15-17, 1961, Sheraton Park Hotel, Wash., D. C. Original papers in all fields of Microwave Research, Development and Application. 500-word summaries by Dec. 12, 1960, to: Gustave Shapiro, Chairman, Tech. Prog. Comm., Eng'g Electronics Sec., Nat'l Bureau of Standards, Wash. 25, D. C.

National Telemetering Conf., May 22-24, 1961, Sheraton - Towers Hotel, Chicago, Ill. Deadline dates: Abstracts: Dec. 15, 1960, Papers: Mar. 1, 1961. Contact: Jack W. Becker, Dept. 32-29, A-C Spark Plug Div., GMC, Milwaukee 1, Wisc.

American Society for Testing Materials Annual Meeting, ASTM, June 25-30, 1961, Chalfonte-Haddon Hall, Atlantic City, N. J. Deadline for papers is January, 1961. Contact Society Hdqs., 1916 Race St., Phila. 3, Pa.

2nd Joint Automatic Control Conf., June 28-30, 1961; Univ. of Colo. Campus, Boulder, Colo., AIEE, ISA, AIChE, ASME and IRE. Submit brief abstracts immediately with rough draft of entire paper by this year's end. Forward to appropriate chairman: ISA—J. L. Harned, Research Lab., General Motors Corp., Warren, Mich. AIChe—Nathan Gilbert, Chem. Eng'g Dept., Univ. of Cincinnati, Cincinnati 21, Ohio. AIEE—Kan Chen, New Products Lab., Westinghouse Electric Corp., P. O. Box 10596, Pittsburgh 35, Pa. ASME—R. E. Kalman, Research Inst. for Advanced Study, 7212 Bellona Ave., Baltimore 12, Md. IRE—Robert Kramer, Electronic Systems Lab., M.I.T., Cambridge 39, Mass.

International Symp. on the Transmission and Processing of Info., Sept. 6-8, 1961, M.I.T., Cambridge, Mass. Receipt of 500-1000 word Abstracts . . . Jan. 1, 1961. Receipt of full length papers . . . Apr. 1, 1961. Submit to: Peter Elias, Research Lab of Electronics, M.I.T., Cambridge 39, Mass.

PSI MICRO-MESA SILICON DIODES

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- *A totally new approach to equipment design!*
- *A totally new concept of cost!*

PSI Micro-Diodes with their companion Micro-Transistors, offer exciting new opportunities to the imaginative circuit designer. They make possible revolutionary new mounting techniques... techniques contributing substantially to higher performance, higher reliability and *lower construction* costs!

And now eleven new Micro-Mesas have been added to the extensive line of PSI Micro-Diodes. These new types offer capacitance as low as 2 pf... recovery as fast as 2 nanoseconds as well as unusually low stored charge.

Note these outstanding specifications!

PSI TYPE	FORWARD CURRENT @ 1 Vdc (mA)	BREAKDOWN VOLTAGE @ 100 μA (volts)	CAPAC. @ 0 Vdc (pf)	INVERSE CURRENT 25°C (μA)	INVERSE CURRENT 150°C (μA)	REV. RECOV.* (nanosec.)	100 LEVEL PRICE
PD301	10	50	4	.025 (–20V)	50 (–20V)	4	$2.85
PD305	10	100	4	.025 (–20V) 5.0 (–75V)	50 (–20V)	4	4.50
PD306	10	50	2	.025 (–20V) 5.0 (–75V)	50 –20V)	4	4.25
PD311	10	75 @ 5μA	2	.1 (–50V)	100 (–50V)	2	5.00

*Switching 10mA to –6 volts recovery to 1mA.

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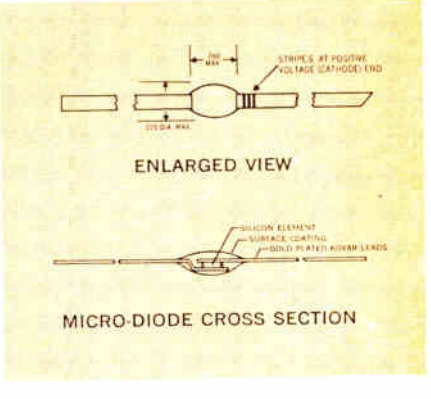

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This new Philco Germanium MADT is specifically designed for high-speed switching applications and is the ideal NOR logic transistor. The MADT Precision-Etch* process makes it possible to manufacture the 2N779 with the tightest control of parameters of any transistor in the entire industry. This extreme uniformity greatly simplifies the design of high performance, low cost switching circuits. For complete data and information, write Dept. EI1260.

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MADT® 2N779

ABSOLUTE MAXIMUM RATINGS

Storage Temperature	−65°C to +100°C
Collector Voltage, V_{CES}	−15 volts
Total Device Dissipation at 25°C	60 mw

ELECTRICAL CHARACTERISTICS (T=25°C)

	Min.	Typ.	Max.	
Static Characteristics				
Collector Cutoff Current, I_{CBO} (V_{CB} = −5v)		1.0	3	μa
DC Current Amplification Factor, h_{FE} (V_{CE} = −0.5v, I_C = −10 ma)	50	90	200	
Base Voltage, V_{BE} (I_C = −10 ma, I_B = −0.5 ma)	0.29	0.33	0.36	volt
Collector Saturation Voltage, V_{CE} (SAT) (I_C = −10 ma, I_B = −0.5 ma)	.09	0.12	0.16	volt
High Frequency Characteristics				
Output Capacitance, C_{ob} (V_{CB} = −3v, I_E = 0, f = 4 mc)		1.9	2.5	μμf
Input Capacitance, C_{ib} (V_{EB} = −1v, I_C = 0, f = 4 mc)		6.0	10	μμf
Gain Bandwidth Product, f_T (V_{CE} = −5v, I_E = 7 ma)	320	450		mc
Switching Characteristics				
Rise Time, t_r (β_C = 10)		13	18	mμsec
Hole Storage Factor, K'_s		39	50	mμsec
Fall Time, t_f (β_{CO} = 10)		10	19	mμsec

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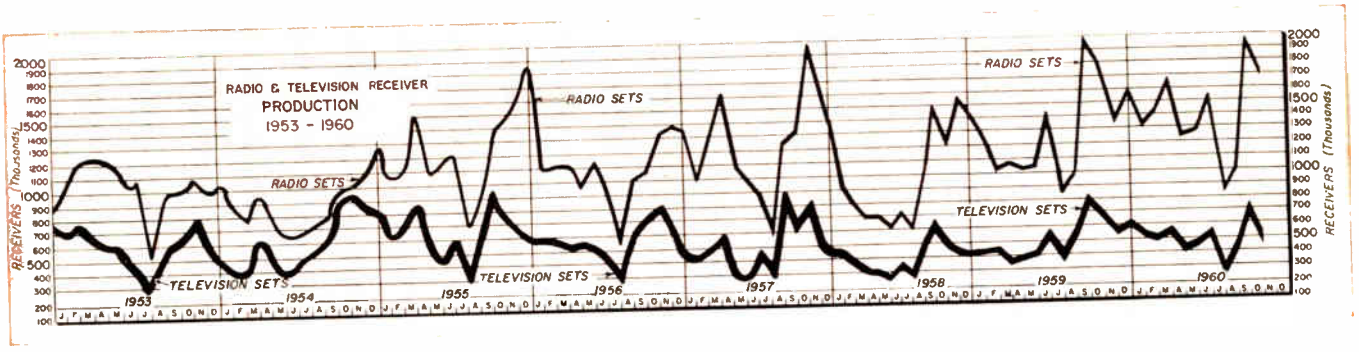

GOVERNMENT ELECTRONIC CONTRACT AWARDS

This list classifies and gives the value of electronic equipment selected from contracts awarded by government agencies in October, 1960.

Amplifiers	65,832
Amplifiers, electronic control	270,223
Amplifiers, r-f	54,252
Analyzers, spectrum	43,367
Antennas	369,507
Attenuators, variable	26,220
Banners, radar reflective	300,601
Batteries	443,278
Batteries, dry	2,099,208
Batteries, storage	384,012
Bases, mast	26,163
Beacons, radio	105,575
Buffers, synchronizer	69,480
Cable assemblies	31,995
Cable, coaxial	82,257
Cable, power	744,524
Cable, telephone	801,069
Calibrators, pulse power	59,500
Clocks, digital	121,750
Coder-indicators	257,339
Coil-tube	44,800
Communications set	122,519
Computers, lift	42,398
Covers, radar set	25,808
Gyros, rate	172,059
Headsets	31,737
Indicators	30,650
Intercom sets	763,579
Loops, antenna	172,800
Loudspeakers	174,151
Meters, frequency	27,171
Microphones	48,800
Noise sources, i-f	48,214
Oscilloscopes	34,574
Panels, relay	32,095
Power supplies	124,186
Probes, hall effect	47,090
Radars	45,594
Radar surveillance equipment	1,410,208
Radio sets	2,126,434
Receivers	173,115
Receiver/transmitters	446,916
Receivers, warning	150,000
Relays	31,052
Relay assemblies	39,337
Relays, solenoid	26,010
Recorders, data	133,954
Recorders, depth	29,942
Recorder/reproducers	141,848
Rectifiers, controlled	40,000
Resistors, variable	25,460
Resolvers	88,084
Servo units	74,065
Sets, detecting	385,474
Shelters, antenna	103,616
Signal generators	216,336
Slotted line-waveguide	341,226
Spectrometers, mass	69,150
Spectrum analyzers	110,184
Standards, frequency	214,503
Systems, telephone carrier	40,354
Tape assembly	42,952
Tape, magnetic	386,266
Test sets, electron tube	508,528
Test equipment, servo	293,934
Transmitters	1,150,055
Transformers, pulse	172,934
Tubes, electron	2,561,389
Tubes, klystron	1,068,415
Tubes, magnetron	84,435
Tuning units	185,309

FACTORY SALES OF ELECTRONIC GOODS

Year	Consumer products	Industrial products	Military products	Replacement parts, tubes semiconductors	Total
1950	$1,500	$ 350	$ 500	$250	$2,600
1951	1,400	450	1,050	350	3,250
1952	1,300	500	2,050	400	4,250
1953	1,400	600	2,650	500	5,150
1954	1,400	650	2,700	650	5,400
1955	1,500	750	2,800	750	5,800
1956	1,600	950	3,450	850	6,850
1957	1,700	1,300	4,100	900	8,000
1958	1,600	1,380	4,400	860	8,240
1959	2,000	1,600	4,700	900	9,200

Source—Electronic Industries Assoc.

ESTIMATED JAPANESE ELECTRONICS OUTPUT

The Japanese Ministry of Trade and Industry (MITI) has revised upward its recent estimates of Japanese electronics output during the five-year period 1960-1964. They now show a projected estimate of overall production for the year 1964 at a level 82% above actual production in 1959, the Electronics Division, B.D.S.A., U.S. Department of Commerce, reported. This 1964 output figure would be at the rate of about $1.8 billion. A tentative estimate announced by MITI in May this year called for an increase of 32%.

Significant upward revisions were made in estimated production of industrial electronic equipment, tape recorders and other acoustic apparatus, receiving tubes, and transistors.

Projected estimates show a decrease in the output of monochrome television receivers and a sharp increase in color television receivers. It is expected that emphasis will be placed on television receivers using transistors.

The plan assumes steady growth in transistor radio exports—an increase of 27% from 1960 to 1961; an increase of 10% annually in 1961 and 1962; and an annual rise of 5% in 1963 and 1964.

	1960	1961	1962	1963	1964
Electronic Equipment	259,400	277,460	295,600	326,930	405,110
X-ray Equipment	2,180	2,300	2,410	2,550	2,700
Electron Tubes	59,520	65,300	75,820	82,700	85,860
Semiconductor Devices	27,000	36,000	45,000	51,000	54,000
Electronic Components	44,460	55,280	66,570	76,820	83,040
TOTAL	392,560	436,520	485,400	540,000	630,710

Note: 360 yen = $1.00

News Briefs

Capsule summaries of important happenings in affairs of equipment and component manufacturers

EAST

ARCO ELECTRONICS has signed a long-term lease on 46,000 sq. ft. of space at Lake Success Business and Professional Park in Lake Success, N. Y.

PHILCO has established a fifth division within its Government & Industrial Group, an outgrowth of the Communications Systems Dept. It will be headquartered in the new 70,000 sq. ft. "Philco" Building at Fort Washington Industrial Park, Fort Washington, Pa.

SYLVANIA ELECTRIC PRODUCTS, INC., a subsidiary of General Telephone & Electronics Corp., has begun construction of a new Electron Tube and Development Center at Emporium, Penna., with occupancy planned for mid-1961. Also, Sylvania's Special Tube Operations has changed its name to Microwave Device Operations.

W. L. MAXSON's Langevin Transformer Div. has been sold to Intercontinental Electronics Corp. (INTEC). Presently located at Old Forge, Pa., the Division will be moved to a 16,000 sq. ft. facility in the Westbury Industrial Park, Westbury, N. Y. There it will be integrated with INTEC's Magnetics Dept. to form a new Division called the Intecoil Manufacturing Div. of INTEC.

REFLECTONE ELECTRONICS has broken ground for its new Florida facility on a 10-acre site in Plantation, near Fort Lauderdale, where production of components and advanced R&D activities will take place in the field of Electronic Simulation and Control.

REPUBLIC AVIATION CORP. has installed a 14-foot wide, 30-foot long Space Chamber in its newly developed $14 million R&D Center, Farmingdale, L. I., N. Y. The $500,000 Chamber's capability extends to 1,600,000 ft. or more than 300 miles above the earth in simulated space flight, measured by new ARDC standards.

TELECHROME MANUFACTURING CORP. is constructing a 40,000 sq. ft. addition to its existing plant in Amityville, L. I., N. Y., to be completed by Feb., 1961. It will include a two-story section to house executive offices, as well as expanded engineering, manufacturing, and laboratory facilities.

AIR SUPPLY-AERO ENGINEERING CO., division of the Garrett Corp., has moved its Mineola, L. I., N. Y., office to 600 Old Country Road, Garden City, L. I., N. Y.

MINNEAPOLIS HONEYWELL REGULATOR CO. has changed the name of its Datamatic Div. to Electronic Data Processing Div.

TERMINAL ELECTRONICS, INC. and **HUDSON RADIO and TV CORP.** have merged to form Terminal-Hudson Electronic, Inc., N. Y. C., with combined U. S. and Overseas sales exceeding $10 million annually.

SUTTON ELECTRONIC CO., Lexington, Ky., division of Nytronics, Inc., will be known as the Automation Products Division.

MICROWAVE DYNAMICS CORP., Plainview, L. I., N. Y., a new subsidiary of Talley Industries, Inc., is located in a new 17,000 sq. ft. plant at 7 Fairchild Court, providing facilities for R&D, manufacturing and administration.

SANDERS ASSOCIATES, INC., Nashua, N. H., will purchase a new production and engineering facility of 50,000 sq. ft. in Plainfield, L. I., N. Y. This is the first step of a major facility expansion program totalling over $2 million.

ADLER ELECTRONICS, INC., New Rochelle, N. Y., has doubled production capacity with the addition of a new 55,000 sq. ft. plant in Pelham, N. Y.

AEROTRON, producer of two-way radio communications equipment, has moved into its new 26,000 sq. ft. building in Raleigh, N. C.

GEOPHYSICS CORP. OF AMERICA has transferred its corporate offices and R&D facilities to new quarters at Burlington Road, Bedford, Mass., from 700 Commonwealth Ave., Boston, Mass.

PRECISION CIRCUITS, INC., manufacturer of military and commercial printed wiring boards and assemblies, has opened its new plant at 85 Weyman Ave., New Rochelle, N. Y.

ESPEY MANUFACTURING & ELECTRONICS CORP. has completed its 5,000 sq. ft. Quality Control Building at the Saratoga Springs, N. Y., Headquarters.

WARD INDUSTRIES CORP., N. Y., and **IDAHO MARYLAND INDUSTRIES, INC.**, Los Angeles, will merge, subject to the approval of the Boards and Shareholders of both companies.

SYNTHANE CORP., Oaks, Pa., has now installed complete West Coast fabricating facilities for its industrial laminated plastics, within a year after having established its first Pacific Coast fabricating plant at 518 Garfield Ave., Glendale, Calif.

MIDWEST

RCA has opened the fourth in its nationwide chain of Electronic Data Processing Centers in the Morton Salt Building, 110 North Wacker Drive, Chicago, Ill.

MALLORY CONTROLS CO., a division of P. R. Mallory & Co., has started construction of a new 140,000 sq. ft. plant on a 45-acre tract in Frankfort, Indiana.

DALE ELECTRONICS, INC., Columbus, Nebraska, recently involved in a multi-million dollar merger with Hathaway Instruments, Inc., Denver, Colorado, has acquired Sioux Radio Products of Yankton, S. D., a nine-year-old firm producing coils and ferrite antennas for radio and television.

ZENITH RADIO CORP. has broken ground for a new plant to be built on a 30-acre tract at Grandview Ave and Route 133, Paris, Illinois, by Central Electronics, Inc., a wholly owned subsidiary.

LYTLE CORP. has concluded negotiations with Industrial Development Engineering Associates, Inc. (IDEA), which gives Lytle the option to purchase, at a future date, all of the outstanding stock of IDEA. In addition, Lytle will furnish IDEA financial and advisory management assistance.

COOK ELECTRIC CO. has acquired N.R.K. Mfg. & Engineering Co. N.R.K. operations will be transferred to a new 42,000 sq. ft. building in the Cook Technological Center, Morton Grove, Illinois.

GENERAL ELECTRONIC CONTROL, INC., Minneapolis, Minn., has acquired the Standard Electrical Products Co. of Dayton, Ohio, and three Standard subsidiaries in Indiana, California and Puerto Rico.

BURTON-RODGERS, INC., has changed its corporate name to Burtek, Inc. The company, formed in 1955, is now in process of relocating its headquarters in Tulsa, Okla.

WEST

CUTLER-HAMMER, INC., has begun operations in its new plant, with 35,000 sq. ft. of floor space housing the company's manufacturing, sales office and warehouse facilities. Plant is located in the newly developed Belmont Industrial Area, San Francisco, Calif.

EMERSON ELECTRIC MANUFACTURING CO., has established an Electronic Acoustic Research (EAR) Div. to develop advanced anti-submarine weapons for the Navy. Headquarters is in Santa Barbara, Calif.

CHANCE VOUGHT AIRCRAFT, INC., Dallas, Texas, took preliminary steps to change its name by dropping out the word "Aircraft." This action will reflect the company's diversity more accurately. Besides aircraft, the company is now functioning in electronics, astronautics, industrial automation, business data processing, mobile homes, and missiles & satellite range systems.

SPEC-TRONICS new $250,000 Headquarters facility, located at 13901 Saticoy St., Van Nuys, Calif., houses full office, production and engineering departments in 14,000 sq. ft. of space, with a 3,500 sq. ft. outside patio for employee relaxation.

PACIFIC SCIENTIFIC COMPANY, Bell Gardens, Calif., has changed the name of its Aeronautical Div. to the "Aerospace" Div., because of the company's increasing role in missile and space age projects.

LABORATORY FOR ELECTRONICS, INC., has established a West Coast facility named "Monterey Laboratory" in Monterey, Calif. Prime responsibility will be operations analysis and computer programming for all LFE systems work.

FLUOROCARBON CO., Southern Calif. producers of fluorocarbon plastics, has purchased the assets of the Kel-F plastic division of Raco Engineering Co., Santa Monica, Calif. Transfer to Fluorocarbon's new plant at 1754 S. Clementine St. has been completed and full production resumed.

LEACH CORPORATION, Compton, Calif., has purchased all the physical assets of Phillip Morris Co.'s liquidated U. S. Relay Co.—a 48,000 sq. ft. facility, complete with a "White" room, air-conditioning, test equipment, etc.

WELEX ELECTRONICS CORP. will obtain full status as a direct Halliburton Company, Duncan, Okla., subsidiary upon transfer of ownership, operations and management to direct parent company control.

F. L. MOSELEY CO., a subsidiary of Hewlett-Packard Co., has completed a new 30,000 sq. ft. manufacturing facility at 45 Eureka St., Pasadena, Calif., adjacent to Moseley's Headquarters Building at 409 N. Fair Oaks Ave.

GULTON INDUSTRIES, INC., has acquired in Los Angeles, the electronics business interests of Electric Machinery Manufacturing Co.'s Mullenbach Div., a subsidiary of Worthington Corp., Metuchen, N. J.

LOCKHEED AIRCRAFT CORP., Burbank, Calif., will secure a new Hyper-Environmental Space Simulation Test Chamber, designed and built by the Space Technology Div., Guardite Company, Wheeling, Illinois. It will be installed in the new Lockheed Environmental Sciences Facility at Rye Canyon, Saugus, Calif. With all accessories, it will have an ultimate vacuum capacity for simulating an altitude of 2,300,000 feet, or more than 400 miles.

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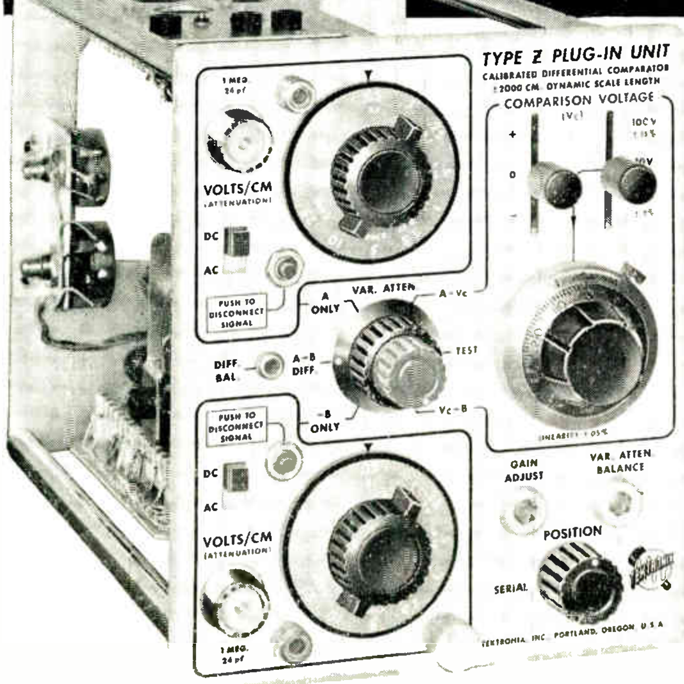
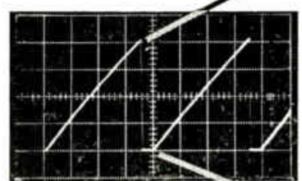


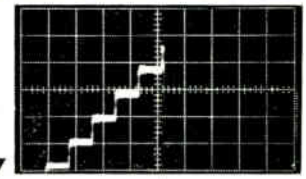
Waveform Details of a 100-v Staircase

Vertical Expansion 500 Times

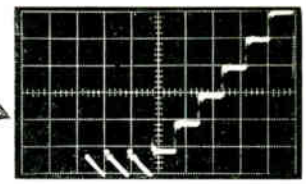
Horizontal Expansion 500 Times



Vertical	Horizontal
25 v/cm	5 ms/cm
$V_C = 0$	



Vertical	Horizontal
50 mv/cm	10 μsec/cm
$V_C = +92.5$	



Vertical	Horizontal
50 mv/cm	10 μsec/cm
$V_C = -5.5$	

TYPICAL APPLICATIONS

FAST-RECOVERY AMPLIFIER—observe small signals riding with large gates.

MODULATION MONITOR—measure amplitude modulation on a digital train pulse.

HIGH-AMPLITUDE HUM REJECTION—reject up to 200 volts peak-to-peak common-mode hum.

SEMICONDUCTOR CHARACTERISTICS—measure Zener diode ac impedance and Zener voltage together, measure transistor output impedance.

PULSE-HEIGHT ANALYSIS—select any pulse above a preset dc level.

COMPONENT MATCHING—check components to easily-interpreted tolerances.

MAIN CHARACTERISTICS

3 Modes of Operation—as a conventional preamplifier, as a differential-input preamplifier, or as a calibrated differential comparator.

50-mv/cm Sensitivity—nine calibrated attenuation steps to 25 v/cm.

Wide Passband—dc to 13 mc with Tektronix fast-rise scopes.

±100-volt Dynamic Range—permits common-mode signals up to 100 volts to be applied to the unit without attenuation.

40,000 to 1 Common-mode Rejection Ratio—allows measurement of differential signals less than 50 millivolts.

Comparison Voltage Accuracy—within 0.25% on the ±1-volt scale; within 0.20% on the ±10-volt scale; within 0.15% on the ±100-volt scale.

Safety Feature—the Type Z eliminates "floating oscilloscope" operation.

AC and DC VTVM—extends oscilloscope accuracy in both ac and dc voltage measurements to 0.2%.

Price, Type Z Plug-in Unit, f.o.b. factory **$525**

New differential plug-in preamplifier rejects up to 100 v of an input signal . . . accepts 100-v waveforms for oscilloscope display at 50-mv/cm sensitivity . . . provides an equivalent vertical scale length of ±2000 centimeters.

You can now display small segments of large waveforms at maximum oscilloscope sensitivity, with vertical expansion equivalent to as much as 500 times. You can select magnified "window" displays of all portions of a waveform, and make amplitude measurements with a degree of accuracy that closely approaches the possibilities of digital techniques. The flexibility and simplicity of the analog (oscilloscope) presentation is retained for accurate analyses of complex waveforms.

The new Type Z Plug-In Unit is a triple-purpose device, acting also as a conventional preamplifier and a differential-input preamplifier. It can be used in all Tektronix Type 530, 540, 550, and *580 Series Oscilloscopes. Ask your Tektronix Field Engineer to demonstrate the dynamic range, waveform resolution, and amplitude accuracy of the Type Z in your application.

**with Type 81 Adapter.*

Tektronix, Inc.

P. O. Box 500 • Beaverton, Oregon

Phone MItchell 4-0161 • TWX—BEAV 311 • Cable: TEKTRONIX

TEKTRONIX FIELD OFFICES: [illegible] • Cleveland, Ohio • Dallas, Texas • [illegible] • Detroit (Lathrup Village, Mich.) • [illegible] • Indianapolis, [illegible] • Los Angeles Area [illegible] • New York City Area [illegible] • Orlando, Fla. • Philadelphia, Pa. • Phoenix (Scottsdale, Ariz.) • [illegible] • San Diego, Calif. • San Francisco (Palo Alto, Calif.) • [illegible] • Toronto [illegible]

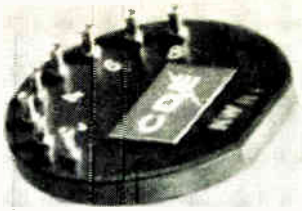
TEKTRONIX ENGINEERING REPRESENTATIVES: [illegible]

In Europe please write Tektronix Inc., Victoria Ave., St Sampsons, Guernsey C.I., for the address of the Tektronix Representative in your country.

Circle 12 on Inquiry Card

flying high

At one time this five section mica capacitor bank was considered "blue sky"; today it is flying high in General Electric's DJ 113 Fuel Flow Meter Indicator. The breakthrough in conventional mica shape limitations came because only CDE has its own complete mica fabrication facilities. The result: a yield several times more capacity per unit of volume than conventional capacitor designs. The main capacitor section delivers .125 plus or minus .00125 microfarads and has a temperature coefficient of 50 parts per million per degree centi-



grade. By combining the remaining four sections, the value of capacitance can be trimmed from .1255 microfarads to .1320 microfarads in thirteen incremental steps of 500 micro-microfarads. And all this in a disc less than .2" thick and under 2" in diameter! Today, as an integral part of fast-growing Federal Pacific Electric Company, CDE is ready and able to help you get your capacitor problems off the ground. Just a call will send us flying. Cornell-Dubilier Electronics Division, Mica Department, 55 Cromwell St., Providence, R. I.

CORNELL-DUBILIER ELECTRONICS DIV. CDE FEDERAL PACIFIC ELECTRIC COMPANY

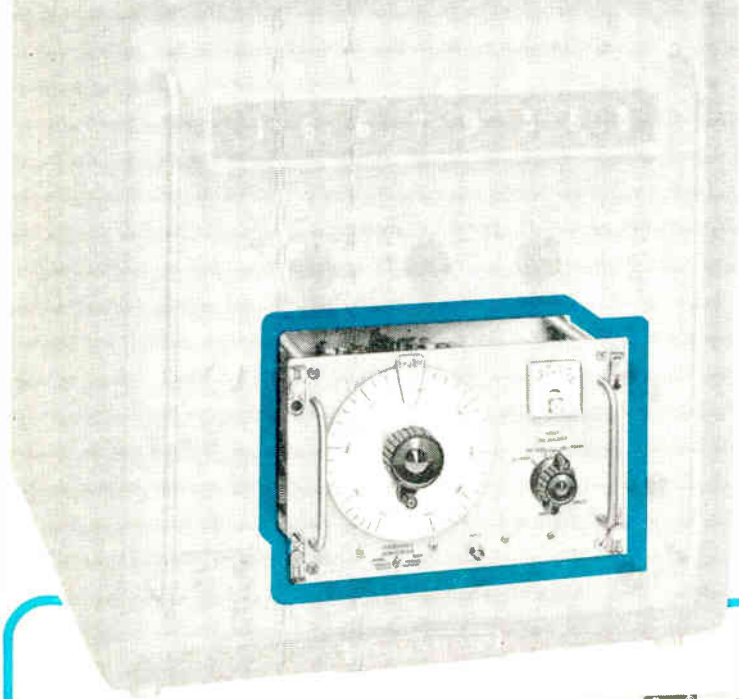
growth through creative energy

• FILTERS • DELAY LINES • PULSE NETWORKS • SEMICONDUCTORS • VIBRATORS • POWER SUPPLIES • RELAYS • ANTENNA ROTORS

Circle 365 on Inquiry Card

This new, inexpensive hp plug-in lets you

MEASURE to 500 MC - with

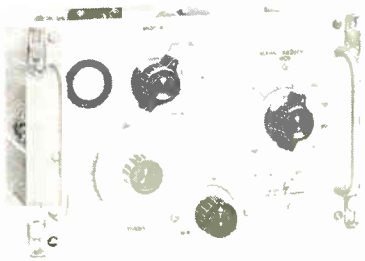


Simple operation with plug-ins—high sensitivity—ideal for telemetering, mobile, production, general purpose measurements

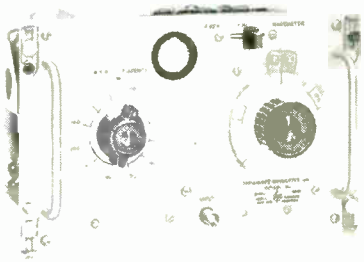
Now hp offers a completely new, 500 MC plug-in—materially improving the versatility and usefulness, as well

Still more versatility for 524 series counters!
Order the measuring capability you need now—later add other plug-ins to increase counter usefulness.

hp 525A Frequency Converter
$250.00, extends counter range to 100 MC



hp 525B Frequency Converter
$250.00, extends range to 220 MC



hp IS HEADQUARTERS FOR ELECTRONIC COUNTERS

Standard of the industry for frequency, period, phase and time interval measurement—accurate, dependable, versatile, economical!

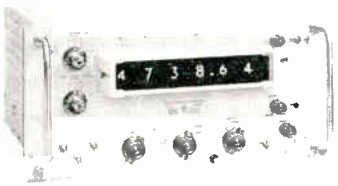
hp 524C/CR ELECTRONIC COUNTERS (shown above)

Measure to 10.1 MC individually, to 500 MC with plug-ins, to 18 KMC with external accessories*. The hp 524C/CR also measures time interval 1 μsec to 100 days or period 0 cps to 100 KC, automatically, directly, without tedious calculation or interpolation. Big, bright in-line readout. Maximum resolution 0.1 μsec; stability $3/10^8$ short term and $5/10^8$ per week. High sensitivity, high impedance, hp 524C (cabinet—shown above) $2,300.00; hp 524CR (rack mount) $2,275.00.

hp 524D/DR Electronic Counter

Offers electronic features identical to those of hp 524C/CR except that it has eight-place neon columnar readout. hp 524D (cabinet) $2,150.00; hp 524DR (rack mount) $2,125.00.

with hp 540B Transfer Oscillator and hp P932A Waveguide Mixer



hp 523CR ELECTRONIC COUNTER

10 cps to 1.2 MC with new 0.1 v sensitivity. Bright in-line readout. Measures time interval 1 μsec to 10^6 sec and period 0.00001 cps to 100 KC and phase angle. Stability $2/10^6$ per week. Improved circuitry prevents triggering by unwanted signals, noise. Results appear in seconds, msec, μsec or KC with automatic decimal. hp 523CR (rack mount) $1,485.00.

hp 523DR Electronic Counter

Offers electronic features identical with those of hp 523CR but has six-place neon columnar readout. hp 523DR (rack mount) $1,285.00.

COUNTER ACCURACY!

as frequency range, of popular hp 524 series 10 MC electronic counters.

Combined with the hp 524C 10 MC counter, for example, the 525C plug-in offers measurement with high sensitivity to 500 MC yet retains measurement accuracy and even increases resolution at high frequencies. Also preserved are 524C measuring ease, digital recorder output capability and its big, bright in-line display.

Specifications hp 525C

Range: Counter converter, 100 to 500 MC; counter amplifier, 50 KC to 10.1 MC. Direct connection for 0 to 10.1 MC.

Accuracy: Retains accuracy of 524 Counter.

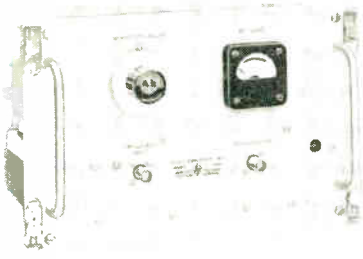
Registration: 9 places, 1st two on converter dial, next 7 displayed by counter.

Input Voltage: 20 mv rms min., 50 KC to 10.1 MC; 100 mv rms min., 100 to 500 MC.

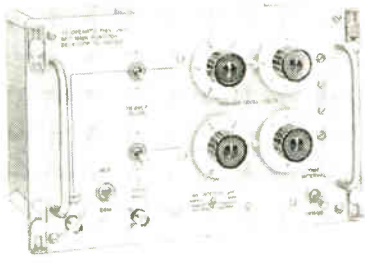
Input Impedance: Approx. 700 ohms, 50 KC to 10.1 MC. Approx. 50 ohms, 100 MC to 510 MC.

Price: hp 525C, $425.00.

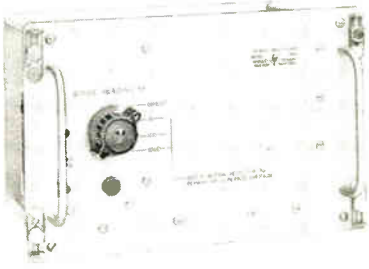
hp 526A Video Amplifier
$175.00, increases sensitivity to 10 mv



hp 526B Time Interval Unit
$175.00, for time interval measurement 1 μsec to 10^7 sec.



hp 526C Period Multiplier
$225.00, increases period measuring accuracy with 100, 1,000, 10,000 cycle multiples



hp 522B/BR ELECTRONIC COUNTER

Popular hp 522B/BR measures frequency 10 cps to 120 KC, period 0.00001 cps to 10 KC, time interval 10 μsec to 10^5 sec. Reads direct in cps, KC, seconds, milliseconds. Time base stability $1/10^5$ per week; counts automatically, resets, action repetitive. Applications include measurement of production line quantities, nuclear radiation, power line frequencies, very low frequencies, and, with transducers, a wide array of physical quantities and phenomena. hp 522B (cabinet) $915.00; hp 522BR (rack mount) $900.00.

hp 521 INDUSTRIAL COUNTERS

hp offers five Model 521 counters, all useful in measuring frequency, random events per unit of time, and, with transducers, speed, rps, rpm, weight, pressure, temperature, etc. Direct readings, display time variable or "hold"; four instruments cover frequency range 1 cps to 120 KC; the fifth measures to 1.2 MC. Two models with big, bright, in-line numeric readout, three with columnar neon display. Prices, $475.00 to $875.00. Cabinet and rack mounts available.

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

See your nearest hp representative or write direct for information, demonstration of any hp electronic counter.

HEWLETT-PACKARD COMPANY
1053B Page Mill Road Palo Alto, California, U.S.A.
Cable "HEWPACK" DAvenport 6-7000
Sales representatives in all principal areas

HEWLETT-PACKARD S. A.
Rue du Vieux Billard No. 1 Geneva, Switzerland
Cable "HEWPACKSA" Tel. No. (022) 26. 43. 36

International News

(*Continued from Page 32*)

U. S. Election Story Told in Esperanto

In its current campaign to inform listeners abroad about the U. S. election process, the U. S. Information Agency's Voice of America is broadcasting in 36 languages—the newest is Esperanto.

Esperanto is a constructed international language based on the elements of most European tongues. It is used with some degree of regularity by an estimated 600,000 people around the world.

A series of six VOA broadcasts in Esperanto this spring resulted in over 1,000 letters of comment—many from behind the Iron Curtain.

New Subsidiary Formed

Leach Corp., Compton, Calif., has formed an international subsidiary, Leach International, S.A. It will begin marketing Leach products in the European common market. It also plans to engage in manufacturing abroad.

The first European office is being opened in Switzerland under general supervision of R. T. Mathias, director of European operations. Kenneth F. Julin, President of Leach, estimates the European market potential at between $200 million and $250 million in the next two to three years.

Visit American Plant

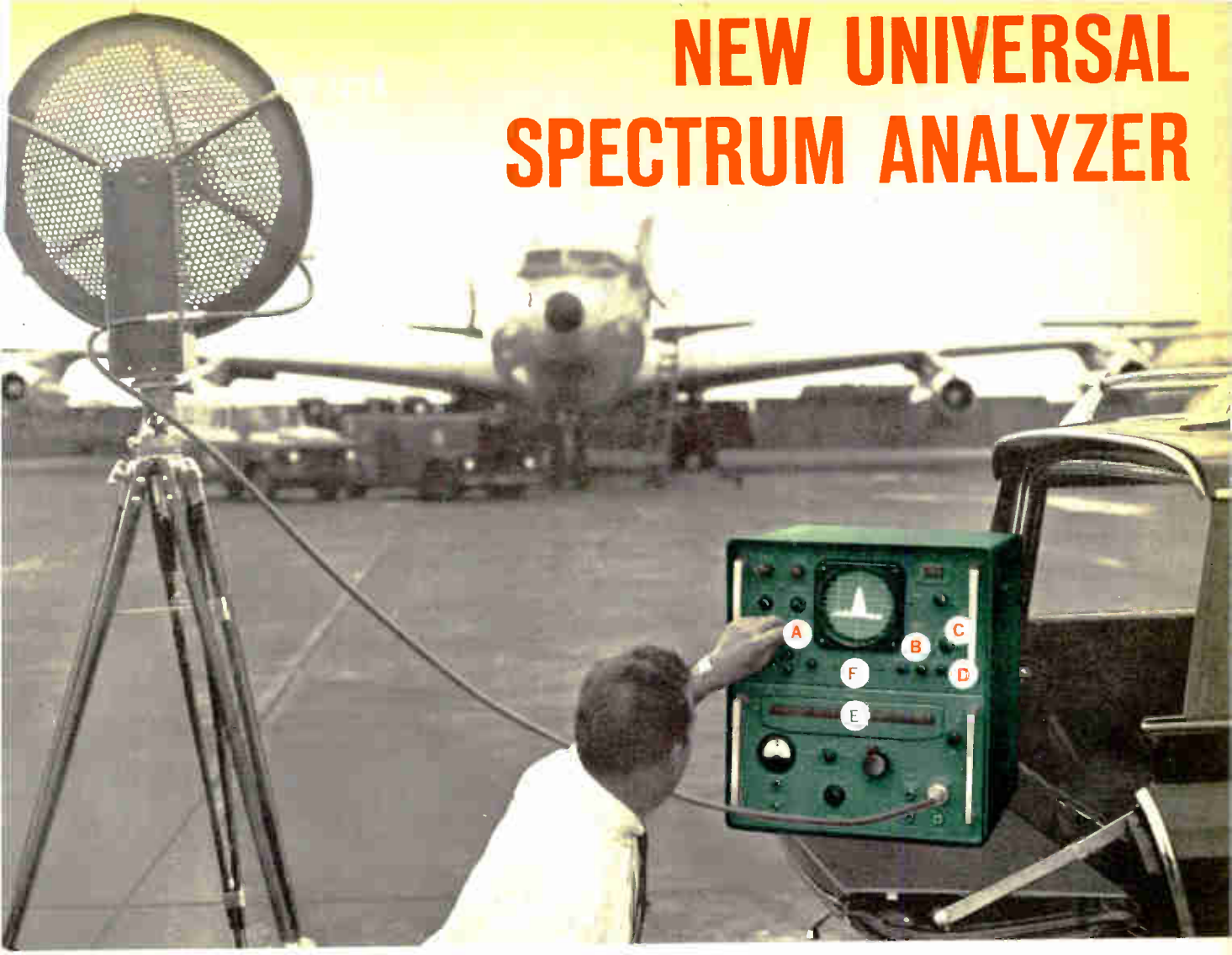
Palo-Alto, Calif.—Brig. Gen. M. Ribes of the French Dept. of Defense has visited Varian Associates' plant on an official observation trip for the French Government. He was here to observe work being done in areas of supergeneration, semiconductor devices, and microelectronics. Visit was part of U. S. and French efforts to coordinate European defense plans.

Loan To Israel for Telephone System

Washington—The Development Loan Fund has approved a U. S. Government loan to the Government of Israel to finance part of the foreign-exchange cost of materials, equipment, and services associated with an overall expansion program for the Israeli telephone system. An estimated $8,000,000 will be spent for items from the U. S.

The project will provide service to 51,500 new subscribers, complete a fully automatic subscriber toll dialing system, and expand toll facilities.

NEW UNIVERSAL SPECTRUM ANALYZER



Polarad Model SA-84W being used to make pulse analysis of radar aboard a Pan American Boeing 707, Jet Clipper®

MODEL SA-84W 10 to 44,000 MC in a single unit

FEATURES:

A **Over 80 mc dispersion**
1 mc to over 80 mc for narrow pulse analysis.

100 kc to 7 mc for wide pulse analysis.

A **Dual Resolution**
7 kc or 50 kc automatically set by dispersion control.

B **Crystal controlled markers from 10 to 44,000 mc.**

C **Provision for use with a multi-pulse spectrum decoder (Polarad Model SD-1)**

D **Log-linear amplifiers**

E **Expanded, direct-reading, slide rule dial.**

F **Accurately calibrated IF attenuator**

The Polarad Model SA-84W is the most accurate universal microwave analyzer to measure nearly all parameters — Pulse, CW, FM, VSWR, antenna patterns, bandwidths and filter characteristics.

FREE LIFETIME SERVICE ON ALL POLARAD INSTRUMENTS

MAIL THIS CARD for specifications. Ask your nearest Polarad representative (in the Yellow Pages) for a copy of "Notes on Microwave Measurements."

POLARAD ELECTRONICS CORPORATION

43-20 34th Street, Long Island City 1, N.Y.
Representatives in principal cities.

POLARAD ELECTRONICS CORPORATION: 123456789

Please send me information and specifications on:

POLARAD

- ☐ Model SA-84W Universal Spectrum Analyzer
- ☐ Model SD-1 Multi-Pulse Spectrum Selector (see reverse side of page)

My application is_____

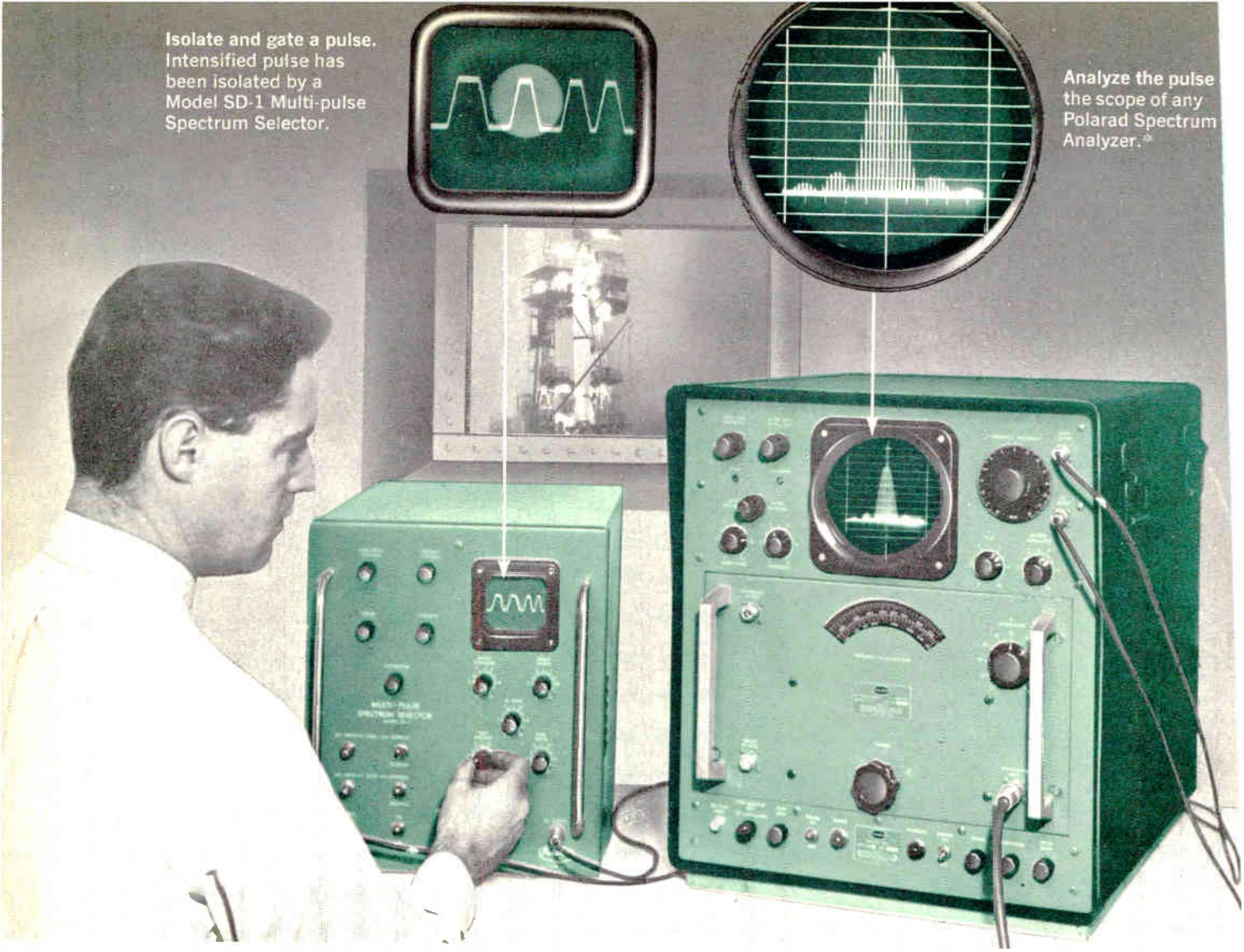
Name_____

Title_____ Dept._____

Company_____

Address_____

City_____ Zone_____ State_____



COMPLEX SPECTRUM DECODING

10 to 44,000 mc.

Signal Analysis for Missiles, Telemetry, IFF, Beacons and Radar

The Polarad spectrum selector permits spectrum analysis and decoding of any selected pulse within a multiple pulse train. Sweep, gate width and position can be controlled. Model SD-1 permits the selection and gating of a group of pulses up to 180 μsec. in length (Model SD-IX permits 350 μsec.)

Works with POLARAD Models TSA, TSA-S, TSA-W, SA-84 and SA-84W spectrum analyzers.

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States.

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Newest, Smallest Bourns Trimpot® —with the square configuration

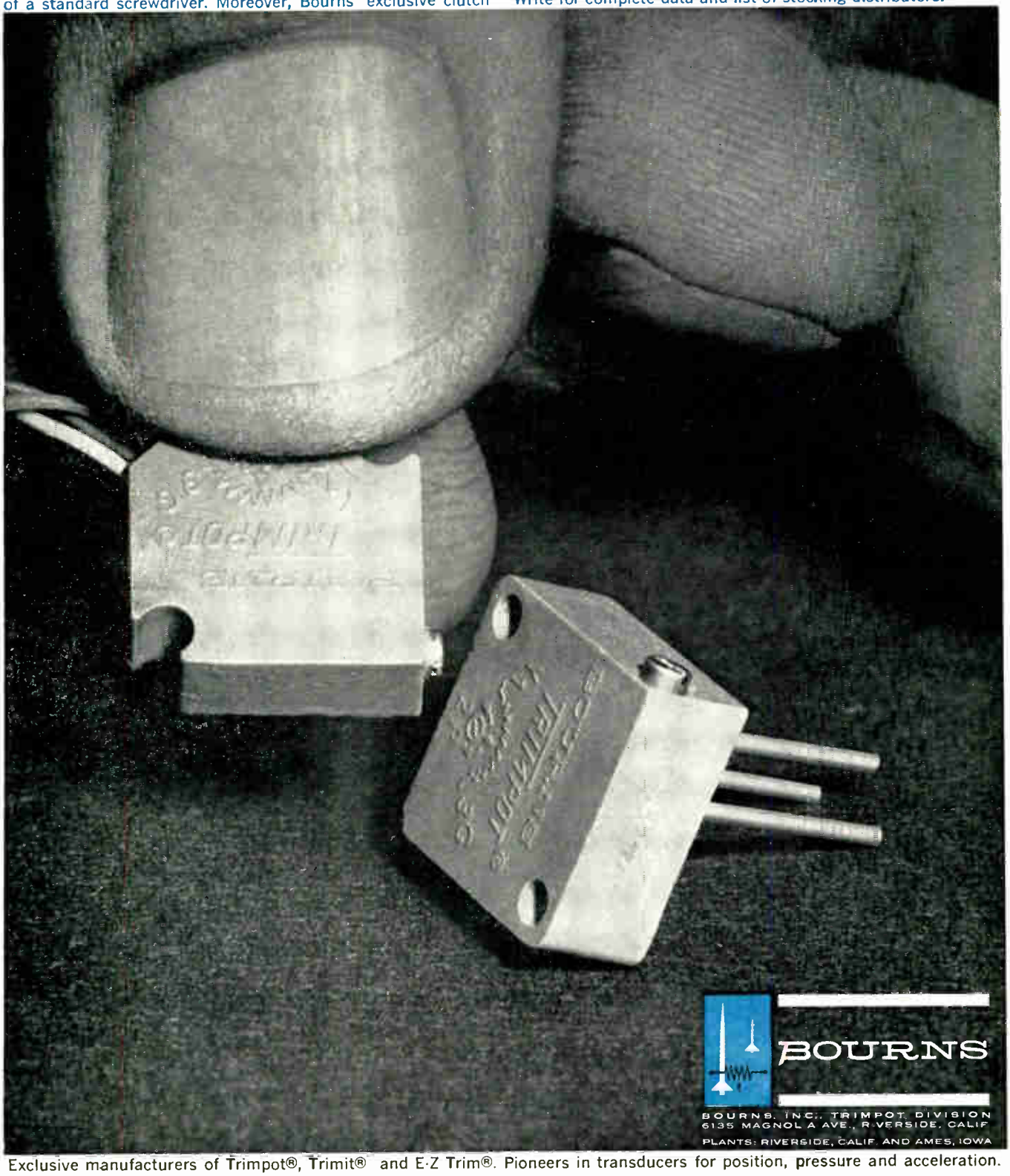
Now . . . Bourns reliability is in an even smaller package; these new wirewound units measure just ½" x ½" x 3/16". In addition, they offer you a choice of two terminal types—insulated stranded leads or printed circuit pins.

Because of unique package design, Model 3250 withstands the most severe environmental conditions . . . meets or exceeds Mil-Spec requirements. Its 25-turn adjustment permits precise balancing, while the shaft head size makes possible the use of a standard screwdriver. Moreover, Bourns' exclusive clutch design, combined with positive end-stops, eliminates any possibility of damage to internal parts.

Like all Trimpot potentiometers, this new model is designed, built and tested to give you performance you can count on.

Max. Operating Temperature	Power Rating	Resistances
+175°C	1 Watt @ 70°C	100Ω to 50K

Write for complete data and list of stocking distributors.



Exclusive manufacturers of Trimpot®, Trimit® and E-Z Trim®. Pioneers in transducers for position, pressure and acceleration.

Tele-Tips

RFI-ODDITY: An airline at Chicago reported interference to its air-ground radio communication. The Allegan and Chillicothe monitoring stations of FCC "fixed" the area of its source and local investigators traced it to a Michigan piano factory. There a radio frequency heater was doing a good job of drying wood glue, but it was also putting out a hefty radio emission that could be heard hundreds of miles away.

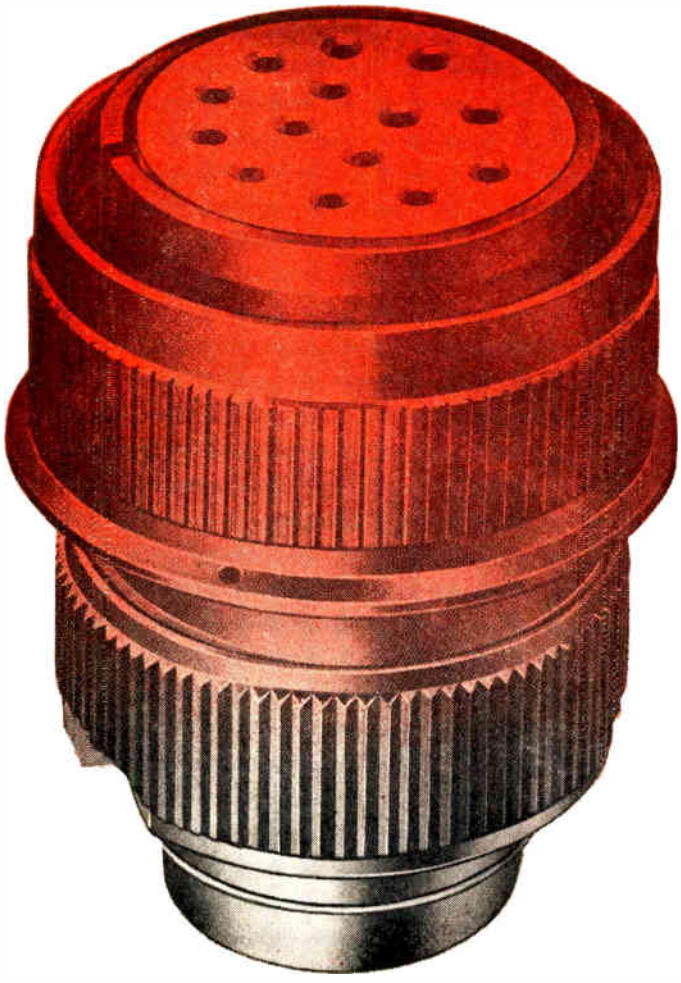
Radar used for air traffic control at Oakland, Calif., experienced interference of long duration before FCC assistance was asked. An FCC engineer with a mobile unit speedily determined that the disrupting signal was coming from a radar installation on Mount Tamalpais. The bearings were accurate enough to show which of the three radar units there was responsible. The Air Force took immediate steps to eliminate its trouble.

One Ohio monitoring station received complaints by an electronics firm about interruptions of its communication in the citizens band. The wayward transmissions were deciphered to be taxicab dispatching messages. However, they were accompanied by no call signals or other identification. Direction finders fixed their origin in Bermuda. Inasmuch as citizen frequencies are used on a shared basis without interference protection, there was no justification for complaining to the British authorities.

When an international telegraph carrier complained of multiple interference on its circuit to Saudi Arabia, the FCC net found that it was caused by 10 different radio stations scattered throughout the world.

SCANDIUM OXIDE, derived from certain nuclear ores, has been cut in price by 50%—but still sells for $2,850 a pound!

(*Continued on page* 44)



HIGH TEMPERATURE CANNON PLUGS

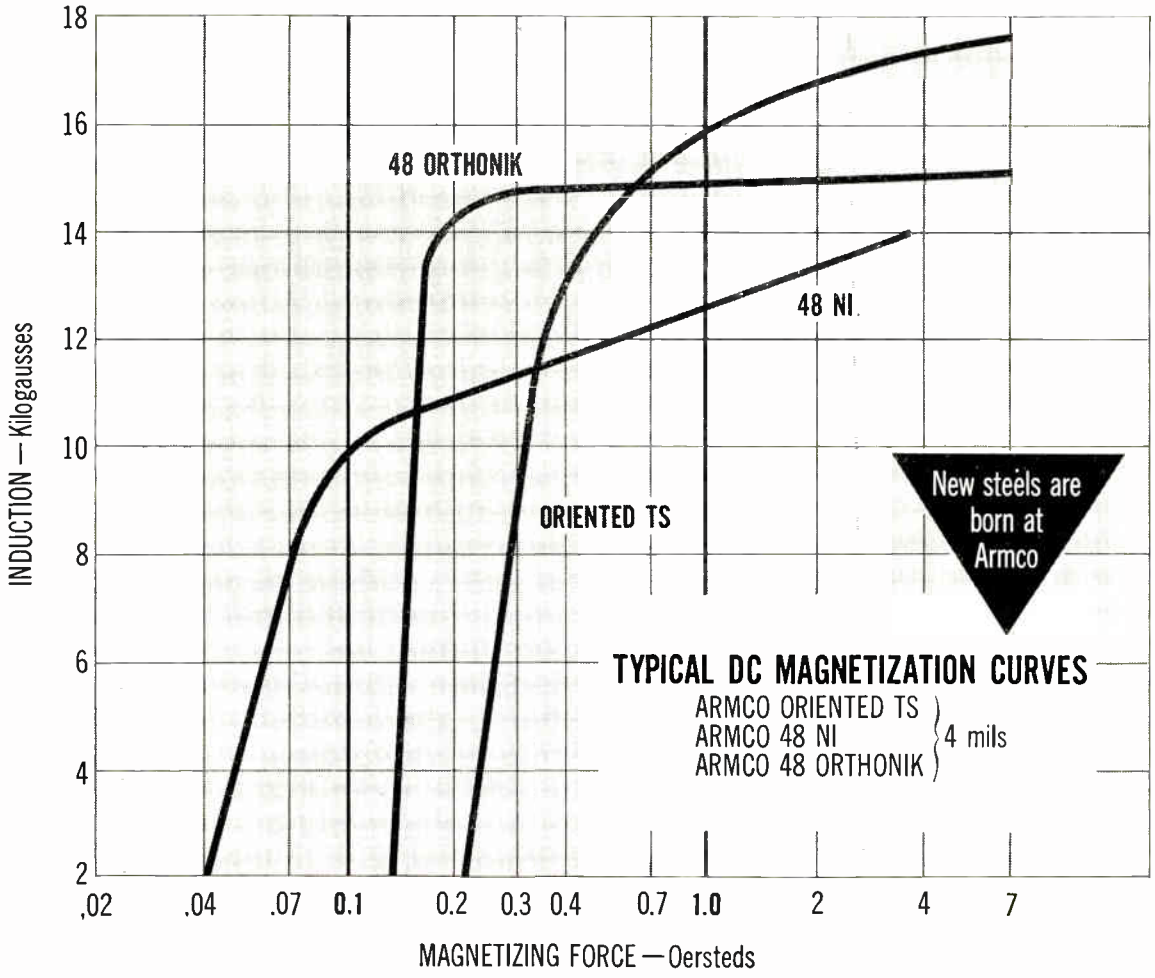
Whatever the application, Cannon's broad line of heat-resistant plugs provides the optimum protection to vital electrical circuits. Continuous or specified operation from 200°F to 2000°F—at aircraft firewalls or industrial facilities...for missiles or the most advanced spacecraft —we have a plug to solve your temperature problem. Another reason why you should consult the world's most experienced plug manufacturer... why you should consult Cannon for all your plug requirements!

CANNON ELECTRIC COMPANY, 3208 Humboldt St., Los Angeles 31, Calif.

Write for literature on high-temperature plugs, or other Cannon products to:

CANNON PLUGS

Armco High Performance Magnetic Materials Provide Selectivity to Meet Specific Needs at Least Cost



Armco Thin Electrical Steels, Armco 18 Ni and 18 ORTHONIK, offer wide range of magnetic properties, thicknesses and costs for most effective design of electronic communications, computer, control and high efficiency equipment.

Armco Thin Electrical Steels—Three different grades, Armco TRAN-COR® T, Oriented T and Oriented TS, are available in thicknesses of 5 and 7 mils; 1, 2 and 4 mils; and 4 mils respectively. They provide high permeability and low hysteresis loss. For applications at 400 cycles and higher, such as servos, magnetic amplifiers, motors and specialty transformers, they permit an efficient balance of performance and cost.

Armco 48 Ni—This Armco nickel-iron material combines high permeability at low and moderate inductions, low coercive force, and low hysteresis loss. Available in thicknesses of 2 to 14 mils, 48 Ni is processed for wound cores or laminations. It is especially suitable for communications equipment, high quality transformers, and other units requiring high permeability.

Armco 48 ORTHONIK®—The combination of a rectangular hysteresis loop with low coercive force makes 48 ORTHONIK an ideal core material for computers, reactors, magnetic amplifiers and modulators, and bi-stable elements for logic circuits. This highly oriented material, available in thicknesses from ¼ to 14 mils, assures consistently reliable performance over a wide range of frequencies.

Use the multiple advantages of Armco's High Performance Magnetic Materials in your products. Their wide range of properties enable you to select a material and gage that meet your needs most economically.

Detailed design data are available to help you use them most effectively. Write us for complete information. Armco Steel Corporation, 2080 Curtis Street, Middletown, Ohio.

Steel

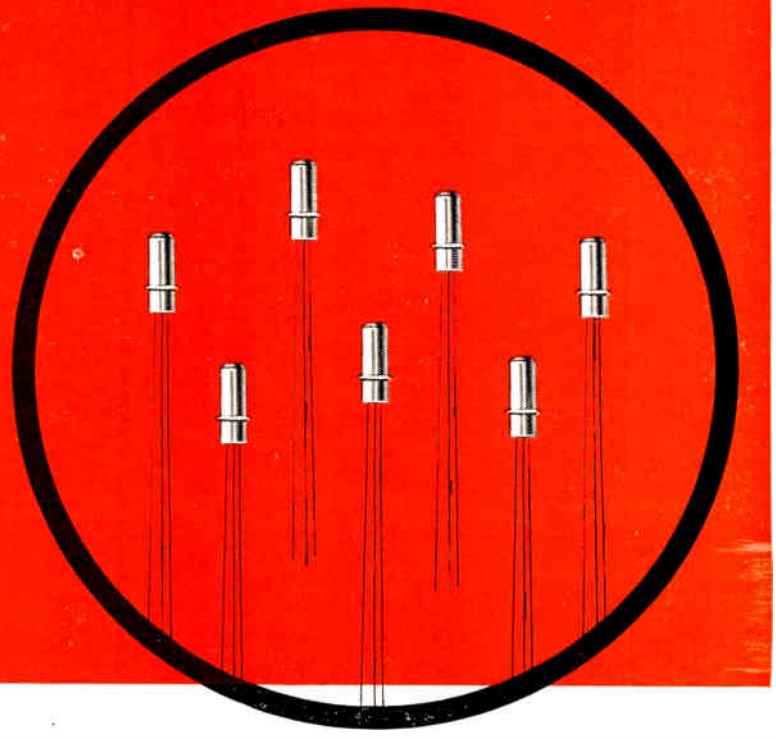
ARMCO STEEL

ARMCO

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

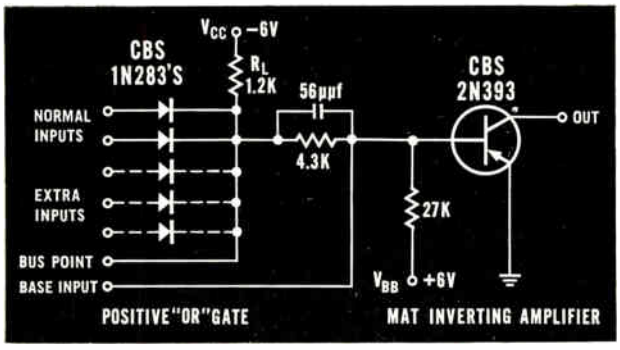
CBS®

MAT* TRANSISTOR CUTS COMPUTER COSTS UP TO 25%



The CBS 2N393 MAT transistor cuts computer costs three ways: *Transistor costs* . . . this transistor far outperforms ordinary alloy switching transistors — and at lower cost, since fewer are required. *Component costs*... the versatile 2N393 simplifies circuits, eliminates many expensive components. *Manufacturing costs* . . . the high-performance 2N393 makes possible a universal, simplified circuit that permits full exploitation of standardization economies. *Total savings* can easily amount to 25%.

Check the CBS 2N393 features and characteristics . . . and the universal computer circuit shown. Order engineering samples from your local Manufacturers Warehousing Distributor or sales office.



UNIVERSAL MAT CIRCUIT PERFORMS 80% OF COMPUTER FUNCTIONS

This basic NOR circuit provides for more than 80% of the logic and storage functions of moderately fast data processing systems: AND gate, OR gate, inverter, and flip-flop. Advantages include economy, reliability, and ease of replacement. Special features are: minimized noise sensitivity and power dissipation . . . worst-case design . . . operating temperatures to 55°C . . . max. input of 22 collectors and diodes . . . repetition rate up to 1 mc.

CBS 2N393 FEATURES

- High gain with high frequency response
- D-c beta linear up to 50 ma
- More efficient high-injection emitter
- Low saturation resistance adaptable to DCTL
- Pyramiding factor of 5 easily attained
- Exceptional uniformity through controlled base width
- Welded TO-24 case hermetically sealed
- Automated production with sequential quality control
- Over-all quality exceeding MIL-S-19500

CHECK THESE DATA

Maximum Ratings

Junction temperature, °C	85
Collector voltage, v	−6.0
Collector current, ma	−50
Dissipation at 45°C, mw	25

Electrical Characteristics (25°C)

Max. I_{CBO} (V_{CB} = −5v), μa	5
Min. h_{fe} (V_C = −3v, I_E = 0.5 ma)	40
Min. h_{FE} (V_{CE} = −1v, I_C = −50 ma)	20
Max. V_{CE} Sat (I_C = −8 ma, I_B = −1 ma), v	0.07
Max. V_{BE} (On) (I_C = −8 ma, I_B = −1 ma), v	0.5
Min. f max. (max. frequency of oscillation), mc	40

*Micro Alloy Transistor, trade-mark Philco Corp.

CBS ELECTRONICS, Semiconductor Operations, Lowell, Mass. • A Division of Columbia Broadcasting System, Inc.

Sales Offices: *Lowell, Mass.*, 900 Chelmsford St., GLenview 4-0446 • *Newark, N. J.*, 231 Johnson Ave., TAlbot 4-2450 • *Melrose Park, Ill.*, 1990 N. Mannheim Rd., EStebrook 9-2100 • *Los Angeles, Calif.*, 2120 S. Garfield Ave., RAymond 3-9081 • *Atlanta, Ga.*, Cary Chapman & Co., 672 Whitehall St., JAckson 4-7388 *Minneapolis, Minn.*, The Heimann Co., 1711 Hawthorne Ave., FEderal 2-5457 • *Toronto, Ont.*, Canadian General Electric Co., Ltd., LEnnox 4-6311

Tele-Tips

(*Continued from page* 40)

UNDERWATER TV CAMERAS made it possible for the atomic submarine "Seadragon" to avoid "menacing ice" during its trip under the polar ice cap. It also helped the crew while away the hours beneath the ice-encrusted water. The sub's skipper, Cmdr. G. P. Steele, reports that "myriads of squid, jellyfish and other marine life could be seen perfectly when the water was clear."

DAFFYNITIONS dreamed up by two Raytheon engineers during an interlude at one of the technical conventions:

Inertial Guidance — permissive parenthood, or leaving well enough alone.

Countermeasures — Dr. Spock's system, the opposite of inertial guidance.

Esaki Diode—verses read at a Tokyo wake.

Triode—what the "beat poet" writes.

Hysteresis—one of those new viruses.

Memory Tube—a wedding ring.

Isolation Network — the office grapevine.

Thermistor—a hot engineer.

Telemetering—why women need unlimited phone service.

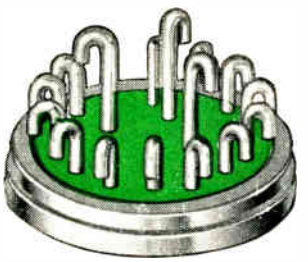
COMPUTER LANGUAGE translation is being researched by a number of firms. Some of the problems come in this form, "How do you tell a computer that a red herring is not just a colored fish" or that "a star may be either in the sky, or on a Hollywood movie lot."

BRITISH AUDIO EQUIPMENT has found an eager market in the U.S. More than half of the U. K.'s hi-fi exports are coming to the U.S.

—LIKE BIRDS! Taking a cue from our feathered friends, workmen on high tension lines will soon be making all of their repairs from "perches" that are at the same potential as the lines they are working on. The men will stand in fibre glass buckets supported by an insulation boom. The bottom of the bucket will be charged to the line voltage by connecting the bucket's metal-mesh lining to the wire.

The Fusite Quality Control Director said,

"1 x 10^{-10} STD CC/SEC"



The Advertising Man said,

"SPEAK AMERICAN, BOY!"

The Fusite quality control director was explaining a testing procedure for Fusite solid glass hermetic terminals.

It seems that every batch of this type (and practically all Fusite Terminals) is given a heat shock treatment to simulate the condition encountered when the customer solders or welds them in his production.

Fusite Terminals have this unique V-24 glass that actually fuses with the metal parts. When the terminal is heated to 500° F in 20 seconds this is supposed to be sheer murder. If the glass is ever going to leak, now is the time.

Well sir, now they put the test terminal on a Veeco Mass Spectrometer which tries to pass helium through the terminal and into the innards of the machine. This thing is so sensitive that it can detect one part of helium in 10 million parts of air and according to this long hair, that's the same as $1x10^{-10}$ std. cc/sec.

If Mr. Veeco gets even a sniff of helium, no terminal from that run ever sees the shipping department.

You can decide for yourself whether or not this is as big a deal as the lab boys make out, by the simple expedient of asking for samples of Fusite Terminals to test in your own way.

They are yours for the asking. Write Fusite Dept. G-6.

INSULATE ELECTRICALLY · GLASS TO METAL · SEAL HERMETICALLY

FUSITE

TERMINALS

PROTECT PRODUCT PERFORMANCE

THE FUSITE CORPORATION

6000 FERNVIEW AVE., CINCINNATI 13, OHIO

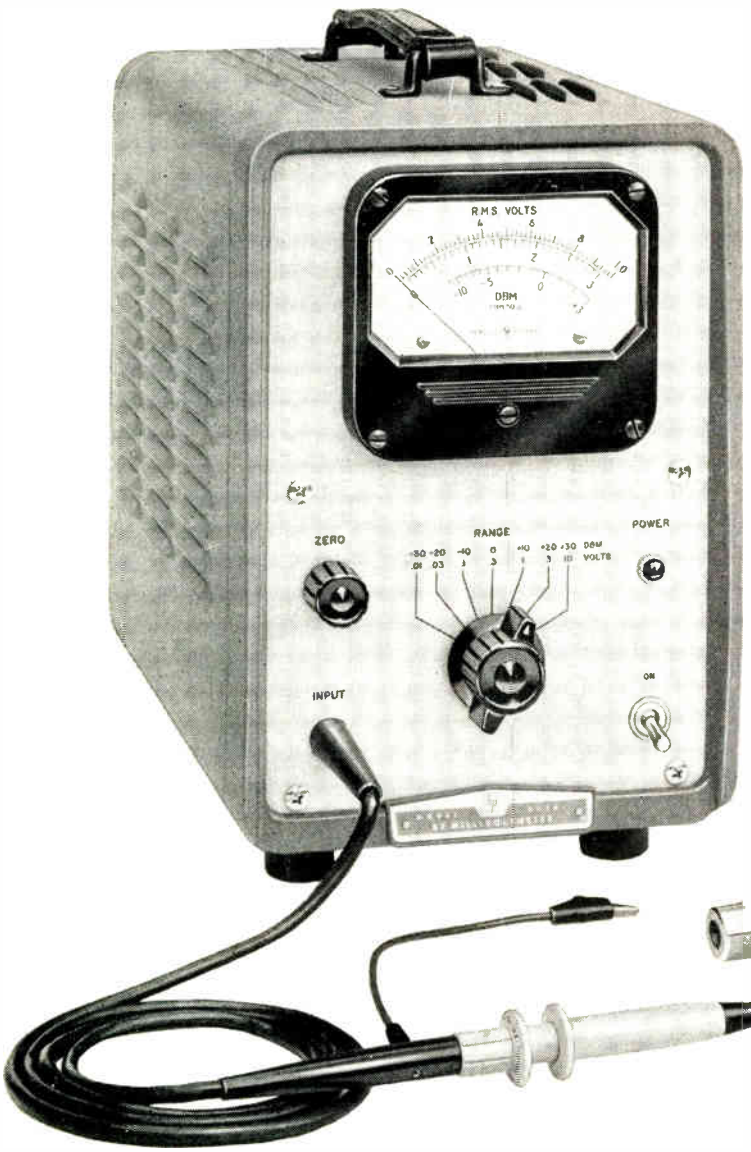
Woodford Mfg. Co., Versailles, Kentucky.

In Europe: FUSITE N. V. Königsweg 16, Almelo, Holland

Now, with one instrument, you can

1 mv at

411A Voltmeter



Specifications

Voltage Range: 10 mv rms full scale to 10 volts rms full scale in seven ranges. Full scale readings of 0.01, 0.03, 0.1, 0.3, 1, 3 and 10 volts rms.

Frequency Range: 500 KC to 1,000 MC with accessory probe tips.

Accuracy: 1 MC to 50 MC, ±3% of full scale; 50 MC to 150 MC, ±6% of full scale; 500 KC to 1,000 MC, ±1 db.

Meter Scales: Two linear voltage scales, 0 to 1 and 0 to 3, calibrated in the rms value of a sine wave. Db scale, calibrated from +3 to −12 db; 0 db = 1 mw in 50 ohms.

Galvanometer Recorder Output: Proportional to meter deflection, 1 ma into 1000 ohms at full scale deflection.

Probe Tip Furnished: Pen type Probe Tip, 500 KC to 50 MC. Shunt capacity less than 3 picofarads at 1 volt, less than 4 picofarads at 10 mv. Shunt resistance depends on voltage and frequency.

Other Probe Tips Available at Additional Cost: VHF Probe Tip, 500 KC to 250 MC. Shunt capacity less than 1.5 picofarads at 1 volt, less than 2 picofarads at 10 mv. Shunt resistance depends on voltage and frequency.

Type N "Tee" Probe Tip, 500 KC to 1,000 MC. SWR less than 1.15 when terminated in 50 ohms.

BNC Open Circuit Probe Tip, 500 KC to 500 MC.

100:1 Divider Probe Tip, 500 KC to 250 MC. Division accuracy ±1%. Shunt capacity 2 picofarads. Shunt resistance depends on voltage and frequency.

Power: 115/230 volts ±10%, 60 cps, 35 watts.

Price: hp Model 411A $450.00.

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

instantly measure

1,000 mc!

or any rf voltage 1 mv to 10 v, over the very broad bandwidth of 500 KC to 1,000 MC. Accuracy is higher than any similar voltmeter known. Measuring is as simple as "touch and read" on the big, high resolution linear scale. Annoying thermal drift errors are eliminated.

Think of the times you would have liked to measure —with utmost accuracy—millivolts at rf frequencies.

Now you can do it, easily and dependably, with one compact instrument—the new hp 411A VTVM.

This remarkable instrument has true linear operation—no correcting networks are required.

It has high temperature stability—negligible accuracy change from 10° to 40°C.

Such performance stems from a unique, hp-developed circuit involving feedback applied to a diode-detector-dc amplifier arrangement; and further involving instantly replaceable, encapsulated, *matched* diodes!

Truly, this circuit has to be seen and operated to be believed. Write for a detailed description (ask for hp 411A Data Sheet) or better yet, call your hp rep for a bench demonstration.

And how about these extra features: (a) the matched diodes are protected against burnout (b) probe is temperature compensated for low drift (c) hp-developed amplifier photochopper eliminates contact noise, guarantees high sensitivity, zero-drift freedom (d) extra probe tips include units for high frequency measurement, for measuring *on* as well as *at termination* of coax transmission lines, and a capacity divider increasing 411A voltage capability to 1,000 volts.

Why put up with complex, cumbersome instruments? Get a new 411A into action on your bench now!

HEWLETT-PACKARD COMPANY
1051B Page Mill Road, Palo Alto, California, U.S.A.
Cable "HEWPACK" DAvenport 6-7000
Sales representatives in all principal areas
HEWLETT-PACKARD, S.A. Rue du Vieux Billard No. 1, Geneva, Switzerland
Cable "HEWPACKSA" Tel. No. (022) 26. 43. 36

Letters to the Editor

Converting Binary to Analog

Mr. Stanley W. Torode
Sylvania Electronics Systems
1100 Wehrle Drive
Amherst 21, New York

Dear Mr. Torode:

Your article in ELECTRONIC INDUSTRIES "Conversion of Binary to Analog Codes" interested me. We have accomplished similar conversions using Magnetic Shift Registers. I think our technique may be of interest to you.

We employ standard DI/AN CTR type Magnetic Shift Registers packaged so that the hole through the magnetic core of each stage can be threaded with a number of windings. Thus, for a single line output a simple serial register of N bits can provide a pulse of 2^N different amplitudes.

The number N can be entered into the shift register either low or high order first. The register must be wired for one condition or the other. It can also be entered in parallel.

A series winding is placed on the N cores. The low order core having 1X windings, the next core $2X_1$, the next $4X_1$ the next $8X_1$ and so on, the N core having $2^{N-1}X$ windings. The amplitude of the output signal is the summation of $X(2^{N-1}H + \ldots\ldots\ldots\ldots 8D+4C+2B+1A)$ output signals when the register is shifted. Where X is the number of twins on the sense winding of the low order bit. Where H.....D C B A is the binary number stored, being unity or zero.

We have used this in two dimensional arrays to obtain pulse amplitude in accordance with a digital matrix of NxM bits where M and N are greater than 1.

Robert D. Kodis
President
DI/AN CONTROLS, INC.
45 Leon St.
Boston 15, Mass.

RFI Editorial Series

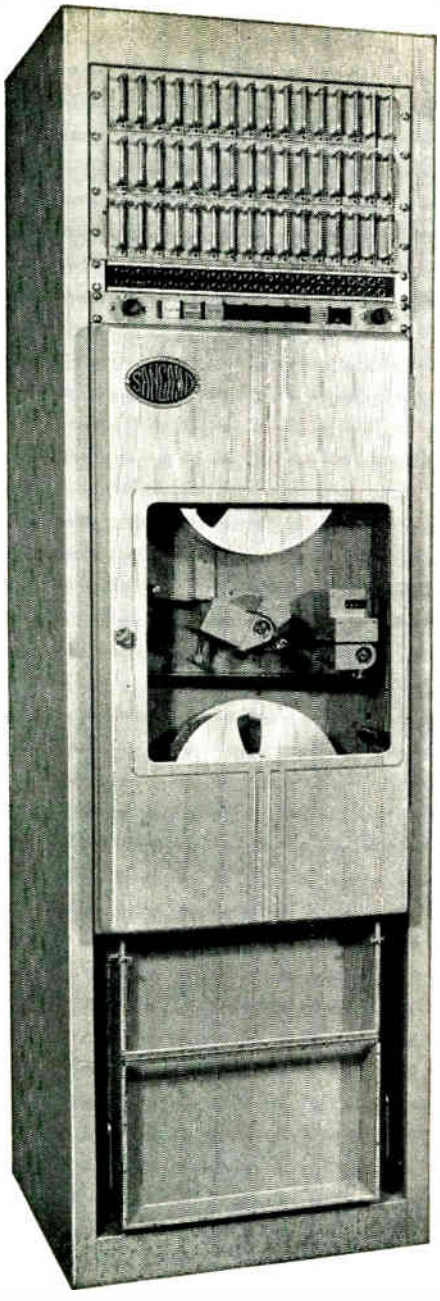
Editor, ELECTRONIC INDUSTRIES:

I would greatly appreciate reprints of your series of articles on Radio Frequency Interference.

I find that this series is most useful and more comprehensive than anything else that I have found on this subject. I feel that additional series giving comprehensive treatment of current problems will prove most helpful for many of your readers.

Eric Brodheim
Principal Research Engr.
Electronics Research Labs
School of Engineering
Columbia University
New York, N. Y.

(*Continued on page* 52)



superior accuracy and reproducibility with the

SANGAMO 460-SERIES TAPE TRANSPORT

The Sangamo 460-Series is a fully transistorized magnetic tape Recorder/Reproducer for application in direct analog, wideband FM, PDM, and PCM instrumentation systems.

Magnetic tape instrumentation system accuracies heretofore considered unattainable have been achieved by Sangamo as a result of reduced instantaneous and long-term record-playback speed deviations. The 460-Series Tape Transport accomplishes this by combining a very low inertia D. C. capstan drive with a high-response, tape-speed, servo control system.

A unique vacuum tension/cleaning pad located immediately in front of the recording or reproducing head provides gentle, but firm and precise, tape tension. The head in turn is mounted almost in contact with the drive capstan. This arrangement results in a very short span of tape that requires controlled positioning. The combination of these features results in minimum skew, less flutter, and fewer dropouts.

Additional features of the Sangamo 460-Series Tape Transport are: Reel-to-reel or loop operation with the same machine • Ability to handle all tapes, from ¼" to 2" in width, 1.0 to 1.5 mil base • All D. C. drives • Fully transistorized •

Sangamo 460-Series Magnetic Tape Record/Reproduce systems are sold through technically qualified Sangamo agents specially selected for their ability to assist you in magnetic tape instrumentation applications. In addition, Sangamo Application Engineers are available to provide further technical assistance wherever necessary. For complete details on the Sangamo 460-Series Record/Reproduce system, write for Bulletin H-460A or contact your nearest Sangamo representative.

SANGAMO 460-SERIES PERFORMANCE CHARACTERISTICS:

START TIME: 1.0 second max. to synchronism with servo speed control at 60 ips up to 1" wide tape.
STOP TIME: 0.2 seconds max. from 60 ips.
INSTANTANEOUS TIME DISPLACEMENT ERROR: 25.0 microseconds max. at 60 ips.
LONG-TERM TIME DISPLACEMENT ERROR: ±0.01% max.
INTER-CHANNEL TIME DISPLACEMENT ERROR: ±2.0 microseconds at 60 ips between outside tracks on 1" tape.
SERVO SPEED CONTROL RANGE: ±15% nominal tape speed.
SERVO RESPONSE: ±15% speed change per second.

BROGAN ASSOCIATES, INC.
Mineola, L. I., New York
Chestnut Hill, Mass.

DATRONICS, INCOPORATED
Houston, Texas
Dallas, Texas

J. E. CUESTA COMPANY
Paoli, Pa.
Washington, D. C.

MEDCO, INCORPORATED
Melbourne, Florida
Huntsville, Ala.

PERLMUTH ELECTRONIC ASSOCIATES
Los Angeles 16, California
San Diego, California
Palo Alto, California

SANGAMO ELECTRIC COMPANY

SPRINGFIELD, ILLINOIS

SC60-9

EPITAXIAL GERMANIUM

MESA TRANSISTORS

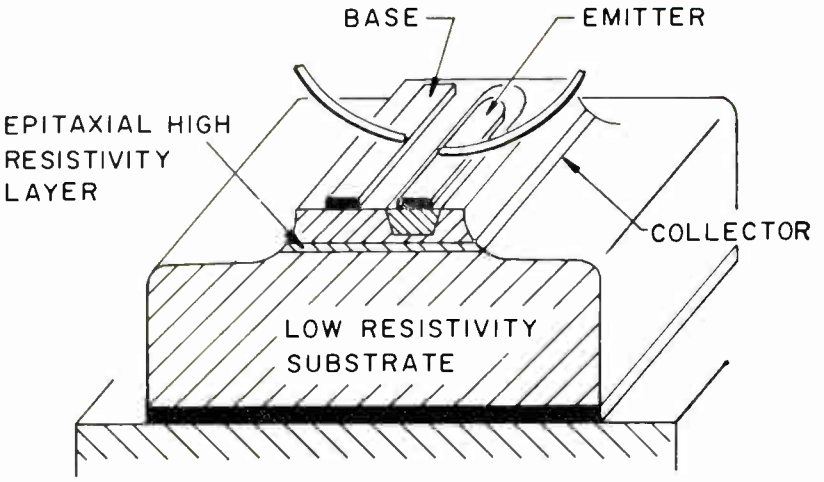
SYL-2300, SYL-2301...now available!

featuring **REDUCED STORAGE TIME**
REDUCED SATURATION VOLTAGE
DECREASED COLLECTOR CAPACITANCE
EXCEPTIONAL UNIFORMITY

SYLVANIA EPITAXIAL GERMANIUM DIFFUSED-BASE MESA TRANSISTORS offer all the advantages of conventional diffused-base mesa transistors *plus* significant reductions in switching time and high-current saturation voltage.

FIRST NEW TYPES to utilize *epitaxial* techniques are two PNP units—SYL-2300 and SYL-2301 in the TO-18 package with the collector internally tied to the case. The Sylvania *epitaxial* structure uses a main body collector region of very low resistivity material with a thin, high resistivity *epitaxially* grown region. This allows a reduction of collector series resistance (saturation voltage) and an increase in switching speed (less excess stored charge) through the use of the low resistivity main body region. Also, collector capacitance is reduced through the use of the high resistivity *epitaxially* grown region. The Sylvania *epitaxial* technique simplifies manufacturing processes, enables extraordinarily tight design control to provide significantly improved uniformity of characteristics.

LEARN MORE about the important performance advantages of Sylvania *Epitaxial* Diffused-Base Germanium Mesa Transistors from your Sylvania Representative. Contact him, too, for price and delivery information. For technical data, write Semiconductor Division, Sylvania Electric Products Inc., Dept. 1912, Woburn, Mass.



EPITAXIAL DIFFUSED TRANSISTOR CONSTRUCTION

Sylvania epitaxial transistor is fabricated by diffusing a base region into a thin, high resistivity layer. This thin layer is vapor grown in epitaxial fashion onto a low resistivity collector substrate. The single crystal structure of the substrate is continued into the thin film.

PNP EPITAXIAL DIFFUSED-BASE GERMANIUM MESA TRANSISTORS

ABSOLUTE MAXIMUM RATINGS: (at 25°C)	SYL-2300	SYL-2301	UNIT
Collector to Base Voltage	−15	−12	V
Collector to Emitter Voltage	−15	−12	V
Emitter to Base Voltage	−2.5	−1.0	V
Collector Current	−50	−50	mA
Power Dissipation (free air)	150	150	mW
Power Dissipation (case at 25°C)	300	300	mW
Storage Temperature	−65 to +100	−65 to +100	°C
Junction Temperature	+100	+100	°C

ELECTRICAL CHARACTERISTICS AT 25°C:

		SYL-2300		SYL-2301		UNIT
Symbol	Conditions	Min.	Max.	Min.	Max.	
BV_{CBO}	$I_C = -100\ \mu A,\ I_E = 0$	−15		−12		V
BV_{EBO}	$I_E = -100\ \mu A,\ I_C = 0$	−2.5		−1.0		V
BV_{CES}	$I_C = -100\ \mu A,\ V_{BE} = 0$	−15		−12		V
h_{FE}	$I_C = -10$ mA, $V_{CE} = -0.22$ V	25				—
	$I_C = -10$ mA, $V_{CE} = -0.25$ V			20		—
V_{BE}	$I_C = -10$ mA, $I_B = -0.4$ mA	−0.34	−0.44	−0.34	−0.50	V
I_{CBO}	$V_{CB} = -5$ V, $I_E = 0$		−3.0		−3.0	μA
V_{CE} (Sat.)	$I_C = -10$ mA, $I_B = -0.4$ mA		−0.22			V
	$I_C = -10$ mA, $I_B = -0.5$ mA				−0.25	V
	$I_C = -50$ mA, $I_B = -2.5$ mA		−0.25		−0.35	V
$t_d + t_r$	$V_{BE(o)} = 0.5$ V, $I_{B(1)} = -1$ mA		70		90	mμsec
t_s	$V_{CC} = -3.5$ V, $R_C = 300$ ohms		45		60	mμsec
t_f	$I_{B(2)} = 0.25$ mA		70		95	mμsec

Available through your Sylvania franchised semiconductor distributor

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

Circle 28 on Inquiry Card

Letters to the Editor

(*Continued from page* 48)

"Electronics In Agriculture"

Editor, ELECTRONIC INDUSTRIES:

In the August 1960 issue of ELECTRONIC INDUSTRIES I read with interest the section devoted to electronic methods of improving farm production and quality control. But of what practical good are such advanced scientific procedures when we still have no way to prevent overproduction of some commodities?

I think the answer to this problem also lies within the realm of electronics. An electronic computer and communication system could be installed to totalize reports from County Agents throughout the country. Total yield could then be determined and compared with an extrapolated value of last year's demand to arrive at a price per unit of each commodity. As new figures were sent in, commodity prices would be changed and daily revisions would be sent to all County Agents. Expected price on each commodity would enable each farmer to make an intelligent decision regarding the crop to plant. Surpluses would be a thing of the past.

It would be good business for the electronic industry as well as the poor taxpayer if a system of this magnitude were installed in the United States. The present bill for farm subsidy is over eight billion dollars annually. The electronics required for this plan would be considerably less than this but certainly not to be scoffed at. And surely no taxpayer would be against such an improvement!

Charles W. Gaston
Systems Engineer (RCA)
3707 Pelzer
Montgomery 9, Ala.

"Power Converters—"

Editor, ELECTRONIC INDUSTRIES:

Congratulations on your excellent "Unconventional Power Converters" article in the September issue of Electronic Industries. Your article provides the basis for a better understanding of some of these esoteric devices.

The intrinsic silicon used in the manufacture of solar cells (Page 115) has impurities on the order of 1 part in 10^9 parts, rather than the 10^{19} parts you stated. This typographical error makes a difficult task appear impossible.

Thank you for your mention of the "shingling" process. This process enables the construction of solar cell converter arrays with a minimum of

(*Continued on page* 54)

"FREON" SOLVENT left this acrylic resin and metal unharmed after prolonged exposure.

ORDINARY CHLORINATED SOLVENT under same conditions dissolves resin, damages metal.

How Freon® solvents help protect your investment in expensive, precision parts

"Freon" solvents provide *selective* solvent action. Result—fast, highly effective removal of oil, grease and dirt—yet complete safety to materials of critical components.

Will not damage metals, plastics or elastomers. "Freon" solvents minimize swelling of plastics and elastomers . . . are non-corrosive to metals . . . won't soften paint, wire coating or insulation.

No residue. Because "Freon" solvents contain no inhibitors, no residue is left on dried parts. Solvent can be recovered readily and reused without need for reinhibiting during recovery cycle.

Safe to personnel. Non-flammable and non-explosive, "Freon" solvents are also virtually non-toxic—will not cause headaches or nausea.

For you this means effective, remarkably safe cleaning of delicate mechanical and electronic equipment—greater protection for your investment. If you'd like more information about "Freon" solvents or technical assistance on solvent use and application, write: E. I. du Pont de Nemours & Co. (Inc.), "Freon" Products Division, Wilmington 98, Delaware.

FREON®
SOLVENTS

DU PONT
REG. U.S. PAT. OFF.

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

Circle 30 on Inquiry Card

Letters to the Editor

(*Continued from page 52*)

exposed inactive area, thus increasing the "watts/area" ratio. This technique, patented by Hoffman Electronics Corporation (U. S. Patent 2938938) has been utilized by Hoffman since 1955.

Frank J. Mihm
Solar Product Engineer
Hoffman Electronics Corporation
Semiconductor Division
1001 Arden Drive, El Monte, Calif.

Editor, ELECTRONIC INDUSTRIES:

Please send me a copy of the article on "Unconventional Power Supplies" that appeared in the September 1960 issue of ELECTRONIC INDUSTRIES.

Incidentally, the article describing the production of thermionic converters by the General Electric Company has a small error. The descriptive headings under the pictures of the vapor and vacuum thermionic are reversed. The vapor converter may be distinguished from the vacuum converter by the cesium reservoir tube attached to the anode of the vapor converter.

Charles D. Buell
EEIT
General Electric Company
Defense Electronics Division
Mountain View Road,
Lynchburg, Virginia

Editor, ELECTRONIC INDUSTRIES:

We are interested in receiving a reprint of the article entitled "Unconvential Power Converters" which appeared in the September 1960 issue of ELECTRONIC INDUSTRIES Magazine, page 103.

This is the best article we have seen to date on this subject.

W. F. White, Dept. A-852
Instrument Evaluation Engineer
Douglas Aircraft Company, Inc.
Santa Monica Division
Santa Monica, California.

"RFI Series—"

Editor, ELECTRONIC INDUSTRIES:

Attending the meetings of the International Special Committee on Radio Interfernce, I was referred to your series of editorial features on Radio Interference in 1960. I am very interested in these problems and would appreciate reprints of the articles.

W. Knopf,
Dipl.-Ingenieur
Kolberg/Kr. Koenigs Wusterhausen,
Germany.

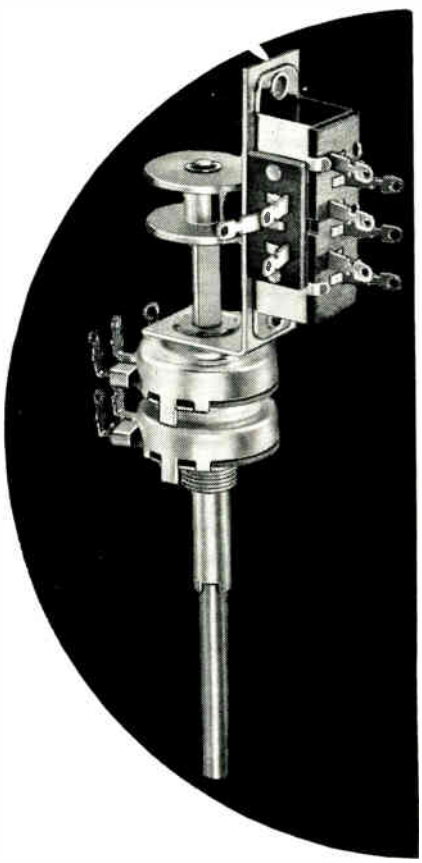
Ed.: The prints are on the way.

ANY SWITCH COMBINATION

FROM SPST to TPDT

with Centralab Switch Type Variable Resistors

CENTRALAB engineering took the conventional Model 2 composition variable resistor and developed these ingenious switching arrangements not available previously, with ratings up to 6 amps, 125 VAC. For use as single, dual concentric, or twin units, they are especially suitable for high fidelity and stereo, radio, television and phonograph applications. The use of these push-pull, push-push, and slide-switch units reduces the number of front panel controls, simplifies operation, and reduces component handling.



MODEL 2 VARIABLE RESISTOR SPECIFICATIONS

Rating 1/2 watt; Size 15/16" diam.
Resistances: 200 ohms to 10 megohms, any taper

SLIDE SWITCH SPECIFICATIONS

Mounting Depth: 2 1/32" from control surface, in any desired radial position for easy assembly of leads

Switch: Positive or spring return styles, ½, 1, 3 or 6 amp, SPST to TPDT, 125 VAC

PUSH-PULL, PUSH-PUSH SPECIFICATIONS

Mounting Depth: push-push; 29/32" from control surface
push-pull; 13/16" from control surface

Switch: SPST, 3 amp, 125 VAC

Industrial quantities of push-pull and push-push types available for immediate delivery at factory prices from your near-by CENTRALAB industrial distributor.

Centralab
CRL
B-6040 ®

The Electronics Division of Globe-Union Inc.
938M East Keefe Avenue • Milwaukee 1, Wisconsin
Centralab Canada Limited • Ajax, Ontario

ELECTRONIC SWITCHES • VARIABLE RESISTORS • CERAMIC CAPACITORS • PACKAGED ELECTRONIC CIRCUITS • ENGINEERED CERAMICS

Books

Coupled Mode and Parametric Electronics

By William H. Louisell. Published 1960 by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16. 268 pages. Price $11.50.

This book emphasizes three specific aspects of microwave electronics. First, it serves as an introduction to the theory of coupled modes and shows how the use of this approach simplifies the study of coupled systems. It then proceeds to the presentation of a unified theory of traveling wave tubes, backward wave oscillators, and similar devices. Finally, it treats the theory of parametric amplifier, oscillators, and frequency converters. The consideration of the theory of coupled modes from a general viewpoint permits its application in many fields.

The reader who is familiar with only the standard treatment of these devices will find the coupled mode approach to the problem illuminating and useful. This approach will yield new insight into the physical mechanisms involved in the coupling of waves.

Thermoelectric Materials and Devices

Edited by Irving B. Cadoff and Edward Miller. Published 1960 by Reinhold Publishing Corp., 430 Park Ave., New York 22. 344 pages. Price $9.75.

This is an authoritative survey of recent progress made in the development of new materials for thermoelectric devices. Based on a special series of lectures presented at New York University, the book features contributions of 20 experts and ranges from basic theory to device design.

The first section is devoted to the theory of thermoelectric processes and thermoelectric circuits. This is followed by a general evaluation of materials, both theoretical and experimental, for use as thermoelements. The ensuing chapters discuss materials currently being used and those being considered for future use. The last section of the book concerns the principles of device design and descriptions of some experimental and prototype units which have been built and evaluated.

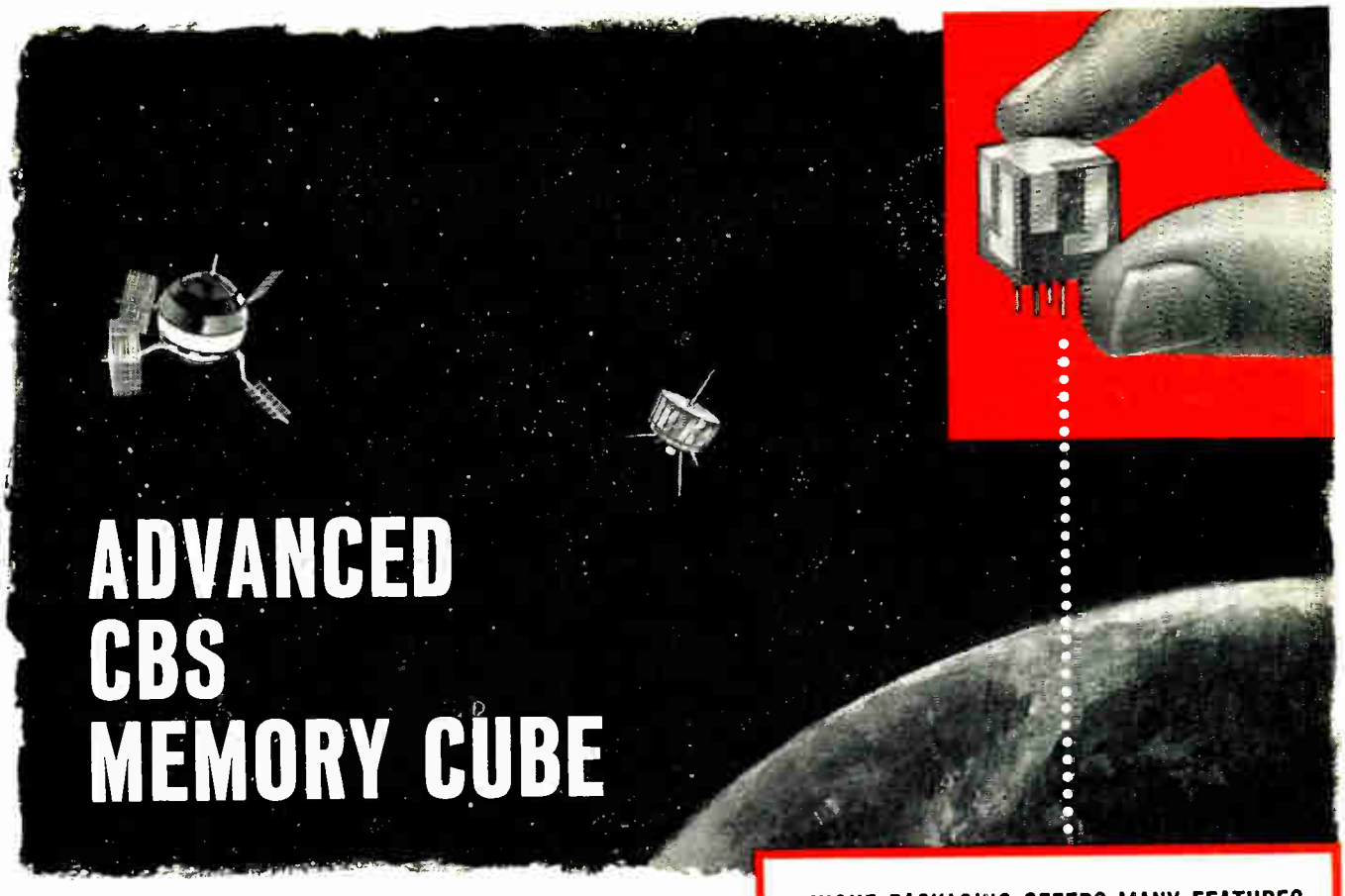
Since the figure of merit of thermoelectric materials holds equally well for power conversion and refrigeration, the two topics are treated in an integrated manner. Where necessary, the authors include brief reviews of background material.

Handbook of Laplace Transformation, Tables and Examples

By Floyd E. Nixon. Published 1960 by Prentice-Hall, Inc., Englewood Cliffs, N. J. 115 pages. Price $6.00.

Dealing thoroughly with a subject

(*Continued on page* 58)



ADVANCED CBS MEMORY CUBE

Now available for evaluation

For customer evaluation, CBS Electronics offers a working 16-bit *sample* memory cube. Its "new-concept" design features plastic-encapsulated ferrites and deposited conductors, resulting in compactness, light weight, and shock resistance never before achieved.

Check the features, unique construction and technical information. Order the CBS M-267 sample memory cube from stock . . . nominal charge $50.00. Evaluate for yourself, firsthand, the benefits of its advanced design.

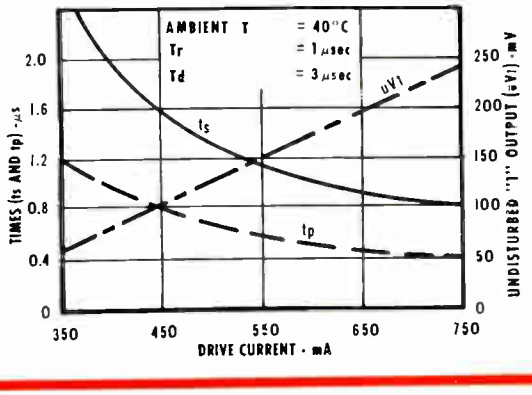
UNIQUE PACKAGING OFFERS MANY FEATURES

Miniaturization . . . techniques used result in significant reductions in volume and weight, with densities up to 2,000 bits per cubic inch. Conventional wiring frame and most hand wiring are eliminated.

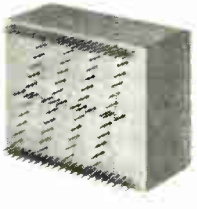
Uniformity . . . the "ONE" outputs of the 16 bits in the test cube reach amplitudes witnin ±5% of each other.

Environmental . . . improved temperature, humidity, shock and vibration characteristics are provided, yet encapsulation techniques employed have no adverse effects on the ferrites.

TYPICAL OPERATING CHARACTERISTICS CBS M-267 at 40°C



CUSTOMIZED SYSTEMS



After your evaluation of the M-267, CBS Electronics can supply development facilities for custom-designing memory systems for your military computer requirements. This typical CBS customized memory pack, a multi-aperture, nondestructively-sensed, word-organized system, achieves a density of 15,456 bits in less than 23 cubic inches. Other CBS custom designs include nondestructive readout memories and ferrite logic systems. The ferrite cores in the memories meet a wide range of requirements for signal output, switching time, and current drive.

CBS® microelectronics

CBS ELECTRONICS, Danvers, Massachusetts, A Division of Columbia Broadcasting System, Inc.

Circle 34 on Inquiry Card

Books

(*Continued from page* 56)

now receiving increased attention in our fast-moving technology, this timely guide provides an up-to-the-minute coverage of Laplace transformation and brings real help to all who use linear differential equations.

The first presentation of its kind to give detailed examples of practical physical problems completely solved by the Laplace transform method, the new handbook contains the most modern and extensive table of transform pairs available today, all number-coded for quick and easy reference.

Electrical Noise

By W. R. Bennett. Published 1960 by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36. 280 pages. Price $10.00.

How noise originates in electrical circuits, the terms in which it is described, how it is measured, and how circuits may be designed to minimize undesirable effects from noise are presented in this book. It describes in qualitative terms the physical nature of various important noise sources, including thermoagitation or resistance noise, shot noise in vacuum tubes and semiconductor junctions, noise from spontaneous emission of electromagnetic radiation, and noise in gas discharges.

Fundamentals needed for analyzing basic sources of noise are covered, and methods of measurement and design are stressed. A discussion of the relation of signal and noise in communication systems of various types is included.

Coverage of recent advances includes a treatment of noise in transistors, masers, and parametric amplifiers. Among the subjects of special interest are properties of thermonoise and its relation to blackbody radiation, and an introduction into the elementary mechanics which is woven into the discussion of the maser and of noise in semiconductors.

Creative Engineering Design

By Harold R. Buhl. Published 1960 by Iowa State University Press, Ames, Iowa. 195 pages. Price $3.95.

This is a good book if you want to develop latent creativity and decision-making ability and obtain new insight into the creative process.

Outlined and discussed are ways to "get off the beaten path," ways to think imaginatively and design creatively.

Supported by pithy examples, apt illustrations and pertinent quotes, the problem-solving phases of recognition, definition, preparation, analysis, synthesis, evaluation, and presentation are set forth in easy-to-follow fashion with a challenge to you to be constructively discontented with the "usual" solution and "modifications."

Another Tinnerman Original...

Self-retaining "U" and "J" SPEED NUTS® cut assembly costs up to 50% or more!

If you are worried about rising assembly costs, let one-piece "U" and "J" SPEED NUTS keep costs down . . . and improve your product.

They can't fall off, once they've been pressed into screw-receiving position. No welding, staking or other secondary fastening devices needed. You eliminate lock washers – spring steel SPEED NUTS are self-locking, make vibration-proof attachments.

SPEED NUTS are ideal for blind assembly or hard-to-reach locations. Apply them *before* you paint panels without danger of paint-clogging. Or *after* porcelainizing, without damage to finishes. The "U" type is similar to the "J" type, shown above, but is used where full bearing surface on the lower leg is required.

A free Fastening Analysis can tell where SPEED NUT brand fasteners belong on your products. Call your Tinnerman representative –he's listed in most major telephone directories. Or write to:

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Books

(*Continued from page* 58)

Foundations of Electrodynamics

By Parry Moon and Domina Eberle Spencer. Published 1960 by D. Van Nostran Co., Inc., 120 Alexander St., Princeton, N. J. 314 pages. Price $9.75.

This closely knit development of electrodynamics covers most engineering applications with maximum simplicity and minimum ambiguity. Using the logical approach, the authors develop field theory on a distinctly macroscopic level, since a completely microscopic treatment is impossible at present. For simplicity, they use the non-realistic approach in the first 10 chapters; only in the final 2 chapters do they consider relativity.

Employing the mks system, the authors make free use of Vector analysis, beginning with a brief presentation in the opening chapter. The principal innovation is a serious attempt to develop electrodynamics on a postulational basis and to define each concept in the most general terms.

Technical Writing Techniques for Engineers

By Joseph Racker. Published 1960 by Prentice-Hall, Inc., Englewood Cliffs, N. J. 234 pages. Price $6.95.

Written for engineers and technicians, this practical book, which was written by an engineer, presents a specific set of rules for writing in the engineering field.

There is a detailed treatment of each phase of technical writing, such as the chapter devoted solely to the rules needed for effective illustrating. There are carefully screened glossaries of Air Force, electronic, computer, guided missile, and other specialized terms needed by a writer working in these fields. This manual equips the engineer with the necessary tools to meet every day communication problems.

It shows the engineer how to select the elements of his material, how to organize them, and how to present them to technical personnel at all levels.

Books Received

Servicing TV Tuners

By Jess E. Dines. Published 1960 by Howard W. Sams & Co., Inc., 1720 E. 38th St., Indianapolis 6, Ind. 272 pages, paper bound. Price $4.95.

Practical Auto Radio Service and Installation

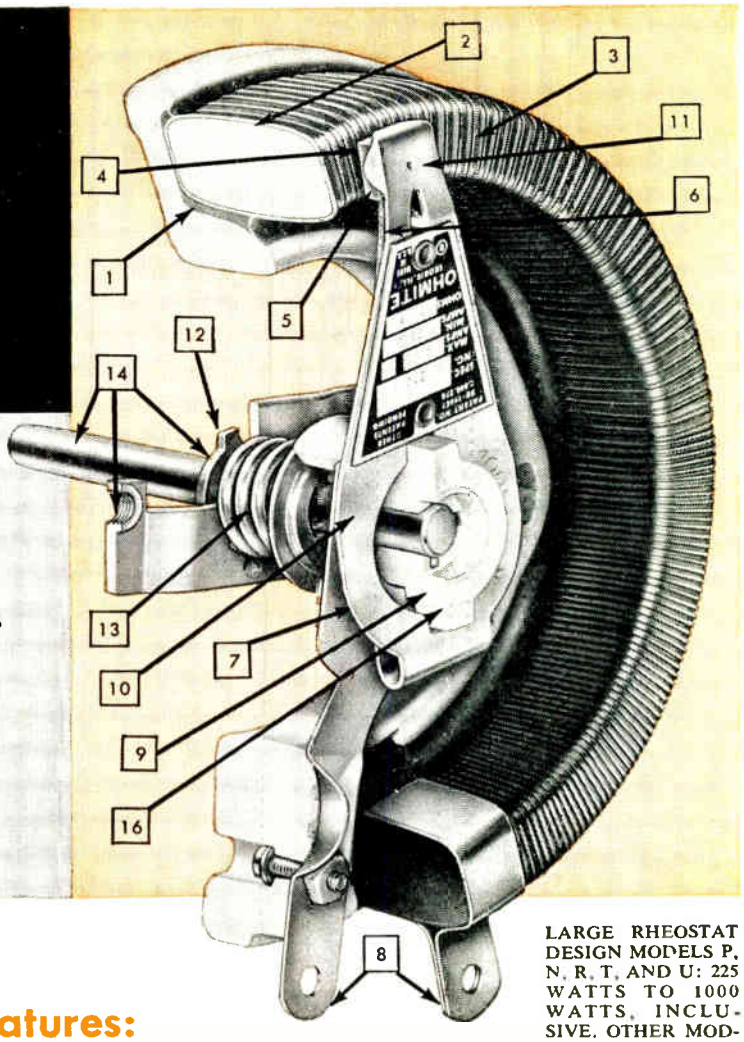
By Jack Greenfield. Published 1960 by Grensback Library, Inc., 154 W. 14th St., New York 11. 160 pages, paper bound. Price $2.95.

OHMITE

RHEOSTATS

NOW 11 Sizes! 12½ to 1000 Watts

Ohmite offers you industry's most complete line of rheostats. All sizes are available from stock in a wide range of resistance values, including the NEW Model "E." Ten sizes are available to meet MIL-R-22A requirements in *each* of the 26 type designations.



LARGE RHEOSTAT DESIGN MODELS P, N, R, T, AND U: 225 WATTS TO 1000 WATTS, INCLUSIVE. OTHER MODELS ARE SIMILAR.

16 Quality Engineering Features:

1. Vitreous enamel bonds the core and base together into one integral unit.
2. The wire is wound over a solid porcelain core, and each turn is locked against shifting by vitreous enamel. Uniform or tapered winding.
3. Close graduation of control. Each turn of wire is a separate resistance step.
4. Large, flat surface upon which the contact brush rides.
5. Metal-graphite contact brush (varied to fit current and resistance) insures good contact, with negligible wear on the resistance wire.
6. Shunt pigtail of ample size carries the current directly to the slip-ring.
7. Large slip-ring of high-current carrying ability minimizes mechanical wear and provides connection from the moving contact to the terminal.
8. Potentiometer use. The rheostats are provided with three terminals so they can be used as potentiometers or voltage dividers.
9. High strength ceramic hub insulates the shaft and bushings from all live parts. All sizes will stand a 3000 volt a-c breakdown test to ground.
10. The contact arm is a long tempered steel spring which assures uniform contact pressure at all times. Cadmium-plated for corrosion resistance.
11. Rounded pivot holds contact brush in flush-floating contact with wire.
12. Stops which are keyed to the shaft and base limit the rotation—thus no torsional strain is imposed on the contact arm on stopping.
13. Compression spring maintains uniform pressure and electrical contact between slip-ring and center lead at all times.
14. Models E, H, J, G, K, and L: End thrust is taken by a retaining ring. Models P, N, R, T, and U: End-thrust is taken by a stop washer. Steel shaft in brass bushing provides a wear-resistant, wobble-free bearing.
15. Ohmite rheostats meet requirements of NEMA and EIA (formerly RETMA).
16. There are only ceramic and metal in the construction of Ohmite rheostats—there is nothing to char, burn, shrink, or deteriorate.

Write on company letterhead for Catalog 58.

OHMITE MANUFACTURING COMPANY
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RHEOSTATS • RESISTORS • TAP SWITCHES
RELAYS • R.F. CHOKES • TANTALUM CAPACITORS
VARIABLE TRANSFORMERS • GERMANIUM DIODES

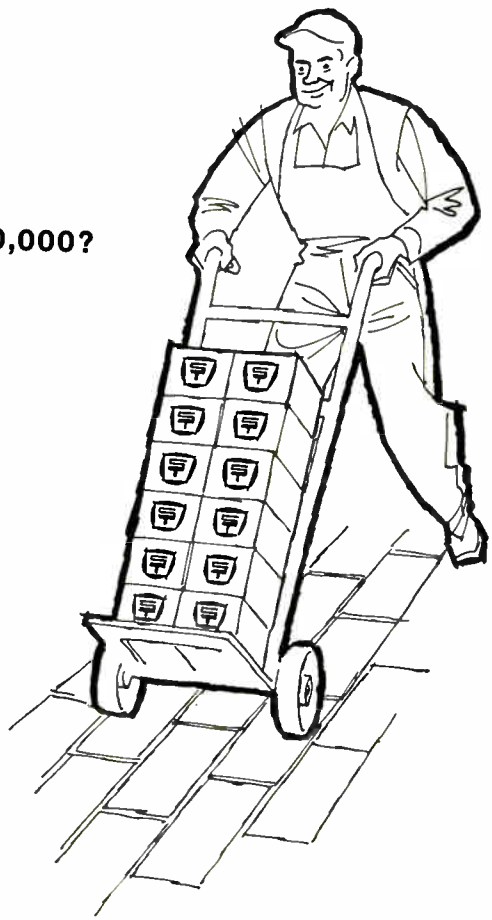
SERIES F TARZIAN Silicon Rectifiers

Tarzian Type	Amps. DC (85° C)	PIV	Max. RMS Volts	Max. Amps.		Jedec Equiv.
				Recurrent Peak	Surge (4MS)	
2F4	.20	400	260	2.0	20	— —
F-2	.75	200	140	7.5	75	1N2482 / 1N2069
F-4	.75	400	280	7.5	75	1N2483 / 1N2070
F-6	.75	600	420	7.5	75	1N2484 / 1N2071

0.2" maximum diameter
0.4" maximum length

How many?

100? 1,000? 10,000? 100,000? 1,000,000?



If Series F units meet your design requirements, then you can specify with full assurance of availability in any quantity.

These Series F units are widely useful. They combine small size, low cost, high performance and Tarzian reliability. They are interchangeable with many other rectifiers. Junctions are oversize—handle inrush currents far beyond normal circuit requirements. Temperature rise is low and reliability is increased.

The insulated body of the Series F units presents no mounting problems. And low cost with high quality results from Tarzian production methods.

For additional information about Series F rectifiers, call your Sarkes Tarzian sales representative, or write Section 5760. Sarkes Tarzian is a leading supplier of silicon, tube replacement, and selenium rectifiers. Practical application assistance is always available.

SARKES TARZIAN, INC.

World's Leading Manufacturers of TV and FM Tuners • Closed Circuit TV Systems • Broadcast Equipment • Air Trimmers • FM Radios • Magnetic Recording Tape • Semiconductor Devices

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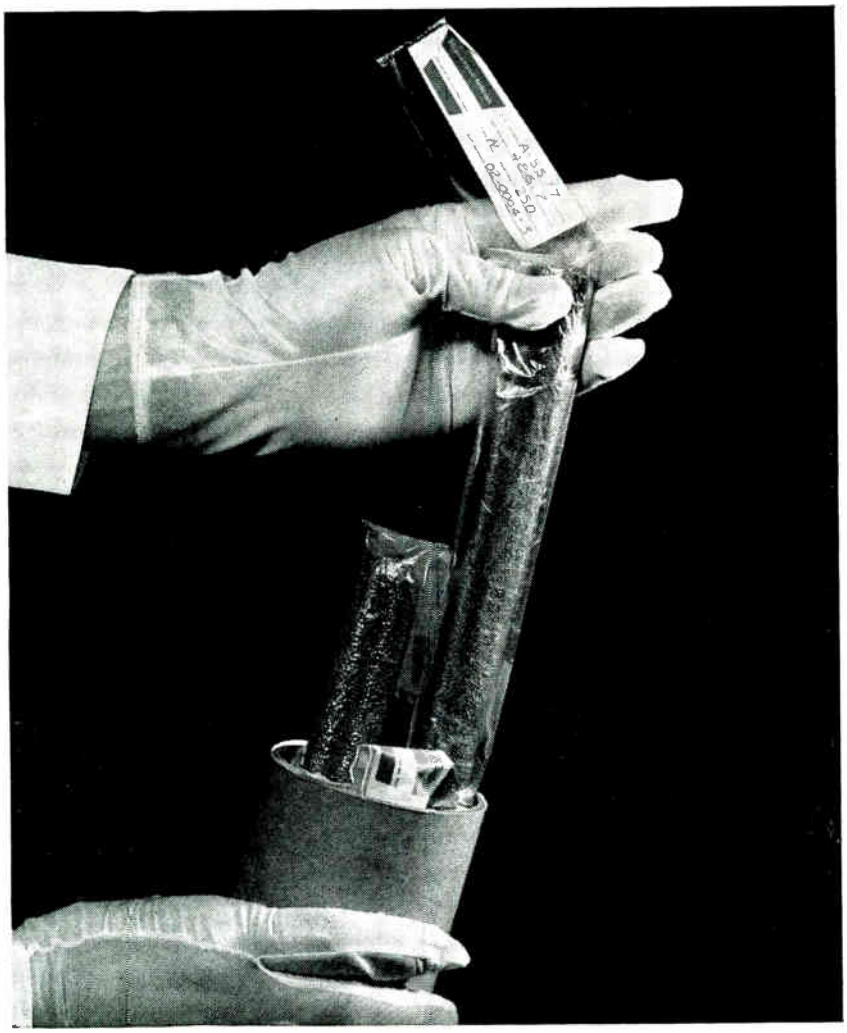
(PART 1)

The Untouchables

Hyper-Pure Silicon... Silicon So Pure Just a Touch Contaminates Its Quality



The highest purity attained in any element refined by man . . . purer than any element found in nature! That's Hyper-Pure Silicon.

With less than one part per billion of boron, Dow Corning Silicon is so pure that just the touch of a finger tip causes contamination — destroys its high quality.

To assure this untouchable purity when you receive them, Dow Corning polycrystalline rods are wrapped in special unbleached cellophane and sealed in airtight polyethylene envelopes.

Purity pays off in quality — in uniformity of properties . . . in relatively flat resistivity and lifetime profiles for the entire length of single crystal silicon grown from Dow Corning polycrystalline rod and chunk . . . in maximum yield.

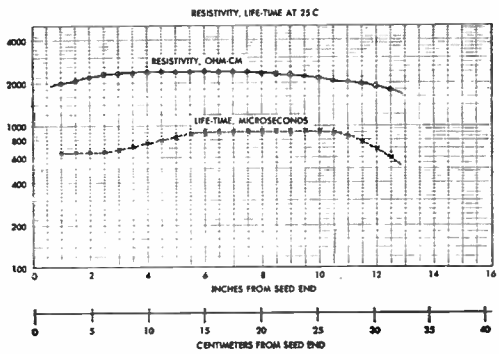
Specify polycrystalline rod if you use the zone refining process for conversion to single crystal — polycrystalline chunk if the Czochralski method is used. Both are of the same high quality.

Why is Dow Corning able to supply this untouchable quality?

Dow Corning has nearly twenty years experience in the production and purification of trichlorosilane, a chemical basic to both *Silicones* and *Hyper-Pure Silicon*. This experience, plus a fully integrated production facility, assures uniformly high quality — minimizes batch to batch variations.

For more information contact our nearest regional office, or write direct.

Typical properties of Dow Corning polycrystalline silicon, together with resistivity and life-time curves for an evaluation crystal, are shown below.



Typical Properties of Polycrystalline Silicon

Acceptor Impurity Content:	0.15 part/billion
Donor Impurity Content:	0.5 part/billion
Rod Diameter:	up to 26 mm (1.0 in.)
Rod Length:	up to 450 mm (17.7 in.)
Resistivity (vacuum zoned evaluation crystal):	>1000 ohm cm
Lifetime (vacuum zoned evaluation crystal):	>400 micro sec.

Free brochure — "Hyper-Pure Silicon for Semiconductor Devices." Write Dept. 3412.

HYPER-PURE SILICON DIVISION
Address: HEMLOCK, MICHIGAN

Dow Corning CORPORATION
MIDLAND, MICHIGAN
ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D.C.

AUTOMATIC RECORDING ANALYSER

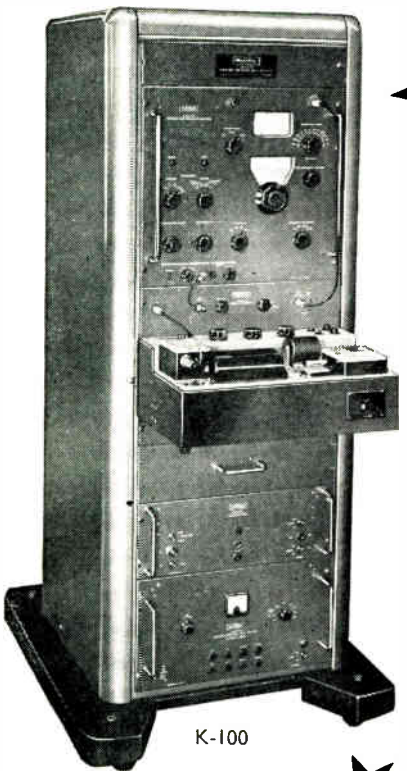
FOR ANALYSIS OF NOISE AND VIBRATION SIGNALS

STEADY AND NON-STEADY SIGNALS ANALYSED AUTOMATICALLY

Many types of noise and vibration signals can be handled. Equipment performs automatic amplitude/frequency analysis of steady signals and automatic amplitude/frequency/time analyses of non-steady (time varying) signals.

COMPLETELY AUTOMATIC OVER FULL FREQUENCY RANGE

Equipment is fully automatic over entire range of 10c/s-19kc/s, but can be made to scan only part of the range.



K-100

CHOICE OF THREE CONSTANT PERCENTAGE BANDWIDTHS

A choice of three bandwidths is available, $\frac{1}{3}$ octave, 5% and 1.5%, giving octave discrimination of 30dB, 54dB and 70dB respectively.

OUTPUT RECORD IMMEDIATELY AVAILABLE

All results are presented on pre-printed amplitude/frequency calibrated or amplitude-calibrated papers.

FREQUENCY ACCURACY IS HIGH

Frequency accuracy of analyser alone is 0.5% and on output record, better than 1%.

WIDE AMPLITUDE RANGE

1mV-300V, dynamic range 44dB generally, or 300mV-300V, dynamic range up to 70dB with steady signals.

SEQUENTIAL ANALYSIS OF SIGNALS

At the end of frequency scan, analyser can be made to select new input signal with automatic chart advance—making multi-channel analysis very simple.

THE MUIRHEAD K-100 WILL SAVE TIME AND SKILLED MANPOWER

A 5% bandwith amplitude/frequency analysis of a steady signal over range 10c/s-19kc/s takes only 12 minutes.

Write for further information

MUIRHEAD

Precision Electrical Instruments

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458

easily recognised

by their superior performance as

MUIRHEAD

Synchros

392

Low leakage and useful h_{FE} at very low collector currents permit low power operation – as low as 30 microwatts per stage. High performance PLANAR transistors and diodes use simplified circuitry (see illustration), keep costs down, reduce power requirements, and permit high-density packaging. Prime applications: missile and space vehicle guidance and instrumentation.

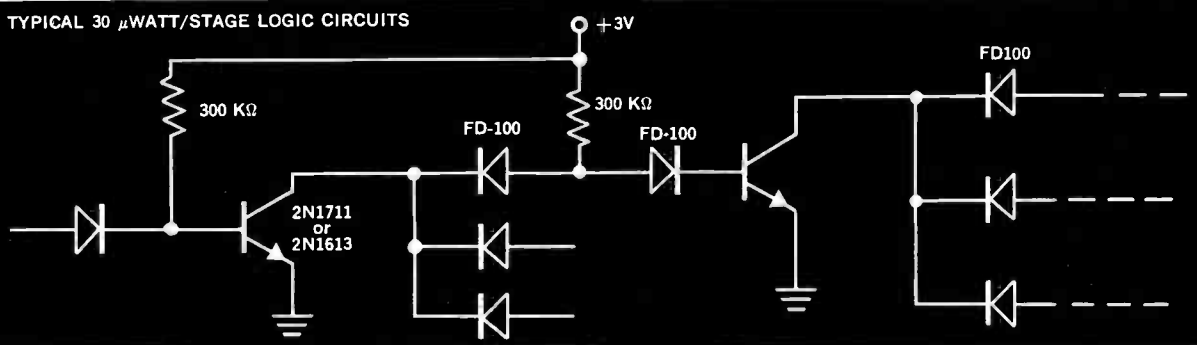
For your down-to-earth needs, where weight, space and power are less critical, similar logic circuits will operate with switching rates greater than 5 mc.

mμA leakage in Fairchild **PLANAR** transistors and diodes permits

MICROWATT LOGIC

FOR SPACE VEHICLES

TYPICAL 30 μWATT/STAGE LOGIC CIRCUITS



MAXIMUM RATINGS AND ELECTRICAL CHARACTERISTICS (25°C except where noted)

	Total diss.	V_{CBO}	V_{EBO}	h_{FE} (I_C=150mA) (V_{CE}=10V)	h_{FE} (I_C=0.1mA) (V_{CE}=10V)	C_{ob} (I_E=0) (V_{CB}=10V)	I_{CBO}	I_{CBO} (V_{CB}=60V) (T=150°C)	I_{CBO} (V_{CB}=50V) (T=125°C)
2N1613	3.0W	75V	7.0V	40-120	20 min.	18pf typ. 25pf max.	0.8mμA typ. 10mμA max. (V_{CB}=60V)	1.0μA typ. 10μA max.	–
2N1711	3.0W	60V	7.0V	100-300	35 min.	25pf max.	10mμA max. (V_{CB}=50V)		10μA max.

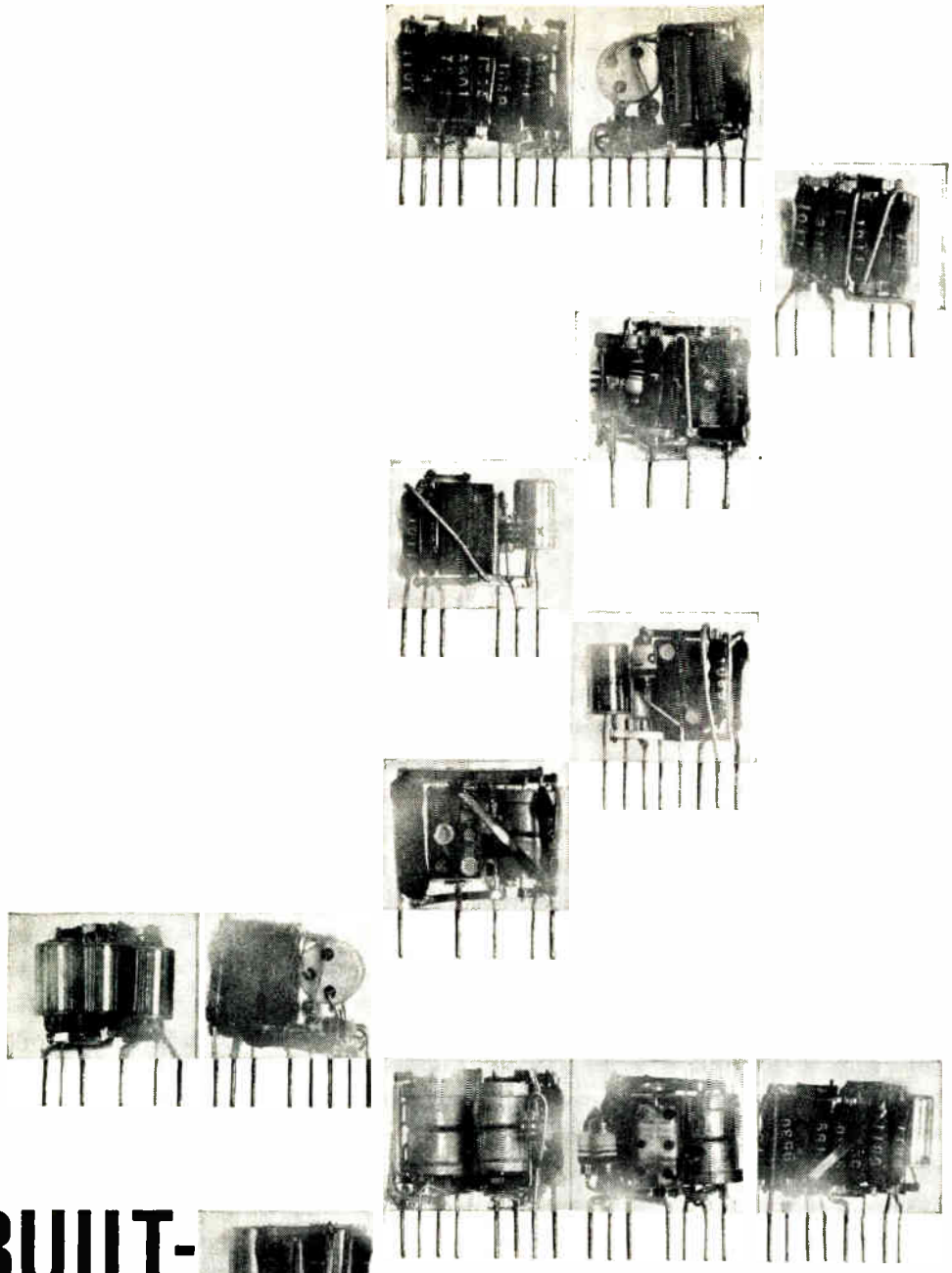
FD100	WIV	P diss.	T_A	T_{stg}	I_R (V= –50V)	R_E (100 mc)
	50V	250mW	–65° to +175°C	–65° to +200°C	0.1μA	45%

545 Whisman Road
Mountain View, California

FAIRCHILD SEMICONDUCTOR CORPORATION

YOrkshire 8-8161
TWX: MN VW CAL 853

A WHOLLY OWNED SUBSIDIARY OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION



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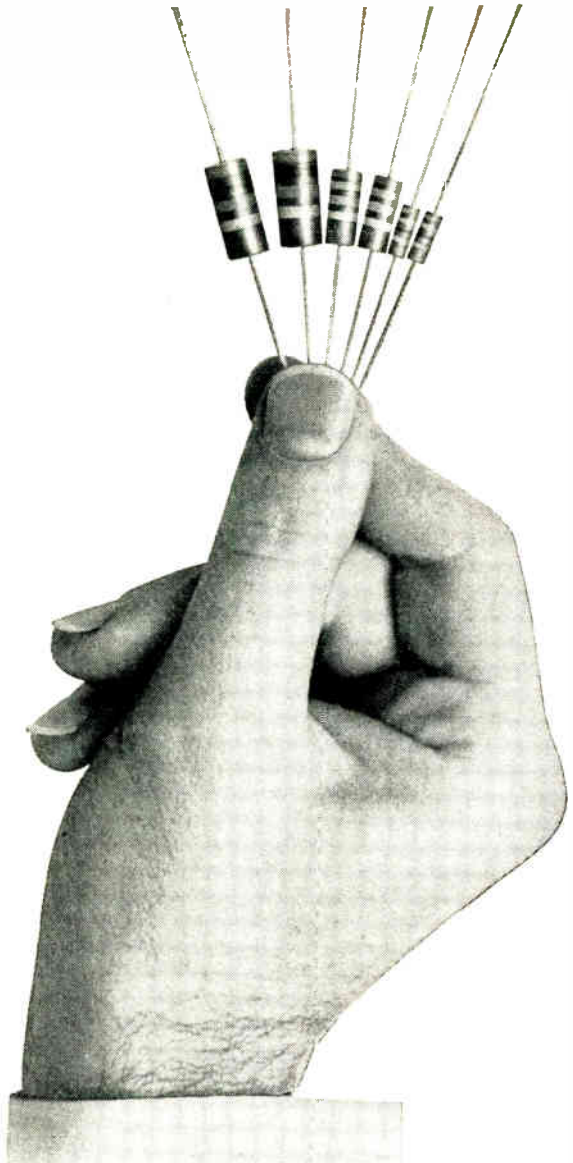
...with off-the-shelf components

Delco Radio can design, develop and deliver digital computers with the speed you need, for airborne guidance and control as well as a wide variety of other special applications. ■ With off-the-shelf Delco transistorized digital circuits, we have, for example, built a computer for a military application in less than three months. ■ These miniature modules contain standard components. They satisfy all MIL-E-5272D (ASG) requirements, which assures extremely rugged, reliable computers. Continuing life tests on these computer circuits now exceed four and one-half million transistor hours *without a failure*. And where space is no problem, you can have these same, reliable digital circuits packaged on plug-in circuit cards. ■ Delco Radio has six sections of highly experienced people with the necessary capabilities to produce complete computer systems: Application Analysis, Systems, Logic, Memory, Circuit Design and Advanced Development. May we review your requirements? Just contact our Sales Department. ■ *Physicists and Electronics Engineers: Join Delco Radio's search for new and better products through Solid State Physics.*

PIONEERING ELECTRONIC PRODUCTS THROUGH SOLID STATE PHYSICS

DELCO RADIO

Division of General Motors • Kokomo, Indiana



for the service
you need...
for the sizes you want...

SPEER RESISTORS

You're sure to find the sizes and types you want in Speer's complete line of 1/2-, 1- and 2-watt fixed composition resistors, which meet or exceed the requirements of specifications MIL RII and RS 172. The fast, efficient service for which Speer has gained a wide reputation can also help you eliminate costly production delays. So next time, specify Speer! *Speer now offers these new sizes:*

Speer Type	MIL Style	Rating in watts	Body		Lead	
			Nominal Diameter	Nominal Length	Wire Size	Nominal Length
					A.W.G.	
SR ½	RC 20	½	.138	.390	#20	1½
SR 1	RC 32	1	.225	.562	#18	1½
SR 2	RC 42	2	.312	.688	#17	1½

Other Electronics Divisions of Speer Carbon Company
Jeffers Electronics, Du Bois, Pa.
Onondaga Electronics, Syracuse, N. Y.

Speer Resistor Division
Speer Carbon Company, Bradford, Pennsylvania

Circle 46 on Inquiry Card

Shallcross

precision circuit news

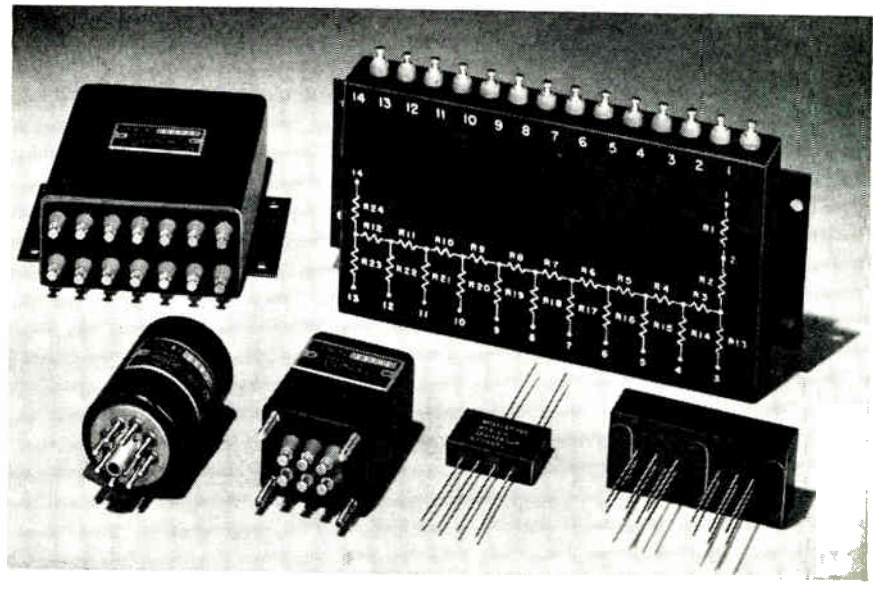
RESISTANCE NETWORKS

. . . the inside story on quality

In reading ads for wirewound resistance networks, you sometimes find the superiority of one technical characteristic emphasized to a misleading degree. Desired accuracy, temperature coefficient, stability, and voltage division obtained in one type of network may be impossible to achieve in another.

Essentially, network quality is determined by the quality of its individual resistors. Beyond this, network performance improves or deteriorates depending on packaging and mounting techniques, AC layout and trimming methods, accuracy of measuring instruments, the manufacturer's production standards and his knowledge of the latest developments in network theory.

Shallcross offers a unique background of experience, reliability data, manufacturing and testing skills to minimize what few error factors remain in Shallcross precision wirewound resistors when the networks are sealed. For a sample of this ability, submit your next network requirement for evaluation by Shallcross engineers. Meanwhile, send for Bulletin A-2 for a practical discussion of proper network design.



Temperature Stabilized COMPUTER NETWORKS

High reliability Shallcross P-Type precision wirewound resistors help these computer networks maintain close AC ratios over wide temperature ranges. To maintain these tolerances, Shallcross has refined resistor manufacturing techniques to provide TC tracking within ± 1 ppm in many cases. Individual resistor reliability is enhanced by stability "exercises" and by new tension relieving devices within each resistor. Beyond this, extremely accurate AC and DC measuring instruments help in final network design, trimming, packaging, and proof-of-performance testing.

From an extensive background of network engineering Shallcross offers analog to digital and digital to analog converters, voltage dividers, summing and integrator networks, and others to virtually any configuration.

WHY PACKAGE RESISTANCE NETWORKS?

Packaging does far more for resistor networks than provide convenient mounting and environmental protection. Some can also increase power dissipation, provide electrical shielding and increase network stability over extended temperature ranges. Principally however, enclosed networks maintain electrical performance by preventing "field introduced" errors brought about by improper mounting or damage to critical AC layouts through improper resistor replacement during maintenance. Where unusually critical voltage division tolerances must be maintained, the design engineer should make provision for a packaged network in his application.

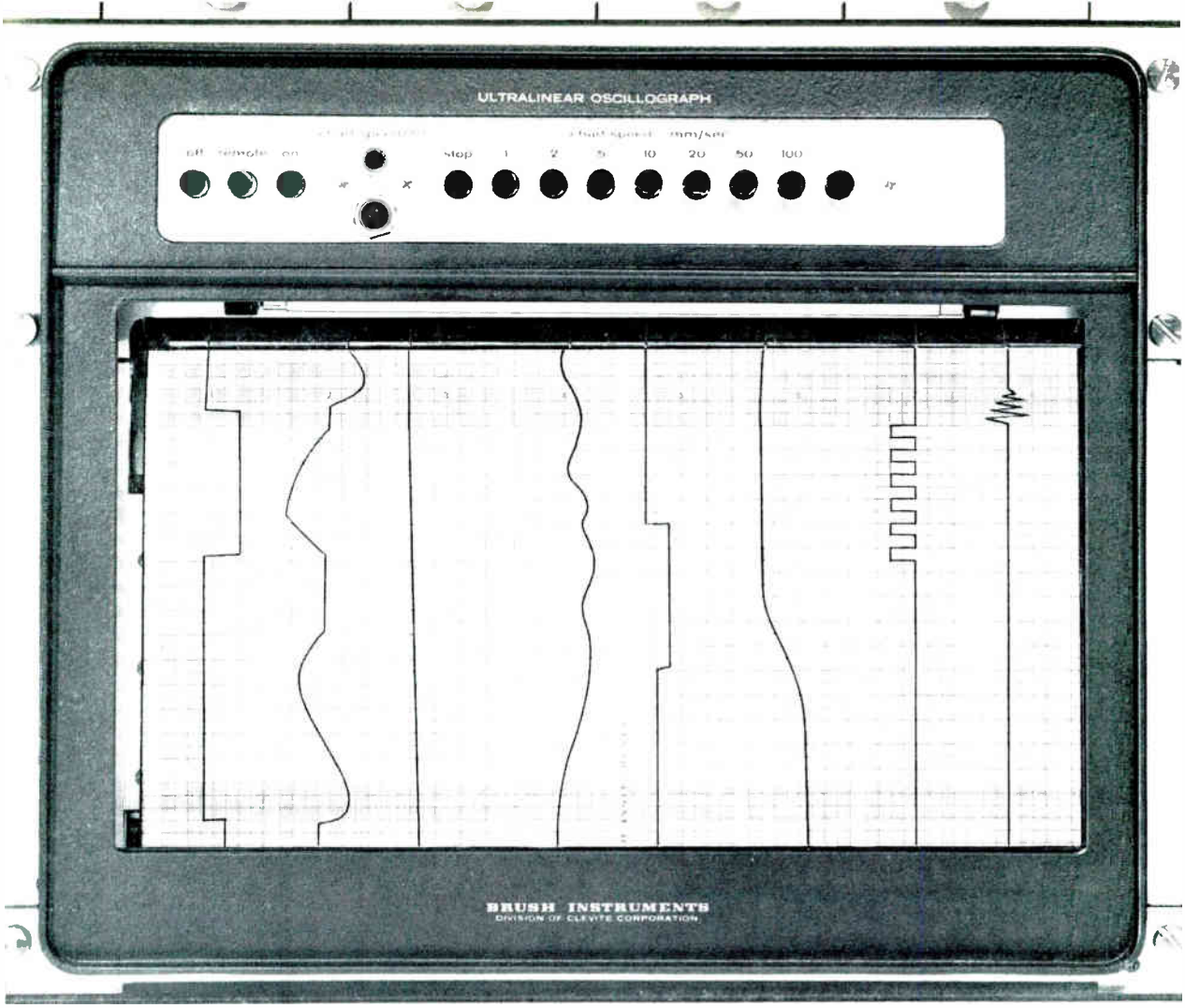
Shallcross regularly supplies networks in many hermetically sealed, encapsulated, and plug-in designs. For a discussion of when to use which style, write for Bulletin A-2.

Shallcross Manufacturing Co. Selma, North Carolina

Precision wirewound resistors, Switches, Instruments, Delay lines, Resistance networks, Audio attenuators.

Circle 47 on Inquiry Card

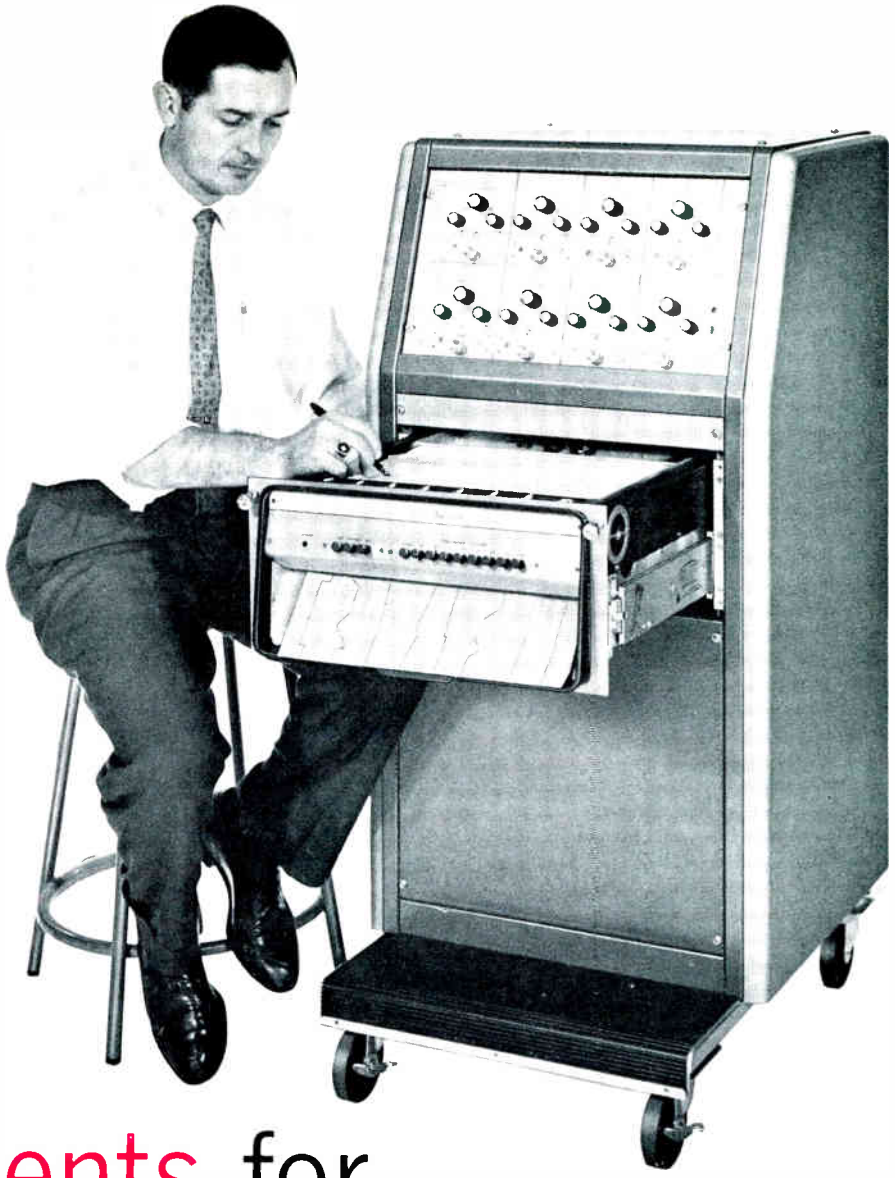
Circle 48 on Inquiry Card →



in multi-channel recording systems there is nothing newer

It's no wonder this recorder has been chosen for today's most advanced telemetry and computer systems. Providing the highest precision and proven reliability, Brush's newest oscillograph instantaneously displays eight 40mm channels of analog data, plus two event markers. Sharp, easy-to-read traces on rectilinear coordinates. Accurate resolution of all signals and positive interpretation of amplitude is assured with 13 electrically controlled, precise chart speeds. All functions are operated by pushbutton and may be remotely controlled if desired. Unique auto-load system locks unit in any position for greatly simplified chart changing . . . without disturbing the styli. Take advantage of industry's most advanced techniques in this space-saving vertical panel oscillograph. Get *all* the facts. Call, write or wire.

brush INSTRUMENTS
DIVISION OF
37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO



only Brush fills all requirements for multi-channel, multi-purpose recorders

If it's precise, instantaneous data acquisition in writing . . . Brush versatile recording systems provide the answer. Whether your requirements call for this "pull-out", horizontal model for convenient annotation and reading . . . or the newest in vertical panel recorders . . . you'll find all of the known refinements in the art of recording by direct writing. Rectilinear presentation gives clear, uniform, reproducible traces for precise readout. Up to 16 chart speeds are selected by pushbutton; jam-proof transmission provides quick response. Interchangeable "plug-in" signal conditioners permit four vital functions in addition to amplification—high input impedance, zero suppression, attenuation and calibration. Event markers, internal timers, remote control and chart take-up are some of the available accessories. Check these advanced recording systems for yourself and you'll see why no one is as qualified as Brush. Write for complete details.

brush INSTRUMENTS

DIVISION OF

37TH AND PERKINS **CLEVITE** CORPORATION CLEVELAND 14, OHIO

Next month

• ONE SOLUTION TO SERVO HUNTING

Usually a servomotor drives a potentiometer so that the input voltage exactly matches the feedback voltage. With precision wire-bound pots this is not always possible because of the voltage difference between windings. Precision carbon film pots seem to be the answer in many cases.

• LEVEL GAUGES IN THE LIQUID HELIUM—LIQUID OXYGEN RANGE

With more and more emphasis being placed on the operational status of missiles and space vehicles, the problem of simplifying fuel level sensing for field use is magnified. The high sensitivity of the thermistor makes it a leading contender for the detector.

• USING JACOBIANS FOR FREQUENCY SELECTIVE NETWORKS

This article is an experiment. Instead of presenting a short discussion for those familiar with Jacobians, and a long table of results for those who are not, the entire article contains only one simple network—so simple that results can be verified intuitively.

• PROBLEMS IN AUTOMATIC DIGITAL TEST EQUIPMENT

There is great interest in automatic test equipment for guided missiles, aircraft and other complex electronic and electromechanical systems—particularly for military applications. This article covers some of the problems involved in the design of a versatile, flexible, high-speed, fully automatic missile checkout system for use in field testing by unskilled personnel.

• COMMON MODE IN LOW LEVEL INSTRUMENTATION

Out of the mushrooming growth of the missile and rocket fields during the past few years, a new science has evolved—the science of low input instrumentation. With its birth a whole Pandora's box of problems was opened. Terminology such as ground loop currents, common mode rejection, long lines, isolated amplifiers, etc., became the vogue. This discussion describes these terms and offers positive suggestions for elimination of systems engineering problems involved.

• LIGHTWEIGHT VIBRATION TRANSDUCER

A need existed in the environmental testing of missile electronic equipment for a lightweight sensing element that would not effect the vibration characteristics of the equipment being tested. The study resulted in the development of a small 0.35 gm. expendable lightweight piezoelectric unit suitable for the numerous special applications.

Plus all our other regular departments

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These small S-band tubes use a permanent magnet focus structure that is miniaturized along with the other tube structures. The result is ruggedized, light weight, wideband 10 milliwatt and one watt tubes that are well suited for confined spaces such as found in airborne vehicles.

New Techniques Lead to

Compact Traveling Wave Tube Design

By H. WOLKSTEIN and C. L. CUCCIA
Electron Tube Div.
Radio Corp. of America
Harrison, N. J.

THE traveling-wave tube is a versatile wide-band amplifier, at microwave frequencies, in which an electron beam and a wave to be amplified interact in a linear electron-beam region that is several inches long. Unlike low-frequency amplifiers, the TWT must provide means to focus the electron beam through this interaction region.

As recently as 1956, traveling-wave tubes used large electron tubes and r-f coupling structures. They were focused in bulky separate solenoids weighing from 50 to 100 pounds and requiring as much as 1 kw of power. Although modern and efficient when compared to the tubes and solenoids of a decade ago, the resulting package was completely unsuitable for airborne systems because of weight. Moreover, the bulk of the package discouraged its use in many ground-based systems.

In 1956, Siekanowicz and Sterzer[1] disclosed a wide-band TWT which used a periodic permanent-magnet (pm) focus structure of the type pioneered by K.K.N. Chang[2] and by Pierce,[3] Mendel, Quate, and Yocom.[4] It provided an integral package which met many of the size and weight requirements of systems designers. This package included the electron tube, the r-f couplers, and a periodic pm focus structure in an aluminum capsule. The entire assembly weighed less than 15 lbs.

Here we describe the development of a pair of S-band traveling-wave tubes based on the design of the Siekanowicz-Sterzer tube, but modified for purposes of miniaturization and ruggedization. Each tube weighs approximately 2 lbs. and comprises a complete S-band amplifier package of very small size suitable for use in confined chassis and enclosures.

Fig. 1: Top tube is a standard solenoid-focused tube while the two lower tubes make use of periodic-focusing.

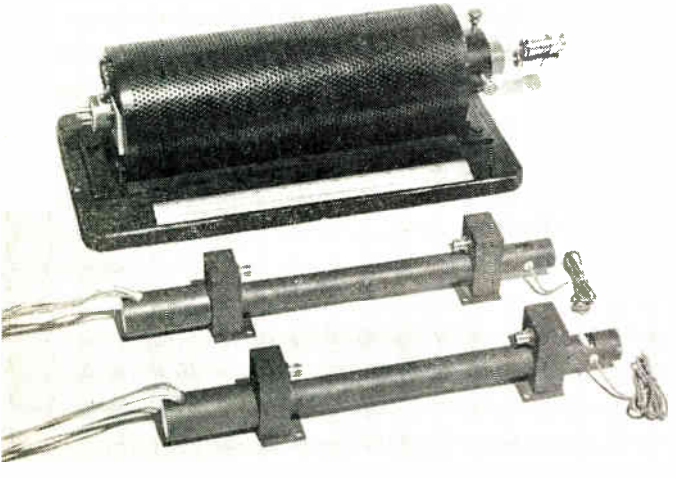


Fig. 1 shows the solenoid-focused RCA-6861 TWT, which is still very modern by many microwave-amplifier standards, together with the pair of S-band tubes. Each tube of the pair is 15¼ in. long and 1 1/6 in. in diameter along most of the package. One tube has a saturated power output of from 10 to 25 mw; the other tube has a saturated power output of from 1.25

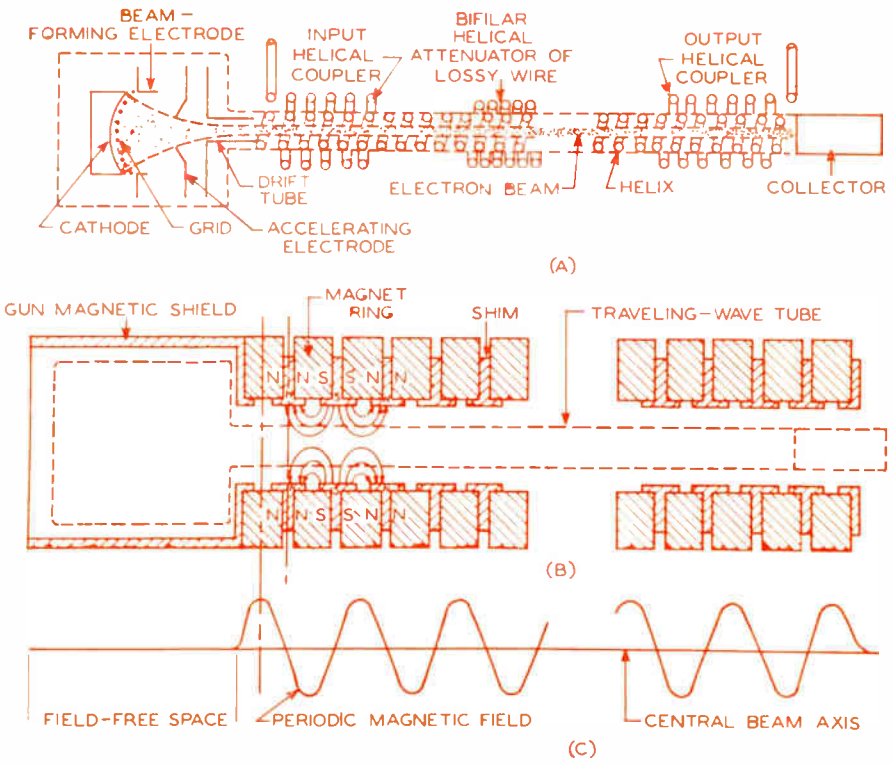


Fig. 2: "A" shows the basic components of a TWT using convergent-flow gun and helical input and output couplers. 'B" is a cross-sectional view of a periodic permanent magnet focus structure. "C" illustrates the magnetic field produced by "B."

to 1.75 watts. Both have gains in excess of 30 db. Each tube is a complete microwave circuit.

Basic Tube Components

The basic structure of a TWT is shown in Fig. 2a. The tube contains a non-resonant, slow-wave structure, such as a helix, along which the wave to be amplified travels, and an electron gun which projects an electron beam through the slow-wave structure to the collector. When the velocities of the traveling wave and the beam are equal ("synchronous operation"), interaction between the electron beam and the traveling wave produces electron bunching in a phase such that energy is transferred from the electron beam to the traveling wave. The wave, therefore, emerges from the end of the helix with a power gain. Because the helix is not a resonant circuit, the interaction between the traveling wave and the electron beam is effective over large bandwidths.

The helical r-f couplers couple to, and propagate the input signal onto the helix, and couple the amplified signal from the end of the helix. The attentuator couples attentuation into the tube midway between the input and output couplers to prevent reflected waves and backward waves in the electron beam from starting unwanted oscillations.

Although the slow-wave circuit, helical couplers, attenuator, and electron-beam circuit complete the electrical circuit within the tube, it is necessary to provide some means to focus the electron beam along the helix to a collector without the interception of substantial numbers of electrons by the helix.

Fig. 2b shows a periodic permanent- magnet focus structure which provides a periodic magnetic focusing field extending from the point at which the converged electron beam enters the helix to the collector. Fig. 2c indicates the configuration of the periodic magnetic field along the beam axis.[5]

The Focus Action

Fig. 2b shows a portion of the periodic permanent-magnet structure of ring magnets and steel shims which produce the periodic magnetic field. The various ring magnets are magnetized so that north and south poles are produced on the side faces. The ring magnets are then stacked with similarly polarized faces adjacent between steel shims. Consequently, the south-pole faces of adjacent ring magnets produce a south pole in the steel shim between them, and the north-pole faces of adjacent ring magnets produce a north pole in their common steel shim. The magnetic field along the axis of such a structure, therefore, varies periodically, having zero strength in a plane through the center of each steel shim, and maximum strength in a plane through the center of each ring magnet.

A beam of electrons passing along the axis of the periodic-magnet structure, and provided with sufficient accelerating voltage, is constrained most in regions where the force exerted by the field is at peak positive or negative value, and least in the region where the flux field passes through zero. The electron beam is thereby alternately deflected towards and away from the central axis, and follows a scalloped path.

Convergent-Flow Gun

The TWT structure (Fig. 2a) includes a convergent-flow electron gun which, in a field-free space, converges an electron beam produced from a large, concave cathode, and projects the converged beam into the helix. The convergent-flow gun was first proposed by J. R. Pierce. The field-free region for the convergent-flow gun is obtained by the use of a steel magnetic shield at the entrance to the periodic pm focus structure, as shown in Fig. 2b. The convergent electron beam enters the periodic magnetic field at a

TWT Design

(Continued)

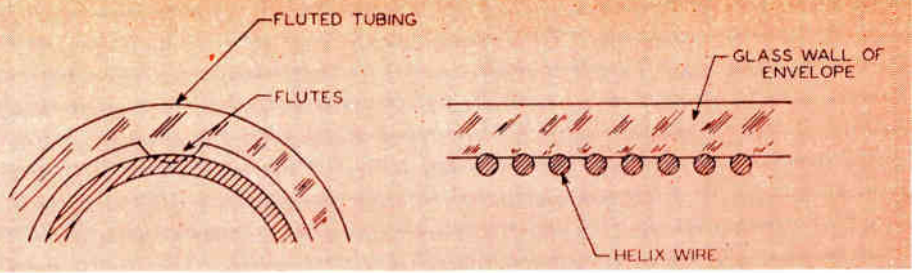


Fig. 3: The helix is supported by imbedding it in flutes on the inside of tube.

point in the drift tube at which the beam has minimum diameter.

A novel form of this type of gun, using a hybrid beam-forming and control-grid design devised by H. Wolkstein, is shown in Fig. 2a. The electrons forming the space charge are emitted by a large, concave cathode under grid control, and are converged by electrodes of appropriate design into a beam of proper diameter at the entrance to the drift tube. A convergence ratio of 4 to 1 is employed. One of the chief advantages of the convergent-flow gun is its use of a very large, lightly loaded cathode and large electrodes. The hybrid arrangement eliminates the need for separate grids and beam-forming electrodes.

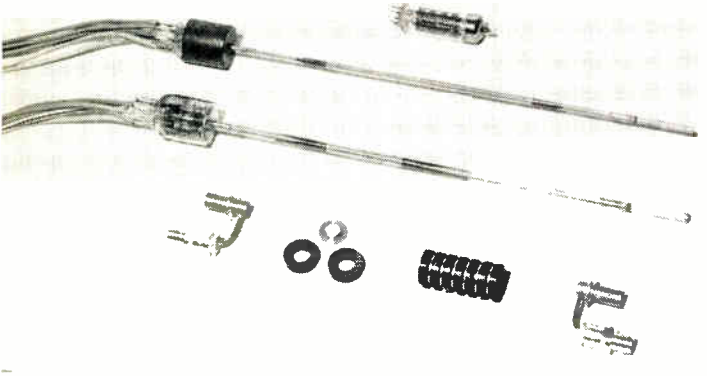
Helix Support

One of the most important considerations in the design of a TWT is the method of supporting the helix. This method determines the diameter of the envelope, the dielectric loading of the helix, the precision with which the helix turns-per-inch ratio is maintained, the ability of the helix to withstand shock and vibration, and the type of input and output coupler that may be used. The helix support used in the design of the miniaturized S-band tubes uses a glass envelope which has flutes along the length of its inner surface, as shown in Fig. 3.

Such fluted-glass envelopes are ideal helix-support structures because the point contacts between the flutes and the helix produce minimum dielectric loading and, therefore, have only slight adverse effect on tube gain. The flutes also permit the helix to be positioned close to the wall of the envelope to assure optimum coupling to helical couplers.

The fluted-envelope support is heated after the precision-wound helix is inserted in the envelope. After the glass softens, the flutes are pressed into the helix.

Fig. 4: The miniaturized TWTs are compared to an electron tube



The helix support provided by this "envelope-shrinking" technique maintains the precise spacing between individual turns of the helix during axial and lateral vibration.

The Helical Couplers

Helical couplers can be made very small, provided an optimum ratio of the diameter of the external helix to the diameter of the internal helix of 1.6 to 1 is approached. Consequently, they are ideally suited to couple through tube envelopes which support the helix at or close to the inside wall of the envelope. The helical coupler is also capable of coupling over far wider bandwidths than the operating bandwidth of the slow-wave helix itself.

The input and output helical couplers shown in Fig. 2a comprise external helices supported in threaded Teflon sleeves. A coaxial cable is connected to each coupling helix for signal transfer to or from that helix, and each helical coupler is positioned with respect to the internal helix for optimum coupling.

Integral-package traveling-wave tubes using fluted glass envelopes are particularly adaptable to external-helix-type attenuators which provide the desired insertion loss by electromagnetic coupling through the tube envelope to the slow-wave helix. The attenuators used are bifilar helices of lossy wire supported by tape, and are proportioned to provide an insertion loss of at least 60 db between the input and output couplers.

Tube Miniaturization

All elements of the electron tube, the couplers, and the focus structure shown thus far are suitable for use in traveling-wave tubes designed for miniaturization without any deterioration of electrical characteristics. The use of a fluted-glass helix envelope not only minimizes the diameter of the helix portion of the electron-tube envelope, but also permits the helical couplers to couple through the fluted-glass envelope to the internal helix over bandwidths far greater than an octave, and with VSWR's less than 1.5.

Fig. 4 shows the electron tube structures for the two miniaturized S-band tubes. These tubes have saturated outputs of 10 mw and 1-watt, respectively. The outer diameters of the helix envelopes are 0.165 in. and 0.210 in., respectively; the diameter of the helical couplers is less than 5/16 in.

The periodic permanent-magnet focus package for these tubes must provide peak magnetic fields of 375 gausses and a cylindrical focus region sufficiently large to accommodate the electron tube plus the helical couplers. It was found that magnet rings of Indox 1 could be made having outer diameters as small as 0.800 in. and still satisfy these requirements. This

magnet-ring size is much smaller than any formerly used, and permits the use of miniaturized tube packages having an outside diameter of approximately 1 inch.

Experimental use of the miniaturized periodic pm focus structure indicated that beam currents of at least 20 ma could be supported at helix voltages of the order of 1000 volts over wide temperature ranges. Accordingly, the 1 w tube was designed to operate at a synchronous voltage of 1100 volts and a beam current of 18 ma to provide minimum saturated power output of 1 w and gain of 27 db. The 10 mw tube was designed to operate at a synchronous voltage of 600 volts and a beam current of 3 ma to provide minimum saturated power output of 10 mw and gain of 27 db. Table 1 lists the average helix, collector, and electron-gun operating characteristics of both tubes.

Integral-Package Details

Fig. 5 illustrates the compactness of the integral-package TWT. This tube, the 1 w S-band type, is 1½ in. in diameter about the gun end, 1⅛ in. in diameter along the helix region, and 15½ in. long, and weighs 2 lbs.

The periodic pm focus structure shown in Fig. 5 is composed of an array of 34 thin, very-light-weight ring magnets and steel magnet shims, which develop a magnetic field that varies sinusoidally along the central axis with a peak value of approximately 375 gausses and a period of ¾ in. Fig. 5 shows the electron-tube and helical-coupler portions of the integral package, and also a number of the individual ring magnets used in the focus structure.

Fig. 6 is a cross-sectional diagram of the integral-package TWT shown in Fig. 5, showing the arrangement of r-f couplers, electron tube, and the periodic permanent-magnet focus structure inside the capsule. The electron tube is mounted at the collector end in a Teflon support; the gun end of the electron tube is mounted on nylon screws (not shown) which are adjusted for optimum focus of the electron beam. When focus is achieved, thermoplastic potting compounds fasten the tube into position.

The integral package typified by the structure of Fig. 5 is uniquely adapted for mass production. The magnet-ring-and-shim structure is separately fabricated and magnetized and inserted in the capsule, with the precision-made helical couplers supported by the inner faces of the adjacent shims. All fabrication, processing, and installation techniques are adaptable to standardization. The electron tube is mechanically separate from the focus structure until the final steps of the assembly, when the tube is focused and potted in place. Thus, the integral package is made up of separately fabricated and processed parts which then require only an assembly and positioning operation.

Grid Control

Both the 10 mw and 1 w tubes use convergent-flow guns employing control grids which need only a fraction of the voltage required by the accelerating electrode or helix for beam control.

Fig. 7a shows a typical curve of collector current and power output as functions of grid voltage for the 10 mw tube, showing the virtual cutoff of beam current occurring at a grid voltage of about −30 volts. Grid-control performance of the 1 w tube given in Fig. 7b, shows a cutoff amplification factor of approximately 5 and a cutoff at −80 volts.

The grid configuration employed for both tube types provides maximum power output when the grid is at cathode potential. This mode of operation assures a relatively high grid-input impedance and no grid-dissipation problem. The input capacitance of the grid, including the stray capacitance of the flying leads, is less than 15 pf and requires a low-level of input drive power. As shown in Fig. 7b, full output power of more than 1 w is obtained at mid-band with a beam current of 12 ma.

The r-f cutoff characteristics of the tube are comparatively sharp because of the fast reduction in circuit interaction as beam-current cutoff is approached. This reduction is caused by the control grid which,

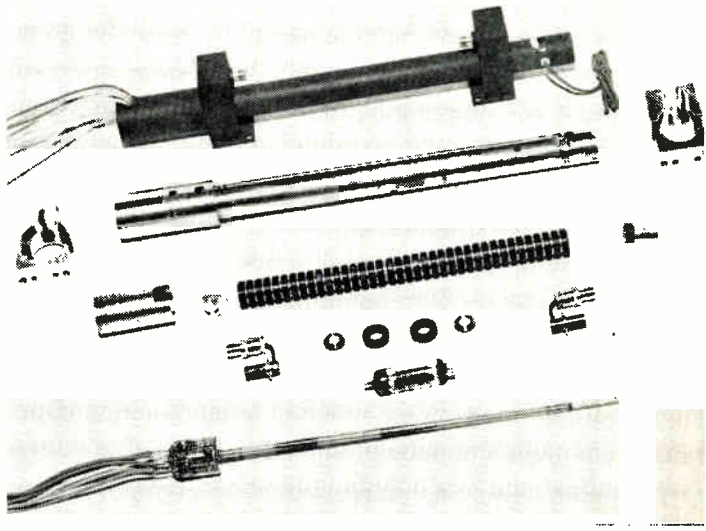


Fig. 5: Photo shows a 1-watt tube and its components

when operated at negative potentials relative to the cathode, causes a reduction in beam diameter as the grid is biased more negatively. As a result, the electron beam is decoupled from the helix, and the influence of the control grid over the degree of power output is enhanced.

The interaction circuit of a traveling-wave tube is normally more than 30 wavelengths long, a length which represents a total phase shift from input coupler to output coupler of more than 2000°. With so great a total phase shift, very slight changes in operation produce small changes in phase shift.[6] The variation of power output by grid control, as indicated by Fig. 7b, is, therefore, accompanied by a phase shift of the output power.

Power-Output Characteristics

When no input power is applied to a TWT, the output power is amplified noise. As an increasing amount of input power is applied to the tube, the output power, which increases as a linear function of the input power, levels off at a maximum value and

TWT Design *(Concluded)*

then decreases. The power outputs developed for low input powers are produced in the maximum-gain region of the TWT.

The maximum value of power output achieved is the saturated power output, or the maximum amount of energy which the beam can deliver to the traveling wave. An increase or decrease in beam current produces a corresponding increase or decrease in the magnitude of the saturated power output.

The use of a single attenuator in the 10 mw tube caused the power-output characteristics beyond saturated power to be substantially different for different frequencies. However, the use of four attenuators, positioned so that the power-characteristic curves at different frequencies fall into the same general power ranges, provided a range of input power of 17 dbm in which at least 10 mw of output power can be produced anywhere in the S-band frequency range.

Gain

Each tube has a saturated gain which occurs near power saturation in the beam. For input signals having power levels insufficient to produce saturation, the tube provides small-signal gain. In general the small-signal gain is approximately 6 db greater than the saturated gain.

The saturated gain of the 10 mw tube is approximately 30 db, and the power output is greater than 10 mw. The minimum saturated gain and power output of the 1 w tube are 27 db and 1 w, respectively, with peak mid-band gain and saturated power output of 35 db and 1.6 w, respectively.

The gain of a TWT is a function of the active length of its slow-wave helix; i.e., the length of helix which is not coupled to attenuators or to helical couplers and is, therefore, available for amplifying action. The small-signal gain of a 1 w tube having a helix of standard length was compared with another model of this tube having an active helix length increased by one inch. This increase in helix length resulted in small-signal gains which were in excess of 50 db in the 2300 to 4000 MC frequency range.

Gain Uniformity

The relationship between gain uniformity and periodic variations in the pitch of TWT helices has been investigated to relate periodic variations in helix pitch to multiples of quarter-wavelengths along the helix. This relationship indicates that the frequencies at which gain variations can be expected are given by

$$f = \frac{3 \times 10^{8}\sqrt{V_o}}{\frac{4 \times 505}{n}} \times L$$

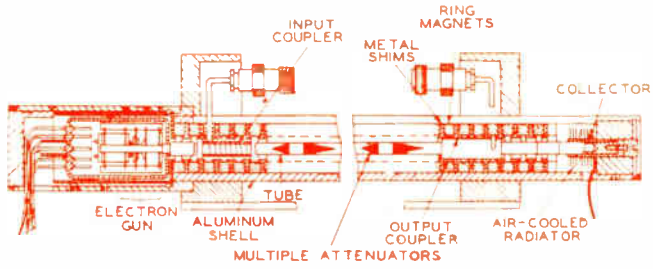


Fig. 6: Cross-sectional view of a miniaturized S-band TWT.

where L is the length between periodic pitch variations or discontinuities, V_o is the axial beam voltage, and n indicates multiples of quarter-wavelengths.

Measurements were made on the uniformity of pitch of a special helix of the type used in the 10 mw tube, in which pitch variations were produced by a periodic eccentricity in the mechanism of the helix-winding machine.

Measurements made while this helix was fastened to a winding mandrel indicated a winding error of 10 microns every sixth turn, with the average distance between turns being 438 microns. In addition, experience has indicated a 5% helix "spring-out" after firing and release of the helix from the mandrel. This spring-out introduces a pitch-winding discontinuity L given by

$$L = \left(\frac{1}{TPI} \times \text{number of turns} + \text{error}\right)(1 + \%\ \text{spring-out})$$
$$= (438 \times 6 + 10)\ (1 + 0.05) \times 10^{-6}$$
$$= 2.77 \times 10^{-3}\ \text{meters}$$

This helix was used in an experimental 10 mw tube employing a beam current of 3 ma and an axial beam voltage of 553 volts. When the values for L and V_o were applied to the equation for frequency, it was determined that gain variations could be expected for frequencies of the form

$f = 1.26 \times 10^{9} \cdot n$; where $n = 1, 2, 3, 4 \ldots$

$= 1260$ MC, 2520 MC, 3780 MC, and the like.

with the odd multiples providing gain dips, and the even multiples providing gain peaks.

Measurements on a series of tubes confirmed these relationships, and indicated the strong dependence of gain uniformity on the precision with which helices

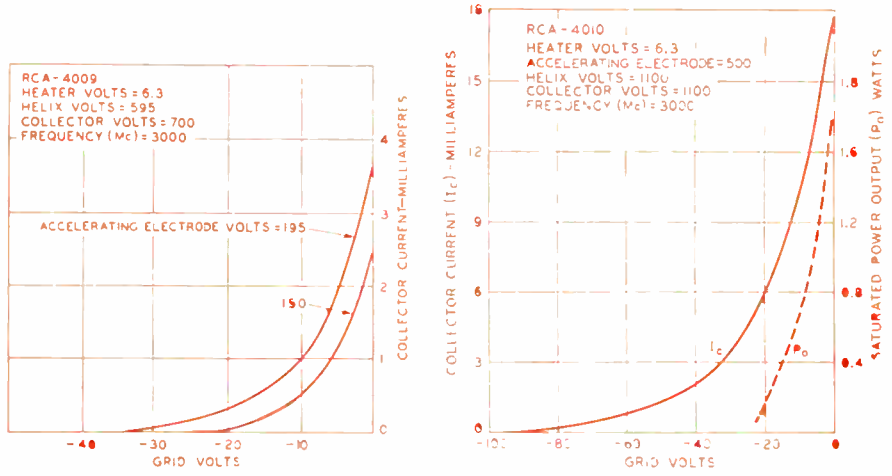


Fig. 7: Graphs show the grid-control characteristics of the miniaturized TWTs

are wound and installed in a TWT. In a related fashion, the precision of the helical-coupler windings strongly affects gain uniformity because this parameter controls the uniformity of the coupling VSWR between the helix and helical-coupler over the amplifier frequency band.

The use of precision-wound helical couplers and helix termination minimizes gain dips and peaks produced by reflections or VSWR peaks in both the slow-wave structure and helical couplers.

Pulse Amplification

A bandwidth of at least $2/T$ is required of a band-pass amplifier to translate and reproduce a pulse of duration T without serious distortion of the pulse shape. When the pulse duration is of the order of a millimicrosecond, then bandwidths of $2/10^{-9}$ or 2000 MC are required of the pulse amplification network.

The 1 w TWT amplifier was used by F. Sterzer[7] to provide not only pulse-rise times of 0.7 nsec with a gain of 20 db, but also as an excellent dynamic check of the amplification bandwith. This amplifier was employed in a circuit using a modulator which converted the dc pulses to r-f pulses of 2750 MC energy. These r-f pulses were applied to the input of the 1 w S-band tube. A demodulator connected to the output of the TWT demodulated the amplified r-f pulses.

Pulses of approximately 1.2 nsec duration and peak input voltages of less than 0.21 volt produced undistorted output pulses, thus showing the amplification bandwidth to be valid from the pulse-response standpoint.

Tube Gain

A traveling-wave tube is capable of multiple-signal operation. The tube amplifies each of a plurality of signals in different portions in the frequency band with substantially no intermodulation and loss of gain, provided that the combination of signals does not represent a power input which drives the beam into saturation, and provided that variations of tube gain as a function of frequency are small.

When a saturating signal involving input power as much as 30 db greater than that required for saturation is applied to the TWT, then the small-signal gains at all other frequencies in the frequency band are greatly reduced. This drop in gain is proportional to the input power and inversely proportional to the frequency of the saturating signal.[8]

Tandem Operation

The 10 mw and 1 w S-band tubes are well-suited for tandem system operation. The 10 mw tube provides more than 30 db small-signal gain from 2000 to 4000 MC. Power output for this tube is maintained above 5 mw for an input-power swing greater than 35 db. This performance insures adequate input drive for the 1 w stage. The 1 w tube provides an output greater than 1 w for a 15 db input-power variation across the band.

Environmental Aspects

The growth in interest in traveling-wave tubes using periodic permanent-magnet focus structures is due not only to their light-weight and compact packaging, but also to their ability to be ruggedized.

Ruggedization of the miniaturized S-band tubes involves at least four major considerations: (1) ruggedized support of the helix in the envelope; (2) ruggedized support of the long helix envelope in the integral package; (3) maintenance of peak magnetic-field strength uniformity during wide excursions of ambient temperature; and (4) hermetic sealing to permit tube operation and storage at high humidity. Each of these considerations is satisfied by the miniaturization techniques used in the two tubes.

Considerations (1) and (2) are met, respectively, by the embedding of the helix in the glass flutes. And by support of the envelope at an intermediate point in the tube structure. The success of these ruggedization techniques is illustrated by the fact that a 1 w tube without an embedded helix showed amplitude modulation of 2 db under axial vibration at approximately 2 g, whereas a similar tube having an embedded helix showed amplitude modulation of only 0.25 db under the same vibration. The addition of intermediate support for the helix envelope reduced this modulation to 0.1 db. Under transverse vibration, the unruggedized tube showed amplitude modulation due to deflection of the center of the helix envelope of 3 db; when intermediate support was included in the structure this modulation was reduced to only 0.2 db.

Maintenance of the peak strength of the periodic focusing field requires temperature stabilization of the permanent ring magnets. Such stabilization is achieved when the ferrite ring magnets used in periodic focusing structures are subjected to periodic freezing at liquid-air temperatures while magnetized to saturation. The 20 ma value used for beam current of the 1 w tube was derived from actual focus experiments conducted with miniaturized magnet stacks. As a consequence, the beam focusing in operating tubes was substantially maintained to temperatures as great as 75° C and to a minimum tolerable storage temperature of 50° C.

Hermetic sealing is accomplished by the use of potting compounds which completely enclose and seal each tube opening so that steam, condensation, and even salt-water spray and other potentially damaging liquid environments can not penetrate the capsule to the magnet rings, shims, couplers, and electron tube.

Reliable high-altitude operation up to 60,000 feet is obtained by the use of separately insulated flying leads to each of the electron-tube electrodes.

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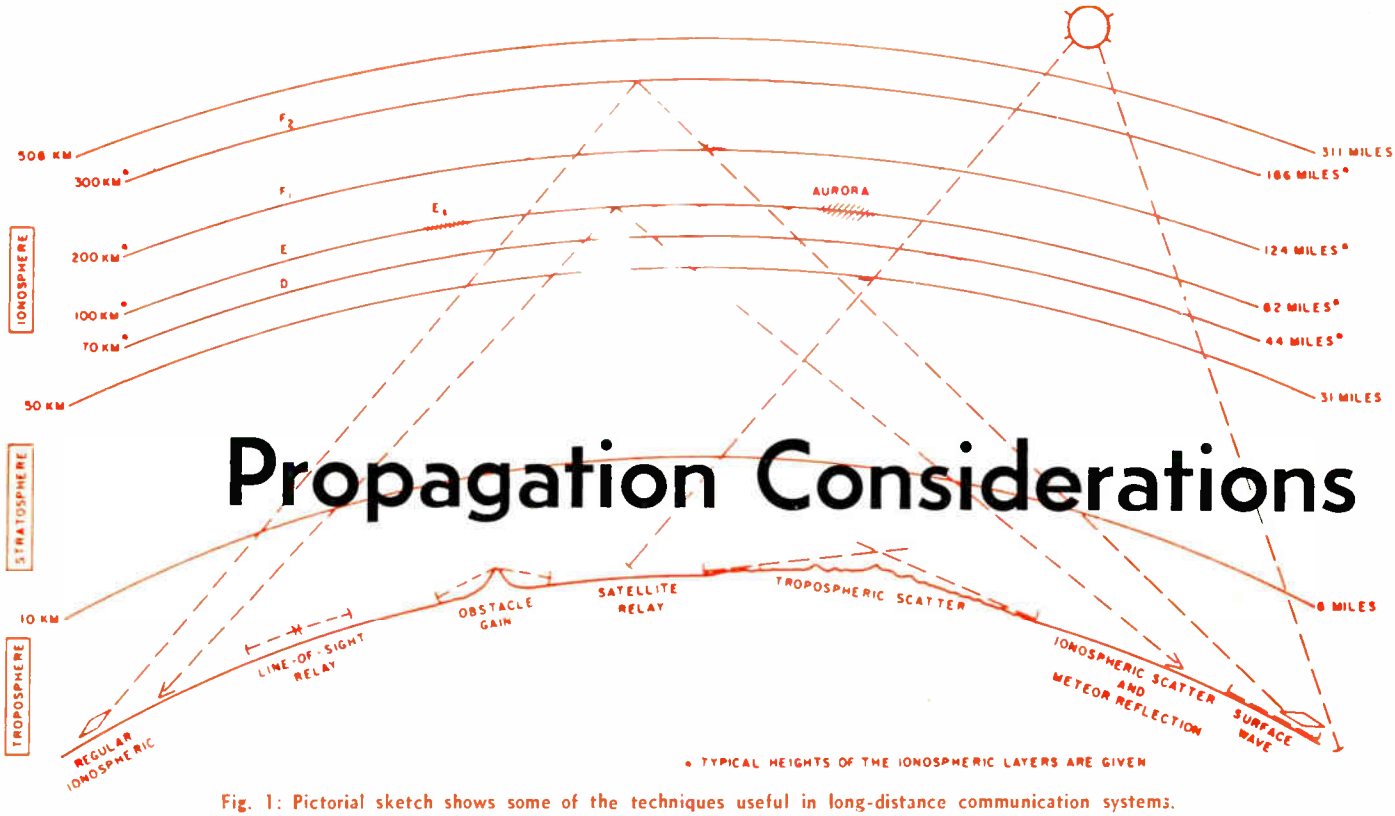


Propagation Considerations

Fig. 1: Pictorial sketch shows some of the techniques useful in long-distance communication systems.

A RADIATING antenna located in the vicinity of the earth's surface will produce an electromagnetic field which is extremely complex. The field is a function of many parameters including height above earth's surface, height of radiating antenna above earth's surface, distance from antenna, antenna pattern, electrical characteristics of the earth's surface and of the atmosphere, wavelength, and many other factors.

This complex field is the result of simultaneous propagation of the energy by several electromagnetic field configurations, or modes. These various modes can be used for accomplishing desired radio wave transmission. Unfortunately these same propagation modes are available to undesired signals as well.

This article will summarize the propagation characteristics of the various modes and will indicate some problems of interest, with emphasis on the propagation aspects of the problem. It will treat principally propagation modes involving the far, or radiation, field of an antenna. In addition, it will also treat to a lesser extent coupling modes between conductors more closely spaced. First, far-field effects involving two types of interference are discussed:

1. Interference to a system caused by other systems, and
2. Interference to a system caused by irregular propagation of the desired signal (self interference).

Both types of interference can cause distortion of the received signal with resultant loss in intelligibility in voice communication systems, increase in error rates in teletype systems, etc. Some pertinent definitions concerning far-field effects follow.

The *transmission loss*, L, of a radio circuit consisting of a transmitting antenna, a receiving antenna, and the intervening propagation medium is defined as:

$$L = \frac{P'_t}{P'_a} \tag{1}$$

where P'_t = the r-f power radiated from the transmitting antenna, and

P'_a = the resultant r-f signal power which would be available from the receiving antenna if there were no circuit losses other than those associated with its radiation resistance.

In order to separate the effects of the transmitting and receiving antenna gains and circuit losses from the effects of propagation, the *basic transmission loss*, L_b, (sometimes called path loss) is defined as the transmission loss expected between fictitious loss-free isotropic transmitting and receiving antennas at the same locations as the actual transmitting and receiving antennas.

When the radio transmission takes place in free-space—i.e., in a region free of all objects which might reflect, refract, or absorb radio energy—the *free space basic transmission loss* L_{bf} is:

$$L_{bf} = \left(\frac{4\pi d}{\lambda}\right)^2, \tag{2}$$

where d = the distance between the transmitting and the receiving antennas,

λ = the free-space wavelength of the radio-frequency signal,

with d and λ expressed in the same units.

Expressed in decibels, the *free space basic transmission loss* is:

$$L_{bf} = 10\ log_{10}\left(\frac{4\pi d}{\lambda}\right)^2$$
$$= 36.6 + 20\ log_{10}\ d_{mi} + 20\ log_{10}\ f_{mc}, \tag{3}$$

By L. VALCIK
and R. B. SCHULZ
Armour Research Foundation
Illinois Institute of Tech.
10 W. 35th St.
Chicago 16, Ill.

in RFI

The electromagnetic field generated by a radiating antenna is quite complex. This complex field is the result of the simultaneous propagation of the energy by several modes. These modes are used for desired transmissions and, unfortunately are also available for undesired signals. The characteristics of these modes are described.

where d_{mi} is the distance expressed in statute miles and f is the radio frequency in megacycles.

The conditions of free-space transmission loss may be met approximately in propagation through outer space, and in propagation within or through the atmosphere in cases where the transmitting and the receiving antennas are within radio line of sight of each other and where reflection, refraction and absorption are not important. Examples include air-to-air or air-to-ground transmission, transmission between a ground station and a space vehicle, transmission between repeaters in a line-of-sight relay system with adequate ground clearance, etc.

In most practical applications of radio-wave transmission on the earth, the effects of reflection, refraction, or absorption, or all of them, must be considered. In fact, they are responsible for the very existence of most of the propagation phenomena described below. Due to the variability of the various important electrical characteristics affecting the propagation, signal levels are sometimes subject to wide fluctuations.

Line-of-Sight Condition

Under standard conditions, the dielectric constant of the atmosphere decreases gradually with increasing height above the earth; therefore, electromagnetic waves propagating along the earth's surface are refracted downward. This refraction gives the waves a slight tendency to be bent around the bulge of the earth, thereby increasing the area of the earth which is within radio line of sight of the transmitting antenna. For this reason, the distance to the radio horizon is usually greater than the distance to the geometric horizon. For a so-called standard atmosphere, or "4/3 earth," the maximum separation distance d within which two antennas are within radio line of sight of each other is:

$$d = \sqrt{2\,h_t} + \sqrt{2\,h_r} \qquad (4)$$

where h_t and h_r are the heights, in feet, of the transmitting and receiving antennas, and d is the maximum separation distance in miles.

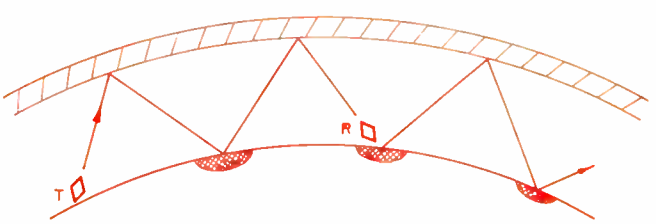
Ducting

When a sharp rise in temperature or drop in water-vapor content, or both, occurs with an increase in altitude above the surface of the earth, a sufficiently marked decrease in refractive index can result, causing a radio wave to be bent back downward to the earth. There it can be reflected upward again, then refracted downward again by the atmosphere, etc., producing the phenomenon known as tropospheric ducting. As a result of this effect, relatively low-loss transmission well beyond line-of-sight is possible, particularly in ducts located over water.

Diffraction

When an opaque obstacle of finite extent (such as the earth) is located between the terminals in a propa-

Fig. 2: Ground-level interference areas along great-circle path for the case of sky-wave propagation is illustrated.



gation path so that it obscures one end from the other, radio energy arrives at the receiving point by diffraction around and over the edges of the obstacle. Diffraction over the earth can cause signals to be received far beyond the radio horizon.

If a *sharp* terrain feature such as a ridge or mountain peak intervenes between a transmitter and a receiver, the received signal can be much greater than it would be over a similar smooth earth path (i. e., without the obstacle). Obstacle gains as great as 70 db and more have been reported. Obstacle gains have been verified at frequencies up to over 1000 MC.; however, in general, obstacle gains are reduced at higher frequencies.

Simple techniques for estimating the basic transmission loss for diffraction over a smooth earth and over an obstructed path are given in Ref. 11 and 19.

Tropospheric Scatter

At points far beyond the radio horizon, the field due to diffraction is reduced to a small value, but a stronger field component—that due to tropospheric scatter—may be present. Such a field is attributed to the reflection or scattering of energy due to the spatial and/or time variations of the atmosphere's refractive index. Transmission via the tropospheric scatter mode is normally accomplished by beaming energy into the atmosphere at a low elevation angle (i. e., at the horizon), and a small portion of the energy is scattered in the direction of the receiver. The scattering is the result of variations of the refractive index within the common volume of the two antenna beams.

The band suitable for tropospheric scatter is approximately 40 MC. to 10,000 MC. The basic transmission loss increases approximately as the cube of frequency and as the eighth power of distance. To give an idea of the transmission loss, for propagation of a 1000 MC. signal over a hypothetical smooth earth the median basic transmission loss would be about 230 db over a 350-mile path with antenna heights of 30 ft. The large basic transmission loss involved in tropospheric scatter transmission necessitates the use of large high-gain antennas (on the order of 40 db gain) and high-power transmitters (10 kw. to 50 kw. typical).

The reason why such high transmitter power is required is to provide reliable operation in the presence of normal signal fading. For the deepest fades against which protection is required, the received signal power will then just be sufficient. During the relatively longer periods when fading is not deep, the received signal strength may be far above the minimum value required; thus the power radiated during such periods is much greater than required, causing consumption of much extra primary power and also radiating much greater potential interference signals. A technique called "controlled carrier" has been recommended as a means of varying the transmitted power so that excess power is not radiated. Such a scheme might be useful in reducing the average radiated power (and potential interference) not only in a tropospheric scatter system, but also in other types of systems in which fading is important. Since the technique requires closed-loop operation, it appears more practical for wide-band, two-way systems.

A tropospheric scatter circuit can experience self-interference due to the normal multipath propagation in the medium and due to the presence of aircraft within the common volume of the antenna beams. Another type of multipath might occur in a tropospheric scatter system operating below about 60 MC. over a path length of about 350 to 650 miles. The received signals may be due not only to tropospheric scatter but also to ionospheric scatter since in that "transition zone" the signals from the two modes can be of comparable strength. Due to its greater path length, the ionospheric scatter signal will be received after the tropospheric signal (see Fig. 1).

Surface-Wave Propagation

Surface-wave propagation is due to the tendency of radio waves to travel along the interface between the surface of the earth and the atmosphere. Transmission loss increases rapidly with increasing frequency and with increasing distance (especially for large distances). Ground conduction losses cause horizontally polarized waves to suffer much greater attenuation than vertically polarized waves. Reference 10 includes extensive curves for estimating the received field strength.

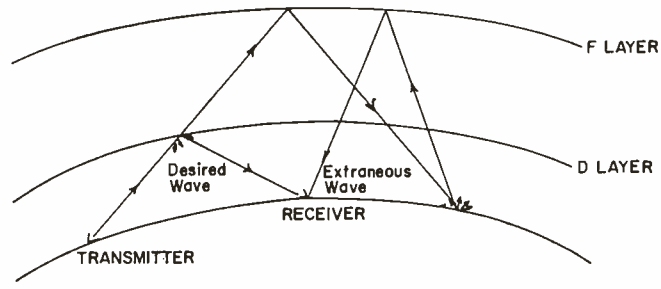


Fig. 3: Sketch shows the geometry of back-scatter multipath in ionosphere scatter propagation.

Ionospheric Reflection

At frequencies less than about 30 or 40 MC. the ionosphere acts much as a metallic reflector in causing waves to be reflected back down to earth. This phenomena has long been used to obtain long-distance transmissions over several thousands of miles. The energy may be received at a distant ground station after one reflection from the ionosphere, or it may be received at some point after successive ionosphere-earth-ionosphere reflections. The highest frequency which the ionosphere will reflect depends upon the degree of ionization within the ionosphere; the greater the degree of ionization, the greater the maximum frequency which can be reflected. Above some upper frequency limit, the incident waves pass on through the ionosphere, with but little energy reflected to earth. The maximum frequency which can be reflected actually depends not only on the ionospheric electron density, but also upon the angle at which the wave is incident upon the ionized layer, more nearly grazing angles allowing reflections of higher frequencies.

The field strength of the received signal propagated via ionospheric reflection depends upon the electrical characteristics of the ionosphere and of the earth along the great-circle path between the transmitter and the receiver. Factors such as time of day, season of the year, solar activity, latitude and longitude, and frequency must be considered in determining the reflection characteristics at the ionospheric reflection points and the absorption of the wave along the path. Ground losses depend upon the type of ground, the angle of reflection, frequency, and number of hops.

For a long-range system, transmitter power might be on the order of 10 kw. and antenna gain roughly 20 db. Some interference from such a system might result from surface-wave propagation. However, the attenuation of surface waves is quite high at the frequencies normally used in sky-wave propagation. The sky-wave propagation mode itself is responsible for most of the interference resulting from such a system. A system with a directional transmitting antenna will cause some of the highest interference levels to be centered on the ground-reflection points along the great circle drawn through the transmitter and receiver (see Fig. 2). However, significant radiation from side lobes can cause interference along other azimuths as well.

Perhaps the two greatest factors responsible for interference from systems using this propagation mode are: (1) the high demand for channel allocation coupled with the comparatively narrow spectrum space available for this mode (approximately 35 MC.), and (2) the variable and somewhat unpredictable nature of the ionospheric characteristics necessitating perhaps assignment of three or four alternate operating frequencies per channel.

Ionospheric "Waveguide" Propagation

At frequencies below about 30 KC, the lowest layer of the ionosphere (the D layer) appears as a sharply bounded, good reflecting layer. Also, at these low frequencies the absorption of energy by the ground is very low, and the ground appears as a sharply bounded good reflector. As a result of these characteristics, propagation at very low frequencies approximates that to be expected within a waveguide composed of two concentric spherical conducting shells. Propagation in this mode is quite insensitive to any roughness of the earth's surface, because irregularities are usually negligible in comparison with the wavelengths used.

The concept of field intensity, rather than transmission loss, has generally been used in characterizing the strength of the signal received via propagation in this mode. The field E some distance d from the source is expressed in terms of E_o, the effective radiated field at one mile from the source. The *ratio* of the field intensity E_o at a distance of one mile, to the intensity E, (expressed in dbs) is given approximately by:

$$20 \log_{10} \frac{E_o}{E} = 8 + Ad\,(10)^{-3} + 10 \log_{10} fd \qquad (5)$$

where E_o = electric field intensity at distance of one mile from the transmitter,

E = field intensity at distance d from transmitter,

d = distance in kilometers,

f = frequency in kc, and

A = an attenuation factor, expressed in db./1000 km.

This relationship applies to the vertically polarized electric field component at great distances (1000 to 8000 km). The factor A has a minimum value of approximately one db./1000 km. occurring at a frequency of about 20 KC., and a maximum of about 20 db./1000 km. near 4 KC.

Ionospheric Scatter

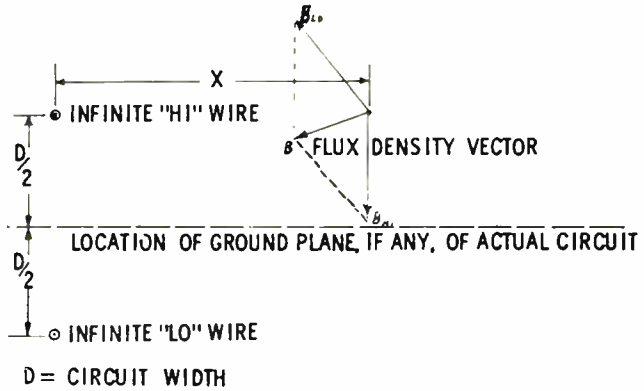
At frequencies of about 30 to 60 MC.—that is, those just above those used for sky-wave transmission—an extremely small fraction of the energy beamed into the ionosphere is scattered downward and can be received by a distant receiver. This scattering is theorized to be caused by irregularities in electron density in the ionosphere, causing spatial variations of the refractive index in much the same way as tropospheric irregularities cause refractive index variations at the lower altitudes. Similarly, the scattering is due to refractive index irregularities within the common volume of the transmitting and receiving antenna beams. Here again, a large basic transmission loss makes necessary high gain antennas (20 db. typical) and high-power transmitters (50 kw. typical).

The high transmitter powers can cause serious co-channel interference. Indications are that such interference is not caused by the ionospheric scatter mechanism, but rather by surface waves and by tropospheric scatter propagation.

Both self interference and interference from external sources can affect ionospheric scatter circuits. Interference from external sources is most likely to occur if the ionospheric scatter system operates at a frequency close to those at which strong ionospheric reflection can occur. Co-channel interference due to regular ionospheric reflection of signals originating even several thousand miles away can result. Therefore, during periods of high sunspot activity, when signals of higher frequencies are reflected by the ionosphere, the use of even higher frequencies, such as 45 to 60 MC., is recommended to reduce interference from both atmospheric noise and signals propagating via ionospheric reflection.

Just as in the case of tropospheric scatter systems, ionospheric scatter systems are affected by a type of self-interference which is inherent in the propagation mode. Again, the result is the reception of the signal

Fig. 4: Use of the model circuit illustrated simplifies the establishment of the maximum field from the source.



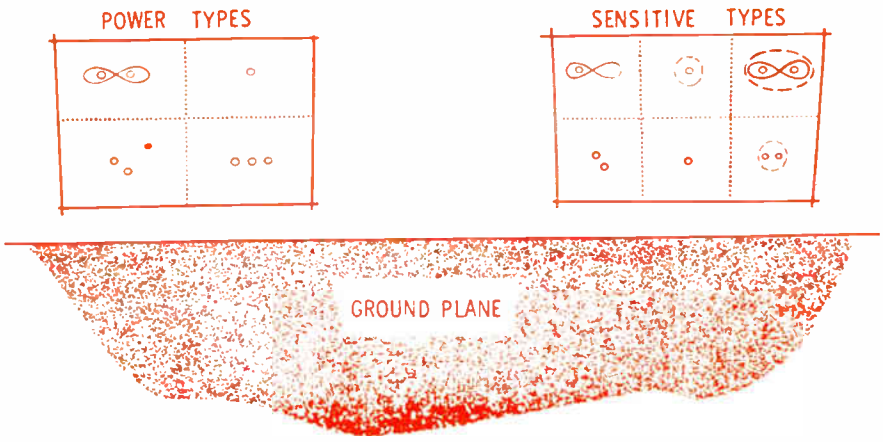


Fig. 5: Illustrated are some of the circuit types that can be approximated by using the model circuit reasoning.

along two or more paths of different lengths causing the reception of multiple signals at slightly different times.

A much more serious self-interference, however, is due to the reception of extraneous signals propagated by means of other modes in addition to the desired ionospheric scatter mode. Extraneous signals from the desired transmitter can be received in the following ways:

1. Back-scattered energy propagated by F or E-region reflection.
2. Reflection from sporadic-E ionization.
3. Reflection from auroral ionization.
4. Reflection from meteoric ionization.

The geometry of back-scatter is shown in Fig. 3. The reception of relatively strong extraneous signals is due to the fact that the reflections from the F layer occur with relatively little loss compared with the scattering loss experienced by the desired wave. Due to the relatively low path loss of the extraneous wave, the received signal can be appreciable even though it enters the receiving antenna through the back lobes.

Sporadic-E ionization can result in signal enhancements and also in multipath. However, the differential delay is much less than that due to F layer back-scatter.

Auroral ionization can cause signal enhancements and also multipath. Another characteristic due to auroras is the extremely rapid fading which can occur (200 to 300 CPS.) This fading is called "sputter" because if the signal is received in an AM receiver it sounds as if it is noise modulated.

Reflection from meteoric ionization results in one of the most serious multipath problems. Since the meteor ionization trails are within the same layer as that from which the desired scattering occurs, the multipath delays are not very great. However, the meteor-reflected signals may be 40 to 60 db stronger than the desired signal. Such reflections cannot be used effectively with ionospheric scatter communications equipment because of the intermittent nature of the meteor signals—individual signals lasting for only a few seconds or perhaps only a fraction of a second at a time. Hence one effect of the meteor signals is the transient increase in signal amplitude.

Another effect is due to the fact that the meteor-reflected signals have their frequency changed slightly (up to a few kilocycles) due to the Doppler shift caused by the lengthening of the meteor ionization trail. This extraneous signal and the desired signal, when combined in the receiver, can heterodyne, resulting in a receiver output which contains short bursts of transient audio-frequency signals. In a radio teletype system using frequency-shift keying (FSK), the Doppler shift can be sufficiently great so that it may not be possible to determine at some instant whether a Mark or a Space has been transmitted. One means for overcoming this problem is the use of a large frequency difference between the Mark and the Space frequencies. Other, more sophisticated, techniques have also been used.*

Meteoric Reflection

The larger meteoric particles falling into the earth's atmosphere produce ionized trails in a certain region of the ionosphere due to ionization of the evaporated meteoric material. These ionization trails provide a mode of communication by serving to scatter, or reflect, a portion of the incident transmitted energy in the direction of the receiver. The usefulness of the various individual meteor trails depends upon the location of the trail relative to the two terminal points and also upon the trail orientation. Suitable trails occur intermittently, necessitating that information be sent in short bursts. Special terminal equipment plus closed-loop (two way) operation of the system is required for sensing when a suitable trail occurs and for transmitting at high rates during such periods and for terminating information transmission in the absence of suitable signals.

Meteor burst systems, almost all of which are yet experimental, operate at frequencies within the band of about 30 to 100 MC. In general, when suitable reflecting trails are present, the basic transmission loss is less than that in ionospheric scatter transmission. Present systems, therefore, employ antennas with comparable or lower gain and transmitters of somewhat less power than used in ionospheric scatter systems.

One of the main sources of error in a meteor-burst communication system is the start-stop operation. For example, the transmission of information might erroneously begin before a suitable transmission path exists, or transmission might continue even after the signal-to-noise ratio dropped below an acceptable value. It is possible for an interfering signal to cause

* "New System Defeats Multipath Effect," page 150, May 1960 issue of *Electronic Industries*.

the first difficulty—premature transmission—if the interfering signal is accepted by one of the receivers and activates the associated transmitter; information would then be lost because information transmission would occur without a suitable reflecting trail. Carrier identification is thus necessary in order to preclude this difficulty.

The directional characteristics of the meteor-reflection process inherently provide a meteor-burst communications system with a certain degree of protection from interference and also from signal intercept. The directivity of the reflection process ensures that the signal reflected from a particular trail can be received within only a limited area on the ground. For ground locations more distant from the intended receiving point, comparatively little information is available. Similarly, the directivity of the meteor-reflection process provides a certain amount of protection against interference generated at some distance from either ground station and propagated via meteor reflection.

The inherent security as discussed above allows two meteor-burst systems using identical frequencies to be located much closer to each other than can other systems operating over comparable distances. Different identifying signals for the two systems would still be desirable.

Propagation by other modes, resulting in self interference, can cause a serious reduction in the performance of a meteor-burst system due to the multiple transmission paths. For example, ionospheric scatter signals are received nearly all the time and generally set the minimum threshold for a meteor burst system operating in the lower part of the VHF band. Sporadic-E propagation, most common in the early summer at temperate latitudes, can produce signals of sufficient intensity to obscure the meteor signals. Tropospheric scatter signals may be troublesome over fairly short paths, where the amplitude of the meteoric signal is reduced.

Near-Field Effects

For near-field effects, the propagation modes or coupling paths are generally treated from an entirely different viewpoint. This is done because the complication in the problem is neither the multiplicity of propagation paths nor the varying nature of such paths, but is instead the relatively complex nature of the field itself associated with the source. The power involved is not only real but also reactive; the ratio of electric to magnetic fields is not a constant but is a function of position with respect to the source and depends upon the very nature of the source itself. Thus, it is not convenient to consider the propagation characteristics separately from the source and receiver antennas.

One further contrast to the far-field case exists: Far-field effects constitute most of the useful modes of r-f energy transmission and have been studied intensively; near-field effects are used to only a small degree for the transmission of useful information and have, by comparison, been studied very little. Thus, quantitative methods for treating near-field problems are as yet quite limited. Among the cases for which quantitative information is available from theoretical bases are: (1) the small ($<<\lambda/2\pi$)-dipole-to-small-dipole coupling, (2) Fresnel-field transmission between large radiators, and (3) induction-field coupling between cables for low-frequency or power-frequency currents. The first case is well covered by many good textbooks on electromagnetic waves and the second has already been discussed by Jacobs[24] in this series of RFI articles. Consequently, only the cable-coupling problem will be covered here.

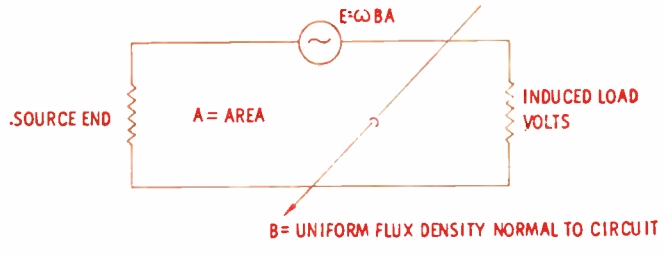
In up-to-date receiving installations, the antenna feed line to a receiver is a well-shielded coaxial cable which involves no substantial coupling problem. Usually, interfering signals at power-line, audio, and other relatively low frequencies couple to control, output, interconnecting, and power-supply cables. In these cases, the input signal is usually introduced into the circuit at some less-sensitive level than the input circuit. Consequently, these effects become important only for large introduced signals; normally, where the receiver is close to the source of interference.

To approach the method, which is a variation on one advanced by Herring,[25] let us first forget about electrostatic coupling. This is justified since designers are, at least currently, willing to use shielded wire whenever circuit impedance and sensitivity indicate a possible need. This shielding is completely effective except for shield breakouts in connector back shells. Magnetic coupling, or transformer-type coupling as it may be called, is thus the only mechanism to be taken into account. This simplification does not help very much, however, because magnetic coupling is harder to prevent than electrostatic coupling, it characteristically depends on the current in the interference-source wire. The coupling is also affected by wire or cable type, grouping of wires into cables, and routing.

The precise way would be to account completely for every variable involved and to attempt exact calculations; this is both elaborate and unnecessary for the intended application. It is normally adequate to obtain a reasonable estimate of an upper bound for the interference. Hence, it is only necessary for us to take into account the most important parameters and ignore the rest in order to arrive at a method which is both effective and practical. The list of possible parameters and variables includes the following:

Source Circuit	*Receiver Circuit*
current	nominal signal level
number of phases	threshold signal level
phase balance	impedance
harmonic content	frequency response
circuit width, length	circuit width, length
circuit type	circuit type
geometry (curves)	geometry (curves)
distance from structure	distance from structure
	shield loops

Fig. 6: Model sensitive circuit describes the receiver.



Propagation & RFI *(Concluded)*

The effects of some of the above cannot be taken into account. The effects of others, however, may readily be calculated or estimated.

Source Field

In order to establish the maximum field from the source, one simplification that can be made is to consider first a simple single wire of infinite length placed above a ground plane by one-half the spacing of an actual cable, as in Fig. 4.

The net vector magnetic field B at points along a line normal to the plane of a power circuit is the vector sum of the individual contributions:

$$B = B_{HI} + B_{LO} \tag{6}$$

and the magnitude B_{rms} is

$$B_{rms} \quad \frac{webers}{cm^2} = \mu \frac{I}{2\pi x} \frac{1}{\sqrt{1+\beta^2}}, \tag{7}$$

where

$$\beta = \frac{x}{D}.$$

It is interesting to note that the resultant field of the two wires is similar to that of a single wire ($B = \mu I/2\pi x$), differing only by the radical in the denominator; this radical gives the cancelling effect of the return current.

The field is specified, at least to our degree of approximation, by naming the current and the circuit width. It is now suggested that the field pattern of most actual circuits can be *approximated* by such a model circuit of appropriate current I and circuit width D. Fig. 5 shows some of the circuit types to which the method may be applied. For instance, a three-phase balanced circuit may be reduced to a two wire, single phase circuit having the same current and a width about three-quarters of the actual circuit width. It turns out that the two variables, current and circuit width, can be adjusted to provide reasonably good accounting for such actual circuit quantities as harmonic content, type of circuit, current, number of phases, phase unbalance, and double grounding.

Receiver Circuit

The receiver circuit is described in Fig. 6. It is supposed that the circuit is subjected to a uniform field normal to the circuit. The induced voltage E calculated on this basis will be on the safe (high) side of the actual voltage if we use for the field strength B the maximum value occurring anywhere in the circuit and for the area A the maximum effective circuit area.

$$E = 2\pi f B A \tag{8}$$

When B is produced by the model source circuit, use of equation (7) yields the expression

$$E = \frac{\mu f I A}{x\sqrt{1+\beta^2}}. \tag{9}$$

By comparison with the model source circuit, the important parameter for the receiver circuit is its area. As before, it is now suggested that the susceptibility of most actual circuits can be approximated with a simple two wire model circuit by properly choosing its area.

Case Leakage

One important case for which theoretical information is totally inadequate is that of r-f leakage from equipment cases. The approach is generally to depend upon experimental values derived for specific equipments. Even so, various types of measurement are employed at present without standardization.

Future Solutions

A common characteristic of all propagation effects is that a large number of variables affect the result. Indeed, a precise knowledge of their instantaneous values is generally not available. Under such circumstances, it is evident that a statistical approach is likely to yield the most information. The best results we can hope to obtain will be in terms of a mathematical expectation of a result—the value *most likely* to occur. Such must be the nature of future efforts in propagation applied to radio-interference situations.

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What's New

Potting Modules for Reliability

Potting techniques are used in producing Navy's Bullpup missile.

KNOWLEDGE of new materials available, design of components to take advantage of these properties and adaptation of new production techniques are some ways in which reliability and cost goals may be reached. An example in improving efficiency and economy is demonstrated in the Navy's Bullpup air-to-surface guided missile program at the Martin Co.'s Orlando div.

A one-part epoxy foam resin, used for potting electronic modules in the Bullpup's radio command system, is the key to the new production method. The resin, "Scotchcast" brand electrical resin No. 603, produced by Minnesota Mining and Manufacturing Co., is incorporated as an integral part of the guidance system, to provide vibration and shock damping, reduce weight and increase moisture and fungus resistance.

The modules were designed for use of this resin, to capitalize on its properties in achieving complete reliability, as well as ease of application and fabrication.

The resin is a ready-to-use, one-part, closed cell structure material, in the form of a free-flowing powder, ideal for foaming-in-place operations. It has an indefinite shelf life, does not require special storage conditions and there are no pot life problems. Curing temperatures and times are relatively low, and the light weight low density of the insulation reduces the overall weight of the missile's guidance system, since it weighs 90% less than a comparable amount of cured solid resin.

The resin has a dielectric constant of 1.55 and an insulation resistance of 10^{12} ohms at 73° F., 6×10^{10} ohms at 250° F., and a foam density of 7 lbs/ft^3.

It is an excellent shock and vibration damping material for protection against acceleration and vibrational forces encountered by airborne electronic components.

The assembled modules are first pre-heated to a temp range of 160 to 180°F., to drive off moisture. The resin is weighed and poured into the module frames. Then a temperatory protective piece is attached over the electrical connector pins protruding from the module end. Each unit is then clamped into its individual mold. The assembly is started through a 2-hr curing cycle, in an automatic, conveyorized convection-type electric oven.

Aluminum molds, coated with Teflon and a silicone oil based release agent, are used to hold the modules during the oven curing cycle. One application of the release agent lasts for several curing cycles.

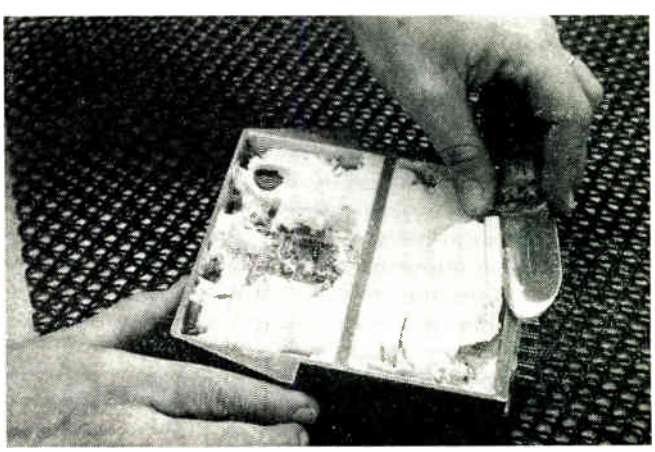
During the curing cycle, the modules are heated from 180°F. to a max. of 230°F. in a step degree rise atmosphere. The resin goes from its powder state to a liquid state and then to a solid state, where it begins to foam. As the temperature increases, the resin begins to set, until the final resin cure is effected before passing out of the oven.

Flexibility is possible within the curing cycle, making the resin suitable for an automated production line. While min. cure times and temperatures are critical, extra time in the oven has no effect on the modules as long as temperatures do not go above the upper limits of the electronic components in the modules.

Because of the foamed, cellular structure of the cured resin, it is possible to salvage every module which does not test out. Resin covering defective parts can be dug out easily to permit replacement, reducing reject cost to the expense of replacing the defective part. Patching is simple, inexpensive — a small amount of resin is poured into the opened cavity and the curing cycle is repeated.

Modules which do not test out can be salvaged.

Aluminum molds, coated with Teflon and a silicone based release agent, are used to hold the modules.



Are Life-Testing Procedures Robust?

THE National Bureau of Standards has been evaluating the robustness of acceptance sampling procedures used in life-testing experiments. Procedures which can be used effectively when some of the underlying mathematical assumptions are not satisfied are termed robust.

Most statistical life-testing techniques assume that the times to failure of components in a life test follow the exponential distribution. In practice, they may not be exponential, so it is important to determine the robustness properties of these procedures; i.e., how well the procedures work when the exponential assumption is not satisfied. Robust procedures are particularly desirable in reliability prediction because the underlying mathematical properties of the phenomena may not be known.

The successful operation of any complex system depends on the operation of the individual components. It is essential that a large proportion of the items from a lot have a minimum acceptable lifetime. It is seldom feasible to assess the lifetime of each component or of even a large proportion of them. Furthermore, when components are given a life test, the testing procedure is sometimes completely destructive. With an acceptance sampling techniques only a sample from the lot is life tested. The data obtained serves as a basis for accepting or rejecting the lot.

The amount of testing necessary depends on:

1. The probability of rejecting components having the desired average or mean failure time (producer's risk);
2. the probability of accepting components having a specified below-par mean failure time (consumer's risk).

These probabilities are assigned to safeguard both producer's and consumer's interest. The consumer wants the chance of accepting poor quality items to be small; the producer to be reasonably sure that good items are not rejected. There is no guarantee, however, that the assigned risk levels will be maintained if the exponential assumption is false. If these risks are appreciably altered, application of acceptance sampling procedure may be disastrous to either the producer or the consumer.

The 4 acceptance sampling plans investigated by NBS for robustness are:

1. fixed sample size plan — a sample of n components is tested until all fail;
2. fixed sample size plan with censoring—a sample of n components is placed on test, and testing is discontinued after the r^{th} failure ($r < n$);
3. truncated nonreplacement plan —a sample of n components is placed on test and testing discontinued after a preassigned time;
4. simple sequential plan — the components are placed on test one at a time, and after each failure a decision is made to accept the lot, reject the lot, or continue testing.

For any one of these acceptance sampling plans, the operating characteristic (OC) curve can be constructed depicting the mean failure time vs the probability of acceptance. This curve is well known when the distribution of failure times is exponential. If it can be shown that the operating characteristic curve is not appreciably changed when the failure times actually come from certain alternative distributions, then the sampling procedure is said to be robust with respect to the alternative distributions.

Three Weibull distributions with different shape parameters were chosen as alternative distributions for studying the robustness of the four plans. This distribution belongs to a class which characterize "wear out" failure, e. g., the longer the item has been in operation, the greater the probability of failure. Further, it is difficult to distinguish between it and the exponential distribution for small sample sizes. This fact has special significance because there will rarely be enough data to decide which assumption holds.

The exact operating characteristic curves for plan 3 were obtained from known theoretical results. On the other hand, the OC curves for plans 1 and 4 were calculated using special analytical approximations developed in the Bureau's Statistical Engineering Lab. The OC curve for plan 2 was calculated by simulating several thousands of life-test experiments on a computer.

The curves indicate that not one of the 4 procedures is robust with respect to Weibull alternative dis-

(*Continued on page* 195)

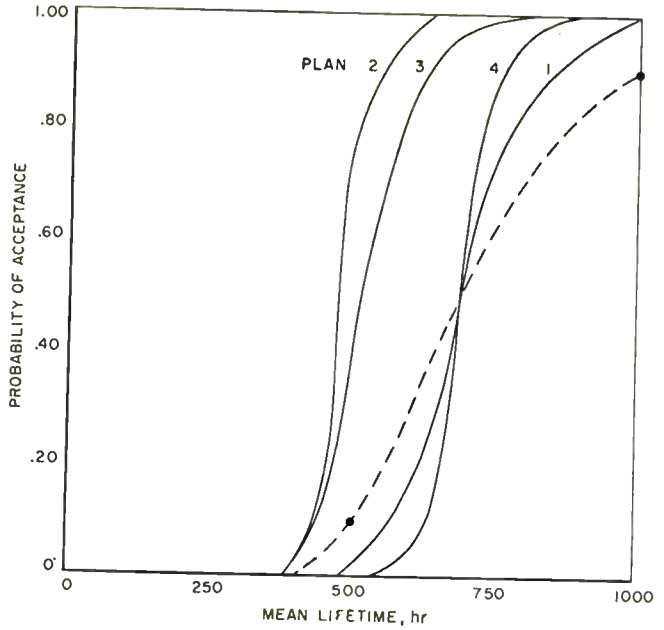
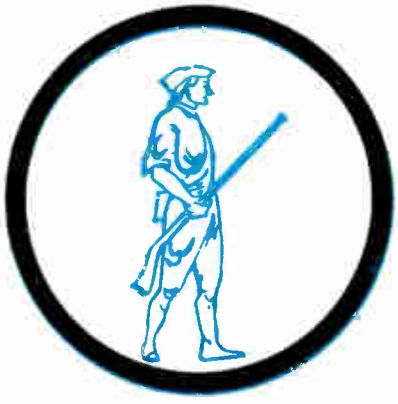


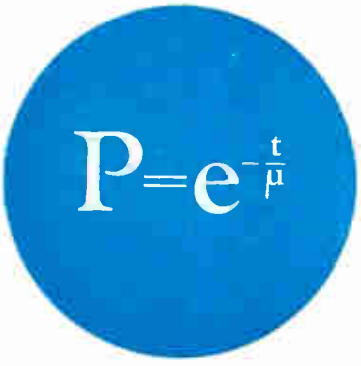
Fig. 1. OC curves computed at NBS for 4 acceptance sampling plans based on the exponential distribution when the failure times actually follow a particular Weibull distribution. If the exponential distribution applies, components having mean lifetimes of 1000 and 500 hrs are accepted with probabilities of 0.90 and 0.10, respectively. This is illustrated by the dashed line—the OC curve for plan 3 when the failure times come from an exponential distribution.

ELECTRONIC INDUSTRIES

A CHILTON PUBLICATION

Minuteman, Catalyst for Reliability

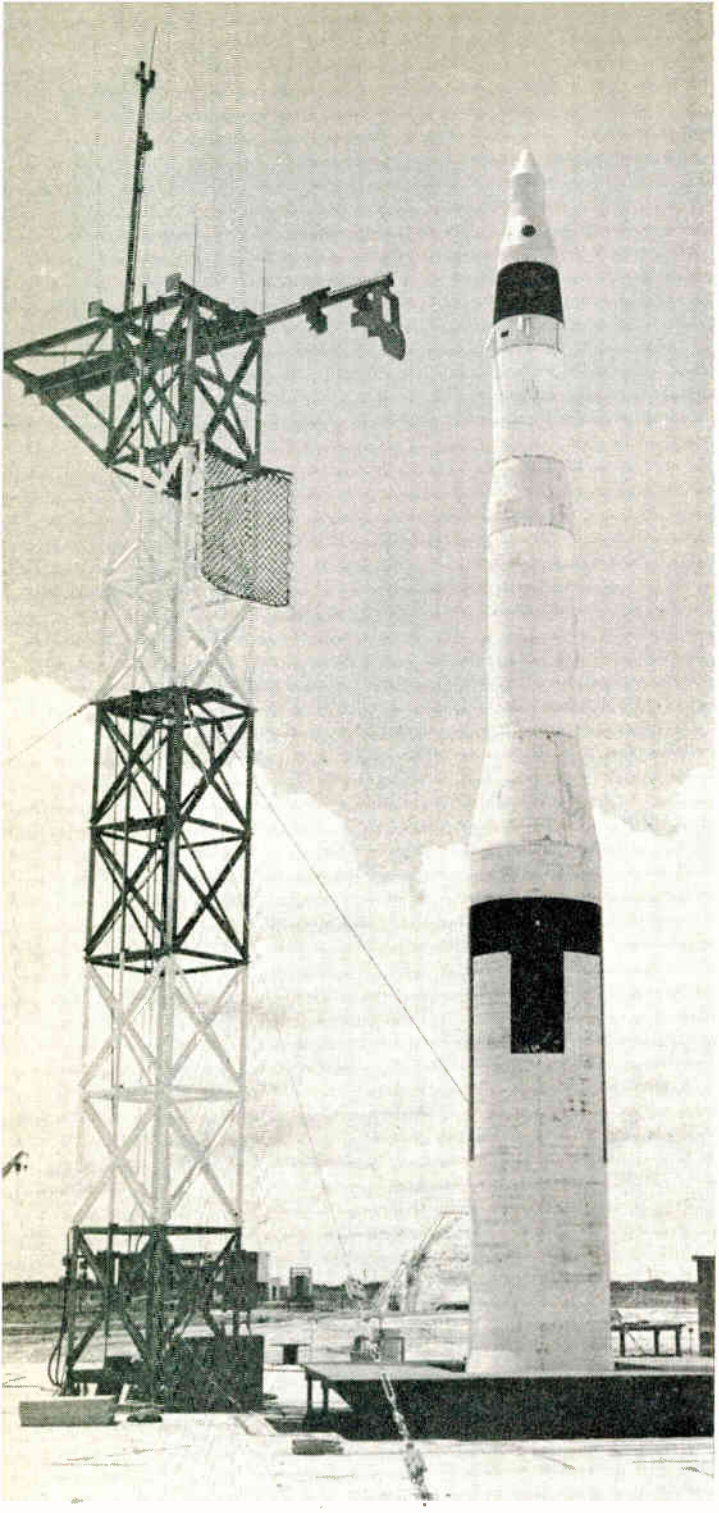


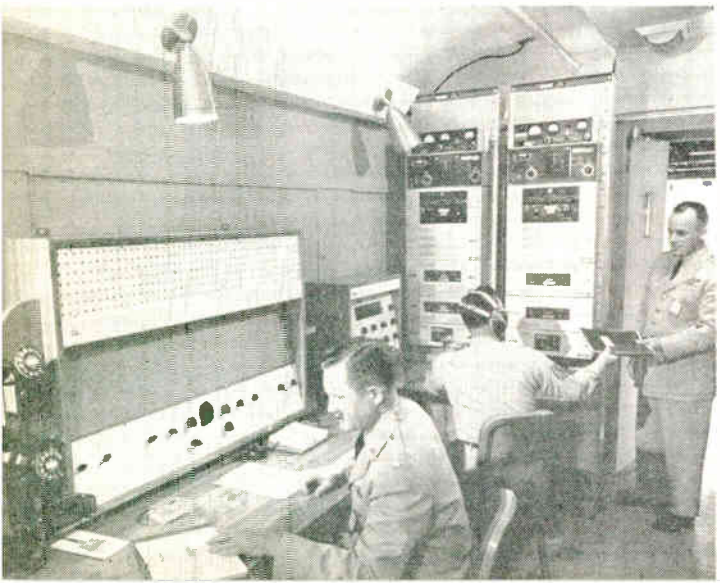


An EI Staff Report

A missile concept—
Using R & D funds to accelerate
component and equipment reliability, now.

December
1960





Out of a $115-million R&D contract for Minuteman guidance and control will come new standards of reliability which will affect the design and manufacture of electronic equipment for years to come.

Minuteman Reliability . . .

Guide for

FOR the past decade, component engineers have been struggling to improve the reliability of their products by a factor of 10. Now, within the period of 18 months, certain firms are striving to improve upon this figure by two orders of magnitude.

Motivating force behind this program is *Minuteman*—a missile concept which has an initial objective, for its airborne guidance and control system, a Mean-Time-Between-Failures of 7,000 hrs.; its ultimate goal is much greater. To put it in simple terms, this would be like having 30,000 television receivers run continuously for a year without a failure.

But we're getting ahead of ourselves. Let's start this reliability story at the beginning.

In 1957, the U. S. Air Force decided that liquid-fueled missiles were not feasible for instant launching. A new missile, capable of immediate launching was conceived—*Minuteman*. Besides being a solid-fuel vehicle, a safety requirement, it would of necessity have to be the epitome of reliability. This means that it would not only be required to fire instantly, but also be capable of proper navigation from the moment of launch.

The long countdown before a missile firing is not merely a device to test the nerves of the personnel involved in the shoot, but rather, among other things, a lengthy trial required to warm up the electronics and to determine if all is operating properly. It takes about 15 minutes warm-up before a missile's gyros

Fig. 1 (top): Non-operational version of Avco Mark 5 re-entry vehicle tops Minuteman training model at the Cape Canaveral test center. (*Photo courtesy of Avco*)

Fig. 2 (bottom): Military personnel simulate operation of typical control room which will be used for rail deployment of missile. (*Photo courtesy of Boeing*)

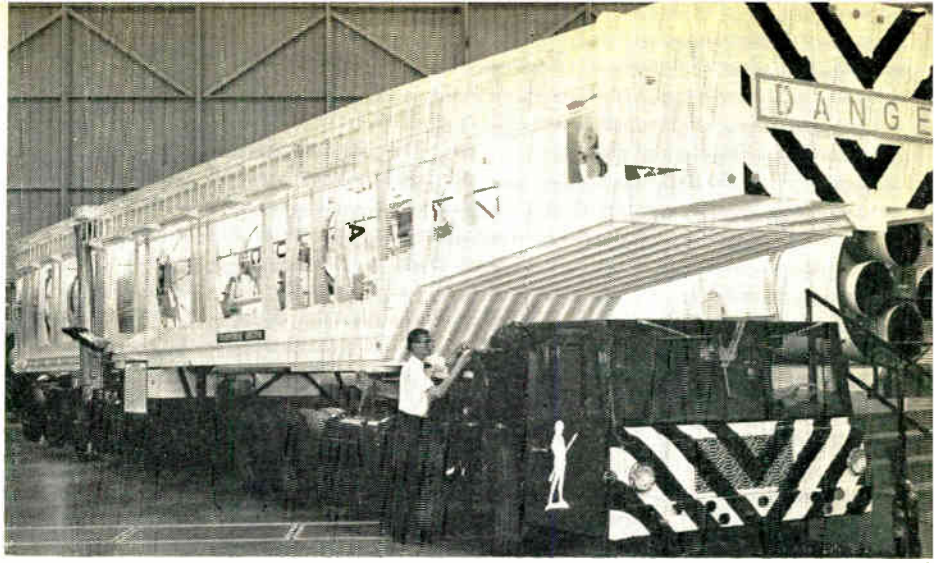


Fig. 3: Transporter-erector which will be used to haul missiles to launch sites and to lower them into the underground silos. The tractor and undercarriage are by GMC Truck Div.; missile container by Cessna; and hydraulic lift system by Bendix-Pacific. (*Photo courtesy of Boeing*)

By RICHARD G. STRANIX
Associate Editor
Electronic Industries

Future Component Manufacturing!

are in operating condition. Fifteen minutes in a missile war could literally be an eternity.

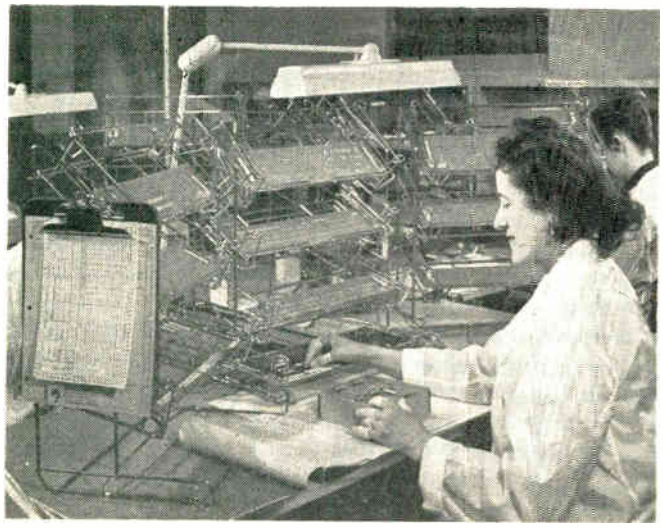
Minuteman eliminates costly warm-up by keeping the electronics "hot"—the entire system is kept operating for the complete period of readiness. In this case, that period is 3 years. The guidance and navigation are inertial. Once a target is set into the missile, the operation of its guidance system is monitored continuously to insure that it is operating properly.

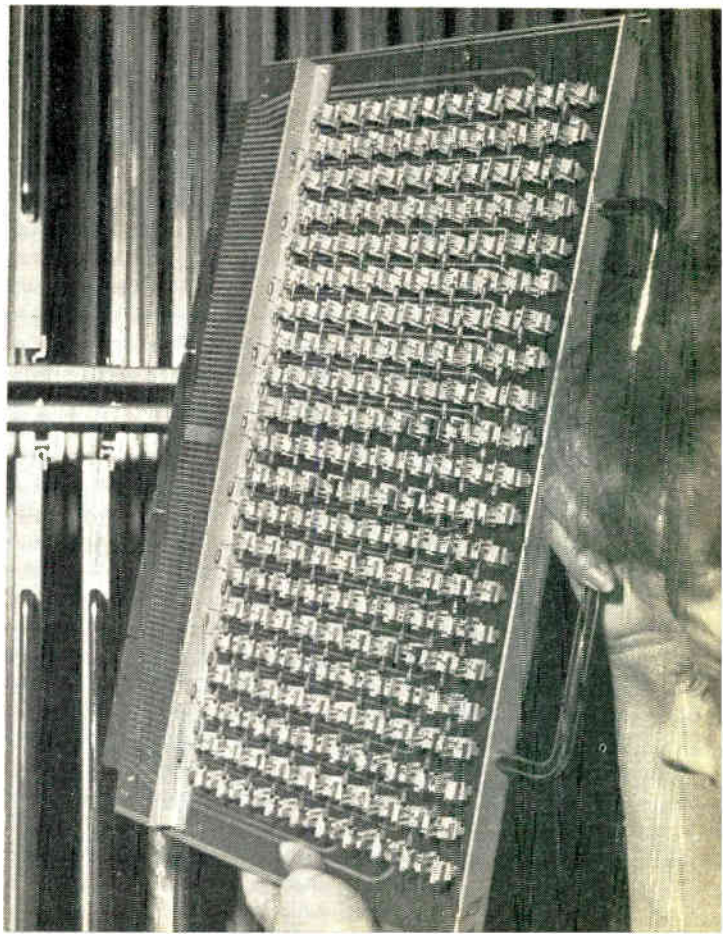
Silo Storage

This missile has two modes of storage. The first, in hard sites, i.e., underground silos where the missile will be stored vertically. All of its necessary ground operating and ground support equipments are connected. The plan is that there will be no maintenance

Fig. 4 (right): Circuit board loaded with diodes is about to be placed in chamber where the units will undergo evaluation tests. (*Photo courtesy of Pacific Semiconductors Inc.*)

Fig. 5 (below): For the first time since leaving the component manufacturer, parts are treated manually in circuit assembly. Note the work station design—a prize winner in materials handling contest. (*Photo courtesy of Autonetics*)





performed on the bird. This is the tentative plan. However, if the monitoring equipment indicates that something has gone wrong with the control or guidance system, the top section of the bird—the location of system—can be removed. That section will be immediately replaced by another one in perfect operating order.

If the ground support equipment indicates that something has gone wrong with the controls for the guidance of the various engine stages, then the whole bird must be removed from the hole and taken to a maintenance area. A new bird will be immediately placed in the vacant hole. As one might expect, this is not the simplest or cheapest operation going. When one considers the large number of these silos which will be in use, the cost of maintenance would be prohibitive unless the desired reliability is achieved.

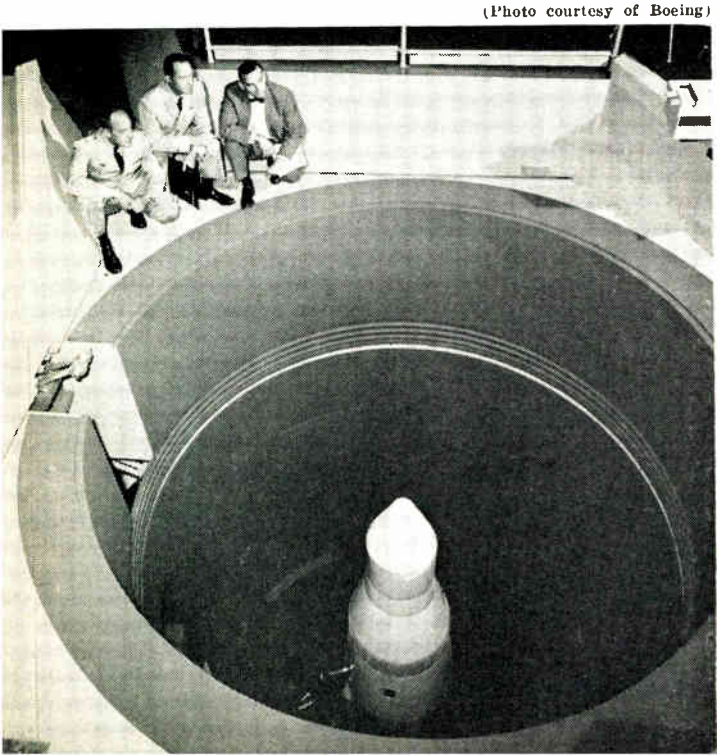
The first operational *Minuteman* ICBM's will be positioned in hardened sites in the vicinity of Malmstrom AFB, Great Falls, Mont. Three squadrons are programmed for deployment in the Malmstrom area. Each *Minuteman* launch position will require approximately two acres of land, plus the necessary easements for entry and communications and power lines.

The first squadron will consist of 55 missiles, all hidden underground in thick concrete silos, protected from all but a direct hit.

In operational deployment, the missile can be delivered by air, rail, or truck. After delivery, it will be lowered into the underground bomb-proof silo, checked out, tied into its communications and monitoring equipment and then the lid will be closed with the missile ready to go upon a moment's notice. It requires very little supporting equipment. The requirement for security can be handled by roving patrols and by the automatic system in the control center.

Fig. 6: Project officers study mockup of launch silo. They are Col. James Foster, Ballistic Missile Center; Col. Sam Phillips, Ballistic Missile Division; and, T. A. Wilson, Boeing Airplane Co.

(Photo courtesy of Boeing)



Each underground control center can handle a large number of missiles.

As far as movement by truck is concerned, a vehicle designed by GMC Truck & Coach Div. will haul *Minuteman* ICBM's to launching pits.

The tractor and trailer undercarriage, literally cushions its intricate cargo on air.

Besides having air ride, the vehicle has 175 hp V-12 gasoline engine power and a low contour. Its 6-ft. cab height permits the missile container to project over the roof, reducing vehicle length.

While GMC supplies the tractor-trailer, other subcontractors provide the missile container and erecting devices.

Being wheeled, the transporter can use the Nation's vast network of highways to haul missiles to underground launching silos. Upon arrival, the container rises straight up, permitting the missile to slide into the pit.

Besides supplying the tractor-trailer units, GMC has developed carriages for hauling the *Minuteman's* first stage engines. These are transported separately.

Rail Deployment

The second mode of storage, or deployment is mobile.

Light, compact and requiring few personnel for maintenance and launching, the *Minuteman* lends itself to mobile deployment aboard specially-designed railroad trains.

According to present plans, about one third of the *Minuteman* force will be placed on specially shock-mounted railway launch cars in trains moving freely about the country. American Machine & Foundry and ACF Industries have both been given contracts to develop such mobile rail cars. Plans are for each train to carry three to five missiles. There will be about 10 trains per squadron.

Designed to be self-sufficient for periods of several weeks, they will carry their own food, water, fuel, and electric power for general operation as well as missile launching and communications. Air Force missile men assigned to SAC's mobile *Minuteman* duty will travel aboard standard Pullman cars. Civilian train crews consisting of an engineer, fireman, a conductor and brakeman will be provided by the respective railroad.

On command from SAC Headquarters at Offutt AFB, Nebraska, the *Minuteman* trains, will be deployed along specified routes of railroad right-of-way. Their movements will be coordinated with key railroad personnel. At any given moment, some trains will be at rest on preselected sidings, the missiles aimed to strike pre-determined targets. Other trains will be on the move always within minutes of one of the many pre-selected sidings or spurs where their missiles could be launched. Several trains may be roving given segments of the Nation's railroads constantly confusing enemy targeting operations.

Minuteman will augment the Atlas and Titan in the blended aerospace force of manned bombers and fighters and missiles.

From the outset, in mid-summer 1957, the *Minuteman* ICBM was designed as a weapon system to optimize operational concepts, base design, training,

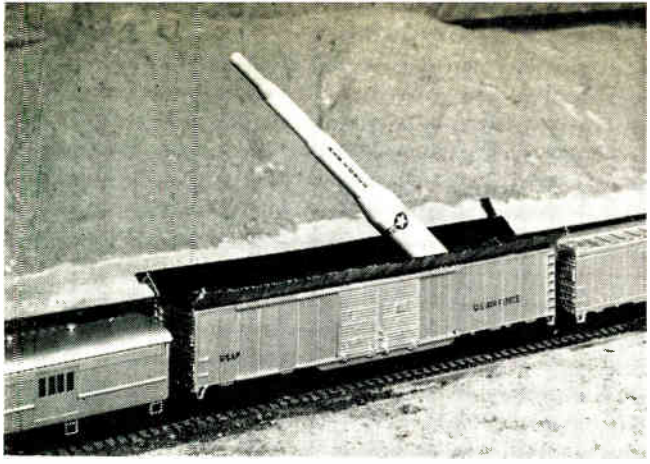


Fig. 7 (left): One of the earlier concepts for a missile car. It does not necessarily depict the final operational configuration.

(Photo courtesy of USAF)

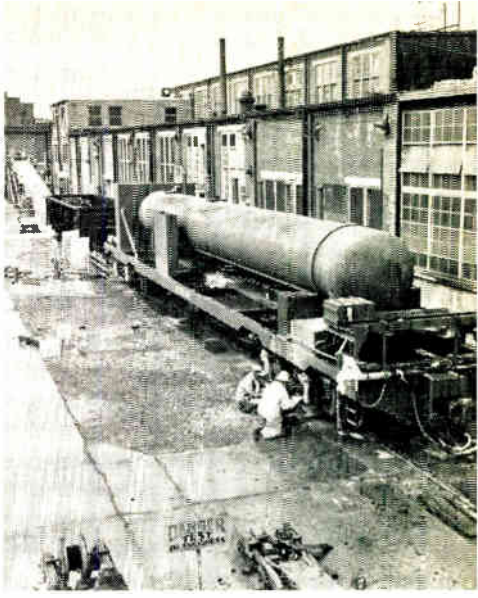


Fig. 8 (right, top) ACF technicians check loadings of steel tank and boxes containing sand, concrete, or water which simulate weights of actual missile and launching gear. This pre-prototype model of the rail car is about to undergo shock-impact testing.

Fig. 9 (right, bottom): Well-connected is this electronic travel gauge used to determine deflection of the large bolster springs on the rail car's undercarriage. Engineer checks the device prior to impact tests conducted to study adequacy of design concepts.

(Photos courtesy of ACF)

employment, maintenance and logistic support. To minimize the total cost, studies were conducted to determine the best trade-off arrangements.

Now that we have reviewed the overall concepts of *Minuteman*, let's get back to the subject with which we are more deeply concerned . . . the guidance and control system. More specifically, building reliability into the system.

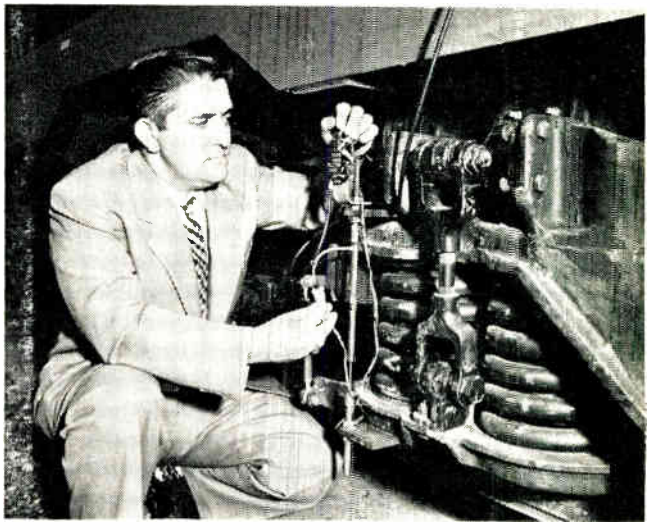
Circuit Engineering

Before submitting a proposal for the *Minuteman* guidance and control system contract, the Engineering Dept. of Autonetics, a Div. of North American Aviation, Inc., performed an extensive study on the problem and came up with a number of steps which should be taken to achieve reliability. Dr. William J. West, the Director of Reliability and Standards was the guiding hand.

The first and most obvious step to take was to simplify the design of the circuitry. While Atlas, Titan and Thor are examples of missiles becoming more and more complex, the trend has been reversed with *Minuteman*. Simplification is a key word in the whole *Minuteman* concept. The Air Force wants a less complicated weapon system. Not only were the number of circuits reduced, but also the different types of components used. Only units with low failure rate histories were permitted in these circuits. Those units with a high usage rate were then chosen for an extensive research and development program in cooperation with participating suppliers.

The next step considered was that of derating. Following the concepts advanced by Radio Corp. of America, the characteristics of components, circuits, and systems were studied under reduced power and voltage conditions. Designers were restricted more tightly than in any other system to voltage and power derating. Further, the system was cooled to take advantage of reducing the failure rate by reducing the temperature. Finally, the electronics were sealed in a dry, non-corrosive atmosphere.

The circuit tolerances were widened to account for the inherent drift in most components. Widening the tolerances would account for any shift in component value brought about by shelf-life or storage. The purpose of this study was to determine just how far



the performance of a component could drop without falling below the minimum acceptable value of the system. By writing equations representative of conditions of circuit failure, each circuit was analyzed by a computer. The computer varied the value of one or more of the parameter. It then calculated what shift caused circuit failure. The resultant curves are called a "Schmoo" plot.

"Schmoo" Plot

The "Schmoo" plot is a graphical representation of the relative output parameter failure condition resulting from varying two input parameters at the same time. This graph facilitates the establishment of an operating envelope within which a particular input parameter may be varied without resulting in circuit failure due to parameter interdependence.

Here, when we say "parameter interdependence" we mean it in the following sense: if the mathematical model of a circuit is such that when two input parameters are varied together, their effect on some output parameter would be complimentary so as to cause greater changes than would result if they were varied individually and the sum of their individual contributions considered.

The name "Schmoo" comes from the comic strip animal which was good for all things.

This method of determining the operating limits of

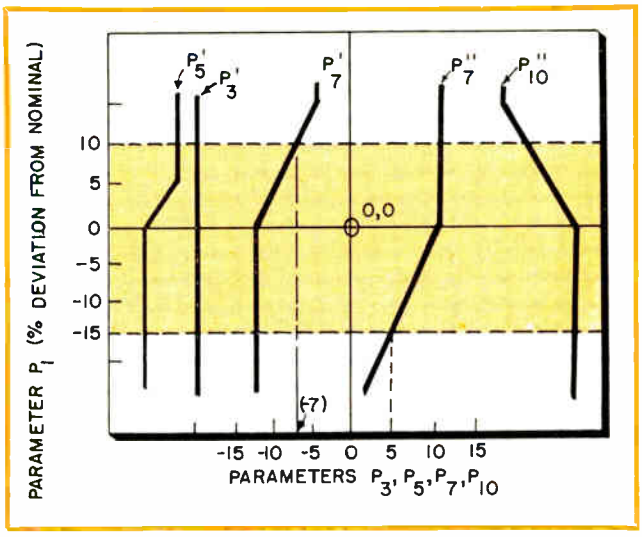


Fig. 10: This is a "Schmoo" plot. The area in color indicates the safe operating envelope of parameter P_1. Breadboard checks curves.

Component Reliability *(Continued)*

an input parameter is an attempt to consider the combinatorial effects of two parameter variation. Since the computer time rises exponentially with the number of possible combinations, the two parameter combination has been chosen as an optimum figure. The number of "Schmoo" plots for a particular circuit equals the number of input parameters. The determining limits of any input parameter results from a careful analytical examination and interpretation of all "Schmoo" plots. Here's a brief interpretation of one "Schmoo" plot:

All straight vertical curves of the "Schmoo" plot, Fig. 10, represents non-interdependent relations between the two involved parameters, e.g., P_1 and P_3 are not interdependent. However, this type of curve does depict the circuit failure operating limits of the abscissa parameter P_3.

All other curve types indicate some form of interdependence and must be interpreted (see P_5, P_7, P_{10}). To illustrate—if the maximum percentage variation of parameter P_1 is set at 10%, parameter P_7's minimum percentage must be set at 7%; otherwise, a circuit failure could result because of an excessive drift in parameter P_7's value. For successful circuit operation the operating point, defined by the coordinate values of a parameter pair, e.g., P_1, P_2, must fall to the original (0,0) side of the failure graph.

In a like manner, parameter P_7'' (maximum value of P_7) in conjunction with P_1, determine the operating limits of P_1. That is, suppose P_7'' must have a 5% value. This allows P_1 to have a minimum value of −15%. If P_1 goes below −15%, a circuit failure will result. Each "Schmoo" plot is analyzed in the above manner. However, those parameter values set by other "Schmoo" plots must be considered as an initial parameter criteria. In this manner an optimum balance of parameter limits is obtained for the entire circuit.

However, the computer results are not considered conclusive. As a double check, the values obtained by varying the parameters on a breadboard are compared with the "Schmoo" plot.

Perhaps the greatest area of improvement is in that of manufacturing. This includes the following subareas: Process specifications, process controls, operating instructions, elimination of test and facility "bugs," quality control instruction, and test equipment and tool certification. All of these areas will be dealt with later. The final steps toward reliability are those of parts and instruments. This involves the reliability improvement program being conducted by the 13 component manufacturers mentioned earlier. These are manufacturers of component types which have a high usage rate. Further, they are manufacturers who have been doing the most on their own to improve reliability.

After the Autonetics Engineering Dept. had completed this preliminary work, here is how they went about selecting suppliers for the program. As in any other contract negotiations, the first step is the request for proposals from suppliers. The prospective suppliers must then render written and oral presentations of exactly how they intend to go about the reliability improvement program. Those suppliers which were tentatively approved, had their facilities inspected by Autonetics engineering personnel. If the facilities met the approval of the inspectors, then products of the suppliers were evaluated by Autonetics to determine exactly how far the company had gone on its own to improve reliability. When all of the results were in and proposals, products and facilities had been evaluated, the suppliers were selected.

When a supplier is selected he must agree to perform fifteen tasks. A synopsis of these tasks is presented in Table 1. Suppliers submit a preliminary program plan when they are operating under a letter contract. When they sign the formal contract, they must submit a formal program plan and agree as indicated in Task 1 to issue within 90 days of the signing of the contract a new program. This program must be revised on the last day of each third month starting three months after acceptance of the new program plan.

Special note should be taken of Task 13, Serialization. When we consider thousands of units which are to be supplied under this program, and the numerous tests which are to be performed on each unit, this one-sentence task involves one of the most extensive bookkeeping jobs ever undertaken by any industry. The data cards referred to in this task accompany the units when they are forwarded to Autonetics.

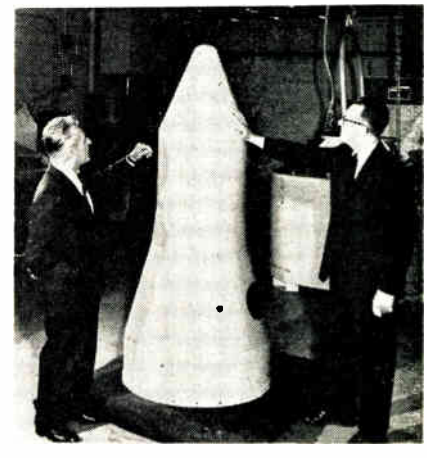


Fig. 11: Engineers examine non-operational version of Avco Mark 5 re-entry vehicle which is used for training in ground handling and check-out procedures.
(Photo courtesy of Avco)

Table 1

Statement of Work

Task 1. Program Plan

Seller shall prepare, submit, and maintain a program plan which will describe in detail each task in the statement of work, and the manner in which these will be implemented and completed. The program plan will delineate approaches, milestones, and schedules the Seller plans to accomplish in the implementation of each task noted herein. It is agreed that Seller's Program Plan shall be understood to be a report of actions and activities planned to be taken. This Preliminary Program Plan is to be superseded by a new program plan which shall be issued within 90 days of the signing of this contract. Revisions to the new program plan shall be issued the last day of each third month starting three months after acceptance of the "New Program Plan" noted above.

Task 2. Production Processes

The Seller shall identify all documents on internal processes and environments relating to materials being used on devices now being produced. Existing documents shall be identified in the flow diagram form of Appendix I by name, number, and release date.

Task 3. Production Control

The Seller shall identify all documents or production control specifications relating to materials and process specifications being used on devices now being produced. Existing documents shall be identified in a sequenced production flow diagram form by name, number, and release date.

Task 4. Failure Analysis

Seller shall establish a skilled group of experienced physicists, chemists, metallurgists, and engineers, as appropriate, to perform failure studies and analyses to achieve the reliability objectives and to complete the tasks set forth herein.

Seller shall establish a list of known failure modes of the devices based on best engineering judgment and historical experience with the device.

Seller shall establish a program to analyze all discrepant devices obtained from Seller's production line and tests, together with discrepant devices returned to Seller by Buyer. For the purpose of this task, a discrepant device is defined as one which does not meet the requirements of Buyer's applicable Item Identification Document, hereinafter referred to as IID, or any of Seller's in-process measurement limits. These discrepant devices contain some of the key information as to the fundamental defects in design materials, processes, and controls in the production of the device.

Seller shall submit a plan for a test program, in addition to Task 8, for the generation of additional failures for the isolation of other failure modes if required to accomplish objectives set forth herein.

Seller shall modify the list of failure modes as a continuing requirement as new failure modes are discovered and analyzed.

The Seller shall associate each failure mode with the generating failure mode defect which may occur in design, materials, production processes, specifications, controls, or human factors.

Task 5. Corrective Action on Production Processes

Seller shall determine methods of eliminating, or sufficiently reducing, the defects which may occur in the design, material, production processes, controls, or human factors identified in Task 4. Buyer will offer results which may be available from in-plant failure analysis as may aid in the accomplishment of this task.

Task 6. Corrective Action on Controls

Seller shall determine a method of eliminating, or sufficiently reducing, process control defects resulting in failure modes as analyzed and identified in Task 4, whether associated with design, materials, production processes, controls, or human factors. Buyer will offer such results as may be available from Buyer's in-plant failure analysis which may aid in Seller's completion of this task.

Task 7. Evaluation of Corrective Action

The Seller shall determine and conduct experimental and numerical studies to determine the significance of the corrective action taken in Tasks 5 and 6 as a result of the effort in Task 4. In addition, those studies will determine any bad side effects that may occur.

Task 8. Tests

The objective of Task 8 is to obtain data on the electrical parameters of the device produced by the Seller. In addition, Task 8 will provide the following information:

(1) Distribution of each critical device parameter.
(2) Changes of distribution with respect to time.
(3) Failure rates at accelerated environment.
(4) Acceleration factor failure rate.

Task 9. Seller's Program Organization

Seller will provide, as part of the program plan, his program organization structure which will include, but not be limited to the following:

(1) Diagram depicting names and job titles.
(2) Comments on responsibility and authority.
(3) Organization control procedure which will indicate chain of command, lines of authority for (a) reporting changes (b) securing approvals, and (c) implementation of changes.

Task 10. Training

The Seller shall establish, conduct, and maintain continuous reliability oriented training courses, programs, and incentives to cover all phases of the program associated with production of high reliability devices. These, as applicable, shall be designed for all levels of management, engineering, quality control, purchasing, and test and production personnel.

Task 11. Test Equipment

Failure diagnostic equipment. The Seller shall identify and prepare a list of the special test equipment used in Tasks 4 and 7. The Seller also shall identify and prepare a list of the general purpose equipment which will be provided by Seller to be used in Tasks 4 and 7.

Task 12. Technical Direction and Monitoring

Buyer will monitor Seller's progress through frequent visits to Seller's plant by administrative and technical authorized representatives as well as a resident engineer supplied by Buyer.

Task 13. Serialization

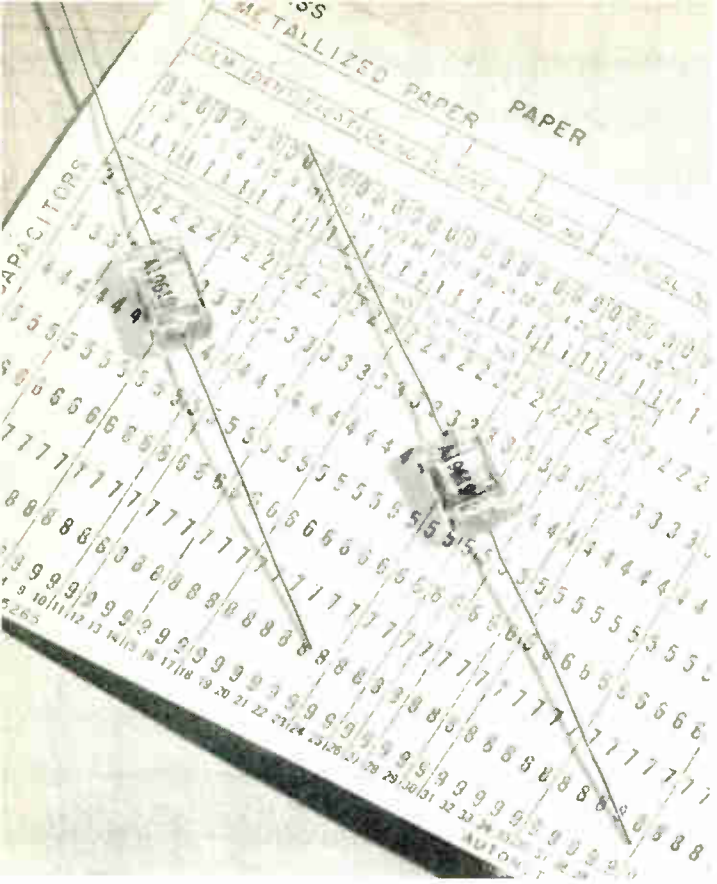
Each device manufactured for the test requirements of Tasks 4, 7, and 8 shall be serialized and the data shall be suitably recorded for machine processing.

Task 14. Handling and Packaging of Devices

The handling of devices from raw material through finished product will be in accordance with process and environmental specifications, as a continuing requirement, as set forth in Task 2.

Task 15. Documentation and Reporting

The Seller shall maintain, in a current status, all documentation pertaining to the program.



(Photo courtesy of GE)

Fig. 12 (above): Reliability specialists analyze data for the Integrated Reliability Data System (IRDS). The system controls all steps in the manufacture of high-reliability capacitors. See Fig. 19.

Fig. 13 (left): Notice serial number on each glass capacitor. This identification plus the punched card record which accompanies each unit permits complete control through entire lifetime of component. (Photo courtesy of Corning Glass)

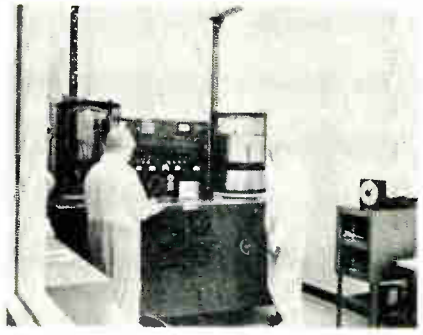


Fig. 14 (right) Typical garb worn by personnel employed in the manufacture of XLT evaporated metal film resistors at IRC (Photo courtesy of IRC)

Fig. 15 (left): Engineers discuss statistics of transformer reliability at seminar. (Photo courtesy of Wheeler)

Fig. 16 (below, left): Operator is completing glass-to-metal seal soldering that hermetically seals each capacitor in a metal case, proof against moisture and extreme environmental conditions. (Photo courtesy of John E. Fast)

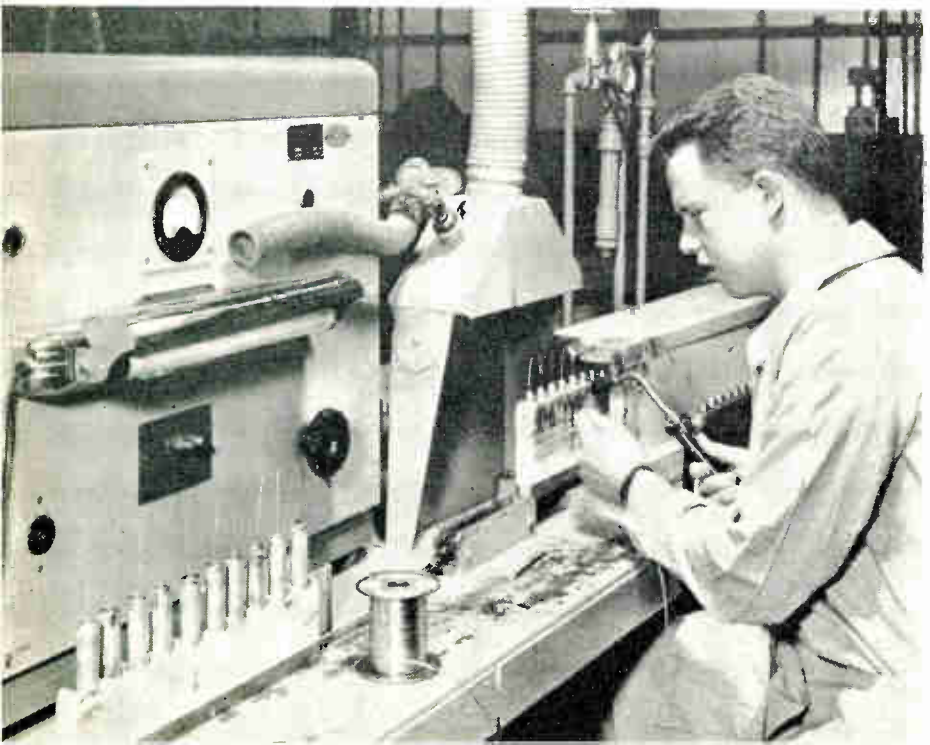


Fig. 17 (below): Quality control inspector adjusts controls for automatic testing of units. (Photo courtesy of Corning Glass)

(Photo courtesy of GE)

Fig. 18 (above): Strict white room procedures admit only holders of a special card which opens the door when inserted in slot.

Fig. 19 (below): Aging of capacitors stabilizes electrical characteristics. Surge voltage is applied at elevated temperature to each unit and data included in IRDS.

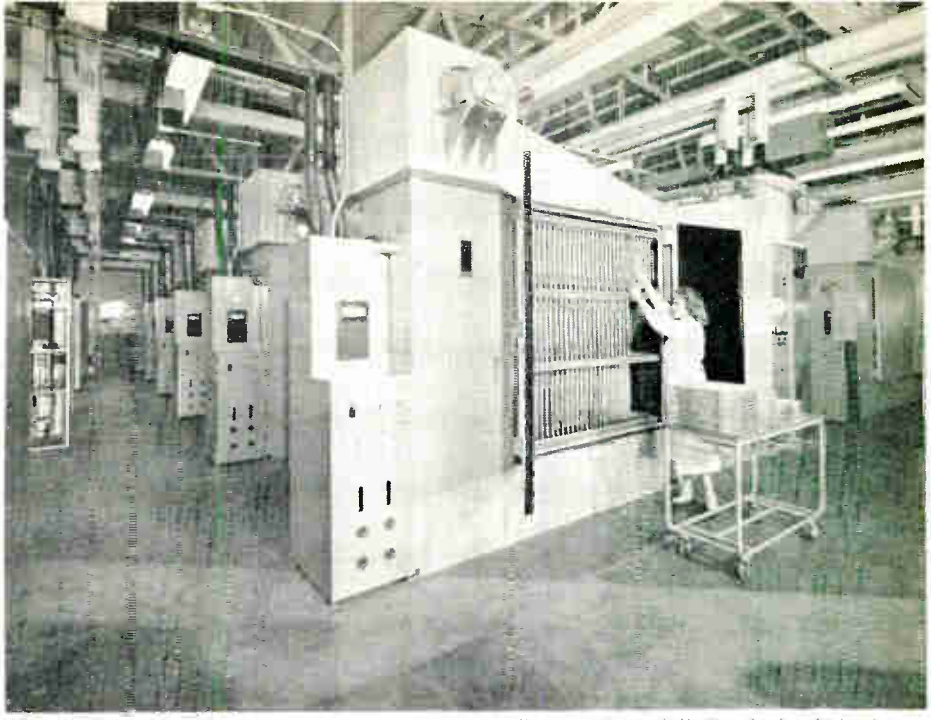
(Photo courtesy of GE)

(Photo courtesy of PSI)

Fig. 22 (above): Operators are required to wear rubber fingers to eliminate contamination of leads at all production stages.

Fig. 23 (below): Peering through microscopes, these women are assembling delicate silicon transistors. Line foreman is checking work at one of the stations.

(Photo courtesy of GE)

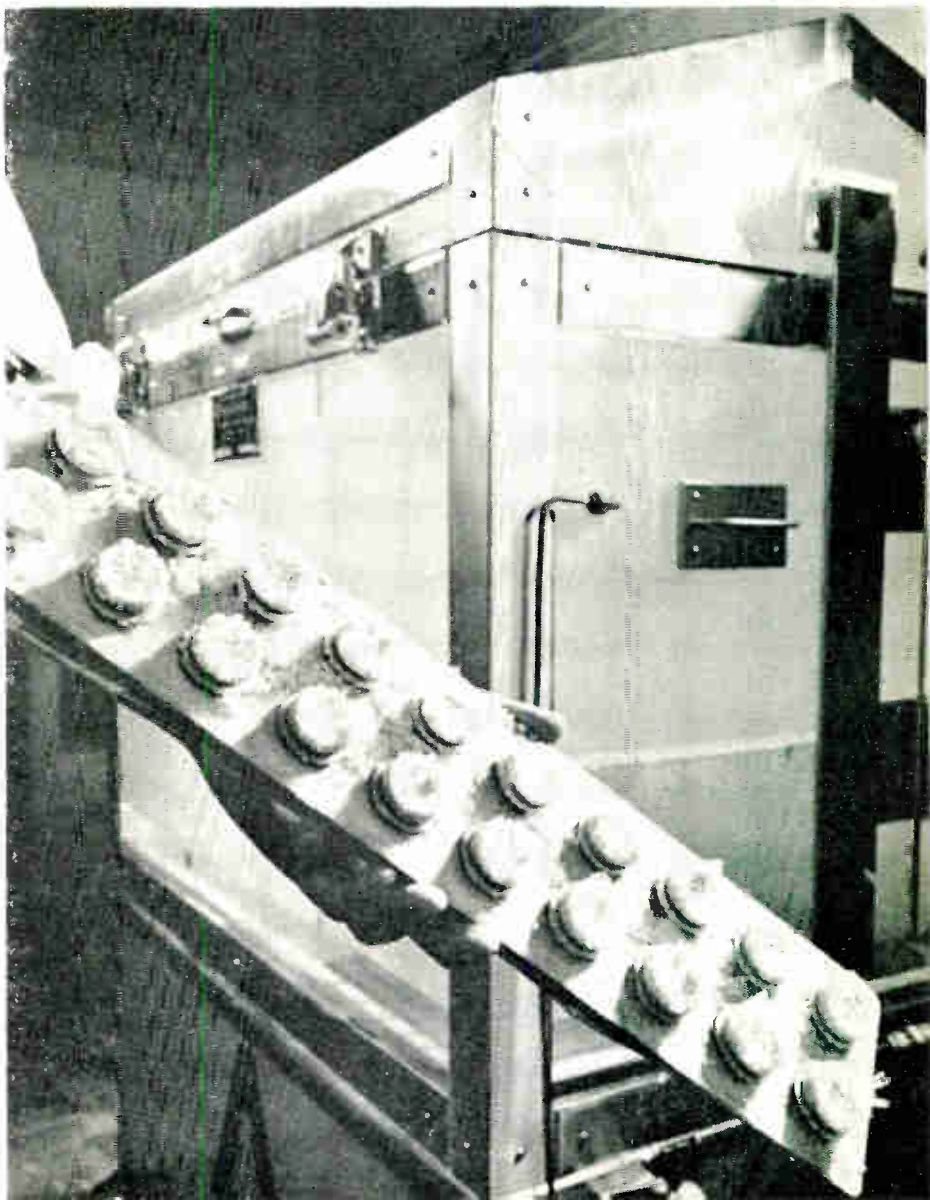


(Photo courtesy of Pacific Semiconductors)

Fig. 20 (above): Even the color of the ovens in this area has been taken into consideration. The chambers are various pastel shades to help reduce operator fatigue problems.

Fig. 21 (below): Power transistors heavily encrusted by salt will be cleaned and inspected for corrosion, erosion, rust formation. Then they will undergo electrical testing.

(Photo courtesy of Delco Radio)



Component Reliability (Continued)

Under normal operating conditions, the supplier also maintains a set of these cards so that his continuing tests may be entered on his copies and Autonetics notified if any noteworthy changes occur.

Autonetics supplies resident engineers at each of the participating suppliers for monitoring purposes.

Another significant aspect of the program is the diagnosis of all failures and the reporting of all data on these failures. No longer are units that do not come up to specifications discarded. These units, it is thought, may be the heart of the system, supplying the needed information to correct manufacturing processes or design specifications. The supplier must analyze all of the failure units and submit them with the complete report of data to Autonetics. Units that fail at Autonetics are returned to the supplier for analysis. The component manufacturer is the focal point for analysis. The supplier and Autonetics will coordinate and discuss their independent findings.

Component Manufacturing

The basic philosophy behind the reliability program is that of cost effectiveness, i.e., although the initial cost of a component may appear high, when related to its long term reliability, it is less than standard components due to the decrease in maintenance, overhaul, repair, and spare parts. Maintenance elimination elimination results in substantial savings.

Most suppliers are required to start separate production lines for components being supplied to Autonetics for the *Minuteman* program. However, there are a few instances where Autonetics is taking almost the complete production of a supplier and consequently instead of setting up new lines, they are converting their entire production facilities to this program.

In this way they will be raising the level of reliability of all their units, or types, while only a few may be headed for *Minuteman*.

We have indicated that the serialization of all the units is one of the biggest bookkeeping jobs ever undertaken. It goes without saying that to get all of this information on data cards, extensive testing must be performed. A few of the earlier reports in the literature have indicated that the reliability program is nothing more than one gigantic testing program. We hope that we have removed this idea from your minds. It does entail extensive testing but this does not build reliability into the units.

The reliability of components must come from the raw materials used and the method of construction. The extensive testing, it is hoped, through stringent failure analysis, will show where the weak points are —whether in the materials or in the manufacturing technique.

It goes without saying that the participating suppliers are really serious on this reliability factor. It is not just so must whitewash. Most concrete evidence of this fact is the investment of approximately an additional 50% of their own funds above and beyond their R&D study contract from Autonetics. As of this date, it is the understanding that the proprietary rights of these various suppliers will be respected. They will then have benefited tremendously in prestige and sales returns when these reliability concepts are applied to the remainder of their lines. Again we must emphasize that these companies can already supply high reliability units to other customers. However, they have not reached the ultimate reliability goal as of this date.

Let's look at a typical operation in a component supplier's plant under the R&D study program.

First of all the engineering and R&D departments must realize and agree to set up an independent management system for the Autonetics program. This group must have the wholehearted and enthusiastic support of top management in the company. While research and engineering are determining the proper materials and techniques to be used in manufacturing, concurrently, workers must be in the process of training. This training must go further than merely teaching them how to construct the components. They must also be properly motivated. A lot more will be said about this motivation when we discuss the manufacturing techniques employed at Autonetics. Suffice it to say here that the workers must be trained to look upon their job as more than another assembly line operation.

Many manufacturers have found it better to employ new personnel rather than transferring more experienced personnel to this operation. In this way they eliminate the need to untrain the workers, i.e., to remove any of their "bad" habits. The stringent requirements of the reliability program often require, what to the eyes of the operator appears to be wanton waste. However, this is not the case. It is better to throw away a device or one of the ingredients for the device if it has been contaminated, rather than to go ahead and use it and subsequently spoil the completed device. If the operators do not follow the established manufacturing process, then it makes the job of failure analysis much more difficult. This group must be able to determine whether such things have occurred and to initiate corrective action in the form of motivational training for the worker.

Paper Capacitors

Typical of the "white room" conditions in component manufacturing are those at John E. Fast & Co., 3580 N. Elston Ave., Chicago 18, Ill.

Temperature controlled, dehumidified, and dust-free air enters production rooms after passing through a dust filter and then a 13,000 v. electrostatic precipitator. The dew-point of this air as it enters the rooms is -45°F, and humidity below 15% is maintained throughout the work areas at all times.

Extreme precautions are taken to prevent contamination of the components, in this case capacitors, during manufacture. Operators are required to wear

(Photo courtesy of Fairchild Semiconductor)

Fig. 24 (above): Assemblers mount transistors on carrier-matrix boards. This is the last time the units are touched till they are placed in the circuit assembly boards.

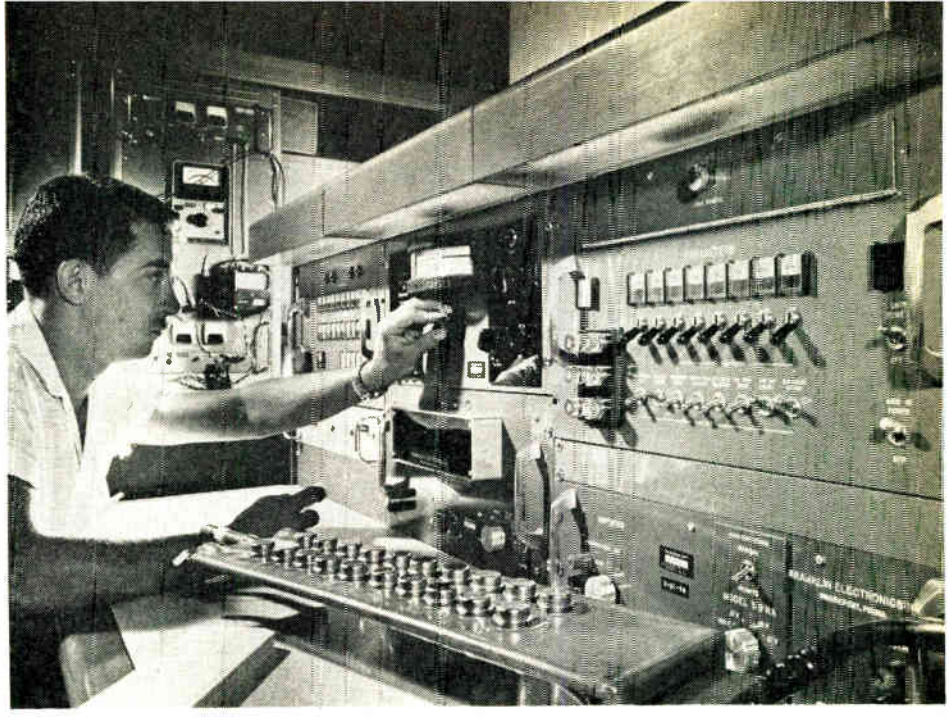


Fig. 25 (right): This test set which automatically tests eight parameters of a device in eight seconds and records the information on IBM cards was built specifically for use in this reliability program.

(Photo courtesy of Delco Radio)

lint-free smocks, rubber gloves, and to refrain from smoking or using cosmetics.

William S. Franklin, Vice-President for Engineering at Fast, states that, "Our objective is, when we put 30,000 capacitors into the beginning of the manufacturing process, that some day we will be able to ship 30,000 without a single reject at the many test operations. Further, our objective with the *Minuteman* Program for Autonetics is a reliability of capacitor that is more than 50 times better than these figures."

Through design and benefiting from automated analytical data, the program at Fast is to build reliability into the capacitor in place of the concept of attempting to inspect quality and reliability into them.

Power Resistors

At Dale Products, Inc., Columbus, Nebr., the *Minuteman* parts improvement program consists of improving resistors as they are presently manufactured. It does not include any redesign or changes of the basic construction. Dale increases emphasis on operator training for their specific duties as well as indoctrination in reliability theory, the importance of their jobs, the reliability of the units, and the operation of the completed missile.

Control is exercised on the outside manufacturing of all parts. Incoming inspection of parts alone is not considered adequate; actual monitoring on the vendor's production processes is conducted.

Finally, elimination of unnecessary handling and reduction of processes where possible should also improve the reliability picture. An example of this is through the use of gold-plating of leads which eliminates lead cleaning and tinning.

Evaluation tests are broken down into three major categories. The most important as far as short-term evaluation is concerned is the accelerated test. These tests consist of short-term operation with conditions similar to those found under actual operation except that the units are greatly overstressed.

Due to the present lack of correlation between the results of these tests and long-term reliability, these tests are intended to provide only comparisons between units under various stages of improvement and to evaluate changes or corrective actions. They are not intended to provide actual reliability information.

The second type of test regularly conducted is the qualification test. These tests are likewise short-term and consist mainly of standard environmental tests similar to those required by military specifications. These tests serve to provide assurance that none of the basic characteristics of the units have been degraded. Actual passing or failing of these tests is not the important criteria, it is the distribution of the changes during the test as compared with previously manufactured units. Careful examination is made of the changes and distributions under all these tests. The data are then correlated with the accelerated tests to determine whether improvements have been made.

The third type of test is the long-term reliability test. These are used for improving reliability both at the beginning of the program and as the program progresses. The first of these tests is the matrix-type in which units are tested under various conditions of ambient temperature and percentages of rated wattage.

The matrix tests are intended to provide information on the life expectancy characteristics of the units under all conditions of ambient temperatures and power ratings. From their data at the high wattages and ambients, information can be obtained regarding the possibilities of the accelerated life tests to determine long-term reliability values with short-time tests.

Glass Capacitors

Richard A. O'Brien, Project Supervisor for the *Minuteman* Program at Corning Glass Works at Bradford, Pa., states that their reliability objective is to have not more than six units of 100,000 fail even if they are used almost a month and a half. A ballistic

missiles flight between continents could take less than a half hour.

Corning, charged with the responsibility for glass capacitors will supply seven different types. The capacitors are made of alternate layers of metal foil and glass, with the entire sandwich then fused into a compact glass unit. This construction allows the capacitors to fulfill the extreme requirements imposed by conditions of shock, temperature, vibration, and moisture associated with missilery.

Corning goes along with the belief that the component makers should shoulder responsibility for development and for proof of reliability.

Transformers

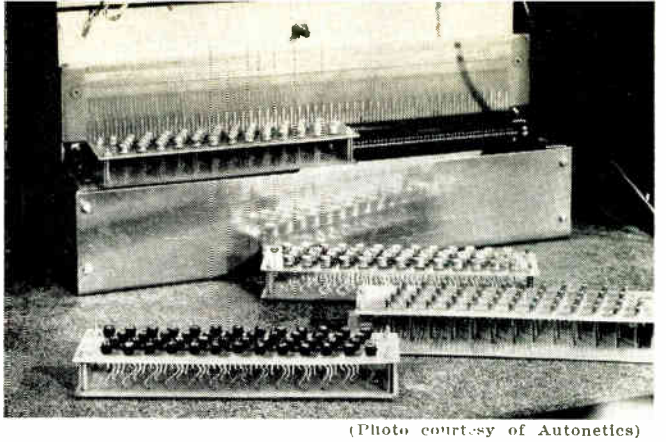
Design of high reliability transformers involves a judicious selection of mechanical and electrical materials and characteristics appropriate to the intended application and environment, using the maximum possible safety factors. Compromises ordinarily permitted in normal commercial applications, such as weight-strength tradeoffs, are not permitted. Extremely narrow tolerances are applied to basic components such as wire, insulation media, magnetic materials, and hardware to assure reliable and invariant performance during operation and to minimize parameter drift in normal and adverse environments after years of storage. Furthermore, only those materials are used whose characteristics are well-known and understood. Wheeler Electronic Corp., Waterbury, Conn., is charged with the responsibility for the *Minuteman* guidance and control transformers.

The different subcontractors under the reliability study program have diffierent ideas on the type of production personnel to employ. Some have found it better to bring in outsiders, others use their most experienced personnel. At Wheeler, production personnel are selected on the basis of superior aptitude and skill. They assemble the transformers in dust-free, pressurized work shields. As with the rest of the subcontractors, the entire *Minuteman* area is maintained at a high level of housekeeping. Operations are based on detailed process sheets, paying particular attention to reliability considerations.

Table 2

Failure Rate Airborne Electronic Parts

PART	STARTING RELIABILITY %/1000 hr	OBJECTIVE RELIABILITY %/1000 hr
TRANSISTORS		
Computer	0.07	0.0007
General	0.1	0.001
Power	0.4	0.004
DIODES		
Computer	0.02	0.0002
Other	0.1	0.001
CAPACITORS		
Solid	0.5	0.001
Foil	0.1	0.001
Glass	0.05	0.0006
Paper	0.001	0.0006
RESISTORS		
Carbon Composition	0.001	0.0001
Metal film & grid	0.04	0.0004
Wire Wound	0.1	0.001



(Photo courtesy of Autonetics)

Fig. 26: Transistors for the inertial guidance and control equipment are shown in their sandwich-type shipping & testing package.

Reliability training in motivation constitutes an extremely important and fundamental aspect of the program. Accordingly, extensive and separate training courses have been established for the engineering staff, for key personnel in the quality assurance and control, sales, manufacturing, purchasing, industrial relations, and methods engineering departments, and for first line supervision.

These courses include such topics as reliability definitions and philosophy, the reliability problem, mathematical tools, design considerations, reporting and data processing, contractual reliability guarantees, etc. Wheeler foremen are enrolled in a job instruction training program designed to improve their job teaching skills. A reliability library also has been established.

In the "Snow White" operation run by General Electric at Syracuse, in addition to white monofilament clothing, production personnel are required to machine-brush their shoes before entering the work area to reduce dirt and lint particles in the air.

Silicon Diodes

Worker motivation has been carried even outside the "white room" by Pacific Semiconductor, Inc., Lawndale, Calif. To make the scene a little less monotonous for workers in the matrix test area, even the huge ovens are painted various pastel shades. PSI found that workers in this area became bored and tired when all of the 27 ovens were all painted a uniform color. In this battery of ovens up to one-half million diodes are electrically and thermally tested at one time.

Each of the oven systems, built by Wyle Mfg. Corp., El Segundo, Calif., can subject up to 18,000 diodes or other semiconductor devices to high or low temperature conditions in conjunction with electrical lead for periods equivalent to years of operational stress. Slots are provided for ninety 10 in. x 18 in. etched circuit cards on each of which up to 200 specimens can be mounted and electrically connected. PSI engineers built the intricate electrical systems which are mounted in the specially designed ovens.

As we stated earlier, reliability improvement is not something new with these 13 manufacturers participating in the study program. The additional funds just make it easier for the task to be accomplished sooner. PSI had actually been conducting testing similar to this on a smaller scale even before the

Minuteman contract. Wherein they now test 200 units on the board, for their production they were testing samples of 20 units. They can and do supply high reliability units to other customers when they are so ordered.

Silicon Transistors

The failure analysis feature of the reliability program is called the "autopsy committee" at Fairchild Semiconductor Corp., Mountainview, Calif. This committee is chaired by a member of the Assurance Group and includes top staff members from engineering, research and development and other key departments. A significant feature of the whole program is the quickness of "feedback." Reports from the committee are reported to engineering and production activities within 8 hrs. Immediately improvements can be incorporated into the manufacturing lines.

After the component has been completely assembled, it is mounted on a specially designed printed circuit board. These boards contain from 20 to 200 such units depending on the size of the particular unit. The boards are so constructed that they will offer rapid testing of the various parameters of each component, extreme care and safety in shipping, ease of storage, and ready identification and location of individual units according to serial number.

It should be pointed out here that the various components are not simply inserted into the printed circuit boards, but rather their lead configuration and length will exactly duplicate that which is required in the final assembly at Autonetics.

Testing

Testing is performed by automatic equipment. Most of it is similar to that performed on resistors at Dale Products, Inc.

Since failure rate is a function of power, time, temperature, and voltage, these characteristics are woven into a matrix and large quantities of each batch of components are tested at different variations. As an indication of the extent of this testing, it might be well to mention that some units will be under test for up to 20,000 hrs., the ambient temperature ranges from 25°C to 300°C.

While the units are still under environmental test, their performance is periodically recorded on the machine records data card which was initially prepared when they were tested at the completion of assembly. In this manner, while the units are still under test, the manufacturer can notify Autonetics if something appears to be going wrong in a certain batch of units. Since all of the units are serial numbered, Autonetics can immediately identify those units of the batch which they received.

Now let us follow a component shipped to Autonetics. The machine record cards which were prepared on the units at the manufacturer's initial test will accompany the units in the same package. Immediately upon arrival at Autonetics, the units are again tested on an automatic tester or checker which is identical to that used by the manufacturer. These test results are also recorded on the punched card. In this way any difference in characteristics can be immediately spotted.

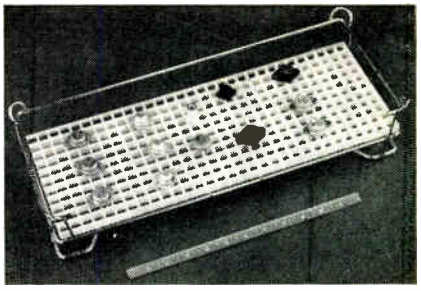


Fig. 27: Honeycomb structure is a loose parts grid holder. The wire frame permits its use with rack unit. (Photo courtesy of Autonetics)

After the units have received their initial inspection test at Autonetics and have been accepted, they are placed in storage. The storage in this sense does not mean they are left in boxes or shipping containers and placed on shelves, here they have partial power applied. The components are kept in this type of storage for approximately three months, periodically interrupted, about every week and a half, for testing and, naturally, data recording. When they have completed the three months of storage they are given a final test.

At this point not only those units which have failed or which no longer fall within the specified limits, but also those units whose history indicates that they will fail or drift sufficiently in a predetermined period of time will also be rejected.

Materials Handling

It has already been mentioned that components are mounted on sandwich-type matrix board assemblies for shipment to Autonetics. Special packaging was designed to protect the components in shipment. A container protects the components from shock and moisture through the use of special cushioning, chipboard containers, corrugated fireboard containers and sleeves, dessicant and foil-plastic moisture-vapor barrier material. Also included in the package are the machine record cards for each of the units mounted in this sandwich-type matrix board assembly.

After incoming inspection, storage, more testing, final acceptance, the components are ready for mounting on circuit boards. You will recall that in the sandwich structure the only place which the components are soldered is to the lower board. Now, by a dip-solder process, the leads of the component are disconnected from the lower board. When they are removed from the dip-solder bath the lower board is removed and the components remain on the upper board—loose. When large numbers of one particular component are required on a circuit board, the units

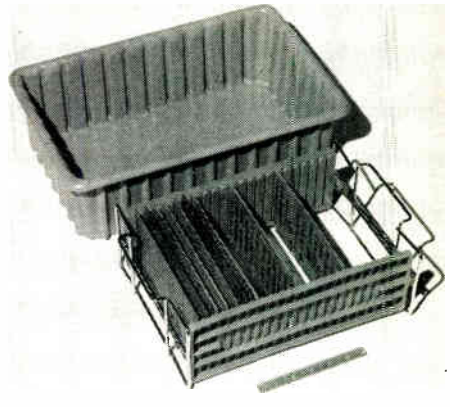


Fig. 28: Injection molded, grooved divider in wire frame fits in modular tote-box. Individual circuit board handling is thereby considerably reduced. (Photo courtesy of Autonetics)

are left on the upper board of the sandwich construction. Where only a few units are required on the circuit boards, the components are removed from the upper board and mounted on honeycombs.

To maintain the reliability built into the components by their manufacturer, the Autonetic's personnel had to completely study their own manufacturing techniques. Complete new work stations were designed for the assemblers.

Anthropometric analysis of the physical limitations of the average female assembler were made and plotted, using, as limiting features, the existing table height and the adjustable seating available at the individual work station. With arm reach distances, line of sight, table height and table dimensions considered, the station was designed to present all materials in a convenient position within the reach and vision of the individual assembler.

To place all components within the reach of the operator, racks had to be stacked. George Peters of Autonetics developed the materials handling concept.

At this point, a two-part problem presented itself. The first part was that of handling components which remained on the carrier board; the second, handling loose parts. The two parts required one solution, and that solution had to be compatible with the overall handling system. After a lengthy study of the problem, the best overall approach appeared to the use of special wire forms. Here are the reasons:

(1) Economy—wire forms can be worked with a minimum tooling cost in a variety of intricate forms suitable for materials handling devices.

(2) Cleanliness—wire forms afford a high degree of cleanliness by minimizing surface areas where dust and debris can accumulate. At the same time wire forms can be easily cleansed and dried to maintain cleanliness or to provide a handling device of materials through cleaning equipment.

(3) Adaptability—wire forms can be adapted to hold complex shapes and at the same time provide for stacking, in-process handling and accommodation for other special devices.

(4) Compatibility—wire forms can be plated with special metallic surfaces or can be plastic coated to withstand a variety of in-process requirements. The matrix board assembly would easily fit into this wire form.

Fig. 29: This metal-stayed box holds the circuit boards during assembly. Diced polyurethane pad mounted in cover holds loose components in place prior to soldering.
(Photo courtesy of Autonetics)

For the loose parts, a special kit holder consisting of a fibreglass-plastic tray mounted in a metal frame was designed. Within the holder was placed a loose parts grid holder—the honeycomb structure we have already mentioned. Next a wire form rack assembly was designed to hold both the matrix board rack assembly and the loose parts kit holder.

Wire is also used on an assembly device which holds the circuit boards during the insertion of the electronic components. The design interestingly incorporated the concept whereby the two sizes of boards are accommodated into one wire—sheet metal formed handling device which also provides for the transporting of the boards through additional operations. By inserting this device into a special set-up fibreboard box with a diced polyurethane pad mounted into the cover, the loose electronic components are held in place on the circuit boards.

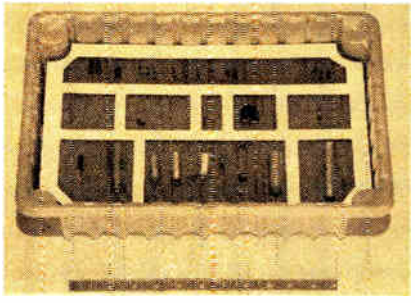


Fig. 30: Small loose parts are held in this honeycomb structure. Larger components are held in the honeycomb shown in Fig. 27.
(Photo courtesy of Autonetics)

This packaging innovation holds a wide degree of other applications where varying dimensional parts require cushioning or hold-down.

Finally, a work station storage rack was constructed from wire. This rack is installed under the table. In this case, the wire form provides an integral lock-in feature to retain the containerized circuit board assemblies.

Too much emphasis cannot be placed on the importance of the work station design and of proper worker instruction and motivation. Everyone agrees that the component manufacturer must build reliability into the device, but it is up to the assembler to maintain this reliability. No matter how good a component is when it leaves the manufacturer, lead contamination, shock, bad solder joints and other assembly possibilities can undo all the reliability which has been built in.

Worker Training

Autonetics, as has most of its participant suppliers, employed personnel for the program from outside of the company, preferably those who had not developed any skill at all in electronic assembly.

The initial phase of a worker's training is orientation. The worker is taught exactly what is expected of her. This includes not only how to follow the diagrams for placement of the various components on the circuit board, but also how to use the other facilities at her disposal such as the racks for mounting stored components.

This is the first time after the component has been soldered into the shipping printed-circuit board at the component manufacturer's plant that the unit is treated manually. To add a little more light to the

subject, we should point out that following the final test, after three months of storage, the circuit boards used for shipping and storage, the connections to the board are unsoldered by a hot-solder bath. Referring to Fig. 26 it can be seen that the circuit board is made up of two parts. One for holding the ones with which the base of the units are flush and another one in sandwich fashion below this which contains the etched circuit. A hot solder bath disconnects the solder connections from this etched circuit board permitting it to drop free and leaving the units simply sitting on a board.

Mr. E. B. Lindaman is Superintendent, Master Production Programming of the *Minuteman* Systems Management Div. at Autonetics. To say the least, he is more than keenly interested in the success of his department. He exhibits an enthusiasm for the *Minuteman* program that is contagious. Not only his staff but every member of the production force is instilled with it.

A personal interview with Mr. Lindaman revealed what might be the key to component reliability for the entire electronic industry—pride! Autonetics, through a motivational program conducted by Mr. Lindaman, has restored to the worker the professional pride of the Guild days—Craftsmanship.

The motivational training course was conducted through the medium of closed-circuit television. Half-hour programs are run about once a month; two a month were run in the earlier parts to catch up. These programs were designed to instill into the worker the feeling of personal responsibility.

The programs were varied. Some were films, others were personal interviews, and still others were informal chats. One of the earlier shows, a film, gave the workers a complete background on the *Minuteman* missile itself, explaining the reliability concepts behind it, how it would be deployed, and how it would fit into the defense picture. Further it went on to include how it would always be operationally alerted.

Other shows explained how the missile was broken down into the various engine stages, reentry vehicle, guidance and control systems, etc. It was explained to the workers that Autonetics was responsible for the guidance and control system as well as the ground support and ground operating equipment for the missile. Autonetics then supplied its own film showing the evolution of the design for the computer and other electronics in the system. It broke down the electronics to show how all circuits were mounted on boards and how all boards were serial numbered. Further it went on to explain the serial numbering of all components that were used on the board and also the history that was kept on punched cards.

Fig. 31: Autonetics President John R. Moore is watched by employees during CCTV program beamed to them to explain reliability concepts. (Photo courtesy of Autonetics)

Table 3

Participants in Reliability Program

Company	Product
Corning Glass Works	Glass Capacitors
Dale Electronics Inc.	Wirewound Resistors
Delco Radio	Germanium Power Transistors
Fairchild Semiconductor Corp.	Silicon Transistors
John E. Fast & Co.	Paper Capacitors
General Electric Co., (Irmo, S. C.)	Foil & Solid Tantalum Capacitors
General Electric Co. (Syracuse, N. Y.)	Silicon Transistors
International Resistance Corp.	Metal Film Resistors
Motorola Semiconductor Div.	Germanium Transistors
Pacific Semiconductor Inc.	Silicon Diodes
Sprague Electric Co.	Foil & Solid Tantalum Capacitors
Transitron Electronic Corp.	Silicon Transistors and Diodes
Wheeler Electronic Corp.	Transformers

It might be well to inject here the fact that the workers viewed the TV sets right from their work stations. They were told to quit work, turn around, view the screen when the program was about to start. This made the worker feel more relaxed rather than being regimented off to an auditorium.

When a half dozen or so of these programs had been completed, the workers were asked to submit their comments to Mr. Lindaman concerning the program—whether they liked them, disliked them—what their exact feelings were toward them. It was my privilege to see as many of these testimonials as I wished. And I don't mean that I was offered a dozen or two to look at. I was offered the complete bundle of hundreds. The workers did not have to sign these comments if they did not wish. In a cursory inspection I saw both signed and unsigned statements. In a little more extensive survey, I detected no derogatory statements concerning the shows. Most of the comments were an expression of appreciation for giving the workers this background into the program. Some of them went on to say that they never realized how far we were engaged in a cold war. And most of them made the statement that because they now understood what was expected of them, and where they fit into the picture, they would do their utmost to make this operation a success.

We have long since learned not to accept information from one source with 100% confidence, especially when other sources are available. Just to see if these testimonials were the real thing, we questioned various employees throughout the manufacturing facilities. At random, we asked a worker what she was doing. The answers confirmed the written testimonials. Not only did they know that they were applying components to circuit boards, but they could tell us the exact function of that circuit board in the system and where the system fit into the complete missile.

Another one of the half-hour programs was an interview with John Moore, the President of Autonetics. Mr. Moore's talk ran for 10 to 15 minutes. We had an opportunity to listen in on a sound track of the show. He spoke with such simplicity and sin-

Component Reliability *(Continued)*

cerity, that we could readily see why some of the employees told us that they felt like he was one of their co-workers rather than a company executive. We feel that he, personally, is responsible for the feeling in the *Minuteman* employees that they are members of a selected group.

Most certainly the initial cost of components has been emphasized to the assemblers, but even more so, the cost should a completed circuit board go wrong in test—or even worse, after it has been mounted in the complete system and placed in the missile. It is sometimes very difficult to impress on an assembler that it is better to leave a $5.00 component go unused should it have accidentally dropped a few inches or its lead become contaminated. But in most cases to date, where completed circuit board assemblies have not come up to par under test, the trouble has been traced to an assembler not following instructions to the letter.

The lead page of this article depicts *Minuteman*—historical and contemporary. The equation in the ball, $P = e^{-t/\mu}$ indicates the probability of success of the system where t is equal to the required period of a successful operation and μ is the actual mean-time-between-failure of the system. The shaded areas of the missile indicate those portions where electronics are used extensively: the guidance system and control center; and, the control units at the first, second, and third stages.

Management Report

Top management at Autonetics is highly satisfied with the results of the program to date. Mr. E. N. Ljunggren, Vice-President, *Minuteman* Systems Management Division, was happy to give this highly significant report. "Normally prototype models of airborne computers operate about 10 hours before failure of an electronic part. Production models usually operate for 85 hours before failure. The prototype model for the *Minuteman* computer operated for 585 hours before failure and then, it was mechanical rather than electronic. We are confident that we can reach the ultimate objective of our reliability program within the specified time."

Table 4

Reliability Terms

Confidence—same as confidence level. The probability that an actual unknown lies in the stated confidence interval.

Confidence Factor—the percentage figure that expresses confidence level, or proportion of times the statement should be correct that the estimated population parameter lies within the given confidence interval.

Confidence Level (Coefficient)—the degree of desired trust assurance in a given result. A confidence level is always associated with some assertion and measures the probability that a given assertion is true. For example, it could be the probability that a particular characteristic will fall within specified limits.

Confidence Interval—The numerical range within which the actual unknown is estimated to lie with the stated confidence.

Defect—A condition considered potentially hazardous or operationally unsatisfactory, and therefore, requiring attention.

Reliability—The probability of a device performing its purpose adequately for the period of time intended under the operating environment encountered.

Exponential Failure Distribution—The distribution that results from a population with a constant failure rate. The cumulative distribution has the form:

$$F(t) = 1 - e^{-\lambda t} = P_f \text{ (Probability of failure)}$$

where λ is the failure rate and t is time.

Failure Rate—Same as hazard. The probability of failure per unit of time of the items still operating. The best estimate of failure rate from a test is

$$\lambda = \frac{\eta}{T}$$

where λ is the failure rate

η is the number of failures

T is the accumulated operating time of the items

Failure rate is normally expressed in percent failures per 1000 hours. For an exponential distribution of failures (constant failure rate) the failure rate is the reciprocal of MTBF.

Mean-Time-to-Failure (MTTF) — the measured operating time of a single piece of equipment divided by a total number of failures of the equipment during the measured period of time. This measurement is normally made during that period of time between the early life and wear-out failures.

Mean-Time-to-First-Failure (MTTFF) — A special case of MTBF where the time T is the accumulated operating time to first failure of a number of devices (failures), η.

Mean-Time-Between-Failures (MTBF)—The limit of the ratio of device operating time to the number of observed failures as the number of failures approaches infinity.

$$\text{MTBF} = \lim_{\eta \to \infty} \frac{T}{\eta}$$

where T is the accumulated operating time of several devices over a period of time in which η failures are observed. The best estimate of MTBF for finite time, T, and finite number of failures, η is

$$\text{MTBF} = \frac{T}{\eta}$$

MTBF is normally measured during the normal operating period of the device.

Minimum Acceptable Reliability—That reliability which must be achieved before approval of the first articles with operational configuration.

Reliability Engineering—A design adjunct which assists in establishing a product design with a high inherent reliability.

Reliability Control—The coordination and direction of technical reliability activities through scientific planning from a system point of view.

(Definitions courtesy of IRC and Autonetics)

"White Room" Advances

Employe gages the cross curvature of an instrument ball bearing in "white room".

ON Nov. 10, 1960, the New Departure Division of General Motors Corp., Sandusky, Ohio, officially opened a new and modern ultra-clean "white room." The event was in commemoration of the firm's 25th year of precision instrument ball bearing production.

Besides the usual techniques of temperature and humidity control, extreme air filtration, and higher air pressure in cleaner working areas, New Departure's plant engineering department has come up with 8 outstanding new features. Those features are:

Lighting at work level is maintained in excess of 200 foot candles, diffused through plastic prismatic lenses to eliminate glare.

Except at door jambs and headers there are no perpendicular or right angle intersections of architectural surfaces. Ceilings and floor surfaces are coved into walls and partitions on sweeping radii. All vertical intersections are broken on 45° or "flatter" angles. Joints at panel and window junctions are closed with stainless steel battens having streamlined edges, thereby avoiding corners that might collect dust.

All vertical walls and partitions are stainless steel or plate glass. All "trim" is stainless steel. All steel is copper-wire grounded to discourage static. Copper grounding is concealed behind streamlined stainless moldings that cover the junction of the floor coves to the partitions.

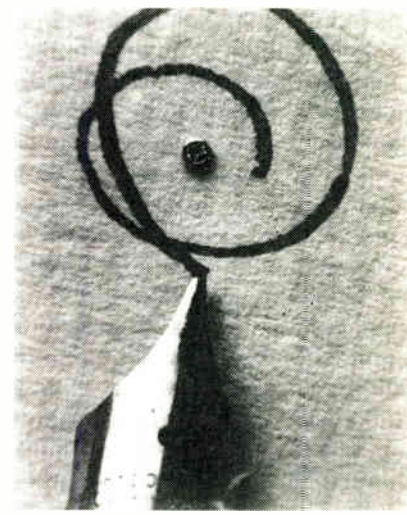
All vertical walls and partitions "lean" into the cleanest areas at approximately 3° off plumb. This deters adhesion of precipitating dust particles and deflects any glare reflected from the high illumination level and the polished stainless surfaces.

Partitions are single-thickness, without studding or other framing. Stainless-steel clad plywood and plate glass are self supporting from structural steel floor curbs to structural steel ceiling members. No thermal insulation is required in partitions, since the same temperature is maintained in adjoining rooms.

Frame-less tempered plate glass doors, with pivots and closing mechanisms flush with casing headers and floor, eliminate the usual moldings and ledges that present even minor dirt accumulating ledges.

Even screwheads, potential resting places for dust, are covered with stainless buttons that streamline them into flat surfaces.

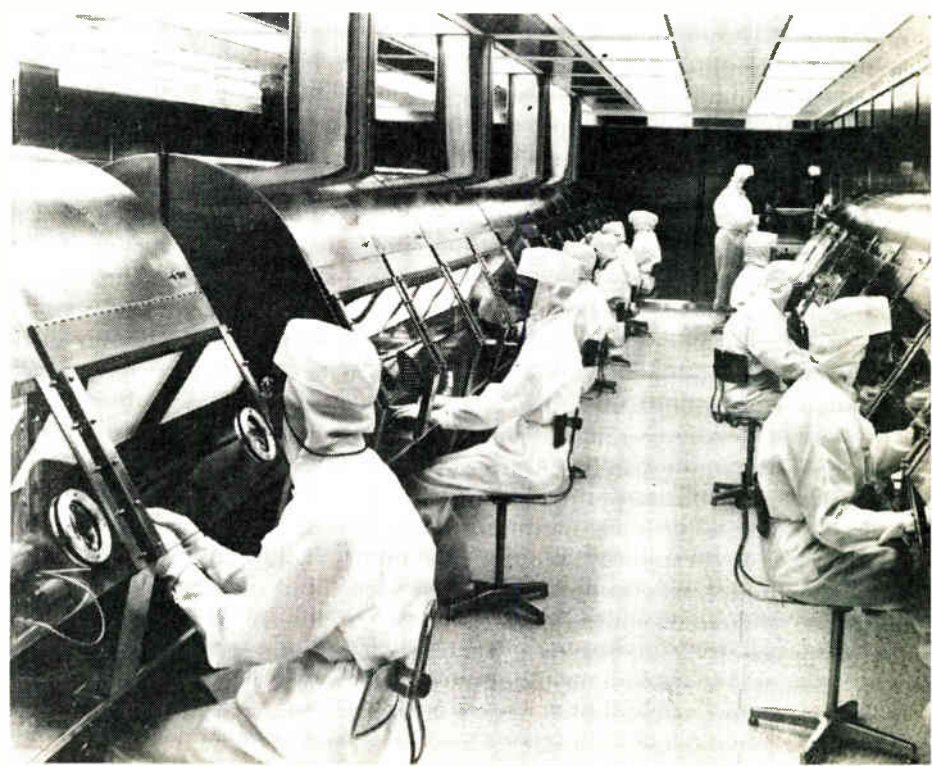
No crevice that could collect dust has been overlooked. Plastic metal, hard enough to require filing or grinding to get smooth, is flowed into all open joints that could not be butted tightly.



Balls for this subminiature bearing are only 0.01 inch in diameter. Outside of bearing diameter is just under 0.047 in.

(Left) Overall view of room also shows the special attire that employees must wear.

(Below) These specially treated nylon uniforms resist static electricity and prevent any contaminants dropping from worker.



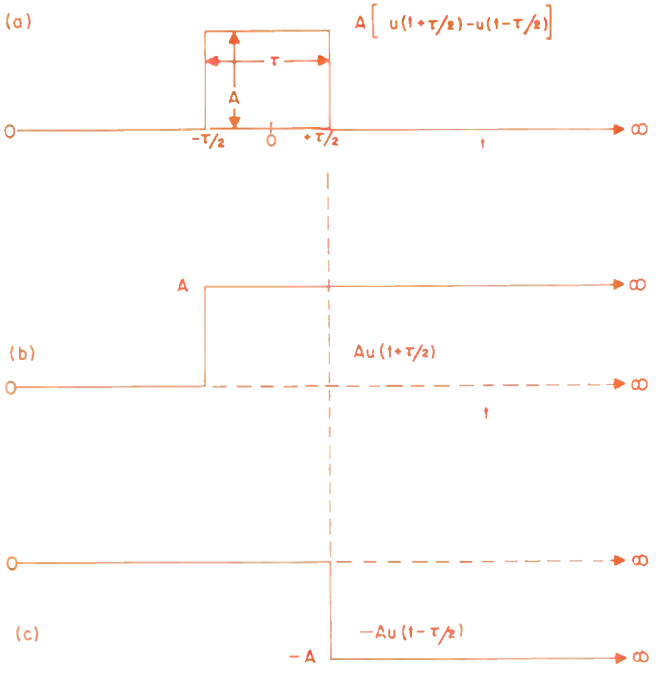
By D. R. J. WHITE
Advanced Research Dept.
Alexandria Div.
American Machine & Foundry Co.
1025 North Royal St.
Alexandria, Va.

Using Transient-Testing Techniques

Transient testing of linear networks has certain desirable features over steady-state techniques. Before considering transient methods, however, a rough idea of the network to be tested should be had to determine which technique to use. This article gives simple tools to make a good choice.

OFTEN, transient-testing techniques are better to evaluate the performance of a network. By knowing the transfer function, the network response to any type of excitation function can be predicted.

Fig. 1: The Laplace transform for the single pulse (a), a combination of the two-step functions (b and c), is given in Eqs. 3 and 4.



It has become important to know this because many electronic equipments are either not operated or do not process signals under steady-state conditions. Among many, two examples are: frequency-diversity radar and PCM telemetry. It is expected that transient testing will more accurately approximate actual-use conditions.

Transient testing often simplifies the tedium of point-by-point measurements (steady-state case) of network frequency response and sometimes provides additional information, e.g., in the case of non-minimum phase-shift networks. the amplitude and phase response are not uniquely related). Through a simultaneous application of a continuum of sinusoidal generators, $f(t)$, to the input of a linear or nearly linear network described by $g(t)$, the response function, $h(t)$, will be the phasor sum of these signals (by superposition) at the output of this network. One can, by observing $h(t)$, on an oscilloscope, usually deduce $G(\omega)$, the system frequency characteristics.

It is generally accepted that transient methods are not recommended for the measurement of networks having other than low selectivity properties; these methods are less accurate than steady-state in measuring the transfer functions in regions having high rate of attenuation change. Although this is normally true, transient testing does lend itself to many networks having narrower bands than perhaps otherwise appreciated. We'll discuss this later.

Excitation Functions

The real angular-frequency relations of the response, driving, and characteristic network functions are respectively:

$$H(\omega) = F(\omega) \cdot G(\omega) \qquad (1)$$

From Eq. (1), it is seen that the frequency transform $F(\omega)$, of the excitation function $f(t)$, should be chosen in such a manner as to simplify measurements, i.e., so that $H(\omega)$ and $G(\omega)$ are easily related and obtainable by measurement techniques. Basically, the two types of desirable excitation functions correspond to pulse testing and square-wave testing. Pulse testing includes an approximation to the impulse or delta-function technique, and square-wave testing includes an approximation to the unit step-function technique. The limits and extents of these approximations are discussed below. By using the two techniques, Eq. (1) becomes respectively:

$$H(\omega) = G(\omega) \qquad (2a)$$

and

$$H(\omega) = \frac{G(\omega)}{j\omega} \qquad (2b)$$

where the transform of δ, the delta function, is 1 and that of the step function is $1/j\omega$. It is also noted that the unit step is the integral of the unit impulse. Eq. (2a) or (2b), therefore, shows that from a knowledge of the response transform, the network transform (transfer function) may be ascertained.

Pulse and Square-Wave Testing

For oscilloscope displays, either impulse or step-function testing tends to be impractical because of the relatively short time-constant phospors that are generally used; that is, the response functions presented would quickly fade away before the results could be observed or noted without using photography*.

Additionally, the energy in a single event is naturally less than in repeated events. If we could repeat the impulses or step functions often enough, the scope presentation will be usable (enhanced brightness and continuous observation) provided the period, T, between either the discrete impulses or the step functions has allowed the transient response of the network under test to decay to a negligible amount (the stationary condition) e.g., by 40-db decay. This means either the pulse-repetition frequency should be less than $1/T$ or the square-wave frequency less than $\frac{1}{2}T$.

Pulse Testing

The Laplace transform (L) of a single pulse of amplitude A, and width τ, centered about $t = 0$, (see Fig. 1) is:

$$L\left\{A\left[u\left(t+\tau/2\right)-u\left(t-\tau/2\right)\right]\right\} = \frac{A}{s}\left(e^{s\tau/2}-e^{-s\tau/2}\right) \qquad (3)$$

$$= \frac{A}{\pi f}\sin \pi f \tau \qquad (4)$$

where $s = j2\pi f$ at real frequencies.

To realize an impulse function we choose $A = 1/\tau$ and form the limit as $\tau \rightarrow 0$. Under this limit condition, the right-hand side of Eq. (4) equals unity. By choosing τ sufficiently small, however, an impulse function may be approximated to within any desired degree insofar as a network having a significant upper frequency response f_u is concerned. For example, from Eq. (4):

$$\frac{\sin \pi f_u \tau}{\pi f_u \tau} = B \leq 1 \qquad (5)$$

where B is the amplitude of the approximate impulse function (τ finite) at any frequency f_u. The solution of Eq. (5), is the well known $\sin x/x$ function, as presented in Table I for various values of B.

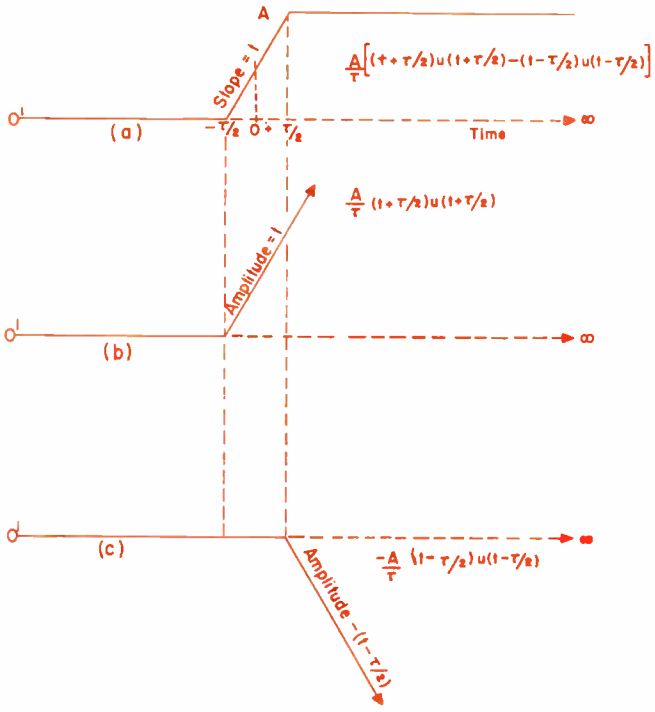


Fig. 2: Step function (a) is combination of functions (b) and (c).

Table I

Requirements of pulse width, τ, for realizing a continuum of driving generators having an amplitude fall off of C percent from a frequency of zero to f_u cps.

B Relative Response		C = (1 − B)		
Amplitude	db	in %	$\omega_u \tau$ radians	τ seconds
1.00	0.0	0	0	0
0.995	−0.05	0.5	0.37	$0.059/f_u$
0.99	−0.1	1.0	0.50	$0.08/f_u$
0.98	−0.2	2.0	0.69	$0.11/f_u$
0.97	−0.3	3.0	0.84	$0.134/f_u$
0.95	−0.5	5.0	1.09	$0.174/f_u$
0.90	−1.0	10.0	1.54	$0.245/f_u$

* With the recent introduction of the storage-tube oscilloscope, the above comment naturally does not hold. This in no way invalidates the subsequent discussion and developments.

Testing Techniques *(Continued)*

For a network having a significant frequency response out to 1 MC, e.g., the required pulse width τ should be equal to, or less than, 0.11 μsec (Table I) so that the measured error introduced by the pulse generator should not exceed 0.2db (2%). Coupled with the importance of clean sharp pulses that have rise times considerably less than 0.1 τ (rise time adds to the maximum 2% error assumed in the above example to increase the uncertainty of analysis), the requirement of 2% becomes difficult to realize in practice.

It appears that fairly precise pulse testing with no carrier frequency is impractical for networks having appreciable real-frequency responses above approximately a few hundred KC. Certain pulse-forming lines can extend this range because of their resulting sharp pulses. They also permit a high-excitation function amplitude (up to the order of 30 kilovolts); this would be required for transient testing of networks having high Q-factors as explained in the following section.

The pulse generator that would be used in the event of a high Q-factor might be akin to a radar modulator of the soft-tube type employing, perhaps, dc resonant charging for controlling the required PRF. It is very doubtful, however, that any standard electrical network to be tested would survive these high voltages.

Square-Wave Testing

The Laplace transform of a single "imperfect" step function of amplitude A and rise time, τ, centered about $t = 0$, is (see Fig. 2):

$$L\left\{\frac{A}{\tau}\left[(t+\tau/2)\,u(t+\tau/2)-(t-\tau/2)\,u(t-\tau/2)\right]\right\} = \frac{A}{s^2\tau}\left(e^{s\tau}-e^{-s\tau}\right) \qquad (6)$$

$$= \frac{A}{s\,\pi f\,\tau}\sin \pi f\,\tau \qquad (7)$$

As in the previous section, for Eq. (6) to provide a continuum of driving generators having an amplitude fall-off with frequency not to exceed C percent from that of a perfect step function at an upper frequency, f_u:

$$\frac{A}{s}\,\frac{\sin \pi f_u \tau}{\pi f_u \tau} = \frac{A}{s}\,B \le \frac{A}{s} \qquad (8)$$

Eq. (8) reduces identically to Eq. (5), and the same requirements for τ hold as those present in Table I. For example, τ must be no greater than 0.1 μsec for fairly accurate (2% fall off) testing of networks out to 1 MC. It should be noted here, however, that τ *is now the rise time of the step function* and is considerably less difficult to realize than the clean pulse width, τ, of 0.1 μsec mentioned in the previous section.

This is an important distinction in the practical problem of test equipment performance and limitations. Therefore, square-wave testing introduces a substantially less error than equivalent pulse testing. In other words, for equal τ, square-wave testing permits an order of magnitude improvement in the upper frequency response to which networks can be measured.

As previously shown, the step function has a transform of $1/j\omega$ at real frequencies. Eq. (2b) defined the response transform of a network and indicated that it was depressed by this weighting function $1/j\omega$. Therefore, this factor must be reinstated in the network frequency-response interpretation of the resulting time-response function displayed on an oscilloscope. In practice, however, this is not necessary since tables of known responses of networks to step functions are available or may be easily compiled. In any case, this limitation does constitute the price paid for the greater physical realizability of pertinent test equipment.

From an instrumentation point of view, it is desirable to establish equipment requirements in terms of certain network responses to a step function. First, however, consider the simple case of a doubly loaded, single-stage band-pass filter depicted in Fig. 3a. The response transform, $E_o(s)$ (voltage developed across R_L) obtained from the integrodifferential equation describing the performance to a step function, $A_u(t)$, is:

$$E_o(s) = \frac{A\,\omega_o}{2\,Q_L}\cdot\frac{1}{(s-s_1)(s-s_2)} \qquad (9)$$

where the poles of the transform, s_1 and s_2, are shown as in Fig. 3b. Q_L is the loaded Q-factor of the band-pass network; $Q_L = \omega_o B$, where ω_o is the center angular frequency of greatest response and B is the 3-db bandwidth as shown in Fig. 3d. For $Q_L > 3$ (bandwidths of less than a third octave—the case of principal interest in this paper):

$$s_1 \cong \frac{\omega_o}{2\,Q_L} - j\,\omega_o, \text{ and } s_2 \cong \frac{\omega_o}{2\,Q_L} + j\,\omega_o. \qquad (10)$$

Using the relations in Eq. (10) the inverse transform (time-response function) corresponding to Eq. (9) is:

$$e_o(t) \cong \frac{A}{2\,Q_L}\left(\exp \omega_o t/2\,Q_L\right)\cos \omega_o t. \qquad (11)$$

It is noted that the maximum amplitude of this time response is reduced to $\frac{1}{2}Q_L$ times the amplitude of the excitation function. From an instrumentation point of view, this means that for a scope with a vertical sensitivity (Deflection factor) of G volts per inch, the amplitude of the excitation function required

to give at least a one inch (practical usable minimum) scope pattern is:

$$A = 2\,Q_L\,G \qquad (12)$$

With a time response pattern such as shown in Fig. 3c, the center angular frequency, ω_o, and loaded Q-factor, Q_L, of the filter are readily determined by measuring the time

$$\left(t' = \frac{\omega_o}{2\,Q_L}\right)$$

and the amplitude, $A/2Q_Le$, on the calibrated face of the scope.

For example, assume Q_L is 100, $f_o = 500$ KC, and $G = 10$ millivolts per inch; the required minimum excitation square-wave amplitude using Eq. (12) would be 2.0 volts with a corresponding maximum rise time of about 0.35 μsec (for $C = 5\%$ or about 0.5 db; see Table I). The maximum square-wave frequency should be $\frac{1}{2}T$ where T is chosen so that

$$\exp - \omega_o\,t/2\,Q_L$$

of Eq. (11) has decayed to at least 0.01 (40 db).

$$\exp - \omega_o\,t/2\,Q_L = 0.01, \text{ or } t = 3 \text{ milliseconds} \qquad (13)$$

hence the maximum usable square-wave frequency is about 170 CPS.

General Test Equipment Requirements

High excitation function amplitudes become necessary with networks having high Q-factors and/or multiple-tuned stages such as those used in providing a Butterworth or Tchebycheff response. For example, it can be shown that the maximum amplitude of a time-response function to a driving step function is depressed by the order of $\frac{1}{2}Q_L{}^n$ where Q_L is the loaded Q-factor of the overall network and n is the number of tuned stages. Generalizing, the required excitation function amplitude is:

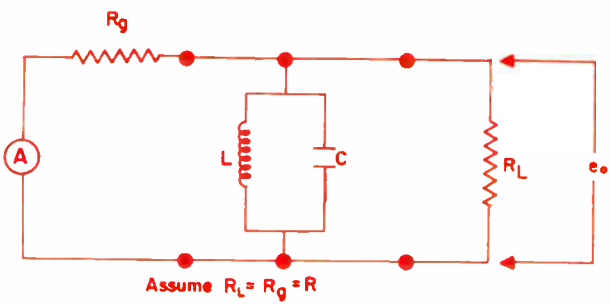
$$A = 2\,Q_L{}^n\,G. \qquad (14)$$

For maintaining a satisfactory minimum error in network response measurements of $\pm\,\beta$ degrees and/or $\pm\,y$ db, the combined test equipment errors must naturally be equal to, or better than, this over the range of appreciable response of the network under test. These equipments include the signal generator-scope combination and any impedance matching networks is required.

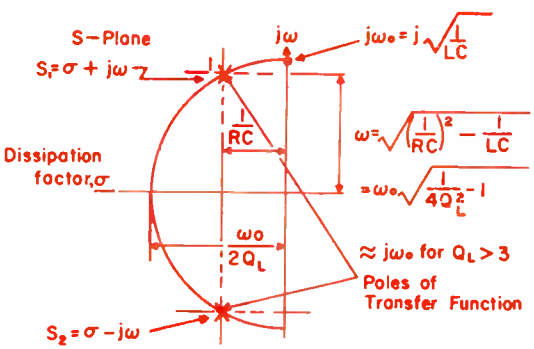
Generally, a figure of about $\pm\beta/3°$ allowable phase nonlinearity and $\pm\,y/3$ db amplitude variation are quite satisfactory, for the combined test equipments. If we apportion this allowable error equally between the square wave generator and scope, then the B term given in Table I should approximate $y/6$ db, and the scope roll-off should not be down more than $y/6$ db at the frequency of appreciable network response, f_n, previously discussed.

Since it is difficult to give numbers for tolerable nonlinearity because of variations in rate of scope roll-off, unknown characteristics of the networks under test, and desired degree of measurement accuracies, from a practical point of view the 3-db upper-cutoff

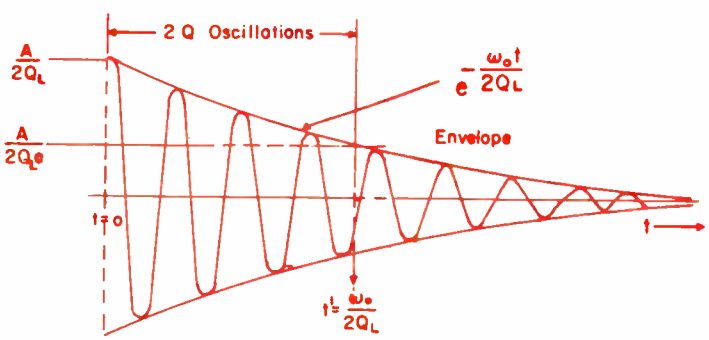
Fig. 3: A single-stage filter network and resulting performance.



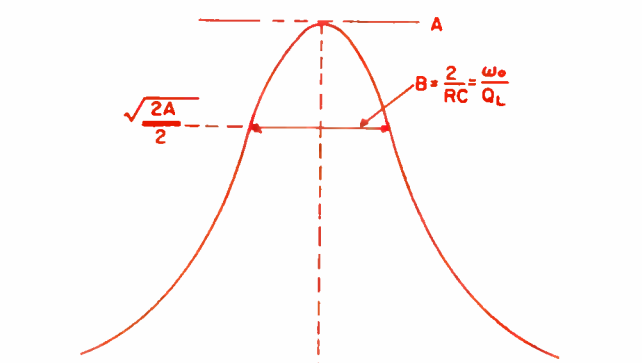
(a) Single—Stage Doubly—Loaded, Band—Pass Filter



(b) S—Plane Pole Distribution



(C) Response Transient



(d) Steady—State Frequency Response

frequency on the scope should exceed 2 f_u. For a gradual scope frequency roll off, this general requirement may be reduced.

Reviewing standard laboratory test instruments, it is noted that square-wave generator voltage of the order of 10 volts applied to loads of the order of a few hundred ohms are typical. Rise times less than 0.05 μsec (corresponding to usable upper frequencies of about 2MC for networks under test; see Table I) are readily obtained. Square-wave frequencies covering from a few cycles to about 1 MC are available and are much more than actually needed.

An impedance transformer, to match the generator driving-source impedance to the test-network driving-point impedance must of course be used if impedances do not already match. A transformer must have a constant amplitude and linear phase *vs.* frequency characteristics over the bandwidth of the network under test; or, provide variations therefrom equivalent to, or less than, that introduced by the scope and generator; and, it should display no ringing tendencies. Should this become difficult to realize, resistance padding networks may be preferable if loss of signal level can be tolerated.

Two useful oscilloscopes include one having a frequency response out to about 10 or 20 MC and deflection factors of about 0.1 volt/inch and another having a response to 10 MC and a 0.013-volt/inch sensitivity. The price for such high-frequency responses is the attendant higher deflection factors consistent with the gain-bandwidth products involved. Special scopes having both low-deflection factors (less than 10 mv/inch) and high-frequency responses (in excess of 10 MC), however, are commercially available, but the average laboratory can not generally afford the luxury of such an investment.

Using Eq. (14) and the above notations on suitable generators and oscilloscopes, the greatest $Q_L{}''$ that can be practically tested by transient testing techniques is:

$$Q_L{}'' \approx 500 \qquad (15)$$

This shows, for example, that single-stage, tuned networks having loaded Q-factors greater than 500 or a three-stage, staggered-tuned filter having a Q_L greater than about 8 should be tested by steady-state methods.

Finally, it is mentioned in passing that by square-wave modulating a suitable carrier frequency located at or near the center frequency of the expected tuned network and by using spectrum analyzers, such as at VHF or micro-wave frequencies, a new set of transient measurements requirements can easily be set up. This subject, however, will be reserved for a subsequent paper.

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Signal Corps

Ft. Huachuca, Ariz.—This 80-year old Mexican Border cavalry camp, rich in memories of the Indian Wars, of Geronimo, and Pancho Villa, has found a new role as the proving ground for Signal Corps electronic equipment.

It owes its new assignment to one unique characteristic that has suddenly become important in testing electronic equipment—it is still a long way from anywhere.

From the Signal Corps standpoint this isolation makes it possible to check out field military equipment for interference problems, without worrying about the confusion caused by surrounding civilian equipment.

The Southern Arizona terrain, sparsely settled and sprinkled with mountain ranges, is ideal.

Within a vaguely defined area, stretching from Phoenix on the north to Yuma on the West, the Signal Corps is undertaking three basic field testing operations. Collectively they are administered as the Electromagnetic Environmental Test Facility (EETF). They are: (A) The Electromagnetic Environment (EME) located at Gila Bend, Ariz. (B) The Drone Test Facility (DTF), including a flight corridor stretching from Huachuca westward 250 mi. to the Yuma Test Station, and (C) The Common Test Facility (CTF) located at the Fort, and providing communication and test facilities to support tests conducted the various technical departments at the Proving Ground.

Electromagnetic Environment

The Electromagnetic Environment (EME) is of prime importance to industry. Within this geographical area southwest of Phoenix, the Signal Corps is assembling all the electronic elements of an army division. In an area 100 mi. square, more than 75,000 transmitters of electronic radiation will be put into operation. How they react on each other will determine to a large extent the future requirements for military field electronic equipment.

The goals of EME are described as:

These SD-2 Combat surveillance drones are checked at Huachuca's drone test facility.

Checks RFI

—at Ft. Huachuca, Ariz.

A. To reveal the incompatibilities of existing Army equipment and systems.

B. To suggest modifications to reduce interference.

C. To provide a firm basis for the establishment of realistic standards.

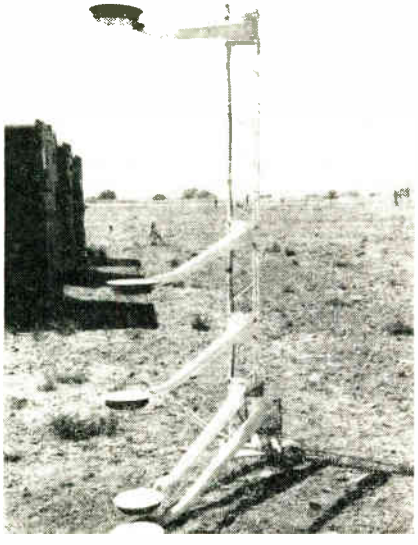
D. To test Army frequency assignment plans.

E. To test all newly developed electronic-communication equipment prior to its acceptance by the Army.

The testing began on a limited scale in July 1960, using a company-size unit operating in the environment of a battle group. Next will be a battle group within a division, and then a division within a corps. Eventually it is planned to study a corps within an army.

The Army is not content to just reproduce the electromagnetic radiation of military gear. It will be including also the typical radiation put out by a typical modern city, and analyzing the effect of this on military transmitters and receivers.

Backing up this study is an IBM 709 computer on which the EETF researchers run out their problems. It works this way: the radiation "picture" of a given piece of electronic equipment is reduced to a mathematical model. When the mathematical models of some hundreds of pieces of equipment are analyzed by the computer the possible areas of interference can be predicted. This is one promising avenue being investigated.



MICRO-METEOROLOGY

At Ft. Huachuca basic research is being conducted in micro-meteorology, the science of forecastng weather on a local basis. This tower is measuring air temperatures at various distances from the earth.

Drone Test Facility

The Drone Test Facility flight-tests and evaluates advanced airborne combat surveillance systems. It consists of launch, control, and recovery areas at Yuma Test Station and an oblong "racetrack" flight area extending about 80 miles east of Yuma Test Station.

Two high-performance jet-powered surveillance drones are involved in the initial tests at the Facility.

Instrumentation in the "racetrack" area includes: Tracking radars and optical systems, surveillance radars, command control systems, and timing and telemetry systems.

To enhance the testing capability of the facility, both for combat surveillance systems and for other systems being tested at the Proving Ground, instrumentation is being extended along a 250-mile flight corridor between Yuma Test Station and Fort Huachuca. A significant amount of this instrumentation is presently installed at Fort Huachuca. This corridor will also provide an entrance to the Electromagnetic Environment Area, thus permitting newly developed air-borne electronic systems to be exposed to the electromagnetic environment of which they will eventually become an integral part.

The over-all civilian responsibility for engineering, installing and operating the Electromagnetic Environmental Test Facility is in the hands of Pan American World Airways. Bell Aerosystems Co. is the main sub-contractor. In March 1960 PanAm was awarded and $18.8 million, 2-year contract by the Signal Corps.

The contract is under the supervision of the Commanding General of the Proving Ground, Maj. Gen. F. F. Uhrhane.

The field of magnetic shielding is notable for its lack of numerical values. While the subject of how to achieve good quality shielding is not emphasized, a significant contribution is made in that the article indicates how to establish the essential shielding objective.

Shielding CRT's from Magnetic Fields

DELIBERATE deflection of electron beams by magnetic fields is common practice in many electronic instruments. At the same time, extraneous magnetic fields, such as the relatively steady field of the earth, or ac fields at the frequency of the power supply from transformers, can cause objectionable deflections, unless suitable shielding is introduced.

For example, an aircraft may have its radar CRT mounted vertically, with a camera above it. Since the magnetic induction is directed, more or less, toward the North Pole, the beam is deflected toward the east, Fig. 1. When the plane is flying north, a compensating voltage or current is applied to center the picture, the compensating force on the electron beam being directed toward the left side of the aircraft. Consequently, if the plane reverses direction, as for an adjacent flight line, both the magnetic field of the earth and the initial compensating force deflect the beam toward the east (now the left side of the aircraft), resulting in twice the positional shift of the earth's field alone. The radar picture, therefore, is no longer properly centered, so that distant targets toward the east do not appear on the face of the tube.

Uniform Magnetic Fields

The trajectory of an electron traveling with constant velocity after entering a uniform magnetic field oriented at right angles to the initial path is a circle of radius.[1]

$$R = 3.3721 \times 10^{-6} \sqrt{\frac{V}{B}} \text{ meters} \qquad (1)$$

REFERENCE PAGES
The pages in this section are perforated for easy removal and retention as valuable reference material.
SOMETHING NEW HAS BEEN ADDED
An extra-wide margin is now provided to permit them to be punched with a standard three-hole-punch without obliterating any of the text. They can be filed in standard three-hole notebooks or folders.

where V is the electron velocity in equivalent volts and B is the magnetic flux density* in webers/m^2. This quantity is presented in the graph of Fig. 2, based on the more precise form[2]

$$BR = 3.3721 \times 10^{-6} \sqrt{V_r} \qquad (2)$$

where V_r is the "effective relativistic potential difference" given by

$$V_r = V + \frac{e}{2 m_0 c^2} V^2 \qquad (3)$$

In this equation, e is the electron charge (1.60206 x 10^{-19} coulomb), m_0 is the rest mass (9.1083 x 10^{-31} kg), and c is the velocity of light (299,792.5 km/sec). At 40,000 volts, the radius of Eq. (2) is about 1.4% greater than that given by Eq. (1). Below 10,000 volts the difference is less than 0.5%, so that it can be neglected in most engineering applications. The graph presents this data with the scales chosen to permit reading values closely enough for most problems.

First Example

An electron traveling at a velocity equivalent to 600 volts passes through a uniform magnetic field of 25 μwebers/m^2, directed normal to its path. This value corresponds to the horizontal component of the earth's field in the southern part of the United States. From the graph we find $BR = 8.25 \times 10^{-5}$, whence

$$R = 3.30 \text{ meters.}$$

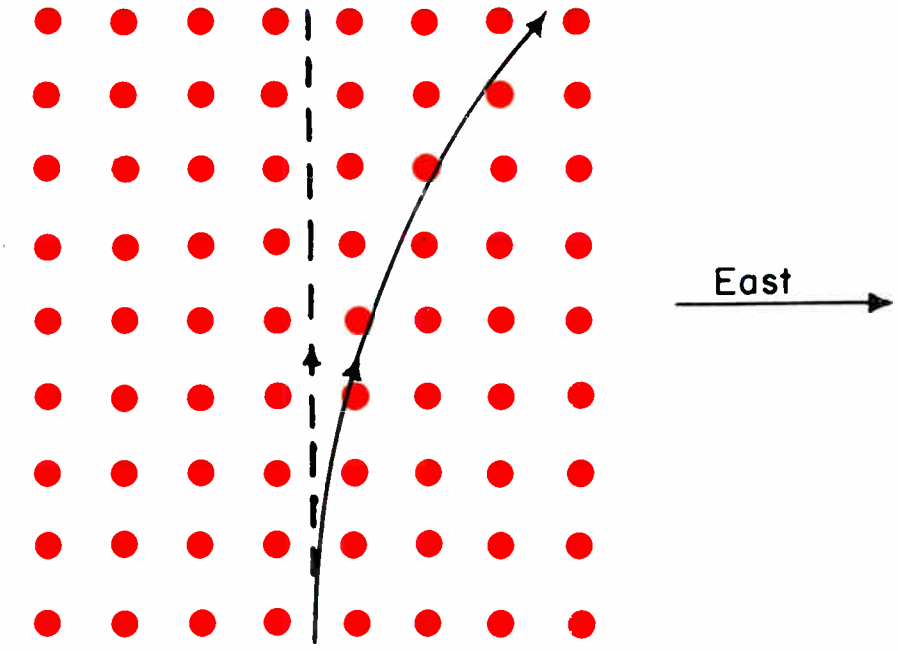
If the length of the path through the magnetic field is less than 3.30 meters, then the electron travels on a straight line after emerging, the equation of the new path being given by**

$$y = \frac{x_M}{R - y_M} x - \frac{R\, y_M}{R - y_M} \qquad (4)$$

where

$$y_M = R\left[1 - \sqrt{1 - (x_M/R)^2}\right] \qquad (5)$$

Fig. 1: A diagram of the deflection of an electron by a uniform magnetic field. The magnetic induction is directed into the page, toward the north, while the undeflected electron path is vertical.



By DR. DANIEL LEVINE
Consulting Engineer
3826 North 55th Drive
Glendale, Arizona

The coordinate system and other notation are illustrated in Fig. 3.

When the extent of the field is very much less than R, a good approximation for the emergent path is derived as Eq. (A-7) in the Appendix:

$$y \doteq \frac{x_M}{R}\left(x - \frac{x_M}{2}\right) \qquad (6)$$

Thus, if the magnetic field of the above example extends for 1 cm, then after 7.78 cm of total travel along x measured from the point of entry, the beam has been deflected

$$y = \frac{0.01}{3.30}(.0728)\text{ m} \equiv 0.220\text{ mm} \equiv 0.009\text{ inch}$$

Second Example

An electron beam having a velocity equivalent to 4500 volts passes through 10 cm of a normally-directed magnetic field having a flux density of 25 μwebers/m². What is the beam deflection at a distance of 18.55 cm from its entry into the field? On the graph, we read $BR = 2.26 \times 10^{-4}$ webers/m, so that R is 9.04 meters. The deflection at 18.55 cm is, from Eq. (6),

$$y = \frac{0.10}{9.04}(.1355)\text{ m} \equiv 1.50\text{ mm} \equiv 0.059\text{ inch}$$

The above results, as well as those of the first example, are presented in Table 1, where the last row gives the data for the following case: the electron velocity is equivalent to 20,000 volts, the magnetic induction of 25 μwebers/m² extends for 18 cm, and we want to determine the deflection at the point of emergence from the field, i.e., $x = x_M$.

Shielding

The voltages and the x_M distances listed in Table 1 are typical of values for several modern high-resolution CRT's which have a spot size of about one-thousandth of an inch. The x-distances apply to the same tube structure, being based on the modification of the physical distance introduced by subsequent higher potentials. Thus, if only the first centimeter of tube length is exposed to a magnetic field, the electron y-component of velocity remains constant while the x-component changes as it passes through each subsequent electrostatic lens. The path, therefore, is not a straight line, but there is an equivalent straight line segment as far as the y-deflection is concerned. Each constant-potential space between lenses contributes a modified distance, based on the transit time; consequently, for the n-th space, where the transit time is

$$t_n = \frac{x_{Mn}}{v_n} \qquad (7)$$

v_n being the electron velocity, the modified distance is :

$$x'_{Mn} = v_1 t_n = x_{Mn}\frac{v_1}{v_n} = x_{Mn}\sqrt{\frac{V_1}{V_n}} \qquad (8)$$

In our example, then the value of x for the first row of the table is

$$x\text{ (cm)} = 1\text{ (first space)} + 10\sqrt{\frac{600}{4500}}\text{ (second space)}$$

$$+ 18\sqrt{\frac{600}{20{,}000}}\text{ (third space)} = 7.78\text{ cm}$$

For the second row, its value is obtained from

$$x\text{ (cm)} = 10\text{ (second space)}$$

$$+ 18\sqrt{\frac{4500}{20{,}000}}\text{ (third space)} = 18.55\text{ cm}$$

Because of the limiting apertures in high-resolution tubes, the axial electrons described in the first row of the table actually would not reach the screen. In other words, the extraneous field focuses a different part of the initial cathode beam through the gun structure. Since a change of anode current can result however, this effect also is undesirable. In any event, some of the deflection introduced in the focusing anode, and all of the anode deflection, can be observed.

The amount of shielding which is required depends

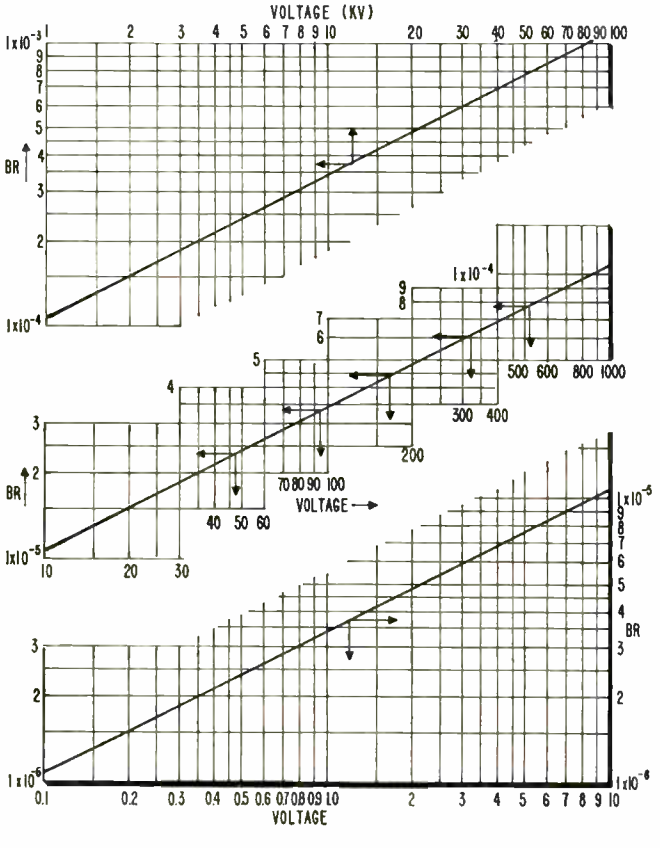
upon the acceptable deflection. If we require that the total shift be less than a spot size for our example of reversed flight course, then the stationary spot should not be deflected more than 0.0005 inch by the extraneous magnetic field. When the shielding is uniform in its efficiency, it reduces the extraneous flux equally throughout the length of the tube, so that the contribution of each section after shielding is proportional to its original value. For this case, the shielding may be expressed in terms of total deflections, as this is equal to the ratio of the initial to the residual magnetic induction:

$$\text{Shielding} = 10 \log \frac{101}{0.5} = 23.1 \text{ db} \qquad (9)$$

In general, the tube installation is not vertical, so that conservative shield design must be based on the total magnetic field, which has a flux density as high as 70 μwebers/m² near the magnetic poles. This calls for an additional 4.5 db of shielding, for a total of 27.6 db.

This shielding objective applies for a specific tube geometry and operating conditions, as well as a specified value of permissible deflection by the residual magnetic field. Any change in these quantities gives rise to a different shielding requirement. It should be mentioned that good uniform shielding often necessitates including at least part of the light-tight enclosure between CRT and camera in the design.

Fig. 2: BR in webers/meter for an electron with velocity equivalent to a constant voltage which enters a uniform crossed magnetic field.



Uniform Crossed Fields

In applying table 1 to a CRT, we have assumed that the equipotential surfaces within the tube are concentrated in the short spaces between electrodes, these spaces comprising the electro-static lenses. As a consequence, the electron travels in a straight line at a constant velocity when between lenses. This assumption is fairly valid for some lenses, but does not apply to short ones of large diameter when the potential difference on either side is large.

Rather than describe a general analysis, we shall consider only the next stage of complexity—an electron starting from rest and accelerated by a uniform electric field, which is at right angles to a uniform magnetic field. The electron trajectory under these conditions is a cycloid. Our interest, however, is centered on the initial portion of the path, which resembles that of Fig. 3, and of the tangent line followed upon emerging from these fields. The expression for this line is derived as Eq. (A-15) in the Appendix, with a good approximation being given by Eq. (A-22) as

$$y = A\, x_M^{1/2} \left(x - \frac{x_M}{3} \right) \qquad (10)$$

$$A = 0.29655 \times 10^6 \frac{B}{\left(\frac{dV}{dy} \right)^{1/2}}$$

For example, the field is 600 volts/cm, B is 25 μweber/m², while x_M is 1 cm, and x is 7.78 cm. These figures are related to the first example for the constant-velocity electron. Then

$$A = 0.29655 \times 10^6 \frac{25 \times 10^{-6}}{\sqrt{60{,}000}} = 0.0302$$

and

$$y = 0.0302 \sqrt{0.01}\ (0.0745) \text{ m} = 0.225 \text{ mm}$$

which is only five microns more than for an electron traveling with a constant velocity equivalent to 600 volts.

Alternating Fields

Because of transformers, motors, etc., alternating magnetic fields at the power frequency often are pres-

Table 1

Assembled data for a high resolution crt.

	Voltage	RB (webers/m)	R¹ (meters)	x_M (cm)	x (cm)	Deflection at screen² (mm)	Deflection at screen² inches
Grid No. 2	600	8.25×10^{-5}	3.30	1	7.78	0.220	0.009
Focusing anode	4500	2.26×10^{-4}	9.04	10	18.55	1.50	0.059
Anode	20000	4.82×10^{-4}	19.3	18	18	0.840	0.033

Table 2

Deflection before and after shielding, in thousandths of an inch.

Deflection at screen	Deflection after shielding
9	0.043
59	0.293
33	0.163

ent in the neighborhood of a CRT. Since these fields are essentially constant during the transit time of an electron, the ac shielding requirements must be based on the peak magnitude. The analysis of course, is similar to that carried out for the constant magnetic field. When the total deflection is specified, it is necessary to improve the dc shielding so that the additional deflection of the residual ac fields leaves the spot within tolerances.

APPENDIX

Simple Electron Trajectories

The path followed by an electron in crossed electric and magnetic fields is treated in many elementary references. Our interest lies in obtaining good approximations when the electron traverses such a field, and then enters a field-free region.

Circular Path

In Fig. 3 the coordinate origin is placed at the point of entry of the electron into the uniform magnetic field. The circular portion has the equation

$$x^2 + (y - R)^2 = R^2 \tag{A-1}$$

where, R is the radius expressed by Eq. 1. If the field terminates at $x = x_M$, than the electron continues on the tangent path, where the slope is obtained from

$$x\,dx + (y - R)\,dy = 0$$

or

$$\frac{dy}{dx} = \frac{x}{R - y} \tag{A-2}$$

Consequently, the path followed by the electron after leaving the field is along the line

$$y = \frac{x_M}{R - y_M}\,x + y_M - \frac{x^2_M}{R - y_M} = \frac{x_M}{R - y_M}\,x - \frac{R\,y_M}{R - y_M} \tag{A-3}$$

where use has been made of Eq. (A-1) in the substitution

$$x^2_M + y^2_M - y_M R = y_M R$$

The expression for y_M in terms of x_M is obtained directly from Eq. (A-1) as

$$y_M = R - \sqrt{R^2 - x^2_M} \equiv R - R\sqrt{1 - \frac{x^2_M}{R}} \tag{A-4}$$

For the values of radius and length, or x_M, in the rows of Table 1, it is evident that $R \gg x_M$, so that a good approximation is furnished by

$$y_M \doteq R - R\left(1 - \frac{x^2_M}{2\,R^2}\right) \equiv \frac{x^2_M}{2\,R},\ x_M << R \tag{A-5}$$

Since the values of y_M are much less than those of the corresponding radii in that table, suitable approximations for the derivative and the path are

$$\left(\frac{dy}{dx}\right)_{x\,=\,x_M} \doteq \frac{x_M}{R} \tag{A-6}$$

and

$$y \doteq \frac{x_M}{R}\,x - y_M = \frac{x_M}{R}\left(x - \frac{x_M}{2}\right) \tag{A-7}$$

Cycloidal Path

The equation of the cycloidal path followed by an electron initially at rest when placed in constant crossed electric and magnetic fields is[3]

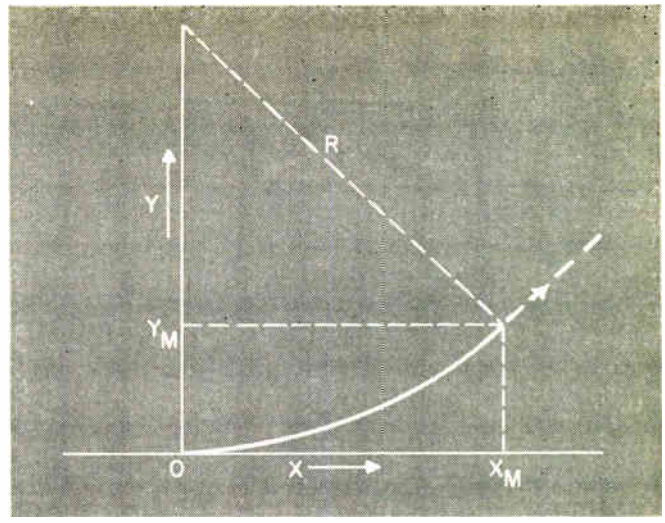


Fig. 3: Geometry of the electron motion for a uniform magnetic field directed out of the page and extending between the y-axis and the line $x = x_M$. The electron enters the field along the negative x-axis.

$$x = \alpha\,(1 - \cos\theta) \tag{A-8}$$

$$= \alpha\,(\theta - \sin\theta) \tag{A-9}$$

where

$$\alpha \equiv \frac{m}{e}\,\frac{\left(\frac{d\,V}{d\,x}\right)}{B^2} \tag{A-10}$$

Then at the farther edge of the magnetic field

$$\theta_M = \cos^{-1}\left(1 - \frac{x_M}{\alpha}\right) \tag{A-11}$$

$$y_M = \alpha\,(\theta_M - \sin\theta_M) \tag{A-12}$$

and the tangent is obtained from

$$\frac{d\,y}{d\,x} = \frac{\frac{d\,y}{d\,\theta}}{\frac{d\,x}{d\,\theta}} = \frac{1 - \cos\theta}{\sin\theta} \equiv \tan\frac{\theta}{2} \tag{A-13}$$

whence

$$\left(\frac{d\,y}{d\,x}\right)_{x_M} = \tan\frac{\theta_M}{2} \tag{A-14}$$

The exact equation of the path after leaving the region of crossed fields is, therefore,

$$y = \left(\tan\frac{\theta_M}{2}\right)(x - x_M) + y_M \tag{A-15}$$

When θ_M is small, the equations can be approximated as follows:

$$x \doteq \alpha\,\theta^2/2 \tag{A-16}$$

$$y \doteq \alpha\,\theta^3/6 \tag{A-17}$$

so that

$$\theta_M \doteq \sqrt{\frac{2}{\alpha}\,x_M} \tag{A-18}$$

and

$$y_M \doteq \frac{\alpha\,\theta^3_M}{6} = \frac{2\,x^{3/2}_M}{3\sqrt{2\alpha}} \tag{A-19}$$

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The Editor
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Magnetic Shielding (Concluded)

$$\left(\frac{dy}{dx}\right)_{x_M} \doteq \frac{\theta_M}{2} = \sqrt{\frac{x_M}{2\alpha}} \qquad \text{(A-20)}$$

Finally, the approximation for the path after emerging from the magnetic field is

$$y = \sqrt{\frac{x_M}{2\alpha}}\,(x - x_M) + y_M = \sqrt{\frac{x_M}{2\alpha}}\left(x - \frac{x_M}{3}\right) \qquad \text{(A-21)}$$

or

$$y = A\,x_M^{1/2}\left(x - \frac{x_M}{3}\right) \qquad \text{(A-22)}$$

where

$$A \equiv \frac{1}{\sqrt{2\alpha}} \equiv \sqrt{\frac{e}{2m}}\,\frac{B}{\left(\frac{dV}{dx}\right)^{1/2}}$$

$$= 0.29655 \times 10^6\,\frac{B}{\left(\frac{dV}{dx}\right)^{1/2}} \qquad \text{(A-23)}$$

References

1. K. R. Spangenberg, *Vacuum Tubes*, McGraw-Hill, 1948; see Eq. (6.62), p. 112.

* All equations are in MKSQ units. In the examples, therefore, distances are converted to meters before substitution.

2. Fig. 2 is derived from L. Marton, C. Marton, and W. G. Hall, "Electron Physics Tables," National Bureau of Standards Circular 571, 30 Mar. 1956.

3. K. R. Spangenberg, *Vacuum Tubes*, McGraw-Hill, 1948; Eqs. 6.85 and 6.86 on p. 118, with x and y expressions interchanged to agree with our coordinate system. The following substitutions have been made as well: $\theta = \omega t$ and $\alpha = a/\omega^2$.

** See Eqs. (A-3) and (A-4) in Appendix.

‡ In the last expression for Eq. (8), the ratio of velocities is replaced by the square root of the ratio of the voltages. A small error is introduced at higher potentials, about 40 kilovolts, because this substitution does not include a relativistic correction. At very high potentials, it is preferable to evaluate the velocities with this correction, as these are tabulated in L. Marton, et al, loc cit.

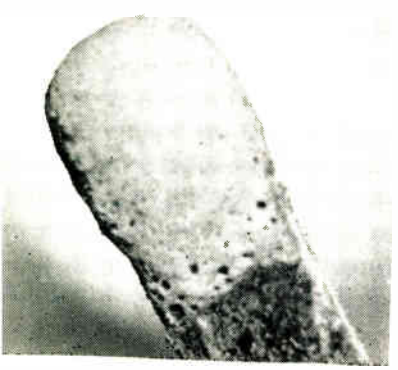
This article will appear in Dr. Levin's book, *Radargrammetry*, which is to be published by McGraw-Hill early this year. Portions were prepared for Northrup Aircraft, Inc., under a contract with the Engineer Research and Development Laboratories, Ft. Belvoir, Va.

[1] The magnetic flux density is 25 μwebers/m².

[2] Deflection at the screen assumes perfect shielding of the other two sections of the tube.

Fig. 1: New diode packages are compared with a conventional package.

Fig. 2: Size comparison of "rivet" and "micro-wedge" types.



Improved Tunnel Diodes

AN improved tunnel diode has been reported by the International Business Machines Corp., 590 Madison Ave., N. Y. 22, N. Y. The developmental diode, which switches at speeds faster than 4/10ths of a billionth of a sec, promises far greater speed and reliability for tunnel diode circuits.

Basic computer circuits, binary triggers, can now operate at speeds 5 to 10 times faster. In addition, the new diode will require much less power.

A second new tunnel diode, somewhat earlier in the experimental stages than the first, has also been reported. This diode has high speed and other characteristics promising for use in computer storage circuits.

Key to the design of the two devices is a new fabrication method which involves an electronically monitored and controlled etching technique. This automatic process takes place after a pellet of germanium has undergone its basic device packaging and assures uniform electrical characteristics in every unit. In the process the germanium is etched away until an almost microscopic pyramid remains.

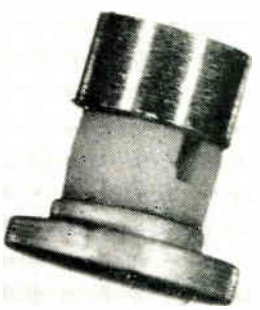
The first development is a germanium tunnel diode designed and built to operate at low peak currents while still maintaining equivalent speeds.

These high-speed, low-current tunnel diodes consume less power. They have been operated as binary triggers at repetition rates as high as 300 MC. This is believed to be the highest speed binary trigger ever constructed. In addition, they have a resistance cut-off frequency of 23 nanocycles and a voltage rise time of 0.4 nsec.

They were produced by alloying spheres of combined indium and gallium into germanium heavily doped with arsenic, then etching the junction down to a dia of 0.4 mil. This action produces the low peak current of 5 ma, which is re-

(*Continued on page* 142)

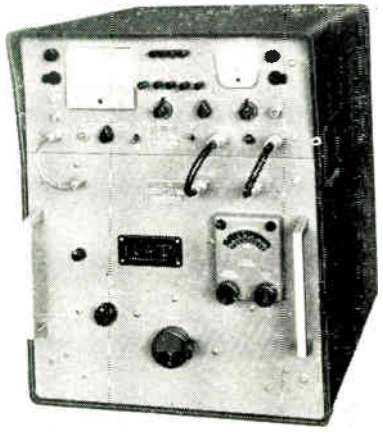
Fig. 3: Etching of new diode is done through the "window."



New Products . . . for the Electronic Industries

FIELD INTENSITY METER

Model FIM Microwave Calibrated Field Intensity Meter and Receiver includes a self-contained power supply and a direct-indicating peak VTVM for ease of frequency location of impulse noise. All input signals can be at-

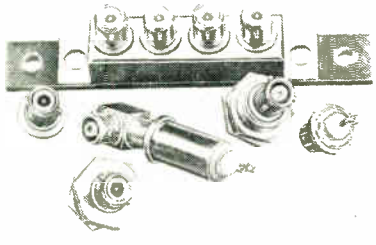


tenuated up to 80 db in 1 db steps. It operates between 1,000 and 10,000 MC. It is a combination highly sensitive triple conversion microwave superheterodyne receiver and calibrated signal generator. It indicates the absolute power level of a radiated or conducted input signal by comparing it against a signal generated internally by the signal calibrator. The signal indication is in μv, db above 1 uv and db above 1 μv/MC. Provision is made to accept additional tuning units extending the range to 20,000 mc. Polarad Electronics Corp., 43-20 34th St., Long Island City 1, N. Y.

Circle 203 on Inquiry Card

ISOLATED GROUND SYSTEM

Isolated Ground DM series coaxial cable connector gives absolute protection from circulating currents and ground loops that cause oscillation and faulty readings of current and voltage. A concentric 3-element, glass-to-metal seal provides hermetically sealed isolated ground without shoul-

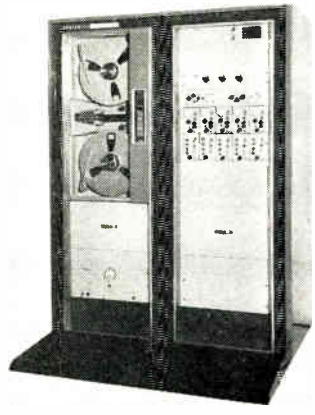


der washers and other insulating or mounting devices. Any system currently utilizing the Dage DM Series may be modified to an isolated ground system. Dage Electric Co., Inc., 67 N. 2nd St., Beech Grove, Ind.

Circle 204 on Inquiry Card

SOLID-STATE TAPE SYSTEM

All-solid-state magnetic tape system with increased FM capabilities, the LAR 7500 (Laboratory Analog Recorder), can accommodate up to 14 channels of FM record and playback in one rack; 6 tape speeds can

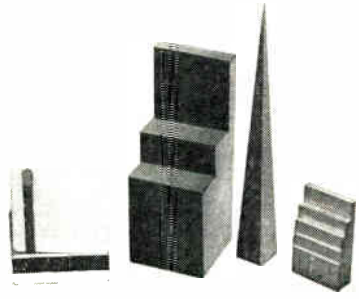


be selected from the front panel and tapes as thin as 0.65 mil base can be handled. Two models available. One uses a tape width of ½, ¾ or 1 in.; the other, widths of 1, 1¼, 1¾ or 2 in. The system accepts analog from dc to 10 KC for as much as 1 hr. continuous recording. Frequency response has been doubled. Accidental tape erasure is prevented by requiring 2 buttons to be pushed simultaneously. Safeguards eliminate tape breakage. Industrial Systems Div., Minneapolis-Honeywell Regulator Co., 10721 Hanna St., Beltsville, Md.

Circle 205 on Inquiry Card

MICROWAVE ABSORBER

New microwave absorber can operate at temp. to 800°C with no detectible change in electrical or physical characteristics. The new permeable dielectric, CMA 701, has a dielectric constant of 50 at 20 MC, and an attenuation of more than 38 db/cm at 8.2 KMC, and of more than 26



db/cm at 10 KMC. It has a density of 4.05. The material can be machined or molded into shapes suitable for waveguide termination. Custom Components, Inc., Caldwell, New Jersey.

Circle 206 on Inquiry Card

PRESSURE TRANSMITTER

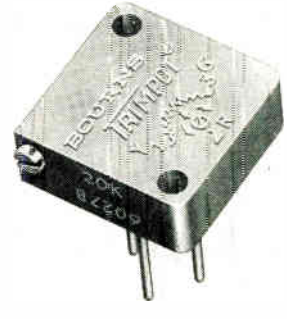
Explosion proof low pressure transmitter features zero and range adjustments accomplished under all operating conditions. Adjustments are external to the case and can be made without breaking seal. Meets NEMA

Class 1 Group D, and Class 2 Group G. In the upright position, unit is also weatherproof. It is made in 6 models with standard ranges from 0-1½ to 0-60 psi differential, gauge or absolute. Resolution is infinite and measurement accuracies to ± 0.15% of range available. A variety of transistor demodulators and power supplies can be mounted within the explosion proof housing to provide voltage, millivolt or other high level ac or dc output signals with a standard 115 v., 60 cycle input. Control Components Div., International Resistance Co., 401 N. Broad St., Phila., Pa.

Circle 207 on Inquiry Card

POTENTIOMETER

Addition of printed circuit pin model to line of square potentiometers, Model 3250P, offers humidity-proof construction, high temp. range, high reliability and sub-miniature size. It measures ½ x ½ x 3/16 in. Some specs: Resistance range, 100 to 50K ohms; power rating, 1 w @ 70°C;



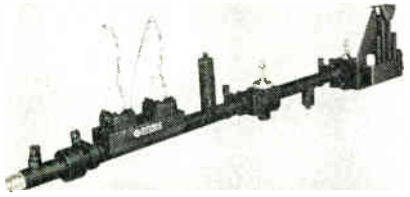
temp range, −65°C to + 175°C; weight, approx. 0.05 oz. The 25-turn adjustment can easily be accomplished with a standard screwdriver. Bourns, Inc., 6135 Magnolia Ave., Riverside, Calif.

Circle 208 on Inquiry Card

New Products . . . for the Electronic Industries

COAXIAL LINE MONOPLEXERS

New microwave components for radar systems using separate transmitting and receiving antennas. Typical monoplexer shown protects the receiver, both from the transmitted signal and from other signals acci-

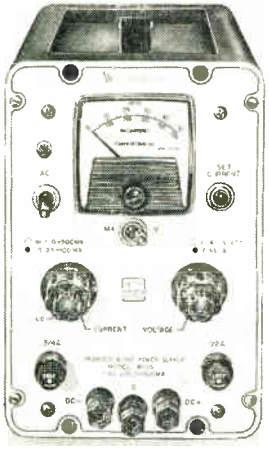


dentally directed at the receiving antenna. Terminated directional couplers are provided for power monitoring purposes, along with 2 receiver protector tubes, and an output band pass filter. Illustrated unit, for ⅞ in. coaxial line, is rated as follows: freq., 406-450 MC; transmitter power peak, 30 kw; transmitter power ave., 50 w. Bomac Laboratories, Inc., Salem Rd., Beverly, Mass.

Circle 209 on Inquiry Card

POWER SUPPLY

Model 4005 transistorized power supply delivers constant voltage or constant current from the same output terminals. It may be operated as a constant voltage source, a constant current source, a constant voltage source with automatic current limiting or a constant current source with automatic voltage limiting. Dual regulator system permits continuous control of voltage or current with preadjustable, transient-free electronic cross-over to either mode of operation. Range is 1-40 vdc at 0-500 ma.



Regulation is better than 0.05%. Ripple content is less than 500μv as a voltage regulator and less than 25 μa as a current regulator. Power Designs Inc., 1700 Shanes Drive, Westbury, L. I., N. Y.

Circle 210 on Inquiry Card

MAGNETIC SHIELDS

New line of Netic Co-Netic shielded enclosures permit temporary or permanent shielding of separately manufactured sub-assemblies designed to be integrated into a total package. Slip-over covers with lead holes and access

plates can be supplied for high-gain transistor amplifiers, miniaturized servo mechanisms, memory cores and other data storage devices, etc. Since the Netic Co-Netic alloys are non-shock sensitive and non-retentive, it is possible to drill additional lead holes in the field without sacrificing shielding effectiveness. Magnetic Shield Div., Perfection Mica Co., 1322 N. Elston Ave., Chicago 22, Ill.

Circle 211 on Inquiry Card

RECORDING SYSTEM

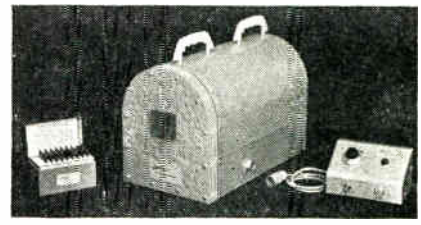
New 8-channel, retilinear writing oscillograph, Model RD 2684 20's, rack mounted and has a 15 in. wide vertical panel. Two channels of high speed coded, event or time data in addition to the 8 40 mm channels of analog data are displayed on a 15-in. chart. Thermal writing recorder has 13 chart speeds ranging from 0.01 mm/sec. to 100 mm/sec. which can be selected instantly and positively. Analog response is essentially flat from dc to 100 CPS. Dc sensitivity is 1.0 ma/chart line and 1.4 v/ 1 mm

chart line. Max. amplitude of the styli is 40 lines up to 30 CPS, 20 lines up to 60 CPS, and 10 lines up to 100 CPS. Brush Instruments Div., Clevlite Corp., 37th & Perkins, Cleveland 14, Ohio.

Circle 212 on Inquiry Card

THERMAL RADIATION STANDARD

Thermal Radiation Standard, Model 55A, is a standard reference source of infrared and visible radiation. The temp. of this precision black body radiator is continuously adjustable



from ambient to 1000° C (1273° K) and is controlled to ± 1° C everywhere within that range. An effective total emmissivity greater than 0.995 is accomplished by using a biconical cavity, the walls of which have a uniformly high natural emissivity. The cavity aperture is 1⅛ in. in diameter. Electronic Communications, Inc., Research Div., 1830 York Rd., Timonium, Md.

Circle 213 on Inquiry Card

CONSTANT CURRENT SUPPLY

Wide range transistorized unit provides constant current regardless of voltage drop across load. Model 151B, covers 0.05 to 500 ma in 4 ranges, regulated to 0.25% for 0-20 v. load and 0.25% for 105-125 v line. Ripple and noise never exceeds 50 μa for peak output and is as low as 1.5 μa on lower ranges. Open circuit voltages may be set to desired max. values and checked on meter, preventing overload damage to externally connected equipment. Provision is made for ac modulation of the dc output current

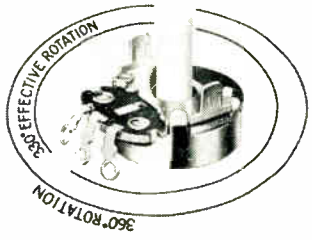
by an external modulating source. It is useful in semiconductor testing, diodeaging and life test, beta tests, potentiometer and current sensitive relay testing, etc. Quan-Tech Labs., 60 Parsippany Blvd., Boonton, N. J.

Circle 214 on Inquiry Card

New Products . . . for the Electronic Industries

VARIABLE RESISTOR

A new 360° continuous rotation composition variable resistor increases effective rotation from approx. 270° to 330°. After each effective rotation, the contact arm returns from max. to min. resistance

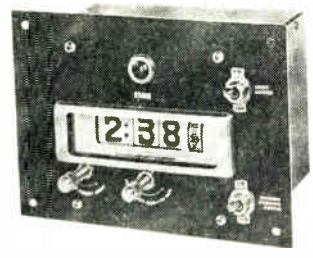


without opening the circuit. Series CR45 has a 15/16 in. dia. and the same 29/64 in. depth as the standard CTS Series 45. Resistance range is 250 ohms thru 10 megohms with linear resistance gradient. Rating is ¼ to ½ w depending on resistance value. Max. operating voltage from terminals to bushing is 750 vdc with a high pot test of 1000 vac for 1 min. CTS Corp., Elkhart, Ind.

Circle 215 on Inquiry Card

DIGITAL CLOCK

Direct reading, full vision, in line digital clock features digits that can be reset individually by independent front panel reset controls, large ⅝ in. digits on the 12 hour clock and 5/16 in. digits on the 24 hour clock,

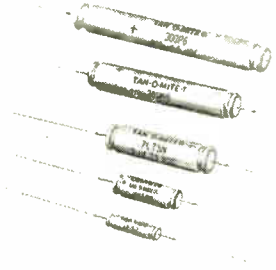


calibrated rotating visual 1 RPM seconds wheel. Clock movement shock resistant to withstand shock of 2000 pounds/inch, clock movement fully enclosed in anodized dustproof aluminum case, size: height 4½ in., width 6 in., depth 3¼ in., weight 3½ lbs. Available in 50 or 60 cycle, in all voltages. Pennwood Numechron Co., 7249 Frankstown Ave., Pittsburgh 8, Pa.

Circle 217 on Inquiry Card

TANTALUM FOIL CAPACITORS

Two new larger case sizes added to line of tantalum foil electrolytic capacitors complete the series of 5 sizes called for by MIL-C-3965B for Styles CL24, CL25, CL34, CL35. The 5 case sizes are stocked in 113 different

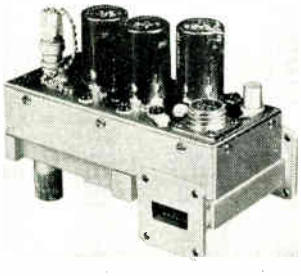


values in plain foil capacitors and 82 values in etched foil capacitors. Stock includes specific values called for by MIL-C-3965B and polar and nonpolar types. Over-all capacitance range for the plain foil type is 0.25 to 400 mfds; for the etched foil variety, 0.5 to 580 mfds. Voltages range to 150 vdc depending upon capacitance. Ohmite Mfg. Co., 3698 Howard St., Skokie, Ill.

Circle 219 on Inquiry Card

MIXER-PREAMPLIFIER

A new 9.6 to 10.7 KMC combination mixer-preamplifier for microwave and guidance systems eliminates problem of variable parameters resulting when separate mixers and preamplifiers are combined. Model 90MB-361F1 serves as a low-noise, wide-band downconverter for maser and parametric r-f amplifiers, Noise figure is less than 9.5 db with min. gain of 25 db. It is fix-tuned with a stabilizing circuit that eliminates need for realignment

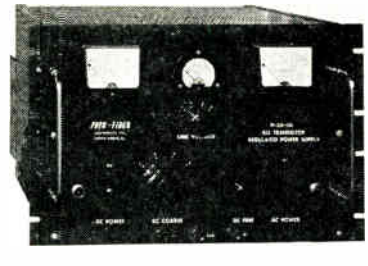


after replacement of tubes or crystal. Output is matched to 50 ohms, allowing the main amplifier to be remotely located. Microwave Development Laboratories, Inc., 92 Broad St., Babson Park 57, Wellesley, Mass.

Circle 216 on Inquiry Card

POWER SUPPLY

The P-30-36, 30 a, 0-36 v. regulated power supply uses silicon rectifiers and an all-transistorized regulator. Panel mounted controls include: 4 range output voltage switch, vernier voltage control, circuit breaker for overload protection and power switch, and pilot light. Voltmeter and ammeter are mounted on the front panel. Features: Transistorized regulator; silicon rectifiers; 0.5% regulation; less than 25 mv ripple; regu-

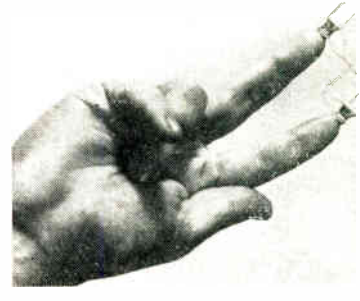


lated against both line and load variations; continuous duty; 50 to 400 CPS; circuit breaker protection. Output current is 0-30 adc. Foto-Video Electronics, Inc., 36 Commerce Rd., Cedar Grove, N. J.

Circle 218 on Inquiry Card

TRIMMERS

Variable trimmer piston capacitors for ungrounded circuit applications, the new "F" mount series, consists of the 44 JFD miniature panel mount trimmers. It is built by soldering the metal lug to the flange of the bushing prior to assembly, and then screwing on and cementing the nylon bushing to the metal base of the trimmer. This renders the trimmers highly resistant to shock and vibration. Capacitance to ground as low



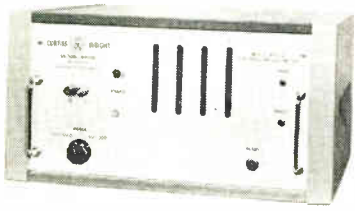
as 0.50 pf are achieved. Where lower capacitance is required, the "FL" mount type using a longer nylon bushing can be specified. Meet MIL-C-14409A. JFD Electronics Corp., 6101 16th Ave., Brooklyn 4, N. Y.

Circle 220 on Inquiry Card

New Products . . . for the Electronic Industries

PEAK READING VOLTMETER

Single Transient Peak Reading Voltmeter for engineering, pulse measurement, production and servicing applications. The PRV-2 accepts and displays the peak values of any positive transient voltage pulse of



arbitrary shape within specified limits. By using an input sensing circuit, the equipment will detect a peak voltage and initiate readout while blocking further input signals until the instrument is reset. Readout is provided as a 4 digit, decimal value, directly in volts with an accuracy of 1%. Inter-Mountain Instruments Branch, Curtiss-Wright Corp., Electronics Div., P. O. Box 8324, Albuquerque, N. M.

Circle 221 on Inquiry Card

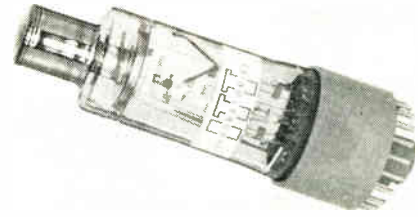
SPECIAL PURPOSE RECEIVER

Special Purpose Receiver, Type 2501-A, for AM and CW reception has a tuning range of 55 to 260 MC. It is for measuring Doppler shifts of incoming signals and features a low noise figure with uniform performance throughout the range. Receiver compares the received input signal with a standard reference signal of known characteristics, the amplitude of which is offset by an amount slightly greater than the max. Doppler shift expected. Output is the difference between the incoming signals. Operating power requirements: 117 v., 60 CPS, ac, 70 w. Nems-Clarke Co., Div. of Vitro Corp. of America, 919 Jesup-Blair Dr., Silver Spring, Md.

Circle 223 on Inquiry Card

MULTIPLIER PHOTOTUBE

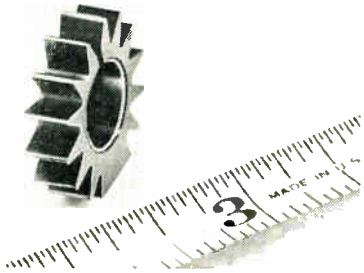
Improved photomultiplier suitable for electronic star tracking. Because of its image section design, the FW-118 uses simple magnetic deflection of the electron beam across a special internal aperture, the output of which is greatly amplified signal of the light received from stars providing error signals to operate matching servo drives. The equivalent noise input measured at 25° C is 5 x 10^{-11} lumen. Value may be reduced further if cathode is operated at lower temp. It is normally supplied with an S-1 cathode peaked at 8000 A. S-11 and S-20 surfaces also available. Component Sales, ITT Laboratories, 3700 E. Pontiac St., Ft. Wayne, Ind.



Circle 225 on Inquiry Card

TRANSISTOR RADIATOR

Radiator reduces heat and permits up to 25% more efficient operation of transistors having TO-8 packages. Model 3AL-705 is for horizontal or vertical mounting on printed circuit boards or metal chassis. When mounted vertically, unit also serves as a retainer for the transistor. Vertical mounting is with a 6-32 tapped hole in the radiator base. Overall dimensions are 1 in. max. dia. x 0.312 in. thick. Inside dia. is 0.480 in. with a counterbore for the transistor base

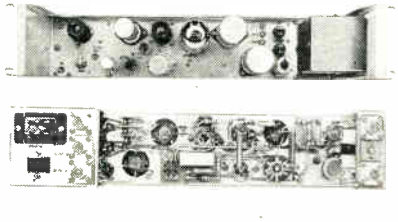


0.078 in. deep and 0.609 min. to 0.619 max. in dia. Material is aluminum; finish is black anodize per MIL-A-8625. The Birtcher Corp., Industrial Div., 745 S. Monterey Pass Rd., Monterey Park, Calif.

Circle 222 on Inquiry Card

AMPLIFIERS

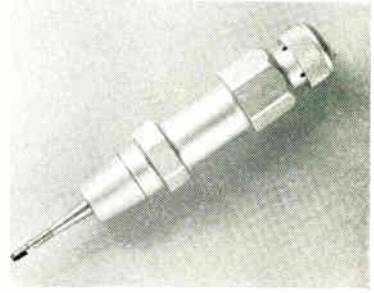
Line of plug-in and rack-mounted video distribution amplifiers. Featured is Type VA-R-201. It provides 3 well-isolated 75 ohm outputs and requires 125 ma. from a + 285 v. regulated source. By changing 2 resistors, nom. gain can be set at unity, +3 db or +6 db. It can handle composite black-and-white or color video signals at a nom. output level of 1 v., and distribute color sub-carrier at 2 v. peak-to-peak output. Nom. input level is 1 v., output regulation is ± 0.1 db @ 3.6 MC, 50 db isolation @ 15 KC. Bandwidth is a flat ± 2% to at least 8 MC. 60 CPS sq. wv. tilt is 2% max. Differential gain at 1 v. out is 0.35° max. Approx. B+ drain is 125 ma. The Daven Co., Livingston, N. J.



Circle 224 on Inquiry Card

INSERTION TOOL

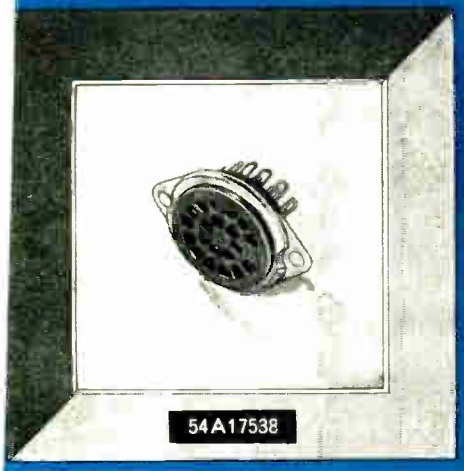
Tool for inserting both formed and solid taper pins into shielded patchcord programming systems and panels. A single push to insert, and a single pull on the pull test handle will seat and inspect the taper pin. Insertion spring is calibrated at 18-20 lbs. When this pressure is reached, the spring will "give" and a dished washer will be actuated, which will make a very positive audible click. The pin is then seated. The pull test device on the tool, which may be used as a standard tool for patchcord programming systems, is calibrated at 6¼ lbs. Poundage is achieved as soon as the pull test handle starts to be displaced from its normal position. AMP Incorporated, Harrisburg, Pa.



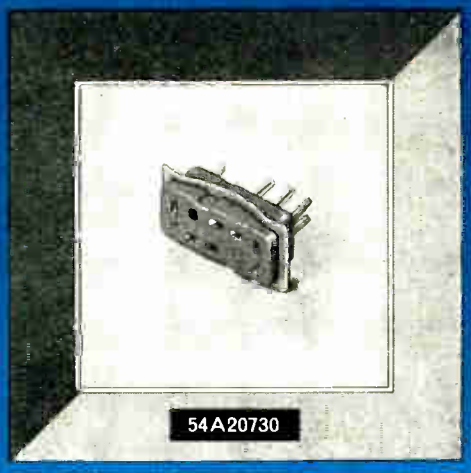
Circle 226 on Inquiry Card

CINCH...your reliable source for quality
PLUG-IN RELAY SOCKETS

Plug-in relays are increasingly the first choice for industrial control sequence, memory and operational circuitry applications. Now Cinch offers rugged, quality mounts for all of the following plug-in relays—



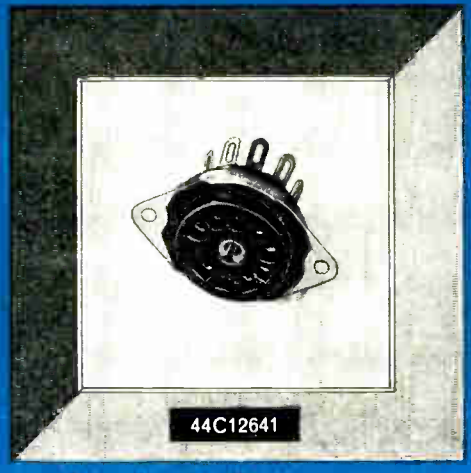
Outer pin circle .656" Dia.
Inner pin circle .312" Dia.
Inner circle contacts arranged for relays with 14 to 20 contacts.



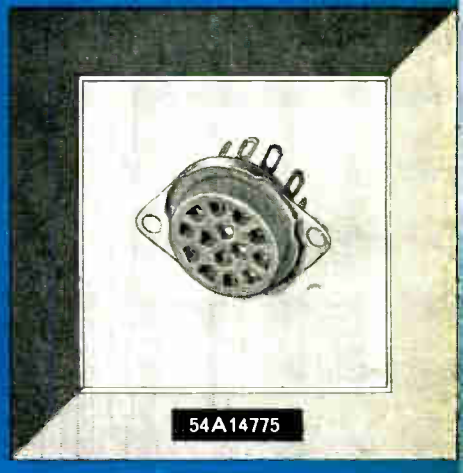
AEMCO 95-3274
Brubaker K110A
Advance MV-2C
Filiors P 26, A1, P 5A
C. E. G200A & G203A
Potter & Brumfield SL
Ace Relay

Potter & Brumfield PW—SM

Advance GH 2C
Sigma 42.72.23
Potter & Brumfield
KRP11, KCP11
Amperite 6N02 Series



Amperite 6N62T Series



Allied Control SKHG
Automatic Electric AE2300-B

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Centrally located plants at Chicago, Illinois; Shelbyville, Indiana; City of Industry, California; and St. Louis, Missouri

Circle 156 on Inquiry Card

New Tech Data for Engineers

Semiconductor Catalog

A 24-page catalog from International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif., covers over 800 semiconductor devices, including ratings, characteristics and descriptive data on silicon glass diodes, silicon small power, medium power and high power rectifier cells, high voltage cartridge rectifiers, zener diodes and reference elements, silicon controlled rectifiers, silicon and selenium rectifier stacks, silicon solar cells and selenium contact protectors. Also a listing of JEDEC rectifier types, with cross reference to device classification, rating and page number.

Circle 160 on Inquiry Card

Magnetic Alloys

New 16-page Blue Sheet entitled "Allegheny Ludlum Moly Permalloy" (2 colors) gives background on this special alloy for use in the electronic industry. Included is information on testing data, hysteresis loops, special heat treating data, magnetization curves, core loss graphs, typical, physical, mechanical and magnetic properties and other data. Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, Pa.

Circle 161 on Inquiry Card

Microwave Instrumentation

Short form catalog (8-pages, 2-colors) is entitled "Microwave Instrumentation." It describes company's line of TWT amplifiers, microwave oscillators, power leveling systems, solenoid and electrostatically focused amplifiers, and solenoids for TWT's and BWO's. Menlo Park Engineering, 711 Hamilton Ave., Menlo Park, Calif.

Circle 162 on Inquiry Card

Semiconductor Alloys

The physical properties of gold-germanium, gold-silicon and gold-antimony alloys are described in a series of technical data sheets from Alpha Metals, Inc., 56 Water St., Jersey City 4, N. J. Each data sheet contains a phase diagram of one of the alloys, a description of its phase relationship and crystal structure, alloy properties and fabrication possibilities.

Circle 163 on Inquiry Card

Coaxial Cable

Listing of non-R/G coaxial cable constructions designed to meet unusual requirements. Cables are grouped in 6 temp. ranges from 80°C to 250°C and impedance values from 35 to 190 ohms. Also given are construction details and general applications. Times Wire & Cable Div., The International Silver Co., Wallingford, Conn.

Circle 164 on Inquiry Card

Conversion Factors Chart

A reference table in wall chart form includes common conversions such as inches to centimeters or watts to hp and many conversions that are difficult to locate in reference manuals. Examples: atmospheres to Kgs/sq. cm, cm/sec to mi/hr, ft^3 to liters, microns to meters, quintal to lbs., etc. Precision Equipment Co., 4411 E. Ravenswood Ave., Chicago 40, Ill.

Circle 165 on Inquiry Card

Voltage References

Four-page brochure from Dynage, 75 Laurel St., Hartford, Conn., discusses miniature solid state voltage references. Featured is the Volt-Ref, a solid-state device designed around highly stable zener diodes. Units are designed for operation from −25 to +75°C. An output voltage of 6.2 v is available from 6 types that allow operation from either 28 vdc or 117 vac (400 or 60 CPS). Voltage regulation is ±0.005% (at 20% line voltage variation). Temp. coefficient is ±0.001%/°C from −25 to +75°C. Specs and mechanical outline drawings included.

Circle 166 on Inquiry Card

Thermoelectricity

Complete bibliography on thermoelectricity includes a critical commentary on each of the listed articles, which may serve to indicate to an engineer the articles which would be of genuine interest to him. AMP Inc., Harrisburg, Pa.

Circle 167 on Inquiry Card

Synchronous Motors

Slo-Syn Folder SE-L2604, 8 pages. Contains tech. characteristics, specs, ratings and outline dimensions of new 50, 150 and 250 oz-in. Slo-Syn synchronous motors. Conventional, militarized and explosion-proof types are offered with or without planetary gear speed reduction assemblies. Basic shaft speed is 72 RPM at 60 CPS. Can be used as constant speed ac motors or as dc stepping or incremental positioning devices. Feature instant starting, stopping and reversing. The Superior Electric Co., Dept. SS, Bristol, Conn.

Circle 168 on Inquiry Card

High Vacuum Gauges

A 32-page booklet from Consolidated Vacuum Corp., 1775 Mt. Read Blvd., Rochester 3, N. Y., discusses: absolute manometers; thermal gauges; ionization gauges; combination thermal-ionization gauges; mag-amp controllers, and sensing tubes. Pages 4 and 5 are a Gauges Data Table. Data, graphs, and photographs are included.

Circle 169 on Inquiry Card

Fluorescent Compounds

New 19-page publication lists several hundred compounds exhibiting fluorescent characteristics as a guide to identifying solutions through their fluorescent properties. It also lists activation and fluorescing wavelengths, pH values, and ultimate sensitivities (concentration in micrograms/milliliter producing a useful (10% full-scale) meter deflection at max. sensitivity). Also, a bibliography of approx. 40 fluorometry papers describing a wide range of research projects. American Instrument Co., Inc., 8030 Georgia Ave., Silver Springs, Md.

Circle 170 on Inquiry Card

Encapsulated Chokes

Data sheet on Custom Quality Radio Frequency Chokes gives detailed information on units to conform with MIL-C-15305A, grade and class 8. Chokes available in 3 sizes in inductances from 0.22 μh to 56.0 μh and in wattage ratings of ⅓, ½ and 1 w. (Catalog 22CA.) Also available, a 20-page catalog covering their line of ultra-precise wire-wound resistors. It covers complete line of encapsulated and bobbin type units featuring standard tolerance of ±1% and special tolerances as low as 1/20%. Cinema Engineering, 1100 Chestnut St., Burbank, Calif.

Circle 171 on Inquiry Card

Electronic Ceramics

A 2-page bulletin gives performance characteristics and physical dimensions on various miniature electronic ceramic devices, including memory cores beginning at 0.030 in. in dia.; cup cores to specified inductance; multiaperature devices; recording heads; poly-crystalline yttrium-iron garnets with min. line width and loss tangent; and high "Q" materials for use as inductors, tuning slugs and transformers with frequency ranges from 1 to 50 MC. Lockheed Electronics Co., Avionics & Industrial Products Div., 6201 E. Randolph St., Los Angeles 22, Calif.

Circle 172 on Inquiry Card

Film Resistors

Metallic film resistors are described in specs from Corning Electronic Components, Corning Glass Works, Corning, N. Y. Resistors are C-20 and C-32 for ½ w and 1 w sizes. They are designed to replace carbon composition types and outperform requirements of MIL-R-11C. Temp. coefficient is ±250 ppm/°C, voltage coefficient equaling 0.001% change in resistance/volt, and resistance change of no more than 3% under load life and under moisture resistance testing.

Circle 173 on Inquiry Card

MINIATURIZE with VARGLAS

thin wall

Silicone Rubber Sleeving

Space-saving thin wall construction and precision ID dimensions make Varglas Silicone Rubber Sleevings the best answer for miniaturization. Highly flexible with dielectric strength up to 8,000 volts, Varglas resists deterioration, cracking, crazing, and "cut through" in temperature from minus 70° to plus 400° F. Meets government specification MIL-I-18057A.

A complete range of sizes from .010" to 3" ID, in brilliant, non-fading colors for instant coding identification. Comes in coils, spools or 36" lengths for off-the-shelf delivery. Of course, Varflex engineers are always ready to work with you at any time to develop the special sleevings and tubings you need for your applications. No obligation or charge for this cooperation.

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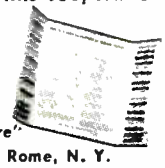

Varflex

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Circle 157 on Inquiry Card

SEND FOR YOUR FREE COPY!

TA's new Manual 210G gives you 94 pages of prints, tables, illustrations, specs and installation tips.

Save money for your company. Conserve your valuable time. Don't design clamps when TA offers you 40,000 of them to choose from at off-the-shelf prices!

This free manual shows all sizes and styles of loop clamps, bonding clamps, multiple clamps, center clamps, wire harness clamps, wave-guide clamps—plus blocks, brackets, busbars, line supports, and related items.

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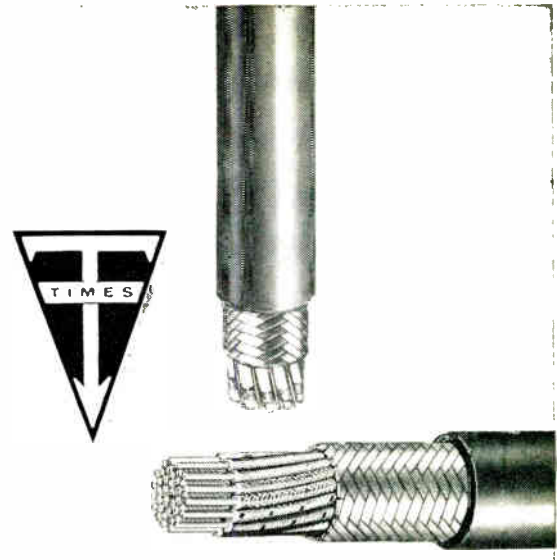
TWX 9863 Glendale, Calif. • WUX CAT Los Angeles, Calif.

Circle 53 on Inquiry Card



High and Medium Temperature MULTI-CONDUCTOR CABLE

For Critical Applications

TIMES' experience in designing and manufacturing R.F. coaxial cable, data transmission cable, and low frequency control cable adds up to multi-conductor versatility to solve *your* problems.

As a "one source" manufacturer of all multi-conductor cable components, TIMES can produce round and ribbon cables utilizing almost infinite combinations of coaxial cable, Teflon®, PVC and polyethylene hook-up wire, and low capacitance cable.

Choose from TIMES *standard* engineered multi-conductor cables, or let our Engineering Service assist you in designing cables and *cable assemblies* to meet your specific requirements. ® DuPont

TIMES WIRE & CABLE DIVISION
The International Silver Company
WALLINGFORD, CONNECTICUT, U.S.A.

Clip This Coupon To Your Calling Card or Letterhead

Please rush FREE literature on.

- ☐ Coaxial Cables
- ☐ Data Transmission Cables
- ☐ Multi-Conductors & Hook up Wire
- ☐ For Info Only ☐ Have Rep. Call

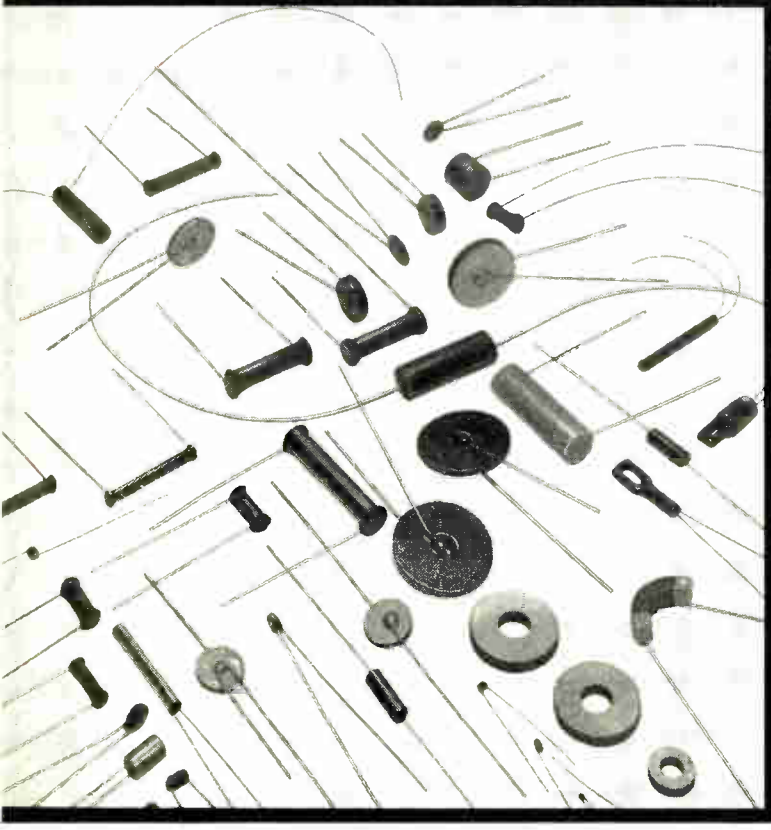
Circle 54 on Inquiry Card

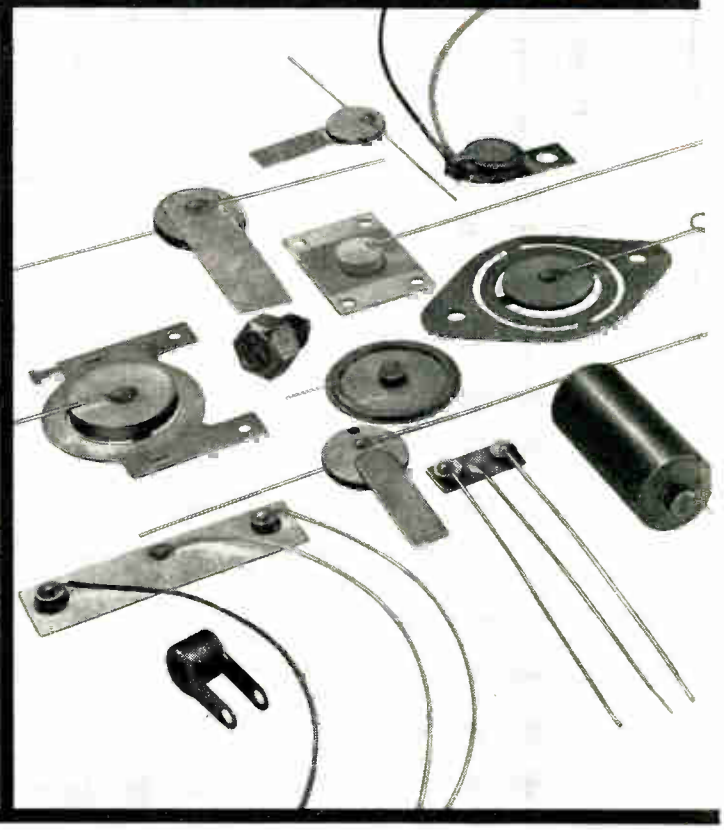
IN THERMISTORS

—the key name is Keystone

...whether you need **10** or **10,000,000** pieces—

STANDARD PARTS ... or SPECIAL ASSEMBLIES





Versatility Plus . . .

A partial list of small discs and rods, all with identical characteristics

Temperature Coefficient (25° C) –3.8% / °C
Beta Value (37.8° C / 104.4°C) 3500° K
Ratio (37.8° C / 104.4°C) 7.3

Resistance 25° C	Keystone Type Number	Diameter (Inches)	Thickness (Inches)
500	L0503-312-73	0.050	0.030
160	L0903-100-73	0.100	0.030
500	L0903-312-73	0.100	0.030
1000	L0909-623-73	0.100	0.100
100	L2003-62-73	0.200	0.030
180	L2006-112-73	0.200	0.060
200	L2006-125-73	0.200	0.060
230	L2006-143-73	0.200	0.060
270	L2008-168-73	0.200	0.080
300	L2008-187-73	0.200	0.080
100	L3006-62-73	0.300	0.060
200	L3008-125-73	0.300	0.080
250	L3008-156-73	0.300	0.080
300	L3018-187-73	0.300	0.180
270	L060637-168-73	Rod, 0.060" square, ⅛" Length.	
5000	L060637-3120-73		
10000	L060437-6234-73		

Special Mounting Requirements

Thermistor applications often dictate special mounting requirements. As a result, Keystone units are supplied with many types of special lead assemblies, mounting tabs, heat dissipating fins. Units are mounted in probes and transistor type cans, attached to plates and metal parts of wide variety.

Keystone has the experience (over almost a quarter of a century), the knowledge and production capability to handle your thermistor requirements in any quantity—of any type and size.

Because of unsurpassed quality control, your tolerance specifications are acceptable to ± 2% on resistance value and Beta value (in fact, we maintain a ± 2% production tolerance on the material constant of *all* Keystone thermistors regardless of resistance tolerance). All parts can be supplied in pairs or sets matched closely in resistance-temperature or voltage drop characteristics.

We can supply discs, washers, rods, beads and special shapes including washer segments, square rods, rectangular wafers, square wafers, etc. Our experienced sales staff and engineering and research and development organizations are available for consultation. Write us or call today.

Circle 55 on Inquiry Card

Keystone
CARBON COMPANY
RESISTOR DIVISION • St. Marys, Pa.
Telephone: Terminal 4-1591

New Tech Data for Engineers

Frequency Comparisons

Four-page pamphlet gives a detailed presentation of high-ratio frequency comparisons using roulette patterns on the crt of Tektronix Types 502, 503, and 536 oscilloscopes. It includes circuitry for displaying roulette patterns, schematic diagrams, and waveforms for various frequency ratios. Tektronix, Inc., P. O. Box 500, Beaverton, Ore.

Circle 174 on Inquiry Card

Wire Striping

"A Design Engineer's Guide to Custom Wire Striping," a 4-page 2-color brochure covers several areas of wire striping and lists the 100 clearest military-approved color combinations, along with the color combinations which should most seriously be avoided. Featured is a chart which breaks down the two most commonly used military specs covering hook-up wire (MIL-W-76A) and (MIL-W-16878C). Chart relates military part number to physical rating. Also, a technical chart relating wire footage and number of pieces/1000 ft. for lengths from ⅛ through 12 in. in 1/16 in. increments. Alpha Wire Corp., 200 Varick St., New York 14, N. Y.

Circle 175 on Inquiry Card

Nuclear Physics Magnets

Facilities brochure and new product descriptions available from Pacific Electric Motor Co., 1009 66th Ave., Oakland 21, Calif. The company manufactures cyclotron coils, deflecting and analyzing magnets, spectrometers, drift tube magnets, quadripole strong focusing magnets, solenoidal focusing magnets, alternating gradient synchroton coils, and air core solenoids. The company specializes in the design and fabrication of magnets and coils used in nuclear physics equipment.

Circle 176 on Inquiry Card

Printed Circuit Board

"Econo-Grid," a stock, paper base epoxy, printed circuit board is discussed in a catalog sheet from Elgin Laboratories, Inc., Waterford, Pa. It included: applications; technical descriptions; stock sizes and prices.

Circle 177 on Inquiry Card

Semiconductor Catalog

New 20-page catalog details the complete and current product line of the Semiconductor Div., Hoffman Electronics Corp., 1001 Arden Dr., El Monte, Calif. Three-hole punched for filing, it contains electrical and physical parameters of Silicon solar devices, silicon transistors, silicon diodes, silicon controlled rectifiers, zener regulators, and zener reference devices.

Circle 178 on Inquiry Card

Corrosion Computer

A 4 x 8 in. card works like a slide rule and tells how each of 8 types of metal withstands the corrosive effects of 141 chemical agents. The metals are: brass and naval bronze; silicon bronze; monel metal. Stainless types 410, 416, and 430; stainless types, 302, 303, 304 and 305; stainless type 316; copper, and aluminum. The H. M. Harper Co., Morton Grove, Ill.

Circle 179 on Inquiry Card

Microwave Equipment

Supplement to Catalog No. 60 gives specs on several new products including microwave mixer-preamplifiers, a telemetry preamplifier, subminiature command receiver, precision laboratory receiver and solid-state microwave receiver. LEL, Inc., 75 Akron St., Copiague, N. Y.

Circle 180 on Inquiry Card

Magnetics—Electronics

Thirty-one classes of magnetic and electronic equipment are illustrated and described in new Product Index from Acme Electric Corp., Cuba, N. Y. In addition to standard lines of dry type transformers, voltage regulating transformers, voltage stabilizing transformers, saturable reactors for the control of current and other types of magnetic components, it includes performance data and specs on magnetic amplifier controlled battery chargers, power supply units for automation and computer applications and electronic transformers including specs on high temp. types.

Circle 181 on Inquiry Card

Electron Tubes

Revised technical bulletin, lists Mullard preferred receiving tubes for Hi Fi AM-FM, television and industrial applications. Complete specs together with base diagrams for more than 60 tube types are listed. Included are tubes, such as the 6EU7, 7247, 6FY5/EC97, 6EH7/EF183, and 6EJ7/EF184, together with characteristics for the full range of Mullard frame grid tubes. International Electronics Corp., 81 Spring St., New York, N. Y.

Circle 182 on Inquiry Card

Bimetal Thermostats

Bulletin 1000, 2 colors, describes Company's Stemco Type S bimetal thermostats. It gives ratings, photographs and schematic diagrams, and lists uses in appliances and industrial applications. Stevens Mfg. Co., Inc., P. O. Box 1007, Mansfield, Ohio.

Circle 183 on Inquiry Card

Tone Generator

Data sheet, bulletin 162, from Alto Scientific Co., 855 Commercial St., Palo Alto, Calif., describes the Model G-137 Tone Generator. It is a subminiature device consisting of 10 high stability tone oscillators within the freq range of 30 to 400 CPS and a mixing amplifier. Unit is designed to indicate the precise occurrence and sequence of remote functions, for example catastrophic failures of missile components or separation of missile stages.

Circle 184 on Inquiry Card

Connectors

Pos-E-Kon® precision connectors for flat conductor cable are described in four-page brochure from Thomas & Betts Co., Inc., Elizabeth, N. J. The connector is engineered to adapt to a broad range of conductor sizes and spacings.

Circle 185 on Inquiry Card

Card Reader Switch

Six-page brochure describes the Cardmatic Card Reader Switch. It contains complete specs on the card reader which employs a rubberized vinyl card as its programming media. The card reader has been used in card programming equipment such as circuit testing consoles, food processing operations and teaching machines. One page describes Model CP-10, engineer's master card punch used to punch the programming cards in one operation. The Hickok Electrical Instrument Co., 10606 Dupont Ave., Cleveland 8, Ohio.

Circle 186 on Inquiry Card

Electric Motors

New product brochure, illustrates range of electric motors. It included examples of dc and ac motors covering a variety of supply voltages and frequencies. Sizes range from fractional horsepower miniature motors to integral horsepower units of 25 hp. Also included are examples of typical ac phasing capacitors and RFI filters. The AiResearch Mfg. Co., 9851 Sepulveda Blvd., Los Angeles 45, Calif.

Circle 187 on Inquiry Card

Direct-Writing Recorders

Four-page, 3-color, brochure describes Mark II portable direct-writing recorders including electric and ink writing types. It discusses choice of ink or electric writing and types of data that can be recorded on the 4 channels (2 analog and 2 event). Brush Instruments, Div. of Clevite Corp., 37th & Perkins, Cleveland 14, Ohio.

Circle 188 on Inquiry Card

New Tech Data for Engineers

Flexible Waveguide

Rectangular Flexible Waveguide chart, bulletin No. TL-604, from Technicraft Div., Electronic Specialty Co., Thomaston, Conn., lists technical specs in tabular form. Two-color chart includes: freq; base material; nom OD; twist; max atten.; typical max. VSWR; max recommended pressures, etc.

Circle 189 on Inquiry Card

Subcarrier Oscillator

Detailed specs on the new Model O-20 voltage controlled subcarrier oscillator for telemetering. In 2-color, 4-page folder, the new silicon transistorized unit features excellent temp. stability over extreme missile environment temps. Dorsett Electronics Labs., Inc., 119 W. Boyd, Norman, Okla.

Circle 190 on Inquiry Card

Temperature Controls

Transistor circuits and thermistor sensing elements of 4 Fenwal Temp. Controllers are described in Bulletin MC 190. Detailed specs are given for the "536," non-indicating controller "561," indicating, "582," thermometer, and "580," indicator accessory for the "536." Major feature of the new line is the wide choice of optional features. Fenwal Inc., Pleasant St., Ashland, Mass.

Circle 191 on Inquiry Card

Voltage Regulators

More than 2,000 voltage regulator models are described in a new handbook, from Raytheon Co.'s Power Supply & Voltage Regulator Operations, Keeler Ave., So. Norwalk, Conn. It provides specs for 2.020 standard magnetic voltage regulator models and offers information to guide in selecting and using regulators in dc power supply design. Electrical and physical characteristics are shown in a large, fold-out chart.

Circle 192 on Inquiry Card

Two-Way Radio

Brochure describes transistorized MOTRAC two-way radio line. It contains explanations and illustrations of the benefits made possible through the incorporation of transistors in the new unit such as low current drain, compactness, reduced maintenance and high audio power. A special section is devoted to the research and engineering of the new line. Motorola Inc., Communications & Industrial Electronics Div., 4501 W. Augusta Blvd., Chicago 51, Ill.

Circle 193 on Inquiry Card

Torque Wrenches

Application illustrations, bolt charts, discussions on assembly characteristics, instructions for torque wrench testing, pictures of modified and special torque wrenches, formulas and illustrated explanations for using adapters, attachments and extensions. Six pages of illustrations and explanations on using a torque wrench correctly. A section on the torque law, correct nomenclature, and an explanation of the torque wrench itself. There are 116 illustrations and 7 tables. P. A. Sturtevant Co., Addison, Ill.

Circle 194 on Inquiry Card

Motor-Run Capacitors

Bulletin from John E. Fast & Co., 3589 North Elston Ave., Chicago 18, Ill., describes motor-run capacitors. Described are the Fast Series 55 capacitors with impregnated paper dielectric, hermetically sealed in oval, drawn metal cases. Silicone rubber bushings with pnenolic cups increase creepage distance in compliance with Underwriter's Labs requirements. Solder terminals as well as single and double blade quick connect terminals may be specified. Capacities range from 2 to 20 uuf. Voltage ratings are 236, 330, 370, 440, and 660 vac.

Circle 195 on Inquiry Card

Magnetic Latching Relay

Babcock BR-9 magnetic latching relays are described in tech. bulletin BR-594. It describes the series, provides electrical and mechanical data and illustrates all types of standard mounting configurations. BR-9, a miniature, crystal-can enclosed, hermetically sealed, 10 a, low power requirement delay, is for aerospace and undersea applications and meets MIL-R-5757C and MIL-R-25018. Babcock Relays, Inc., 1640 Babcock Ave., Costa Mesa, Calif.

Circle 196 on Inquiry Card

Radiation Review

Monthly newsletter, "Radiation Review" will be directed to users of high voltage particle accelerators for research and electron accelerators for industrial processing. It will publish newsworthy and informative feature material such as a series of suggested nuclear physics experiments using a high beam current accelerator. Other features planned: tables and nomographs pertaining to radiation or ion beam technology; practical applications of the electron accelerator; and description of developments in areas of nuclear physics research with high current accelerators. Dept. RR-1, Radiation Dynamics, Inc., Westbury, L. I., N. Y.

Circle 197 on Inquiry Card

DC Magnetic Amplifiers

Bulletin M-24 describes low level FERRAC magnetic amplifiers which provide linear outputs of ±7.5 vdc with input signals in the low mv range. Transfer curves, electrical connections, dimensions and detailed specs provided. Units operate over a temp. environment of −55°C to +85°C and are used in complex data amplification and control systems. Airpax Electronics Inc., Seminole Div., Ft. Lauderdale, Fla.

Circle 198 on Inquiry Card

Electronic Hardware

A 76-page, illustrated engineering design manual (Bulletin 212 G) offers a listing of materials and specs, recommended application, and techniques for mounting tubing, wiring and similar hardware. Also, a description of the complete line of clamps, brackets, shims and line supports for almost any application. TA Mfg. Co., Engineering Dept., 4607 Alger St., Los Angeles 39, Calif.

Circle 199 on Inquiry Card

Radar-Sonar

Four-page brochure describes equipment and facilities for manufacturing massive radar, sonar, and nuclear products. Illustrated brochure contains photos of machine tools and fabricating equipment. Dept. ST-1, Portland Industries, Inc., South Portland, Me.

Circle 200 on Inquiry Card

Portable Power Supply

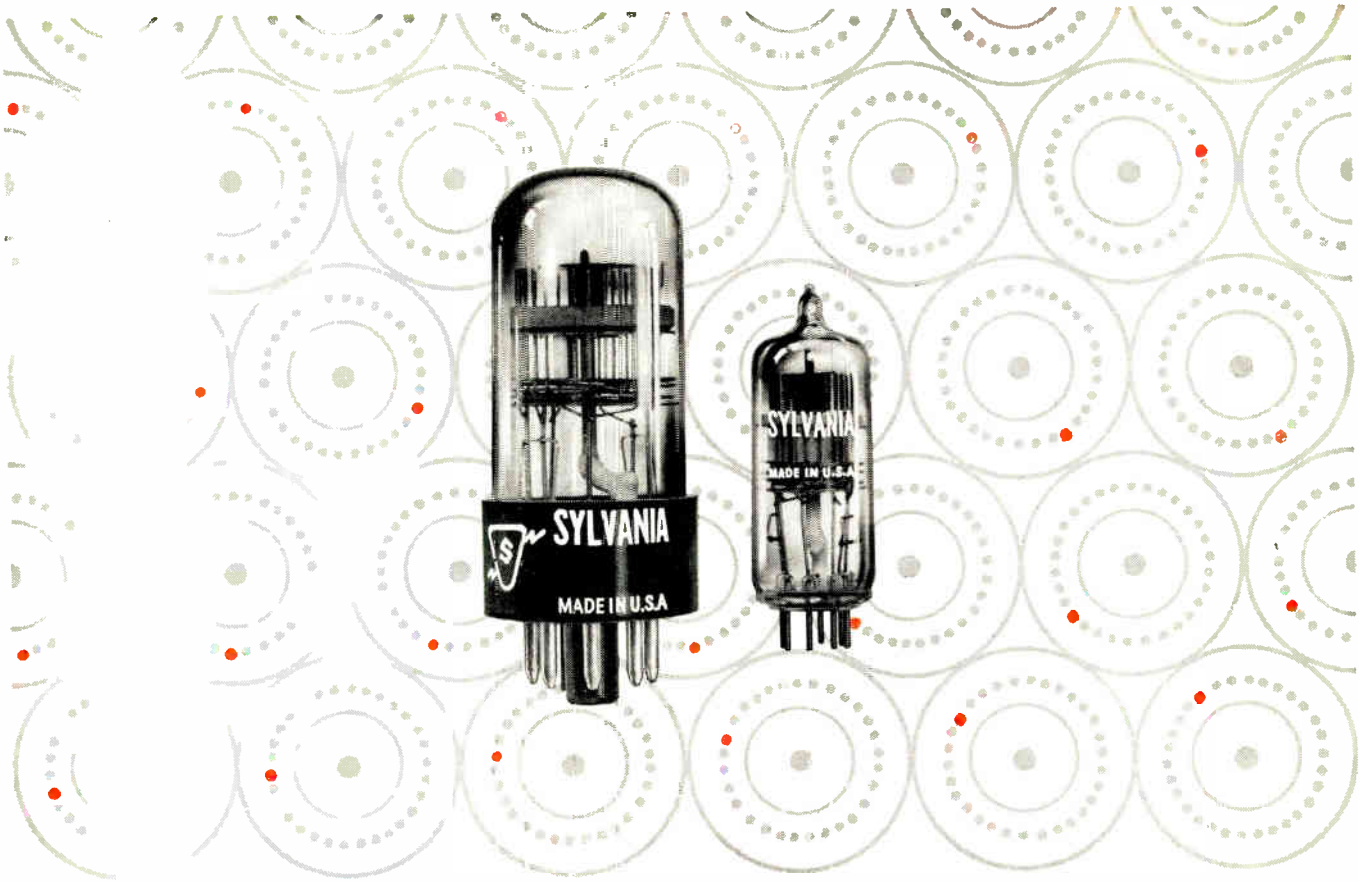
New 2-page bulletin describes a miniature portable power supply for remote programming and experimental work with transistor circuitry. Transistorized, the MP40-2 power supply has a load regulation of 0.05% and features electronic overload protection. Performance specs included. Mid-Eastern Electronics, Inc., 32 Commerce St., Springfield, N. J.

Circle 201 on Inquiry Card

Comfort Conditioning

Information on combination light and air diffusers is contained in a new 24-page catalog from the Barber-Colman Co. and Day-Brite Lighting, Inc. Data for selecting and predicting performance, and drawings illustrating how the new combination light and air diffusers are installed and balanced, are included. Catalog (F 9768) Barber-Colman, 1300 Rock St., Rockford, Ill.

Circle 202 on Inquiry Card



10 ADVANTAGES OF DESIGNING WITH SYLVANIA COLD CATHODE DECADE COUNTER TUBES

1 Sylvania Decade Counter Tubes combine actuating and direct visual readout capabilities. (Visual information is obtained by observing a sharply defined ion glow moving around a common anode on a peripheral ring of 30 cathodes.) **2** This significantly reduces circuitry and component requirements, **3** enables compact design, **4** enhances circuit reliability, **5** reduces equipment costs.

Further, Sylvania Counter Tubes feature **6** "add-subtract" capabilities, **7** low power requirements, **8** comparatively low cost. They offer **9** improved performance under standby operation, **10** reliable long life. (As assurance, large samples are tested under standby conditions, thermal and mechanical shock conditions, and cycled life operation.)

Have a design problem? Count on your Sylvania Sales Engineer for full data and engineering assistance. For the informative Decade Counter Tube Handbook, contact your Sylvania Industrial Tube Distributor or enclose 15¢ to Electronic Tubes Division, Sylvania Electric Products Inc., Dept. 1912, 1100 Main St., Buffalo 9, N. Y.

Sylvania Types	Total Anode Current (mA) Min.	Total Anode Current (mA) Max.	Min. Anode Supply Voltage (Vdc)	Min. Double Pulse Amplitude (V)	Min. Double Pulse Width (μsec)
(0-4KC) 6476(T-11) 6802(T-9) 6879(T-5½)	0.3	0.6	350	—75	60
(0-100KC) 6909(T-9) 6910(T-11) 7155(T-5½)	0.6	0.8	400	—85	4

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

Circle 56 on Inquiry Card

Unmatched purity for electronics production

B&A® ELECTRONIC-GRADE HYDROFLUORIC ACID and HYDROGEN PEROXIDE

Hydrofluoric Acid **Code 2753**
HF **M.W. 20.01**

Meets A.C.S. Specifications

Assay (HF)	49.00±0.25%
Fluosilicic Acid (H_2SiF_6)	0.01%
Residue After Ignition	0.0005%
Chloride (Cl)	0.0005%
Phosphate (PO_4)	0.0001%
Sulfate (SO_4)	0.0001%
Sulfite (SO_3)	0.0002%
Arsenic (As)	0.000005%
Heavy Metals (as Pb)	0.00005%
Copper (Cu)	0.00001%
Iron (Fe)	0.00005%
Nickel (Ni)	0.00001%
Lead (Pb)	0.00001%
Boron (B)	0.000001%

Check these new, stringent specifications in which impurities are held to the lowest level ever attained. For the first time, maximum limits for lead and boron have been established. *This is the highest purity "Electronic-Grade" HF yet.*

Hydrogen Peroxide, 3% Solution **Code 2773**
H_2O_2 **M.W. 34.02**

Assay (H_2O_2)	3.0–3.5%

Maximum Limits of Impurities

Residue after Evaporation	0.020%
Free Acid (as H_2SO_4)	0.010%
Chloride (Cl)	0.0005%
Nitrogen Compounds (as N)	0.005%
Phosphate (PO_4)	0.003%
Sulfate (SO_4)	0.005%
Arsenic (As)	0.00001%
Heavy Metals (as Pb)	0.0001%
Iron (Fe)	0.00005%
Preservative (Phenacetin)	0.035%

Hydrogen Peroxide, 30% **Code 2774**
H_2O_2 **M.W. 34.02**

Meets A.C.S. Specifications

Assay (H_2O_2)	29.0–32.0%
pH	2.5–3.5

Maximum Limits of Impurities

Residue after Evaporation	0.002%
Free Acid (as H_2SO_4)	0.003%
Chloride (Cl)	0.0005%
Nitrate (NO_3)	0.0005%
Phosphate (PO_4)	0.00025%
Sulfate (SO_4)	0.0005%
Ammonium (NH_4)	0.0005%
Heavy Metals (as Pb)	0.0001%
Iron (Fe)	0.00005%

Hydrogen Peroxide, 30% "Stabilized" **Code 2775**
H_2O_2 **M.W. 34.02**

Assay (H_2O_2)	29.0–32.0%
pH	3.0–3.5

Maximum Limits of Impurities

Residue after Evaporation	0.03%
Free Acid (as H_2SO_4)	0.005%
Chloride (Cl)	0.0005%
Phosphate (PO_4)	0.020%
Sulfate (SO_4)	0.001%
Heavy Metals (as Pb)	0.0001%
Iron (Fe)	0.00005%

Here are two typical examples of the outstanding purity achieved in the production of Baker & Adamson "Electronic-Grade" chemicals. Utilizing the most advanced manufacturing and quality control techniques, B&A offers "Electronic-Grade" Hydrofluoric Acid and Hydrogen Peroxide with impurities held to the lowest levels ever attained. These ultra-high-purity B&A chemicals help assure improved production process control, fewer rejects and higher quality of finished product.

B&A "Electronic-Grade" chemicals are available in small or bulk packages. Seven manufacturing plants plus 24 stock points across the nation assure *same* or *next day delivery* in most major electronics centers.

For the free booklet, "B&A Electronic Chemicals," which includes a listing of products with specifications and uses, write General Chemical on your company letterhead.

Allied Chemical

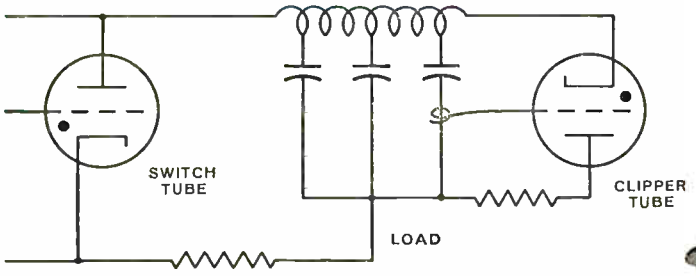
GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

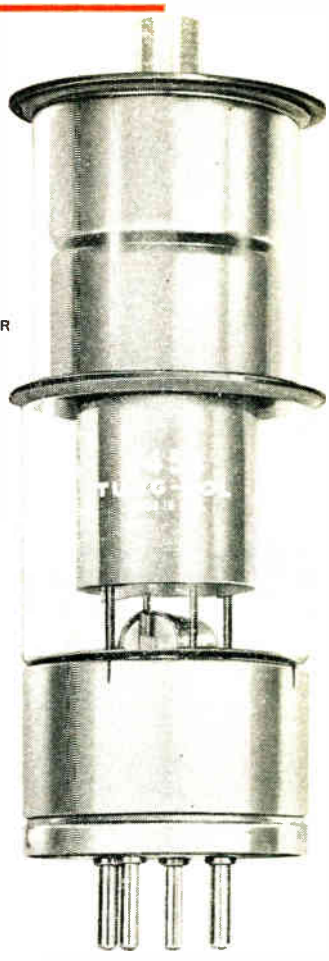
BAKER & ADAMSON® "Electronic-Grade" Chemicals

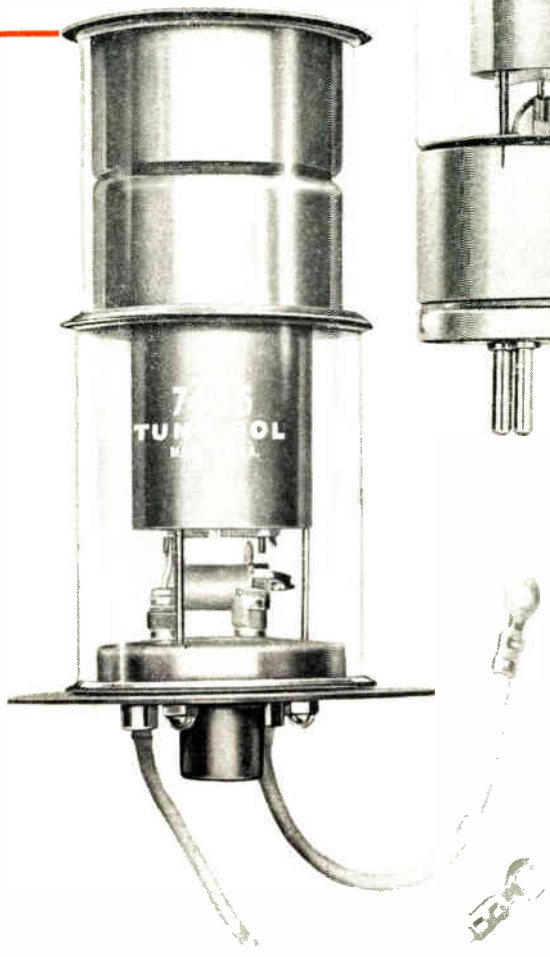
Circle 57 on Inquiry Card

End-of-line clipper

Clipper tube is connected across the far end of the pulse-forming network in series with a resistive load whose value approximates the network impedance. When the clipper tube is triggered, the pulse-forming network terminates in its characteristic impedance thereby reducing the inverse voltage to zero.







Positive protection against destructive voltages with Tung-Sol Clipper Thyratrons

Line-type radar modulators require clipper protection against excess inverse voltages, which can destroy costly components and increase equipment downtime. Clippers also perform valuable circuit service by regulating pulse amplitudes and reducing switch tube loading.

But until Tung-Sol developed these high-reliability hydrogen-filled clipper triodes previously used clipping devices brought some serious disadvantages to the job.

Now, however, you can be sure of *perfect* clipping action when you design Tung-Sol clippers into your equipment. More rugged and less costly than solid state devices, more efficient with a much lower dynamic impedance than vacuum clippers, and faster acting and more resistant to arc-back than gas diodes, the new Tung-Sol thyratron clippers are designed and built to deliver uncompromised performance.

The low "firing" voltage and the ability to carry large peak currents make these hydrogen clipper thyratrons ideal for this application. These tubes also feature hydrogen reservoirs which promote long life by providing an automatic mechanism for replenishing hydrogen lost by "cleanup".

Circuit requirements are simple whether the Tung-Sol thyratrons are used as "end of the line" clippers, "across switch" clippers or "tail biters".

Write for complete technical details on the new 7454 and 7455 Clipper Thyratrons. Tung-Sol Electric Inc., Newark 4, N. J. TWX:NK193.

TUNG-SOL®

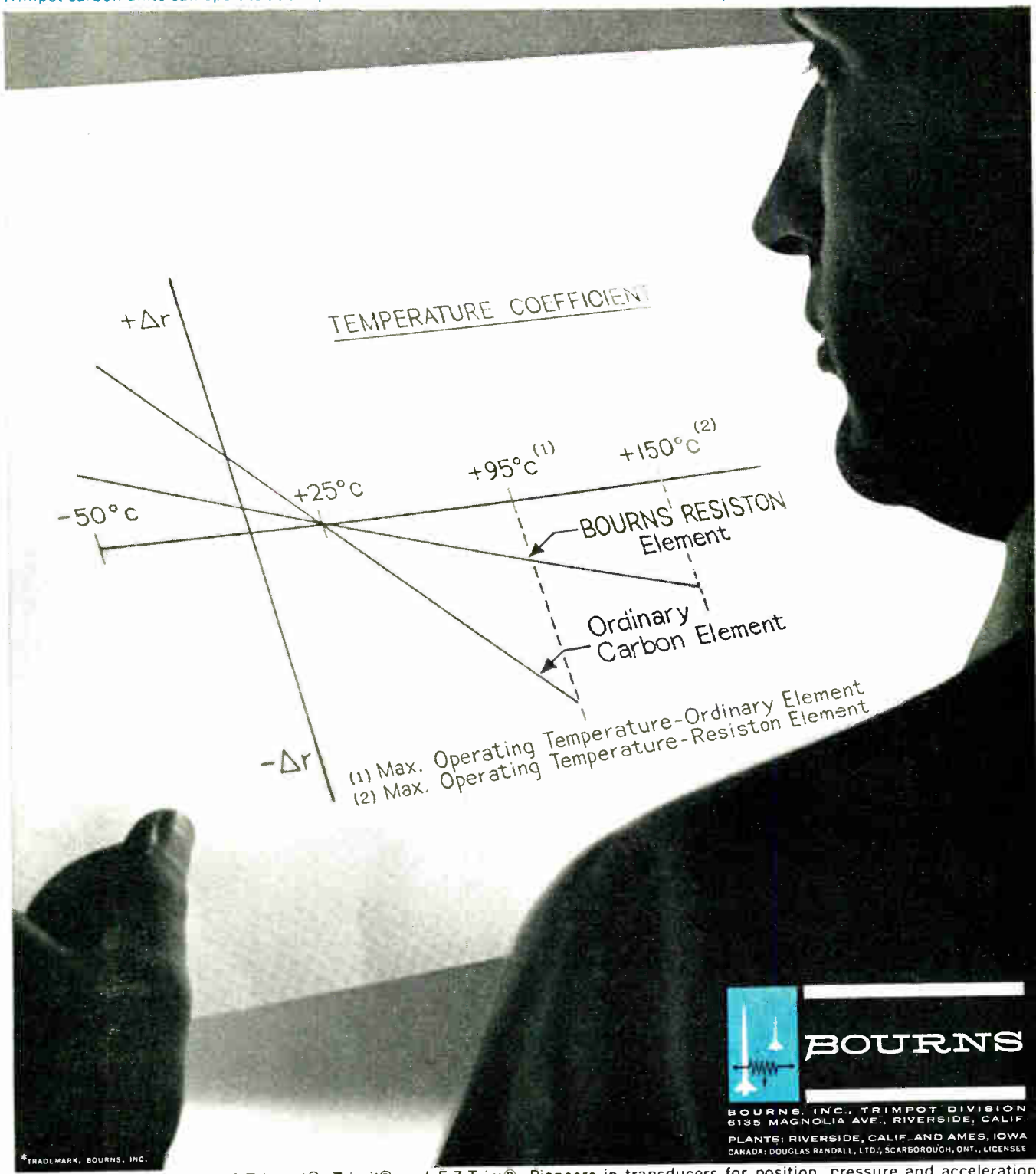
Technical information available through ATLANTA, GA.; COLUMBUS, OHIO; CULVER CITY, CALIF.; DALLAS, TEXAS; DENVER, COLO.; DETROIT, MICH.; IRVINGTON, N. J.; MELROSE PARK, ILL.; NEWARK, N. J.; PHILADELPHIA, PA.; SEATTLE, WASH. IN CANADA: ABBEY ELECTRONICS, TORONTO, ONT.

At Last—High Reliability in Carbon-Film Potentiometers!

Bourns Trimpot® carbon-film potentiometers now offer you twice the stability of any carbon unit heretofore available... at temperatures as high as 150° C. Now, for the first time, you can incorporate high-resistance, infinite-resolution potentiometers in your circuit without sacrificing reliability. The reason: Resiston*, a remarkable new carbon element that virtually eliminates the problems normally caused by extremes of temperature and humidity.

Thanks to this exclusive Bourns development, Trimpot carbon units can operate at temperatures up to 150° C—with resistance shift only half that of ordinary carbon elements. In addition, they far exceed the requirements of Mil-Specs for humidity and MIL-R-94B.

Trimpot Resiston units are available from factory and distributor stocks with three terminal types... three mounting styles ... and standard resistances ranging from 20K to 1 Meg. Resiston elements are available in most Bourns configurations. Write for the new Trimpot summary brochure and list of stocking distributors and representatives.



BOURNS

BOURNS, INC., TRIMPOT DIVISION
6135 MAGNOLIA AVE., RIVERSIDE, CALIF.
PLANTS: RIVERSIDE, CALIF.-AND AMES, IOWA
CANADA: DOUGLAS RANDALL, LTD., SCARBOROUGH, ONT., LICENSEE

*TRADEMARK, BOURNS, INC.

Exclusive manufacturers of Trimpot®, Trimit® and E-Z-Trim®. Pioneers in transducers for position, pressure and acceleration.

Circle 62 on Inquiry Card

Tech Data

for Engineers

Switch Catalog

Subminiature-switch Catalog No. 20-1 contains information on line of Unimax subminiature switches. Listings include high-temp., sealed, environment-free, and MIL-Spec types as well as phenolic-cased, pushbutton, toggle, and integral-actuator subminiature switches. Unimax Switch Div., The W. L. Maxson Corp., Ives Rd., Wallingford, Conn.

Circle 301 on Inquiry Card

Rubberized Abrasives

A 22-page manual on the uses and applications for rubberized abrasives. It gives case histories on a variety of typical applications and outlines the most efficient methods for mounting, dressing and trueing. Recommended operating speeds are also listed. Field applications pointing up time saving methods are described. Cratex Mfg. Co., Inc., 1600 Rollins Rd., Burlingame, Calif.

Circle 302 on Inquiry Card

Oscilloscope

Application notes 44A and 44B describe uses of Model 185A oscilloscope. The oscilloscope, equipped with a new slim probe, is usable up to 1 KMC with the 3 db point greater than 800 MC. Notes discuss methods of synchronizing high frequency oscilloscopes, and pulse and waveform analysis with the 185A. Included is a data sheet which describes accessories. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif.

Circle 303 on Inquiry Card

Hi Temp Servo

Data sheet illustrates and gives tech. details on shorter, hi temp, size 8 precision servo motor for smaller space applications. Included are electrical performance, mechanical and physical characteristics, outline drawing, torque curves and schematic. John Oster Mfg. Co., Avionic Div., Racine, Wis.

Circle 304 on Inquiry Card

Radio Transmitters

Details of the Westrex 11-Type radio transmitting equipment are in a 4-page illustrated brochure from Westrex Communications Equipment Dept., 540 W. 58th St., New York 19, N. Y. Equipment meets requirements for high-frequency communication systems, including radio-telephone, telegraph or teleprinter. Applications include traffic control, news gathering and emergency communications. Complete specs and performance characteristics included.

Circle 305 on Inquiry Card

In PRECISION POTENTIOMETERS if it's news, expect it first from IRC

NEW...

Subminiature Rotary Trimmer surpasses environmental MIL tests

You can throw the book—the tough environmental tests of MIL-R-12934B and NAS-710—at IRC 5001 precision potentiometers. These miniature rotary trimmers exceed all applicable MIL requirements. They are completely interchangeable with other makes.

Miniature size: ½" long x ½" diameter. Housing: premium quality metal case. Mounting: bushing or servo. Resistance: 50 to 150,000 ohms. Tolerance: ± 5%. Power: 2 watts at 60°C. Construction: all welded electrical connections.

Write for Bulletin A-9. International Resistance Co., 401 N. Broad Street, Philadelphia 8, Pa.

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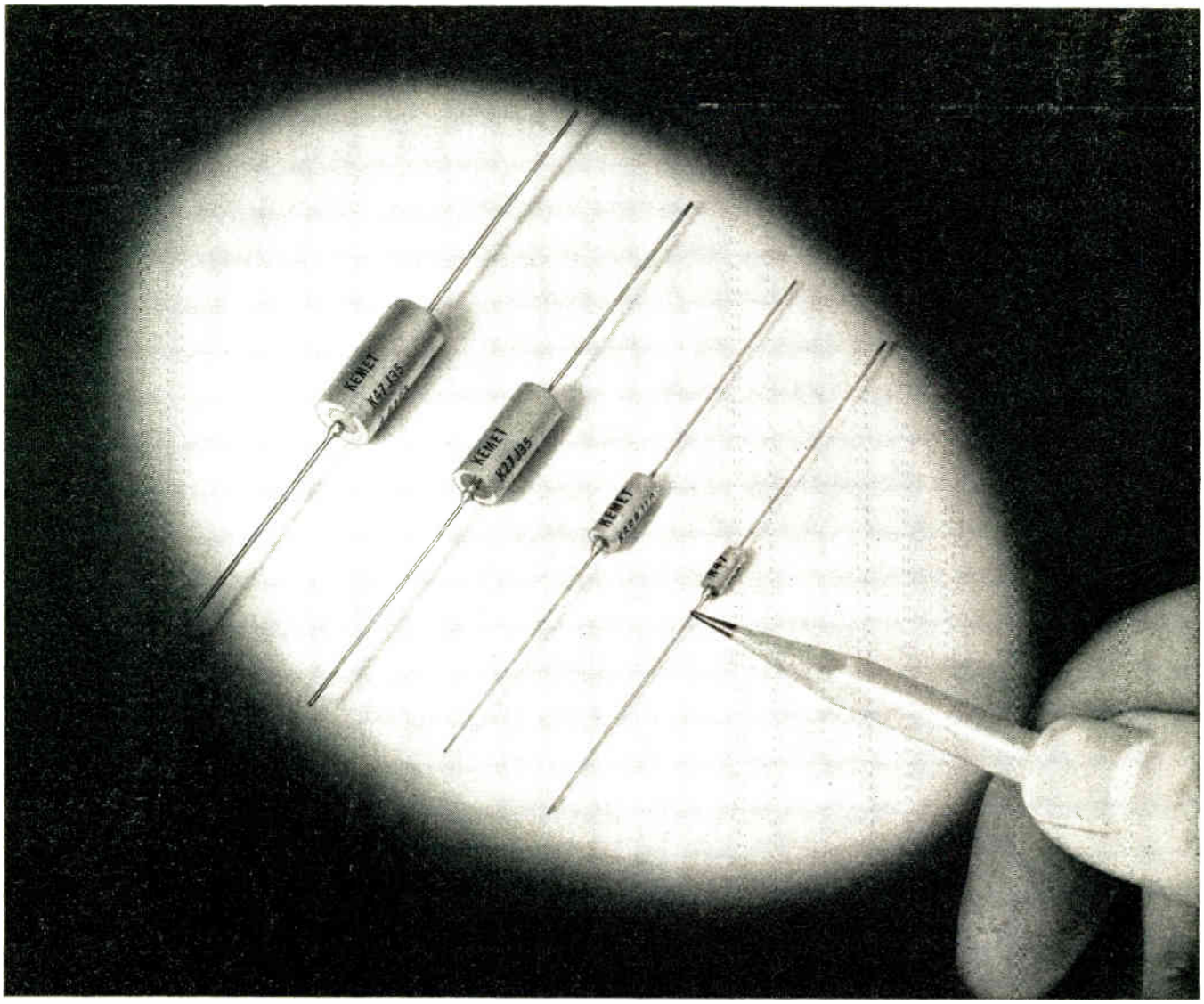
IRC

Leading supplier to manufacturers of electronic equipment



KEMET COMPANY EXPANDS ITS SOLID TANTALUM CAPACITOR LINE!

These new, smaller sized J-series capacitors — an addition to the proved and accepted H-series solid tantalum line—comply with and in many instances exceed the requirements of MIL-C-26655A.

For example, these capacitors are available in capacitances up to 22 microfarads at working voltages of 50 volts at 85 degrees C. At 125 degrees C., they operate at two-thirds of the 85 degree C. working voltage. Available with or without insulating sleeves, the new J-series capacitors maintain the excellent low leakage current characteristics associated with the H-series line, even though they occupy about ⅓ of the space of the earlier types.

These new capacitor designs are made possible by the advanced research facilities available at Union Carbide Corporation, plus the fact that "Kemet" is not dependent on other suppliers for the mining or processing of tantalum.

For literature, write Kemet Company, Division of Union Carbide Corporation, 11901 Madison Avenue, Cleveland 1, Ohio.

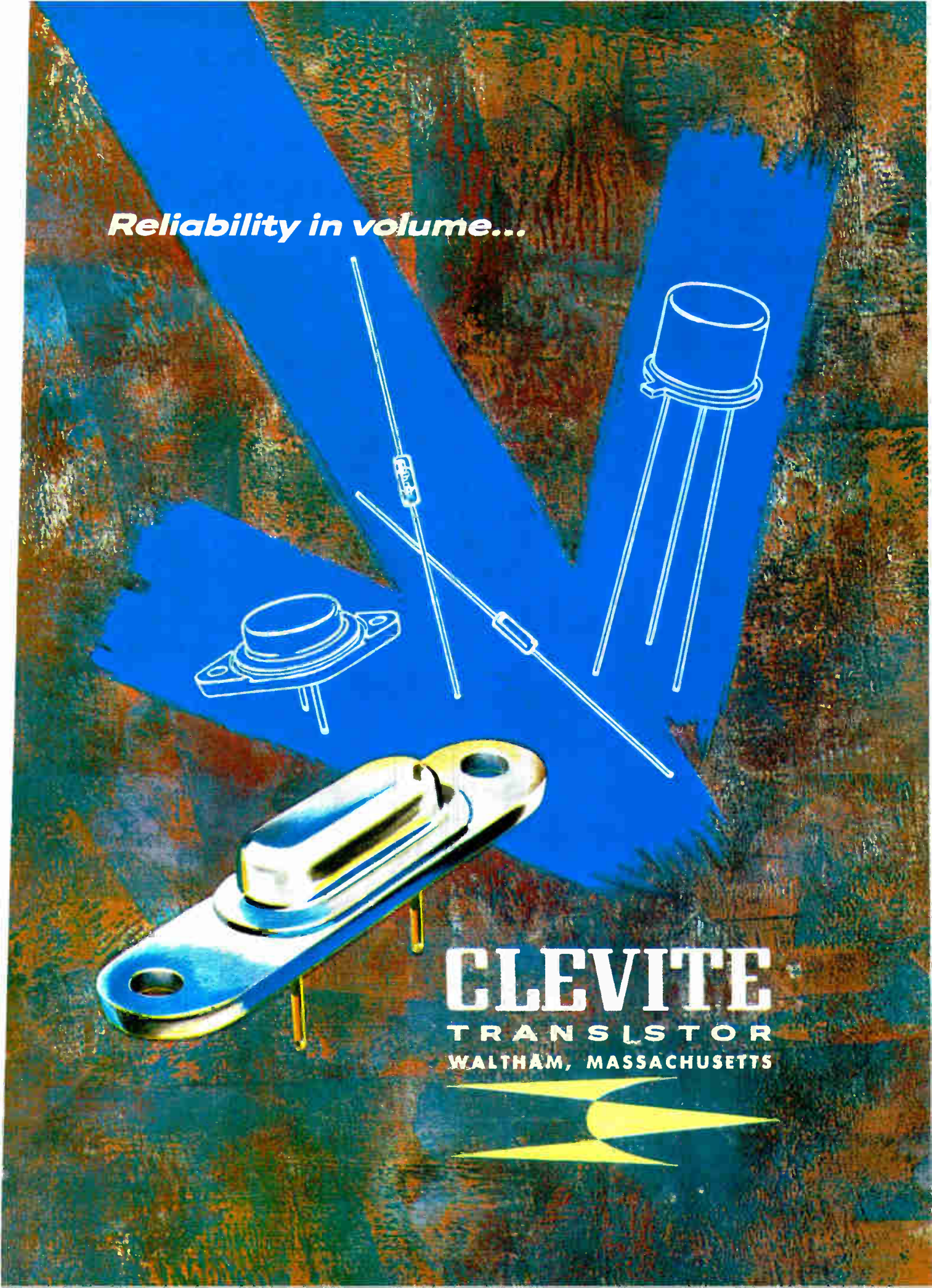
"Kemet" and "Union Carbide" are registered trade-marks for products of

KEMET COMPANY

UNION CARBIDE

Circle 65 on Inquiry Card

Circle 66 on Inquiry Card →


Reliability in volume...
CLEVITE
TRANSISTOR
WALTHAM, MASSACHUSETTS

Clevite's rectifiers find broad use as general purpose diodes in computers and as rectifiers in magnetic amplifiers, dc to dc converters and power supplies.

They are particularly useful in airborne applications where switching of equipment may generate high voltage transients in the line which would burn out ordinary diodes. Designed for maximum reliability, Clevite rectifiers provide high dissipation — 600 mw . . . high voltage — up to 600 v . . . high temperature — up to 150 ma at 150°C.

Where fast switching is not required, these rectifiers offer definite advantages in size, costs and superior overload protection. They are available in military types conforming to MIL-E-1/1143 (USAF).

Send for bulletin B217-3B

DIFFUSED SILICON RECTIFIERS

Diode Type	Maximum DC Inverse Operating Voltage (volts)	Maximum Average Forward Current @ 25°C (ma)	Maximum Forward Voltage Drop @ 25°C (volts @ ma)
1N645	225	400	1.0 @ 400
1N647	400	400	1.0 @ 400
1N649	600	400	1.0 @ 400
1N677	100	400	1.0 @ 400
1N681	300	200	1.0 @ 200
1N683	400	200	1.0 @ 200
1N685	500	200	1.0 @ 200
1N687	600	200	1.0 @ 200

A DIVISION OF CLEVITE CORPORATION

Reliability In Voltage...

CLEVIT[illegible]TOR

200 Smith Street, Waltham [illegible]

here's why Amperex®

VHF P·A·D·T High-Gain Transistors ARE BETTER... for AM/FM, mobile communications, car radio, and instrumentation!

1 Maximum Uniformity and Interchangeability By combining the best qualities of both the alloy and the diffusion approaches to transistor construction – and by means of special "self-jigging" techniques – the Amperex Post Alloy Diffusion Process achieves maximum yield and uniformity, virtually eliminating the need for "selection". From drawing-board to final quality control checkpoint, the PADT process rigidly maintains the specifications of each transistor you require. not only to provide hitherto unattainable uniformity, but also maximum interchangeability with competitive types – plus...

2 High Beta The revolutionary PADT process provides a guaranteed *minimum* beta of 40... an average of 150 ...with resultant high power gain! Therefore, PADT transistors can now guarantee...

3 Maximum Design Freedom for Engineers The unprecedented characteristics of PADT transistors provide easier temperature stabilization, lower bias circuit loss, higher dissipation reserve, superior K factor, high alpha cut-off frequencies and safe, extremely conservative collector voltage ratings.

7 NEW P·A·D·T PNP TYPES specifically designed for specific applications – and now in mass production at the new Amperex semiconductor plant in Slatersville, Rhode Island

APPLICATION	TYPE NO.	FUNCTION	FEATURES
CAR RADIO	PADT-23	RF amplifier in 6 or 12 volt car radio applications from .5 to 1.5 mc, or in portable broadcast receivers.	Low leakage and high current gain minimizes AGC current requirements. Improved noise figure. High base-to-emitter voltage rating minimizes danger of breakdown.
	PADT-24	IF amplifier (455 or 262.5 kc), or in mobile communication receivers; at 6 or 12 volts.	Low collector-to-base capacitance; plus extremely small collector cut-off current. Minimum Beta of 40 to facilitate the design of AGC circuits.
	PADT-27	Mixer, oscillator or converter, 455 or 262.5 kc; at 6 or 12 volts.	Low mixer noise averaging only 3 db at 1 mc. Low leakage, less than 50 μa at 60°C.
MOBILE COMMUNICATIONS	PADT-25	High frequency IF amplifier in mobile communication and airborne receivers.	Unusually high output resistance for improved receiver selectivity. Less than 50 μa leakage at 60°C improves AGC operation.
	PADT-26	RF or IF amplifier, or mixer, in receivers operating up to 100 mc.	Typical power gain greater than 14 db at 100 mc, with a noise figure less than 9 db. High base-to-emitter breakdown voltage for extreme safety.
	PADT-28	RF amplifier for service in the 175 mc region.	Typical gain of 14 db at 200 mc. Noise figure, 5.8 db. Maximum frequency of oscillation, 700 mc. Extremely low base resistance.
	PADT-31	Mixer, oscillator, or frequency multiplier at frequencies up to 60 mc.	High output resistance (30,000 ohms typical at 10.7 mc). Power gain – more than 14 db at 60 mc. Conversion gain 20 db min. at 27 mc.

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MILO ELECTRONICS
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RADIO SHACK CORP.
BOSTON, MASS.
STAMFORD, CONN.
W. HARTFORD, CONN.
NEW HAVEN 10, CONN.

R. V. WEATHERFORD COMPANY
GLENDALE 1, CALIF

P·A·D·T TRANSISTORS 'COMPARISON-TESTED' WITH COMPETITIVE CAR RADIO BRANDS

Stage	Parameter	Amperex PADT Transistor	Brand X	Brand Y
ALL	$f_{\alpha co}$(mc)	70 typ	42 typ	Approx 12.6 min(1)
	h_{fe} (f=1 kc)	40 min 150 typ	60 typ	RF 20–80 CONV 20–200 IF 20–100
	f_{max} (mc)	262(2) typ	—	50 min
	P_c (mw at 45°C)	67	60(3)	30
	I_{CBO} (25°C)	8 μa max 1.5 μa typ	7 typ	10 max
RF	Maximum Available Power Gain 1.5 mc	47.5 db(4)	47.5	—
IF	Maximum Available Power Gain 455 kc	60.6 db(4)	54.5 db	55

(1) Calculated on the basis of f_{max}=50 mc and $r_b \cdot C_c$=200 $\mu\mu$s substituted in the following equation: $f_{\alpha co} \approx f_{max} 8\pi r_b \cdot C_c$
(2) Calculated value based on a maximum available power gain of 28 db at 10.7 mc and a power fall of 6 db per octave.
(3) Based on P_c at 25°C of 80 mw, P_c at 55°C of 50 mw and a linear derating factor which is 1 mw/°C.
(4) Calculated by the following equation: $PG_{max\ avail} = \frac{|Y_{fe}|^2}{4 g_{ie} g_{oe}}$

Coming soon! New P·A·D·T Switching, UHF and Power types!

ask Amperex
for detailed data and applications assistance (including complete circuits designed to your specifications)

AMPEREX ELECTRONIC CORPORATION
230 DUFFY AVENUE, HICKSVILLE, L. I., NEW YORK
In Canada: Rogers Electronic Tubes & Components, 116 Vanderhoof Ave., Toronto 17, Ont.

Tunnel Diodes

(*Continued from page* 116)

producible to a tolerance of ±1% by a servo-etching technique.

Inherent in the development are two new packaging concepts: one is a "rivet" package, the other a "micro-wedge" package. Both are compared on an optical comparator to a conventional package (a TO-18 header) in Fig. 1. These give excellent structural support while maintaining low values of electrical characteristics. Typical values are: total capacitance of 3 picofarads, total inductance of 0.4 nanohenries and total series resistance of 3 ohms.

The second development is a tunnel diode with room temp. peak-to-valley ratios well over 40:1. These high peak-to-valley ratio diodes were made using germanium doped with gallium rather than arsenic.

Capacitance is 0.15 picofarads/ma and a current density in the range of 35 thousand a/cm². Because of this high current density,

(*Continued on page* 144)

TAPCO ELECTRICAL POWER COMPONENTS

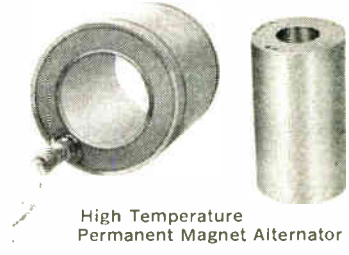
TAPCO Group primary and auxiliary electrical power systems for space, missile, aircraft and ground power applications are tried and proven. Systems performed under environmental conditions including nuclear radiation, high-temperature, liquid metal vapor, zero-G and vacuum.

Below are typical TAPCO components now available for integration into systems for such applications. Other available TAPCO electrical power components include tachometer generators, speed sensors, high temperature electromagnets and solenoids, nuclear reactor rod drive controls, static inverters, voltage regulators and electronic power conversion devices.

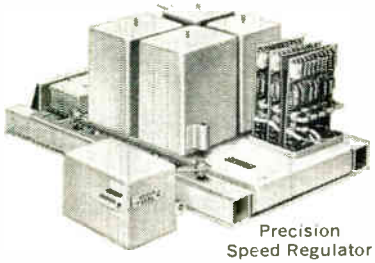
ALTERNATORS

Among the special purpose rotating machines designed by TAPCO is a series of high temperature alternators. These range in capacity from a few watts to 15 kw at temperatures up to 1000°F.

PERFORMANCE DATA: TYPICAL ALTERNATOR—**Power Rating:** 3 kw, 0.8 pf lagging. **Ambient Temp.:** 700°F. max. **Operating Speed:** 40,000 rpm. **Output:** 115v, 2000 cps. **Inherent Voltage Regulation:** ±5%. **Harmonic Content:** 5% total. **Efficiency:** 85%. **Weight:** 9 lbs w/o shaft and bearings. **Size:** 3⅜" OD, 5⅛" long. **Special Conditions:** Operates in mercury vapor.



High Temperature
Permanent Magnet Alternator



Precision
Speed Regulator

VOLTAGE REGULATION AND SPEED CONTROLS

Associated with the TAPCO alternator and drive systems are system speed and voltage controls for extremely accurate frequency and voltage regulation. The unit shown is adaptable to many drive systems.

PERFORMANCE DATA: TYPICAL SPEED REGULATOR: **Frequency Stability:** 1 part in 100,000 integrated over minimum 1 hour period. **Input:** 115v, 400 cps. **Output:** 0-10v, 400 cps (phase reversing). **Feedback:** Valve position 0-57.5v, 400 cps. **Environmental Conditions:** −65 to +200°F, 50g snock for 11 millisec., vibration 0.1" double amplitude from 3 to 23 cps, 10g from 23 cps to 10 kc. **Weight:** 10 lbs. **Size:** 12" x 6" x 5".

LIQUID METAL PUMPS

A rotating permanent magnet driven by an external source induces pumping force in the liquid metal within a hermetically sealed system. This concept provides operation without friction-producing rotating seals and provides exceptional reliability and life.

PERFORMANCE DATA: TYPICAL ELECTROMAGNETIC PUMP—**Fluid:** Sodium. **Fluid Temperature:** 1000°F. **Capacity:** 20 lbs/min. **Driving Speed:** 40,000 rpm. **Pressure Rise:** 3 psi. **Weight:** 3 lbs. **Size:** 2¾" diam. flange bolt circle, ½" nominal pipe size.

Electromagnetic Sodium Pump

Tapco Group Export Representative:
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DESIGNERS AND MANUFACTURERS FOR THE AIRCRAFT, MISSILE AND SPACE, ORDNANCE, ELECTRONIC AND NUCLEAR INDUSTRIES

peak currents are usually greater than 24 ma. They can switch in less than 1 nanosecond.

The servo-etching technique sprays a fine jet of etching solution through a window cut into the ceramic material surrounding a germanium pellet. This technique can be used with either the "rivet" or "micro-wedge" package design. Choice of the package depends upon the type of printed circuit board in which the diode is to be used. Fig. 2 is a size comparison between the two packages. Fig. 3 shows the window in the "rivet" package.

For automatic control of the process, an ac pulse (the top half of a sine wave) "interrogates" the diode being etched. These pulses are continually compared with similar pulses generated across a reference tunnel diode. When the pulses match, the desired peak current is reached. Then the etching is automatically stopped and the junction washed. An impressive yield of diodes has been produced by this technique —with peak current tolerances within ±1%.

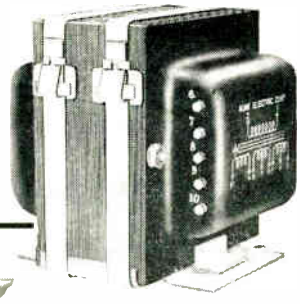
NEED ENCAPSULATED TRANSFORMER COMPONENTS?

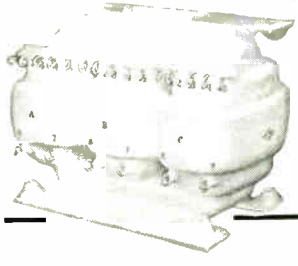
Do you need transformer components that must withstand high temperatures, low temperatures, excessive humidity or other environmental conditions and still perform in field service as well as under optimum laboratory conditions?

Then send your specs to Acme Electric and get the kind of cooperation you've always wished for — a complete study and analysis of your design, recommendations based upon the latest state of the art and suggestions for improvements and/or economies that will be of value to you.

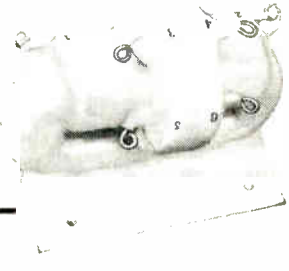
T-40902
Primary (1-2) 115 volts, 60 cycles
Secondary No. 1 (3-4-5)
71.5-0-71.5V RMS @ 77ma DC
F.W.C.T. Capacitor Input

MIL-T-27A
Grade 5
Class T
Life Expectancy X





T-34671
VA: 705, weight: 4¼ lbs.
165°C rise, 125°C ambient
12 KV test at 30,000 feet



T-36126
VA: 47.8, weight: 14 ounces
50°C rise, 250°C ambient
12 KV test at 30,000 feet

ACME ELECTRIC CORPORATION
8912 Water St. Cuba, N. Y.

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TRANSFORMERS

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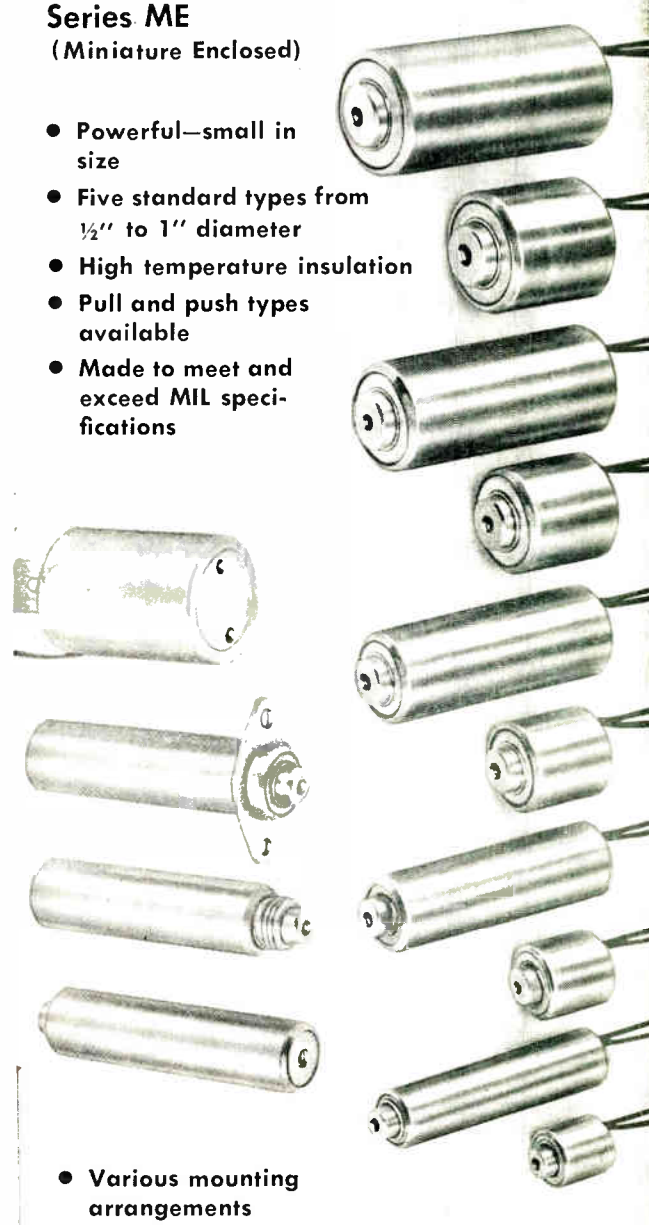
MINIATURE SOLENOIDS

Series ME
(Miniature Enclosed)

- Powerful—small in size
- Five standard types from ½" to 1" diameter
- High temperature insulation
- Pull and push types available
- Made to meet and exceed MIL specifications



- Various mounting arrangements

Designed for DC application only, these units are available with ratings up to 125 volts, unique construction meets exacting specifications, provides long life.

Write for complete information.

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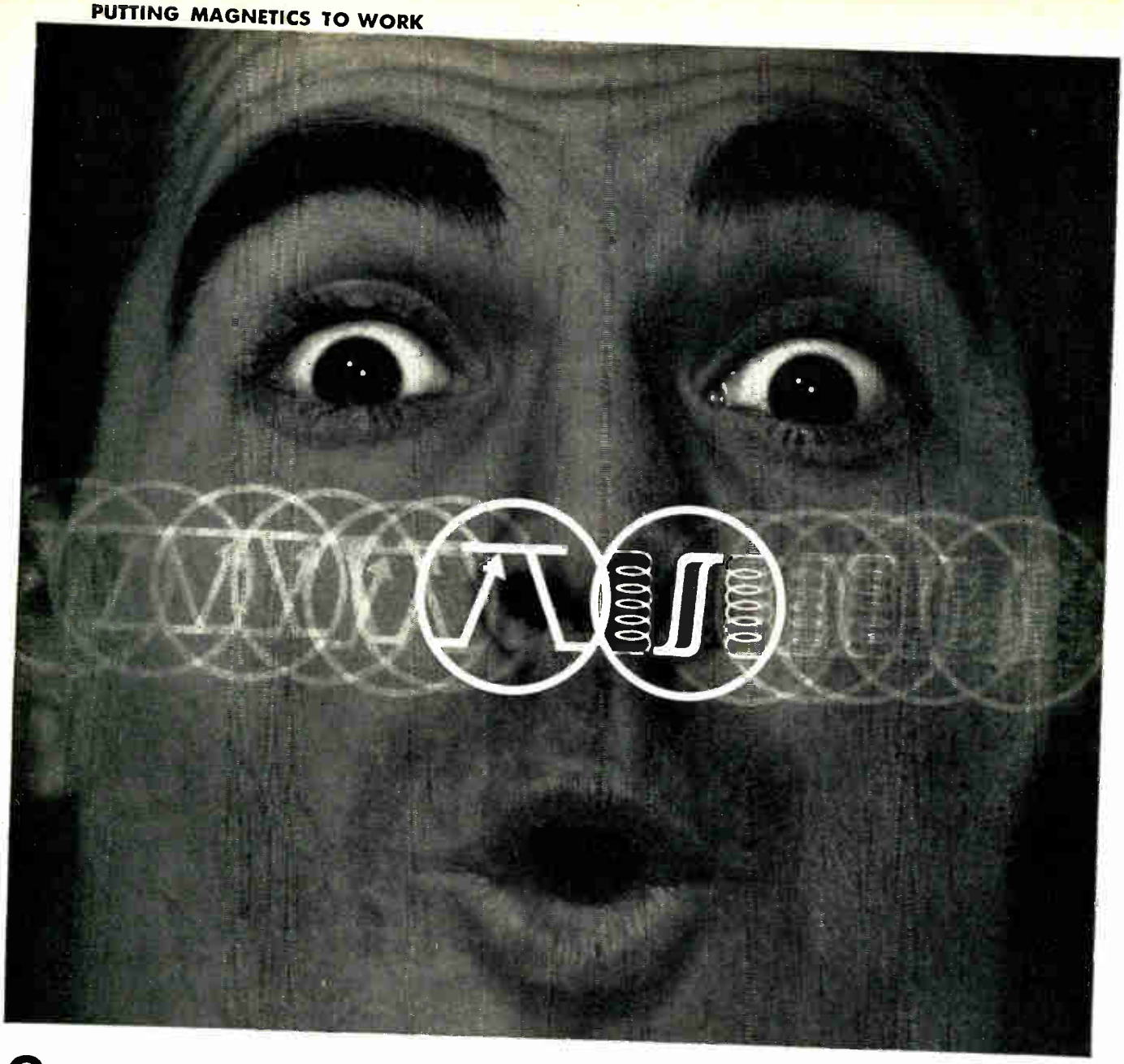

Open your eyes to new amplifier designs!

See how to combine tape wound cores and transistors for more versatile, lower-cost, smaller amplifiers

Tie tape wound cores and transistors into a magnetic-transistor amplifier, and open your eyes to new design opportunities.

To start with, these are static control elements—no moving parts, nothing to wear or burn out. Next thing you find is that you reduce components' size—your amplifier is smaller and costs less. That's because between them the core and the transistor perform just about every circuit function . . . and then some.

For instance? The core has multiple isolated windings. Thus you can feed many inputs to control the amplifier. The core also has a square hysteresis loop, and thus acts as a low loss transformer. That means you save power. In addition, the core can store and remember signals—so time delay becomes simple.

There's no need for temperature stabilization, either. The transistor acts only as a low loss, fast, static switch—and in this function it has no peer.

How do you want to use this superb combination? As a switching amplifier—or a linear one? In an oscillator? A power converter (d-c to d-c or d-c to a-c)? You'll have ideas of your own—and if they involve tape wound cores, why not write us? Ours are Performance-Guaranteed.

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PRODUCES TOTAL RELIABILITY

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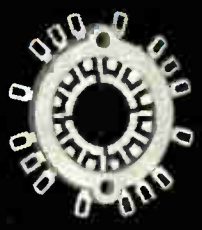
plus *Exclusive* Glass Alkyd Molded Permanence

plus *Exclusive* Full Silver Coverage on Contact Surface

equals **NEW CTS NON-DRIFT COMPACT SELECTOR SWITCHES**

Formerly manufactured by Trolex Corporation, now a part of CTS. 1⅛" diameter 12-position indexed rotary switches are designed primarily for low power exacting military and commercial RF, VHF and UHF circuit applications. Series 212 surpasses MIL standards.

UNPRECEDENTED SWITCH UNIFORMITY FROM ENTIRELY NEW AUTOMATED MANUFACTURING CONCEPT



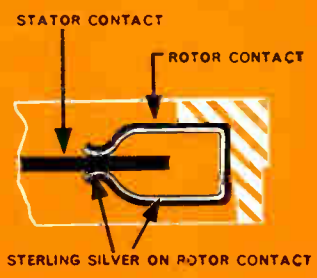
- Drift virtually eliminated by molding terminals into exact, immovable, permanent position in stator, entirely by machine . . . making all switches identical in each production run. Machine exactitude replaces human error and variations, eliminating the wider tolerances characteristic of hand assembly.
- Delicate switch parts are not exposed to breakage; many parts are not even handled.
- Superior insulation due to repetitive exactness in terminal spacing and molded glass alkyd material.
- Heat from soldering cannot loosen terminals.
- Natural design barrier prevents solder from flowing into circuit elements during soldering.

SAFER, QUICKER, EASIER HANDLING IN YOUR PRODUCTION LINE

Molded glass alkyd stator won't break or crush during ordinary handling or if accidentally dropped. Terminals cannot be dislodged or moved. Both stationary and movable contacts are enclosed for additional safety and handling convenience.

LONGER LIFE CONTACTS

- After 1,200,000 index operations, life tests reveal virtually no change in rotor contact resistance.
- 1000% *more* silver than used by most commercial switches has been *evenly* applied at actual point of contact by exclusive process. (See Sketch). Optional solid sterling silver contacts and stator available for additional contact performance.
- Rotor contacts are double-wiping and self-cleaning.
- Stator contacts are integral with terminals.



NOW! NEWLY TOOLED CLUSTER AND 3-FINGER CONTACTS

Offered for numerous additional circuits not previously available. Tremendous range of options meet most requirements without special tooling.

OTHER FEATURES

- Series 212 is available in numerous combinations with CTS variable resistors and power snap switches.
- Condensed assembly. Wafers can be stacked adjacent to each other. No spacers required.
- Non-toxic combustion fumes—an important advantage in submarine or similar closed space applications.
- Exclusive balanced detent mechanism has 2 dissimilar detent forms for definite feel and long pull in.
- New balanced lever arm and star wheel detent assembly free from end and side thrust for extremely long life and accurately controlled torque. Optional at extra cost.

Founded 1896

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International Electronic Sources

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AWA Tech. Rev. AWA Technical Review
Proc. AIRE. Proceedings of the Institution of Radio Engineers

CANADA

Can. Elec. Eng. Canadian Electronics Engineering
El. & Comm. Electronics and Communications

ENGLAND

ATE J. ATE Journal
BBC Mono. BBC Engineering Monographs
Brit. C.&E. British Communications & Electronics
E. & R. Eng. Electronic & Radio Engineer
El. Energy. Electrical Energy
GEC J. General Electrical Co. Journal
J. BIRE. Journal of the British Institution of Radio Engineers
Proc. BIEE. Proceedings of Institution of Electrical Engineers
Tech. Comm. Technical Communications

FRANCE

Ann. de Radio. Annales de Radioelectricite
Bull. Fr. El Bulletin de la Societe Francaise des Electriciens
Cab. & Trans. Cables & Transmission
Comp. Rend. Comptes Rendus Hebdomadaires des Seances
Onde. L'Onde Electrique
Rev. Tech. Revue Technique
Telonde. Telonde
Toute R. Toute la Radio
Vide. Le Vide

GERMANY

AEG Prog. AEG Progress
Arc. El Uber. Archiv der Elektrischen Ubertragung
El Rund. Electronische Rundschau
Freq. Frequenz
Hochfreq. Hochfrequenz-technik und Electroakustik
NTF. Nachrichtentechnische Fachberichte
Nach. Z. Nachrichtentechnische Zeitschrift
Rundfunk. Rundfunktechnische Mitteilungen
Vak. Tech. Vakuum-Technik

POLAND

Arch. Auto. i Tel. Archiwum Automatyki I Telemechaniki
Prace ITR. Prace Instytutu Tele-I Radiotechnicznego
Roz. Elek. Rozprawy Electrotechnizne

USSR

Avto. i Tel. Avtomatika i Telemakhanika
Radio. Radio
Radiotek. Radiotekhnika
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Iz. Acad. Bulletin of Academy of Sciences USSR.

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ANTENNAS, PROPAGATION

An Analog Computer for Aerial Radiation Diagrams, H. Page, et al. "Rundfunk." Oct. 1960. 4 pp. The paper describes an analog computer for easily determining aerial radiation diagrams for any given combinations of unit elements with different orientation around a central axis. (Germany.)

Ferrite Rods for Broadcast Receiver Antenna Coils, C. M. Wright. "Proc. AIRE." June 1960. 3 pp. Equations are presented for the design of antenna coils wound on ferrite rods. (Australia.)

Some Medium Frequency Sky Wave Measurement, J. M. Dixon. "Proc. AIRE." June 1960. 3 pp. Sky wave field strength measurements at broadcast frequencies for distances up to 2,000 miles are reported for the period 1953-1958. Correlation of the field strength with sunspot number and E layer critical frequency are discussed. (Australia.)

Tropospheric Propagation at VHF, J. M. Dixon. "Proc. AIRE." June 1960. 9 pp. An analysis of VHF field strength recordings for propagation beyond the horizon is presented. The study results from measurements made to establish the interference field strength between common channel television transmitters when the propagation path is over undulating country without mountain ranges. (Australia.)

Mutual Impedance Between Parallel Staggered Half-wave Dipoles, H. E. Green. "Proc. AIRE." Aug. 1960. 2 pp. This paper presents a tabulation of the real and imaginary parts of the mutual impedance between parallel staggered filamentary half-wave dipoles. (Australia.)

The Triangular "V" Aerial, E. O. Willoughby. "Proc. AIRE." Aug. 1960. 7 pp. An aerial is described consisting of a transmission line uniformly expanded in cross-section, of constant characteristic impedance and whose open end is a large aperture. (Australia.)

ILS-VAR Test Beacon, P. B. Free. "Proc. AIRE." Aug. 1960. 6 pp. The ILS-VAR Test Beacon, which is currently under development, radiates a series of signals which simulate those received by an ILS receiver during an instrument approach. The basic requirement embodied in the electrical specification, is described and this is followed by a description of the equipment which will be used to meet this requirement. (Australia.)

AUDIO

Sound Insulation and Noise Control in Broadcast Studios, N. K. D. Choudhury and S. N. Salgarkar. "J. ITE." April 1960. 9 pp. The theory of lightweight partitions, single and double panel, has been discussed. The results of experiments conducted with indigenous panels and porous damping material have been presented and compared with theoretical predictions. The transmission loss observed experimentally is much higher than what is predicted by mass law. On the basis of these results a design of sound-proof door is briefly discussed. (India, in English.)

The Transmission of Room Information, Klaus Wendt. "Rundfunk." Oct. 1960. 4 pp. The acoustical properties of a closed room influence the development in time and space of the sound pressure that is caused by the occurrence of a sound in the room. (Germany.)

CIRCUITS

The Influence of Parameters of a Semiconductor Blocking Oscillator on the Pulse Shape. E. E. Dovjykov. "Radiotek" No. 9, 1960. 7 pp. In this article, the author determines the influence of parameters of a semiconductor blocking oscillator on the amplitude, duration, and shape of the peak of the pulse and the repetition period of the generated pulses. The results of this analysis facilitate the design and construction of semiconductor blocking oscillators, as they enable intelligent selections of their system's individual parameters. (U.S.S.R.)

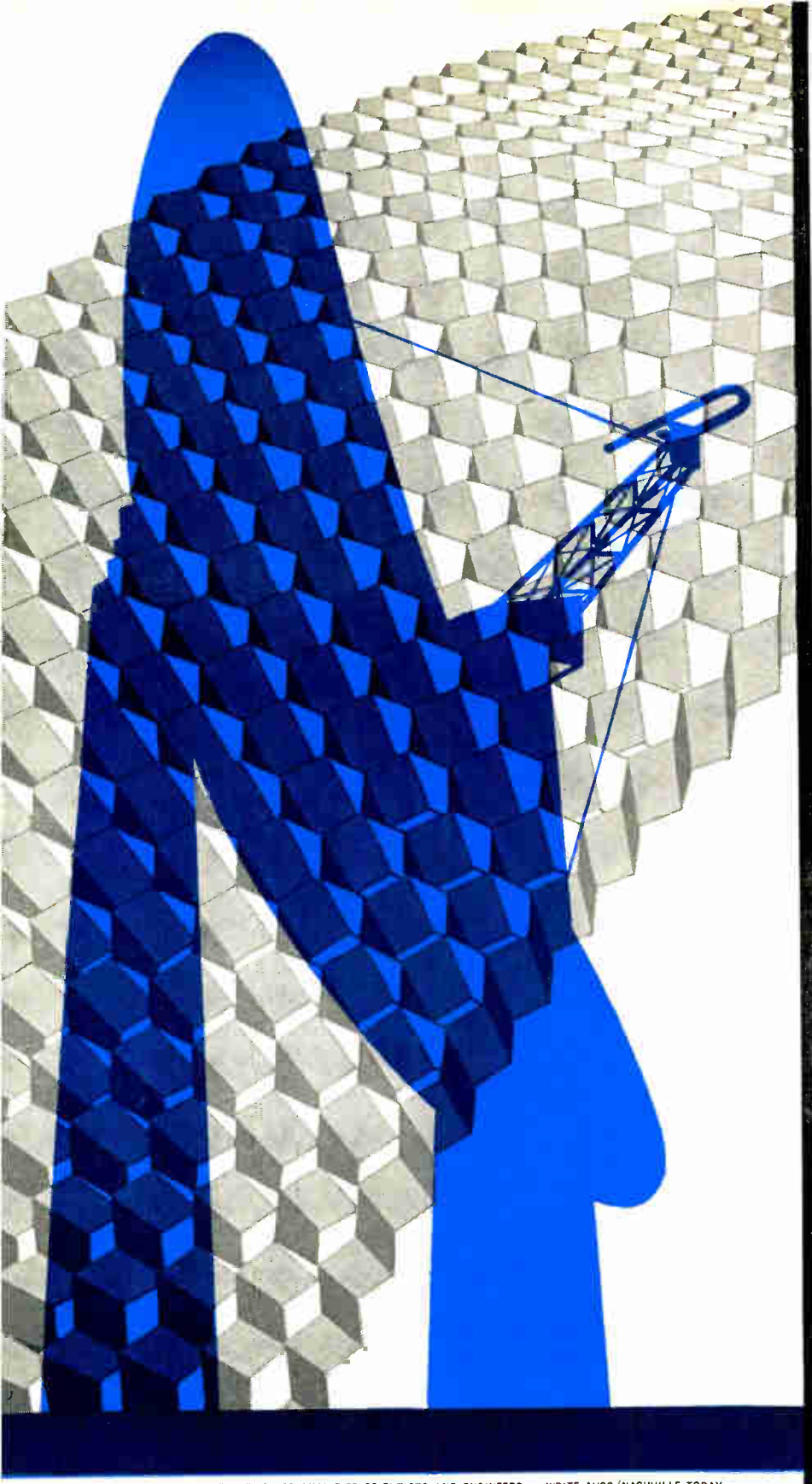
Cascode Amplifier with an Increased Gain, G. P. Petin. "Radiotek" No. 9, 1960. 3 pp. It is shown that the gain of a vacuum-tube cascode amplifier is increased between two and four times, and the internal noise in the tube considerably reduced, by adding a resistor which serves as an additional load in the plate circuit of the first tube, provided the plate load of the second tube is much greater than its internal resistance. Formulae are given for the gain and the passband of this new circuit. (U.S.S.R.)

A Cascade of Non-Reversible Four-terminal Networks, W. Herzog. "Nach. Z." Oct. 1960. 2 pp. A cascade of n unequal, non-reversible, asymmetrical four-terminal networks is replaced by one four-terminal network but with the restriction that the individual four-terminal networks have equal iterative impedances and that their open circuit transfer impedances have an arbitrary but equal ratio. (Germany.)

Generation of High Voltage Pulses, K. D. Mosner. "El. Rund." Oct. 1960. 4 pp. A delay network with suitably charged capacitors may be used as the energy source for a delay-network pulse generator. (Germany.)

A Simple Circuit for a Light Source of Constant Intensity, H. van Suchtelen. "Phil. Tech." #8, 1960. 5 pp. A light source of constant intensity is commonly obtained by supplying an incandescent lamp from accumulators or a stabilized power supply. It is more logical, however, to stabilize the luminous intensity itself. A circuit designed for this purpose is described. (Netherlands, in English.)

The Design of Direct Coupled Pre-Amplifiers, L. Dally, et al. "Proc. AIRE." July 1960. 3 pp. Two hybrid (electrometer) triode-transistor amplifiers are discussed. Positive feedback effectively reduces the input capacity of one amplifier. The analysis of the feedback is given. (Australia.)



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Optimum Pass Band of a Filter in an FM Receiver System with Tracking Tuning, Y. G. Rodionov. "Radiotek" No. 9, 1960. 7 pp. In this article, the author establishes the value of the pass-band of a filter in a system with tracking tuning, in order to provide maximum signal to noise ratio and to reproduce the useful signal with the highest fidelity. The pass-band of the filter adjusts itself to the instantaneous frequency of the useful received signal. (U.S.S.R.)

GENERAL

A Method for Interpolating Functions Using Exponential Polynomials and its Application to Synthesis of Circuits Based on Time Characteristics, N. S. Kotchanoff. "Radiotek" 15, No. 8, 1960. 6 pp. The author analyzes a method to set up exponential polynomials, according to the requirements of the time function and its first derivative in several equally spaced points of interpolation. An application of this method is shown in the design of a four-pole network which forms a bell-shaped pulse. (U.S.S.R.)

Quantitative Characteristics of Reliability, H. L. Smolitzky, P. A. Chukreyev. "Radiotek" 15, No. 8, 1960, 7 pp. Failure rate of a complex system as affected by a constant replacement of failing components by new ones is analyzed. It is shown that during continuous operation of equipment the failure rate reaches a certain level, which corresponds to the average operation time of the system components. (U.S.S.R.)

Dehydration Freezing and Storage of Meat, K. Neumann. "Vak. Tech." May 1960. 5 pp. (Germany.)

The Evaporation of Metals in Vacuum and the Dependence of Their Properties on the Evaporating Substrate, L. E. Preuss and C. E. Alt. "Vak Tech." May 1960. 4 pp. A new method which has been developed for the self-imaging of the spatial confines of the distillation geometry at geometry of vacuum evaporation sources, has been used in this work to map the regions of distilland emanation from a series of simple metal evaporation sources. (Germany.)

Calculation of the Transfer Function from the Value of the Transfer Characteristics, G. Wunsch. "Freq." July 1960. 4 pp. It is possible that with the applications of this theory one arrives at conclusions that are contradictory to the principle of casuality. This paper shows how the system theory of Kupfmuller can be generalized and improved at an important point in a way that no physical contradictions are possible any longer and all conclusions are rigorously valid in the sense that they can be realized by networks with any desired degree of accuracy. (Germany.)

The Quantization of Speech with a Small Number of Steps, W. Andrich. "Nach. Z." Aug. 5 pp. (Germany.)

Electronics in Medical and Biological Research, W. J. Perkins. "Brit. C&E." Aug. 1960. 5 pp. (England.)

Detecting Metallic Particles in the Eye, H. R. Shaylor and P. D. Whitaker. "Brit. C&E." Aug. 1960. 3 pp. A recent development in ophthalmic surgery has been the introduction of electronic instruments for the detection and location of foreign bodies. (England.)

Nuclear Structure, J. Hamilton. "Endeavour." July 1960. 9 pp. This article reviews the experimental evidence for the structure of the nucleus and discusses its relevance to the shell model. (England.)

New High-Vacuum Technique, Constructional Kits for Students, J. H. Owen Harries. "El. Tech." Aug. 1960. 6 pp. A students' kit has

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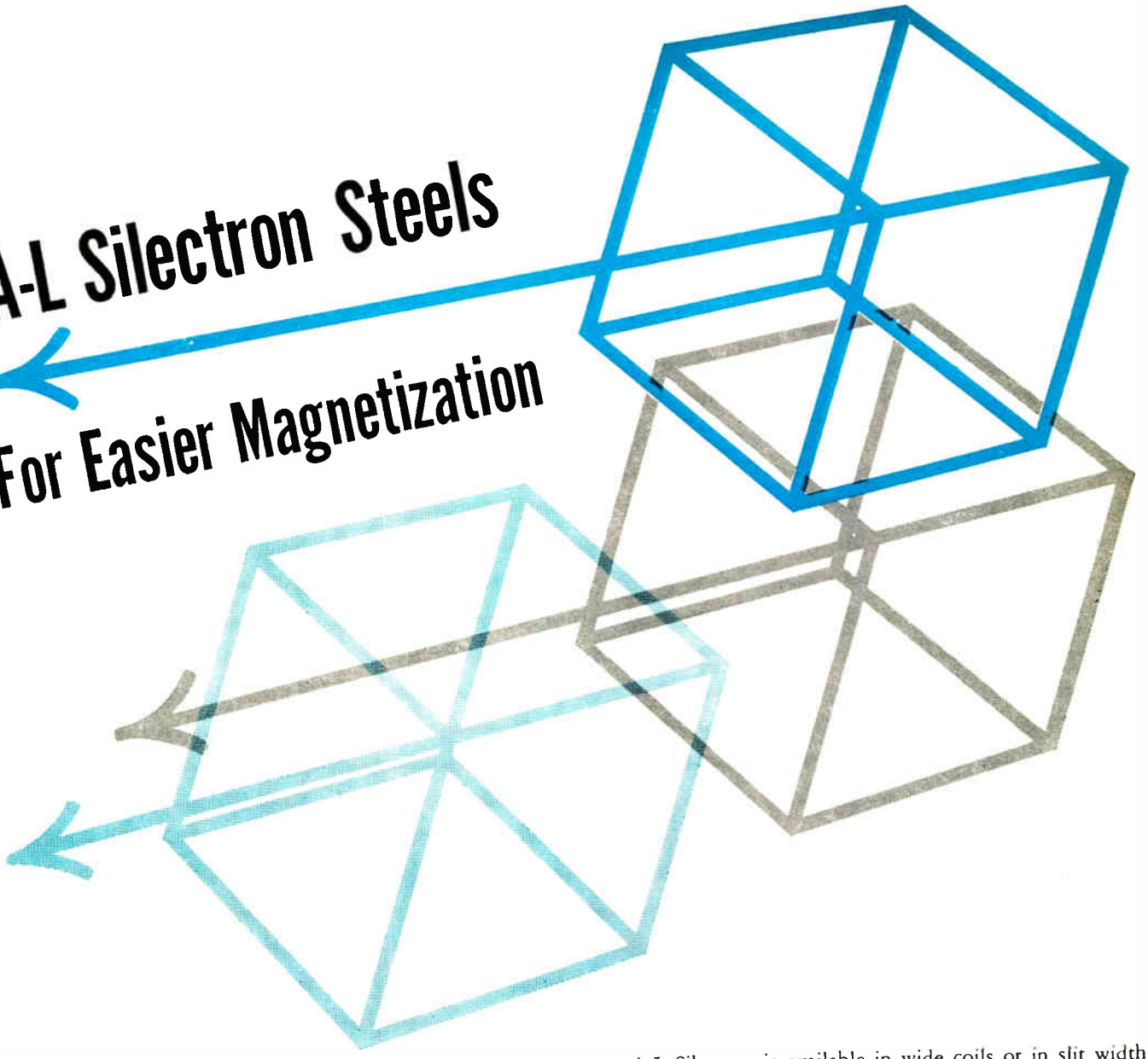

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been designed and exhibited. Some classroom experiments have been demonstrated. The vacuum technique and kits have applications in research and industry as well as in teaching. (England.)

The New Electronics, Superconductivity, Phonon. "El. Tech." Aug. 1960. 5 pp. (England.)

The New Electronics, Magnetism 1, Phonon. "El. Tech." Sept. 1960. 4 pp. (England.)

The New Electronics, Magnetism 2, Phonon. "El. Tech." Oct. 1960. 4 pp. (England.)

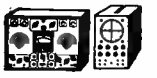
Precision Crystal Chronometer, R. A. Spears. "El. Tech." Oct. 1960. 5 pp. In between conventional mechanical clocks and the caesium or ammonia maser equipment there is a wide gap. This gap exists in respect of performance complexity and cost. A new crystal chronometer has been designed to reduce this gap and to provide time and impulse facilities having an accuracy of a high degree. (England.)

Angle-Modulated Wave, A Further Note on Associated Power, W. C. Vaughan. "El. Tech." Oct. 1960. 2 pp. (England.)

A Simple Speech Synthesizer, D. J. Woollons and A. M. R. Gill. "El. Tech." Oct. 1960. 3 pp. (England.)

Determination of Rapid Frequency Changes with an Accuracy of 10^{-9} to 10^{-13} through the Measurement of the Period of the Oscillation, R. Mitterer. "Freq." May 1960. 6 pp. For the investigation of crystal oscillators the paper states the demands on frequency accuracy and permissible measurement methods. (Germany.)

Dependence of the Impedance of Carbon Film Resistors on the Frequency and DC Resistance, A. Debel and L. Hechler. "Freq." June 1960. 5 pp. The paper describes a measuring arrangement, whose mounting dimensions are referred to a standardized size (length of the resistor). The characteristic shape of the impedance-vs. frequency function found with this arrangement is described. (Germany.)



MEASURE & TESTING

Multiple Indication of Electric Measurements, G. Kosel. "El. Rund." July 1960. 3 pp. (Germany.)

Novel Building-block System for Electronic Measuring and Control, H. von Tolnai. "El Rund." Aug. 1960. 4 pp. (Germany.)

Electronic Measuring of Speed and Flow, K. Zeilinger. "El Rund." Aug. 1960. 3 pp. (Germany.)

New Oscilloscopes. "El Rund." Aug. 1960. 3 pp. (Germany.)

On the Stability of Impulse Synchronized Relaxation Oscillations, E. de Castro. "Alta Freq." April 1960. 26 pp. The stability of impulse synchronization of relaxation oscillators is studied. (Italy.)

Temperature Coefficient of Capacitance and of Inductance, D. A. Bell. "El. Tech." Sept. 1960. 4 pp. (England.)

Recording Atmospheric Radio Noise, Use of Magnetic Tape, C. Clarke. "El. Tech." Sept. 1960. 1 p. A comparison of noise structure on 24 kc/s obtained from direct measurement and via the medium of tape recording shows that the results are statistically indistinguishable. (England.)

AC Bridges with Inductive Ratio Arms, Compensations for Leakage Reactance Effects. F. Butler. "El. Tech." Aug. 1960. 7 pp. (England.)

RADAR, NAVIGATION

Input Impedance of Interference Meters for the Broadcast Frequency Band, I. M. Fourmanhoc. "Radiotek" 15, No. 6, 1960. 4 pp. Equations are derived for calculations of the input impedance of interference meters for the broadcast band of frequencies (0.15-20.00 Mgcs). The input impedance is determined for the typical model -12-2M interference meter. Offered is the input circuit of the meter with a matched divider for measurements of radio interference. Circuit is in the equivalent circuit form. (U.S.S.R.)

TUBES

The Generation of X-rays in Valves, Reusse. "Nach. Z." Feb. 1960. 4 pp. The physical conditions under which X-rays may be produced in valves used in communications are explained briefly. Also the resulting possible radiation hazards for the personnel operating communication equipment are reported taking the recommendations of the "International Commission on Radiological Protection" into consideration. (Germany.)

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151 Kester Solder Company — Resin-core solder.
55 Keystone Carbon Company—Thermistors
108 Kulka Electric Corp.—Terminal blocks.

37 Lenz Electric Manufacturing Company—High voltage lead wire.
23 Light Electric Corp.—Custom transformer.
360 Ling-Temco Electronics, Inc. — Micromodular components.
61 Littelfuse—Indicating fuse posts.

144 Magnetic Amplifiers Division—Static inverter supply.
158 Magnetics, Inc.—Tape wound cores.
140 McKinstry Metal Works, Inc.—Waterproof wiring boxes.
137 Methode Manufacturing Corp.—Multiple contact connectors.
94 Microtran Company, Inc.—Transformer catalog.
29 Microwave Associates, Inc.—Magnetrons.
123 Miller Company, W.—Molded choke coils.
96 Motorola Semiconductor Products, Inc.—Power transistors.
43 Muirhead Instruments, Inc.—Noise and vibration recording analyzer.

Employment—Use the handy card below to get more information on the engineering positions described in the "Professional Opportunities" Section which begins on page 207 of this issue.

Postcard valid 8 weeks only. After that use own letterhead describing item wanted. DEC. 196

PROFESSIONAL ENGINEERING OPPORTUNITIES

Please send me further information on the engineering positio I have circled below.

501	506	511	516	521
502	507	512	517	522
503	508	513	518	523
504	509	514	519	524
505	510	515	520	525

YOUR NAME .....TITLE.....

HOME ADDRESS .....

CITY or TOWN .....ZONE.....STATE.....

DEC. 196

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I wish a new complimentary subscription to ELECTRONIC INDUSTRIES ☐ Yes ☐ No

Company Name: .....

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Company Address: .....

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

Specific Products Manufactured .....

YOUR NAME .....TITLE..... DEC. 196

FIRM .....

FIRM ADDRESS .....

CITY OR TOWN.....ZONE.....STATE.....

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	2
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41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	6
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	8
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	10
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161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	18
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	20
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221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	24
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	26
261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	28
281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	30
301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	32
321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	34
341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	36

Postcard valid 8 weeks only. After that use own letterhead describing item wanted. 361 362 363 364 36

Please send me further information on the items I have circled above.

149 Newman Corporation, M. M.—Spirally-cut plastic tubing.

38 Ohmite Manufacturing Company—Rheostats.

10 Pacific Semiconductors, Inc.—Micro-mesa silicon diodes.

107 Pennwood Numechron Company—Elapsed time counter and digital clock.

11 Philco, Lansdale Division — Switching transistor, high-speed.

135 PIC Design Corporation—Precision instrument parts catalog.

16 Polarad Electronics Corporation—Spectrum analyzer.

17 Polarad Electronics Corporation—Spectrum selector.

128 Potthoff, William C.—Management consultant.

104 Power Designs, Inc. — Regulated DC power supply.

120 Powertron Ultrasonics Corp.—Ultrasonic cleaners.

69 PRD Electronics, Inc.—Bolometers, barretters, and thermistors.

143 Quan-Tech Laboratories—Noise analyzers.

1 Radio Materials Company—Ceramic disc capacitors.

110 Raytheon Company, Industrial Components Div.—Long-life twin power triodes.

86 Reeves-Hoffman, Div. of Dynamics Corp. of America—Crystal oscillators.

131 Rohn Manufacturing Company — Communication tower.

98 Rondo of America, Inc.—Paper packaging units.

108 Sangamo Electric Company—Electrolytic capacitors.

27 Sangamo Electric Company—Magnetic tape recorder/reproducer.

39 Sarkes Tarzian, Inc.—Silicon rectifiers.

80 Scientific-Atlanta, Inc. — Antenna pattern recorders.

47 Shallcross Manufacturing Company — Wirewound resistance networks.

361 SIFCO Metachemical, Inc.—Electroplating equipment.

46 Speer Carbon Company—Fixed composition resistors.

81 Sperry Semiconductor Div. of Sperry Rand Corp.—Silicon mesa transistors.

2 Sprague Electric Company—Tubular capacitor.

134 Stainless, Inc.—Commercial towers and supports.

129 Stanpat Company—Adhesive base drafting aid.

117 Stewart Engineering Corporation—Backward wave oscillator.

146 Stromberg-Carlson, Div. of General Dynamics—Relays.

56 Sylvania Electric Products, Inc., Electronic Tubes Div. — Decade counter tubes.

28 Sylvania Electric Products, Inc., Semiconductor Div. — Germanium mesa transistors.

84 Sylvania Electric Products, Inc., Special Tube Operations—Ka-band magnetron.

41 Synthane Corporation—Laminated plastics.

114 Syntron Rectifier Div.—Silicon rectifiers.

148 Syntronic Instruments, Inc.—Deflection yokes.

53 TA Mfg. Corp.—Engineering supply catalog.

12 Tektronix, Inc.—Calibrated differential comparator.

35 Tensor Electric Development Company, Inc.—AC-DC Reference source.

42 Texas Instruments, Inc.—Silicon transistors.

58 Thompson-Ramo-Wooldridge, Inc.—Electrical power components.

54 Times Wire & Cable Div., The International Silver Company—Multi-conductor cable.

36 Tinnerman Products, Inc.—Locknuts.

95 Trak Electronics Company—Controllable inductors.

71 Tung-Sol Electric, Inc.—Clipper thyratrons.

87 United Transformer Corporation—Transistor transformers.

157 Varflex Sales Co., Inc.—Silicone rubber sleeving.

74 Varian Associates—Amplifier klystron.

109 Waveline, Inc.—Attenuators.

59 Westinghouse Electric Corp., Semiconductor Dept.—Silicon rectifier stacks.

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NEW* Revolutionary† DO-T and DI-T TRANSISTOR TRANSFORMERS

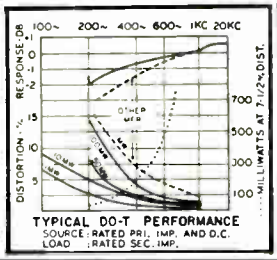
FROM STOCK—Hermetically Sealed to MIL-T-27A Specs.

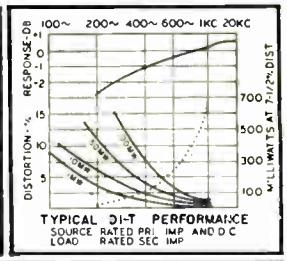
There is no transformer even twice the size of the DO-T and DI-T series which has as much as 1/10th the power handling ability . . . which can equal the efficiency . . . or equal the response range. And none to approach the reliability of the DO-T and DI-T units (proved to, but exceeding MIL-T-27A grade 4).

High Power Rating	up to 10 times greater.
Excellent Response	twice as good at low end.
Low Distortion	reduced 80%.
High Efficiency	up to 30% better . . . compare DCR.
Moisture Proof	hermetically sealed to MIL-T-27A.
Rugged	completely metal cased.
Anchored Leads	will withstand 10 pound pull test.
Printed Circuit Use	(solder melting) plastic insulated leads.
Suited to Clip Mounting	use Augat #6009-8A clip.

TRANSFORMERS PICTURED ACTUAL SIZE
DO-T: 5/16 Dia. x 13/32", 1/10 Oz.; DI-T: 5/16 Dia. x 1/4", 1/20 Oz.

Typical Printed Circuit Positioning





DO-T No.	Pri. Imp.	D.C. Ma.‡ in Pri.	Sec. Imp.	Pri. Res. DO-T	Pri. Res. DI-T	Mw. Level	DI-T No.
DO-T1	20,000	.5	800	850	815	50	DI-T1
	30,000	.5	1200				
DO-T2	500	3	50	60	65	100	DI-T2
	600	3	60				
DO-T3	1000	3	50.	115	110	100	DI-T3
	1200	3	60				
DO-T4	600	3	3.2	60		100	
DO-T5	1200	2	3.2	115	110	100	DI-T5
DO-T6	10,000	1	3.2	790		100	
DO-T7	200,000	0	1000	8500		25	
	500	0	100,000	—			
	Reactor 2.5 Hys./2 Ma., .9 Hy./4 Ma			630			DI-T8
DO-T8	" 3.5 Hys./2 Ma., 1 Hy./5 Ma			630			
DO-T9	10,000	1	500 CT	800	870	100	DI-T9
	12,000	1	600 CT				
DO-T10	10,000	1	1200 CT	800	870	100	DI-T10
	12,500	1	1500 CT				
DO-T11	10,000	1	2000 CT	800	870	100	DI-T11
	12,500	1	2500 CT				
DO-T12	150 CT	10	12	11		500	
	200 CT	10	16				
DO-T13	300 CT	7	12	20		500	
	400 CT	7	16				
DO-T14	600 CT	5	12	43		500	
	800 CT	5	16				
DO-T15	800 CT	4	12	51		500	
	1070 CT	4	16				
DO-T16	1000 CT	3.5	12	71		500	
	1330 CT	3.5	16				
DO-T17	1500 CT	3	12	108		500	
	2000 CT	3	16				
DO-T18	7500 CT	1	12	505		500	
	10,000 CT	1	16				
DO-T19	300 CT	7	600	19	20	500	DI-T19
DO-T20	500 CT	5.5	600	31	32	500	DI-T20
DO-T21	900 CT	4	600	53	53	500	DI-T21
DO-T22	1500 CT	3	600	86	87	500	DI-T22
	600	5	1500 CT	—			
DO-T23	20,000 CT	.5	800 CT	850	815	100	DI-T23
	30,000 CT	.5	1200 CT				
DO-T24	200,000 CT	0	1000 CT	8500		25	
	500 CT	0	100,000 CT	—			
DO-T25	10,000 CT	1	1500 CT	800	870	100	DI-T25
	12,000 CT	1	1800 CT				

DO-T No.	Pri. Imp.	D.C. Ma.‡ in Pri.	Sec. Imp.	Pri. Res. DO-T	Pri. Res. DI-T	Mw. Level	DI-T No.
	Reactor 4.5 Hys./2 Ma., 1.2 Hys./4 Ma.				2300		DI-T26
DO-T26	" 6 Hys./2 Ma., 1.5 Hys./5 Ma.			2100			
	Reactor .9 Hy./2 Ma., .5 Hy./6 Ma.				105		DI-T27
DO-T27	" 1.25 Hys./2 Ma., .5 Hy./11 Ma.			100			
	Reactor .1 Hy./4 Ma., .08 Hy./10 Ma.				25		DI-T28
DO-T28	" .3 Hy./4 Ma., .15 Hys./20 Ma.			25			
DO-T29	120 CT	10	3.2	10		500	
	150 CT	10	4				
DO-T30	320 CT	7	3.2	20		500	
	400 CT	7	4				
DO-T31	640 CT	5	3.2	43		500	
	800 CT	5	4				
DO-T32	800 CT	4	3.2	51		500	
	1000 CT	4	4				
DO-T33	1060 CT	3.5	3.2	71		500	
	1330 CT	3.5	4				
DO-T34	1600 CT	3	3.2	109		500	
	2000 CT	3	4				
DO-T35	8000 CT	1	3.2	505		100	
	10,000 CT	1	4				
DO-T36	10,000 CT	1	10,000 CT	950	970	100	DI-T36
	12,000 CT	1	12,000 CT				
*DO-T37	2000 CT	3	8000 Split	195		100	
	2500 CT	3	10,000 Split				
*DO-T38	10,000 CT	1	2000 Split	560		100	
	12,000 CT	1	2400 Split				
*DO-T39	20,000 CT	.5	1000 Split	800		100	
	30,000 CT	.5	1500 Split				
*DO-T40	40,000 CT	.25	400 Split	1700		50	
	50,000 CT	.25	500 Split				
*DO-T41	400 CT	8	400 Split	46		500	
	500 CT	6	500 Split				
*DO-T42	400 CT	8	120 Split	46		500	
	500 CT	6	150 Split				
*DOT-43	400 CT	8	40 Split	46		500	
	500 CT	6	50 Split				
*DO-T44	80 CT	12	32 Split	9.8		500	
	100 CT	10	40 Split				
DO-TSH	Drawn Hipermalloy shield and cover 20/30 db						DI-TSH

‡ DCMA shown is for single ended useage (under 5% distortion—100MW—1KC) . . . for push pull, DCMA can be any balanced value taken by .5W transistors (under 5% distortion—500MW—1KC)

† DO-T & DI-T units designed for transistor application only. Pats. Pend.

* DO-T37 thru DO-T44 newly added to series.

And Special Units to Your Specifications

Circle 87 on Inquiry Card

UNITED TRANSFORMER CORPORATION

150 Varick Street, New York 13, N. Y.

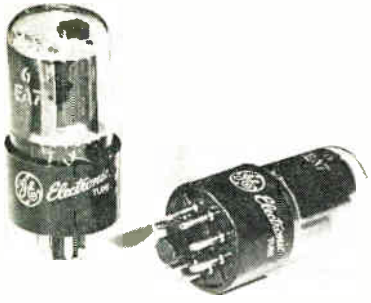
PACIFIC MFG. DIVISION: 4008 W. JEFFERSON BLVD., LOS ANGELES 16, CALIF.

EXPORT DIVISION: 13 EAST 40th STREET, NEW YORK 16, N. Y. CABLES: "ARLAB"

New Products . . . for the Electronic Industries

DOUBLE TRIODE

The 6EA7 is a new low-high plate dissipation double triode tube for vertical-deflection oscillator and amplifier applications in television receivers. Tube contains both a high-mu triode (section 1) and a low-mu, high-per-



veance triode (section 2). It is an octal "GT" type. Section 1 has a design max. rating of 350 plate v. with peak negative grid voltage of 400 and plate dissipation of 1.0 w. Section 2, with a design max. plate voltage rating of 550 vdc, is rated at 10 w plate dissipation and 175 ma of peak cathode current. General Electric Co., Receiving Tube Dept., Owensboro, Ky.

Circle 227 on Inquiry Card

PORTABLE CALIBRATOR

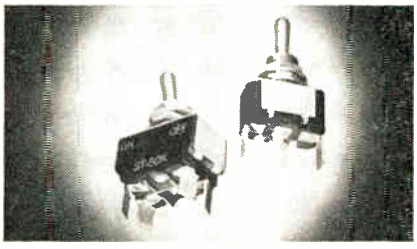
Portable, self-contained vibration exciter for field calibration of vibration pickups operates directly from a 60 CPS power line and has a simple, reliable amplitude indicator. For quick checking of small vibration pickups, it permits on the spot checking of vibration and pressure transducers without using elaborate and complex test equipment. Electrical Characteristics: power source, 110 v., 60 CPS, 5 w; calibration point, 10 g peak (other calibration points available); frequency, 60 CPS (from

power supply); accuracy, within 5% at 60 CPS; Mechanical Specs: carrying case, wood; dimensions 9½ x 8½ x 7 in.; weight, 8 lbs. Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J.

Circle 228 on Inquiry Card

TOGGLE SWITCHES

Line of single pole and double pole, aircraft-type toggle switches have ¼ in. wide male tab connections for use with Burndy, AMP, or Kent female connectors. They meet military specs and are available in all circuit

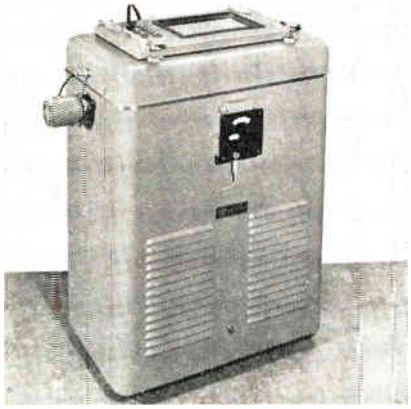


configurations including momentary ON/OFF modes. They are for dc or ac applications to 1600 CPS. Barrier design is used between all connections for longer leakage paths and min. chance of direct contact short circuits. New tab connections are of brass, electro-tinned to prevent corrosion. Kulka Electric Corp., 633-643 So. Fulton Ave., Mt. Vernon, N. Y.

Circle 229 on Inquiry Card

HI-LO TEMPERATURE CHAMBER

For both moderate production and environmental testing, continuous operation or intermittent use, this 2 ft.³ unit, Model A-120-2-HC, affords a temp. range from as low as −150° F to as high at +300° F (± 2°) with indicating controller. (Recording-programming as optional features). Chamber 24 x 12 x 13½ in., fin coil and blower, two 2 in. ports and lid with multipane frost-free window make this self contained unit ideal for job shop or R/D applications. It



is mounted on casters for portability. It has lifetime silent signal and internal illumination for safety and convenience. Cincinnati Sub Zero Products, 3932 Reading Rd., Cincinnati 29, Ohio.

Circle 230 on Inquiry Card

LINEAR TRANSFORMER

Size 8 linear transformer model 9708-005 can deliver ½ w of power into a 500 ohm load while retaining its linearity of 0.33% over range of ±30°. Working into a 3000 ohm load the unit is linear to ±50°. It has a

26 v., 400 cycle input, with phase shift control capabilities to ± 30'. It meets Mil spec requirements for 1200 hrs rotational life and other conditions of MIL-E-5272 and MIL-E-5400. Operating temp. range is −55°C to + 125°C with short time exposure capabilities to 200°C. imc. Magnetics Corp., Western Div., 6058 Walker Ave., Maywood, Calif.

Circle 231 on Inquiry Card

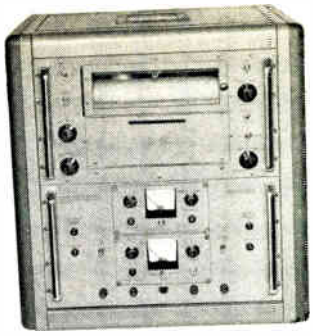
HIGH GAIN AMPLIFIERS

Two low level, high gain amplifiers added to line. For 60 and 400 CPS excitation, these self-saturating full wave magnetic amplifiers can be used as linear or bi-stable amplifiers, with dc or ac output. They can operate relays from low energy dc signal sources. Supplied with 3 independently isolated control windings — 2 high gain and 1 low gain-bias or feedback; they have a max. power output of 0.85 w and a power gain in excess of 100,000. Operating amb.

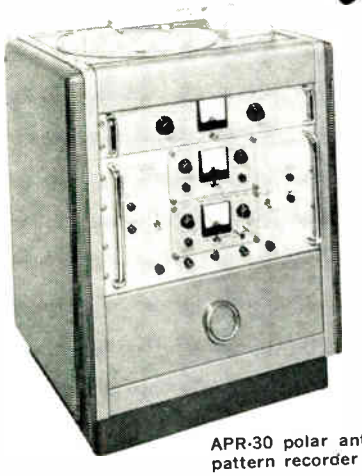
temp. is −55° C to +100° C. The MA-31, 400 CPS, is 1½ in. in dia. and 1½ in. long. The MA-36, 60 CPS is 2¾ in. in dia. and 3½ in. long. Magnetico, Inc., 6 Richter Court, E. Northport, L. I., N. Y.

Circle 232 on Inquiry Card

Flexibility and Refinement



APR-20 rectangular antenna pattern recorder

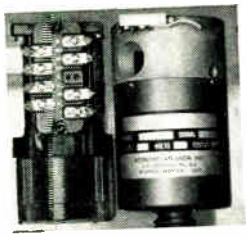


APR-30 polar antenna pattern recorder

...The reason most antenna pattern recorders come from

It's the little things that make the difference. Little things, refinements, "extras," and top-notch workmanship all add up to preference for S-A instrumentation.

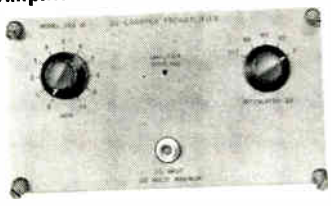
Things Like Plug-In Balancing Potentiometers...



Series P plug-in pen balancing potentiometers

Series P potentiometers are used in both rectangular and polar coordinate pattern recorders. By interchanging potentiometers together with the appropriate pen function amplifier, different responses—linear, square-root, and logarithmic—are obtained. Interchanging these new self-aligning potentiometers can be accomplished in less than thirty seconds. Stocking spare units cuts downtime. Of dust and dirt proof construction, Series P plug-in balancing potentiometers are offered with exchange pricing.

DC Amplifiers...



DCA-21 amplifier for dc input signals

Scientific-Atlanta's DCA-21 amplifier lets APR 20/30 recorders accept dc input signals. A narrow band amplifier preceded by an electromagnetic chopper, the sensitive DCA-21 has a linear dynamic range of 80 db. The unit is directly interchangeable with Series CBA-20 Crystal-Bolometer amplifiers.

Recorder Pen Programmers...

Up to five different pen writing codes can be selected by adding the Model RPP-1 Recorder Pen Programmer to an APR 20/30 installation. Compact, lightweight, and rack mounted, the programmer provides solid line, dot, dash, dash-dot, and space-dot-dot codes at an adjustable code rate of 30 to 90 cycles per minute.

Modification C, Chart Compression...

Modification C, which must be ordered at the time of recorder purchase, provides both standard and compressed cycle charts from a single APR 20 Rectangular pattern recorder. Standard chart cycle is 20 inches, compressed 8 inches. Compressed recordings are conveniently sized to fit standard 8½ x 11 notebooks and reports.

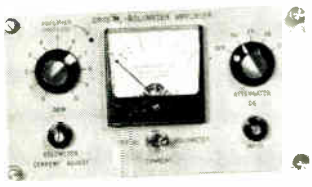
Chart Paper, Recording Pens, Ink, and Accessories...

Scientific-Atlanta offers its customers one-day service by stocking, for immediate delivery, a wide variety of chart paper, recording pens, and other recording necessities.

But above all, it's the engineering philosophy of a company run by antenna engineers for antenna engineers.

Call your nearby S-A engineering representative for more information on S-A pattern recorders and accessories. For complete technical information, please write to Box 44.

Crystal Bolometer Amplifiers...



High gain, low noise crystal-bolometer antenna

Sensitive, narrow-band Crystal-Bolometer amplifiers are miniaturized units designed for use as preamplifiers in S-A polar and rectangular pattern recorders. Five models, CBA-21 through CBA-25 are available. Features include bolometer burnout protection, low noise figure, triaxial signal ground return, up to 108 db gain, 80 db linear dynamic range, adjustable bandwidth (CBA-23), high rejection (CBA-24), variable center frequency (CBA-25).

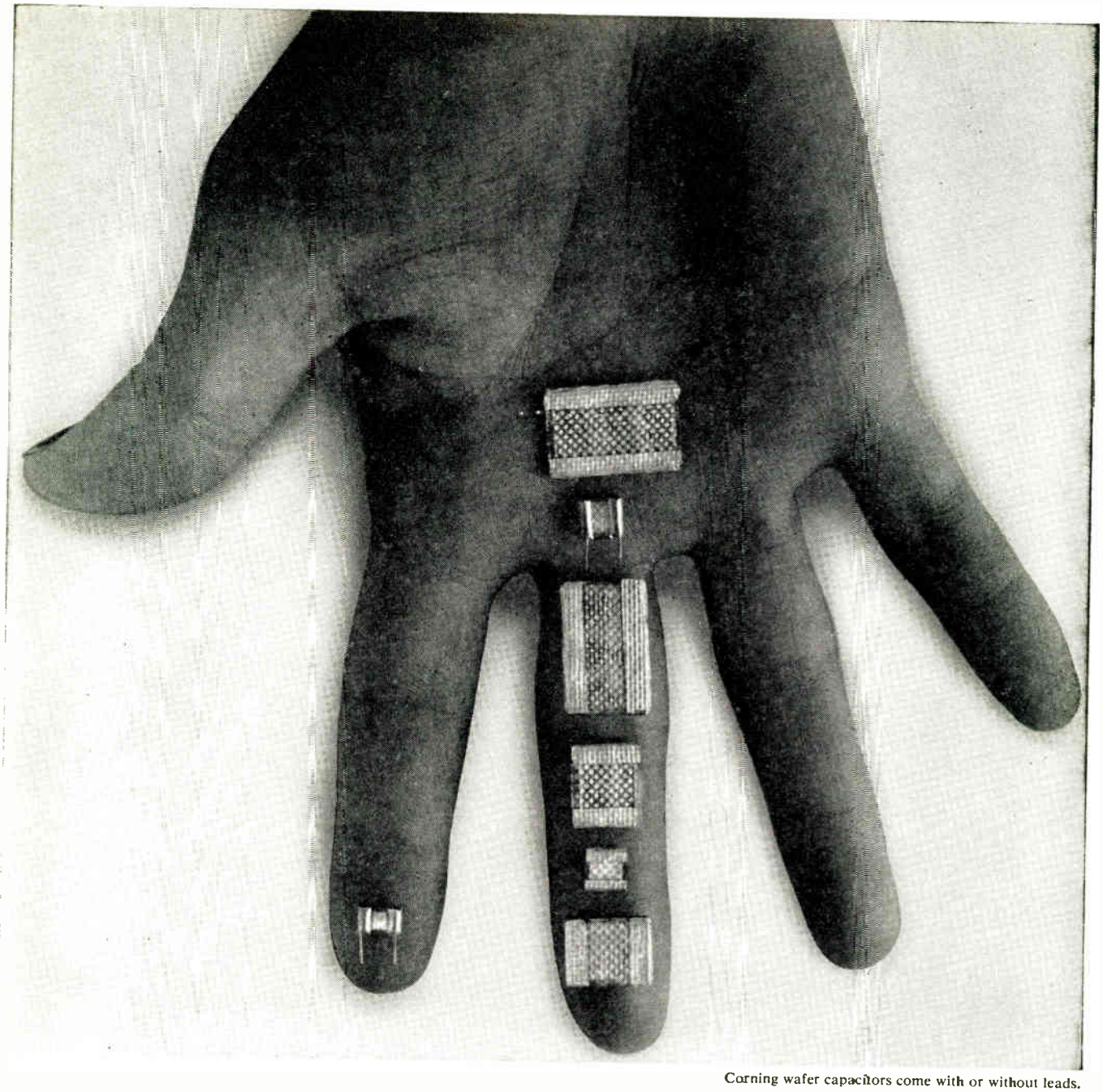
SCIENTIFIC-ATLANTA, Inc.

2162 Piedmont Road, N.E. • Atlanta 9, Georgia

TRinity 5-7291

7

Circle 80 on Inquiry Card



Corning wafer capacitors come with or without leads.

You can cram a lot of stable capacitance into a wafer

Uuf for uuf the smallest, most stable capacitors you can get for printed circuits and high reliability components.

Never has so much capacitance been crammed into so little space with so much ruggedness and reliability.

The smallest gives from 1 to 560 uuf while resting in a space only 0.00204 cubic inch in volume.

The largest runs from 4301 to 10,000 uuf and takes up only 0.02106 cubic inch.

You sacrifice nothing for size. The flat shape gives you more options in mounting, e.g., slot or flat mounting in printed circuits.

When you need leads we can provide those too, in 3/16-inch lengths, in the WL series.

These capacitors are rugged and reliable. The dielectric and conductor layers are fused at high temperatures and need no encasement. You'd almost have to smash one completely to stop its operation. Meets or exceeds the performance requirements of MIL-C-11272A.

For complete specs write for a new 4-page bulletin to Corning Glass Works, Dept. 546, Bradford, Pa.

Capacitor	Capacitance (uuf)	Volume (approx.)
W, WL-5	1 to 560	0.00204 in.^{3}
W, WL-4	561 to 1000	0.00327
W, WL-3	1001 to 2700	0.00702
W, WL-2	2701 to 4300	0.01951
W, WL-1	4301 to 10,000	0.02106

CORNING ELECTRONIC COMPONENTS

CORNING GLASS WORKS, BRADFORD, PA.

A NEW CONCEPT IN SCAN CONVERSION

from G E C

Now a low cost completely transistorized Scan Conversion unit is available which is capable of:

- TRANSLATION of video information from one scanning mode to another;
- STORAGE and INTEGRATION of video information;
- Expansion or reduction of bandwidth through TIME—COORDINATE TRANSFORMATION.

This completely transistorized, versatile system can be readily tailored to your specific needs through its plug-in printed circuits. For more information about conversion of radar PPI to TV, TV standards conversion or conversion of slow scan narrow band systems to standard TV or vice versa, contact GEC today.

. . . advanced electronics at work

G E C

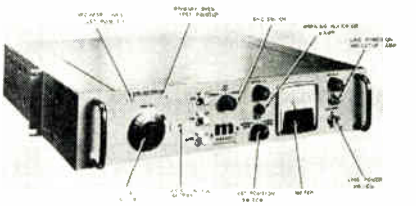
GENERAL ELECTRODYNAMICS CORPORATION

4430 FOREST LANE • GARLAND, TEXAS • BROADWAY 6-1161

New Products

FREQUENCY STANDARD

Transistorized Frequency Standard, Model RD-180, provides stable output frequencies of 5 MC, 1 MC and 100 KC for frequency control systems. Stability is ± 5 parts in 10^{10} day. Specs: 1 MC and 100 KC (simultaneous) output levels, 1 v RMS +



50/—10%; 5 mc output level, 25 mv./into 1 K ohm load; output impedance, 1 MC & 100 KC into 50 ohms; amb. temp., 0 to 50°C; amb. humidity, 0 to 95% RH; warm-up, 6 hrs.; freq. stability (after 4 mon. aging) under these conditions, ± 5 parts in 10^{10}/day; 25°C amb. ± 5 parts in 10^{10}; ± 20% change in 50 ohm load, ± 2 parts in 10^{10}; 28 vdc input changed ± 4 vdc, ± part in 10^{10}; freq. adjustment, 500 parts in 10^{9} total. Fine freq. adjustment: 150 parts in 10^{9} for 15 rev.; 1 part in 10^{9} per rev.; 1 part in 10^{10}/div. (100 div./rev); coarse freq., 350 parts in 10^{9}; input voltage requirement, 115 vac ± 10%, 50-400 CPS. Manson Labs., Inc., 375 Fairfield Ave., Stamford, Conn.

Circle 233 on Inquiry Card

DIGITAL DISPLAY

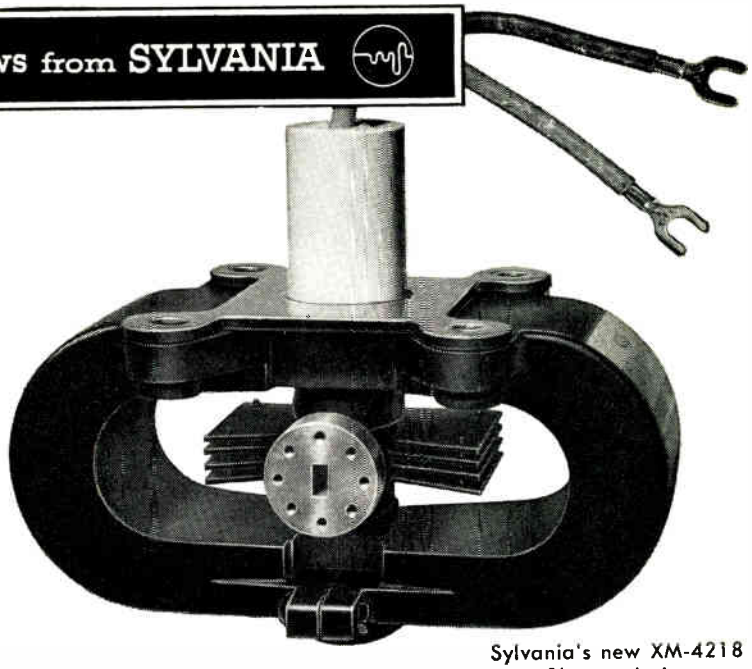
The Digistrobe digital display employs the stroboscopic principle to provide an in-line, in-plane, high-definition, white-on-black display. Specs: power, single-phase, 60 CPS, 115 v., (±10%); min. strobe tube life, 2000 hrs.; max. transition time from display quantity to display

quantity, 56 msec.; dimensions, 2 x 4 x 15¾ in.; character height, 0.226 in.; space between columns, ¼ in.; viewing angle, 54° vertical, 90° horizontal. Kearfott Div., General Precision, Inc., 1150 McBride Ave., Little Falls, N. J.

Circle 234 on Inquiry Card

Microwave Component News from SYLVANIA

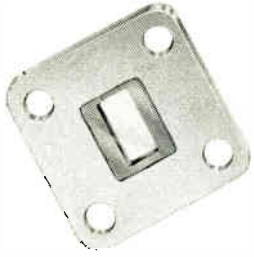
NEW



Sylvania's new XM-4218
3/5 actual size

Ka-band magnetron rugged, lightweight, low in cost

Designed for missile and airborne applications... mapping, surveillance, drones, fire control... this 25 kilowatt Ka-band unit operates at 33,000 ft. without capsule pressurization or potting compound. Corona problems are eliminated by a unique new ceramic cathode support design. The tube withstands 10 G vibration (50 to 2000 cycles), and meets military environmental specifications. It is extremely light in weight (approx. 4 lbs.) making it one of the lightest-weight medium power Ka-band tubes. Engineering samples are available.



WG-4223
actual size 3/4" x 3/4"

...with matching waveguide window

Made to operate with the new Ka-band XM-4218 is WG-4223... 32 to 37 kmc... 50 kilowatt peak power and 1.10 VSWR. It withstands 35 psig.

This is one of 29 Sylvania waveguide windows covering frequencies from 2.6 to 37 kmc. Both glass and mica windows are available. In addition to existing units, new types can be designed to specific requirements for applications from pressurized radar systems to microwave links.

• • •

For more information on these and other units in Sylvania's extensive line, wire or phone your nearest Sylvania tube sales office, or contact Sylvania Microwave Device Operations (formerly Special Tube Operations), 1891 East Third St., Williamsport, Pa.

SYLVANIA

Subsidiary of GENERAL TELEPHONE & ELECTRONICS

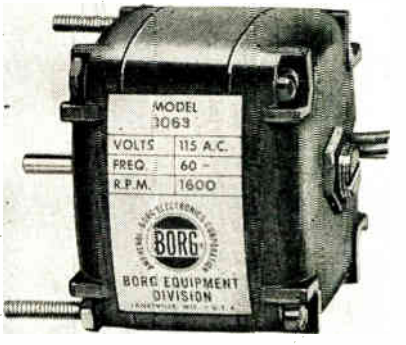
GENERAL SYSTEM

Circle 84 on Inquiry Card

New Products

INSTRUMENT MOTORS

1060 Series Low-Inertia Sub-Fractional Horsepower Motors. Characteristics include: Models 1063 (no gear train) and 1065 (gear train); 115 v/60 CPS, single phase; 12 w input at stall; no-load speed, 1600 RPM; dc resistance, 2700 ohms each winding at



stall; effective resistance (at unity power factor), 5500 ohms each winding; rotor moment of inertia, 0.10 oz./in.²; standard gear train limit output torque, 150 in./oz. over 36 to 1 ratio. Models 1065 (no gear train) and 1066 (gear train): 115 v/60 CPS, single phase; 14 w input at stall no-load speed, 1600 RPM; stall torque, 4.2 in./oz.²; dc resistance, 400 ohms each winding; impedance, 1700 ohms each winding at stall; effective resistance (at unity power factor), 2800 ohms each winding at stall; rotor moment of inertia, 0.13 oz./in.². Borg Equipment Div., Amphenol-Borg Electronics Corp., 120 So. Main St., Janesville, Wis.

Circle 235 on Inquiry Card

R-F CONNECTORS

Red line series of miniature r-f connectors are half the weight and size of standard TNC connectors. For use with the new MIL-type subminiature coaxial cable, the series introduces a low-reflection, metal-to-metal cable clamping method which eliminates combing out cable braid. They feature a screw-type coupling and are

weatherproof. They have a 50 ohm characteristic impedance, a peak operating voltage of 500 v. and may be used at freq. up to 10,000 MC. Gremar Mfg. Co., Inc., North Ave., Wakefield, Mass.

Circle 236 on Inquiry Card

Circle 86 on Inquiry Card

Quick delivery...a specialty at Deutsch! Naturally, we can't make delivery on the 1st if you order on the 7th ... unless you let us use the calendar shown above. But we can promise delivery of catalog items in a week or less from either our eastern or western stock locations. As a matter of fact, we usually ship on receipt of your advance order, without waiting for confirmation. And this goes for our entire line of standard environmental miniature electrical connectors: solder or snap-in types, self-aligning cylindrical and rectangular rack-and-panel models, and hermetics that never leak. If you have a tight production schedule staring you in the face, contact your local Deutschman today. He'll do his best to make delivery yesterday. For location of your nearest Deutschman write for Data File A-12.

DEUTSCH

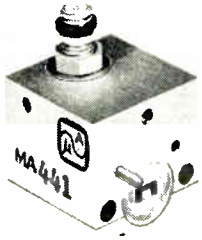
Electronic Components Division • Municipal Airport • Banning, California

ADVANCED SPECIFICATION MINIATURE ELECTRICAL CONNECTORS

New Products . . . for the Electronic Industries

BROADBAND VIDEO DETECTOR

Broadband video detector, MA-441, for high tangential sensitivity receiver use over 40-75 KMC. Min. tangential signal sensitivity over the range is —27 dbm for a receiver bandwith of 2.5 MC and 100 KC low

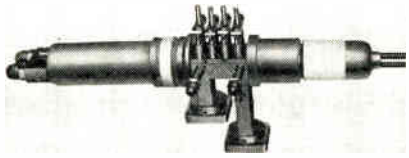


freq. cutoff. Smooth response without resonance power drop out ripples is achieved over the entire freq. range. No external holder is required. Waveguide connection is provided for adaptation to ridged RG-98/U or to a taper for standard RG-97/U (MA-803) or RG-98/U (MA-512) waveguide. Diode and whisker are mounted across a section of ridged RG-98/U waveguide for best broadband response. Conducting surfaces are silver plated. Microwave Associates, Inc., South Ave., Burlington, Mass.

Circle 237 on Inquiry Card

AMPLIFIER KLYSTRONS

New VA 849 series of amplifier klystrons are rated at 20 kw, covers 7.125 to 8.5 KMC and are tunable over a 60 MC range. The 4-cavity tubes have been tested to more than 25 kw. For very low AM and FM

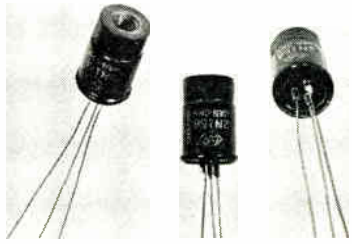


residual noise, power gain is 37 db and the bandwidth is a min. of 30 MC. Synchronously tuned power gain and bandwidth are 53 db and 15 MC. Tubes are focused electromagnetically, are self-centering in the focusing electromagnet and no critical focusing adjustments are necessary. Cooling is by water applied to the collector and the body of the tube. Eight gal./min. is required for the collector and 2 gal./min. for the tube body and focusing electromagnet. Tube Div., Varian Associates, 611 Hansen Way, Palo Alto, Calif.

Circle 238 on Inquiry Card

POWER TRANSISTOR

Military pnp germanium power transistor, JAN-2N158 meets MIL-S-19500/24A. Environmental testing includes constant acceleration of 5000 g, shock of 500 g for 1 msec and variable vibration of 10 g from 100



through 1000 CPS. Max. ratings at 25° C are: —60v. collector-to-emitter voltage, 2 a emitter current, 17 w dissipation, and —65 to + 85°C storage junction temp. range. It features a min. current gain of 21 and a max. input voltage of 0.85 v. for an Ic of 0.5 a and a V_{CB} of —2 v. Saturation voltage V_{CE} (sat) is 0.75 v. at an Ic of 1 a and an Ib of 150 ma. Thermal resistance (junction to case) is 2.5°C/w. CBS Electronics Information Services, 100 Endicott St., Danvers, Mass.

Circle 239 on Inquiry Card

Extra quality at no extra cost with Bendix Semiconductors

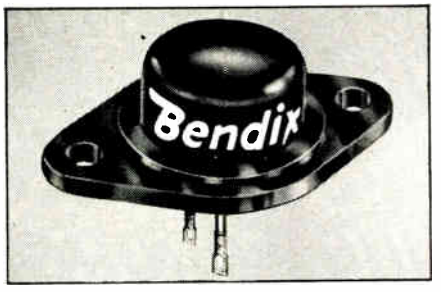
Bendix Bulletin

NEW 25-AMP DAP TRANSISTORS SWITCH IN MICROSECONDS

High Current–Fast Switching–High Voltage —give engineers wider design latitude

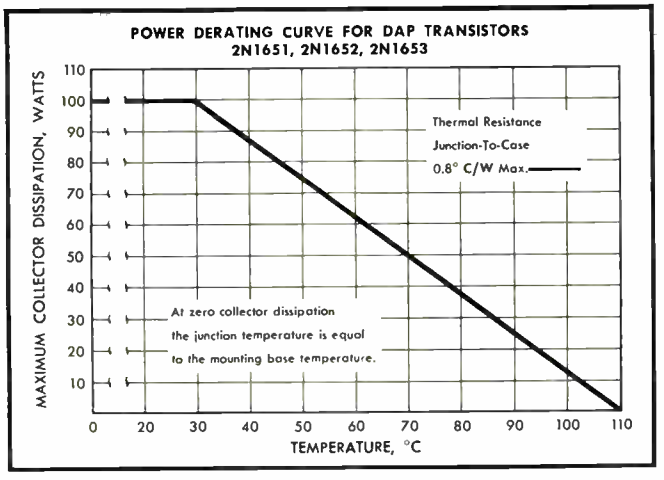
The new 25-amp germanium PNP Bendix® Diffused Alloy Power DAP® transistor line—with its microsecond-fast, higher-current switching (typically 5 μsec at 25 amperes)—frees engineers from the design restrictions set up by ordinary germanium alloy transistors. *Only* Bendix offers such a high-current, high-speed DAP transistor line.

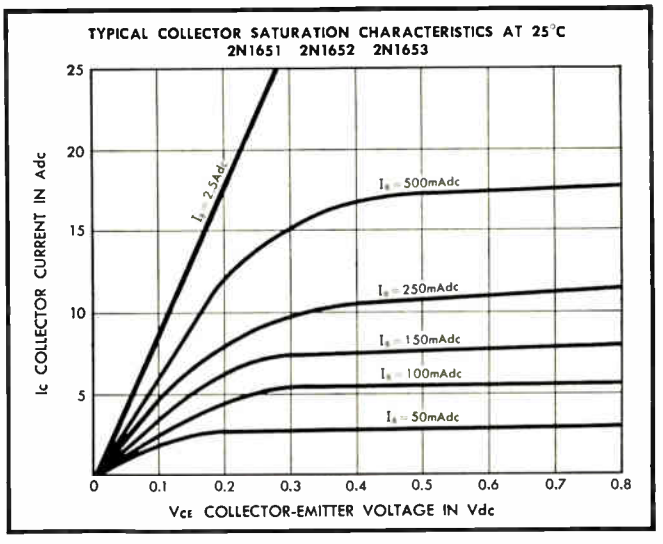
But high current is by no means the whole story. Bendix DAP transistors make possible increased circuit stability over a wider range of temperatures—from −60°C to +110°C. They are also rated at higher collector-to-emitter breakdown voltages, while providing lower input resistance, controlled current gain, and lower saturation voltages. In short, here is a special high-frequency, high-voltage line that opens the door to many new design ideas and applications.



For details on our complete line of power transistors, power rectifiers, and driver and MIL-type transistors, write on your letterhead for your BENDIX SEMICONDUCTOR CATALOG.

ATTENTION ENGINEERS: Write our Employment Manager for information about challenging opportunities we offer in semiconductors.





ABSOLUTE MAXIMUM RATINGS

TYPE NUMBERS	Vce Vdc	Vcb Vdc	Veb Vdc	Ic Adc	Pc W	T Storage °c	Tj °c
2N1651	−60	−60	2.0	25	100	−60 to +110	110
2N1652	−100	−100	2.0	25	100		
2N1653	−120	−120	2.0	25	100		

Ideal for such applications as: ULTRASONICS • HORIZONTAL OUTPUT AMPLIFIERS FOR TV OR CATHODE RAY TUBES • POWER CONVERTERS • HIGH CURRENT AC SWITCHING • CORE DRIVERS • HI-FI

THE Bendix CORPORATION

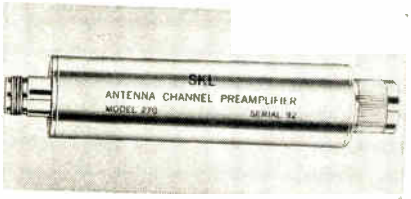
SEMICONDUCTOR PRODUCTS
Red Bank Division
HOLMDEL, NEW JERSEY

Main Office: South Street, Holmdel, N.J.—Phone: SHadyside 7-5400 TWX Holmdel NJ 1388 • Midwest Office: 2N565 York Road, Elmhurst, Ill.—Phone: BRowning 9-5050 TWX Elmhurst Ill 393 • New England Office: 4 Lloyd Road, Tewksbury, Mass.—Phone: ULysses 1-7495 • West Coast Office: 117 E. Providencia Avenue, Burbank, Calif.—Phone: Victoria 9-3961 TWX BRB 9808 • Bendix International: 205 East 42nd Street, New York 17, N. Y.—Phone: MUrrayhill 3-1100 TWX NY 1-4800

New Products

VHF CHANNEL PREAMPLIFIER

Transistorized, lightweight, miniaturized TV and telemetering channel preamplifier in the VHF spectrum, Model 270, has a flat response across 6 MC. Amplifier provides 16 db of gain and has a noise figure of 9 db or less. It is packaged in a weatherproof cylinder; over-all dimensions

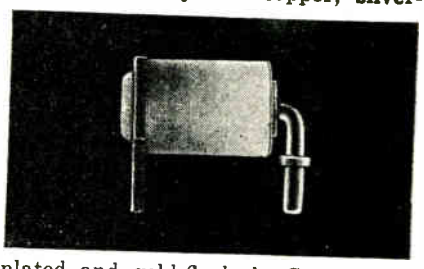


1¼ in. outside dia., length including connectors 5¾ in.; total weight 10 oz. Primary power is 28 vdc supplied through the output cable. Spencer-Kennedy Labs., Inc., 1320 Soldiers Field Rd., Boston, Mass.

Circle 240 on Inquiry Card

TEST POINTS

Chemelec printed-circuit test points, in 2 styles, added to line of miniature electronic components. The test points, insulated with Teflon TFE, have a flashover of 3000 v RMS and a capacitance of 0.25 mmfd. Their brackets are made of silver-plated and gold-flashed brass; the contact material is beryllium copper, silver-



plated and gold-flashed. Components available in the 10 standard RMA colors; white, red, green, blue, violet, yellow, orange, brown, gray and black. Garlock Electronic Products, Garlock Inc., Camden 1, N. J.

Circle 241 on Inquiry Card

NEW...from MOTOROLA

JAN 2N174
POWER TRANSISTORS

MOTOROLA TO-36 15 AMP POWER TRANSISTORS

Type	MAXIMUM RATINGS P_c watts	T_j °C	BV_{ces} volts	BV_{ceo} volts	I_c amps	Electrical Characteristics h_{FE} @ I_c min	max	amps
2N441	150	100	40	40	15	20	40	5
2N442	150	100	50	45	15	20	40	5
2N443	150	100	60	50	15	20	40	5
2N174	150	100	80	70	15	25	50	5
JAN 2N174	150	100	80	70	15	25	50	5
2N1358	150	100	80	70	15	25	50	5
2N1100	150	100	100	80	15	25	50	5
2N1412	150	100	100	80	15	25	50	5
2N277	150	100	40	40	15	35	70	5
2N278	150	100	50	45	15	35	70	5
2N173	150	100	60	50	15	35	70	5
2N1099	150	100	80	70	15	35	70	5

WIDEST SELECTION OF STANDARD POWER TRANSISTOR TYPES AVAILABLE

In addition to TO-36 power transistors, Motorola offers over 118 power transistors in the industry-standard TO-3 case. 3, 5, 10, 15 and 25 amps . . . up to 120 volts . . . 90 watts power dissipation . . . 0.8° C/W maximum thermal resistance . . . 100° C junction temperature . . . 3 military types . . . special "Meg-A-Life" units provide military quality for industrial use.

Motorola is your most complete and most dependable power transistor source for industrial and military applications.

For complete technical information and applications assistance, contact your Motorola Semiconductor distributor or your Motorola district office.

in the improved...

"low silhouette" TO-36 case

Now, Motorola offers you a JAN 2N174! It's one of twelve 15-amp power transistors in Motorola's much-improved TO-36 case . . . transistors that provide outstanding design advantages.

- "low silhouette" case requires 30% less headroom than other TO-36 packages
- 0.5° C/W maximum thermal resistance (0.35° C/W typical) — 43% less than other TO-36 devices
- 150 watts power dissipation . . . the highest rated germanium power transistor
- 100° C continuous junction temperature
- h_{FE} ranges from 20 to 70—in 2 to 1 spreads
- 40 to 100 volts BV_{CB}
- Improved internal construction and cold weld
- 100% lot life-tested to assure maximum reliability

MOTOROLA
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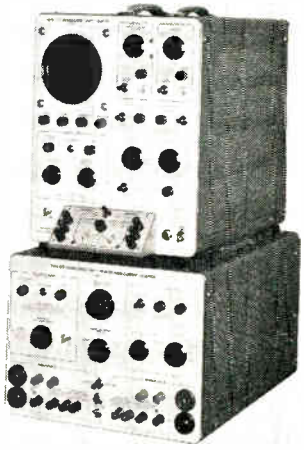
Circle 96 on Inquiry Card

New Products

HIGH-CURRENT ADAPTER

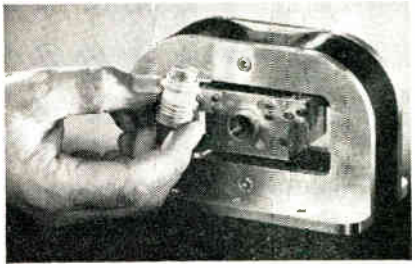
For use with a Tektronix Type 575 Transistor-Curve Tracer, it provides 200-a collector displays, 3 ranges of collector supply, and 12-a base supply, and permits plotting and displaying on the crt the characteristic curves of high-powered transistors. For observation and measurement of characteristic curves of both npn and pnp transistors, and diodes, it permits display of characteristic curves with collector current on the vertical axis and the either collector-to emitter voltage or base-to-emitter voltage on the horizontal axis. For transistors, collector-current curves can be plotted to 200 a or more. (For diodes, curves can be plotted to 100 a or more.) Tektronix, Inc., P. O. Box 500, Beaverton, Ore.



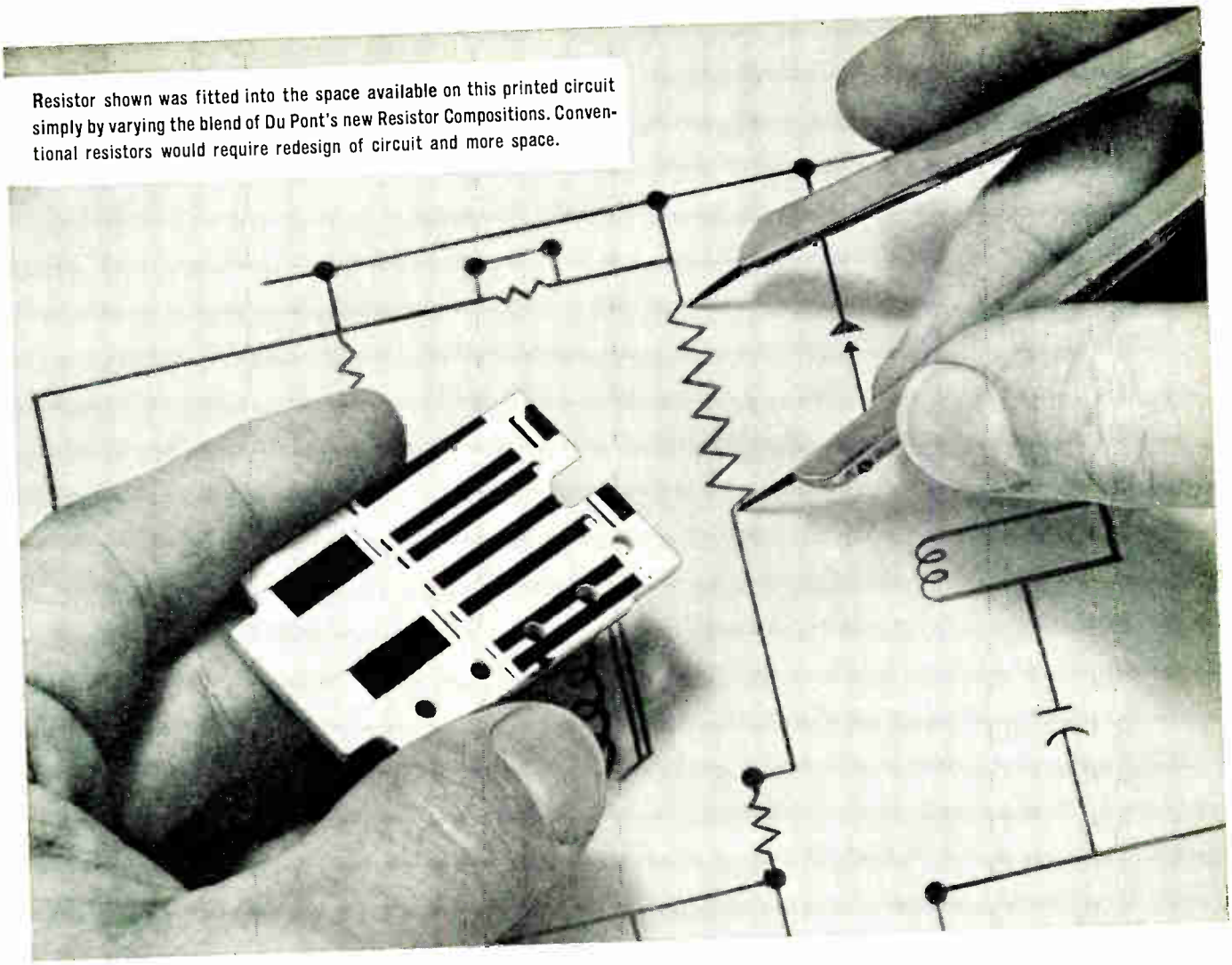
Circle 244 on Inquiry Card

MAGNETRON

New tube, the X-747, can be electronically tuned over 400-1200 MC with a nom. output power of 100 mw. No complicated regulation of heater voltage is needed; and heater power supply can be either ac or dc. Back heating is eliminated through Eimac's indirectly-heated matrix cathode and through advanced electron injection design. It has extremely linear tuning characteristics. Eitel-McCullough, Inc., Microwave Tube Div., San Carlos, Calif.



Circle 245 on Inquiry Card



Resistor shown was fitted into the space available on this printed circuit simply by varying the blend of Du Pont's new Resistor Compositions. Conventional resistors would require redesign of circuit and more space.

Du Pont announces—New Resistor Compositions that permit varied resistance values without changing geometric form . . . simplify design, save space

Now, new Du Pont Resistor Compositions offer a second dimension for controlling resistance. You can vary resistance values by changing the composition of the resistor without the need for altering the geometric form. These new resistor compositions give you greater design flexibility, essential for miniaturized circuits. Du Pont Resistor Compositions are available at three approximate resistance values: 500, 3,500 and 10,000 ohms/square per mil thickness, and they can be blended to give a range of intermediate values.

Du Pont Resistor Compositions are easy to apply . . . may be brushed, dipped, screen-printed or sprayed. Surfaces can be fired under normal atmospheric conditions in the 1100-1400°F. range.

Printed resistor patterns and coated rods have abrasion and impact resistance similar to fired silver coatings and show only small variations in resistivity under humidity, overload, temperature and voltage conditions as typical laboratory data show:

Temperature coefficient	±350 ppm./°C. from -55°C. to +125°C.
Voltage coefficient	Less than .02%/volt, negative
Humidity exposure	± 1% change after 250 hr. @ 95% relative humidity
Overload	±0.5% change with standard short-time overload
Temperature cycling	±1% change after 5 cyclings from -55°C. to +125°C.
Load life	±2% change after 1,000 hr. at 70°C. at full load

Fired samples are available for your own evaluation. Request them on your letterhead, indicating application you have in mind. Complete technical information will also be sent. Write: Du Pont, Electrochemicals Dept., Ceramic Products Div., Wilmington 98, Delaware. Du Pont does not manufacture resistors . . . produces only resistor compositions and other high-quality conductive coatings: gold, silver, platinum and palladium.

DU PONT RESISTOR COMPOSITIONS

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . THROUGH CHEMISTRY

Circle 99 on Inquiry Card

New Products

PRINTER TUBES

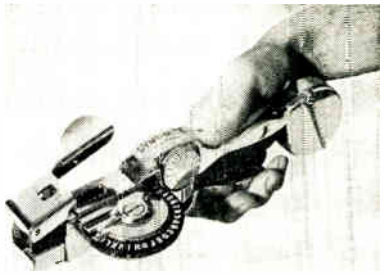
Four new electrostatic printer tubes can translate electronic signals into printed words and pictures on paper. The high speed tubes can print 20,000 characters/sec. or more than 10,000 lines of computer output information a min. The tubes resemble flattened

CR tubes with wire matrices resembling stubbly beards across their faces. Tiny wires, 0.001 in. thick and spaced 250 to the in., extend brush-like through the faces of the tubes. The varying cathode ray beam current inside the tube passes through the wire brush, or matrix, depositing electrostatic charges on paper as it passes against the tube. Applications include high speed printing of photographs transmitted over telephone and telegraph lines and radio channels. The tubes can print up to three 8½ x 11 in. sheets/sec. Industrial Components Div., Raytheon Co., 55 Chapel St., Newton, Mass.

Circle 242 on Inquiry Card

LABELING TOOL

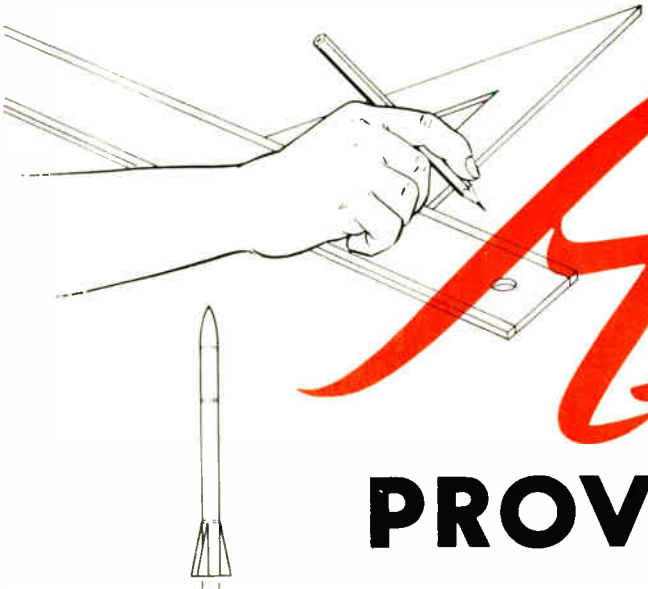
Addition to line of "on-the-spot" labeling tools, the Dymo-Mite-Model M-3, features a chrome-plated lightweight aluminum body and built in corner rounding and hole punch de-



vice. The new M-3 will emboss Dymo's complete line of tapes, both pressure-sensitive colored plastic and metals. Dymo Corporation, 2546 Tenth Street, Berkeley 10, California.

Circle 243 on Inquiry Card

From the home of *Planned Pioneering*

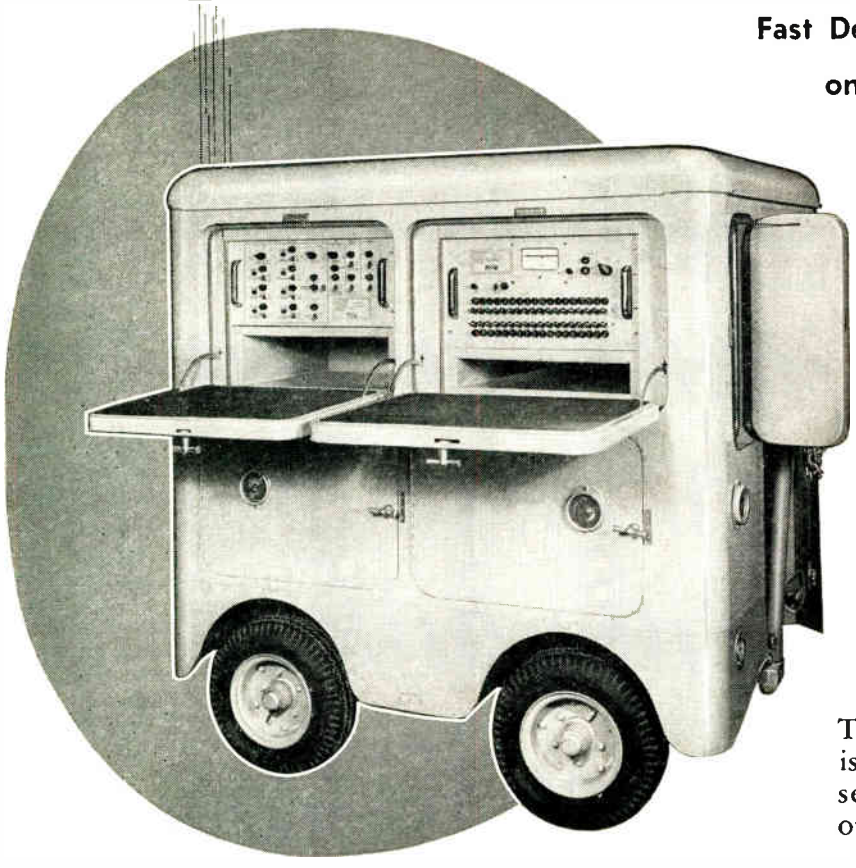


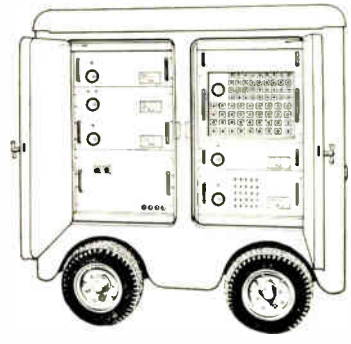
Actioneering

By CENTURY

PROVIDED BOEING

Fast Design — Production and Delivery on the Minuteman ICBM Portable Telemetry Check Out Cart





SIDE VIEW

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century

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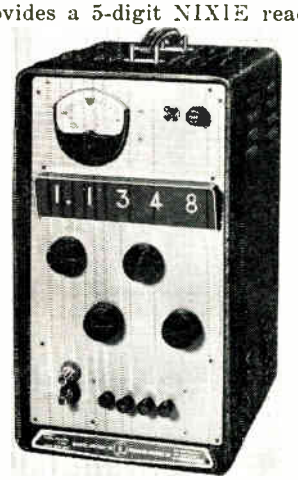
New Products

RMS VOLTMETER

A true RMS voltmeter capable of measuring a wide range of complex waveforms to ¼% accuracy. Measurements with Model 350 are not limited to sinewaves to obtain the accuracy. It provides a 5-digit NIXIE readout.

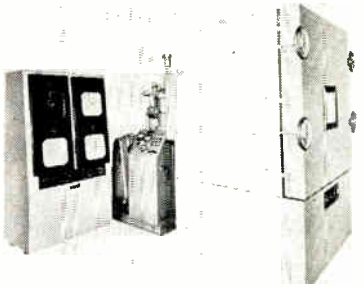


Range is 0.1 v. to 1199.9 v. Freq range of input signal is from 50 CPS to 20 KC with harmonic content to 50 KC. Featured is the wide range of waveforms which can be measured to ¼% accuracy, i.e., from sinewaves to squarewaves so long as the ratio of peak to RMS is not over 2. Accuracy is reduced to ½% for voltages above 300 and for freq. below 100 CPS and above 10 KC. Ballantine Laboratories, Inc., Boonton, N. J.

Circle 246 on Inquiry Card

ENVIRONMENTAL CHAMBER

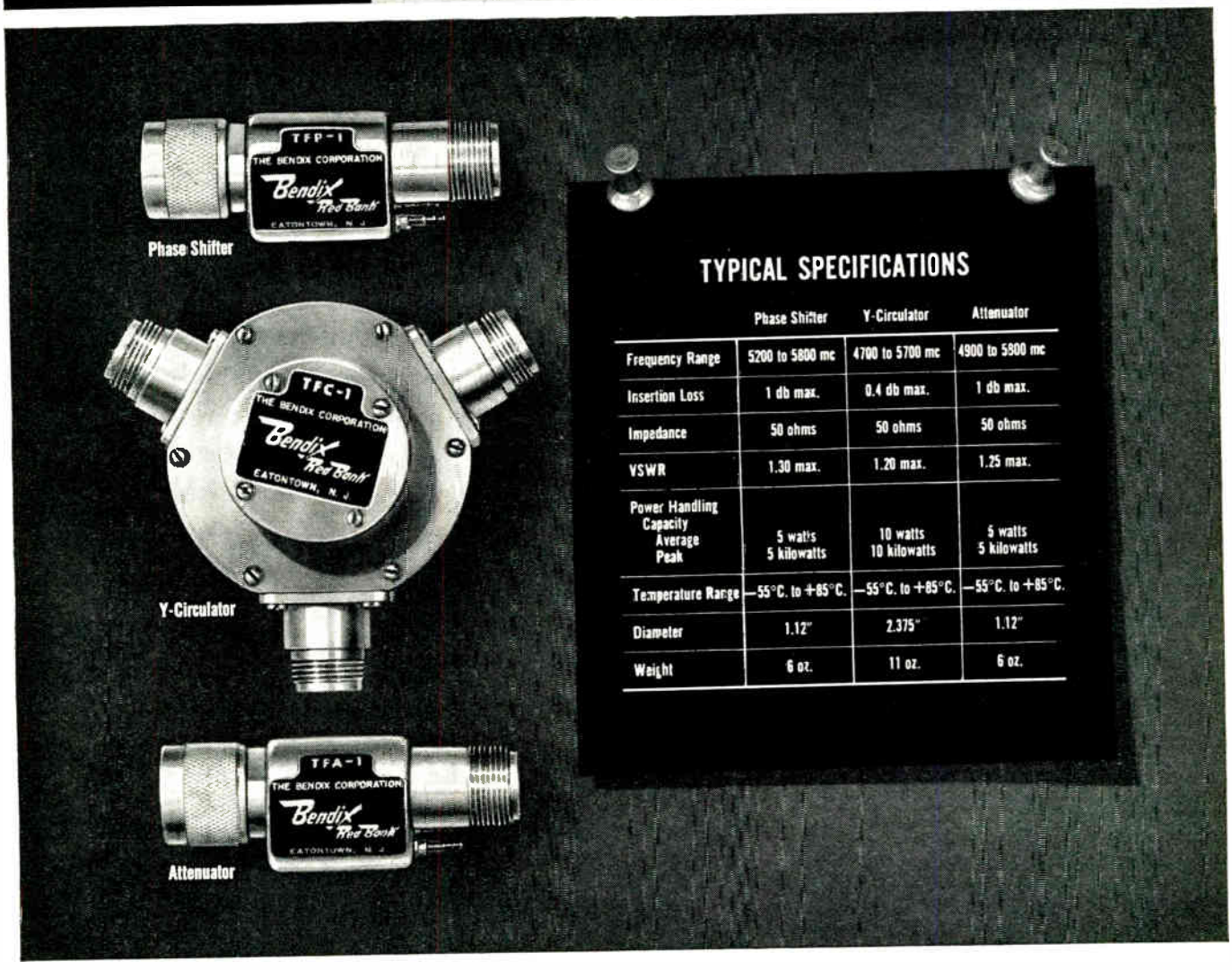
Environmental chamber simulates space conditions up to 500,000 ft. Model WF-27-125+350, has an adjustable temp. range from −125°F to 350°F. Pull down over the entire range requires 90 min., while heat up takes 60 min. A combination of cold wall and air circulation simulates true high altitude conditions. Special vacuum equipment simulates 4 x 10^{-6} mm of mercury in 45 min. Inside dimensions are 36 x 36 x 36 in. The



interior is ⅜ in. stainless steel, reinforced to withstand a pressure of 3.4 x 10^{5} mm of Hg without distortion throughout all temp. changes. Webber Mfg. Co., Inc., P. O. Box 217, Indianapolis 6, Ind.

Circle 247 on Inquiry Card

Bendix Craftsmanship at work for you



TYPICAL SPECIFICATIONS

	Phase Shifter	Y-Circulator	Attenuator
Frequency Range	5200 to 5800 mc	4700 to 5700 mc	4900 to 5800 mc
Insertion Loss	1 db max.	0.4 db max.	1 db max.
Impedance	50 ohms	50 ohms	50 ohms
VSWR	1.30 max.	1.20 max.	1.25 max.
Power Handling Capacity Average Peak	5 watts 5 kilowatts	10 watts 10 kilowatts	5 watts 5 kilowatts
Temperature Range	−55°C. to +85°C.	−55°C. to +85°C.	−55°C. to +85°C.
Diameter	1.12"	2.375"	1.12"
Weight	6 oz.	11 oz.	6 oz.

NEW BENDIX® MICROWAVE FERRITE DEVICES.*

1 The Electrically Variable Phase Shifter, TFP-1, can produce phase shifts in excess of 90° over a minimum bandwidth of 10%. Chief uses are as phase modulator, fast shift, and in a wide variety of r-f direction finding devices. **2** The Y-Circulator, TFC-1, offers at least 20 db isolation with less than 0.4 db insertion over bandwidth exceeding 20%. Ideal for use with masers, and parametric amplifiers. **3** The Electrically Variable Attenuator, TFA-1, has a range exceeding 25 db over a minimum bandwidth of 15%. Useful in fast AGC circuits and remote level control applications. Write today.

*PAT. PENDING

ELECTRON TUBE PRODUCTS

Red Bank Division

EATONTOWN, NEW JERSEY

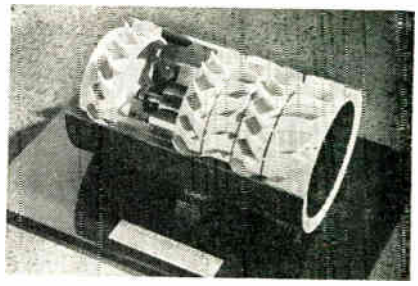
THE Bendix CORPORATION

Circle 106 on Inquiry Card

New Products

HIGH PERFORMANCE FAN

New motor-driven fan provides ground cooling for electronic gear at low noise level. Axial flow machine turns at 3375 rpm and uses 3 aerodynamic stages. It obtains a static pressure rise of 3.2 in. of water at

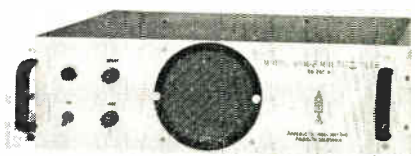


a flow rate of 120 ft. 3/min. with sea level pressure at the fan inlet. Performance is delivered at a wheel tip speed of 81 ft./sec., from use of relatively high blade loading factors. The 2 pole motor operates with a 60 cycle, 3 phase power supply of 115/200 v. and draws 0.60 a/phase. Electrical stator is silicon steel laminations wound with copper wire having high temp. resisting insulation. The dia. is 5.62 in., length is 10 in. and weight is 12 lbs. AiResearch Mfg. Div., 9851 Sepulveda Blvd., Los Angeles, Calif.

Circle 248 on Inquiry Card

MULTICOUPLER

Wideband VHF receiving multicoupler, Model VHM-2, permits use of as many as 6 receivers from a single antenna while affording high system sensitivity and excellent receiver isolation. Unit covers the 30 to 260 MC range without tuning, is designed for wideband spectrum monitoring, telemetry, air-to-ground communications, etc. Noise fig. is 8 db max. in a 52-ohm system. Nom. gain is 15 db between input and any output. Isolation between multicoupler outputs is 40 db min.; between outputs and input 70 db min. Intermodulation products, refer-



red to the input, are at least 40 db down with respect to interference-producing signals having levels of −40 dbm or less. Applied Technology, Inc., 930 Industrial Ave., Palo Alto, Calif.

Circle 249 on Inquiry Card

Circle 128 on Inquiry Card

Experience is the optimum test for Energy Storage Capacitors...

time-proven Sangamo Type DCM Electrolytic Capacitors exceed operating requirements of practically every application

Sangamo Type DCM Electrolytic Capacitors are housed in seamless, drawn-aluminum containers with a molded thermosetting plastic top that is sealed with a gasket to prevent electrolyte leakage and contamination. Terminal construction insures minimum contact resistance in current-carrying members. Cover design provides an adequate safety vent in case of heavy overload.

Sangamo was the first capacitor manufacturer to produce and establish standards in the manufacture of electrolytic energy storage capacitors. Since 1949, design and manufacturing techniques have been developed to such a scientific degree that Sangamo is still regarded as the leader in the field with the Type DCM. The time-proven characteristics of the DCM more than meet normal requirements of operating temperature, equivalent series resistance and life expectancy. Those techniques mean, too, that maximum capacity can be put in the smallest case size consistent with good engineering practice and performance reliability.

Occasionally applications call for energy-storage capacitors to meet special requirements — including higher temperature, and higher ripple current. Sangamo is uniquely qualified and equipped to engineer and produce to the most exacting specifications. We would appreciate the opportunity of supplying your future needs.

Complete data on capacitance and voltage combinations on Type DCM Capacitors is detailed in Sangamo's Engineering Catalog 2231. Contact your Sangamo Representative, or write us for your copy.

Maximum Capacity in Mfds VS Case Size in Inches								
Rated Voltage	Surge Voltage	D=1-7/16 L=4-1/2	D=1-13/16 L=4-1/2	D=2-1/16 L=4-1/2	D=2-1/16 L=6	D=2-9/16 L=4-1/2	D=3-1/16 L=4-1/2	D=3-1/16 L=6
5	8	14,750	25,500	33,000	48,750	55,500	85,000	125,000
10	15	10,500	18,500	23,500	35,000	40,000	60,000	90,000
15	20	8,000	14,000	18,000	26,500	33,300	46,000	68,500
20	30	6,650	11,700	14,750	22,000	27,000	38,000	56,500
30	40	5,100	9,000	11,400	16,900	19,000	29,000	43,000
35	50	4,000	7,000	9,100	13,500	15,400	23,500	34,800
40	50	4,000	7,000	9,100	13,500	15,400	23,500	34,800
50	75	2,650	4,765	5,900	8,800	10,000	15,300	22,500
75	100	1,350	2,400	3,000	4,500	5,400	7,750	11,450
100	135	1,000	1,790	2,250	3,350	4,000	5,750	8,500
150	185	720	1,250	1,600	2,400	2,800	4,000	6,000
200	250	500	900	1,100	1,650	2,000	2,750	—
250	300	390	690	880	1,300	1,550	2,200	—
300	350	275	490	620	900	1,000	1,500	—
350	400	190	350	440	650	775	1,100	—
400	475	170	300	380	570	680	975	—
450	525	150	260	340	500	600	850	—

NOTE: Case dimensions include insulating sleeve. Subtract 1/16" from diameter and 3/8" from length for overall dimensions of uninsulated case.

SC-60-4

SANGAMO ELECTRIC COMPANY, Springfield, Illinois

—designing toward the promise of tomorrow

New Products

DIGITAL READOUT

Slide Plate Readout accepts any BCD (Binary Coded Decimal) or teletype code up to 6 bits, does its own translating, and displays the proper character. No auxiliary translaters, relays, or diodes required. Size of

character is 1⅜ in. It may be operated with only 10 mw/bit, and connected directly into computers. Featuring electro-magnetic operation, it displays up to 20 characters/sec. Also featured is character storage. It will display the last character entered after all signal-pulse and set-pulse power have been removed. If all power is removed, information will be retained and be re-displayed when power is restored. Industrial Electronic Engineers, Inc., 5528 Vineland Ave., No. Hollywood, Calif.

Circle 250 on Inquiry Card

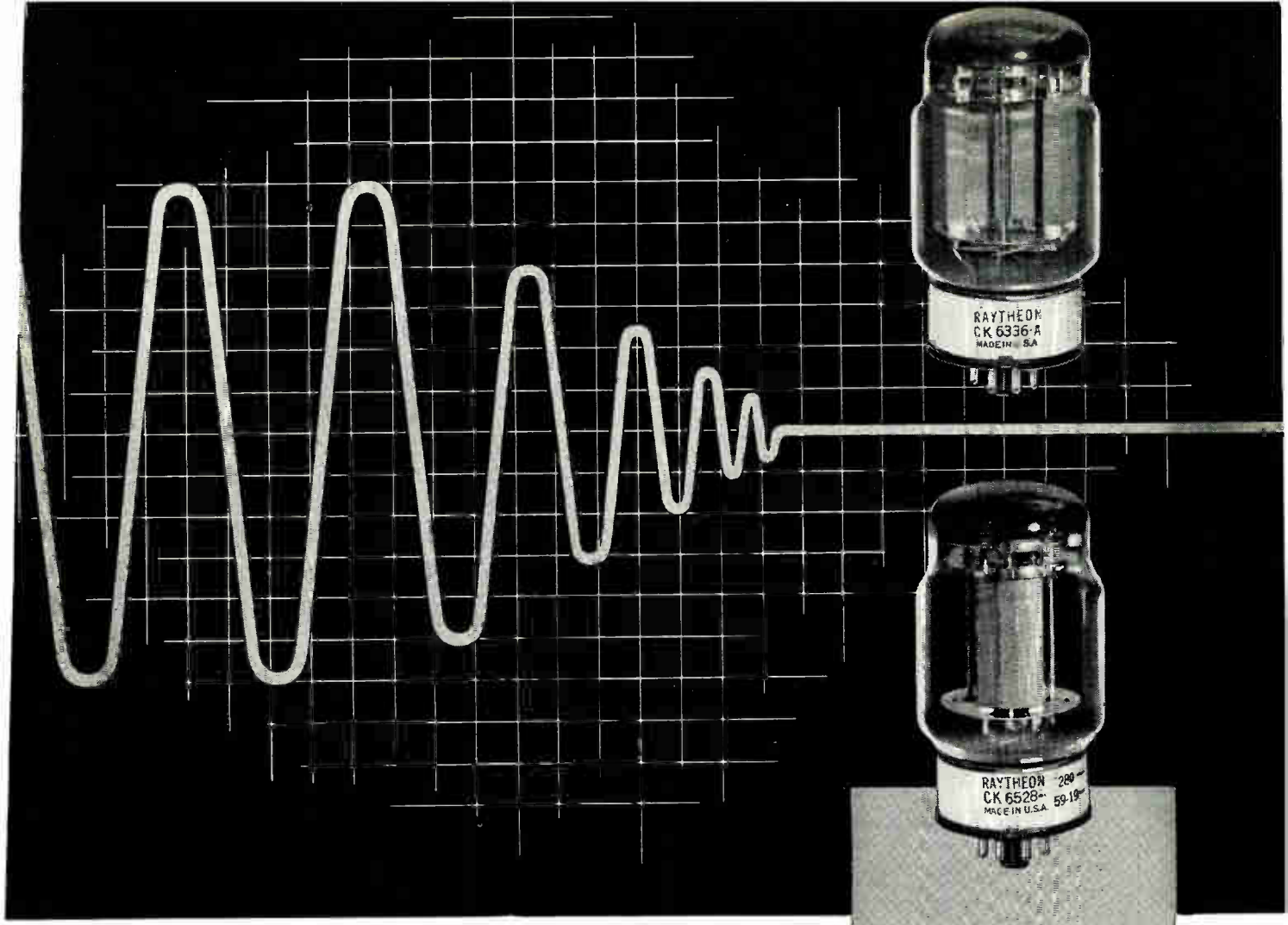
ENVIRONMENTAL CONNECTOR

The Hi-Reli-Acon environmental type connector, series ME-20000 and FE-2000 meets the rugged environmental requirements of MIL-C-26500. Design features include resilient silicone rubber inserts which provide sealing throughout extremes of temp. and pressure. Contacts are crimp style, removable, basically designed

about the performance requirements of MIL-C-26636. They are presently available in 55 contacts with strain relief clamp hardware if desired. Methode Mfg. Corp., 7447 W. Wilson Ave., Chicago 31, Ill.

Circle 251 on Inquiry Card

Circle 110 on Inquiry Card →



A Pair of Smoothies For Series Regulator Service

The Raytheon CK6336A and CK6528 are mechanically rugged, long-life twin power triodes. They are designed to handle large currents over a wide voltage range and at high temperatures in regulated power supplies. Zirconium coated graphite anodes, ceramic insulators, gold plated molybdenum grid wires, and hard glass envelopes are some of the advanced design features of both types.

Stringent power supply regulation requirements are no problem for these "smoothies." Get full technical data on the CK6336A and CK6528 as well as Raytheon's expanding line of high voltage rectifiers, pulse modulators, and transmitting types. Please write to: Raytheon, Industrial Components Division, 55 Chapel St., Newton 58, Mass.

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

RATINGS

	Max. Plate Voltage	Max. Plate Dissipation Watts	Max. Plate Current (per plate)	Amplification Factor
CK6336A	400	2 x 30	400 mAdc	2.7
CK6528	400	2 x 30	300 mAdc	9

RAYTHEON COMPANY

INDUSTRIAL COMPONENTS DIVISION

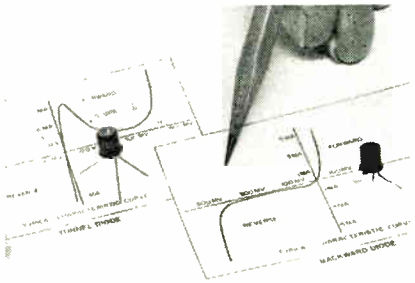
RAYTHEON CK6336A AND CK6528

RAYTHEON

New Products

TUNNEL DIODES

A series of 1 and 5 ma germanium tunnel diodes. Also, 2 complementary germanium backward diodes. Backward diode leakage current is specified at 400 mv and the forward voltage at 15% of the companion tunnel diode's

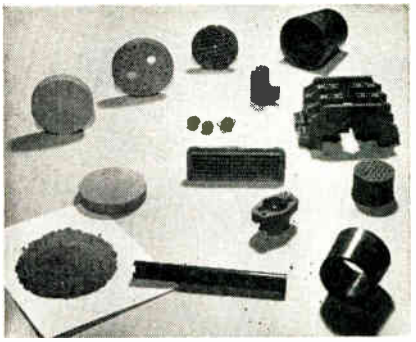


peak current. Backward diodes have a typical shunt capacitance of 3 $\mu\mu$f, making it possible to drive several from one tunnel diode with little reduction in speed. Forward voltage drop is a guaranteed max. of 30 mv. Characteristics (tunnel diodes): Peak current, 5 ma, 1 ma, tolerance on peak current, 2, 5 or 10% (depending upon type); peak to valley ratio, 8:1; capacitance, 6 pf/ma; temp. range, −55° C to +100° C. Transitron Electronic Corp., 168 Albion St., Wakefield, Mass.

Circle 252 on Inquiry Card

SILICONE COMPOUND

A specially-compounded mineral-filled silicone molding compound for use in long-term operation to 700°F. Units molded from this granular, thermosetting material, M-6-4156, also have outstanding dimensional stability and thermal shock resistance over a temp. range of −67 to 700°F. Parts demonstrate high arc resis-

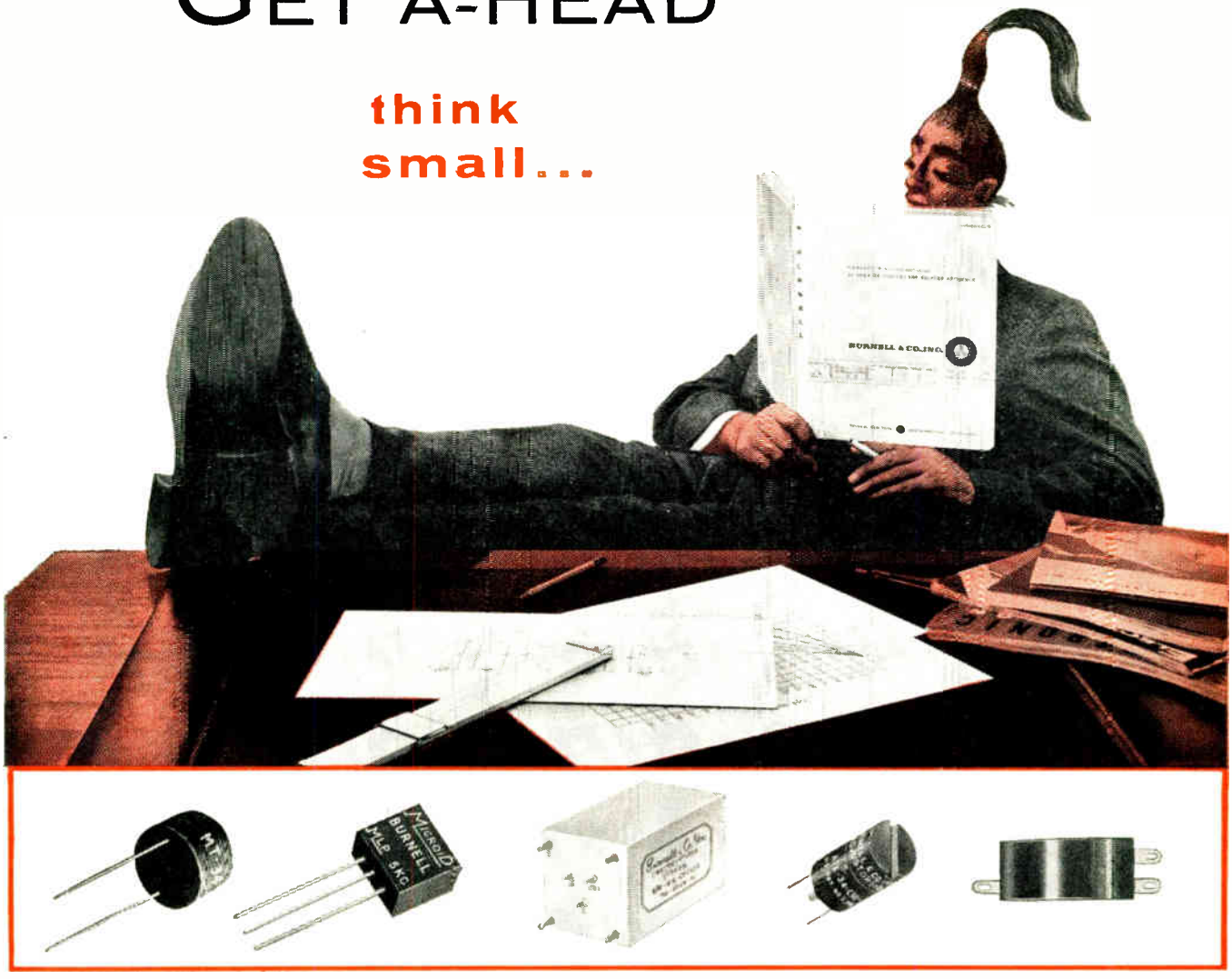


tance, over 400 sec. and dissipation factors as low as 0.002 at 10^6 CPS. It is easily molded using conventional compression or transfer molding equipment. Dow Corning Corporation, Midland, Michigan.

Circle 253 on Inquiry Card

GET A-HEAD

think small...



At Burnell & Co., our engineers devote a big part of their thinking to shrinking—reducing the size (and cost) of components to the least common denominator consistent with high performance standards. From this staff have come such components as:

The Kernel ATE Adjustoroid®—This variable toroid contains an actual complete toroid with all the excellent characteristics of the non-adjustable type. Valuable in oscillators, discriminators, variable tuned circuits, etc.

MLP and *MHP* *MICROID* ® Filters — Microminature counterparts of the popular Burnell TCL and TCH low pass and high pass filters, they range from 5 kc to 100 kc with a standard impedance of 10k ohms. Cascading the *MLP* with the *MHP* produces excellent response band pass characteristics.

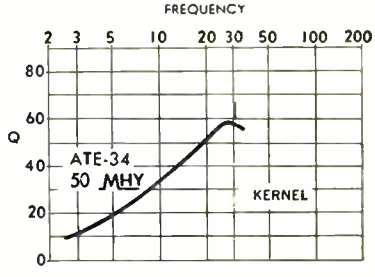
"Cheerio" Toroids — Subminiature high Q coils in a range of frequencies that make them ideal for transistorized equipment.

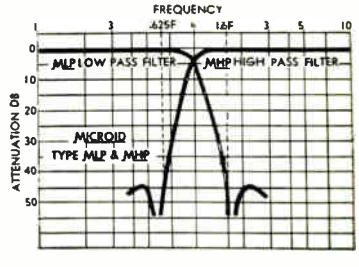
Crystal Filters—Advanced engineering techniques enable Burnell to offer at nominal cost, high selectivity, high attenuation crystal filters covering the extraordinary range of 1 kc to 30 mcs with considerable latitude in impedance.

Pulse networks, interference filters, active networks and magnetic amplifiers are among the newer additions to our product line.

Write for latest catalog.

Burnell & Co., Inc., has a number of positions available for engineers capable of thinking big and shrinking small. Inquiries are invited.





If you haven't already done so—send for your free membership in the Space Shrinkers Club.

Burnell & Co., Inc.

PIONEERS IN microminiaturization OF TOROIDS, FILTERS AND RELATED NETWORKS

EASTERN DIVISION
DEPT. I-39
10 PELHAM PARKWAY
PELHAM, N. Y.
PELHAM 8-5000
TELETYPE PELHAM 3633

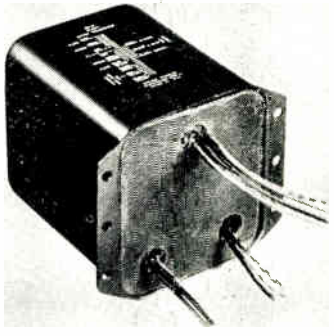
PACIFIC DIVISION
DEPT. I-39
720 MISSION ST.
SOUTH PASADENA, CALIF.
MURRAY 2-2841
TELETYPE PASACAL 7578

Mfd. in Canada by Edo (Canada) Ltd., Cornwall, Ont. • WEllington 2-6774

New Products

OUTPUT TRANSFORMER

New 65-w high fidelity output transformer, Part No. BO-15, can be used with 6550, EL34 or KT88's for construction of a 40-w or 60-w hi-fi amplifier with tertiary feedback.

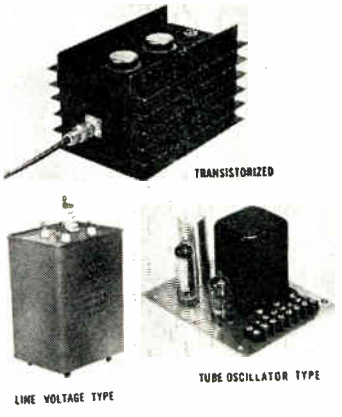


The 60-w amplifier has a total harmonic distortion of less than ± 1 db from 20 to 20,000 CPS. Power response of the 60 w amplifier is −1 db from 20 to 20,000 CPS. Chicago Standard Transformer Corp., 3501 W. Addison St., Chicago 18, Ill.

Circle 254 on Inquiry Card

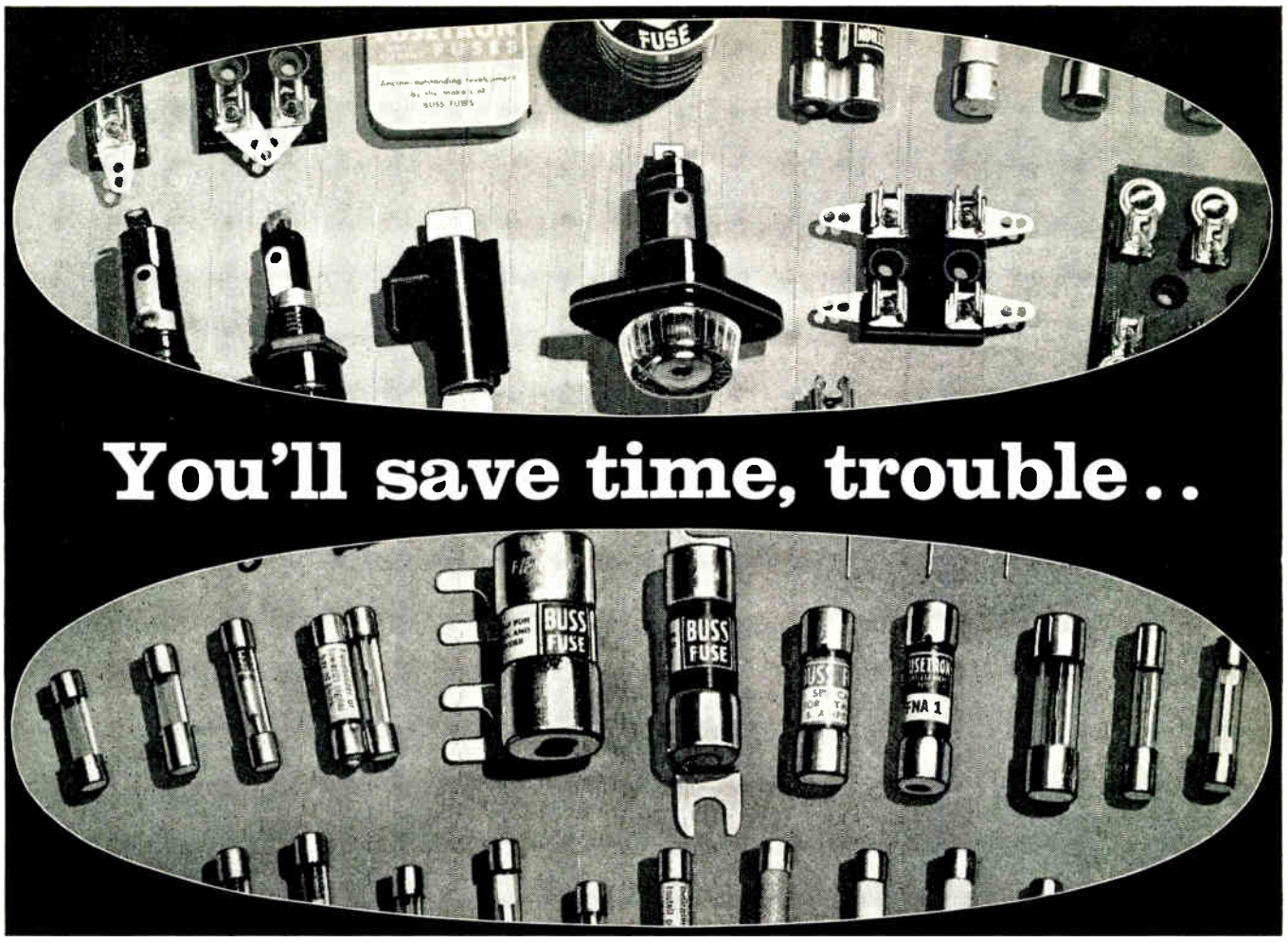
POWER PACKS

New series of high voltage, low current power packs in 3 types. First is 6-28 vdc input - transistorized type available from 2 to 50 kvdc output and are for portable equipment. 2nd type is the tube oscillator type which operates from 200 to 300 vdc, with 2 to 30 kvdc output available. These are for radar indicators, scopes, airplane guidance systems, etc. 3rd type included a number of line voltage 60-400



cycle power packs for lab equipment on shipboard, electrostatic precipitators, and electron microscopes. Voltages from 2 to 100 kv available. Plastic Capacitors, Inc., 2620 No. Clybourn Ave., Chicago 14, Ill.

Circle 255 on Inquiry Card



You'll save time, trouble..

... by turning FIRST to BUSS for fuses of unquestioned high quality

By relying on BUSS as your source for fuses, you can quickly and easily find the type and size fuse you need. The complete BUSS line of fuses includes: dual-element "slow-blowing", single-element "quick-acting" and signal or visual indicating types . . . in sizes from 1/500 amp. up — plus a companion line of fuse clips, blocks and holders.

BUSS fuses are made to protect — not to blow needlessly

When you specify BUSS fuses — users of your equipment receive maximum protection against damage due to electrical faults. And just as important, users are safeguarded against irritating, useless shutdowns caused by faulty fuses blowing needlessly.

A component part that operates as intended helps to maintain the reputation of your equipment for quality and service. That's why it pays to rely on dependable BUSS fuses.

If you should have a special problem in electrical protection . . . the world's largest fuse research laboratory and its staff of engineers are at your service — backed by over 46 years of experience. Whenever possible, the fuse selected will be available in local wholesalers' stocks, so that your device can be easily serviced.

For more information on BUSS and Fusetron small dimension fuses and fuseholders . . . Write for bulletin SFB.

BUSSMANN MFG. DIVISION,
McGraw-Edison Co.
University at Jefferson, St. Louis 7, Mo.

1260

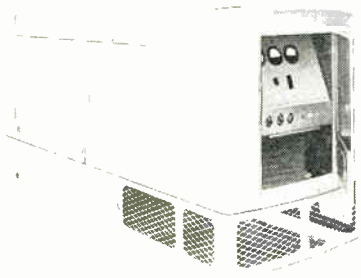
BUSS fuses are made to protect - not to blow, needlessly.
BUSS makes a complete line of fuses for home, farm, commercial, electronic, electrical, automotive and industrial use.

FUSETRON
TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS
McGRAW EDISON

New Products

ELECTRIC PLANTS

Standard line of gasoline-driven electric generating plants provide full-rated power in both single and 3-phase current. New generating sets are variations of standard Onan



plants having the specific advantage of delivering dual-phase power from one source. They are available in 12 sizes ranging from 6 kw single-phase, to 85 kw 3-phase. D. W. Onan & Sons Inc., 2515 University Ave., S. E., Minneapolis 14, Minn.

Circle 256 on Inquiry Card

POWER SUPPLY TRANSFORMERS

New line of high reliability transistor power supply transformers the H-141 through H-147 series. They are designed for transistorized circuits operating from 115 v. 50/60 cps input. Outputs range from 10 v. to 43 v. at from 0.3 a to 20 a. Both full-wave and half-wave models available. H-141 and H-142 have center tapped secondaries. H-143 through H-146 are tapped for dual secondary

voltages. Size and weight ranges from 1 15/16 x 1 13/16 x 2 7/16 in., ⅞ lbs.; 5¾ x 5¾ x 7⅛ in., 22 lbs. All units hermetically sealed to MIL-7-27A. United Transformer Corp., 150 Varick St., New York 13, N. Y.

Circle 257 on Inquiry Card

Another New Achievement from El-Menco

A New Smaller Size Dipped Silvered Mica Capacitor

El-Menco's SUB-MINIATURE DM-10 Mica Capacitor...

Approx. 5/16" long...

1/4" wide...

1/8" thick!

Smaller than a 1-carat diamond!

Sets New Standard in Miniature Reliability!

This sub-miniature DM-10 Mica Capacitor retains the same superior electrical characteristics of silvered mica capacitors as found in much larger sizes. It assures a high order of performance in extreme miniaturization applications — missiles, printed circuits and all compact electronic equipment. Parallel leads provide greater versatility. Tough phenolic casings protect against physical damage and penetration of moisture.

Capacity and Voltage Ranges

Working Voltage	Capacity Range
100 WVDC	1 MMF thru 360 MMF
300 WVDC	1 MMF thru 300 MMF
500 WVDC	1 MMF thru 250 MMF

Operating Temperature: *up to 150° C.*
Characteristics: *C, D, E and F, depending on capacitance value*
Leads: *#26 AWG (.0159") Copperweld wire*

EL-MENCO'S DM-10 MEETS ALL THE ELECTRICAL REQUIREMENTS OF MILITARY SPEC. #MIL-C-5B AND EIA SPECIFICATION RS-153

Other sizes also ideal for miniaturization applications —
DM-15...up to 820 mmf at 300 VDCW, up to 400 mmf at 500 VDCW.
DM-19...up to 5400 mmf at 300 VDCW, up to 4000 mmf at 500 VDCW.

WRITE FOR SAMPLES OF EL-MENCO DM-10 CAPACITORS and brochures describing El-Menco's complete line of capacitors.

EL-MENCO'S SUB-MIDGET DM-10 . . . THE NEW SMALLER MINIATURE MICA CAPACITOR

El-Menco Capacitors

THE ELECTRO MOTIVE MFG. CO., INC.

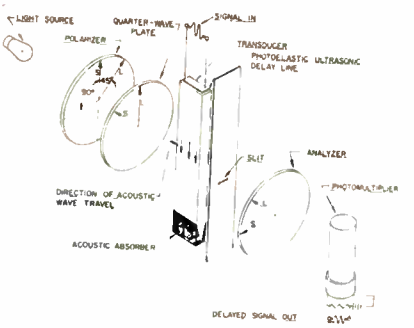
Manufacturers of El-Menco Capacitors
WILLIMANTIC CONNECTICUT
• molded mica • dipped mica • mica trimmer • dipped paper
• tubular paper • ceramic • silvered mica films • ceramic discs

Arco Electronics, Inc., 64 White St., New York 13, N. Y.
Exclusive Supplier To Jobbers and Distributors in the U.S. and Canada

New Products

ULTRASONIC DELAY LINES

Continuously variable time delay has been achieved with photoelastic ultrasonic delay lines. Capabilities also include multiple tapping without loss of signal, and addition and multiplication of two or more signals. Delays up to 160 μsec up to 30 mc have been achieved, with input signal reproduced cycle-for-cycle at the output photomultiplier. Corning Glass Works, Electronic Components Div., Bradford, Pa.



Circle 258 on Inquiry Card

POSITION TRANSDUCER

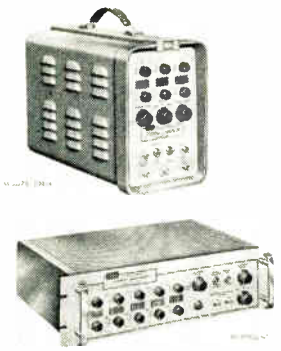
Miniature transducer converts a mechanical shaft input into a precise linear electrical output when a 28 vdc signal is applied. Backlash in the gearing is held to 6 min. max. Dimensions, not including mounting pads and projecting shaft are: width 1.875, depth 1.875, height 3.0 in. Rated for continuous duty in an amb. of 85° C and intermittent duty up to 100° C amb. Shaft inputs up to 50° are converted into precise linear electrical outputs when the clutch is energized, and when the clutch is de-energized the linear transformer returns to electrical zero within ± 3 min. of arc. Clifton Precision Products Co., Inc., 5050 State Rd., Drexel Hill, Pa.

Circle 259 on Inquiry Card

New Products

MARKER GENERATORS

Two crystal controlled marker generators, Models CM-6 and CM-10, contain 6 and 10 crystal oscillators respectively, and use harmonic and side band techniques to get more marking indications. Using a single



center frequency oscillator, it is possible to choose 2 side band oscillator freq. to provide a total of 5 marks, 1 at the center freq., 2 at the band edges and 2 at the 3 db down points. Output amplitude is individually controlled. Generators also provide dc marker indications, for use with "X-Y" recorders. A 40 db variable gain oscilloscope preamplifier facilitates response measurements of higher attenuation devices. Jerrold Electronics Corp., 15th and Lehigh Ave., Phila. 32, Pa.

Circle 260 on Inquiry Card

RF POWER BRIDGE

An ¼% accuracy of substituted dc power (above 500 μw) can be achieved with precision R-F Power Bridge, Model PB-1. Instrument is designed for use with 200 ohm bolo-

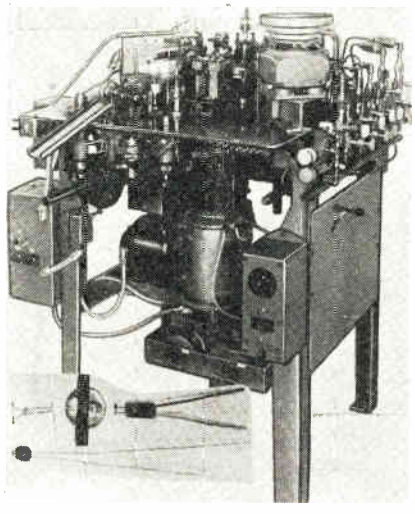
meter mounts using either 4.5 or 8.75 ma barretters or a pair of 13 ma thermistors. An accuracy of ¼% in substituted power is achieved between 500 μw and 20 mw. Weinschel Engineering Co., 10503 Metropolitan Ave., Kensington, Md.

Circle 261 on Inquiry Card

New Products

FILAMENT MOUNTER

Improved model of assembly machine for ignitor used in photoflash lamps as well as detonators. Unit is fully automated and has self-monitoring features: Machine assembles unit (on photo) at the rate of 1,200

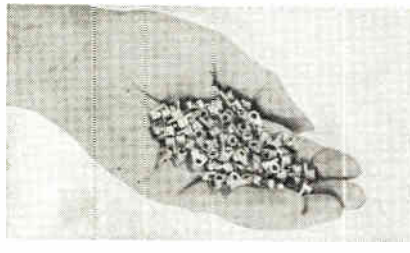


pieces/hr, starting with two spools of copper-clad wire, a spool of 0.0003 in. dia tungsten wire (the ignitor), and preforms of glass. The turret is indexed through the use of a drum cam. Machines can be modified to assemble other similar electronic and mechanical components. The Eisler Engineering Co., Inc., 750 So. 13th St., Newark 3, N. J.

Circle 262 on Inquiry Card

SERVO MOUNTING CLAMPS

Standard mounting hardware for synchros, servomotors, and pots. Two clamp sizes, each anodized in a different color, may be used on a total of 6 different housing sizes. Each is ma-



chined from solid aluminum stock for greater strength under shock and vibration than conventional powdered metal and stamped construction. Theta Instrument Corp., 520 Victor St., Saddle Brook, N. J.

Circle 263 on Inquiry Card

Life Testing

(Continued from page 88)

tributions. The fixed sample size plan with censoring (2) and the truncated nonreplacement plan (3) are strikingly nonrobust because the particular choice of Weibull distributions in this study, components having a low mean failure time showed a high probability of acceptance. On the other hand, the fixed sample size plan (1) and the sequential plan (4), while not robust, are less sensitive to departures from the exponential assumption.

The study demonstrates the risks when an acceptance sampling procedure is adopted without sufficient knowledge of the underlying properties of the phenomena. The results also indicate the need for research leading to statistical methods for life testing that are insensitive to distributional assumptions.

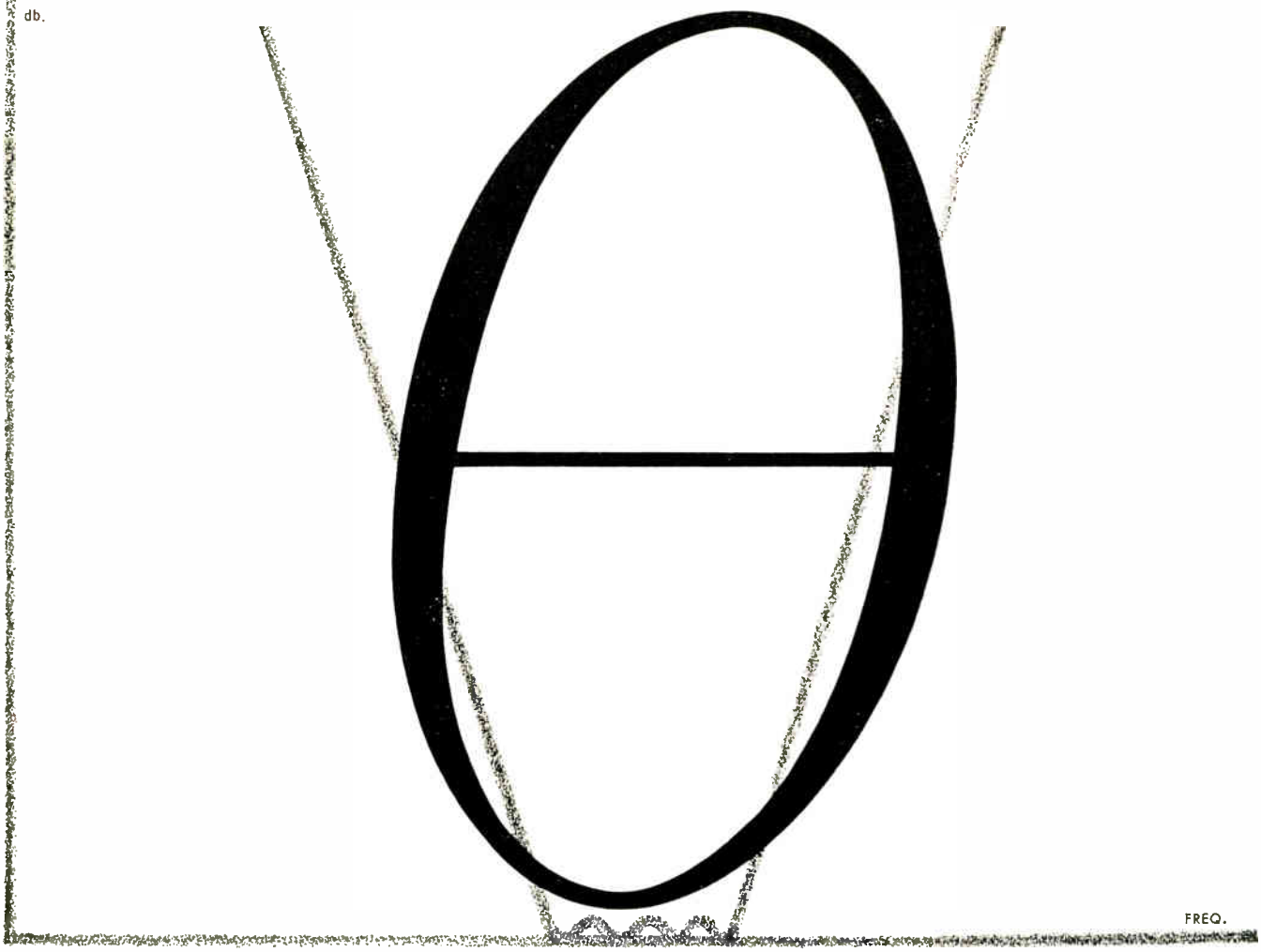
References

1. For further information, see the robustness of life testing procedures derived from the exponential distribution, by M. Zelen and M. C. Dannemiller, *Technometrics* (to be published, Feb. 1961).

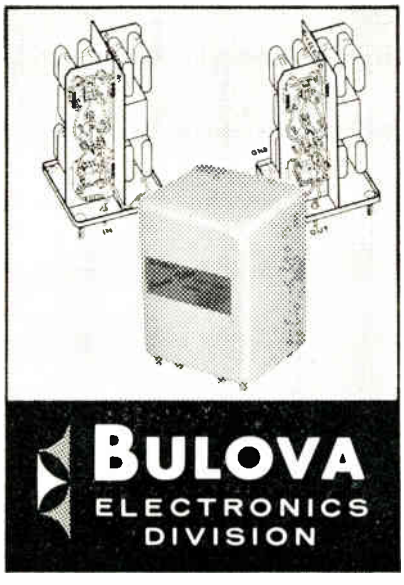
2. Mathematical research on reliability prediction, NBS Tech. News Bul. 44, 24 (1960).

Circle 88 on Inquiry Card
← Circle 127 on Inquiry Card

Circle 129 on Inquiry Card



BULOVA PRECISION CRYSTAL FILTERS



Whatever the frequency you wish to "isolate", Bulova experience with prototype and production quantities of precision filters assures maximum sensitivity and stability. The following examples show Bulova's mastery of the most difficult problems in high-performance filter engineering.

BAND PASS FILTERS—In a band of 30 filters, insertion loss variation between filters, and over the temperature range 25° C to 75° C, held to .3db between highest and lowest. *Part #69-A-RP-13-2N* (1 thru 30)

SINGLE SIDE BAND FILTERS—Band ripple held to ± ½db, both 1 and 3db points defined, over the temperature range 0° C to 85° C, and 300 to 2000cps vibration at 30G level. *Part #117B-FC-22-4WU*

DISCRIMINATOR—Center frequency held to within 10cps, frequencies equally spaced from center, held to 5.4v peak ± 5%. *Part #186C-TN-22A-WD*

BAND SUPPRESSION FILTERS—2kc wide band attenuated 60db, right next to it a pass band held flat to ± ¼db for 150kc. *Part #158-TF15-6R*

If you're faced with tough filtering problems, need additional information or practical application assistance, contact Bulova for engineering specialists to assist in selection of filters best suited to your needs. Write Department 1820, Bulova Electronics, Woodside 77, N.Y.

Tele-Tech's ELECTRONIC OPERATIONS

The Systems Engineering Section of ELECTRONIC INDUSTRIES • DECEMBER 1960

SYSTEMS—WISE . . .

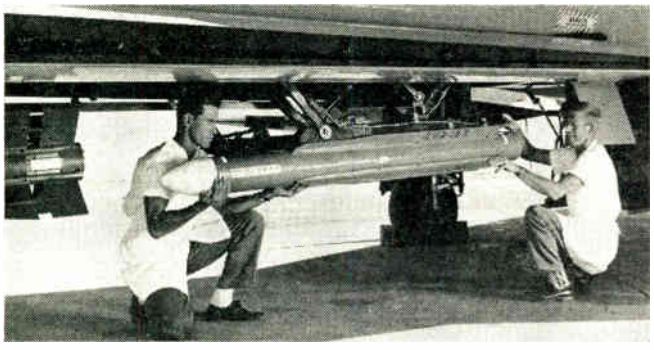
▸ The FCC has extended (60 days from Oct. 31) the period in which TV VHF repeaters built before July 7, 1960, can apply for temporary authorizations to continue operation pending compliance with new VHF translator rules. It was done as a convenience to many operators who are having delays in getting approval of TV stations whose programs they pick up and repeat.

▸ **All five stereophonic broadcast systems tested in field trials at Uniontown, Pa., by the NAB gave good results. The FCC is expected to establish FM Stereo standards shortly, but which of the 5 (or combination) will be selected is unknown. A "dark horse" entry may even be used if one should develop.**

▸ Our military commanders would have enough information to launch a retaliatory attack within 10 sec. after the first enemy missile is detected. That's all the time the BMEWS system's data processing equipment needs to determine speeds, trajectories, time and area of impact, and the point of enemy launches.

▸ Ampex Military Products Co. has been awarded a BuShips contract to develop a 7-channel, 4-speed magnetic tape recorder/reproducer for the Navy. The AN/UNQ-8 will be used in evaluating and recording shipboard-gathered material.

FRUSTRATED FALCON

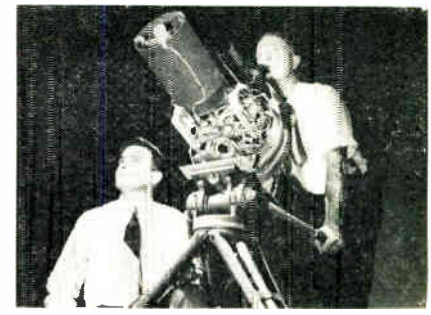


This WSEM (Weapon System Evaluator Missile) fires but never launches from Air Defense Command all-weather interceptors. Developed by Hughes Aircraft Co., it checks compatibility between Falcon air-to-air guided missiles and interceptor's armament control during a simulated air attack. There are radar and infrared versions.

▸ **Aerojet-General Corp. is modifying the Titan ICBM rocket engine so that it can be controlled by a pilot. The engine is slated to be used in the Air Force's man-in-space Dyna-Soar program. Dyna-Soar glider will orbit the earth, but, unlike the Mercury program, enter the atmosphere under pilot control for a conventional landing.**

▸ Work has begun on converting Social Security information (now on punched cards) into magnetic tape. RCA's new Chicago data processing center has transcribed over 3,000,000 of over 22,000,000 cards. Data, which had formerly been stored in 101 conventional filing cabinets, are now on 97 reels of tape. 10 in. in dia. These can be stored in 4 cabinet drawers.

CHECK SATELLITE TUMBLING



Device developed by Raytheon Co. locks onto light reflected by satellite and tracks automatically. It gives instantaneous data on location and tumbling. Engineers A. Krutchkoff (L) and W. Haywood are tracking Echo 1. Scope is for preliminary sighting.

▸ **Communications system designed by Air Research & Development Command's Rome Air Development Center doubles the usual transmission speed used in conventional transmission of information stored in computers. It can also send digital data at this rate. The AN/GSC-4 accepts information from punched cards, magnetic tape, etc.**

▸ New multi-polarized antenna developed by the Electronics Div., Chance Vought Corp., can do the work of four separate types of antennas in operating with missiles and space vehicles. It can perform the functions of vertically polarized, horizontally polarized, and clockwise and counter-clockwise helical antennas. Polarization is selected by either remote switching or automatically; providing instant response.

▸ **First prototype model of a target intercept computer designed by Remington Rand Univac Div., Sperry Rand Corp., for the guidance of the Army's Nike Zeus anti-ICBM missile has been installed at White Sands Missile Range, New Mexico.**

▸ A new electronic load control communications center, integrated by microwave, has been placed in operation by Philadelphia's Water Dept. It will provide information on what is happening to the distribution of water and in general will improve water service. General Electric set up the microwave system and administers supervisory control. Telemetry is by Radio Frequency Labs; Instrumentation by Manning, Maxwell & Moore; and data reduction system by Kybernetes Div., Hagens Corp.

▸ **Hamilton Standard Div., United Aircraft Corp. will produce a dead reckoning system for a hydrofoil ship which will be used for anti-submarine warfare. System will give a continuous reading of distance traveled and current latitude and longitude. It will continuously plot the ship's and the target's position on the basis of radar and sonar information.**

▸ A file organization that will permit masses of scientific information to be sorted, classified, and made available by the file itself is being studied by the Advanced Information Systems Co., a subsidiary of The Electrada Corp., 9744 Wilshire Blvd., Beverly Hills, Calif. Work is being done for the National Science Foundation.

Put Hi-Fi

MANY engineering advances have been made in the high fidelity field that have not yet been applied to broadcast equipment. If a "hi-fi" enthusiast were to set the limits for flatness of frequency response and limits for distortion for an AM radio station, he would probably require a response of plus or minus one-half db from at least 50 to 12,000 CPS. He would not think of allowing a total distortion level of over 1%.

If he were to build a station that would perform within these limits he would find even the newest equipment usually allows a variation of two db or more from 50 to 12,000 CPS and that 2 to 3% distortion is considered generally excellent performance.

In this article I shall attempt to show how some of the advances made in "hi-fi" engineering can be inexpensively applied to the existing or to the new AM station to bring it within the limits set by our hypothetical "hi-fi" enthusiast. First, what are the major enemies of fidelity in today's AM broadcast system? We would list them as:

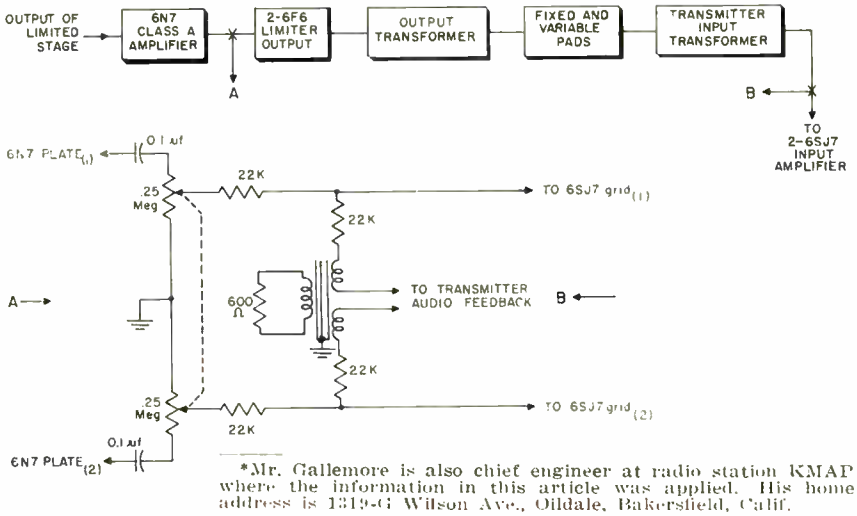
1. Audio transformers
2. Repeated functions introducing the same losses many times
3. Lack of necessary feedback networks to compensate for system losses
4. Limitations by FCC regulations

I will show what was done to eliminate these problems at KMAP, Bakersfield, California, where I am chief engineer. The result has been to give the station an entirely new sound at an expense of approximately $100.00.

The system at KMAP was a standard system originally. Table 1 gives the before and after story on proof of performance.

The transmitter building at KMAP holds a Collins 300J, 250 watt transmitter and a Collins 26-W limiter. These are top quality items and the differences, whether plus or minus, between these and those of other major broadcast equipment manufacturers are generally insignificant from a performance standpoint.

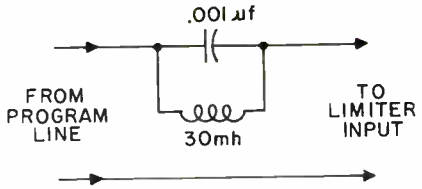
Fig. 1: Two audio transformers were eliminated—the limiter and output transformers.



*Mr. Gallemore is also chief engineer at radio station KMAP where the information in this article was applied. His home address is 1319-G Wilson Ave., Oildale, Bakersfield, Calif.

By BERT GALLEMORE*
Engineer
KLYD-TV

Fig. 3: Circuit shows a series filter that was used with a phone equalizer.



With a few changes and about $100 existing or new AM Broadcast equipment can be made to meet today's hi-fi standards.

into Your Broadcast System

The first point of concern from the preceding list was audio transformers. Every audio transformer between input and antenna causes loss of response and distortions from hysteresis, etc. At the KMAP transmitter two audio transformers were eliminated—the limiter output transformer and the transmitter input transformer. The method used is shown in Fig. 1. This also helped in regard to the second point of the preceding list by eliminating the power output stage of the limiter. This stage was left functioning normally into a dummy load, however, since it is used to furnish the limiting voltages. Contrary to popular belief this step, with its consequent introduction of a high impedance line, had no observable influence on the residual noise level.

Returning to our list of "enemies of fidelity," we find the next item to be a lack of the necessary feedback networks to compensate for system losses. Although an individual feedback network is incorporated in the transmitter, it compensates only for losses from the transmitter input to the plates of the modulator tubes. This network was not disturbed, but to cover all losses from limiting stage to r-f output, the feedback network shown in Fig. 2 was installed.

Precautions for the use of such a network would include normal phasing as well as the fact that the amplifiers involved will always have a certain degree of phase distortion. As a consequence, the feedback becomes gradually regenerative as the frequency of the audio signal goes up. The capacitors in the r-f filters following the 1N64's were large enough to limit the highest audio frequency at which audio feedback occurs in this instance. This might

(Continued on following page)

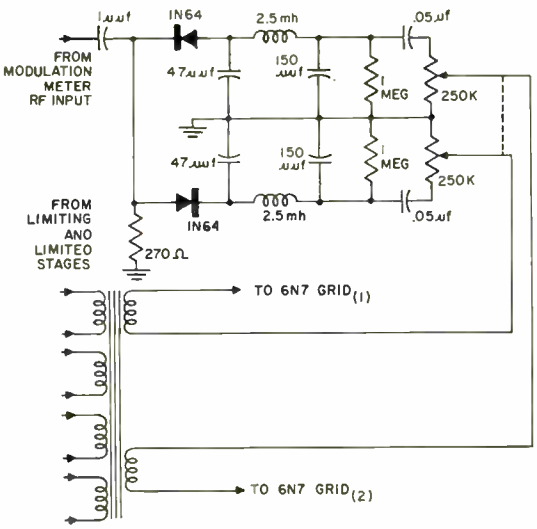
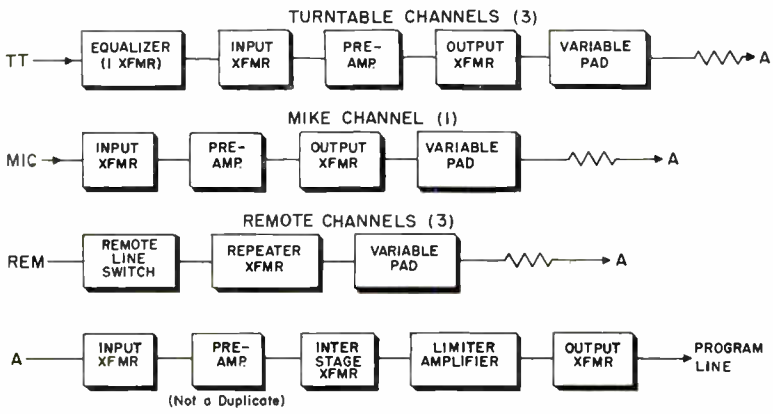


Fig. 2 (left): Additional feedback was added to transmitter.

Fig. 4 (below): Block diagram of the author's studio equipment.



not be the case with other transmitters and limiters.

The final point of concern at the transmitter was to keep the operation within the prescribed FCC limits. Legally there are few specific restrictions. However, all broadcasters will want to keep their interference within reasonable limits as it affects other stations. No doubt too, the Commission can and would enforce this as required. In this particular case, KMAP has an assigned frequency of 1490 KC. The neighbor with which we would most likely interfere is on 1460 KC in a nearby town. This means that in all fairness, even the slight power contained in audio material in the neighborhood of 30,000 CPS should not be broadcast to avoid interference to listeners of the 1460 KC station. The series filter in the line equalizer (built to extend the phone line equalization) eliminates this possibility. (See Fig. 3.)

At the studios the equipment was not quite so "standard." The console was a composite duplicate of a Collins 365E-1 Limiter Amplifier used as the program amplifier with composite duplicates of the monitor amplifier and pre-amplifiers used in the Collins 212A console. These were well built and closely equivalent to their commercial counterparts in all respects. Fig. 4 shows a block diagram.

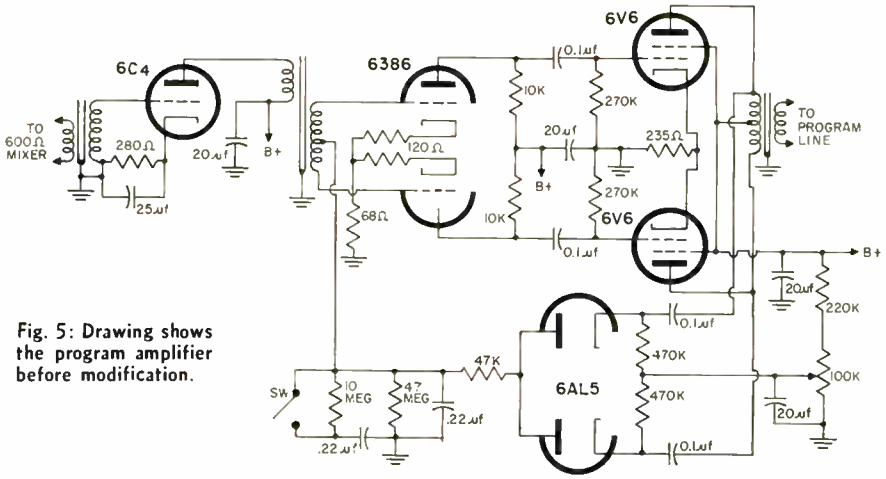


Fig. 5: Drawing shows the program amplifier before modification.

The principal studio problem was audio transformers. In the case of the console, we were virtually surrounded by them. Having had no problems with high impedance lines used at the transmitter, we felt we could use the high impedance approach here also. All pre-amplifiers were replaced with the standard GE UPX-003B mike/phono-preamps with outputs fed to a high impedance mixer as shown in Fig. 6. The original program amplifier is shown in Fig. 5. Figure 6 shows how the low impedance remote channels were combined with the output of the high impedance mixer as well as the changes made in the program limiter/amplifier. These

(*Continued on page 226*)

Table 1

	Old System	Re-equalized Phone Line	Modified Console	Modified Limiter Xmitter	New System
Frequency Response					
100 – 7,500 cps	±2 db	±⅛ db	±0 db	±0 db	±⅛ db
50 – 12,000 cps	. . .	±1 db	±¼ db	±½ db	±¾ db
50 – 20,000 cps	. . .	. . . .	±½ db	±½ db	. . . .
Peak Distortion					
100 – 7,500 cps	4.8%	. . .	0.10%	0.15%	0.30%
50 – 12,000 cps	.	. . . .	0.20%	0.50%	0.75%
50 – 20,000 cps	. . .	. . . .	0.5%	1.5%	. . . .
Residual Noise					
(Below 100% Modulation)	−58 db	. . . .	−61 db	−60 db	−58 db

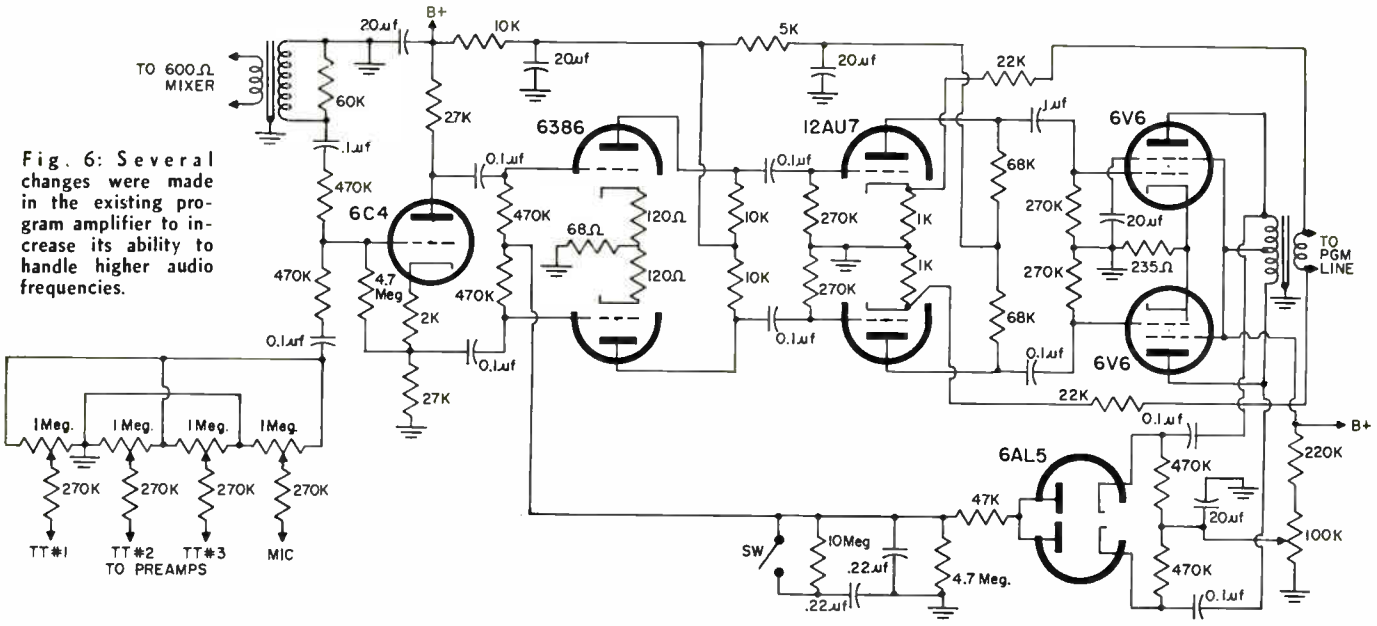
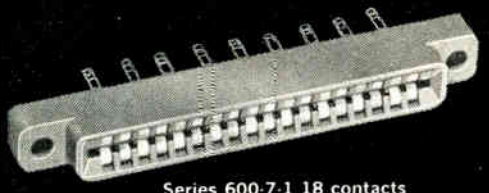
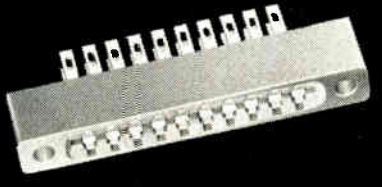


Fig. 6: Several changes were made in the existing program amplifier to increase its ability to handle higher audio frequencies.

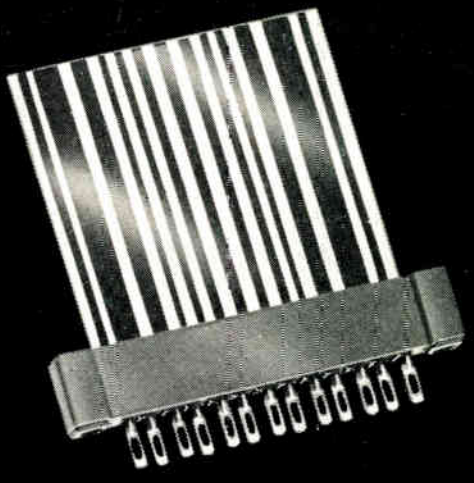
ACTUAL SIZE



Series 600-7-1 18 contacts
for 3/64" PC board or cable



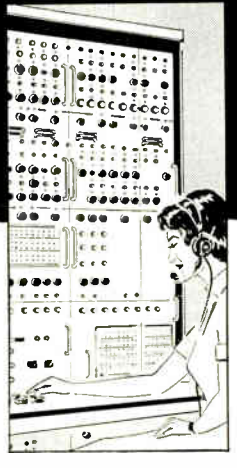
Series 600-4PC10 10 dual contacts
for 1/32" PC board or cable



Series 600-4PCSC13 13 contacts
for 1/32" PC board or cable

Continental Connector
MINIATURE PRINTED CIRCUIT CONNECTORS

Continental printed circuit connectors and "Bellowform" contacts are covered by patent number 2,875,425



WHERE RELIABILITY IS A MUST

and space limitations are critical . . .
specify Continental Miniature PC Connectors

Series 600 precision miniature printed circuit connectors provide a positive, space-saving connection between printed circuitry and conventional wiring, through printed circuit boards, tape cables or plug-mounted sub-assemblies.

SERIES 600-7-1. For 3/64" printed circuit board or tape cable. 18 contacts for #24 AWG wire. Solder lug terminations are staggered to simplify soldering operations.

SERIES 600-4PCSC13. For 1/32" printed circuit board or tape cable. 13 staggered contacts accommodate #22 AWG wire. Module design permits stacking of any reasonable number of single units. Contacts have minimum spacing with maximum contact wiping surface.

SERIES 600-4PC10. Accepts 1/32" printed circuit board or tape cable. Double row of 10 contacts with solder lug terminations provides a total of 20 connections. For #22 AWG wire. Overall length only 1 7/8".

Continental Connector's "Bellowform" contacts are used in this series and provide coil spring action grip that clasps the printed circuit board firmly over the entire contact area regardless of board tolerance variations.

Contact material is spring temper phosphor bronze with gold plate over silver plate. Body molding compound is glass reinforced Diallyl Phthalate (MIL-M-19833, Type GDI-30, green color).

Technical literature on Continental Connector Series 600 Miniature PC Connectors is available on request. Write to Electronics Division, DeJUR-AMSCO CORPORATION, 45-01 Northern Boulevard, Long Island City 1, N. Y. (Exclusive Sales Agent)

CONTINENTAL CONNECTORS

MANUFACTURED BY
CONTINENTAL CONNECTOR CORPORATION,
AMERICA'S FASTEST GROWING LINE OF
PRECISION CONNECTORS

Circle 133 on Inquiry Card

TOWER TIPS

INSURANCE

If a station decides to hire its own erector to install the tower, it is recommended that the following evidence of insurance from the erector (in the form of certificates) be obtained. *The following different insurance certificates are customary today:*

1. Workmen's compensation and occupation diseases, including employer's liability insurance. LIMITS: This insurance should be checked with the statutory requirements as applicable in the state in which the work is being performed. Employer's liability should be at least $25,000.
2. Contractor's public liability insurance which covers damage and injury to objects and people not under the care and custody of the contractor. LIMITS: Bodily injury, $15,000/100,000; property damage, $15,000/100,000.
3. Contractor's protective liability insurance protects the contractor with his subcontractors. For example, the contractor may sublet the foundations or sublet the electrical work or paint because of union problems. LIMITS: Bodily injury, $15,000/100,000; property damage, $15,000/100,000.
4. Automobile liability insurance. This covers all motor vehicles owned or leased including nonownership liability covering contractors' employees' personal cars and trucks. LIMITS: Bodily injury, $100,000; property damage, $100,000.
5. Direct damage insurance. This insurance provides for protection against all risk of the tower, antenna, lines, and the equipment which the erector is working on or material which is in his (erector's) custody until completion of the job. LIMITS: Should be set to cover the value of the tower, lights, coaxial lines, antenna, and any other equipment he is installing, plus erection labor involved.

The owner should have an insurance policy covering any loss to the tower once the tower erection is completed and the customer has accepted the tower. Values are set for replacement values, namely, the price which he has paid for the tower and equipment on the tower plus the cost of erection.

(Reprinted from NAB Engineering Handbook)

Walter L. Guzewicz

CUES for Broadcasters

Switch Spring Replacement

GIL WALLACE, Ch. Eng.

WFIW, Fairfield, Ill.

Stations using the Gates CB-100 transcription turntables have probably had trouble with the small spring on the push switch breaking. It is a fairly common problem.

The spring from a ball point pen can easily be cut to size for an exact replacement. The number of ball point pens around a station usually precludes the purchase of refills. Before discarding the pens, remove the springs. These springs vary in size with different pens and many uses other than the above can be found for the springs.

Low Voltage Neon Indicator Source

M. A. SUNTOP

38 Berkshire St.
Rochester 7, N. Y.

It isn't well known that a neon lamp can be fired from a low voltage source merely by the action of a capacitor arranged in the circuit shown in Fig. 1.

From the characteristics of a neon lamp it is known that the firing voltage differs from the turn-off voltage by as much as 30 volts. Thus if the turn-off potential is 56 volts, as in the case of the NE-51, maximum supply required need only be this value necessary to maintain its action.

In the normally closed condition, the neon lamp remains off. However, the capacitor C is being charged by the supply to 67.5 volts. Reversing the switch to the normally open condition momentarily adds to the supply voltage, such that the potential across the neon lamp is twice that of the supply. This is sufficient to fire the lamp and then be maintained by the lower value.

There are many ways to turn off the neon lamp. A method shown in Fig. 2 incorporates a switch SW-1. When depressed, the anode voltage goes to ground, and on release, the plate potential is insufficient to fire the lamp.

Charging the capacitor in position shown and then switching the capacitor to the other position will cause the NE 51 to light

Fig. 1

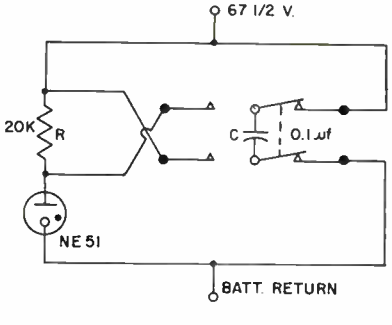
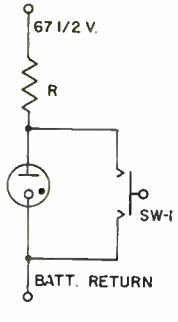


Fig. 2



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Circle 135 on Inquiry Card

DORSETT D-20

NEW
SUBCARRIER OSCILLATOR
FOR FM TELEMETERING

SPECIFICATIONS

Input: 0 to 5 volts, or ±2.5 volts.

Output: 0 to 4 volts RMS (adjustable).

Power Requirements: Less than 70 milliwatts (+20 volts and −20 volts). Specify model PS-20 power supply for 28 volt systems.

Impedance: Output, 10 K. Input, 1 megohm.

Linearity: Less than .5% deviation from best straight line.

Harmonic Distortion: Less than 1%.

Stability: Temperature, 2% fbw change in center frequency or band width for any 50°C change between −55°C and +125°C. No more than ±1% fbw shift in center frequency or deviation sensitivity under 50 G linear acceleration; 20 G vibration, 55-2000 cps; or following a 100 G, 11 millisecond shock.

Size: 2.25" x 1.875" x .875".

Weight: Less than 4 ounces.

Holddown: Special captive screws.

Controls: Output. Centering. Deviation Sensitivity.

DORSETT ELECTRONICS LABORATORIES, INC.

119 WEST BOYD • NORMAN, OKLA. • JE 4-3750

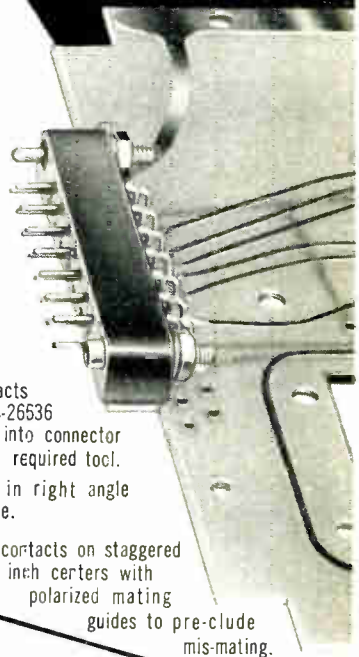
Circle 136 on Inquiry Card

Methode Multiple Contact Connectors

Designed for aircraft, radar, and missile applications. Especially suitable for use with printed circuit boards or, Plyo-Duct, Methode's flat multi-conductor cabling.

PRINTED CIRCUIT PIN and SOCKET CONNECTOR
Series MD-1100 and SD-1100

Exceed the requirements of MIL-C-8384 specifications, these new connectors utilizing pin and socket contacts will be most desirable for many applications.



The solder pocket type socket contacts resist test prod damage of MIL-C-26536 specifications. Can also be inserted into connector block after wiring with no special required tool.

The male connector is available in right angle mounting or upright style.

Available with contacts on staggered .100 inch centers with polarized mating guides to pre-clude mis-mating.

RELI-ACON FEED-THRU STYLE CONNECTOR Series FTD 1500

These connectors employ a tri-fucated contact which withstands and exceeds the extreme vibration requirements of MIL-E-5272. Presently available in 15 contacts on .100 inch centers for a nominal card opening of .062 inch. Environmental seal is available about the board or cable entrance.

Flexible multi-conductor wiring is available in standard sizes from stock or custom patterned to your specifications.

COMPLETE information and data are available on both of above connector types .... write today.

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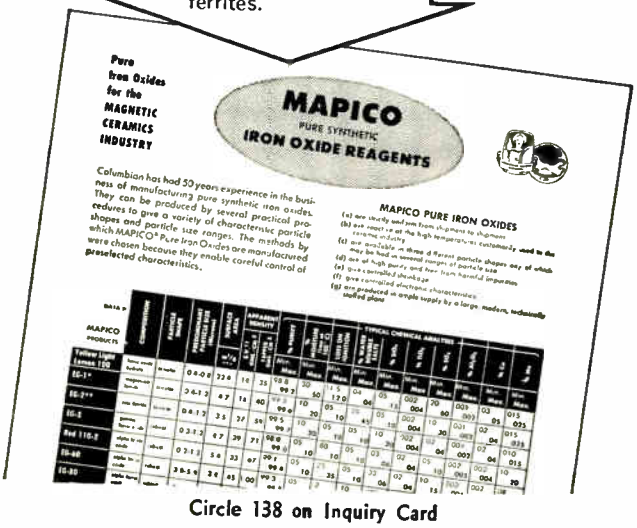

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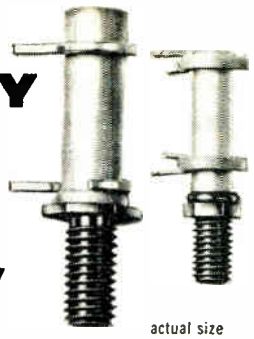

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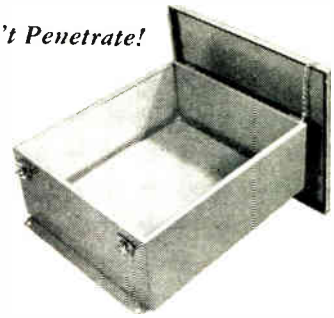
McKINSTRY JIC Wiring Boxes provide complete protection against seepage of oils, dust, dirt or water, whether they are installed indoors or outdoors. For dependable performance, look for the McKINSTRY trademark before you buy. You can pay more, but you can't buy better quality JIC Wiring Boxes.



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WASHINGTON News Letter

MOVE TO ALL-UHF TELEVISION—Commissioner Robert E. Lee has proposed that the FCC impose a permanent freeze on new VHF TV stations and changes in VHF station assignments, so that all television eventually can be moved into the UHF spectrum. In his plan, presented before the National Association of Educational Broadcasters, Commissioner Lee stressed that he would press for legislation for all-channel TV receivers. Also he would license new UHF stations to the lowest channels available. He asserted his program would provide spectrum space for over 750 TV stations and for educational reservations.

PROMISE OF VAST SPACE—In his proposal, Commissioner Lee declared that, if the FCC moves all TV operations to UHF bands, many additional frequencies will be available for common carrier and private mobile radio communications. These services, he emphasized, "have been long crowded into a relatively narrow portion of the spectrum, which can scarcely contain them." Because of this situation, mobile services are still seriously hampered in most large cities. Air-to-ground telephone, for commercial airlines, is also severely limited for lack of frequencies.

GOVERNMENT SPACE POLICY—T. Keith Glennan, head of NASA, contends that the use of satellites, to provide communications links as a part of ordinary commercial services, should be developed and used by private industry, with the government lending assistance. Such action would accelerate the nation's progress toward the practical application of such communications systems. Mr. Glennan's statements were deemed certain to cause much discussion, particularly in the next session of Congress.

NASA GUIDELINES—In spelling out the guidelines of government policy on space communications, Administrator Glennan said, "NASA's efforts to realize the promise of space technology in the communications satellite field will be accelerated. However, they will not be conceived as a 'crash' program, nor will they duplicate well-conceived activities of the military, or the commercial projects of private companies. NASA's efforts will proceed, technically, along a sufficiently broad front, to assure the objective of achieving a system, capable of practical application. Finally, NASA will continue its research and development efforts in this field, only so long as is necessary, to assure that timely development of a commercially feasible communications system will be completed by private industry."

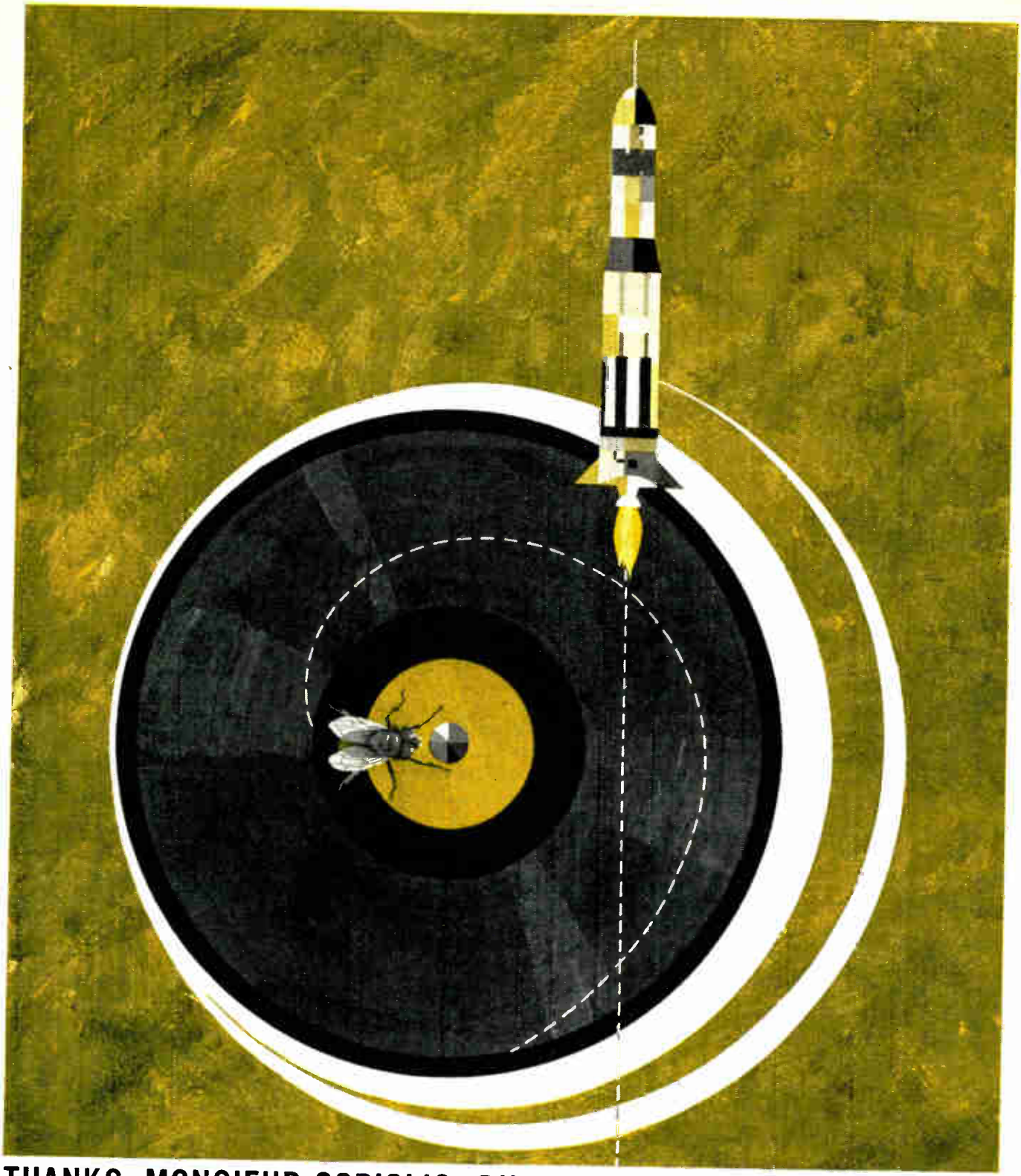
AT&T PLAN—The American Telephone & Telegraph Co. has presented, in an application with the FCC seeking approval of a satellite experiment, the first formal step toward commercial application of a satellite communications system. AT&T said it was prepared to put the first station of a satellite relay system into space, within a year, to provide for the experimental transmission of telephone calls, television, data transmission and other types of communications between the U. S., the U. K., and continental Europe. It proposed that broadband microwave techniques would be employed in the frequency bands 6425-6525 megacycles and 6775-6875 mc. The initial ground station in this country would be at Bell Telephone Laboratories' Holmdel, N. J., installation, where current Bell System space communications work is going on.

ORBIT OF ABOUT 2200 MILES—The AT&T informed the FCC that it is planning a system that would make use of solar-powered satellites orbiting at an altitude of about 2200 miles. Electronic amplifiers aboard the space station would catch signals from the earth and, immediately, boost and relay them onto ground stations in the U. S., the U. K. and Western Europe. No estimate was placed on the cost of launching the first space satellite, but an AT&T spokesman said that later satellites put into orbit would cost on an average of $1 million.

MICROWAVE MAIL—In the Post Office Department's facsimile "Speed Mail" system, which has been launched experimentally between Washington, Chicago and the Civil Defense headquarters at Battle Creek, Mich., microwaves are employed for the sending of letters between these cities. The International Telephone & Telegraph Corporation is the prime engineering contractor of the project. The Stromberg-Carlson Division of the General Dynamics Corp. is the important supplier of the scanning and receiving equipment.

National Press Building
Washington 4
ROLAND C. DAVIES

ATTACK WARNING CAPABILITIES — Leo A. Hoegh, Director of Civil and Defense Mobilization, reports significant developments in the nation's defenses against surprise attack: An OCDM Indoor Warning Buzzer called NEAR (National Emergency Alarm Repeater) and activation of the first of three BMEWS (Ballistic Missile Early Warning System) at Thule, Greenland. The Civil Defense Warning System is linked to BMEWS through Continental Air Defense Headquarters. NEAR was successfully tested on a city-wide basis in Charlotte, Mich. on Oct. 11, 1960.



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Your theory is a little complicated for us. Rather than work in rotating coordinates and compensate for your famous acceleration, we avoid the problem. Our guidance system platforms are stabilized in inertial space instead of rotating Earth space. The result is simpler guidance system computations for missiles like Titan. If you are challenged by reducing classic theory to practical hardware, and have a BS, MS or PhD in Physics, ME, EE, or Math, please contact Mr. C. J. Allen, Director of Scientific and Professional Employment, 7929 S. Howell, Milwaukee 1, Wisconsin.

AC SPARK PLUG ❀ THE ELECTRONICS DIVISION OF GENERAL MOTORS

PROFESSIONAL OPPORTUNITIES

Reporting late developments affecting the employment picture in the Electronic Industries

Design Engineers • Development Engineers • Administrative Engineers • Engineering Writers
Physicists • Mathematicians • Electronic Instructors • Field Engineers • Production Engineers

AF Electronic Techs Learn By Machine

An Air Force student group (14) is being taught electronics with a newly developed teaching machine. The machine, the AutoTutor (developed by Western Design Div., U. S. Industries, Inc., 250 Park Ave., N. Y. C.), lets the student advance according to his ability. It requires him to show understanding at each step of the course, automatically records his progress, and charts his reasoning process.

The program is being carried out under strictly controlled conditions. A second group is studying the same material by the conventional classroom-instructor method. Day-by-day comparisons of progress for both groups, as well as for the individual student, are being made.

LIFE MEMBER

Ralph L. Power, PhD., Hoffman Electronics Corp., is now honorary life member of the Australian Institution of Radio Engineers—an honor shared by only 12 others. He was cited for: "his interest and study in wireless history, radio theory, the economics of communications and corporate planning and administration." He is also a Companion of the Institution. He has worn many hats: radio editor, publicity manager for WESCON and WCEMA, Exec. Sec. of the L. A. Reps Chapter, L. A. market editor of Radio-TV Weekly and many others.

Drafting Scientists—Engineers Same As "Trench Warfare"—S. B. Ingram

The director of Technical Employment at Bell Telephone Labs, Murray Hill, N. J., S. B. Ingram, compared the Selective Service System's "drafting of young scientists into the armed services" to "trench warfare." Soviet Russia, he said, "has a more realistic approach to its scientific and engineering manpower problem." His paper, "Our Scientific and Engineering Manpower Problem," was delivered at the AIEE's Fall General Meeting in Chicago.

In comparing the Russian and American systems, he reported that the Russians place a much higher value on their scientific and engineering talent—in both money and prestige. He pointed out that the Russians are graduating 100,000 engineers a year compared to our 38,000.

He said that we were actually drafting only a few scientists right now because there is a large pool of draftable youths to choose from. The Selective Service System (backed by the DOD) has been rather liberal with occupational and educational deferments.

But, he said, "the provisions of the Selective Service Act are completely out-dated in the fundamental premise and what is needed is a new law based on a new concept of service." The new law should make it possible for engineers and scientists to discharge their obligation through either civilian or military service as the public interest and the national welfare may require. Assignments to either type of service should be by local Selective Service Boards acting under directives from the Selective Service System.

Chart Engineer Demand

The demand for engineers and scientists is being charted by Deutsch & Shea, Inc., 230 West 41st St., N. Y. 36, N. Y. The Engineer Scientist Demand Index is based on a monthly measurement of the recruitment advertising appearing in a selected group of technical journals and in leading newspapers in 20 key market areas. It does not show the actual number of engineers and scientists being sought, but it does provide a continuing measure of the industry's recruiting programs.

Two types of data will be provided: the total number of recruiting ads and the total linage of these ads. The ratio of linage to ads indicates the size of advertising space used and, hence, the amount that companies are spending to reach engineers and scientists.

The table below shows the demand for engineers and scientists during the first 6 months of 1960.

Demand For Engineers/Scientists
Jan.-June 1960

Month	Ads	Pages	Ave. Ad Size
Jan.	565	290	.51 of page
Feb.	560	262.4	.47 " "
Mar.	570	283.5	.50 " "
Apr.	534	246.4	.46 " "
May	555	255.2	.46 " "
June	495	225.7	.46 " "

FOR MORE INFORMATION . . . on positions described in this section fill out the convenient inquiry card, page 157.

Science Society Is 300 Years Old

The Royal Society—its full title is "The Royal Society of London for the Promotion of Natural Knowledge" — is celebrating its 300th anniversary in London.

By **WILLIAM D. HITT**
Assistant Division Chief
Systems Engineering Division
Battelle Memorial Institute
505 King Avenue
Columbus 1, Ohio

A Tool for Industrial Managers . . .

Applied Psychological Research

Twenty years ago psychology was considered an academic science of interest only to college professors. But now it has come out of the classroom and into the factory improving products, reducing costs, solving complex man-machine relationships and even helping to decide who the next "boss" may be. The research psychologist is a scientist with sometimes limited tools but he can often provide valuable help.

A PLANT manager wants to select the most promising candidates for foreman training. The designer of an electronic computer wants to simplify the many dials and knobs that might confuse the operator. A manufacturer of perfume wants to improve the quality without increasing the cost.

These problems have one element in common: all three are "human factors" problems. That is, the solution of these problems requires a knowledge and understanding of people—their preferences, their capacities, their limitations. To help solve problems involving people in industry, psychologists are developing and applying many useful techniques.

Methods

The research psychologist is by no means an expert who has remedies for any and all problems. He is a scientist who has limited "instruments" that sometimes produce knowledge and sometimes prove unproductive. Two instruments that have been of definite value are experimental methodology and statistical analysis. It is generally accepted that the stature of a science is measured by the degree to which it makes use of mathematics. Stevens asserts that "When description gives way to measurement, calculation replaces debate."[9]

An Example

Automobile makers periodically modify their cars in an effort to improve riding comfort. One manufacturer was conducting riding-comfort tests in the following manner. First, some component of the car was modified. Several of the company personnel, possibly a supervisor and three engineers, would take a ride in the car to evaluate its riding comfort. After the rides these "judges" would rate the care on a five-point "comfort scale."

A company research scientist noticed these sources of error in the evaluation technique: (1) No distinction was made between riding in the front seat and riding in the back seat. (2) The same "judges" would not be present during each of a series of tests. (3) The "judges" were not given adequate instruction in the use of the rating scale. (4) It was apparent that the engineers were attempting to *agree with their supervisor* in each of their ratings.

The research psychologist would attack the riding-comfort problem in a systematic manner. He would first attempt to identify all pertinent variables, or determinants of riding comfort, such as spring rate or tire pressure. He would next manipulate in a systematic manner the one or more variables under study. Extraneous variables would be controlled. The experimenter would then be in a position to state with some confidence the nature of the relation between the particular modification and the riding-comfort scores.

Statistical Analysis

Statistical methods represent an efficient means for organizing and describing sets of data. In analyzing the riding-comfort data, the research psychologist probably would wants to compute some measure of central tendency, such as the *arithmetic mean*, to represent the average rating for each experimental condition. He also might want to compute some measure of variability, i.e., of the "scatter" or "spread" of the separate ratings around their central tendency, such as the *standard deviation*, to demonstrate the degree of consistency among raters. Statistics used like this are considered *descriptive statistics;* that is, they describe the data at hand.

Equally useful are *inferential statistics*, which permit us to generalize beyond our sample data. For instance, in the riding-comfort problem, four different modifications in car construction might have produced four different mean riding-comfort scores. We would then ask whether these differences could actually be attributed to the

modifications or might they be attributed only to chance factors. Inferential statistics would provide an answer.

Many of the statistical methods used by the research psychologist are the same as those used by, say, the quality-control engineer. Other statistical methods, however, are unique to psychology. Psychophysics, for example, is an extremely useful tool that has been used extensively by psychologists but hardly at all by other scientific disciplines. Psychophysics is the science that investigates the quantitative relations between physical events and corresponding psychological events.

The psychological scaling methods, including such methods as pair comparisons, ranking method, and rating scales, also have been of considerable value to psychologists. Whether we are evaluating riding comfort, supervisory performance, complex man-machine systems, or cookies, we can be more accurate if our evaluations are presented quantitatively rather than qualitatively.

These examples illustrate only a few of the many ways in which the psychologist makes use of experimental methodology and statistical analysis, two of his most useful tools.

Areas of Concentration

Because applied psychological research is still comparatively new, the areas of concentration are not so clearly defined as they are in such sciences as physics or chemistry. However, three areas that have received a considerable amount of attention from the psychologist are engineering psychology, personnel psychology, and sensation and perception.

Engineering Psychology

Engineering psychology is defined as the adaptation of human tasks and working environment to the sensory, perceptual, intellectual, physical, and other attributes of people. This adaptation for human use applies to such functions as the design of equipment, instruments, and man-machine systems, and to the development of optimum work methods.

One important factor that has contributed to the reduction in number of aircraft accidents during the past several years is that the pilot's displays and controls have been "human engineered." A comprehensive human-engineering study conducted several years ago[3] revealed that the most frequent errors made by pilots were the following: errors in interpreting multi-revolution instrument indications, reversal errors, signal interpretation errors, legibility errors, and substitution errors. By analyzing the causes of such errors and then taking corrective action, military and civilian agencies have been able to reduce the number of aircraft accidents.

There are other examples that could be cited. Human-engineering problems found in the automobile are known to practically every adult. Why aren't headlights standardized so night drivers can better estimate the distance of an approaching vehicle? Why are hand brakes so difficult to reach? Even the kitchen stove presents some interesting human-engineering problems. For instance, does the knob on the far right control the front burner or the rear burner? What types of automatic signaling devices should be incorporated in the stove?

The designer of a complex electronic computer must consider numerous human-engineering problems involved in such an intricate system. First, he must determine the requirements for the system as a whole. Next, he must allot certain functions to the machine and certain functions to the operator. With regard to the inputs into the system, the designer must decide what information the operator will need, and how best to present this information to the operator. The controls also must be designed so that they can be efficiently used by the operator.

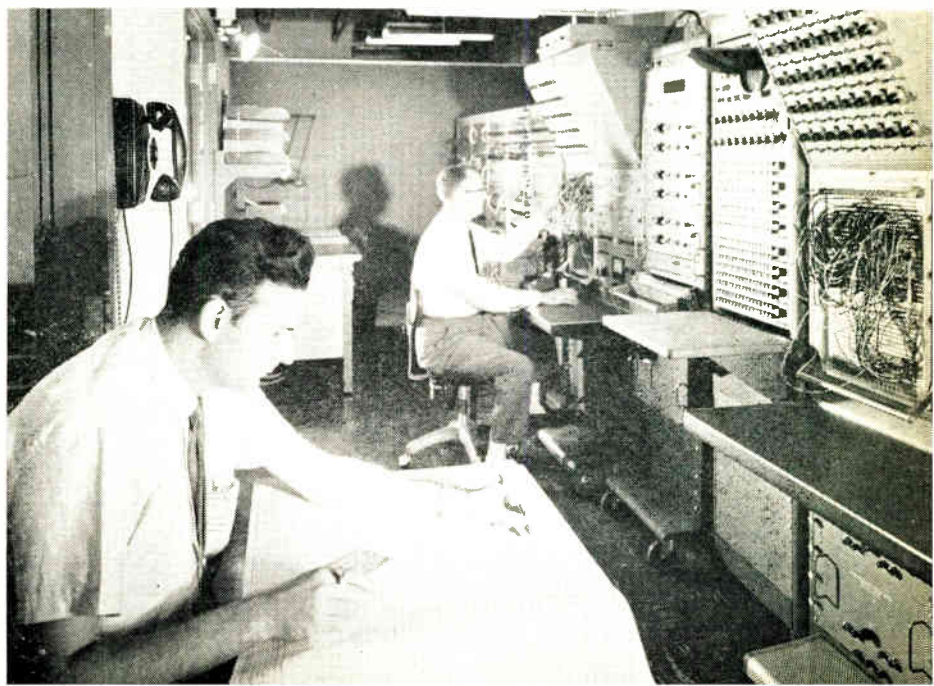
As a team, the design engineer and the engineering psychologist can design such a computer system so that it does not overload the operator. Moreover, they must consider the possibility that a highly automatized system will demand *too little* of the operator's attention and, in turn, result in only monotony and boredom on the part of the operator.

Personnel Psychology

Personnel psychology deals with employment procedures, selection, training, performance evaluation, and other aspects of the human problem in work situations. The most significant contribution of the personnel psychologist has been the development of psychological tests. Practically every adult American male has been confronted with a battery of psychological tests sometime during his career, either in the military service or in industry.

Professional psychologists do not claim that testing will solve all selection problems. A testing program should be considered merely a way of improving a company's batting average in the selection process.

Preparing a patch diagram—a road map of computer interconnections—an important step in analog simulation study of dynamic systems. Complex equipment must be "human engineered" for optimum system performance.



Psychological Research *(Continued)*

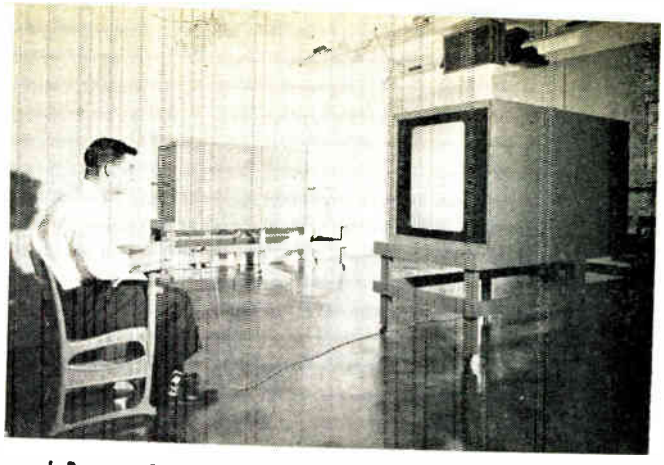
Unfortunately, there are few occasions in personnel selection when ready-made techniques can be applied. Most psychologsits prefer to tailor-make a test battery for the company's specific needs. The personnel selection, then formulate working hypotheses, devise the necessary tests, try them out experimentally, check on the validity of his hypotheses by use of statistical analysis, and finally revise his tests in accordance with his findings. Each of these steps is a separate problem to be solved before the actual selection of individuals is undertaken.

Psychological tests can often be valuable as one of several "hurdles" in a selection procedure. Consider the plant manager who wants to select from among all his hourly-paid personnel those men who are the most promising candidates for foreman training. To select the best candidates, some companies have found it profitable to use three "hurdles": supervisory ratings, psychological tests, and a panel interview.

A satisfactory supervisory rating generally indicates that a man's *work performance* has been at least acceptable. The psychological test scores give some indication of a man's *potential ability* for handling a foreman's job. Then, finally, the panel of interviewers, after an extensive interview with the candidate, will attempt to assess those characteristics not included in either the supervisory rating or the psychological tests.

After the training program commences, the personnel psychologist can again help. Such questions as the following can in large part be answered by psychological techniques.

(1) What should be taught?
(2) How should the material be presented?
(3) How long should formal training continue?



Rear-view projection facility for presentation of visual-display materials. Results of this study served as criteria for designing displays for a large data-processing system.

Sensation and Perception

Product evaluation is an example of applied research in the area of sensation and perception. For example, the manufacturer of perfume who wants to know what physical properties of his product are most highly related to consumer preference has, essentially, a problem concerning sensation and perception. He needs to know how his perfume affects the sense of smell.

A research psychologist probably would conduct a laboratory experiment to ascertain the significant relations. He would first decide which properties should be evaluated. Each property would then be varied over a number of levels to provide the samples to be evaluated. A group of people would serve on a test panel.

After smelling each sample, the subjects would indicate on a scale the degree to which they liked or disliked that particular sample. After completion of the experiment, the data would be analyzed to demonstrate the quantitative relation between each of the physical properties and subject preference. With this information, the manufacturer could then decide how to manufacture his perfume to maximize consumer acceptance.

A Summing Up

The industrial manager is confronted with many difficult problems in his efforts to deal with the human element in industry. Human behavior obviously consists of a large number of complex variables . . . and quite often these variables cannot even be identified, much less measured in any exact fashion.

Chapanis[2] describes the dilemma of psychological research like this: "Call man a machine if you will, but do not underestimate him when you experiment on him. He's a nonlinear machine; a machine that's programmed with a tape you cannot find; a machine that continually changes its programming without telling you; a machine that seems to be especially subject to the perturbations of random noise; a machine that thinks, has attitudes, and emotions; a machine that may try to deceive you in your attempts to find out what makes him function, an effort in which, unfortunately, he is sometimes successful."

Mathematical equations of human behavior are often found to be "temporary and fleeting." But even with the numerous problems encountered in the field of applied psychological research, significant strides have been made. Psychologists today can measure many aspects of human behavior in terms of quantitative units. Prediction of human behavior can be achieved with at least a moderate degree of accuracy. Sensory processes can be described in detail.

It is safe to say that applied psychological research will continue to grow as a valuable technique for providing answers to many questions concerning human behavior in industry.

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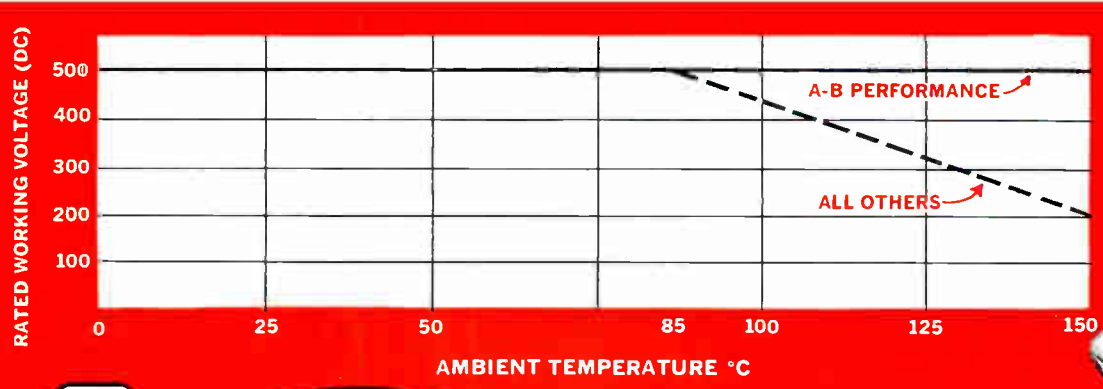

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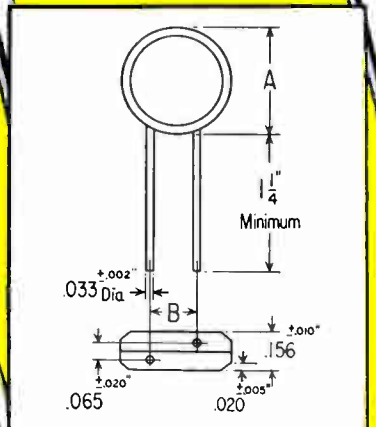

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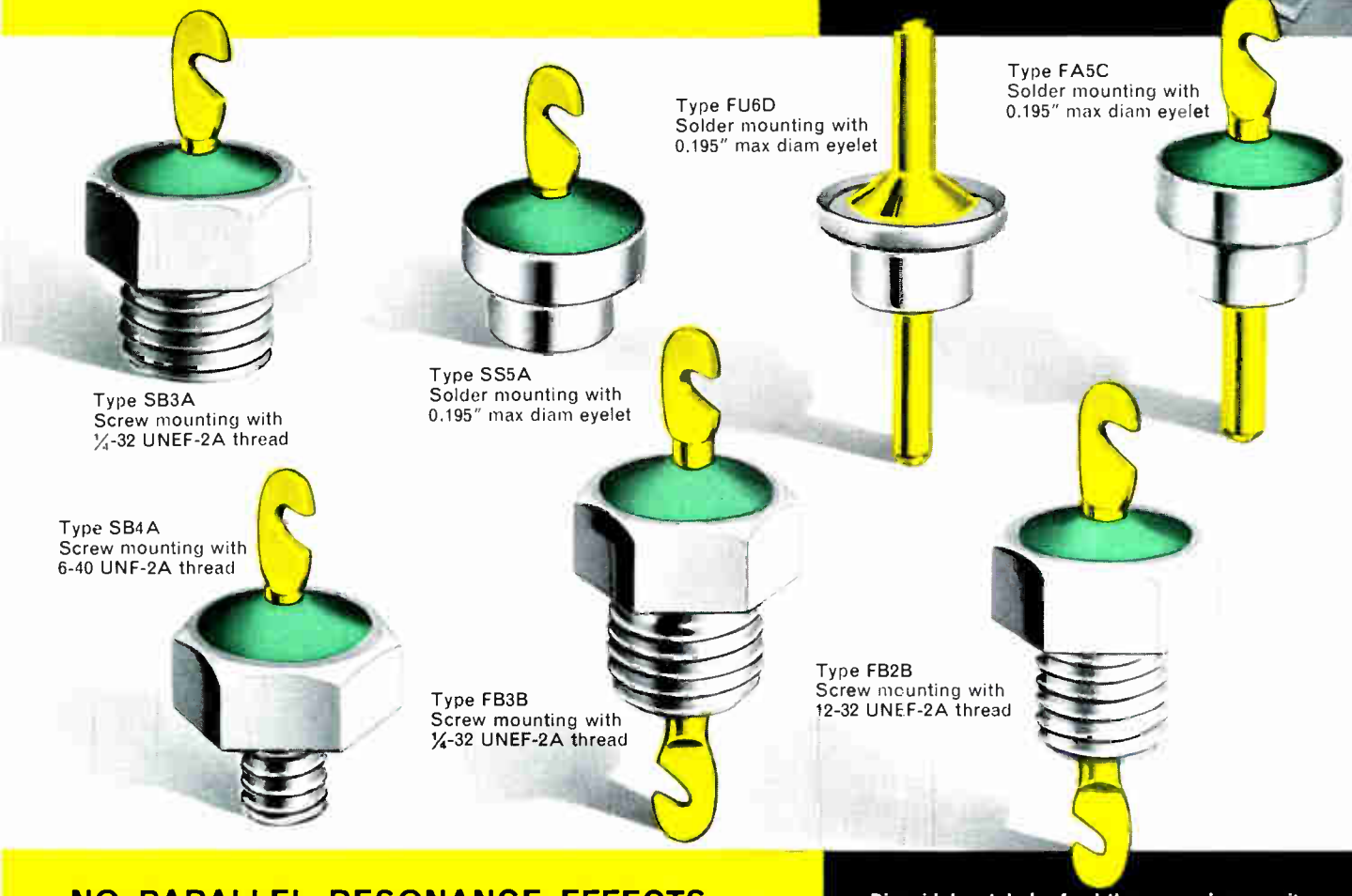

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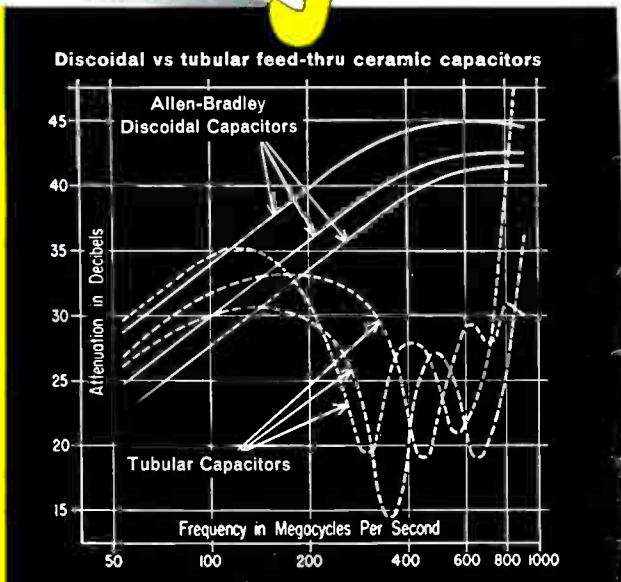

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Because this can be mighty important to an engineer and his family, we've developed a completely new technique that should be as enjoyable as it is helpful to you — *technical quizzes* on Radar, Microwave, Communications, Packaging... and, for those interested in Engineering Administration, a special psychological questionnaire.

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Simply check off any 2 subjects on the coupon and we'll mail you the corresponding tests, answer sheets and evaluation guides.

During a quiet evening hour, work them through and grade yourself with the answer sheet. Then, use the evaluation guide to figure out your own probability for success on the Light Military staff.

MAIL THIS COUPON FOR YOUR TESTS

Current Areas of Activity At The Light Military Department

Space Communications & Telemetry • Missile & Satellite Computers • Space Vehicle Guidance • Undersea Warfare Systems • Thermoplastic Data Storage • Space Detection & Surveillance • Command Guidance & Instrumentation • Infrared Missile Applications

LMED

LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

FRENCH ROAD, UTICA, NEW YORK

Mr. R. Bach 24-ML
Light Military Electronics Dept.
General Electric Company, French Road, Utica, New York

Please send me tests (limited to 2 subjects per individual) answer and self-evaluation sheets covering the areas checked:

☐ RADAR ☐ MICROWAVE
☐ ELECTRONIC PACKAGING (ME)
☐ COMMUNICATIONS ☐ ADMINISTRATIVE ENGINEERING

Name_____

Home Address_____ Home Phone_____

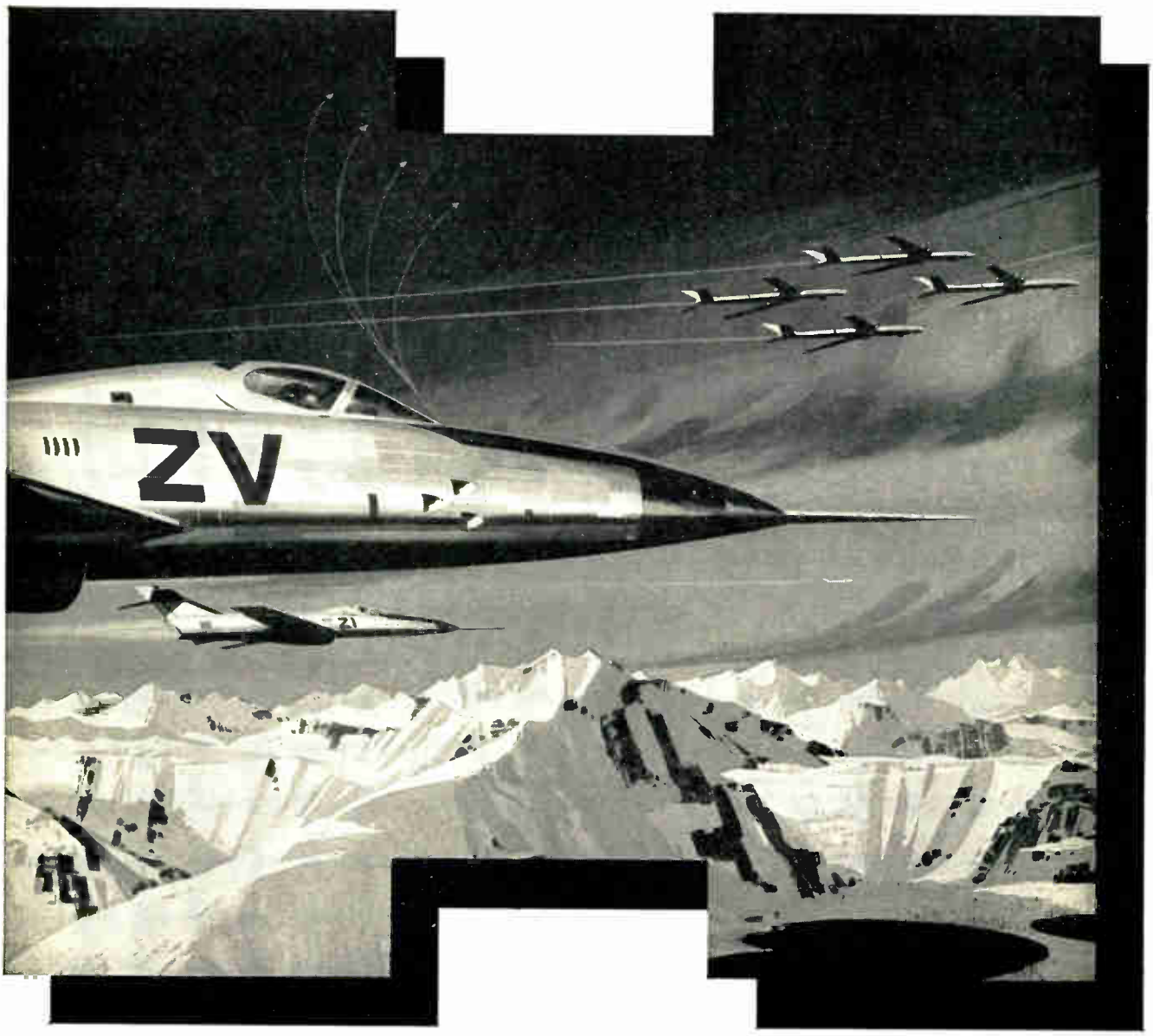
City_____ Zone_____ State_____

Degree(s)_____ Years(s) Received_____

Please write direct to the above advertiser

Circle 142 on Inquiry Card

How will this picture look



in ten seconds?

With the high speeds of today's jet aircraft, keeping track of hundreds of planes is a difficult problem. The tactical situation is not only complex, but fast-changing.

Hughes Fullerton engineers have solved this problem with a unique and highly advanced digital computer. This computer simultaneously tracks large numbers of aircraft and provides three-dimensional coordinate and velocity information on them.

These Fullerton engineers have designed the computer to provide extrapolated position data to the observer several times per second. In addition, it will measure the position and report velocity characteristics changes every few seconds for each of a large number of targets.

The computer utilizes advanced semiconductor circuitry throughout. The out-puts to the displays are made through high-speed digital to analog converters capable of providing an accuracy of one part in ten thousand – and within 10×10^{-6} seconds.

This giant transmitting antenna *creates the beam for experimental antenna pattern measurements – part of the Hughes microwave research and development programs.*

Housed in the tip *of this Hughes survey meter is the smallest, fastest, most accurate radiation detector ever devised – just one example of Hughes' activities in the expanding field of nuclear electronics.*

Utilizing the latest techniques in packaging and subminiaturization, Hughes Fullerton Engineers have designed this unit as a mobile system which will withstand rigorous field use.

Other Hughes activities provide similarly stimulating outlets for creative engineers. Constantly moving forward into new areas, Hughes projects include: hydrofoil systems, anti-submarine warfare systems, miniaturized communications systems, new solid state electronics devices, nuclear electronics systems and unique navigational systems – just to name a few.

The commercial activities of Hughes have many interesting projects for engineers in the research, development and manufacture of semiconductors, microwave components, storage tubes, radiation detectors, radiation handling equipment and microwave tubes.

Whatever your field of interest, you'll find Hughes' diversity of advanced projects gives you widest possible latitude for professional and personal growth.

Newly instituted programs at Hughes have created immediate openings for engineers experienced in the following areas:

Computer Components	Semiconductor Product Eng.
Infrared	Microwave & Storage Tubes
Anti-submarine Warfare	Communications Systems
Digital Computers	Inertial Guidance
Electro-optics	Field Engineering
Systems Design & Analysis	Circuit Design & Evaluation

Write in confidence to Mr. M. W. Welds
Hughes General Offices, Bldg. 6-C-12, Culver City, Calif.

Creating a new world with ELECTRONICS

HUGHES

HUGHES AIRCRAFT COMPANY
Culver City, El Segundo, Fullerton, Newport Beach, Malibu, Oceanside and Los Angeles, California; Tucson, Arizona.

Industry News

Roger P. Holman—named Procurement Manufacturing Manager, and **Burr Odell**—named Marketing Manager, Boeing Associated Products, Boeing Aircraft Co., Seattle, Wash.

Curtis B. Hoffman, Vice President-Electronics Group—elected Director, Clevite Corporation, Cleveland, Ohio.

George W. Westfall, former Sales and Market Research Manager for Hotpoint Div. of G. E., has been appointed Marketing Research Director of the Electronic Industries Association, a newly created position, by EIA's Board of Directors. New marketing studies and expansion of existing studies will be made, particularly in the industrial and military fields, by Mr. Westfall in his new position.


G. W. Westfall


G. M. Scott

George M. Scott—fills new post of Employee Relations Director, Keuffel & Esser Co., Hoboken, N. J., responsible for all of the firm's personnel and industrial relations functions.

Robert J. Seymour—joins the National Electronics Facilities Organization, Inc., (NEFO), 600 Old Country Road, Garden City, N. Y., as Assistant to Executive Vice President Phillip H. Goodwin.

John P. Pittman—appointed Regional Sales Manager, Burrough's Electronic Tube Div., Plainfield, N. J. He will supervise sales activities throughout the entire Eastern Seaboard area, excepting Metropolitan New York.

William W. Cloud — appointed to Washington Office Staff of Varian Associates, Palo Alto, California.

Bernard W. Menke—appointed Manager of Administration, American Machine & Foundry Co.'s Government Products Group, N. Y., N. Y.

Dr. John F. Nobis—named Director of Product Planning and **William O. Hess**—named Inter-Company Technical Coordinator, Formica Corporation, a subsidiary of American Cyanamid Co., Cincinnati, Ohio.

Circle 502 on "Opportunities" Inquiry Card

Industry News

C. J. Breuer—named Director Of Administration and Finance, Ramo-Wooldridge, a Div. of Thompson-Ramo-Wooldridge. He replaces J. S. Webb, who has been promoted to Director of Administration and Finance for TRW's Electronics Divisions, Canoga, Park, California.

Stewart T. Pardee—joins the Marketing Dept. of the Defense Products Div., Fairchild Camera and Instrument Corp. as Manager of Technical Information.

Tore N. Anderson, Executive Vice President of FXR, Inc., Woodside, N. Y.—named President of the firm, succeeding Henry Feldmann (the Founder) who moves up to the newly created post of Board Chairman.

T. N. Anderson

W. L. Davis

William L. Davis—elected Executive Vice President of Emerson Electric Manufacturing Company, St. Louis, Mo. He also serves as General Manager of the Electronics and Avionics Div.

James M. Toney, Vice President, RCA Sales Corp.—appointed to staff of W. Walter Watts, Chairman of the Board and President of the Corp., in charge of Product Planning and Development, with headquarters in New York. **C. Richard Johnston**—appointed Manager, Product Planning and Development, RCA Sales Corp.

Edward J. Greenholt—named Sales Manager, for recently formed Equipment Development and Manufacturing Operations at Philco's Lansdale Div., Pa.

James Edward Halligan, Jr. —named Manager of the Radar Laboratory's Field Service and Support Dept. at Hughes Aircraft Co.'s Ground Systems Group.

Anthony Easton—appointed Director of International Sales; **Harry M. Rich**—named Manager of the newly created Import Dept. at Westrex Corp., division of Litton Industries, Beverly Hills, Calif.

National*

Presents opportunities for personnel qualified for the following openings located at Dayton, Ohio

RESEARCH & DEVELOPMENT

DATA TRANSMISSION ENGINEER: For advanced planning in ON-LINE REAL TIME SYSTEMS. Applications would generally be focused on large-scale business and finance operations. Appropriate engineering degree and 6-10 years of experience necessary.

RESEARCH PHYSICIST: Ph.D. Physicist with 2-3 years minimum experience in semi-conductor R & D.

PHYSICAL CHEMIST: Ph.D. with interest in Materials R & D. Experience beyond doctoral work required.

MAGNETICS: Ph.D. Physicist with primary interest in magnetics research. experience beyond doctoral work required.

SYSTEMS ENGINEER: B.S. or M.S. in Electrical Engineering with interest in development of business machine systems with 3-6 years of experience which should include some advanced circuit design preferably for Computer Development. but other may suffice.

DIGITAL COMMUNICATIONS PROJECT LEADER: 6-10 years. experience in military R & D projects related to Digital Communications. Background in circuits or systems desirable as well as some supervision.

OPERATIONS RESEARCH SPECIALIST: With interest or experience in Business Systems Research. Must have utilized advanced OR techniques. prefer Ph.D. or equivalent. Position entails research group guidance involving interrelated complex business functions.

ANALYST-PROGRAMMER: Experienced in conducting data processing feasibility studies for business systems applications.

ELECTRONIC DATA PROCESSING

PROGRAMMERS

DATA PROCESSING CENTER: Opportunities exist in our centers at Dayton, Ohio and New York City. Work involved is varied and challenging involving programming for our 304 large-scale computer. Advancement and growth potential for above-average personnel. Applicants should have at least two years' programming experience and a B.S. degree in Business Administration or Mathematics or equivalent. Tape systems background desired.

SALES SUPPORT: At least two years of programming experience plus B.S. or M.S. in Business Administration or Mathematics will qualify for challenging work with EDP sales organization. Opportunities are varied and include:

Programming
Manual Writing
Systems Analysis
Programming Research
Programming Instruction

FOR THESE and other opportunities including:
Senior Electronic Design Engineer
Mathematician (Ph.D)
Technical Writer
Chemical Engineer (Development)
Mechanical Engineer (M.S. applied mechanics)

WRITE NOW TO:
T. F. Wade
Technical Placement **F9-5**
The National Cash Register Company
Main and K Street. Dayton 9. Ohio

THE NATIONAL CASH REGISTER COMPANY, DAYTON 9, OHIO

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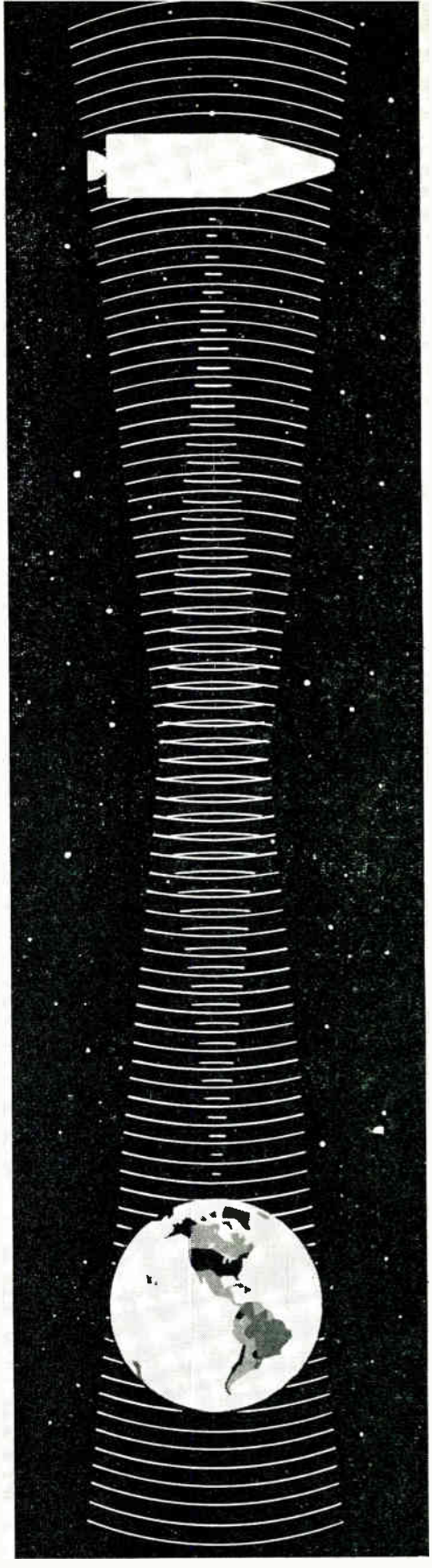
National*

ELECTRONIC DATA PROCESSING
DIVERSIFIED CHEMICAL PRODUCTS
ADDING MACHINES • CASH REGISTERS
ACCOUNTING MACHINES • NCR PAPER

Expanding the Frontiers of Space Technology in

ELECTROMAGNETICS



Lockheed Missiles and Space Division maintains extensive research capabilities for the development of antennas and electromagnetic devices for space vehicle applications.

Laboratory studies in antennas and electromagnetic propagation include the application of solid state materials to microwave transmission line component and parametric circuits; the design of antennas to survive the rigors of space flight; and the effects of scattering from missile and space vehicle structures.

Research is also being conducted in the application of MASERS; on problems of radio transmission between space vehicles and Earth; effects of reentry ionization on radio transmission and reception; and development of antennas for data link systems between satellites and ground stations.

Engineers and Scientists

Lockheed Missiles and Space Division has complete capability in more than 40 areas of science and technology – from concept to operation. Its programs reach far into the future and deal with unknown and challenging environments. If you are experienced in electromagnetics or in related work, we invite you to share in the future of a company with an outstanding record of achievement and make an important individual contribution to your country's scientific progress. Write: Research and Development Staff, Dept. L-48, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense industrial security clearance required.

Lockheed / **MISSILES AND SPACE DIVISION**

Systems Manager for the Navy POLARIS FBM; the Air Force AGENA Satellite in the DISCOVERER, MIDAS and SAMOS Programs

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA • CAPE CANAVERAL, FLORIDA • HAWAII

Personals

E. D. McArthur—heads new Superpower Microwave Tube Laboratory in Power Tube Dept., G. E. Co., Schenectady, N. Y.

L. Peter Retzinger—named Director, Computer Systems Laboratory of the Guidance and Control Systems Div., Litton Systems, Inc., Beverly Hills, California.

Sergio A. Alessio—appointed Senior Staff Engineer, Staff Research and Engineering, Amphenol-Borg Electronics Corp.

Dr. Gilford G. Quarles—appointed to new post of Director for Long-Range Military Planning, Bendix Corporation, Detroit, Michigan.

Dr. Arthur Kohlenberg, Scientific Consultant to the President—named Technical Director, Applied Science Div., Melpar, Inc., Watertown, Massachusetts.

Dr. A. Kohlenberg

Dr. M. Cohn

Dr. Marius Cohn—appointed Manager, Mathematics and Logic Research Dept., Remington Rand Univac Military Division, St. Paul, Minnesota.

Daniel S. Schwartz—appointed Senior Research Physicist of Gulton Industries, Inc., Research and Development Div., and **Aaron Waldman** — named Supervisor of the Instrumentation Div.'s Electromechanical Group. The firm is located in Metuchen, N. J.

Jay Schwalbe—appointed Manager of Manufacturing, Computer Measurements Co., Sylmar, California.

Richard L. White—appointed Engineering Product Manager, Industrial Products Div., Hoffman Electronics Corp., Los Angeles, California. He will head future product development work using solid state devices.

Dr. Richard W. Damon—appointed to newly created position of Director, Research and Development Group on Microwave Solid-State Control Devices. Microwave Associates, Inc., Burlington, Massachusetts.

News of Mfrs' Representatives

REPRESENTATIVES WANTED

Manufacturer and designer of all types of Magnetic Equipment, Transistorized Controls, and a special line of Diesel Engine Motor Controls is seeking representatives in the New York-New Jersey area, the entire Southeast, and the Rocky Mountain states. Box 12-1, Editor, ELECTRONIC INDUSTRIES.

The William Briney Company, a new manufacturers' representative, is located in the Orpheum Bldg., 524 B Street, San Diego 1, Calif.

Eastern Associates, Inc., sales representatives, has changed its corporate name to Eastern Instrumentation, Inc. The company has moved its Home Office to 613 Cheltenham Ave., Phila., Pa.

McDowell-Redlingshafer Sales Co., St. Louis, Mo.—appointed sales representative in the Central States area (Missouri, Kansas, Iowa, Nebraska and Illinois) by the Semiconductor Div. of Syntron Company, Homer City, Pa.

Edwards-Lohse Co., Cleveland, Ohio — appointed representative in Ohio, Kentucky, West Virginia, western Pennsylvania and Michigan for Thermal Wire of America.

Chafin and Associates, Los Angeles and Menlo Park, Calif.—appointed West coast sales agents for Electronic Products, Inc., Burlington, Mass.

Peninsula Associates, Redwood City, Calif.—appointed representative in northern California for Somerset Radiation Laboratory, (SLR, INC.), Stirling, N. J.

R. E. Breuer Company, Chicago, Ill.—appointed sales representatives in New York, Pennsylvania, and New England for the Ensign Division of Admiral Corporation.

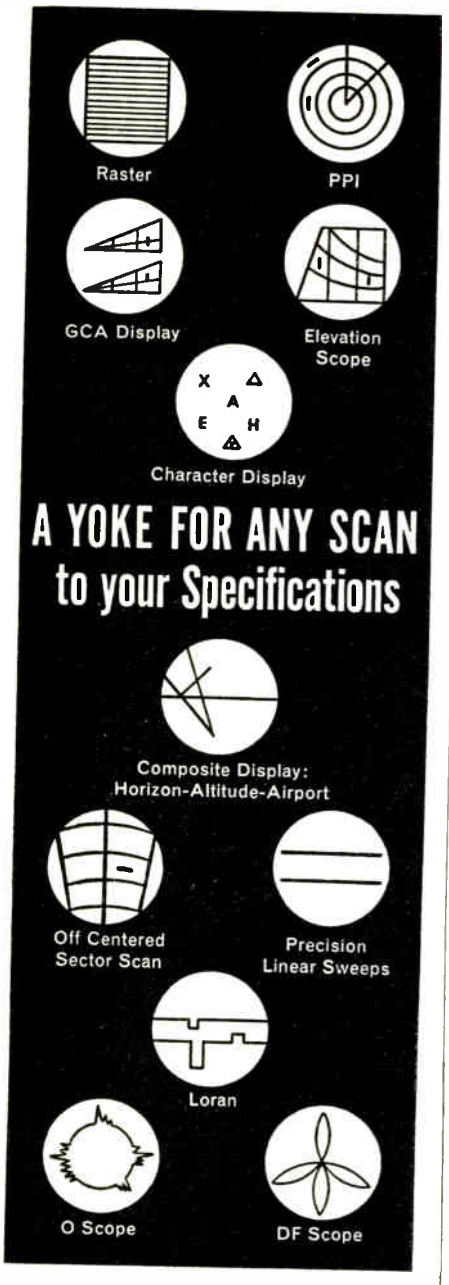
Deere Electronics, Inc., San Carlos, Calif.—new representative of PCA Electronics, Inc., Sepulveda, Calif. for all of California north of San Luis Obispo, Kern, and San Bernardino Counties.

Duncan Electronics, Inc.—appointed Todino Engineering Sales, Inc. sales and service engineering services representatives in the New England area. **J. H. Electronic Sales Co.**, Townson, Md. and Camden, N. J.—appointed to represent Duncan in southern N. J., eastern Pa., and northern N. C.

Arthur E. Selnick—appointed representative in Philadelphia, Pa.; Baltimore, Md.; Harrisburg, Pa.; Washington, D. C.; and Richmond, Va. for Pentron Sales Co., Inc., Chicago, Ill.

Smith-Dietrich Sales Co., a new electronic instrumentation representative office, has been opened in Inglewood, Calif. at 405 W. Manchester Blvd.

(Continued on page 222)



COMPLETE LINE of deflection yokes for every military and special purpose—in production quantities or custom designed to your exact requirement.

For engineering assistance with your display problems, call on your nearest

SYNTRONIC YOKE SPECIALIST today:

New York Area: Jules J. Bressler Co.
Phone: N.Y., OXford 5-0255; N.J., UNion 4-9577

Philadelphia Area: Massey Associates
Phone: MOhawk 4-4200

Washington-Baltimore Area: Massey Associates
Phone: GRanite 4-2071

Indianapolis: Joe Murphy
Phone: VIctor 6-0359

Los Angeles: Ash M. Wood Co.
Phone: CUmberland 3-1201

syntronic
INSTRUMENTS, INC.
100 Industrial Road, Addison, Illinois
Phone: KIngswood 3-6444

Circle 148 on Inquiry Card

News of Mfrs' Representatives

Fred H. Haight Co., Seattle, Wash. —appointed representative of the Electro Products Div. of Western Gear Corp., Pasadena, Calif., in the Pacific Northwest territory (Wash., Oregon, Idaho, and the western section of Montana.)

James C. Simon, Los Angeles, Calif.—appointed sales representative in southern California, New Mexico, and Arizona for Deltime, Inc., Mamaroneck, N. Y.

Addy and Luby Machinery Company, Detroit, Mich.—appointed representative for Thomson Electric Welder Co., Lynn, Mass.

Burns Electric Co., Pittsburgh, Pa. —appointed representative in western Pa. and northern West Va. for Multi-Amp Electronic Corp., Union, N. J.

William McCoy Company, Branford, Conn. and **Emory Equipment and Design Co.**, Birmingham, Alabama—named new sales representative in New England and Alabama, Georgia, Florida areas, respectively, for Glenair, Inc., Glendale, Calif.

R. L. Stone Sales Co., Los Angeles, Calif.,—appointed representative in the southern California area for Tevco Insulated Wire, Burbank, Calif.

John Hines Co. 1181 Long Hill Rd., Cheshire, Conn., will service the New England area specializing in electronic components.

Bind Wires Fast... At Low Cost with Heli-Tube®

HELI-TUBE is a spirally-cut plastic tubing. Its shape-retaining characteristics make it ideal for binding electrical wires into cables. Wraps on like tape; holds wires together tightly; individual wires, taps, or lead-offs can be led out at any point. Earns cost back in time and labor-saving.

Available in 5 forms . . .

- Clear for general applications
- Nylon—wide temperature range . . . very light weight
- Ultraviolet-Resistant
- Fire-Resistant
- Type 275° F (High-temperature)

Each form in three diameters:

Instrument Size: 1/8" O.D. — for bundles up to 1/2" dia.
Harness Size: 1/4" O.D. — for bundles up to 2" dia.
Giant Cable Size: 1/2" O.D. — for bundles up to 4" dia.

At your distributor for immediate delivery or write

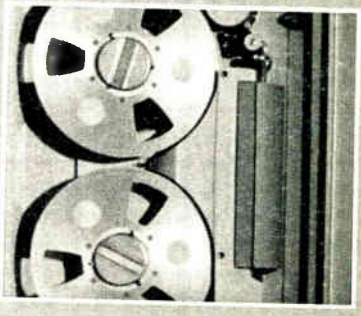
M. M. NEWMAN CORPORATION, DEPT. 5
79 Clifton Ave., Marblehead, Mass.

Circle 149 on Inquiry Card

HOW TO RECORD RADAR ON MAGNETIC TAPE

For needed frequency response, use Ampex's new 4-megacycle tape recorders. Magnetic tape arrests radar giving you a second look or second try in reconnaissance, tracking, simulation, evaluation or training.

Want to know more? Write Ampex at the address below.



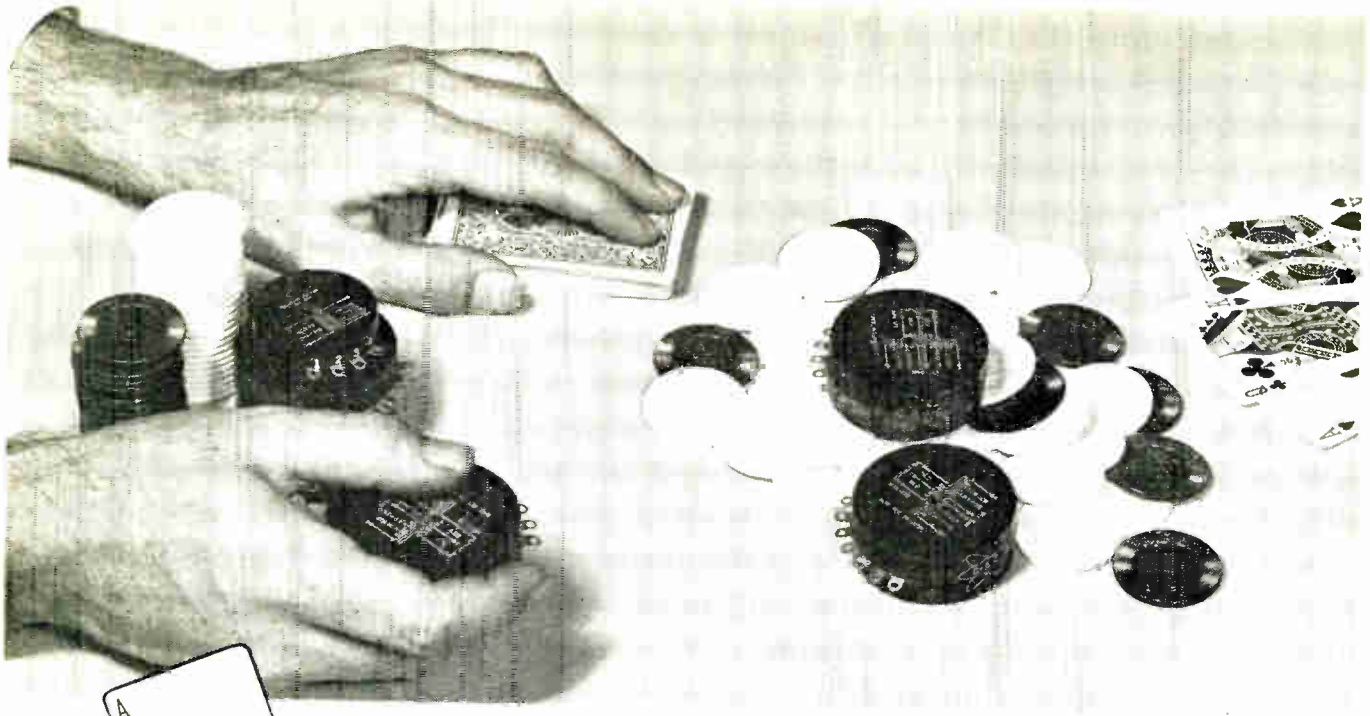
AMPEX

AMPEX DATA PRODUCTS COMPANY
Box 5000 Redwood City, California

Circle 150 on Inquiry Card

ANNUAL INDEX–1960

The annual index of ELECTRONIC INDUSTRIES has been arranged by subjects for easy reference to related topics. The first figure indicates the month in which the article appeared; the second figure indicates the page number.



WHY GAMBLE WITH MAGNETIC COMPONENTS?

SPECIFY NEW A7 "POKER CHIP" PACKAGING FOR TOROIDS

C-A-C

APPLICATION: Power and Audio Transformers — Coils — Saturable Reactors.

CORE SIZES: Wide Selection.

MOUNTING: Stack Well, Clear Hole.

HI-POT: Good Characteristics.

MARKING: Good Contrast, White or Black.

FINISH: Semi-matte.

COST: Economical Compared to HS Cans.

TYPE NO.	MAX. DIA.	MAX. THICKNESS	MAX. NO. TERMINALS WITHIN 180°	APPROX. VA AT 400 ~	AMBIENT TEMP.	MIL-T-27 GRADE	MIL-T-27 CLASS
#137	1 3/8"	11/16"	5	1 VA	85°C	5	S
#175	1 3/4"	11/16"	9	7 VA	85°C	5	S
#225	2 1/4"	15/16"	13	25 VA	85°C	5	S

SPECIAL EPOXY CAST ASSEMBLIES

C-A-C's MATERIAL AND PROCESS DEVELOPMENT DEPARTMENT can assist you in meeting unique and unusual PACKAGING REQUIREMENTS for magnetic components. EPOXY CASES with exceptionally good bonding characteristics and CAST UNITS with very tight terminal and mounting stud dimension tolerances are available.

Send us your current requirements . . . new design, re-design . . . POKER CHIP packaging may be your answer for improved component quality.

C-A-C

COMMUNICATION ACCESSORIES COMPANY

Lee's Summit
Missouri

Phone Kansas City
LAclede 4-3500

316

INSTRUMENTS, MEASUREMENTS, TEST METHODS

MICROWAVE

PRODUCTION METHODS

RADAR

RADIO FREQUENCY INTERFERENCE

RELIABILITY

SEMICONDUCTORS

SYSTEMS

TELEVISION

TUBES

PAGE FROM AN ENGINEER'S NOTEBOOK

Hi-Fi Broadcast

(*Continued from page 200*)

include changing the 6C4 from preamp to phase inverter and adding a 12AU7 stage. This new stage gives added gain to compensate for the feedback loop installed around the output transformer.

The foregoing modifications are generally simple and inexpensive. They are, however, a basis for changing the sound of an average AM station to compare favorably with the sound of better FM stations. Application of these modifications to other systems will no doubt require a variety of alterations, but basic principles that should be retained are these:

1. Eliminate all audio transformers possible
2. Use feedback whenever possible
3. Use off the air feedback at the transmitter as far back as possible
4. Eliminate unnecessary power stages
5. Eliminate duplication wherever possible

ELECTRONIC INDUSTRIES Advertisers—December 1960

This index is published as a convenience. No liability is assumed for errors or omissions.

WHAT'S NEW

Computers

Components

General

Measuring Equipment

Production

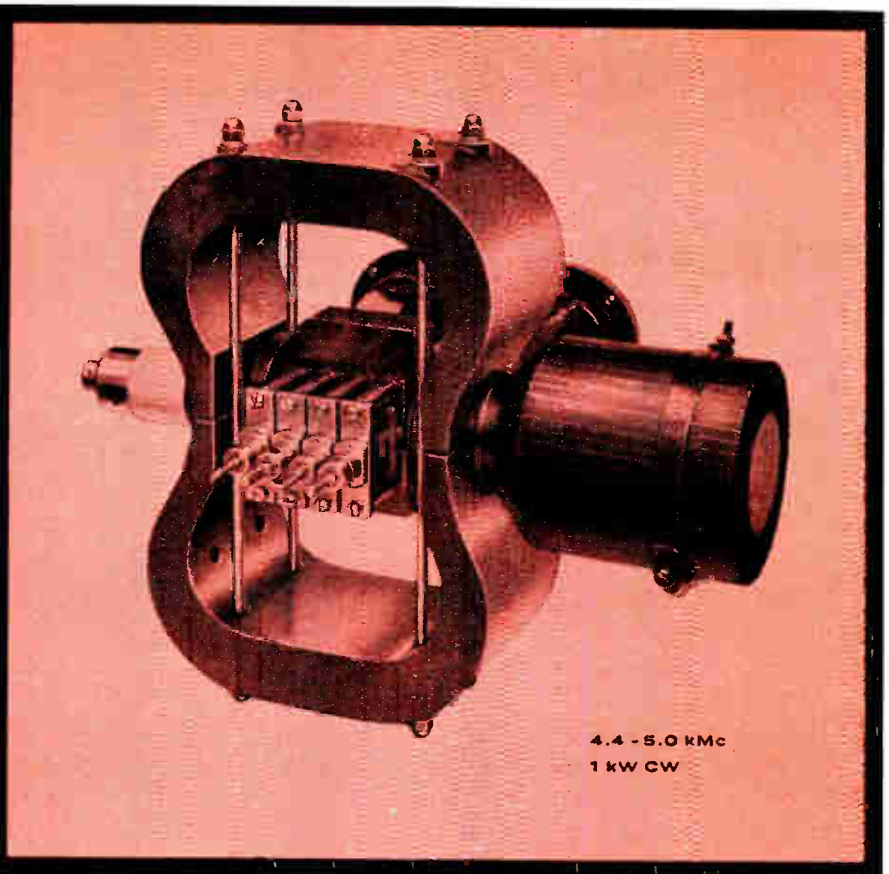
Semiconductors

AUTHOR'S INDEX

Varian presents the
VA-834B amplifier klystron
—1 kW CW—rugged
—lightweight—for

tactical mobility

In Forward
Scatter Transmitters



Need a rugged power amplifier tube for transportable microwave field equipment? Varian's VA-834B klystron is air-cooled and permanent-magnet focused. Simplifies operation and minimizes prime power requirements. Quick and easy to install. Only adjustment necessary — just tune to desired frequency. Tunable 4.4 to 5.0 kMc with 1 kW CW output. Lightweight — only 60 lb. including magnet.

Specifically developed for tactical and transportable equipment. Suited to commercial forward-scatter communications and radar transmitters.

FEATURES ■ 1 kW CW ■ 4.4 to 5.0 kMc
■ Efficiency up to 40% ■ 45 db Gain ■ 7.5 Mc Bandwidth

Sound interesting? We'll be pleased to send you full technical data. Just write Tube Division.

VARIAN associates

PALO ALTO 19, CALIFORNIA

BOMAC LABORATORIES, INC.
VARIAN ASSOCIATES OF CANADA, LTD.
S-F-D LABORATORIES, INC.
SEMICON ASSOCIATES, INC.
SEMICON OF CALIFORNIA, INC.
VARIAN A. G. (SWITZERLAND)

Circle 74 on Inquiry Card

FIRST SILICON MESA IN THE TO-36 CASE BROADENS THE COVERAGE OF THIS COORDINATED SILICON LINE

Similar to JEDEC TO-3 Case

2N1487
2N1488
2N1489
2N1490

JEDEC TO-8 Case

2N1483
2N1484
2N1485
2N1486

JEDEC TO-5 Case

2N1479
2N1480
2N1481
2N1482

RCA Announces Four New Silicon Mesa Power Transistors in the Popular TO-36 Case

Available immediately in quantity...four new NPN Diffused-Junction Types... 2N1511, 2N1512, 2N1513, 2N1514 • electrically equivalent to 2N1487, 1488, 1489, 1490 respectively • utilize the industry-preferred JEDEC TO-36 single ended stud package with cold-weld seal • Designed for a wide variety of military and industrial applications

With RCA's new Silicon Mesa Power Transistors in the JEDEC TO-36 case, you gain all of these design advantages:

- **More positive heat sink contact** and excellent high-temperature performance up to 175°C plus the greater application flexibility of JEDEC TO-36 stud mounted case.
- **Low saturation-resistance** characteristics with high collector-current and voltage ratings.
- **Wider application** in military and industrial equipment—in power switching circuits, oscillator, regulator and pulse-amplifier circuits.
- **The dependability** of the cold-weld seal, proved by RCA through years of experience.
- **Coordinated line of 16 RCA Silicon Power Transistors.** These four new RCA transistors together with the 12 RCA Silicon Power Transistors shown in the accompanying table provide the designer of Industrial and Military equipment with a comprehensive selection of types to fit his specific needs.

ELECTRICAL CHARACTERISTICS
Minimum and Maximum Values at Case Temperature=25°C

RCA Type	Min. V_{CEX} (volts)	Min. V_{CEO}* (volts)	Max. I_C (amp)	Max. I_{CBO} (μa)	Max. Saturation Resistance ohms	h_{FE}	Max. Dissipation Watts 25°C Case	Max. Dissipation Watts 100°C Case
				V_{CB}=30v	I_C=1.3 amp	I_C=1.3 amp		
2N1514	100	55	6	25	0.67	25-75	60	30
2N1513	60	40	6	25	0.67	25-75	60	30
2N1512	100	55	6	25	2.00	10-50	60	30
2N1511	60	40	6	25	2.00	10-50	60	30
				V_{CB}=30v	I_C=1.3 amp	I_C=1.3 amp		
2N1490	100	55	6	25	0.67	25-75	60	30
2N1489	60	40	6	25	0.67	25-75	60	30
2N1488	100	55	6	25	2.00	10-50	60	30
2N1487	60	40	6	25	2.00	10-50	60	30
				V_{CB}=30v	I_C=0.75 amp	I_C=0.75 amp		
2N1486	100	55	3	15	1.00	35-100	15	7.5
2N1485	60	40	3	15	1.00	35-100	15	7.5
2N1484	100	55	3	15	2.67	15-75	15	7.5
2N1483	60	40	3	15	2.67	15-75	15	7.5
				V_{CB}=30v	I_C=0.2 amp	I_C=0.2 amp		
2N1482	100	55	1.5	10	7	35-100	4	2
2N1481	60	40	1.5	10	7	35-100	4	2
2N1480	100	55	1.5	10	7	15-75	4	2
2N1479	60	40	1.5	10	7	15-75	4	2

*sustaining volts

Call your RCA representative today for complete information. For additional technical data write to RCA Semiconductor and Materials Division, Commercial Engineering, Section L-50-NN, Somerville, N. J.

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