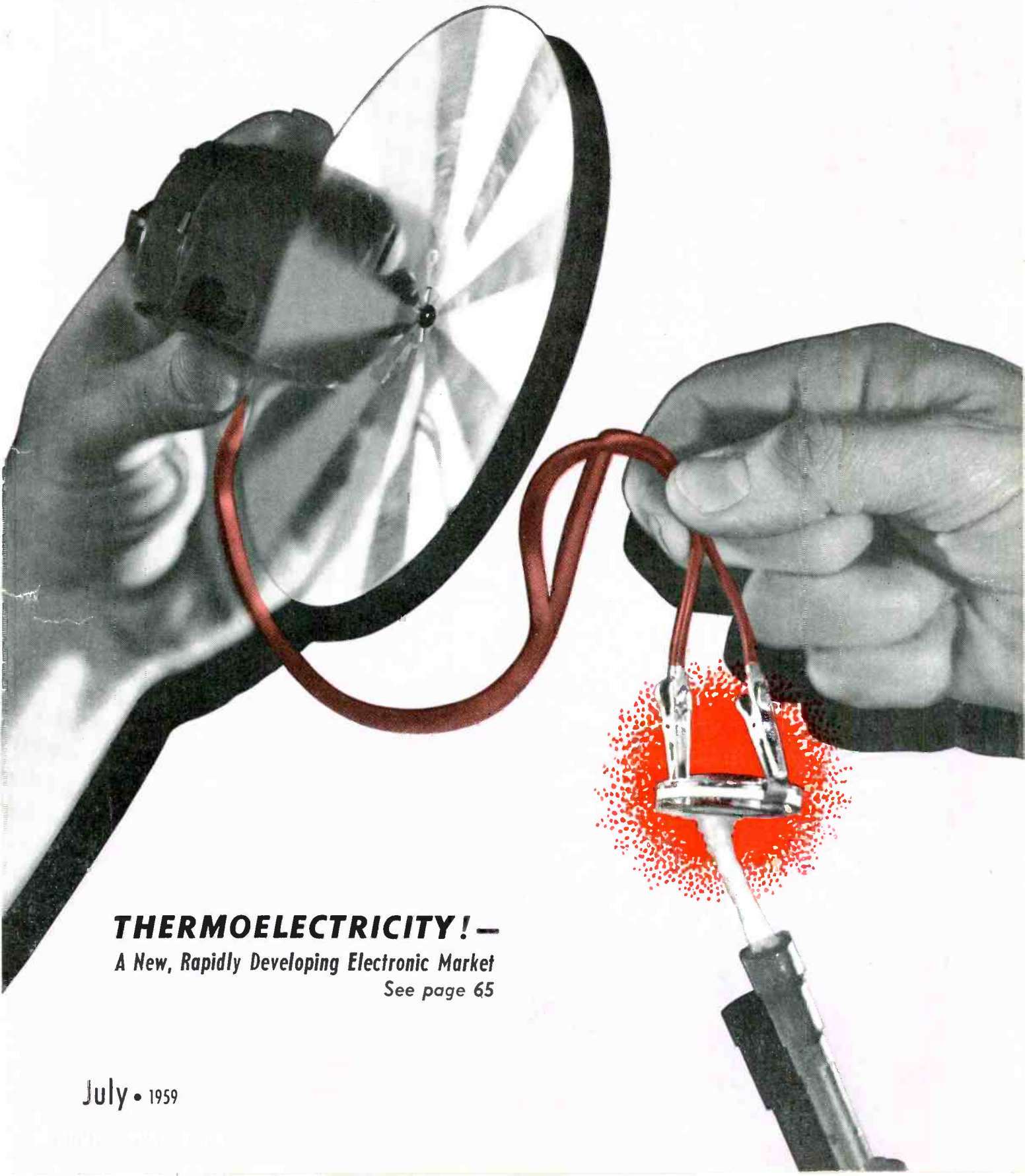
ELECTRONIC INDUSTRIES



THERMOELECTRICITY!—

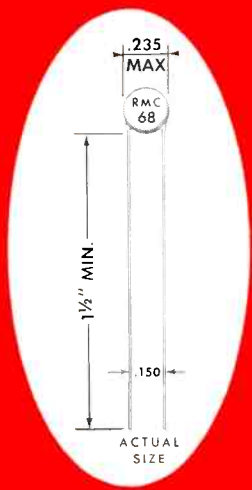
A New, Rapidly Developing Electronic Market

See page 65

July • 1959

ANOTHER *rmc* FIRST!

Subminiature Temperature Compensating DISCAPS



SPECIFICATIONS

POWER FACTOR: Over 10 MMF less than .1% at 1 megacycle. Under 10 MMF less than .2% at 1 megacycle.

WORKING VOLTAGE: 500 V.D.C.

TEST VOLTAGE (FLASH): 1250 V.D.C.

CODING: Capacity, tolerance and TC stamped on disc

INSULATION: Durez phenolic-vacuum waxed

INITIAL LEAKAGE RESISTANCE: Guaranteed higher than 7500 megohms

AFTER HUMIDITY LEAKAGE RESISTANCE: Guaranteed higher than 1000 megohms

LEADS: No. 22 tinned copper (.026 dia.)

TOLERANCES: ±5% ±10% ±20%

The capacity of these capacitors will not change under voltage.

Capacity MMFD.	NPO	N75	N150	N220	N330	N470	N750	N1500	N2200
1.5 to 9	±120	±120	±120	±120	±120	±120	±120	±250	±500
10 to 68	±60	±60	±60	±60	±120	±120	±120	±250	±500

In modern electronic equipment allowable space for component parts is rapidly shrinking. The demand is for small and then smaller units to meet today's design requirements.

Recognizing this fact, RMC's Technical Ceramic Laboratories have incorporated the features of Type C DISCAPS in a subminiature size. With a maximum disc diameter of only .235, Type C Subminiatures are ideal for the latest designs in TV tuners and other electronic equipment and are available in the following TC values:

NPO	1.5-13
N- 75	3-13
N- 150	3-15
N- 220	3-15
N- 330	3-15
N- 470	3-20
N- 750	3.6-24
N-1500	10-51
N-2200	20-68

If you require smaller, yet fully reliable temperature compensating capacitors it will be to advantage to investigate these new subminiature DISCAPS.

DISCAP CERAMIC CAPACITORS

rmc

RADIO MATERIALS COMPANY
A DIVISION OF P. R. MALLORY & CO., INC.
GENERAL OFFICE: 3325 N. California Ave., Chicago 18, Ill.
Two RMC Plants Devoted Exclusively to Ceramic Capacitors
FACTORIES AT CHICAGO, ILL. AND ATTICA, IND.

Circle 1 on Inquiry Card

ELECTRONIC INDUSTRIES

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

Views and Reviews

EACH year, after publication of the June Directory and All-Reference issue, we pause briefly to review editorial accomplishments during the first half of the year, and to reaffirm our editorial program and scheduling for the second half. During each six months cycle many elements of reader interest and importance appear, but the actual reporting of these items is delayed because of their transient or incomplete nature. We thought you might be interested in just two of the items remaining in this years semiannual editorial "hold" file. We make no conclusions on these matters at this point. Rather, we present them in the interests of furthering enlightened public opinion.

1. Foreign Competition: The March - April 1959 issue of WCEMA Westerner, the bulletin of the West Coast Electronic Manufacturers Association, contains an extremely interesting editorial entitled "Is Industry Meeting Foreign Competition." Here it is pointed out that Japan, Germany and the USSR continue to significantly increase their roads into this nation's domestic electronic markets with high quality electronic products. The biggest push is in the commercial and industrial spheres. Momentarily more than 50% of the U. S. electronic gross national product is in the government and military area. These commercial and industrial spheres are the very ones that our industries ultimately have for healthy expansion programs.

Tom Campbell, editor-in-chief of The Iron Age, a sister Chilton publication, in his June 18th editorial "Lost Leadership . . . It Could Happen to Us" points out: "With foreign aid, we have built up nations which are now competing with us. So much so that our exports are dropping rapidly and our imports are increasing by leaps and bounds. We have the highest wage rates in the world. They keep going higher. This is costing jobs here at home. But more than that, the day will come when many metalworking (electronic?) companies will close up or build plants abroad." Some experts predict that it will become increasingly difficult to establish branch plants abroad, particularly in Europe, as the effects of the "European Common Market" become more and more pronounced.

Some of the foreign product is apparently politically aimed and deliberately underpriced competitively. Such is the indication contained in recent releases from the Scientific Apparatus Manufacturers Association. They point out that the Russians were offering classroom laboratory apparatus to an American importer at prices averaging one fifth those of comparable American made items. Fortunately Federal funds for the purchase of this Communist-made equipment has been restricted by law. Otherwise, America might again have suffered from a severe propaganda and economic attack.

(See photo page 124)

2. Inflation: On June 8, President Eisenhower, in an address to members of the Society of Business Magazine Editors at the White House in Washington which we attended stated . . . "To start, there is an old military saying, "You can do nothing positive except from a firm base." . . . "The great base today on which America must stand is a sound, expanding, healthy, and vigorous economy . . . "That (national) debt is important because we are taking today more than eight billion dollars out of your pockets for interest payments alone, with no reduction of the debt itself. That eight billion dollars of interest is going up. This is so because in this time of great prosperity, every kind of economic activity is seeking new money. There are new demands for new machinery in our productive processes, for building every kind of home and industrial facility, for roads and communications—for everything. The demand for money by municipalities, states, school districts, irrigation districts, and all the rest is unprecedented.

"America—the Federal Government—has to compete with that kind of demand, not only for the eight billion dollars in interest payments on our national debt, but we have to compete in the market place in selling our bonds, which must be kept sound.

"There is one method which is too often advocated for keeping the bonds at a nominal par value. That is to force them upon a central bank—make the central bank purchase them. Well, that's a very fine system, if you can make it work. But since the effect of the buying of our bonds by the central bank (Federal Reserve) increases the amount of credit, the result is inflationary. No country ever has made such a plan work over a long period. You don't have to go further back in history than a year or two to find where these unfortunate results were experienced in one great European country.

"But, if the United States Government is not to be in a position to compete with every business and every worthwhile economic activity for money in managing our 285-billion-dollar debt, we are going to be in trouble, particularly if we are denied the right to bid on a business basis—that is at realistic interest rates. We cannot resort to artificial, forced methods and still keep our own confidence, and the confidence of the world in the American dollar."

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ELECTRONIC INDUSTRIES

Vol. 18, No. 7 July, 1959

MONTHLY NEWS ROUND-UP

NEW PRODUCTS & TECH DATA

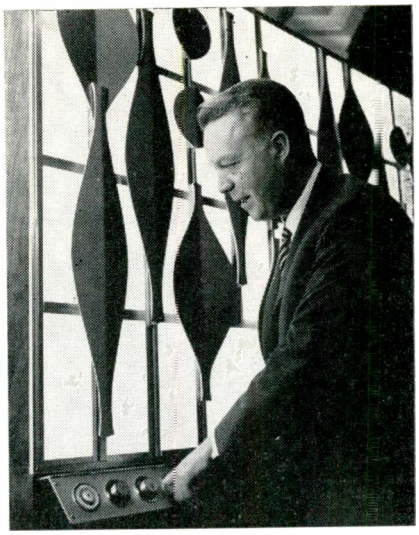
DEPARTMENTS

Highlights

Of This Issue

THERMOELECTRICITY—New Electronic Market! page 65

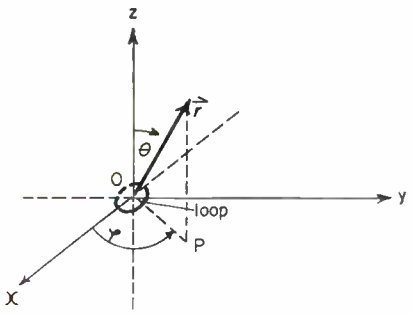
The practical, direct conversion of heat to electricity is approaching reality. Research on thermoelectric materials and the fabrication of the materials into working devices has progressed to a point where many scientists are predicting devices which could be competitive with some commercial devices within a couple of years. Already these devices are considered practical by the military for equipment in which, reliability, ruggedness and simplicity are prime considerations.



THERMOELECTRICITY!

Remote Control By "Near" Magnetic Field page 82

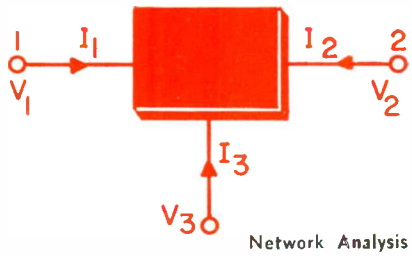
At first glance communication by electromagnetic induction over short distances seems a relatively unsophisticated technique. Actually it poses a surprising number of involved engineering problems.



Near-Magnetic Zon.

Small Signal Analysis By The Y-Matrix page 86

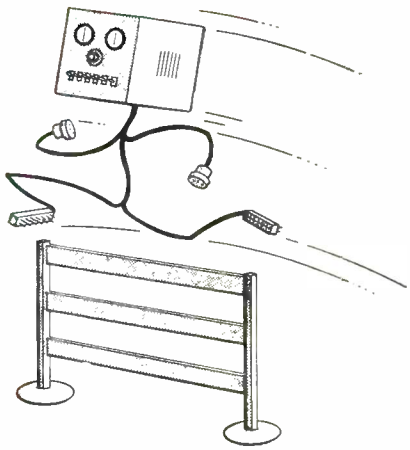
Small signal analysis of linear active circuits can be simplified by applying matrix algebra concepts—particularly when the circuit consists of cascaded stages. Three-terminal networks—designed around transistors—are examined here. The method can also be extended to networks with more than three terminals.



Network Analysis

Noise Parameters in VHF-UHF Circuit Design page 90

To properly evaluate VHF and UHF-TV head-end tubes the noise parameters should be known. Conventional measurements give the noise figure at one frequency and one source impedance. Here is a method for calculating the lowest possible noise figure and the optimum source of resistance for a wide range of frequencies.

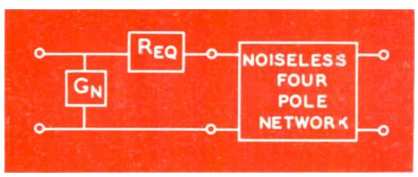


System Reliability

System Reliability—What and Why! page 118

For the word 'reliability' to have any real meaning it must be associated with actual numbers, tests and measurements. To do this requires some knowledge of probability and statistics. Here we will first define the important terms relating to 'reliability' and then state a few principles of the theory of random, discrete events—specifically equipment failures.

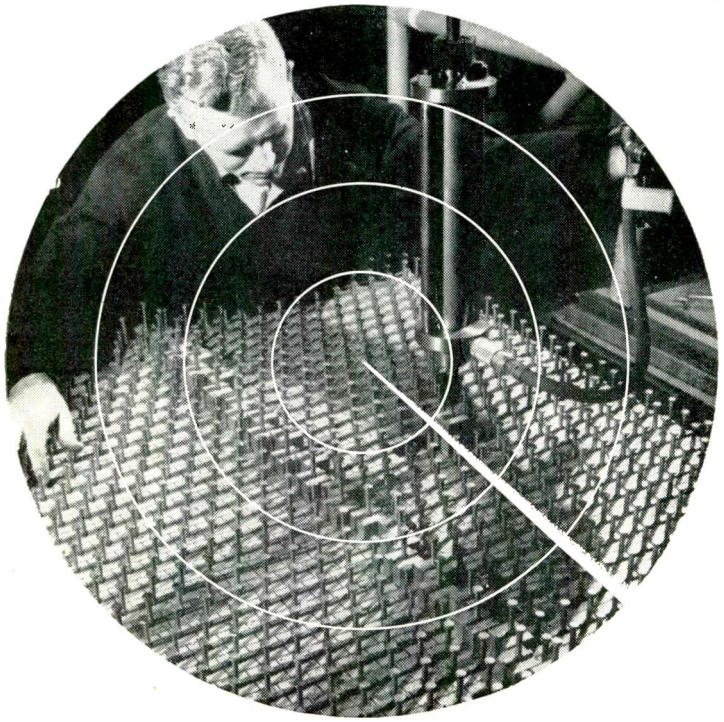
Noise Parameters



Components—And Military Standardization page 146

Military standardization calls for coordination of efforts between a large number of groups—r & d, vending, equipment fabrication, applications, quality control and quality assurance, cataloging and stock management, procurement, field engineering, logistics, inspection acceptance and international standardization, together with all industrial and professional standardization groups.

RADARSCOPE



MISSILE GUIDANCE LENS

This plastic lens, of 4100 cells, doubles the effective power of the Navy SPG-49 Talos missile guidance radar developed by the Surface Armament Division of Sperry Gyroscope Co. Molded of plastic impregnated fiber glass and coated with silver, the lens efficiently focuses high energy radar beams to detect distant targets.

NEW FOREIGN COMPETITION hits the American market in the form of giant French computer manufacturer La Compagnie des Machines Bull. Largest European data processing manufacturer and third largest in the world, behind IBM and Rem-Rand, the Bull organization sampled the U. S. market for the past few years, now feels that time has come to make a full-scale assault. Officials of the French firm are discussing possibilities of marketing partnership with one of the prominent U. S. computer firms. Rem-Rand and Burroughs are mentioned prominently.

INCREASING SIGNS that some concrete action to minimize the pinch felt by foreign imports is being planned came up at the recent meeting of EIA in Chicago. D. W. Gunn, chairman of the EIA Tube and Semiconductor Div. asserted, "A major problem confronting the Division's Semiconductor Section, and in fact all divisions of EIA, is the importation of goods from abroad. Due to the size and nature of the product, transistors have been affected most severely by the importation of sets and devices, and it is apparent that some action must be taken to control these imports if the domestic industry is to survive.

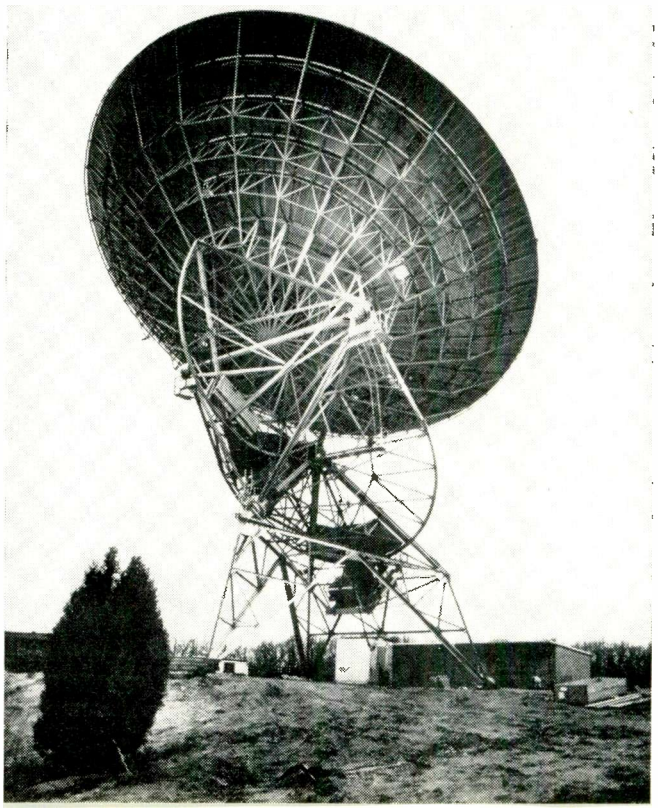
SPACE PROJECTS have been granted $485,300,000 by Congress for this year. Included in this figure is $70,000,000 for Project Mercury, the program for putting a man into space.

IT WILL BE INTERESTING to follow the progress of the two prominent miniaturization programs, the Signal Corps' "micro-module" and ARDC's "molecular electronics." At the moment the two seem quite dissimilar. The "module" concept is using, for the most part, conventional components in miniaturized form, mounted on convenient uniform wafers. Molecular electronics is making the jump directly into "solid circuits," where all components are cast in a solid block. But the logical evolution of the "micro-module" concept seems to point in the same direction. So it becomes a matter of judgment: has the time arrived, or is it near, when the bulk of the military's electronic equipment can be reduced to "solid circuitry?"

THE BROADCAST INDUSTRY anticipates a 2.5% increase in radio revenues for 1959 and an increase of 7.2% for television.

STAR TRACKER

This 85-ft. diameter radio telescope just completed at the University of Michigan observatory by Blaw-Knox is designed to withstand 120-mph winds without permanent deformation. Equatorial mounting, with the unit's axis parallel to the axis of the earth, simplifies task of keeping celestial objects within view of the telescope.



Analyzing current developments and trends throughout the electronic industries that will shape tomorrow's research, manufacturing and operation

TRANS-ATLANTIC TV got its first showing last month in a 1-minute film from London showing the departure of Queen Elizabeth II for London Airport. Video was transmitted over the telephone cable, and rumors in the industry say that regular programs—news reports, at the very least—will be regular fare by the latter part of the year.

PRODUCTION CAPABILITY of the U. S. electronics industry is estimated at $12.635 billion worth of equipment on a single-shift basis, operating at capacity. The Office of Naval Material released the figures after an exhaustive survey. In 1958 a total of 513,636 employees worked in electronics plants, compared with 492,391 in 1957. The industry averaged $15,654 sales per employee last year.

TV MANUFACTURERS are making a concerted bid to win back the allegiance of the radio-TV servicing fraternity after a half dozen years of steadily worsening relations. Partly because of the fierce competitive pressure, partly out of sheer bull-headedness manufacturers took little notice of the servicemen's influence as sales. When printed circuity was pushed as an economic necessity little effort went into selling the service technicians on the need for it. And when the servicemen raised bitter complaints about the difficulties of servicing printed circuit equipment the manufacturers collectively ignored them. The results: an unorganized but highly effective smear campaign that discredited the entire printed circuit art, and in the process brought a reputation for "quality" and "reliability" to manufacturers who continued to produce hand-wired receivers.

This month Motorola unveiled a printed circuit receiver designed with the serviceman's problems in mind. Wiring on one side of the extra-rigid board is duplicated on the other side in ink to allow easy circuit tracing. Most important, the entire printed circuit board can be removed from the chassis without disconnecting any wires.

Philco and RCA have introduced similar innovations. Both are including on the board, alongside each component, the circuit number of the part.

Now RCA is making additional effort to bring the service dealers in on the push for color TV, through cut-rate arrangement to buy color receivers.

COLOR TV got a boost last month when Admiral revealed a full line of color receivers at their distributor convention in Chicago. Interesting sidelight: Admiral has the largest single slice of the b&w portable TV market—18%.

"SEMI-CONDUCTIVE" CAPACITOR, also called the "hole capacitor," invented in Japan, operates efficiently at 200° C. In the manufacturing process the surface of tantalum is electrolytically acidified and germanium is evaporated onto the surface. This is followed by an aluminum film. The units can be made to very small dimensions. One size mentioned is 6 mm in width, and 36 mm in length, and indications are that they can be reduced still further.

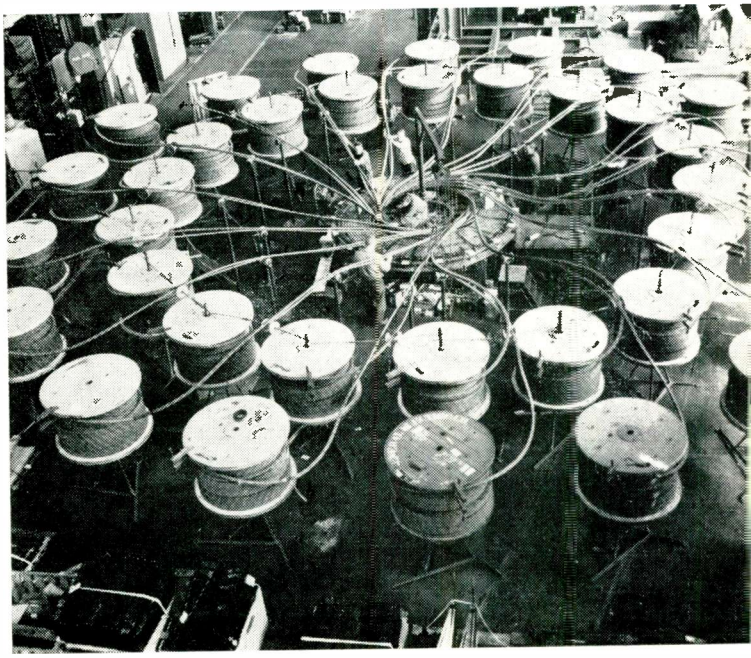
MILITARY MARKET for electronics will approach $5 billion this year, approximately 52% of industry sales. Missiles alone will account for about $2 billion.

NATION-WIDE REGISTRY of scientists and engineers is being considered as a military defense measure by the House Committee on Astronautics and Space.

CLOSED CIRCUIT TV was claimed inadequate and costly by Long Island Agricultural & Technical Institute. They ran a 15-week course via TV simultaneously with a course taught conventionally. They found that some students resisted this type of teaching, while most claimed it made the course more difficult.

TO HANDLE 1,000,000 AMPS

This huge induction coil being constructed at GE's Pittsfield, Mass. plant will contain 6 mi. of heavy copper cable, weigh 60 tons, and stand 5 ft. high. Designed for the Air Force hypersonic wind tunnel at Arnold Engrg. Dev. Center, Tullahoma, Tenn., the coil will handle 1,000,000 amps and magnetic clamping forces to 6,000 tons.



SPRAGUE® RELIABILITY in these two dependable wirewound resistors

MINIATURE

Blue Jacket®

VITREOUS-ENAMEL POWER RESISTORS

Sprague's new improved construction gives even greater reliability and higher wattage ratings to famous Blue Jacket miniature axial lead resistors.

A look at the small *actual sizes* illustrated, emphasizes how ideal they are for use in miniature electronic equipment with either conventional wiring or printed wiring boards.

Get complete data on these dependable minified resistors, **write for Engineering Bulletin 7410.**

TAB-TYPE BLUE JACKETS: For industrial applications, a wide selection of wattage ratings from 5 to 218 watts are available in Sprague's famous Tab-Type Blue Jacket close-tolerance, power-type wirewound resistors. Ideal for use in radio transmitters, electronic and industrial equipment, etc. **For complete data, send for Engineering Bulletin 7400A.**

NEW SMALLER SIZE

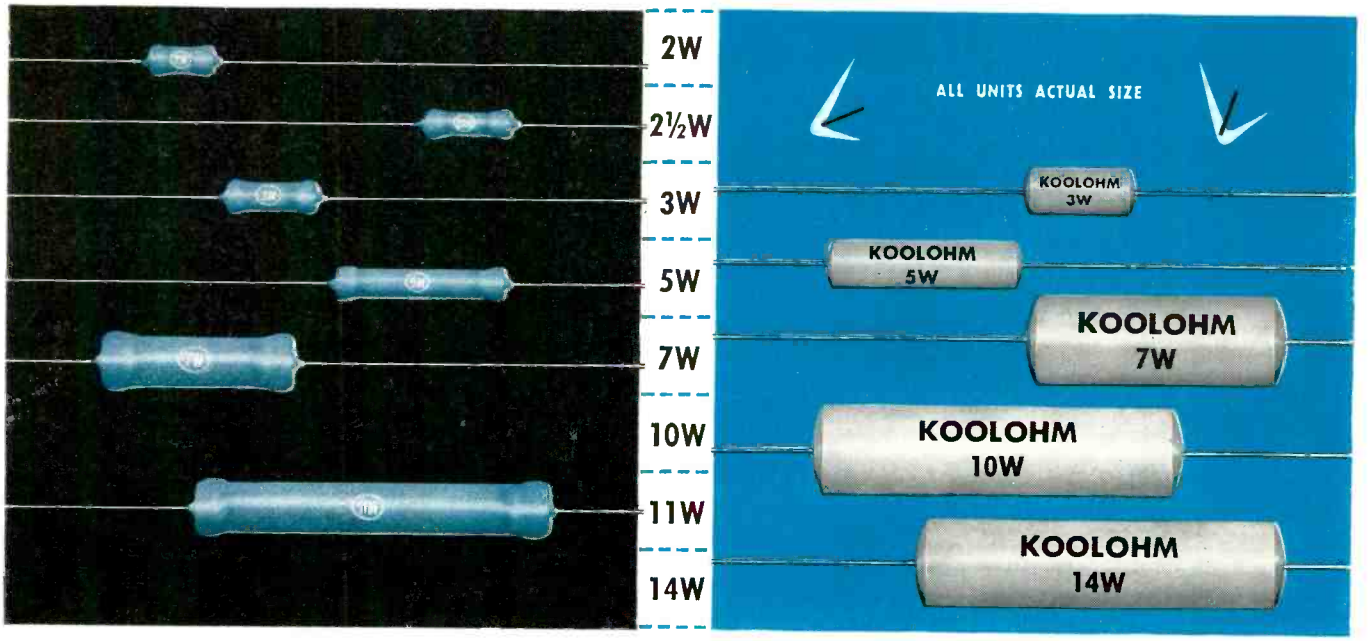
KOOLOHM®

INSULATED-SHELL POWER RESISTORS

New Koolohm construction features include welded leads and winding terminations—Ceron ceramic-insulated resistance wire, wound on special ceramic core—multi-layer non-inductive windings or high resistance value conventional windings—sealed, insulated, non-porous ceramic outer shells—*aged-on-load* to stabilize resistance value.

You can depend upon them to carry maximum rated load for any given physical size.

Send for Engineering Bulletin 7300 for complete technical data.



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SPRAGUE COMPONENTS: RESISTORS • CAPACITORS • MAGNETIC COMPONENTS • TRANSISTORS
INTERFERENCE FILTERS • PULSE NETWORKS • HIGH TEMPERATURE MAGNET WIRE • PRINTED CIRCUITS

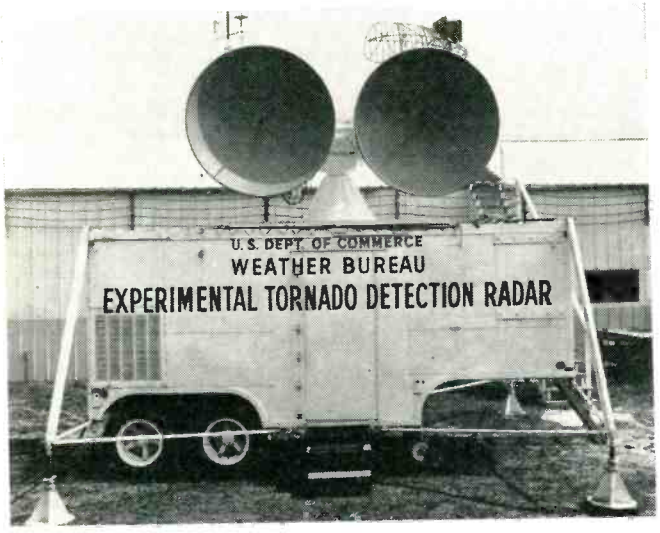
As We Go To Press...

ARPA Study Contract For Satellite System

A $600,000 contract calling for a detailed study of a satellite interceptor system has been awarded to R. C. A. by the Advanced Research Projects Agency of the Department of Defense.

"As part of ARPA's Project Defender, this will be the first comprehensive investigation of a defence system capable of dealing with possible hostile satellite vehicles," according to ARPA Director Roy Johnson. "This study," he said, "is expected to provide the information required to design a system which would become operational during the 1965-1970 time period."

The study, to be conducted by the Missile Electronics and Control Department of RCA at Burlington, Massachusetts, is scheduled for completion in about six months and will encompass all aspects of the satellite interception problem, such as detection, tracking, identification and intercept.



TORNADO DETECTOR

The device (at left), is a sensitive research tool to determine the feasibility of using Doppler Radar for tornado detecting. Sponsored by the U. S. Dept. of Commerce Weather Bureau and developed by Radiation Inc., of Melbourne, Fla; recent improvements were made to improve receiver sensitivity, reduce transmitter noise and eliminate transmitter mode skipping

Raytheon To Set Up R. I. Anti-Sub Center

The nation's first integrated electronic anti-submarine warfare and sonar center will be established at Portsmouth, R. I. by Raytheon Co.

Within three years, if present plans prove feasible, the center could house upwards of 1500 employees with an annual payroll of $8-10 million.

The proposed ASW center, a new Raytheon sub-division to be headed by W. Rogers Hamel, is designed to help speed the development and production time for new special equipment required for the Navy's important undersea warfare program.

The center will be located near the Newport Naval Base which houses the headquarters of the Destroyer Force, Atlantic Fleet and its 110 fighting ships.

Flexible Radar Links For Outside Defenses

A universal air weapons control system made up of radar, communications and data processing equipment is being developed as the Air Force's answer to the problem of air defense outside the Continental U. S.

Designated the Air Weapons Control System 212L, this new electronic system will be capable of providing air control from a variety of situations. For example, the system could be used to defend a single airfield. Or, by linking control sites together, it could be used in a limited action to provide air control for an area the size of Alaska or Korea. Similarly, by linking the capabilities of countries together, a system could be provided for the air control of an entire continent.

GE's Heavy Military Electronics Dept. will manage the overall 212L System for the Air Force. It will also design, develop and produce the data processing and display subsystem which will be the heart of the 212L System.

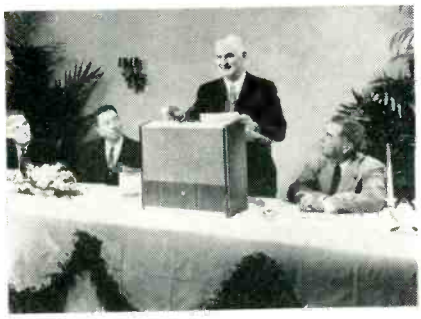
This subsystem will be capable of rapidly and automatically detecting and tracking air targets without human assistance, except under unusual circumstances.

The data processing and display subsystem will be transistorized and modular in both construction and function so that it can be readily tailored to fit the requirements of a wide variety of air control situations. For tactical use, the equipment will be designed so that it can be transported easily.

Management of this project is by Air Materiel Command's Rome Air Materiel Area, Griffiss AFB, N. Y.

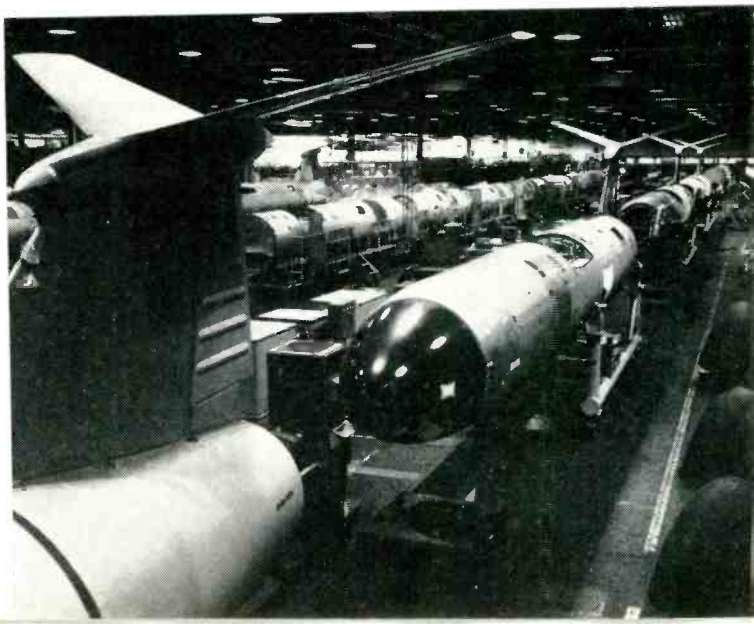
1-UNIT P.A. SYSTEM

Suitcase sized portable sound system, by RCA contains all the electronic equipment a speaker or lecturer requires. A microphone can be attached or worn by speaker, one side can be elevated to form the lectern top.



MATADOR SUCCESSOR

MACE missiles shown here coming off Martin's Baltimore plant. An all weather missile, capable of carrying a nuclear warhead; it is now replacing the MATADOR in USAF operational units in West Germany. Mace is "most reliable and least complex" nuclear weapon delivery system in US defense inventory.



ELECTRONIC SHORTS

▶ The Navy has awarded Sperry Gyroscope Co. the first navigation systems management contract for its new, second-generation, 608-class POLARIS submarines. In this first for a private contractor, the Navy assigned full responsibility to Sperry's Marine Div. for design through installation of the system. The blind, underwater navigation, required to launch a missile accurately after long periods of submergence, depends on inertial guidance. It is backed-up by a series of devices that measure ocean currents, and allow underwater star fixes through the periscope. A computer is fed the information from over 12 such instruments, weighs it, and selects the most accurate bearing and position.

▶ Major roles in the control of air traffic along the approaches to two of the world's busiest traffic hubs have been taken over by computers. The FAA commissioned a Univac for daily use at Idlewild and Washington. By late summer, additional systems will be installed at Pittsburgh, Cleveland, and Boston. Computers will be used to relieve controllers of their "bookkeeping chores" and lessen mental stress and fatigue. They will not replace the human air traffic controllers, who must still make the control decisions.

▶ Latest entry in the closed-circuit television field is CIBA, worldwide drug, dye and plastics concern. Eidophor Inc., a newly formed, wholly owned subsidiary, is named for the Eidophor TV projector, developed in Switzerland with the assistance of CIBA and brought to this country last year by that firm. (See Electronics Industries, March 1959, page O15). Mr. Roderic L. O'Connor has been named President and will make his headquarters at CIBA Limited, 260 Madison Ave., New York, N. Y.

▶ A full-scale working model of part of one of the bases now being built in the Far North to form the BMEWS will appear in the form of a curious-looking dome-shaped structure reaching as high as a 15-story building within view of motorists on the New Jersey Turnpike, near Moorestown, N. J. The building will be used to inspect and check-out the elaborate radar equipment to be shipped to the northern bases. The dome, a plastic sphere 140 ft. in diameter, will top a three-story base, which houses the high-power transmitting apparatus and high-speed computers. Required accuracy is so critical that the tower supporting the antenna and radome is built completely independent from the rest of the building—on structural pylons descending through the building and resting on a 55-foot-wide, eight-foot-thick octagonal slab in the ground.

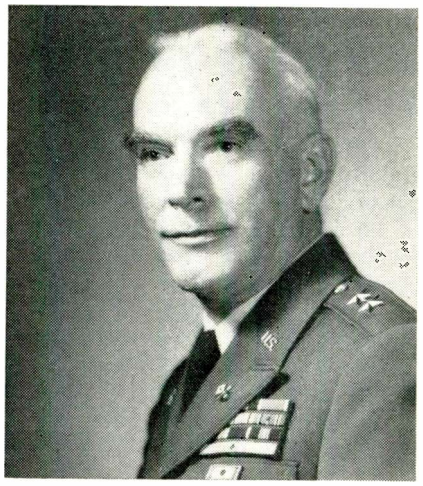
▶ The Space Market, through fiscal year 1970, will be slightly over $14-billion, of which $4.8-billion or approximately 1/3 will be devoted to electronics, according to EIA in their report, "Space Electronics Market—1959-1970." NASA funding will raise from the present $.5-billion annually to nearly $2-billion by 1970. The electronics portion of this funding is expected to increase from 20% to nearly 45%.

▶ Plans for the development of saucer-like platforms which would be stationed miles above the earth for long periods of time have been disclosed. The "weightless fuel" which will supply the power to keep the flying stations aloft will be provided by high frequency radio waves in the microwave region. A scientific breakthrough, development of the high-frequency, high-power microwave tube—the Amplitron, makes these stratospheric stations feasible. Earlier tubes would have required reflectors and power converters on the station much too large to be practical. A previous microwave engineering vice now becomes a virtue. In communications, engineers try to keep generated heat to a minimum. On the platform, as more heat is generated, more propulsion power is available.

▶ A new data processing system is being used by the Navy to keep track of its missiles and ammunition throughout the world. The method devised by the Bureau of Ordnance, will use an RCA 501, all transistor, high-speed system. As the initial step in a 5-phase logistics program, the system is expected to provide high-speed inventory control of missiles, mines, torpedoes, bombs and bullets from the time they start through the production line until they are expended in training exercises or actual warfare.

As We Go To Press . . .

NEW CSigO



Major General, Ralph T. Nelson, the new Chief Signal Officer of the U.S. Army.

23-Inch Picture Tubes Add New TV Dimension

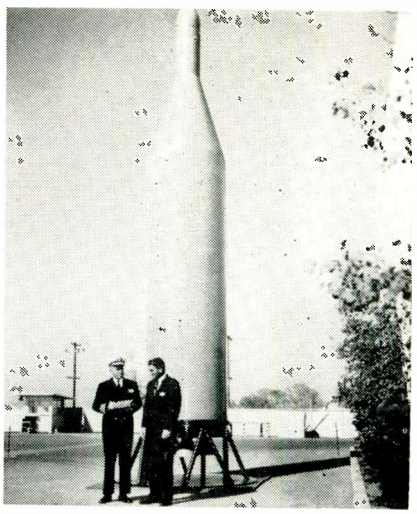
In a move that some industry spokesmen see as a bowing-out of the familiar 21-in. size TV receivers Admiral last month introduced a 23-inch picture tube, the first new size in several years, in its 1960 television line.

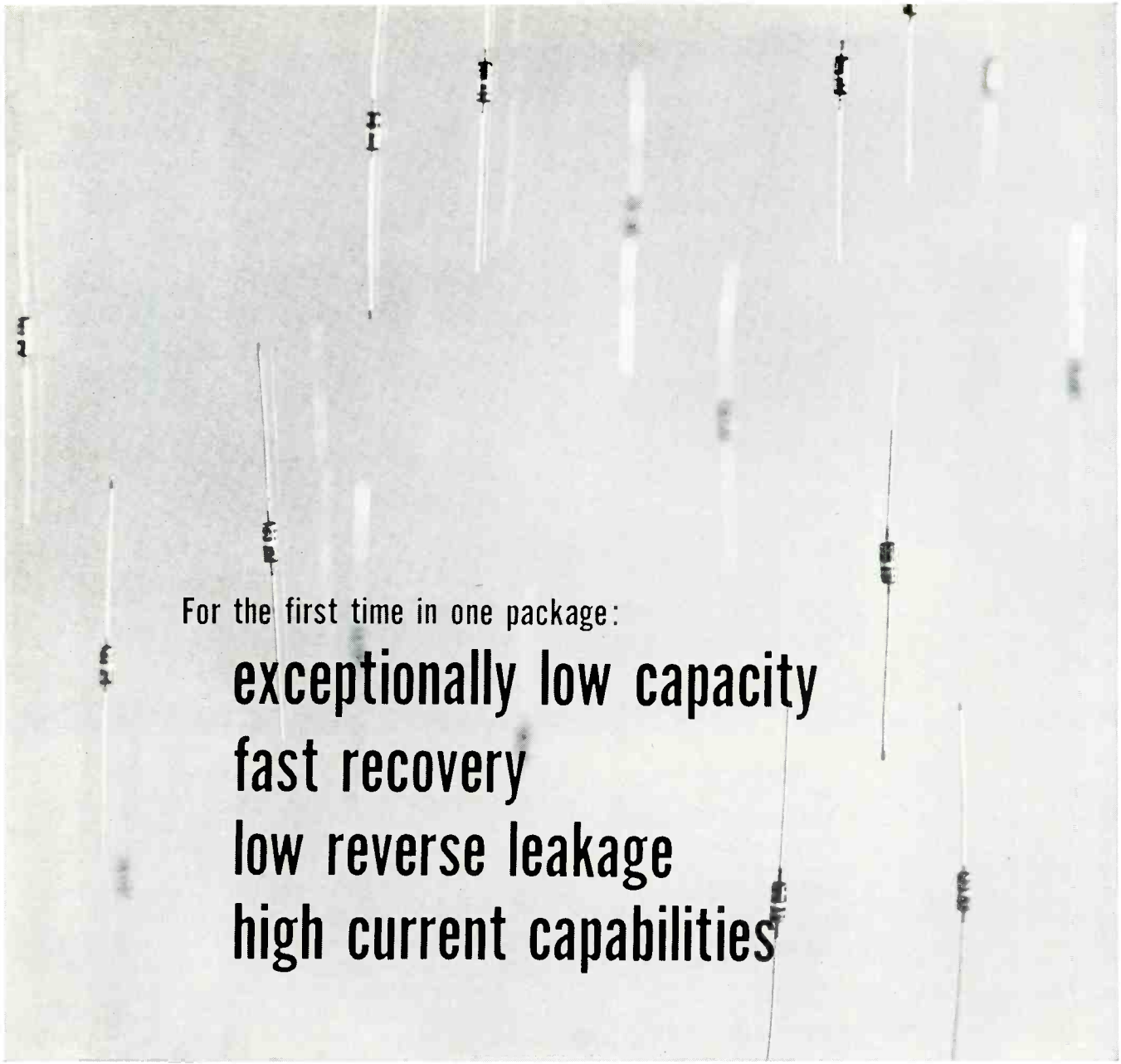
The aluminized 23-inch, 110° black and white tube provides a 282 sq. in., wide angle picture—nearly 10% larger than the customary 21-in. TV image

The tube provides a nearly rectangular picture and the tinted filter safety glass is an integral part of the tube. It is sealed directly to the faceplate, reportedly reducing light reflection by 50% and preventing dust from collecting between the filter and the front of the tube.

ANNAPOLIS POLARIS

A static test dummy Polaris missile, used in tests at Cape Canaveral last year has been refurbished and presented to the U.S. Naval Academy by Lockheed's Missiles Division.





100 mA Min. @ 1V Forward Current...0.3 μsec recovery...4 μμf at −2V...that's what you get with the new Hughes computer diodes. With these characteristics, *these diodes will cover practically every major computer switching requirement.*

You can always count on them for top performance. Hermetically sealed in glass envelopes, these Hughes computer diodes have been engineered for extreme reliability under adverse environmental conditions.

For additional information concerning these unique Hughes diodes call or write the Hughes sales office nearest you. They are located at:

***Boston,** 4 Federal Street; Woburn, Mass.; WOburn 2-4824*
***Newark,** 80 Mulberry Street; Newark 2, N. J.; MArket 3-3520*
***San Francisco,** 535 Middlefield Road; Palo Alto, Calif.; DA 6-7780*
***Syracuse,** 224 Harrison Street; Syracuse 2, N. Y.; GRanite 1-0163*
***Chicago,** 6120 West North Ave.; Chicago 39, Ill.; NAtional 2-0283*
***Philadelphia,** 1 Bala Avenue; Bala-Cynwyd, Penn.; MOhawk 4-8365*
***Los Angeles,** 690 N. Sepulveda; El Segundo, Calif.; OR 8-6125*

Or write, Hughes Products, Marketing Department,
SEMICONDUCTOR DIVISION, NEWPORT BEACH, CALIFORNIA.

TYPICAL SPECIFICATIONS:

Type	Min. E_S (@ 100μA)	Min. Forward Current @ 25°C (@ +1.0V)	Max. Reverse Current (μA) @ 25° C	Max. Reverse Current (μA) @ 100° C	Reverse Recovery* Reverse Resistance (R) (ohms)	Reverse Recovery* Maximum Recovery Time (μsec)
1N840	50	150	0.1 @ 40V	15 @ 40V	400 K	0.3
1N837A	100	150	0.1 @ 80V	15 @ 80V	400 K	0.3
1N841	150	150	0.1 @ 120V	15 @ 120V	400 K	0.3
1N843	250	150	0.1 @ 200V	15 @ 200V	400 K	0.3
1N844	100	200	0.1 @ 80V	15 @ 80V	400 K	0.5
1N845	200	200	0.1 @ 160V	15 @ 160V	400 K	0.5

*Measured in JAN test circuit and switched from 30mA forward current to −35V.

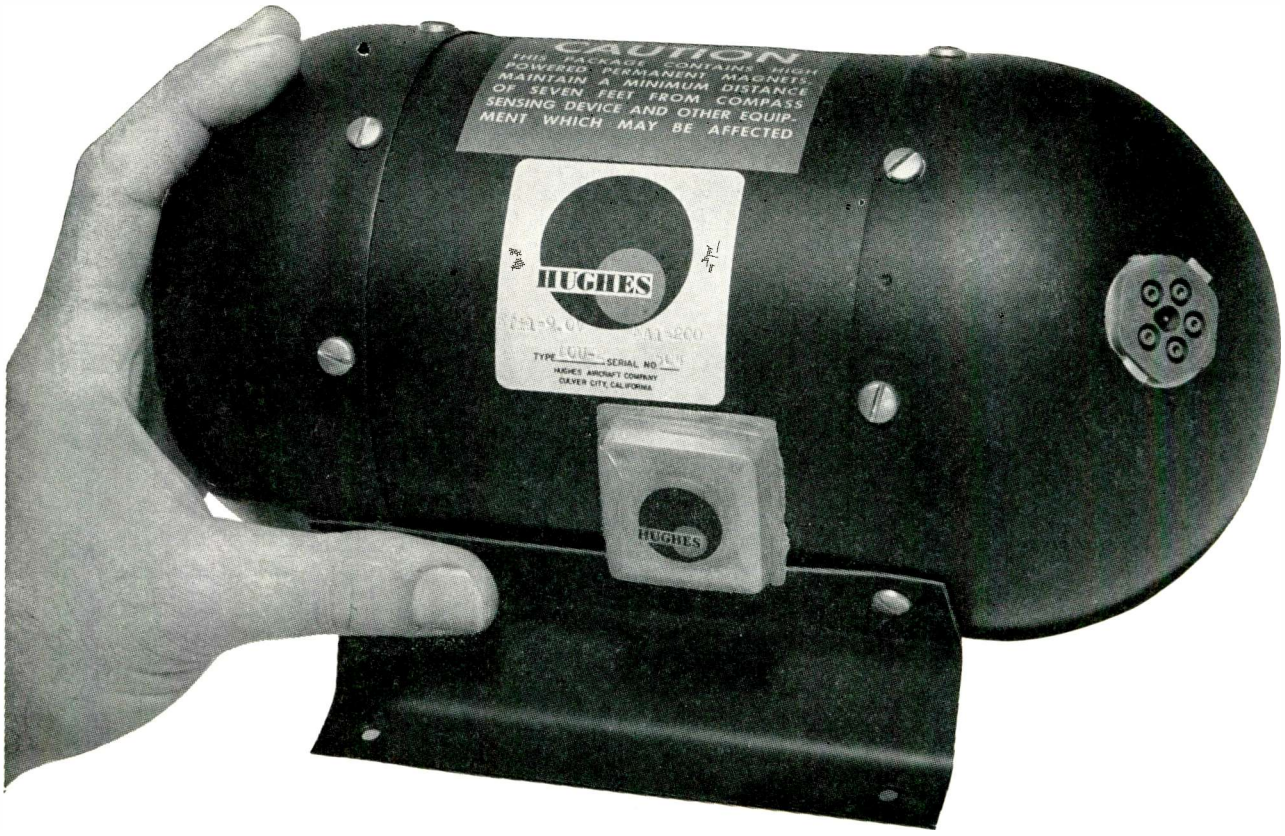
TYPICAL CAPACITANCE: C_{-10}=2.2μμf $C_{-1.5}$=4.4μμf C_{-0}=9.0μμf

Operating Temp. Range: −65°C to +150°C Storage Temp. Range: −65°C to +200°C

Creating a new world with ELECTRONICS

HUGHES PRODUCTS

SEMICONDUCTOR DEVICES · STORAGE AND MICROWAVE TUBES · CRYSTAL FILTERS · OSCILLOSCOPES · RELAYS · SWITCHES · INDUSTRIAL CONTROL SYSTEMS



Available from stock...**MICROWAVE GENERATORS**

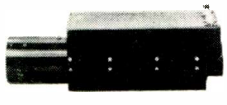
Now available for immediate delivery are several high-performance Hughes microwave tubes... including the Model LOU-2 pictured above. This Ku band backward oscillator is completely ready for insertion into a system. The prepackaged LOU-2 tube gives you power output of from 10 to 60 milliwatts over the band ...and tunes the frequency range of 12.4 to 18.0 kmc/sec.

Since the tube is housed in a self-contained permanent magnetic focusing package, no separate power supply for a focusing electromagnet is necessary. Result: you get a lighter and more compact package.

Reliability has been engineered into the tube—and has been proven in more than 2 years of life tests. The package is completely sealed and magnetic structures are potted in epoxy resin.

Developed by the famed Hughes Research & Development Laboratories, the LOU-2 helps solve your problems associated with microwave signal generators, panoramic receivers and spectrum analyzers, frequency scan radars, navigational radars, microwave links, and countermeasures.

Hughes also offers you from stock these other high performance microwave tubes:



S-band traveling wave amplifier—Periodically focused, the type MAS-1A has a peak power output of one kilowatt over a band of 2-4 kmc at duties up to 0.005. The tube has a gain of 30 to 33 db, giving an excess of one kilowatt over most of the band.

S-band backward wave amplifier—Type PAS-2, a voltage-tuned amplifier, features: frequency range 2.4-3.5 kmc, tube noise figures of less than 5 db, crystal protection, spurious input signal elimination, cold isolation greater than 80 db and image rejection.

X-band backward wave amplifier—Featuring a noise figure of 4.5 db, the PAX-1 tube, also offers a 12 MC bandwidth which is electronically tunable over the X-band spectrum.

For additional information please write: Hughes Products, Electron Tube Sales, International Airport Station, Los Angeles 45, California. For export write: Hughes International, Culver City, California.

Creating a new world with ELECTRONICS

HUGHES PRODUCTS

SEMICONDUCTOR DEVICES • STORAGE AND MICROWAVE TUBES • CRYSTAL FILTERS • OSCILLOSCOPES • RELAYS • SWITCHES • INDUSTRIAL CONTROL SYSTEMS

Coming Events

A listing of meetings, conferences, shows, etc., occurring during the period July-October that are of special interest to electronic engineers

July 1-16: Annual Meeting, International Electrotechnical Commission; Stockholm, Sweden.

July 15-17: 10th Annual Conf. of the Forestry, Conservation Communications Assoc.; Arlington Hotel, Hot Springs, Arkansas.

July 25 (Opening date): American National Exhibition, Sokolniki Park, Moscow, U.S.S.R.

July 25-28: Trade Show, National Audio-Visual Assoc., Inc.; Morrison Hotel, Chicago, Ill.

Aug. 3-6: 25th Annual Convention, Associated Police Communications Officers, Inc., Shirley Savoy Hotel, Denver, Colo.

Aug. 9-12: Heat Transfer Conference, ASME; University of Connecticut, Storrs, Conn.

Aug. 10-17: Meeting International Assoc. of Electrical Leagues; El Cortez Hotel, San Diego, Calif.

Aug. 17: 1st National Ultrasonics Symposium, IRE (PGUE); Stanford University, Stanford, Calif.

Aug. 18-21: WESCON, West Coast Electronic Manufacturers Assoc., 7th Region IRE; Cow Palace, San Francisco, Calif.

Aug. 20-24: Annual Convention, Nat'l Alliance of TV & Electronic Service Assoc.; Congress Hotel, Chicago, Ill.

Aug. 24-26: Meeting, American Rocket Society; Evanston, Ill.

Aug. 27-29: Meeting, American Physical Society, AIP; Hawaii.

Aug. 31-Sept. 2: Conference on Semiconductors, Metallurgical Society of AIME, Statler Hotel, Boston, Mass.

Sept. 1: 6th International Meeting, Institute of Management Sciences; Paris, France.

Sept. 5-6: New England Division Convention, American Radio Relay League; Hartford, Conn. (Tent.)

Sept. 10-11: Midwest Sections Conf., SPI; Sheraton Hotel, French Lick, Ind.

Sept. 10-21: Radio, TV, and Records Exhibition, Federation Nationale Des Industries Electroniques; Exhibition Park, Porte de Versailles, Paris, France.

Sept. 13-16: 11th Electronic Industry Conf., Electronic Representatives Assoc.; Excelsior Springs, Missouri.

Sept. 15: Conf. on Photosensitive Materials and Silk Screen Processes, Western Assoc. of Circuit Manufacturers; Rodger Young Aud., Los Angeles, Calif.

Sept. 16-18: Engineering Management Conference, ASME; Statler Hilton Hotel, Los Angeles, Calif.

Sept. 17-18: Engineering Writing & Speech Symposium, IRE (PEGWS); Boston & Los Angeles.

Sept. 17-18: 2nd Conf. on Nuclear Radiation Effects on Semiconductor Devices, Materials, and Circuits, ODR, Advisory Group on Electron Tubes; Western Union Auditorium, New York City.

Sept. 20-23: Petroleum Mech. Engrg. Conf., ASME; Rice, Houston, Tex.

Sept. 21-22: 8th Annual Meeting, Investment in Survival, Standards Engineering Society; Somerset Hotel, Boston, Mass.

Sept. 21-23: 8th Annual Meeting, Standards Engineers Society; Somerset Hotel, Boston, Mass.

Sept. 21-25: 14th Annual Instrument-Automation Conf. & Exhibition, ISA; International Amphitheater, Chicago, Ill.

Sept. 22-24: Quarterly Conf., Electronic Industries Assoc., Plaza Hotel, New York City

Sept. 22-24: 3rd Industrial Nuclear Technology Conf. ARF, AEC; Morrison Hotel, Chicago, Ill.

Sept. 23-25: 4th Annual Special Technical Conf. on Non-linear Magnetics & Magnetic Amplifiers, AIEE, IRE; Shoreham Hotel, Washington, D. C.

Sept. 28-30: National Symposium on Telemetering, IRE (PGTRC); Civic Auditorium and Whitcomb Hotel, San Francisco, Calif.

Sept. 30-Oct. 1: Industrial Electronics Symposium, IRE, AIEE; Mellon Institute, Pittsburgh, Pa.

Oct. 1-2: 15th New England Section Conf., SPI; Wentworth-by-the-Sea, Portsmouth, N. H.

Oct. 5-7: 5th National Communications Symposium, IRE; Hotel Utica, Utica, N. Y.

Oct. 5-9: 11th Annual Convention. Audio Engineering Society; Hotel New Yorker, New York, N. Y.

Oct. 5-9: 86th Semiannual Convention, including Equipment Exhibit, Society of Motion Picture & TV Engineers; Statler Hotel, New York, N. Y.

Oct. 5-16: 7th Anglo-American Conference, IAS, Royal Aeronautical Society, Canadian Aeronautical Institute, Institute of the Aeronautical Sciences; Hotel Astor, New York, N. Y.

Oct. 6-7: Value Engineering Symposium, EIA; University of Pennsylvania, Phila., Pa.

Oct. 6-8: 5th Conf. on Radio-Interference Reduction, Armour Research Foundation, IRE, U. S. Army Signal Research and Development Labs; Chicago, Ill.

Oct. 6-9: 2nd International Symposium on High Temperature Technology, Stanford Research Institute; Asilomar Conference Grounds, Cal.

Oct. 7-9: National Symposium on Vac. Tech., American Vacuum Society; Hotel Sheraton, Phila., Pa.

Oct. 7-9: Canadian Convention, IRE; Toronto, Canada.

Oct. 8-10: Meeting, Optical Society of America; Chateau Laurier, Ottawa, Canada.

Oct. 11-15: 3rd Pacific Area National Meeting, ASTM; Sheraton-Palace Hotel, San Francisco, Calif.

Oct. 11-16: Fall General Meeting, AIEE; Morrison Hotel, Chicago, Ill.

Oct. 12-14: Annual Conference, National Electronics Conference, IRE, AIEE, EIA, SMPTE; Hotel Sherman, Chicago, Ill.

Oct. 13-16: Midyear Meeting of Lab Apparatus & Optical Sections; Scientific Apparatus Makers Assoc.; The Cavalier, Virginia Beach, Va.

Oct. 15-17: Fall Meeting, National Society of Professional Engineers, Olympic Hotel, Seattle, Wash.

Oct. 17-25: International Fair of Plastics Ind., Duesseldorf, Germany.

Oct. 18-22: Meeting, The Electrochemical Society, Inc., Deshler-Hilton Hotel, Columbus, Ohio.

Oct. 19-21: Fall Meeting, URSI, IRE; Balboa Park, San Diego, Calif.

Oct. 19-22: 6th Annual Conf. Int'l Municipal Signal Assoc.; Stardust Hotel, Las Vegas, Nev.

Oct. 20: Plating Techniques as Applied to Printed Circuitry, Western Assoc. of Circuit Manufacturers; Rodger Young Aud., Los Angeles, Calif.

Abbreviations

AIEE: American Institute of Electrical Engineers

AIME: American Institute of Mining & Metallurgical Engineers

AIP: American Institute of Physics

ARF: Armour Research Foundation

AEC: Atomic Energy Commission

ASME: American Society for Mechanical Engineers

ASTM: American Society for Testing Materials

EIA: Electronic Industries Association

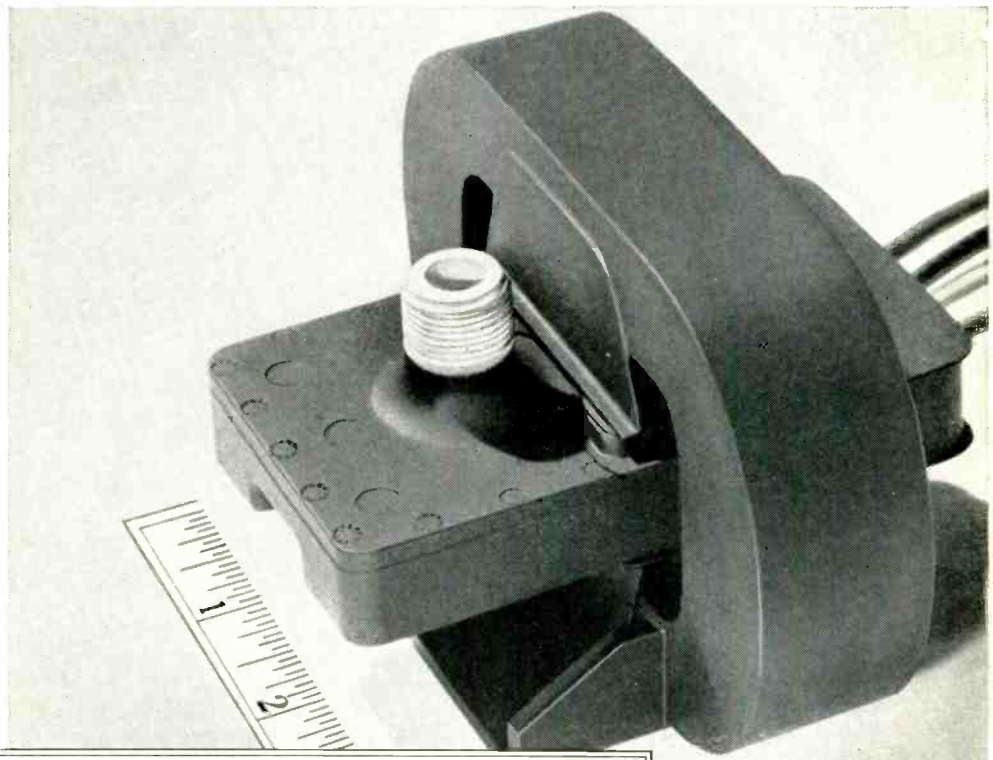
IRE: Institute of Radio Engineers

ODR: Office of Director of Defense Research

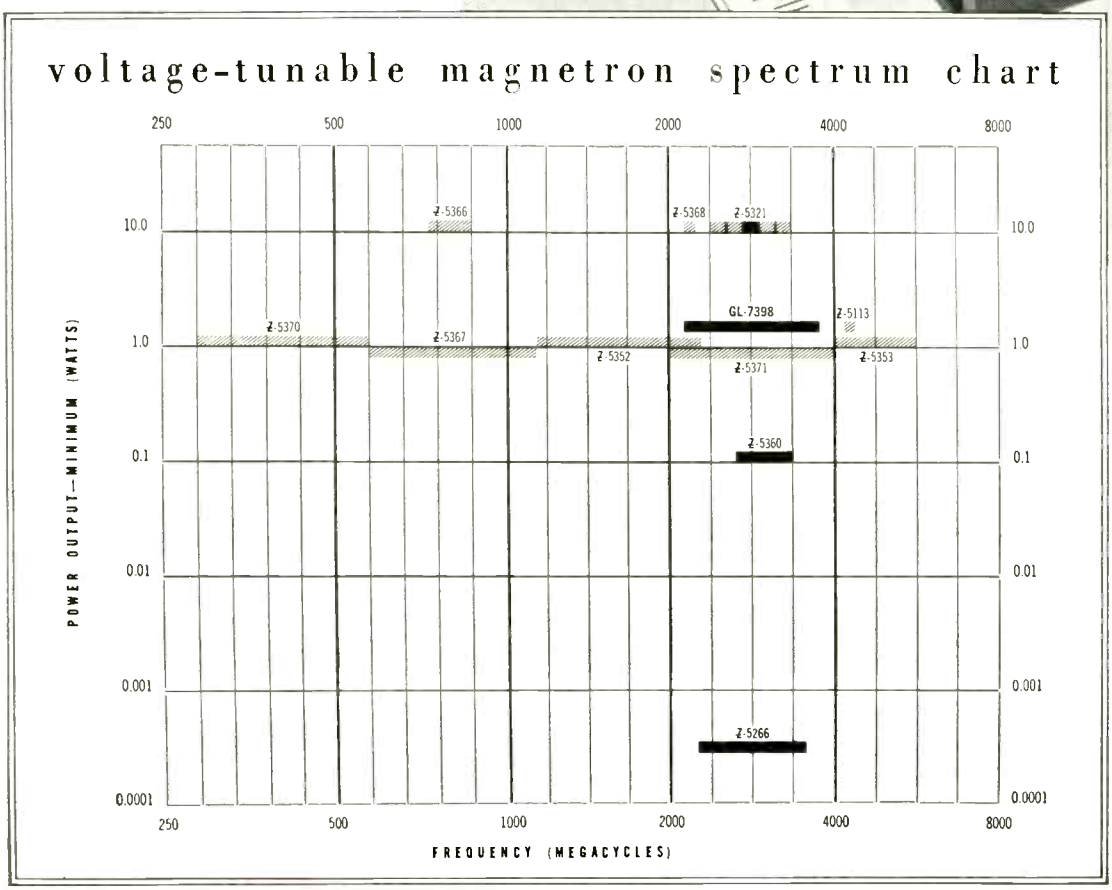
SMPTE: Society of Motion Picture & TV Engineers

GENERAL ELECTRIC GL-7398* VOLUME PRODUCTION, AVAILABLE

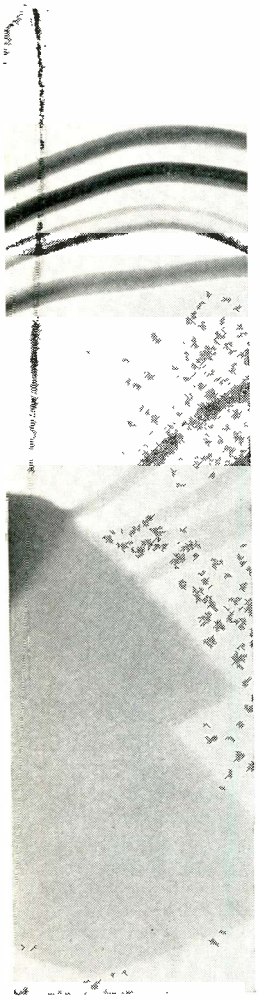
**formerly designated Z-5300*



Voltage-tunable magnetrons now available are indicated by solid areas. Other developments are shown by cross-hatched areas.
▼



VOLTAGE-TUNABLE MAGNETRON IN FOR IMMEDIATE DELIVERY!



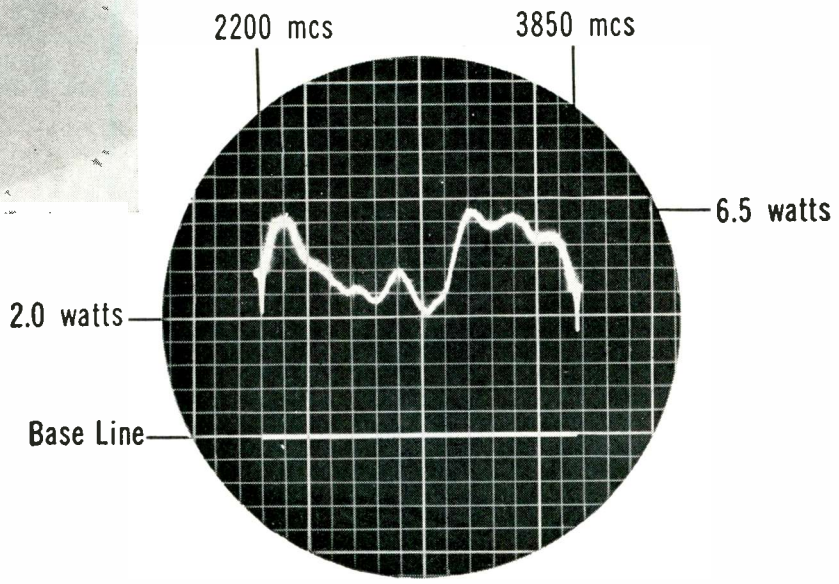
The General Electric GL-7398 voltage-tunable magnetron, a complete RF power source ideal for FM modulation, is now in volume production and available for immediate delivery. Moreover, samples are currently available or can be developed by use of proved technology to meet any need within the frequencies charted on the opposite page. The GL-7398 is designed for use in many applications, such as:

- FM telemetering or video transmission
- Beacon transmitters
- Local oscillators in electronically tunable radars
- Drivers in pulse-to-pulse frequency-shift radars
- FM altimeters
- Broad-band signal generators
- Countermeasure transmitters
- Drivers for countermeasure amplifiers

Output frequency can be varied linearly over a range of nearly 2 to 1 by sweeping the anode voltage. Power output is relatively flat at a minimum of 2 watts. The GL-7398 is a rugged, compact, packaged unit with these characteristics:

Anode voltage at 3 kmc	— 1250 volts
Anode current	— 10-20 ma
Frequency range	— 2200-3850 mcs
Tuning rate	— approx. 3 mcs/volt
FM rate	— 10 mcs or higher
Weight	— 3.1 lbs.

By use of internal narrow-band circuits, a variation (Z-5321) is available which gives a minimum of 10 watts power over a 200 mc bandwidth at a factory-predetermined centerpoint in the 2 to 4 kmc band. Other variations with built-in attenuators for local oscillator applications can be supplied (Z-5360 and Z-5266). *Power Tube Department, General Electric Company, Schenectady, New York.*



◀ Typical power – frequency of the GL-7398 shows power constant over the full band to within plus-or-minus 3 db.

Progress Is Our Most Important Product

GENERAL ELECTRIC

9545-8481-22

As We Go To Press (cont.) . . . .

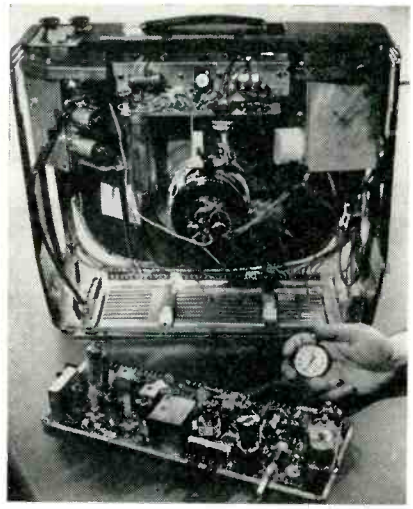
New TV Receiver Has Serviceman In Mind

Motorola is making an open bid for TV technicians' support with a new "serviceable" printed circuit TV receiver designed to overcome complaints of inaccessibility, poor reliability, and general servicing difficulties.

The new receiver features an exceptionally strong printed circuit board, high bond strength of the plated wiring, and a quick-removal arrangement that permits the circuit board to be removed from the cabinet without disconnecting any wires.

All connections between the plated chassis board and its power supply and associated receiver parts, with the exception of four simple clip connectors, are made by inserting the board into three specially developed and Motorola tooled female connectors with 12 contacts each. The board can be removed from the set by loosening three screws and disconnecting four clip leads.

For trouble shooting, the board can be pulled so that every single component on it is available under operating conditions. Complete removal of the board or loosening it for trouble shooting occupies in either case less than 33 seconds. Lead length has been allowed for so there is adequate room to work with the receiver operating.



Loosening 3 screws, disconnecting 4 clip leads, and activating a spring loaded lever ejects the plated chassis board from Motorola's new TV set. Complete removal, or loosening for trouble shooting takes 33 sec.

The entire bottom of the set is completely clean, without any obstruction to hinder the serviceman in his trouble shooting.

The board is completely color coded following the RETMA wiring code. The complete schematic is right on the board where every circuit can be traced. The top configuration has been transposed to the bottom of the chassis and the bottom has been transposed to the top so that there is no need to turn the board over to trace a circuit.

CIBA Sets Up TV Firm

CIBA, worldwide drug, dye and plastics concern, is entering the closed-circuit TV field through the formation of a wholly-owned subsidiary, Eidophor Inc.

The new company is named for its new Eidophor® TV projector, developed in Switzerland with the assistance of CIBA and brought to this country by CIBA last year.

Roderic L. O'Connor has been named president of Ediphor Inc. Mr. O'Connor is a former Assistant Secretary of State and has been since January 1, 1959, Vice-President and Counsel of CIBA States Limited, which heads CIBA's U. S. operations.

"MOLECULAR ELECTRONICS"

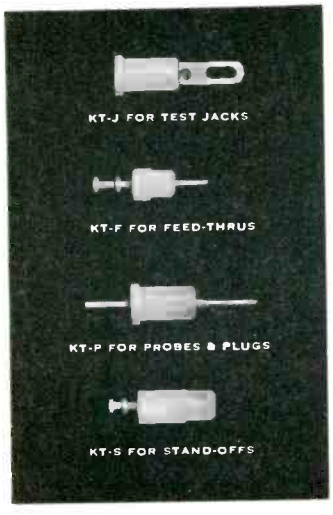
Westinghouse's J. J. Coleman watches ribbon-like germanium crystal rise from a molten pool in this furnace at the Company's Research Labs. Strips require none of the costly, cutting and grinding that wastes up to 80% of conventional ingots used in semiconductor device fabrication.

AIR PHOTO PRINTER

Air Force automatic picture printer (left) allows monitoring by operator before reaching the take up roll. Xerographic prints are completely finished 22 second after exposure of the aerial roll negatives. Haloid Xerox Inc., developed the unit for the Air Force.

"FREEDOM FIGHTER"

Northrop's new N-156F is unveiled before an audience of forty nations. The multi-purpose, supersonic, fighter is designed for the defense of U. S. allies at much less cost than current fighters. It is designed in parallel with the T-38 Talon basic trainer.



PERMANENTLY INSTALLED IN 4 SECONDS OR LESS by pressing the self-fastening insulator through pre-drilled mounting holes. The resilient properties of the "Teflon" insulation secures the terminal and provides permanent vibration proof installation, with no soldering or screw attachment needed to hold terminal in place. New Cannon "KT" Terminals offer simplified electrical connection especially adapted for circuitry in microwave communications, radar, scientific instrumentation and other crowded space applications. ▪ **VOLTAGE RATINGS FROM 2380 V. TO 4250 V.** (Sea Level) depending on size of terminal. Special types are available where higher operating voltages are encountered. ▪ **TEFLON BUSHINGS** available in diameters of 0.148" to 0.264." Terminal lengths range from 0.120" to 2.500." Standard pin diameters are 0.040," 0.046," 0.050," and 0.078." Pin material is brass with 0.0003" silver plate. A wide variety of finishes, colors and soldering lugs can be supplied to order. ▪ "KT" Terminals are immediately available in a wide variety of sizes and shapes. Cannon also produces special configurations for specific applications: Write for Cannon Catalog KT-1. Please refer to Dept. 201, Cannon Electric Company—3208 Humboldt Street, Los Angeles 31. Factories in Los Angeles, Santa Ana, Salem, Toronto, London, Paris, Melbourne and Tokyo. Distributors and Representatives in the principal cities of the world.

CANNON PLUGS

MARCA REG. IN MEXICO

Circle 6 on Inquiry Card

TEKTRONIX TYPES 545A, 541A, 535A & 531A

Redesigned for:

EASIER OPERATION

Simplified Panel Layout.

Color-Correlated Controls.

Single-Knob Sweep Time Control.

Simplified Display Control.

Internal Triggering for Sweep Delay.

Single-Knob Calibrator Control.

Improved One-Shot Sweep Operation in Types 535A and 545A.

HIGHER PERFORMANCE

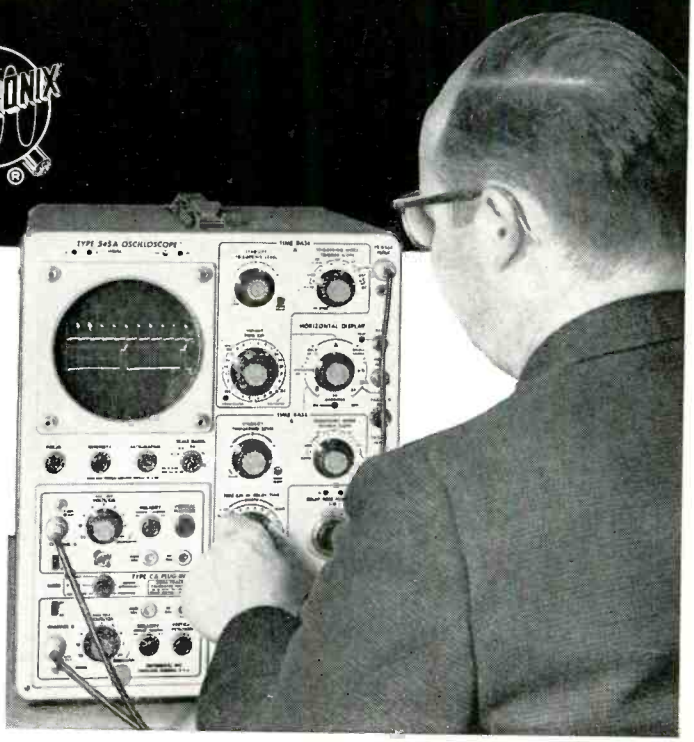
New DC-to-15 MC Vertical Amplifiers in Types 531A and 535A.

New Wider Sweep-Delay Range in Types 535A and 545A.

GREATER RELIABILITY

New Frame-Grid Twin Triodes Replace Older Types.

Silicon Rectifiers Replace Selenium in Power Supplies.



Type 545A Fast-Rise Oscilloscope with Sweep Delay

VERTICAL SPECIFICATIONS

DC-to-30 MC passband, 12-mμsec risetime, 50-mv/cm deflection factor with Type K Plug-In Preamplifier.

Many other plug-in units available for specialized applications.

Signal delay permits observation of leading edge of waveform that triggers the sweep.

HORIZONTAL SPECIFICATIONS

Two Time-Base Generators—

Time Base A—0.1 μsec/cm to 5 sec/cm in 24 calibrated steps.

Continuously adjustable from 0.1 μsec/cm to 12 sec/cm.

5x magnifier increases calibrated range to 0.02 μsec/cm.

Single sweep provision for one-shot applications.

Time Base B—Also functions as a sweep delay generator. 2 μsec/cm to 1 sec/cm in 18 calibrated steps.

Sweep Delay—Two modes of operation

Triggered—Delayed sweep started after the delay period by the signal under observation. Steady display, even of signals with inherent jitter.

Conventional—Delayed sweep started at the end of the delay period by the delayed trigger. Time jitter less than one part in 20,000.

Range of Delay—1 μsec to 10 sec in 18 calibrated ranges, each range divisible into 1000 parts by 10-turn control with incremental accuracy of 0.2%.

OTHER CHARACTERISTICS

10-KV Accelerating Potential.

Amplitude Calibrator—0.2 mv to 100 v.

Electronically-Regulated Power Supplies.

Price—Type 545A, without plug-in units..... **$1550**

Type 541A Fast-Rise Oscilloscope

Same as Type 545A, except that it does not have Time-Base B or provision for sweep delay or single sweeps.

Price—Type 541A, without plug-in units..... **$1200**

Type 535A Wide-Band Oscilloscope with Sweep Delay

Same specifications as Type 545A, except for main vertical amplifier. DC-to-15 MC passband, 23-mμsec risetime, 50-mv/cm deflection factor with Type K Plug-In Preamplifier.

Price—Type 535A, without plug-in units..... **$1400**

Type 531A Wide-Band Oscilloscope

Same as Type 535A except that it does not have Time-Base B or provision for sweep delay or single sweeps.

Price—Type 531A, without plug-in units..... **$995**

Rack-Mounting Models Also Available

Prices f.o.b. factory

Tektronix, Inc.

P. O. Box 831 • Portland 7, Oregon

Phone CYpress 2-2611 • TWX-PD 311 • Cable: TEKTRONIX

TEKTRONIX FIELD OFFICES: Albertson, L. I., N.Y. • Albuquerque • Atlanta, Ga. • Bronxville, N.Y. • Buffalo • Cleveland • Dallas • Dayton • Elmwood Park, Ill. • Endwell, N.Y. • Houston Lathrup Village, Mich. • East Los Angeles • West Los Angeles • Minneapolis • Mission, Kansas Newtonville, Mass. • Orlando, Fla. • Palo Alto, Calif. • Philadelphia • Phoenix • San Diego St. Petersburg, Fla. • Syracuse • Towson, Md. • Union, N.J. • Washington, D.C. • Willowdale, Ont.

TEKTRONIX ENGINEERING REPRESENTATIVES: Hawthorne Electronics, Portland, Oregon,, Seattle, Wash.; Hytronic Measurements, Denver, Colo., Salt Lake City, Utah.

Tektronix is represented in 20 overseos countries by qualified engineering organizations.

Electronic Industries International

EUROPE

French Missiles for NATO

The U. S. Army is buying $7,500,000 in anti-tank missiles from Nord Aviation of Paris. Six and one-half million dollars is for the operational SS-10 missile and $1,000,000 is for buying and testing the SS-11 missile, which has more than double the range of the SS-10. These missiles (cost between $755 and $1,000) are said to be capable of knocking out any tank, including the U. S.'s M-48 (cost $139,000).

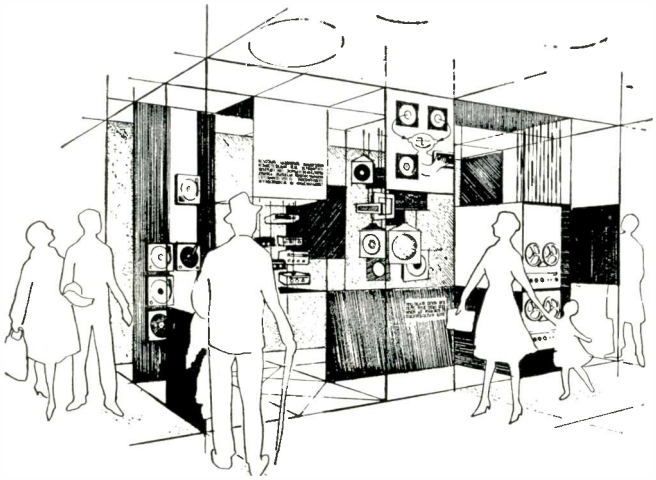
CANADA

IRC Forms Canadian Sub

International Rectifier Corp., El Segundo, Calif., has formed International Rectifier of Canada Ltd., headquarters at 1581 Bank St., Ottawa, Ontario.

The Company will supply Canadian industry with selenium, germanium, and silicon semiconductor materials, silicon solar cells, and selenium self-generating photocells.

Earl F. Johnson is secretary-manager of the new firm.



Russia

U. S. Hi-Fi in Moscow

The Institute of High Fidelity Mfrs' stereophonic high fidelity exhibit at the American National Exposition in Moscow was designed by George Nelson & Co. Featured are: Ampex tape decks; amplifiers and preamplifiers by Audax and University; and United transformers.

Burroughs Buys French Plant

Burroughs Corp., Detroit, Mich., expanding its manufacture of business machines in France, has purchased a 110,000 ft² factory at Villers-Ecalles, near Rouen.

The factory will begin operations around July 1 employing nearly 600 people in fabricating and assembling Burroughs Ten Key adding machines.

New TV Stations for Sweden

Five new Band 111 TV stations are being built at Borlange, Sundsval, Vasteras, Emmaboda, and Vastervik, Sweden. The Borlange station will have two transmitters in parallel and the remaining four will have single transmitters feeding directional antennas. Equipment will be supplied by Marconi's Wireless Telegraph Co., England.

Danes Get Nike

A complete set of Nike Guided Missile Equipment — radars, launcher, vans—are going to the 1st Danish Nike battalion at Fort Bliss, Texas. The battalion will be the first Nike unit in Denmark's air defense system. The battalion has been training in the U. S. under the U. S. Army Air Defense School and the 1st Guided Missile Brigade.

AFRICA

Royal Visit on TV

Special TV equipment will be installed to supply live coverage of the visit of Britain's Queen Elizabeth to Ghana in November. Under an agreement between the Ghana Broadcasting Authority and two British firms: Marconi's Wireless Telegraph Co., Ltd., Chelmsford, and Pye Ltd., Cambridge, receivers will be installed in community centers, hospitals, and other public places. Complete facilities, including telecine and video tape equipment, will be set up in Accra, Ghana's capital city.

Congo Gets British Instrument Landing System

A $170,000 contract between Pye Telecommunications Ltd., and the Belgium Congo Government calls for installation of a Pye Instrument Landing System to be installed at the Leopoldville and Elizabethville airports.

The relative merits of the British and American Instrument landing systems has recently been a controversial subject. A meeting of the International Civil Aviation Organization last winter gave a preliminary recommendation to the U. S. system. The British are opposing the recommendation and are going ahead with development of their system.

JAPAN

New Japanese Rep for Aerojet

Aerojet-General Corp., Azusa, Calif., will distribute its products in Japan through Mitsui & Co., Ltd., Tokyo. Under the recently signed agreement Mitsui will be sales rep for the company's JAT09 jet assist take-off rockets and for the Aerobee series of high altitude sounding rockets.

Electric Current Abroad

The kinds of current used in the principal cities of almost 150 countries and territories are given in a new 77-page booklet, "Electric Current Abroad," $0.25, issued by the Bureau of Foreign Commerce, U. S. Dept. of Commerce.

Types, phases, cycles and voltages are listed for cities grouped by countries in alphabetical arrangement. Booklet may be obtained from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

MIDDLE EAST

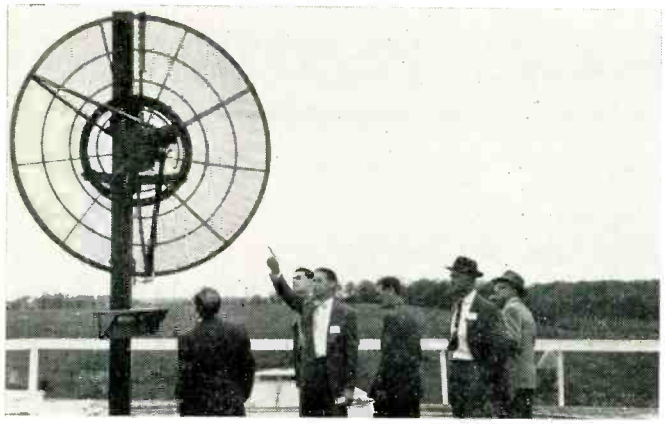
Radar for Jordan

A long-range early warning radar station, communications networks and automatic direction finding equipment will be built for the Royal Jordanian Air Force by Marconi's Wireless Telegraph Co., Ltd. Personnel of the Jordanian Air Force are receiving instructions on the equipment at the Marconi College at Chelmsford, England.

(*Continued on page* 24)

The aerial tower at Kuhe Sefid, a VHF multichannel radio station built by Marconi's Wireless Telegraph Co., Ltd., in Iran, looks out over the range of mountains crossed by a chain of radio repeater stations.

Snapshots . . . of the Electronic Industries



ANTENNA TOUR

IRE sponsored tour of Andrew Corp.'s engineering and production facilities provided members of Chicago Antennas and Propagation and Microwave Theory and Technique Groups with an opportunity to examine equipment used in developing antennas and transmission lines

"ON THE SPOT"

As maintenance specialist works on a jet fighter plane at Lowry AFB TV picture is relayed over RCA closed circuit TV to classrooms at Lowry training center

ABOUT TUBES

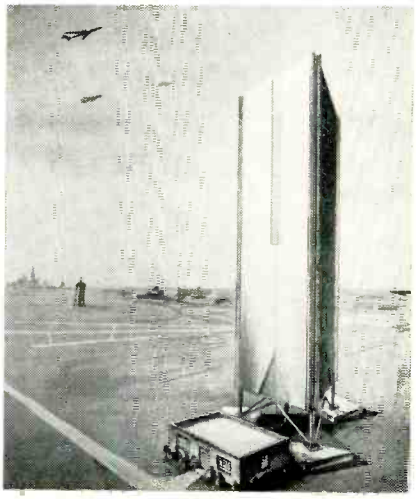
Scene from "The Teacher Wore White," new film by GE on how vacuum tubes are made

NAVY COMPUTER

Capt. R. L. Meyers, Cdr. F. Spillman and Capt. D. S. Embree check plug-in unit of Burroughs 220 computer recently installed at Ordnance Supply Office, Mechanicsburg, Pa.

AIR TRAFFIC RADAR

The Federal Aviation Agency has awarded a $1.7 million contract to W. L. Maxson Corp. to develop this 150-ft. high radar to supply altitude information to airport controllers



MOSCOW BOUND

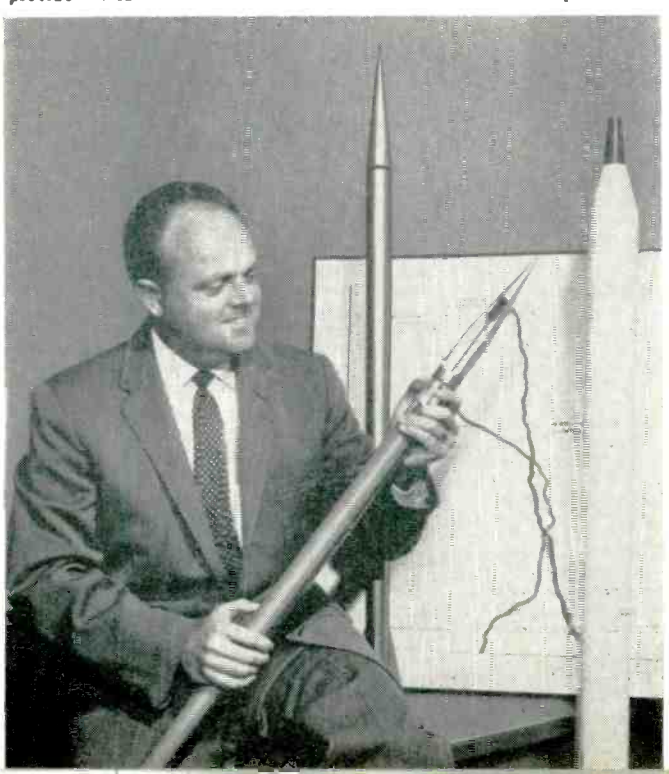
Ampex chairman A. M. Poniatoff and N. K. McNaughten supervise shipment of Videotape color tv recorder to the American National Exhibition, Moscow. At right are Ampex engineers J. Roizen, W. Barnhart and J. Miller who will supervise operation in USSR

NIGHT FIRING

Blast from Discoverer satellite's Bell liquid fueled engine lights up the night sky during test firing at Lockheed Missiles and Space Division's 4,000-acre Santa Cruz testbase. Lockheed is prime contractor and systems manager for the ARPA satellite.

MISSILE WEATHER SCOUT

Project engineer R. Thomas displays "Owl" meteorological rocket designed for ARDC by BJ Electronics Div., Borg-Warner Corp. to provide weather information for ballistic missile operations.



"ONE OF THE LONGEST . . ."

General Electric is delivering this 78-ft. long, 4-bay batwing, one of the longest TV antennas ever delivered in one piece, to KTVI-St. Louis, to replace antenna wrecked by a February tornado.

Electronic Industries' News Briefs

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

EAST

WESTINGHOUSE ELECTRIC CORP.'s Electronic Div., Baltimore, Md., will build advanced shipboard radar systems for the Navy under an $8 million contract. This contract is a supplement to an existing production program worth over $8 million that was awarded the division June 1958.

AUDIO DEVICES INC., manufacturers of magnetic tape have doubled their administrative office space at 444 Madison Ave., New York City, due to the high increase in business.

RADIATION, INC., Melbourne, Fla., and **LEVINTHAL ELECTRONIC PRODUCTS, INC.,** Palo Alto, Calif., have announced the merger of the two firms. Under the merger plan, Levinthal becomes a wholly-owned subsidiary of Radiation and will continue operation under existing management.

INDUCTION MOTORS CORP., Westbury, N. Y., has announced the acquisition of Mason Electric Corp. of Los Angeles, Calif.

GENERAL ELECTRIC CO.'s Heavy Military Electronics Dept. has been awarded a $2 million contract for development of what is believed to be the world's largest surface ship sonar. Known as the AN/SQS-26, this new search sonar will greatly enhance the U. S. Navy's capabilities for detection, identification and destruction of enemy submarines. It is being designed for installation aboard Destroyer Leader Class ships.

GENERAL INSTRUMENT CORP. has acquired the Harris Transducer Corp. of Woodbury, Conn. The company expects the new acquisition to expand their scientific and product base in defense electronics and commercial ultrasonics.

FXR, INC. of Woodside, N. Y., has just received an $800,000 contract from Sperry Gyroscope Co. The contract is for high-voltage power supplies that will be an integral part of Radar Set AN/SPG-55A.

SERVO CORP. OF AMERICA, New Hyde Park, N. Y., are now manufacturing equipment for teaching and understanding servo control for use in engineering schools. This complete servo system laboratory answers a need for educational equipment to facilitate instruction in this new technology.

ANALAB INSTRUMENT CORP. has been formed to design and manufacture analytical laboratory instruments for science and industry. They will specialize in the field of scientific instrumentation.

RAYTHEON CO., Waltham, Mass., has started construction on a new headquarters building for the Distributor Products Div. in Westwood, Mass. It will be located on a five-acre site in the Westwood Industrial Park section, about 10 miles south of downtown Boston.

ALLEN B. DU MONT LABS., INC., has just received a $230,000 contract for the development of extremely sensitive, lightweight television systems and controls for use in aircraft. The systems will be designed to provide reconnaissance capabilities at night as well as in daylight.

BENDIX AVIATION CORP., Pioneer-Central Div., has placed a new electronic unit that senses the presence of liquids and any change from liquid to gas or vice-versa into production. Orders for the sensor have been received by Bendix from The Martin Co.—Denver facility for use on the Titan missile.

AMERICAN ELECTRONIC LABORATORIES, INC., has announced the completion of an additional plant on a 50-acre tract in Colmar, Pa. This addition will provide a 40% increase in working space. The newer facilities will house their research and development programs for the manufacture of microwave and conical helical antennas that are being produced for the government for use in "Operation Moonwatch," a world-wide tracking program for missiles.

CLEVITE CORP., Cleveland, has announced the start of construction for a $3 million transistor and diode manufacturing plant in the Boston area. It will be located on a 45-acre tract in Waltham, Mass. It will contain about 125,000 sq. ft. of space and is scheduled for operation early next year.

MID-WEST

C. P. CLARE CO. has reduced prices from 7½% to 10% on mercury wetted contact relays Types HG, HGP, and HGS.

WEBCOR, INC., Government Electronics Div., has developed a magazine loading magnetic tape recorder for use in Government aircraft. The recorder can be loaded in less than 10 seconds merely by removing the used magazine, which contains both spools, and inserting a fresh unit, much like present-day movie cameras are loaded.

GOODYEAR AIRCRAFT CORP.'s Arizona Div., has started the development of an advanced radar mapping system for the U. S. Army.

GATES RADIO CO., Quincy, Ill., has announced the receipt of an order for six 50 KW short wave broadcast transmitters. The order was placed by the United States Information Agency for use by the Voice of America.

FORMICA CORP., Cincinnati, Ohio, has developed a new glass melamine laminated plastic which will continue to give excellent fire and arc resistance under damp, or even wet conditions. Laminated plastic is designated FF-60.

ROHN MFG. CO., Peoria, Ill., announced the addition of a new general-purpose communication and heavy-duty TV tower to its line. Listed as the No. 25 tower, it features a 12½ in. equilateral triangular design, utilizes special 1¼ in. extra-heavy-gauge tubing for side rails and "ziz-zag" solid steel cross-bracing. It can be utilized as self-supporting to 50 ft. heights or guyed up to 150 ft. heights.

THE KLEINSCHMIDT DIV. OF SMITH-CORONA MARCHANT has confirmed that it is seeking to enter into negotiations to bid on the Air Force's Comlog Net project, a proposed electronic communications system linking U. S. airbases here and abroad.

THE RICHARDSON CO., Melrose Park, Ill., is now furnishing copper clad laminates with a distinctive new finish. This new customer benefit is due to the installation of new modern equipment which burnishes the copper surface mechanically.

JOHN OSTER MFG. CO., Racine, Wis., has just received a subsystem contact award from North American Aviation for a new type of "easy reading" instrument system for in-flight monitoring of high thrust engines powering the Air Force B-70.

P. R. MALLORY & CO., Inc., of Indianapolis, Ind., manufacturers of electronic components, have entered into an agreement with Arbame, S. A. to form a company in Brazil for the manufacture of electrolytic capacitors.

WEST

PERKIN ENGINEERING CORP., El Segundo, Calif., has announced a complete new line of standard silicon industrial rectifiers ranging in size from 25 kw to 500 kw.

AMERICAN ELECTRONICS, INC., Los Angeles, Calif., has formed an American Data Div., Brooklyn, N. Y., to handle the design, manufacture, and marketing of its peripheral data processing equipment.

GERTSCH PRODUCTS, INC., Los Angeles, Calif., has increased their Board of Directors to several members in preparation for the company's new expansion program.

VARIAN ASSOC., Palo Alto, Calif., has announced the formation of new research and development subsidiary, S-F-D Laboratories, Inc. The new research organization will be located in Northern New Jersey.

TECHNOLOGY INSTRUMENT CORP. OF CALIF. is currently building an ultramodern plant in Newbury Park in the Hanss Corp., Conejo Light Mfg. & Research Center. The new plant is designed and will be equipped to provide optimum environmental conditions for the production of precision components and instrumentation.

CONSOLIDATED ELECTRODYNAMICS CORP. has announced the availability of a complete line of magnetic tape for either analog or digital tape recordings. Tape is available from DataTape Div. The tape is manufactured, tested, and spooled to CEC specifications by Reeves Soundcraft Corp.

LOCKHEED AIRCRAFT CORP. and STAVID ENGINEERING, INC., announced they have agreed to combine the two firms into one of the nation's most complete aircraft-missile-electronic teams.

TAMAR ELECTRONICS, INC., has announced a newly created Engineering Publications Dept.

AUTONETICS, A div. of North American Aviation, Inc., has started construction on a new 162,000 sq. ft. manufacturing building.

AIRTRON, INC., div. of Litton Industries, has just opened a new West Coast plant in Los Angeles.

NON-LINEAR SYSTEMS, INC., Del Mar, Calif., has announced the availability of a new NLS 125 Series of ac to dc converters for use with NLS digital voltmeters in making automatic, precise ac voltage measurements.

LING ELECTRONICS, INC., Culver City, Calif., has started construction of a new manufacturing facility at the Anaheim plant of the Altec Companies. The new plant of 45,000 sq. ft. is costing in excess of a half million dollars.

HEWLETT-PACKARD CO., Palo Alto, Calif., has announced the award of $1,993,770 contract covering construction of two 85,000 sq. ft. buildings and a 50,000 sq. ft. underground warehouse at its plant in Stanford Industrial Park. An additional $772,000 will be awarded for the air conditioning, substation, cafeteria and various mechanical equipment.

INTERNATIONAL RECTIFIER CORP. is expanding its El Segundo, Calif. facilities with an 80,000 sq. ft. building now under construction at 222 Kansas City. This will bring to 15 the number of structures in the area.

EPSCO-WEST has just opened a new electronic data handling systems plant in Anaheim.

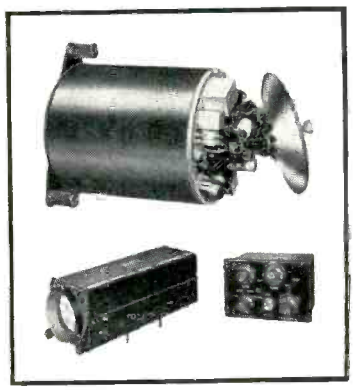
BURTON MFG. CO., Santa Monica, has acquired Trans Electronics, Inc., through an exchange of common stock.

AIRBORNE RADAR...

The APS-67 Airborne Radar . . . designed and developed by *The Magnavox Company* in conjunction with the Navy Department, gives eyes that see by both day and night to the Crusader.

The APS-67 delivers the utmost in performance and reliability for this Navy Fighter . . . clearly demonstrating *The Magnavox Company's* ability to produce and work as prime contractor on a complex electronics project.

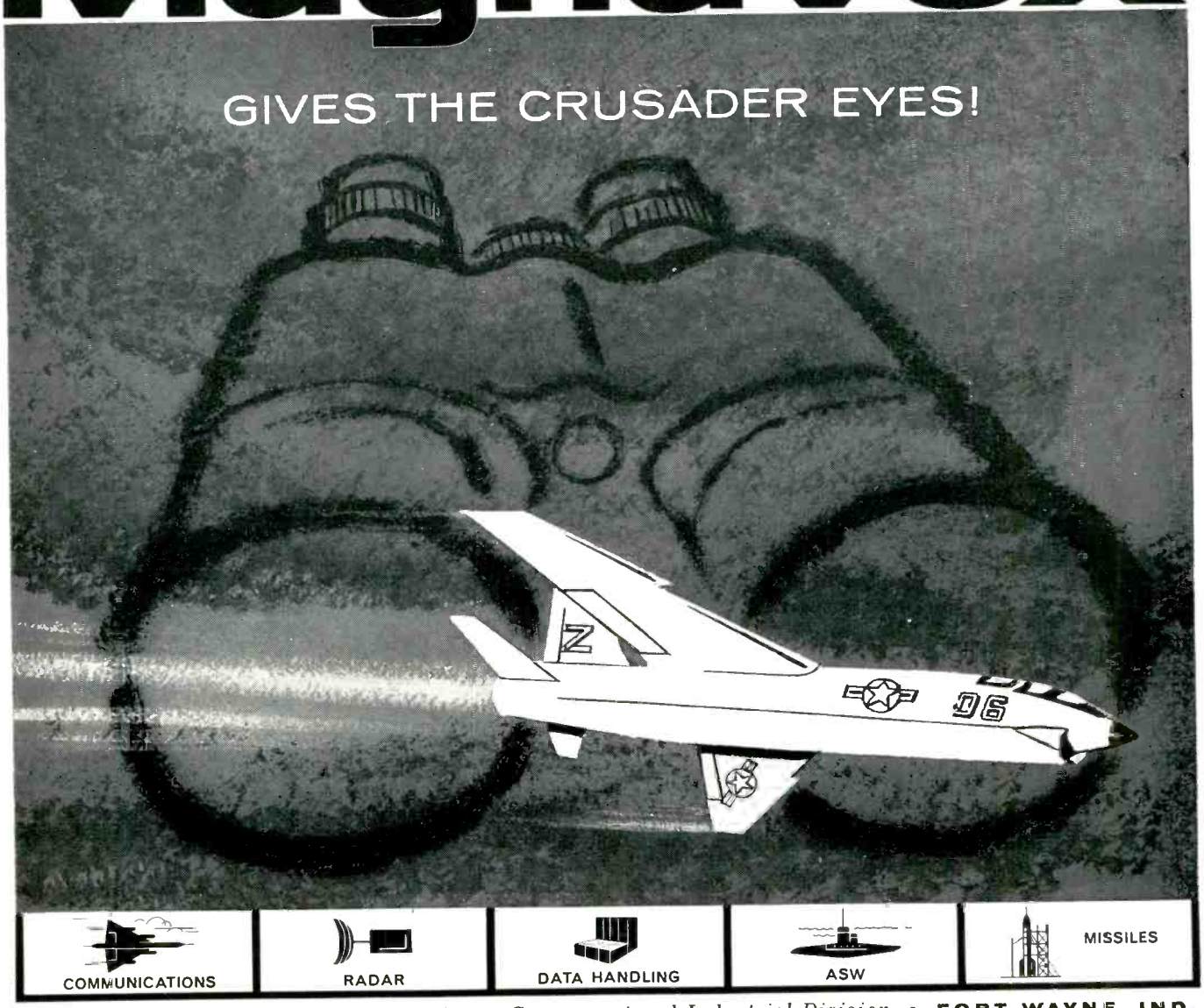
MAGNAVOX capabilities are in The Fields Of Airborne Radar, ASW, Communications, Navigation Equipments, Fusing and Data Handling . . . your inquiries are invited.



PRODUCTS
THAT SEE BY
THEMSELVES

Magnavox

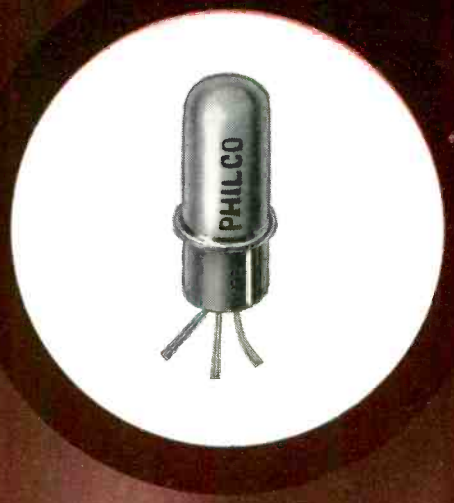
GIVES THE CRUSADER EYES!



THE MAGNAVOX CO. • DEPT. 91 • *Government and Industrial Division* • FORT WAYNE, IND.

PHILCO

Silicon Surface Alloy Transistors



For Reliable Performance at High Temperatures

These field proven Philco Silicon Transistors (SAT*) permit complete transistorization of military and commercial circuits that are subjected to high ambient temperatures . . . with excellent performance at junction temperatures ranging from −65° C to +140° C.

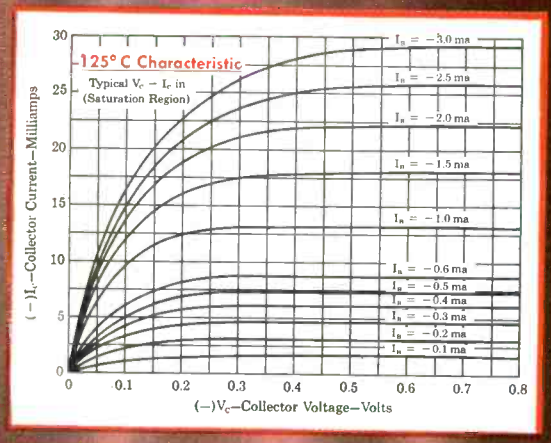
Type 2N495 is a general purpose silicon transistor designed for amplifier and oscillator applications at frequencies through 15 mc.

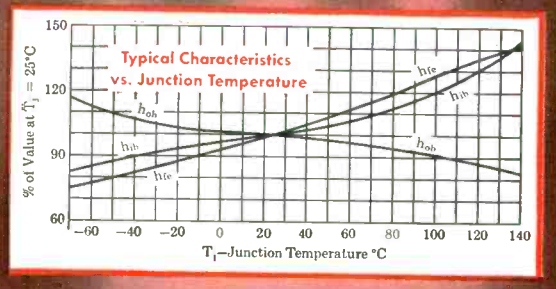
Type 2N496 is specifically engineered for high speed switching circuits. The frequency at which beta equals unity (f_t) is typically 18 mc. It gives the designer the advantages of low saturation resistance and low voltage operation, at high junction temperatures.

These units are environmentally tested in accordance with MIL-T-19500A.

Complete information will be supplied upon request. Write Lansdale Tube Company, Division of Philco Corporation, Lansdale, Pa., Dept. EI-759.

**Trade Mark Philco Corp. for Surface Alloy Transistor*





CHARACTERISTICS OF TYPES 2N495 and 2N496

CHARACTERISTIC	CONDITION	TYPICAL VALUE	
		2N495	2N496
Current Amplification Factor, h_{fe}	$V_{CE} = -6$ v, $I_E = 1$ ma	20	
Current Amplification Factor, h_{FE}	$V_{CE} = -0.5$ v, $I_C = -15$ ma		16
Output Capacitance, C_{ob}	$V_{CB} = -6$ v, $I_E = 1$ ma	7 μμf	7 μμf
Maximum Frequency of Oscillation, f_{os} max.	$V_{CB} = -6$ v, $I_E = 1$ ma	21 mc	
Frequency for Beta = 1, f_t*	$V_{CE} = -6$ v, $I_E = 1$ ma, $f = 4$ mc		18 mc
Cutoff Current, I_{CBO} or I_{EBO}	V_{CB} or $V_{EB} = -10$ v	.001 μa	.001 μa

Maximum Power Dissipation—150 mw

Maximum Collector Voltage 2N495—25 V, 2N496—10 V

*f_t (the frequency at which beta is unity) is typically 85% of the alpha cutoff frequency.

Immediately available in quantities 1 to 99 from your Philco Industrial Semiconductor Distributor

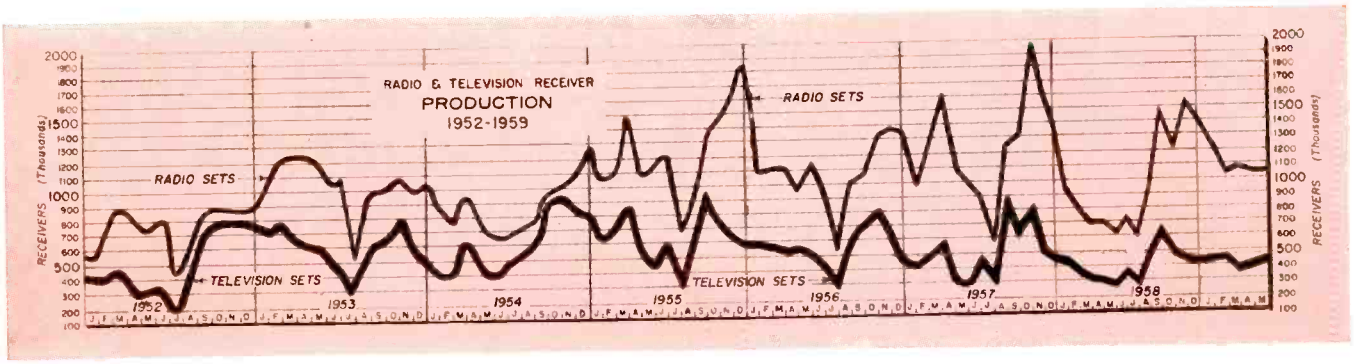
PHILCO®

LANSDALE TUBE COMPANY DIVISION

LANSDALE, PENNSYLVANIA

TRANSISTOR CENTER U.S.A.

Circle 9 on Inquiry Card



GOVERNMENT ELECTRONIC CONTRACT AWARDS

This list classifies and gives the value of electronic equipment selected from contracts awarded by government agencies in May 1959.

Amplifier, a-f	64,225
Amplifiers	4,146,619
Antennas & antenna systems	761,233
Assemblies, electronic	81,635
Batteries, dry	492,326
Batteries, storage	226,047
Beacon, radar	103,300
Bridge, impedance	71,887
Cable assemblies	123,794
Cable, electronic	806,100
Cable, telephone	35,581
Calibrators	36,750
Chargers, battery	180,694
Choppers	73,104
Computers	56,551
Connectors	406,154
Crystal units	167,083
Duplexer, X-band beacon ferrite	49,072
Equipment, communications	106,475
Handsets	81,874
Headsets	849,210
Meters	131,627
Meters, alpha	49,188
Meters, volt	295,768
Meters, watt	151,828
Monitors, radio frequency	42,582
Monitors, telemetric data	326,500
Multimeters	40,142
Oscillators	142,930
Potentiometers	27,000
Power supplies	68,450
Rodar sets, accessories & components	11,246,011
Radio sets	3,284,907
Radiosonde equipment	223,398
Receivers, loran	548,650
Receivers, radio	336,596
Recorders/reproducers, accessories, components	617,546
Relays, armature	670,714
Relays & assemblies	334,980
Resistors	683,599
Semiconductor devices	91,303
Solenoids	117,418
SSB equipment	72,228
Standards, frequency	57,553
Switches	262,769
Switches, pressure	53,634
Test sets, teletypewriter	187,212
Transducers	47,878
Transformers, isolation	82,748
Transistors	319,121
Transmitter, coordinate data	350,000
Transmitters, radar	870,457
Transceivers	127,703
Transmitters, telemetering	37,257
Tube, electron	5,611,911
Tube, klystron	516,290
Tuners, r-f	57,227

$9 BILLION LEVEL EXPECTED

The electronics industry generally has enjoyed a continuance of its growth during the fiscal year 1958-59 according to the parameters measured by the EIA Marketing Data Department.

Although TV sales to consumers declined during this fiscal year to 5.2 million units as compared to 5.9 million units the previous year, sales of table, clock and portable radios increased 400,000 units to 8.6 million and sales of phonographs increased 200,000 units to 4.7 million.

The military market for the calendar year 1959 is expected to reach the $5 billion level, in terms of factory sales, and to exceed the $21 billion level by 1970. Sales of transistors, which have increased more than twenty fold in terms of dollars since 1954, may well rise to the $200 million level—nearly 100% greater than the $113 million sales recorded during 1958.

With these strong growth factors, total factory sales of the electronic industries should easily reach the $9 billion mark during the calendar year 1959 as compared to $7.5 billion last year. Already the 5th largest U. S. industry employing 700,000 persons in manufacturing, these new sales levels promise a rapid ascendancy to an even higher rank.

—Frank W. Mansfield, EIA Chairman

BUSINESS EXPECTATIONS 3RD QUARTER 1959

		Total Mfrs.	Manufacturers Durable	Manufacturers Non-durable
Net Sales	No. Companies Reporting	756	420	336
	Per cent Expecting Increase	77	81	73
	Per cent Expecting No Change	21	17	26
	Per cent Expecting Decrease	2	2	1
Net Profits	No. Companies Reporting	700	390	310
	Per cent Expecting Increase	64	70	57
	Per cent Expecting No Change	32	28	37
	Per cent Expecting Decrease	4	2	6
Selling Prices	No Companies Reporting	740	407	333
	Per cent Expecting Increase	24	31	16
	Per cent Expecting No Change	73	67	81
	Per cent Expecting Decrease	3	2	3
Level of Inventories*	No. Companies Reporting	752	418	334
	Per cent Expecting Increase	37	41	32
	Per cent Expecting No Change	57	52	64
	Per cent Expecting Decrease	6	7	4
Number of Employees*	No. Companies Reporting	759	423	336
	Per cent Expecting Increase	22	28	13
	Per cent Expecting No Change	76	70	84
	Per cent Expecting Decrease	2	2	3
New Orders	No. Companies Reporting	684	390	294
	Per cent Expecting Increase	65	70	58
	Per cent Expecting No Change	33	27	41
	Per cent Expecting Decrease	2	3	1

*End of Quarter

—Dun & Bradstreet

(*Continued from page* 17)

UNITED KINGDOM

Electronic "Ear" for Mine Rescue

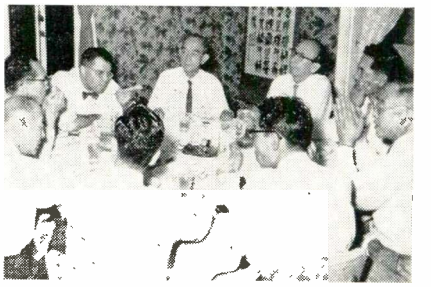
Scientists at the General Electric Co. of England, Magnet House, Kingsway, London, have invented a listening aid which enables the distress signal tapping made by miners' pickaxes to be heard through a barrier of solid rock. Signals can be heard over 700 yds. away in a quiet mine and at 440 yds. in a mine where background noise is present.

Operation of the device depends on the unique frequencies generated tapping on rock. Safety measures are incorporated in the device to insure against explosions should a tube break. An explosive mixture of air and methane is often present in mines.

Form New Nuclear Firm

General Mills, Inc., Minneapolis, Minn., and Savage and Parsons, Ltd., Watford, Eng., have jointly formed Nuclear Equipment, Ltd. The new firm, located at Watford, will be managed by John Savage, present managing director of Savage and Parsons.

The new company will make and sell remotely controlled handling equipment mainly for use in the nuclear energy field. Prime market will be in western Europe and the British Commonwealth.



J. R. Popkin-Clurman (bow tie), Pres. of Telechrome Mfg., N.Y., visits officials of the Japanese TV industry. He was U.S. Delegate to the International Radio Consultative Committee of the International Telecommunication Union's meeting in Moscow.

LATIN AMERICA

New Firm in Puerto Rico

Kelvin Corp. of Puerto Rico has been formed in Fajardo, Puerto Rico. William I. Elliott, president of Kelvin Electric Co., Van Nuys, Calif., has been elected president of the new firm in Puerto Rico. The company will manufacture precision electrical and electronic components.

"PACKAGING" MICROWAVES FOR MOUNTAIN TOPS

"TJ" radio-relay station at Black Mesa, Arizona

In Arizona, the telephone company faced a problem. How could it supply more telephone service between Phoenix and Flagstaff—through 135 miles of difficult mountain territory?

Radio offered the economical answer: a new microwave radio-relay system recently created at Bell Telephone Laboratories. Operating at 11,000 megacycles, it was just right for the distance, and the number of conversations that had to be carried.

But first other problems had to be solved: how to house the complex electronic equipment; how to assemble and test it at hard-to-reach relay stations way up in the mountains; and how to do it economically.

On-the-spot telephone company engineers had some ideas. They worked them out with engineers at the American Telephone and Telegraph Company and at Bell Telephone Laboratories. The result: a packaged unit.

The electronic equipment was assembled in trailer-like containers at convenient locations and thoroughly checked out. The complete units were then trucked up the mountains and lifted into position.

The system, now operating, keeps a watch on itself. When equipment falters, a relay station switches in stand-by equipment, then calls for help over its own beam.

The new Phoenix-Flagstaff link illustrates again how Bell System engineers work together to improve telephone service. Back of their efforts is the constant development of new communications systems at Bell Telephone Laboratories.

BELL TELEPHONE LABORATORIES *World center of communications research and development*

Tele-Tips

YOUNG ENGINEERS should be given responsibility for a specific assignment soon after they are employed by industry, says a researcher at the Univ. of Michigan. Prof. J. W. Riegel, director of the Bureau of Industrial Relations, advises, "The introduction to company products and processes can be brief. Information pertaining to company organization, personnel policies, and so forth, can be presented on a part-time basis over a number of months while the new man is engaged in some practical and remunerative work."

AT THE RISK of starting another MOLE fiasco we pass along this bit of info. The Russians have a rocket tunnel digger, spouting compressed air and liquid flame. Details were released by Hungarian magazine Magyar Nemzet.

AIR TRAFFIC experts estimate that by 1965 the volume of civil helicopter landings and takeoffs will amount to 30,000,000.

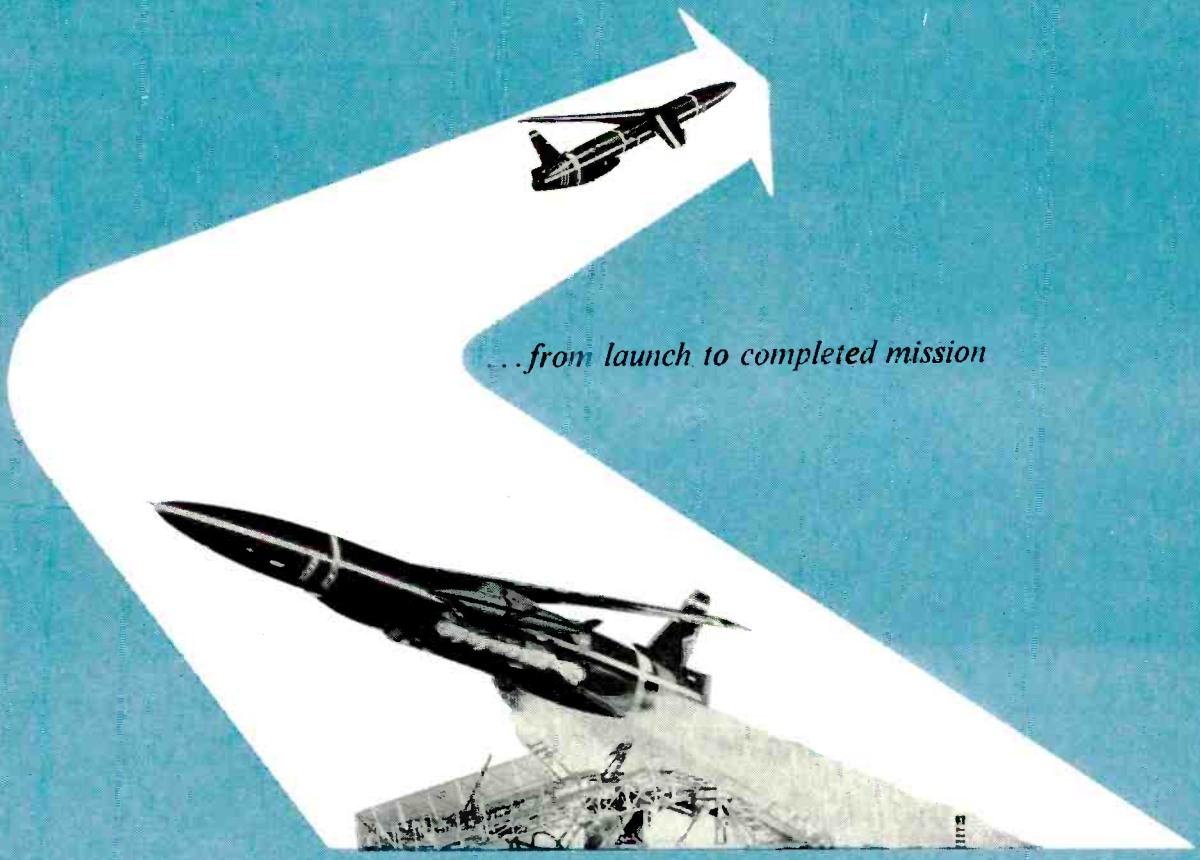
ETA KAPPA NU, national electrical engineering honor society, is looking for candidates for this year's "outstanding young electrical engineer." Nominations should be sent to Prof. Paul K. Hudson, Executive Secretary, Eta Kappa Nu Assn., Dept. of Electrical Engineering, Univ. of Illinois, Urbana, Ill.

"GLOSSMETER" designed by the National Bureau of Standards could very accurately measure the shininess of ladies' noses, but in practice, the instrument assures a uniform gleam in the porcelain enamel on refrigerators and other appliances.

"When a wife buys things on credit, she is merely displaying confidence in her husband."

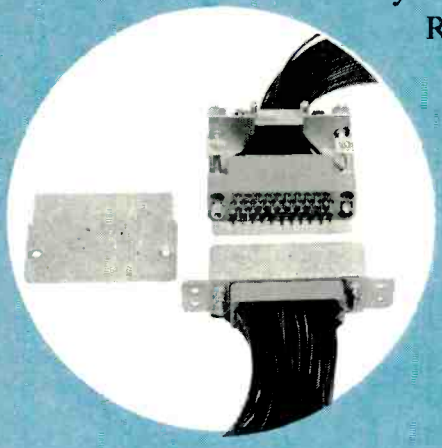
CHESS-PLAYING COMPUTER designed by Carnegie Inst. of Technology will provide opposition for a "fairly good player." This is the third chess-playing machine to be put on a set of instructions in this country, and reportedly the best. The Russians have a similar chess player, believed to be on about the same level.

(*Continued on page* 28)

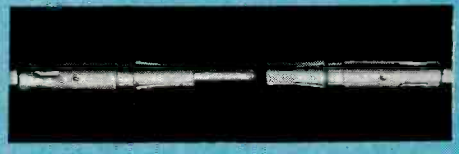


. . . from launch to completed mission

CONNECTOR RELIABILITY is the most important specification you can buy. CEC's NEW Series 500-C Multi-Contact Rectangular Connectors have it in every detail! Consider the all-important contact insulator block, for example. a *glass-filled* diallyl phthalate composition with high strength, lightweight, and excellent dialectric properties. Snap-in contacts stay put in the block and individually resist a rear axial pull of 20 lbs. . . . that's a CEC guarantee!



A four-way crimp holds wires into contacts for positive, fail-proof electrical continuity. Standard CEC connectors come in 8-, 26-, 34-, 42-, 50-, 75-, and 100-contact types . . . in a wide variety of mounting configurations. Special connectors are designed and manufactured to your requirements. Call Connector Department, EMI Division, SYcamore 6-9381, Pasadena, Calif., or write for Bulletin CEC 4004-X18.



Electro Mechanical Instrument Division

CEC

CONSOLIDATED ELECTRODYNAMICS / *360 Sierra Madre Villa, Pasadena, Calif.*

Tele-Tips

(*Continued from page* 26)

"LARGEST AUDIO AMPLIFIER," now under development by a British firm, will weigh 10 tons and have an output of 300 kw, on a range from 1 to 5 kc. Distortion will be as low as 5% at full power and the signal-to-noise ratio will be 40 db.

MISSILE WARHEADS are said to have a safety factor of 1,000,000-to-1. The techniques that the American watch industry learned in designing missile and arming systems is now being used in developing safer equipment for airlines.

"There are two doors to opportunity: push and pull."

OPERATING BUSINESSES in the U. S. now total 4.6 million. Over 55,000 firms were added during 1958, a gain of 1¼%. This is typical of the gains made during the recent years. Service and finance firms gained relatively the most during '58; each group was up about 2½%.

AIRCRAFT AND MISSILE industry employs about 67% of its total force of about 85,000 scientists and engineers in research and development projects.

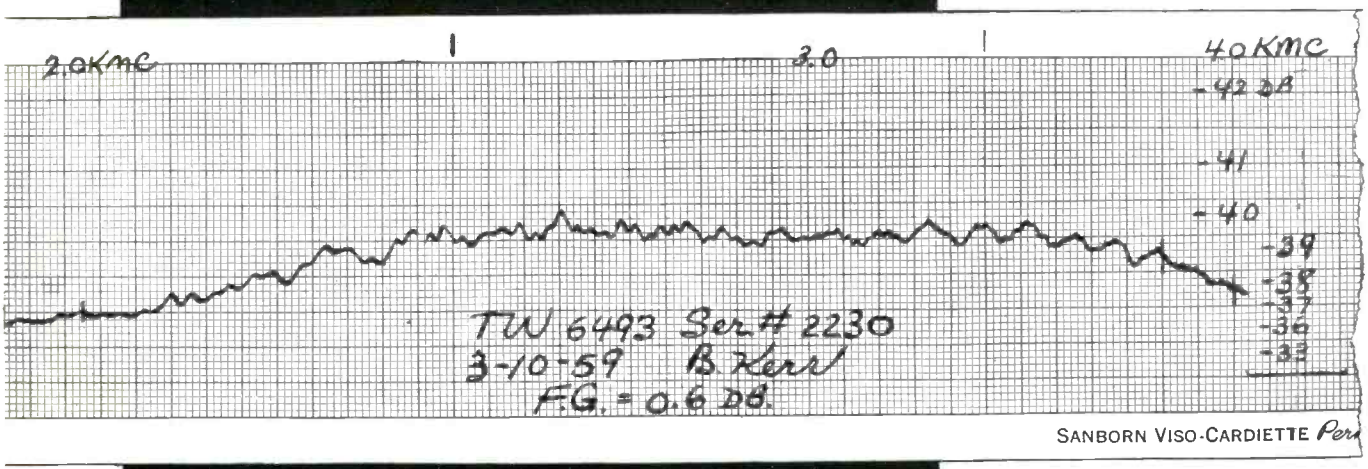
RADAR is being used to plot the migration of birds by researchers in England and Switzerland. The technique was discovered somewhat accidentally when scientists found that the heavy intensity of nocturnal migration was interfering with the radar tracking of aircraft.

NEW RADARS in use by the Ballistic Missile Early Warning System (BMEWS), are nearly the size of a football field and can detect a missile as far out as 3,000 miles.

MANAGEMENT PERSONNEL, contrary to popular belief, sometimes are compensated for overtime work. Of 434 companies responding to a new American Management Assoc. survey, 224 (52%) reported that they grant payment or time off for overtime work to employees exempt from the compulsory overtime pay provisions of the Fair Labor Standards Act.

Microwave Component News from SYLVANIA

Now available—a wide range of traveling wave tubes



Actual strip chart recording of test on a production tube shows the uniform gain characteristics of this Sylvania tube over the 2.0 KMC to 4.0 KMC spectrum

ONLY SYLVANIA CAN OFFER YOU

AVAILABILITY — now in production, 16 types of traveling wave tubes covering the microwave spectrum from 1 to 11 kmc, and milliwatts to kilowatts. Backward wave oscillators are also available. Modifications and new designs for your special requirements are part of Sylvania's service.

HIGHEST GAIN — Sylvania's traveling wave tubes deliver 2 to 5 times the gain of competitive types. For example, TW-4002 delivers a minimum gain of 37 db over its full 2 to 4 kmc band.

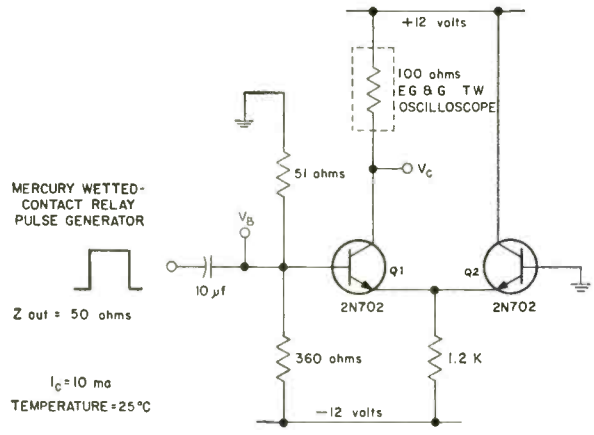
GUARANTEED UNIFORMITY — Sylvania guarantees gain variations one-half those of other tubes; i.e. 2 to 3 db narrower limits. Other test limits are correspondingly more rigid.

PROVEN RUGGED DEPENDABILITY — Sylvania traveling wave tubes have proved their performance by meeting tough military standards and by being specified and used in modern supersonic aircraft.

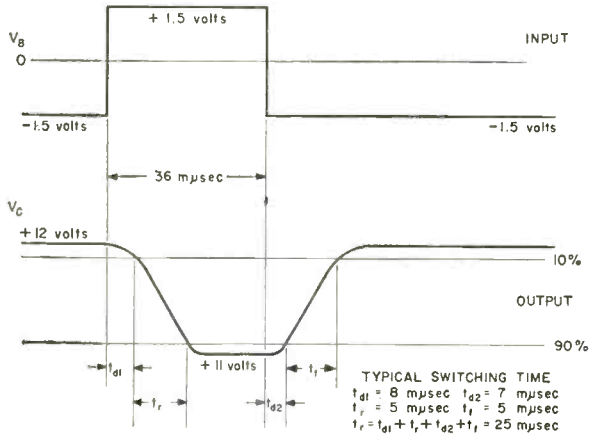
For more information
write your nearest Sylvania tube sales office or
Sylvania Electric Products Inc.,
Special Tube Operations,
500 Evelyn Ave., Mountain View, Calif.

SYLVANIA
Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

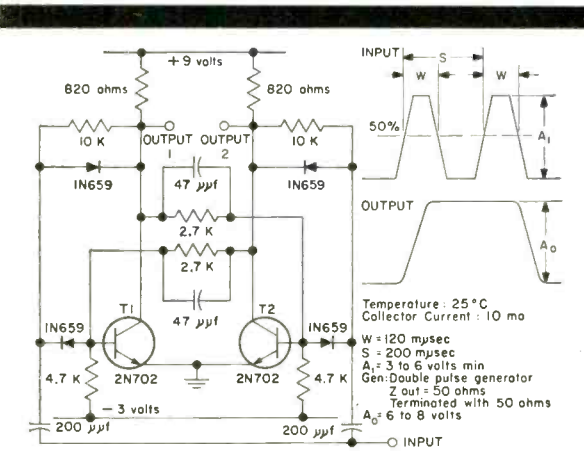
Circle 15 on Inquiry Card



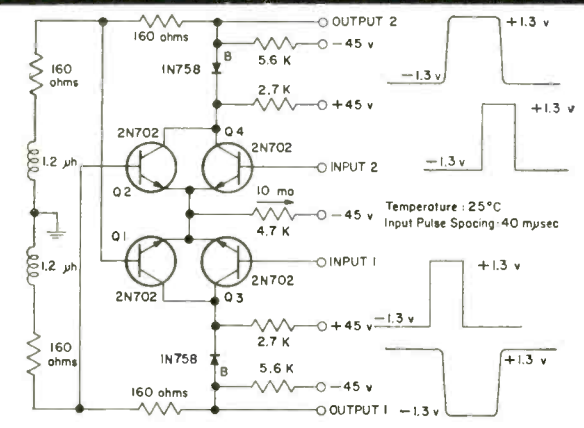
TYPICAL NON-SATURATED LOGIC SWITCHING CIRCUIT



TOTAL SWITCHING TIME NON-SATURATED CIRCUIT



TYPICAL CIRCUITRY FOR OBTAINING 5-MC REP RATE IN SATURATED FLIP-FLOP



TYPICAL CIRCUITRY FOR OBTAINING 25-MC REP RATE IN NON-SATURATED FLIP-FLOP

NEW SILICON

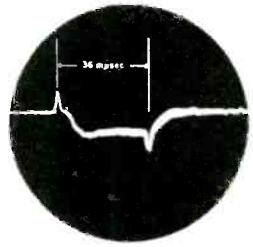
TO-18 PACKAGED DIFFUSED-BASE 'MESA' TRANSISTORS

Now available for your evaluation, the subminiature 2N702 is built specifically for your 5-20 ma transistor logic switching applications.

This newest addition to TI's line of diffused-base 'mesa' transistors features . . .

- **Guaranteed dc beta of 15 to 45**
- **50 mc minimum unity beta frequency (f_t)**
- **Maximum 12 μμf output capacitance**
- **Subminiature TO-18 package**

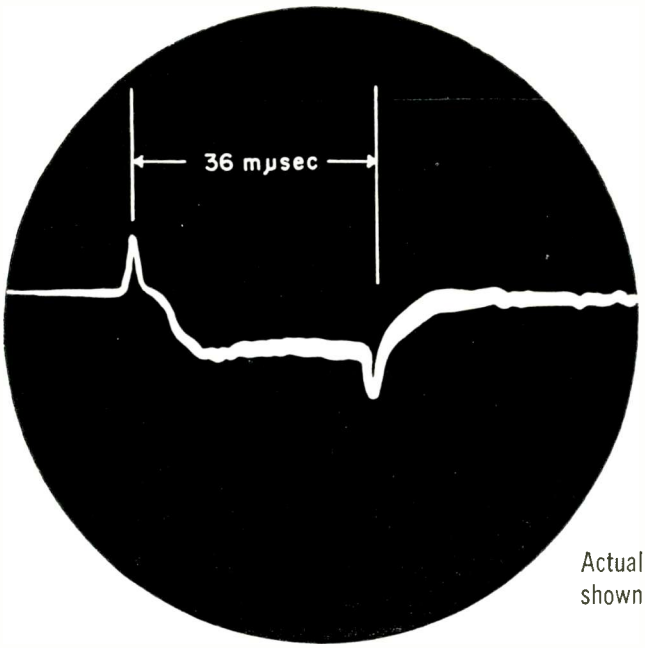
As do all other TI semiconductors, the 2N702 carries a *full-year guarantee* to published specifications. Check the specs at right and contact your nearest authorized TI distributor or your TI sales office for detailed information.



TEXAS

FROM THE WORLD'S LARGEST SEMICONDUCTOR PLANT

25 mμsec
SWITCHERS FROM TI



Actual photo of collector wave form as shown on traveling-wave oscilloscope

absolute maximum ratings (25°C)

Collector Voltage Referred to Base	20 v
Collector Voltage Referred to Emitter	15 v
Emitter Voltage Referred to Base	5 v
Collector Current	50 ma
Dissipation (100°C Free Air, Derate 0.5°C/mw)	150 mw

design characteristics at 25°C (except as indicated)

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
I_{CBO}	Collector Cutoff Current	$V_{CB} = 10$ v, $I_E = 0$			0.5	μa
I_{CBO}	@ 150°C	$V_{CB} = 10$ v, $I_E = 0$			50	μa
BV_{CBO}	Breakdown Voltage	$I_{CBO} = 10$ μa, $I_E = 0$	20			v
BV_{CEO}	Breakdown Voltage	$I_{CEO} = 10$ μa, $I_B = 0$	15			v
h_{FE}*	DC Beta	$V_{CE} = 5$ v, $I_C = 10$ ma	15		45	
BV_{EBO}	Breakdown Voltage	$I_E = 10$ μa, $I_C = 0$	5			v
V_{BE}*	Input Voltage	$V_{CE} = 5$ v, $I_C = 10$ ma	0.7		1.2	v
C_{ob}	Output Capacitance	$V_{CB} = 5$ v, $I_E = 0$ f = 1 mc		7	12	μμf
f_t	Frequency at which h_{fe} is unity	$V_{CE} = 5$ v, $I_E = 10$ ma	50	100		mc
V_{CE}* (Sat)	Saturation Voltage	$I_C = 10$ ma, $I_B = 2$ ma			0.6	v

* Tested using pulse measurement.

NOTE: These units meet JEDEC outline TO-18 dimensions. A drawing of this package is attached.

INSTRUMENTS
INCORPORATED
SEMICONDUCTOR – COMPONENTS DIVISION
13500 N. CENTRAL EXPRESSWAY
POST OFFICE BOX 312 • DALLAS, TEXAS

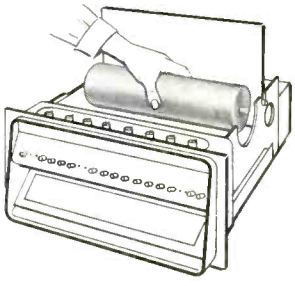
Write on your company letterhead describing your application for specific details on TI products.

These features of

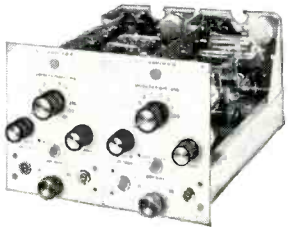
new Brush ultralinear recording systems...

. . . give you more application versatility!

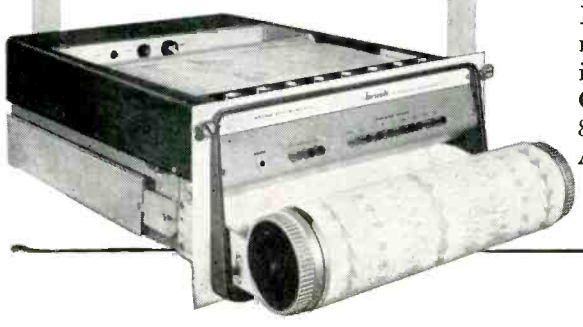
Simplified Chart Re-loading.



Interchangeable, plug-in signal conditioners.



Positive Chart Take-up Drive.



In the fields of telemetry, ground support systems, analog computing and laboratory testing, Brush recording systems have incorporated features which have consistently kept ahead of engineering requirements. Here are a few that show why—

INTERCHANGEABLE PLUG-IN SIGNAL CONDITIONERS. You get your *choice of sensitivities*—you get high input impedance—zero suppression.

SIMPLIFIED FAST CHART RE-LOADING. Loaded from the top—features automatic alignment and tracking.

ACCURATE, EASILY REPRODUCIBLE RECORDINGS. Your choice of rectilinear or curvilinear charts—rugged "throw-proof" pens.

Illustrated above is a Brush RD-1684 rectilinear, 8 channel recording system. Sensitivity of 10 millivolts per chart line—input impedance, 10 megs balanced or 5 megs grounded. Complete system includes mobile cabinet, oscillograph and 8 signal conditioners. No additional preamplifiers required. Available from stock.

brush INSTRUMENTS

DIVISION OF

37th & PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

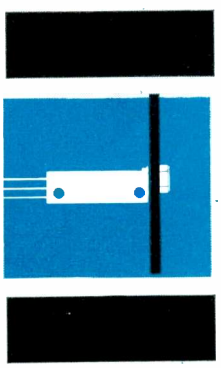
Subminiature ...
Proven Reliability

ACTUAL SIZE

TRIMPOT® MODEL 220

As many as 17 of these compact units can be mounted in a space of just one cubic inch. Designed for printed circuits and modular assemblies, Trimpot Model 220 measures less than 3/16″ x 5/16″ x 1″. Power rating is 1 watt and maximum operating temperature is 175°C. This Potentiometer meets or exceeds Mil-Specs for humidity, salt spray, fungus, sand and dust, as well as acceleration, vibration and shock. Self-locking 15-turn shaft insures sharp, stable settings...exclusive Silverweld* fused-bond termination and ceramic mandrel provide extreme temperature stability. The Model 220 is available in a wide variety of resistance ranges and a choice of two terminal types—gold-plated Copperweld wire or insulated stranded leads.

Stocked by leading electronic distributors across the nation, these units are ready for immediate delivery. **Write for complete technical data and list of stocking distributors.** AVAILABLE AS PANEL MOUNT UNIT (illustrated at right) with same specifications. *Trademark



BOURNS Inc.

P.O. Box 2112G, Riverside, California

Plants: Riverside, California and Ames, Iowa

In Canada: Douglas Randall (Canada), Ltd., licensee

Exclusive manufacturers of Trimpot®, Trimit®. Pioneers in potentiometer transducers for position, pressure and acceleration.

Circle 18 on Inquiry Card

USE LOTS OF TAPE?

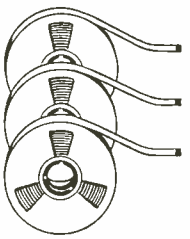
"SCOTCH" BRAND Instrumentation Tapes cut operating costs

Let's develop our own small theory of relativity. For everything's relative, after all—even economy. Clearly, an economy effected now and *corrected* later is no economy at all. In instrumentation tape, there's only one genuine economy—reliable performance. And in performance, the last two words for any acute tape-user are "SCOTCH" BRAND.

First to last, "SCOTCH" BRAND Magnetic Tapes offer uniformity and reliability—born of the experienced 3M technology that created the first practical magnetic tape and continues to advance the art of tape-making day by day.

But let's look at economy from another viewpoint—in terms of some things around the periphery that might not come so readily to mind—storage, use, waste, and time saved.

What other kind of record is so permanent it may last a lifetime, yet requires so little space for storage? Three reels of "SCOTCH" BRAND like those at the right "contain" 30 million characters. What other medium serves input, output and memory functions at such high speeds? Accepts both digital and analogue data?

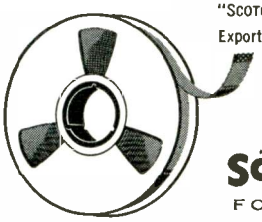


What other kind of record is not *consumed,* even when it is used? "SCOTCH" BRAND Magnetic Tape is run and rerun for analysis, erased and used again, permits retaping with corrections, editing and new data.

Last, but far from least—in these days when time is money, what other medium speeds up data acquisition, reduction and control programming in a way that keeps critical projects rushing forward at full tilt? Or cuts production lead time and human error to a point where a 1000% saving may be realized?

At any cost, "SCOTCH" BRAND Magnetic Tapes would be a good buy. And in every application, "SCOTCH" BRAND Tapes offer that greater economy—reliability. "SCOTCH" BRAND High Resolution Tapes 158 and 159 let you pack more bits per inch, offer extra play reels. "SCOTCH" BRAND Sandwich Tapes 188 and 189 end rub-off, build-up, cut head wear to an absolute minimum, show little wear in 50,000 computer passes. "SCOTCH" BRAND High Output Tape 128 offers top output at low frequencies, even under ambient temperature extremes. "SCOTCH" BRAND Instrumentation Tapes 108 and 109 offer top performance at lowest cost.

Where there's no margin for error, there's no tape like "SCOTCH" BRAND Magnetic Instrumentation Tape. For details, write Magnetic Products Div., 3M Company, Dept. MBR-79, St. Paul 6, Minn., or mail the reader inquiry card.



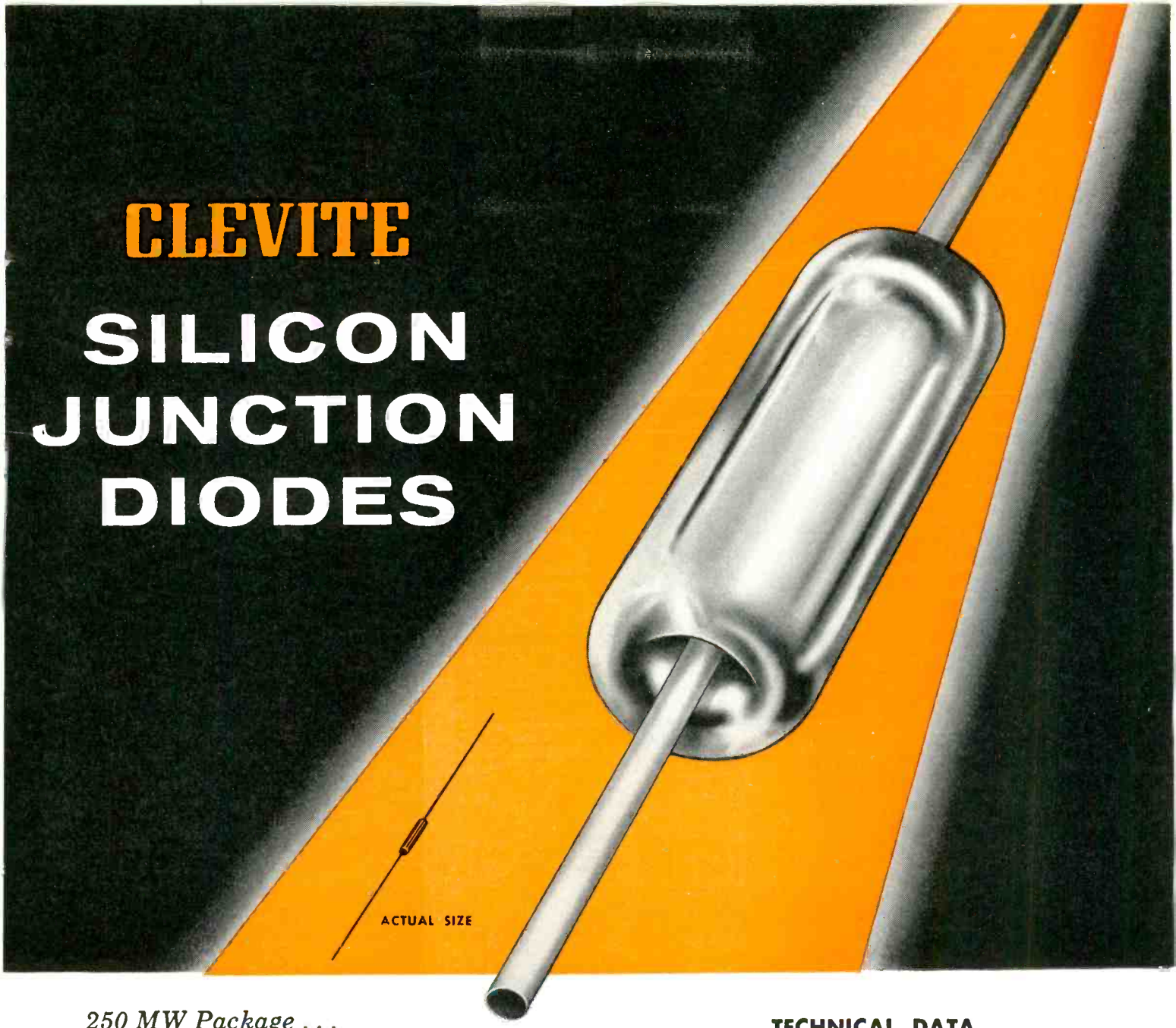
REG U.S. PAT. OFF.
SCOTCH BRAND MAGNETIC TAPE
FOR INSTRUMENTATION

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

CLEVITE

SILICON JUNCTION DIODES



250 MW Package . . .
Fast Switching and General Purpose Types
Featuring . . .

- **MECHANICAL RELIABILITY** —— Rugged, hermetically sealed, subminiature packages. Designed to meet both military and commercial requirements.
- **ELECTRICAL SUPERIORITY** —— Excellent high temperature operation . . . thermally stable . . . high forward conductance . . . efficient rectification.
- **PRODUCT UNIFORMITY** —— Tight manufacturing controls.

For details, write for Bulletin B217A-1 B217A-2

TECHNICAL DATA

Type	Max. DC Inver. Oper. Voltage	Forward Current @ Specified Voltage	Max. Inverse Current @ 25°C	Max. Inverse Current @ 150°C	Test Volts
1N457	60 V	20 ma @ 1.0 V	0.025 μa	5.0 μa	60 V
1N458	125 V	7 ma @ 1.0 V	0.025 μa	5.0 μa	125 V
1N459	175 V	3 ma @ 1.0 V	0.025 μa	5.0 μa	175 V
1N662	90 V	10 ma @ 1.0 V	20 μa	100 μa (@ 100° C)	50 V
1N663	90 V	100 ma @ 1.0 V	5.0 μa	50 μa (@ 100° C)	75 V
1N778	100 V	10 ma @ 1.0 V	0.5 μa	30 μa (@ 125° C)	100 V
1N779	175 V	10 ma @ 1.0 V	0.5 μa	30 μa (@ 125° C)	175 V

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Silicon Junction Diodes Germanium Diodes Power Transistors Solder Lug Power Transistors

CLEVITE

TRANSISTOR PRODUCTS

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TWinbrook 4-9330
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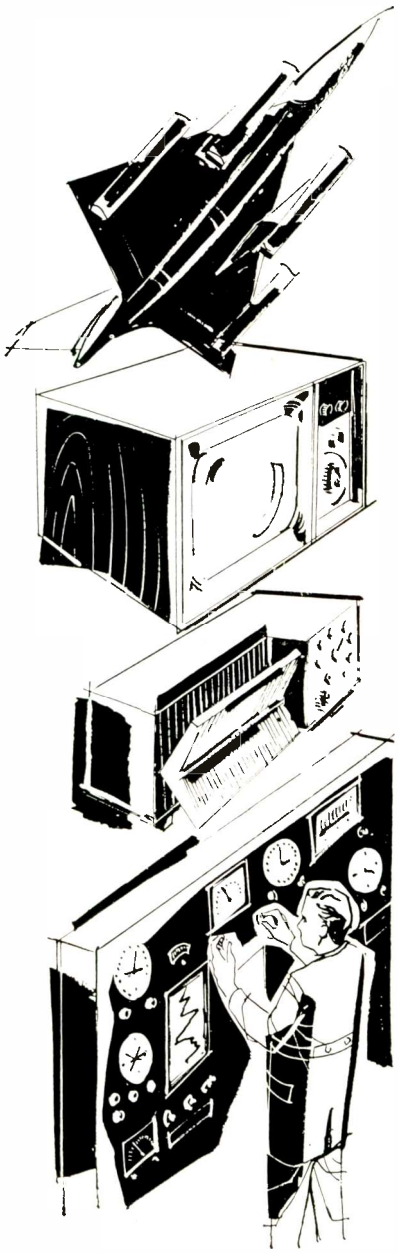
A DIVISION OF CLEVITE CORPORATION

New steels are born at Armco

Improve Efficiency, Cut Cost of High Frequency Components

with Armco Thin Electrical Steels



AIRCRAFT
Servo-mechanisms
Motors
Magnetic amplifiers
Converters

TV
Deflection yoke cores
Fly-back transformers
Horizontal- and vertical-sweep transformers

RADIO
Audio-frequency filters
Frequency modulators

CONTROL
Timing pulse generators
Impulse-storing and memory devices
Charging reactors
Magnetic amplifiers
Intermediate frequency transformers

High permeability silicon steels in 1 to 7 mils thicknesses lower energy loss, permit reductions in core dimensions and weight of equipment.

Armco Thin Electrical Steels provide a unique combination of exceptional magnetic and physical properties that create opportunities to produce better high frequency electrical and magnetic equipment at less cost.

In addition to exceptionally high permeability and low hysteresis loss, assured by precise processing and control, these special Armco Steels give you:

High lamination factor and gage uniformity. Smoothness, flatness, close tolerances, and edge-to-edge gage uniformity mean maximum efficiency and most effective use of core material, simplify fabrication.

Minimum interlaminar loss. Armco processing produces a thin, smooth insulation of high resistivity that is not affected by the recommended stress-relieving anneal.

Assured results. Magnetic properties are fully developed at the mill. You design with extensive data that permit most efficient balance of performance and cost.

Three different grades enable you to make maximum use of the advantages of Armco Thin Electrical Steels:

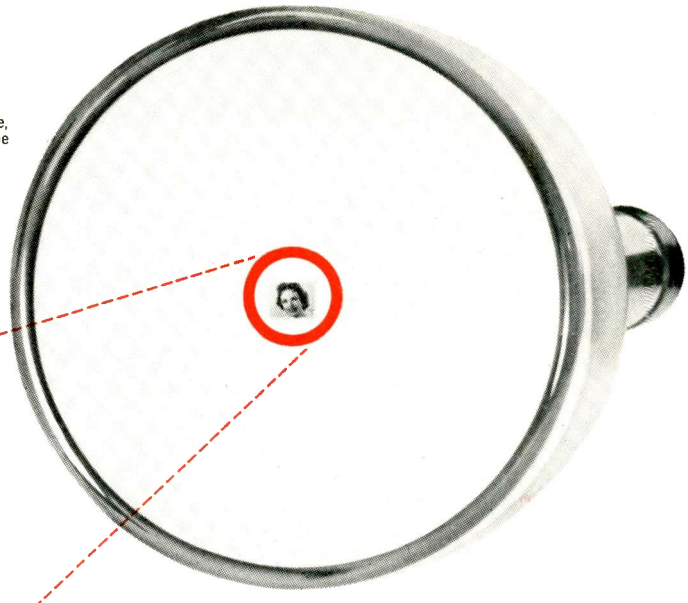
Armco TRAN-COR® T—7 and 5 mils, non-oriented
Armco ORIENTED T—4, 2, and 1 mil
Armco ORIENTED TS—4 mils, super-oriented

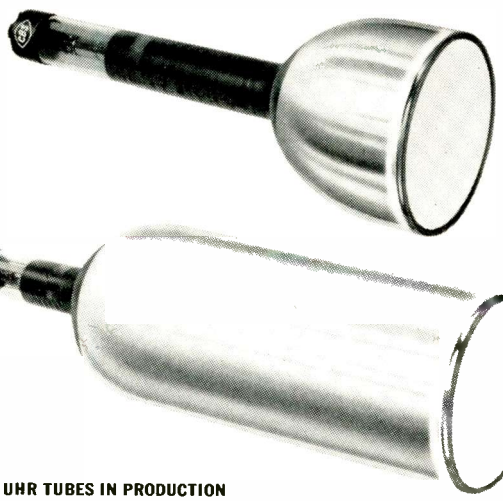
For more information on the applications of Armco Thin Electrical Steels or design data, write Armco Steel Corporation, 2319 Curtis Street, Middletown, Ohio.

ARMCO STEEL

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

Actual size,
3-inch ultrahigh-resolution tube





Now... 262 Square Inches of information in 1/20 Square Inch!

New CBS ultrahigh-resolution tubes, for example, can compress into 0.047 square inch all the detail on a 21-inch picture tube screen. This is twice the resolution previously attainable . . . resolution far beyond the capabilities of the unaided human eye and modern printing. And the closest yet to the resolution of modern photographic film.

MANY APPLICATIONS NOW POSSIBLE Many new and advanced applications become practical in strip radar • photo reconnaissance • visual indication • photo reproduction • information transfer • industrial and medical closed circuit TV • remote data pick-up • information conversion • etc.

12 CBS UHR TUBES IN PRODUCTION

These tubes offer a choice of four resolution levels . . . three screen sizes . . . and three screen phosphor characteristics. They are even more rugged and dependable than standard oscilloscope tubes. And they can be supplied with interchangeable yoke, focus coil and video driver stage to achieve maximum resolution. Check the table for summary data. Write for complete technical Bulletin E-330 and information regarding your particular application.

TYPE NUMBER	RESOLUTION (Lines per Inch)	SPECTRAL COLOR	PERSISTENCE TIME
3AVP5	1500	Blue	Very Short
3AVP11	1000	Blue	Short
3AVP16	500	Near UV	Very Short
3AWP5	2000	Blue	Very Short
5CQP5	1500	Blue	Very Short
5CQP11	1000	Blue	Short
5CQP16	500	Near UV	Very Short
5CRP5	2000	Blue	Very Short
7AVP5	1500	Blue	Very Short
7AVP11	1000	Blue	Short
7AVP16	500	Near UV	Very Short
7AWP5	2000	Blue	Very Short

More reliable products through Advanced-Engineering

CBS® tubes

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

Letters

to the Editor

Bonuses for Patents?

Editor, ELECTRONIC INDUSTRIES:

I should like to have a reprint of the article "Should Engineers Receive Bonuses for Patents," by Eugene Raudsepp, which appeared in the November 1958 issue of ELECTRONIC INDUSTRIES.

I also offer the following comments on the results of the survey. The experts polled seem all to have been management and administrative personnel. The people who are actually in a position to receive the bonuses seem not to have been asked for their opinions. As the administrator of a program of modest financial reward for patentable contributions, I can assure you that the people who get the money are glad to have it. I do not believe that it is in any way a major motivation, as some of the experts feared it might become, but it provides the inventor with a tangible assurance that his work has in fact been noticed. The management approval suggested by some is not a concrete motivation unless the inventor knows that management is aware of his work.

The objection to awards made by William R. Gentry, Jr., on the ground that it is hard to determine who is responsible for an invention does not seem valid to me. If a patent application is to filed, a decision *must* be made as to who the inventor is.

Raymond P. Wallace
Patent Attorney
Research Division
Curtiss-Wright Corporation

"Transistorizing a Flip-Flop"

Editor, *Electronic Industries:*

Enclosed are recent changes for my manuscript.

Allen I. Perlin

Ed: Mr. Perlin's corrections arrived when the article was already running on the press. His modifications are listed below.

On page 97, May 1959, substitute the following for the paragraph starting "(V_{be})': Twice . . .":

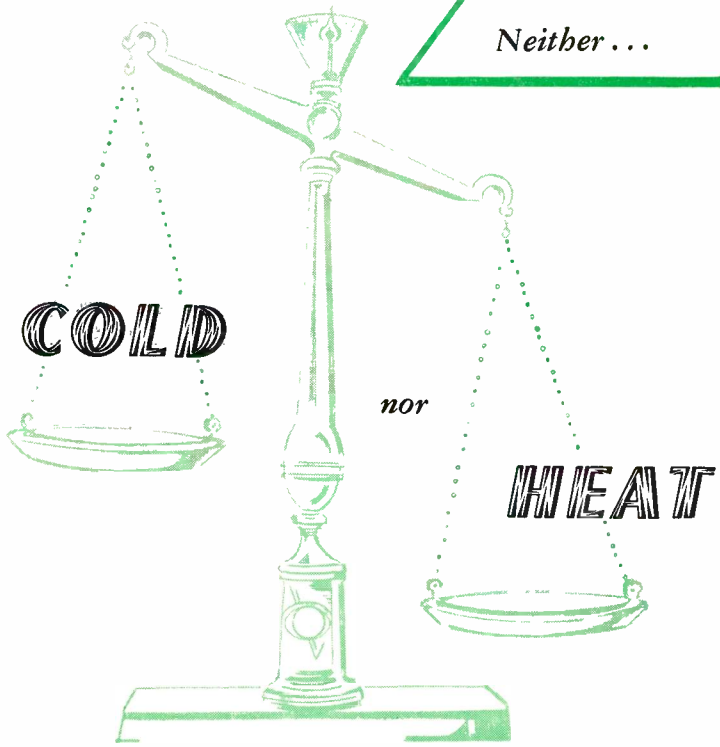
Five times the base-to-emitter voltage of the transistor while a collector current I_c (defined later) is flowing in the circuit. This value is incorporated to permit design realizability by assuring adequate current into the base of the ON transistor of the pair.

On the same page, insert the following paragraph before the paragraph which begins "It is next necessary to . . .":

(*Continued on page* 40)

NEW
— different

Neither . . .



*nor microwatt range stays these instruments from drift-free measurements of RF power.**

MODEL B831A

Price $335.00
F.O.B. Woodside, N. Y.

TEMPERATURE COMPENSATED POWER METER

- Temperature compensation gives greater stability and more accurate measurements.
- Readings are virtually drift-free, even in the 10 μW range.
- Accuracy: maximum positive accumulative error ± 5%. Standard deviation, or RMS probable error, ± 1.7%.
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- DC calibration at all levels.
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- An *FXR SERIES 218 TEMPERATURE COMPENSATED THERMISTOR HEAD* is a required accessory. These broadband coaxial and waveguide components are available throughout the frequency range from 0.01 to 40 KMC/SEC.

FXR, Inc.

Design • Development • Manufacture •

26-12 Borough Place
Woodside 77, N. Y.

PRECISION MICROWAVE EQUIPMENT • HIGH-POWER MODULATORS • RADAR COMPONENTS • ELECTRONIC TEST EQUIPMENT

* *With a bow to Herodotus, the 5th century B.C. Greek historian who wrote the much-quoted words appearing on the facade of the New York Post Office and paraphrased here.*

Letters

to the Editor

(*Continued from page* 38)

The design to be discussed herein allows the circuit to be established with relative freedom from the considerations of transistor parameters. This is essentially true, even in practice, since many transistors within a particular class will have identical performance in a given bistable circuit, the primary differences being those incurred by temperature variation and voltage tolerance differences. In the discussion here, it will be assumed that β of the selected transistor is high enough to make the base current requirement of that transistor negligible relative to the current flow in the R_b, R_c, R_L series divider. Such an assumption allows a consideration of the design on the basis of voltage alone, with several empirical approximations compensating for the actual effects of using a current-controlled device such as a transistor. The choice of $(V_{be})'$, above, is such an approximation.

On page 99, May 1959, at the end of the first paragraph on Problem Solution, change "$(V_{be})'$ is 0.2 v." to "$(V_{be})'$ is 0.5 v."

Change step 3 to read

$$R_c = \frac{-3.8 \times 10^4}{12\ (0.83 - 1)} = 18{,}700\ \Omega$$

Change step 4 to read

$$R_b = \frac{0.5\ (4 \times 10^3 + 20 \times 10^3)}{12 - 0.5} = 1043\ \Omega$$

Change step 5 to read

$$C_c \ll \frac{1043 + 4000 + 18{,}700}{\pi \times 10^3 \times 18{,}700\ (5043)} = (0.79\ \mu f)$$

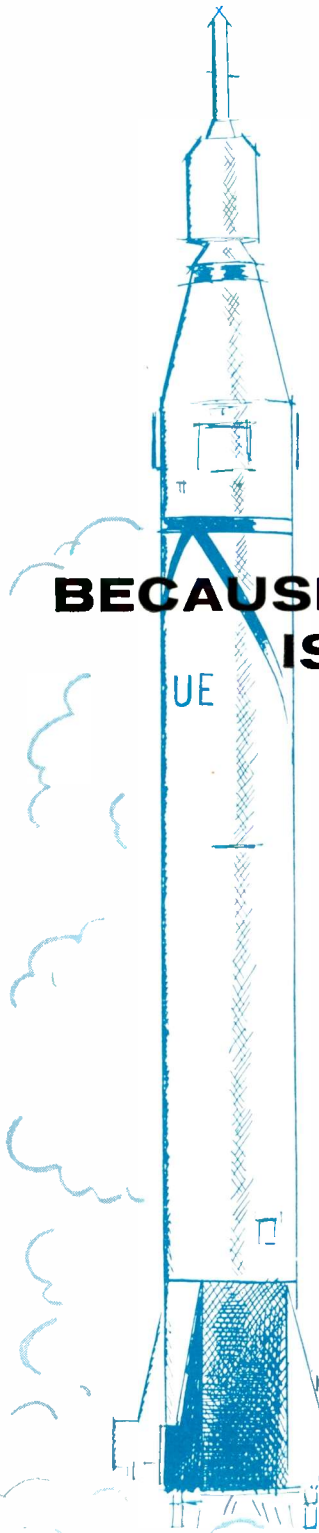
On the second last line of page 99, change 407 to 1043.

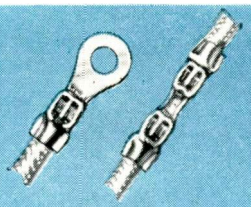
In the first equation on page 100, change 0.907 to 1.543.

At the top of the second column on page 100, change 470 to 1000.

HIS NECK WAS OUT

Col. Gail S. Carter (left), Exec. Officer of NEDA receives the Turtle Award from S. I. Neiman of Public Relations Affiliates. Plaque is awarded to the person sticking his neck out farthest in the industry.





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- up to 1200°F. operating temperature
- solid, stranded or combination conductors
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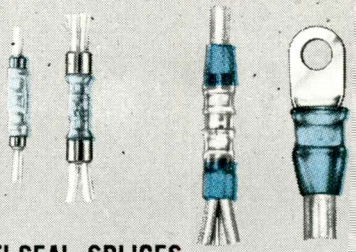
- serrated inner barrel for maximum tensile strength



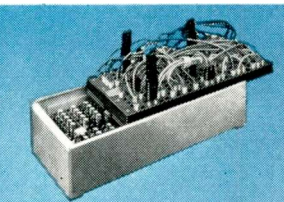
CERTI-SEAL SPLICES
AMPLI-NYL TERMINALS AND SPLICES

- combined wire size range 22-2/0 AWG
- exceed millivolt-drop specifications
- finest nylon pre-insulation
- shock and corrosion resistant
- color coded by wire size

BECAUSE CIRCUIT RELIABILITY IS VITAL . . .

. . . AMP's product is more than fine circuit terminals . . . more than remarkably precise compression-crimp tooling . . . more than an error free, fast method of attachment.

AMP's product is finished crimp-type terminations on your circuitry wires . . . by the hundreds or millions . . . of the highest reliability . . . performing under gruelling conditions . . . from basic terminals to complete patchcord systems.



PATCHCORD PROGRAMMING UNITS
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- universal or shielded systems
- patented wiping action pre-cleans pins and contact springs
- nylon sleeve insulates and firmly seats patchcord pin in board
- contacts have rear board accommodation for taper pins to provide reliable solderless lead terminations

200 CONTACT CABLE CONNECTORS

- extremely reliable disconnect for ground electronic and instrumentation application
- connector can be electrically disengaged without mechanical separation
- five indexed positions to permit strain-free cable exit
- identical inserts and contacts in both halves
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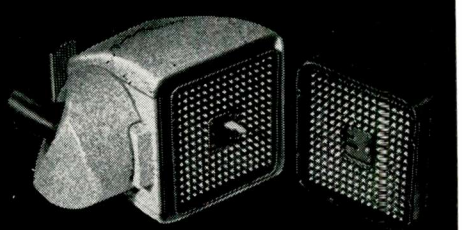

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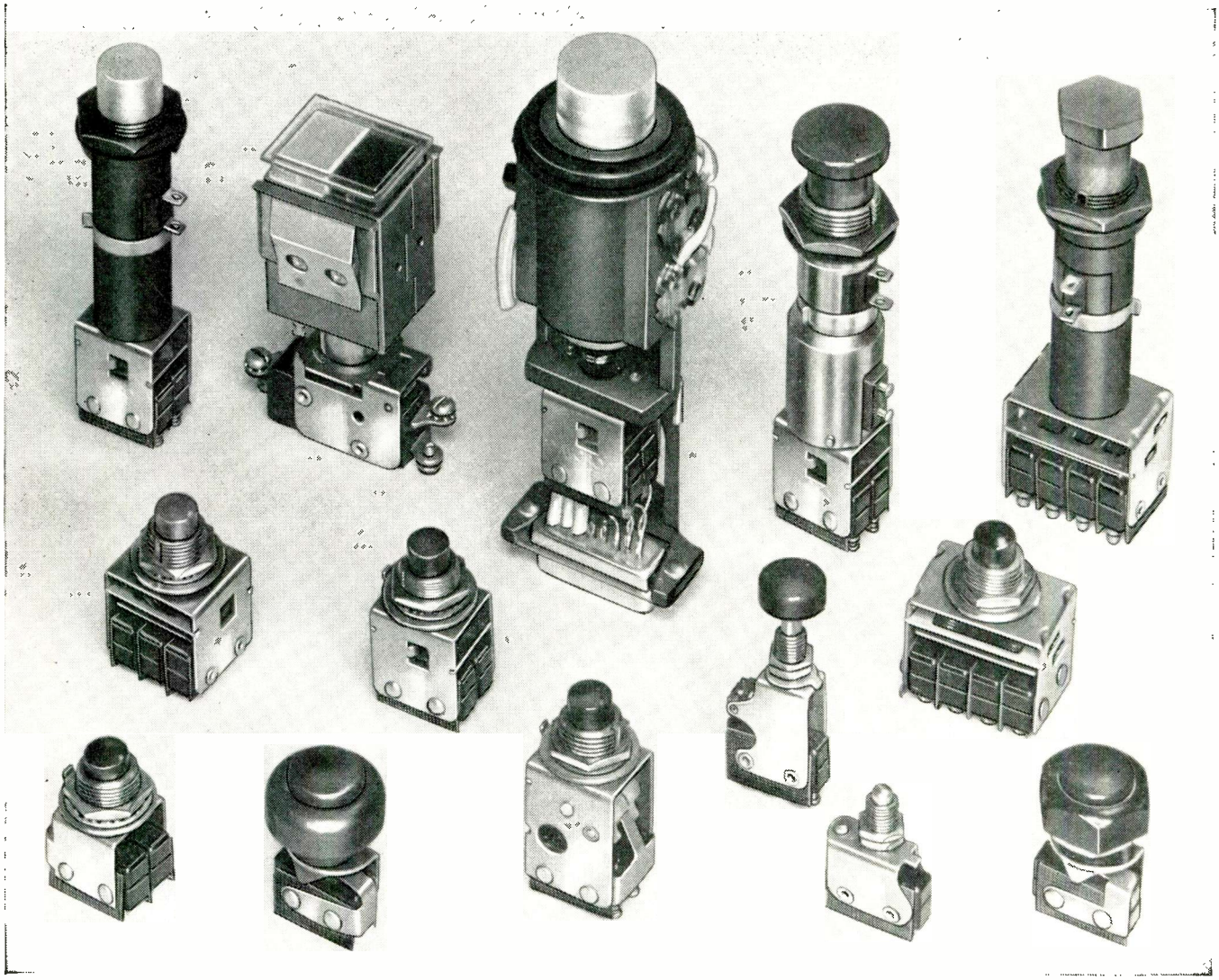

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These assemblies are typical of many different series of MICRO SWITCH pushbutton switches. Each series offers many variations of electrical and operating characteristics.

Operational characteristics include: momentary action, lock-down, alternate action, two-position alternate action, and magnetically held. Direct control of up to fourteen double-throw circuits is offered. Short and long button strokes can be provided. Sealed switches are available when protection is required from oil, water, sand, or salt spray. Special shock and vibration-resistant features are built into switches for rugged duty service. Switches with illuminated pushbutton display are available. These include switch devices with interchangeable modular indicator and pushbutton units.

Experienced engineering assistance to help you select the pushbutton switch best suited to your requirements is as near as your MICRO SWITCH branch. There is no obligation.

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MICRO SWITCH Precision Switches

Circle 27 on Inquiry Card

Circle 28 on Inquiry Card →

SMALLEST
LIGHTEST
CARCINOTRONS

with wide band sole tuning

Though it has just recently made its debut into the high society of Litton microwave tubes, this M-Type carcinotron (our model L-3298) has already been commended by the military for its exceptionally clean design. Every engineer concerned with upgrading the performance of ECM equipment will surely find much of interest in this medium-power tube, with which Litton takes a major stride toward truly simultaneous noise-jamming capability by affording faster tuning rates than any previously attainable.

The Litton family of eight electrically-compatible carcinotrons is the first to incorporate the critical capability of wide band sole tuning without frequency or power holes when the tube is operated into as much as a 2-to-1 mismatch. Litton carcinotrons are the first to use wider-than-normal-band RF output couplers, minimizing many system components such as antennae, waveguide plumbing, and load isolators.

We cite these firsts not for glory's sake, but rather for their meaningful contribution to more efficient system design, smaller size and lighter weight.

The notable suitability of these carcinotrons is not limited to ECM. You can also consider them for other military applications such as drivers for communications links—in fact, wherever medium-power tubes with extremely rapid tuning and low tuning power are required. And while you are considering, remember: these versatile tubes are not just drawing-board products—you can order them now.

Feel free to lodge your inquiry about voltage-tuned power oscillators of whatever nature with us at Litton Industries Electron Tube Division, Office E16, 960 Industrial Road, San Carlos, California. Your request for our newest catalog or for answers to your specific questions will be honored promptly.

LITTON INDUSTRIES **Electron Tube Division**

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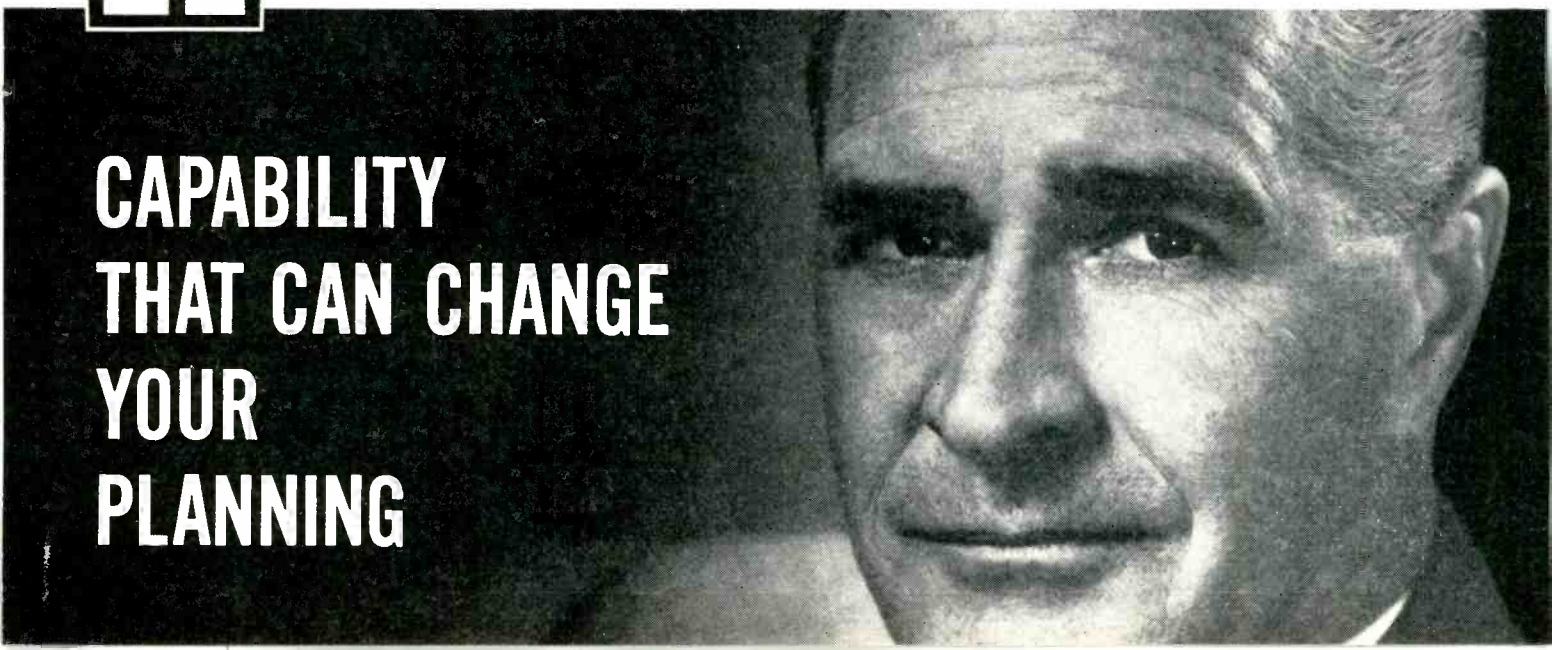


FREQUENCY STANDARDS

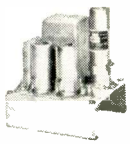
*3⅛" high
400 - 1000 cy.

PRECISION FORK UNIT
TYPE 50

Size 1" dia. x 3¾" H. Wght., 4 oz.*

Frequencies: 240 to 1000 cycles
Accuracies:—
Type 50 (±.02% at —65° to 85°C)
Type R50 (±.002% at 15° to 35°C)
Double triode and 5 pigtail parts required
Input, Tube heater voltage and B voltage
Output, approx. 5V into 200,000 ohms

FREQUENCY STANDARD
TYPE 50L



Size 3¾" x 4½" x 5½" High
Weight, 2 lbs.

Frequencies: 50, 60, 75 or 100 cycles
Accuracies:—
Type 50L (±.02% at —65° to 85°C)
Type R50L (±.002% at 15° to 35°C)
Output, 3V into 200,000 ohms
Input, 150 to 300V, B (6V at .6 amps.)

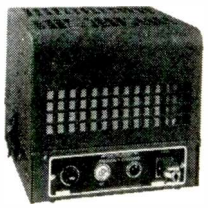
*3½" high
400 to 500 cy.
optional

PRECISION FORK UNIT
TYPE 2003

Size 1½" dia. x 4½" H. Wght. 8 oz.*

Frequencies: 200 to 4000 cycles
Accuracies:—
Type 2003 (±.02% at —65° to 85°C)
Type R2003 (±.002% at 15° to 35°C)
Type W2003 (±.005% at —65° to 85°C)
Double triode and 5 pigtail parts required
Input and output same as Type 50, above

FREQUENCY STANDARD
TYPE 2005



Size, 8" x 8" x 7¼" High
Weight, 14 lbs.

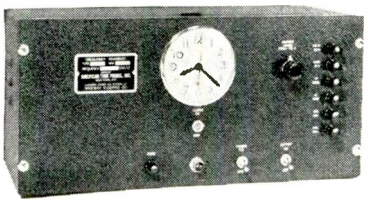
Frequencies: 50 to 400 cycles (Specify)
Accuracy: ±.001% from 20° to 30°C
Output, 10 Watts at 115 Volts
Input, 115V. (50 to 400 cycles)

FREQUENCY STANDARD
TYPE 2007-6 *NEW*
TRANSISTORIZED, Silicon Type

Size 1½" dia. x 3½" H. Wght. 7 ozs.

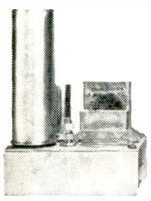
Frequencies: 400 — 500 or 1000 cycles
Accuracies:
2007-6 (± .02% at —50° to +85°C)
R2007-6 (±.002% at +15° to +35°C)
W2007-6 (±.005% at —65° to +125°C)
Input: 10 to 30 Volts, D. C., at 6 ma.
Output: Multitap, 75 to 100,000 ohms

FREQUENCY STANDARD
TYPE 2121A



Size
8¾" x 19" panel
Weight, 25 lbs.

Output: 115V
60 cycles, 10 Watt
Accuracy:
±.001% from 20° to 30°C
Input, 115V (50 to 400 cycles)

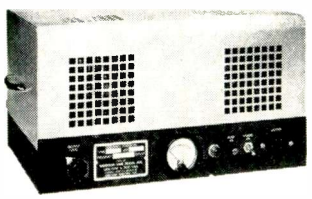


FREQUENCY STANDARD
TYPE 2001-2

Size 3¾" x 4½" x 6" H., Wght. 26 oz.

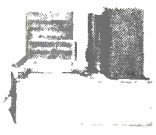
Frequencies: 200 to 3000 cycles
Accuracy: ±.001% at 20° to 30°C
Output: 5V. at 250,000 ohms
Input: Heater voltage, 6.3 - 12 - 28
B voltage, 100 to 300 V., at 5 to 10 ma.

FREQUENCY STANDARD
TYPE 2111C



Size, with cover
10" x 17" x 9" H.
Panel model
10" x 19" x 8¾" H.
Weight, 25 lbs.

Frequencies: 50 to 1000 cycles
Accuracy: (±.002% at 15° to 35°C)
Output: 115V, 75W. Input: 115V, 50 to 75 cycles.



ACCESSORY UNITS
for TYPE 2001-2

L—For low frequencies multi-vibrator type, 40-200 cy.
D—For low frequencies counter type, 40-200 cy.
H—For high freqs, up to 20 KC.
M—Power Amplifier, 2W output.
P—Power supply.

This organization makes frequency standards within a range of 30 to 30,000 cycles. They are used extensively by aviation, industry, government departments, armed forces—where maximum accuracy and durability are required.

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PLEASE SPECIFY TYPE NUMBER

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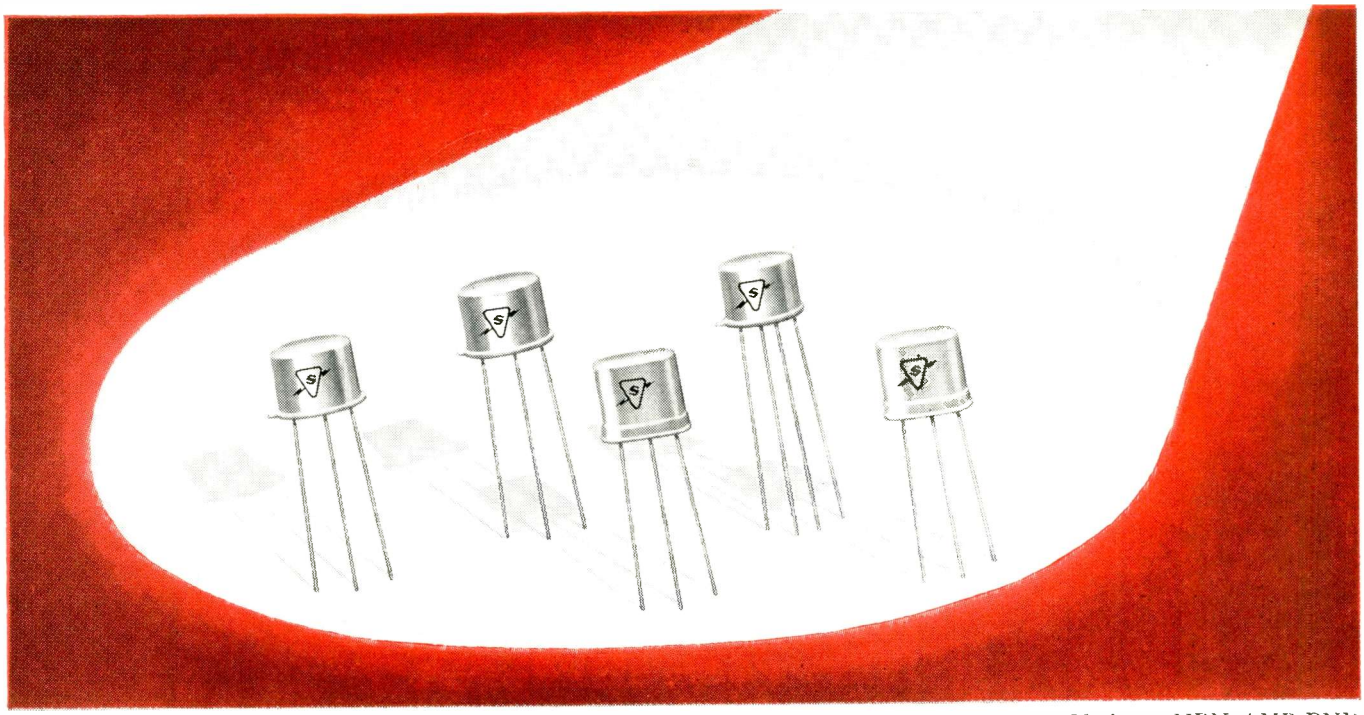
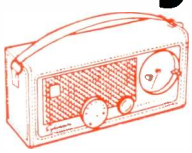
Watch Master
Timing Systems

580 Fifth Ave., New York 36, N. Y.



60 Choices—NPN *AND* PNP

Sylvania Entertainment Transistors



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Sylvania's broad entertainment transistor line is one of the most complete in the industry. It offers the creative design engineer a full range of types from one source to meet his most selective needs. Twenty new types have been added, bringing the total number to over 60 top-quality types including PNP, NPN, PNP (Drift), Medium Power and Low Power transistors. The entire line incorporates hermetic seal construction for maximum protection against humidity and other environmental conditions that can affect performance.

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POPULAR SYLVANIA ENTERTAINMENT TRANSISTORS

PNP

Type	Description	Type	Description
2N34	GP Audio	2N412	HF, IF Conv
2N109	GP Audio	2N591	Med Power, Audio
2N217	GP Audio		
2N405	GP Audio	Syl 1430	Ent
2N406	GP Audio	Syl 1536	Ent
2N407	GP Audio	Syl 1537	Ent
2N408	GP Audio	Syl 1549	Ent
2N409	HF, IF Amp	Syl 1604	Ent
2N410	HF, IF Amp	Syl 1608	Ent
2N411	HF, IF Conv	Syl 1621	Ent

NPN

Type	Description	Type	Description	Type	Description
2N35	GP Audio	2N216	HF IF Amp	2N1102	GP Audio
2N94	RF Amp	2N228	GP Audio	Syl 1279	Ent
2N193	HF Osc	2N229	GP Audio	Syl 1310	HF Conv
2N194	HF Conv	2N233	HF RF Amp	Syl 1311	HF Conv
2N194A	HF Conv	2N233A	HF RF Amp	Syl 1312	HF Conv
2N211	HF Osc	2N515	HF RF-IF Amp	Syl 1313	RF Amp
2N212	HF Conv	2N516	HF RF-IF Amp	Syl 1329	Ent
2N213	GP Audio	2N517	HF RF-IF Amp	Syl 1524	Ent
2N213A	GP Audio	2N1058	HF Mixer	Syl 1538	Ent
2N214	Matched Pair	2N1059	GP Audio	Syl 1539	Ent
2N214 (single)	GP Audio	2N1101	GP Audio	Syl 1547	Ent
				Syl 1583	Ent

(Drift) PNP

Type	Description
2N247	HF RF
2N370	HF RF
2N371	HF RF
2N372	HF RF
2N373	HF IF
2N374	HF Conv
2N544	HF RF
Syl 1475	Ent
Syl 1509	Ent

Circle 30 on Inquiry Card

Personals

Kartar Dhanjal is now Senior Electronics Engineer for Epsco-West, California Div. of the Boston data control firm. He was formerly with B-J Electronics Corp.

Jack C. Hoagland has been appointed Director of Engineering at Daystrom Pacific, Los Angeles. He was previously Executive Engineer, Lockheed Missile Systems Div.

Roland Lawrence has been appointed Director of Engineering and Research at The Deutsch Co., Electronic Components Div. He was formerly with Douglas Aircraft Co., Inc.

Dr. David R. Helman is now Consulting Computer Engineer—Operations Analysis—General Electric Co.'s Computer Dept., Phoenix, Ariz.

Robert W. McNair, has been appointed Assistant General Manager. Tamar Electronics, Inc. His previous associations were with the Western Electric Corp., and Beach Aircraft Co.

R. McNair

E. Kohler

Emil Kohler is now Product Engineer, transistorized power supplies and other transistorized power equipment, at The Daven Co., Livingston, N. J.

John F. Kauwling is now General Manager of the Electronics Div., Elgin National Watch Co. He was formerly Operations Manager.

Albert Preisman, Silver Springs, Md. has resigned as V. P. in Charge of Engineering from Capitol Radio Engineering Institute. He is expanding his consulting electronic engineering practice which includes the fields of patent litigation and the preparation and writing of engineering reports.

James G. Tabler, Former Senior Staff Engineer with the Associate Director of Engineering has been named Chief Engineer of the new Industrial Div. of Cubic Corp., San Diego.

(*Continued on page* 156)

AUTO-LITE® OFFERS ONE-STOP SERVICE WITH THE COMPLETE LEAD WIRE LINE

SILICONE RUBBER

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PVC FILMS

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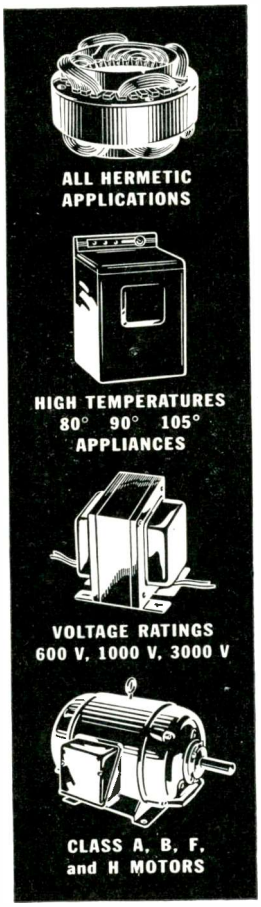
Uniform quality plastic insulation for temperatures from —65° C to 105°C. Offered in many formulations.



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Company_____

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City and State_____

Circle 32 on Inquiry Card

Books

Analytical Transients

By T. C. Gordon Wagner. Published 1959 by John Wiley & Sons, Inc., 440 4th Ave., New York 16. 202 pages. Price $8.75.

This work represents the means of acquiring the more advanced mathematical knowledge necessary for a greater understanding of network analysis, Fourier series, and the Laplace transformations. An elementary acquaintance with all these subjects is presumed.

Network analysis is presented in a general manner, then studied in detail. Much of the discussion in the book is devoted to the Laplace transformation in order to provide a substantial idea of the subject as a whole, and to convey the sense of balance needed to perceive the limitations and applications of this calculus. The treatment of Fourier series in intervals establishes a logical basis for the Laplace transformations; a thorough consideration is given to the covergence of the series, the sampling theorems, and Gibbs phenomenon.

In the Upper Atmosphere

By H. S. W. Massey and R. L. F. Boyd. Published 1959 by Philosphical Library, Inc., 15 E. 40th St., New York 16. 333 pages. Price $17.50.

This is an authoritative account of the phenomena for the upper atmosphere studied during the international geophysical year. Present day knowledge of this subject is outlined and the techniques used in investigation are fully described. These include the use of sound and radio waves, spectroscopic devices, searchlights, balloons, rockets, and artificial satellites. Methods of finding the positions and speed of rockets and satellites, and of interpreting their coded signals, are explained.

Among the phenomena to receive detailed attention are radio fadeout, radio absorption, night airglow, aurorae, meteors, cosmic rays, and currents responsible for magnetic variations. The effects produced in the atmosphere by the sun, which include the ionized regions so important for long distance radio transmissions, are described in relation to solar phenomena.

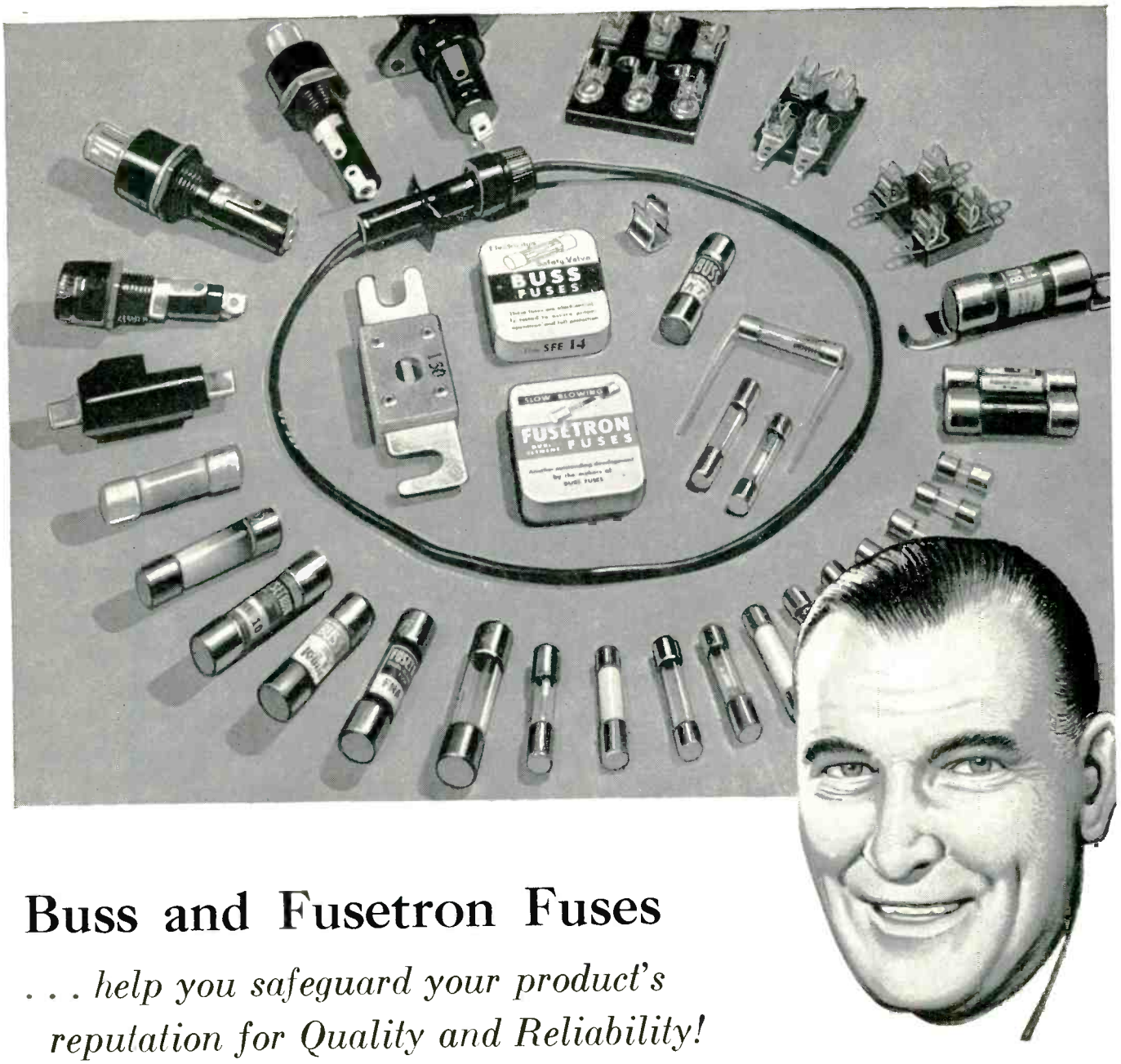
Magnetic Amplifier Engineering

By George N. Attura. Published 1959 by McGraw Hill Book Co., Inc., 330 W. 42nd St., New York 36. 304 pages. ***Price $7.50.***

This volume contains guidance on the theory, operating principles, and practical application of all types of magnetic amplifiers, presented in the language of the electronic circuit and systems engineer.

The book gives you basic information on electric and magnetic variables, describing their interrelation through the equations of Faraday and Oersted. The special characteristics of the magnetic amplifier reactor are

(*Continued on page* 50)



Buss and Fusetron Fuses

. . . help you safeguard your product's reputation for Quality and Reliability!

Undoubtedly, you take pride in the products your company manufacturers . . . and try to avoid using any components that could result in customer dissatisfaction . . . which in turn can affect your company's sales curve.

That's why it doesn't pay to gamble with fuses that could be faulty and create trouble for your customers — either by failing to protect and causing useless damage to equipment, or by blowing needlessly and causing unnecessary shutdowns.

With BUSS and FUSETRON fuses safe, dependable electrical protection is assured. Before one of these fuses ever leaves our plant, it is electronically tested to make sure it is right in every way . . . to make sure it will protect, not blow needlessly.

When you specify BUSS or FUSETRON fuses, you are safeguarding against customer complaints for you have equipped your product with the finest electrical protection possible. You are also helping to maintain the reputation of your product for service and reliability.

To meet all fuse requirements, there's a complete line of BUSS and FUSETRON fuses in all sizes and types . . . plus a companion line of fuse clips, blocks and holders.

For more information on BUSS and FUSETRON Small Dimension fuses and fuseholders, write for BUSS bulletin SFB.

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759

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 BUSS — TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION — McGRAW EDISON

Books

(*Continued from page* 48)

clearly discussed, and the magnetic amplifier reactor is contrasted with the performance of the linear inductor. Also to be found is a full discussion on the special core materials, and the manufacture and test of these special reactors.

Linear Network Analysis

By Sundaran Feshu and Normal Balabanian. Published 1959 by John Wiley & Sons, Inc., 440 4th Ave., New York 16. 571 pages. Price $11.75.

This book develops the foundations of network theory carefully, smoothing out the transitions between (a) steady state and transient responses, (b) time and frequency responses, and (c) analysis and synthesis. The authors begin with fundamentals, that is—Kirchhoff's laws, the number of independent equations, and direct the reader to the threshold of some of the most advanced concepts in network theory, including, network synthesis, realizability conditions, and feedback and control systems.

Almost all results are carefully proved, and all assumptions that are made in the development are clearly explained. Throughout, active and passive networks are treated simultaneously. The book contains numerous illustrations, and problems accompanying each chapter.

Transistors

By Angelo C. Gillie. Published 1959 by Prentice Hall Inc., Englewood Cliffs, N. J. 262 pages. Price $7.95.

Coming at a time when transistors are being universally adopted, this new book fills a real need for a work which provides an understanding of the behavior of transistors in various applications, without the usual prerequisite of advanced mathematics. The principles are presented in such a way as to be easily understood by anyone familiar with Ohm's law, a-c theory and fundamental algebraic prophecies.

The organization of the material is simple and logical, from general linear and non-linear conductors, to linear resistive control devices, to the transistor—and finally to its application.

The first three chapters serve as an introduction to both transistors and vacuum tubes, since they point out the similarities as well as the basic differences of the two devices—and when combined with Chapter 11, which covers special semiconductor devices, the book provides a complete treatment of semiconductors.

The material is designed to overcome character thinking that a study of transistors necessarily implies a radically different approach; the

(*Continued on page* 54)

RAYTHEON

Save Time and Money on Industrial Tubes

What the Raytheon-Machlett Story Means to You

BROADEST TUBE COVERAGE—Raytheon now offers the broadest line of industrial tubes and electronic hardware available anywhere... 1967 Raytheon types! You now get complete coverage on *all* your tube requirements through your Raytheon Distributor.

FASTER TUBE DELIVERY—Raytheon Distributors' inventory backup program has been extended to Machlett tubes. This means 24-hour local delivery of any tube when you need it. Simply list your tube requirements with your Raytheon Distributor.

ADDED ENGINEERING HELP—Raytheon field engineers are available to provide applications assistance on Raytheon and Machlett Tubes. Just call your Raytheon Distributor.

About Machlett Quality . . .

by John Hickey,
Raytheon Industrial Products Manager:

Merger of Machlett and Raytheon means that Raytheon Tube Distributors now offer fast local delivery of the finest quality power tubes for your industrial heating and communications sockets. Machlett Laboratories' people have a watchword: "What is good, stays good." They back it with 100 per cent inspection and the finest quality control in the industry. If you have equipment or designs which can use one of the more than 100 Raytheon-Machlett types, I believe you will see measurable improvement in performance, reliability, and tube life. Just specify "Raytheon-Machlett" as the brand, "Local Raytheon Distributor" as the supplier.

RAYTHEON

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Baltimore, Md.
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RAYTHEON COMPANY • DISTRIBUTOR PRODUCTS DIVISION

Circle 42 on Inquiry Card

DELCO POWER TRANSISTORS

NEW TYPES

MILITARY
COMMERCIAL

TYPICAL CHARACTERISTICS AT 25°C

EIA	2N297A*	2N297A	2N665**	2N553
Collector Diode Voltage (Max.)	60	60	80	80 volts
HFE (I_c = 0.5A) (Range)	40-100	40-100	40-80	40-80
HFE (I_c = 2A) (Min.)	20	20	20	20
I_{co} (2 volts, 25°C) (Max.)	200	200	50	50 μa
I_{co} (30 volts, 71°C) (Max.)	6	6	2	2 ma
F_{ae} (Min.)	5	5	20	20 kc
T (Max.)	95	95	95	95°C
Therm Res. (Max.)	2	2	2	2° C/W

*Mil. T 19500/36 (Sig. C.)
**Mil. T 19500/58 (Sig. C.)

NOTE: Military Types pass comprehensive electrical tests with a combined acceptance level of 1%.

Delco Radio announces new PNP germanium transistors in 2N553 series — the 2N297A and 2N665, designed to meet military specifications. These transistors are ideal as voltage and current regulators because of their extremely low leakage current characteristics. All are highly efficient in switching circuits and in servo amplifier applications, and all are in *volume* production! Write today for complete engineering data.

DELCO RADIO
Division of General Motors • Kokomo, Indiana

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Tel: Mitchell 2-6165

Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465

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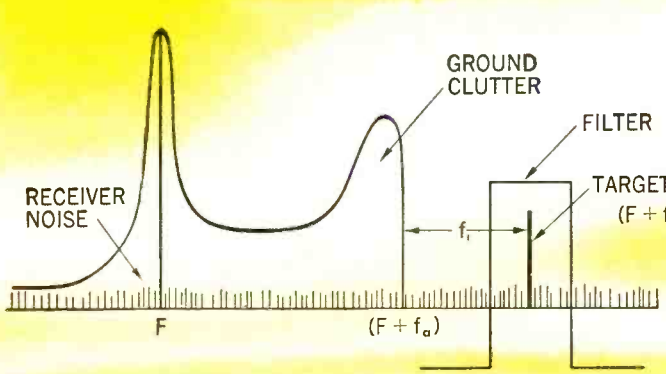
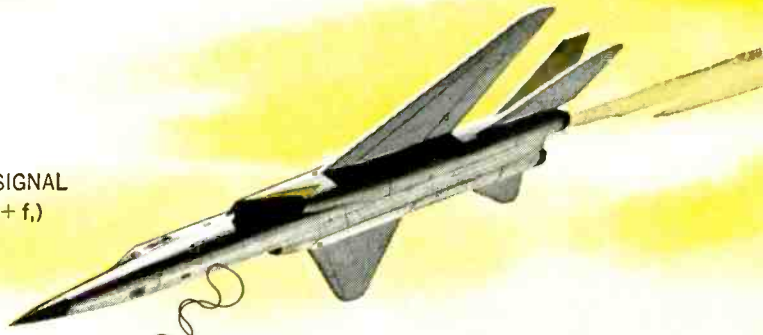
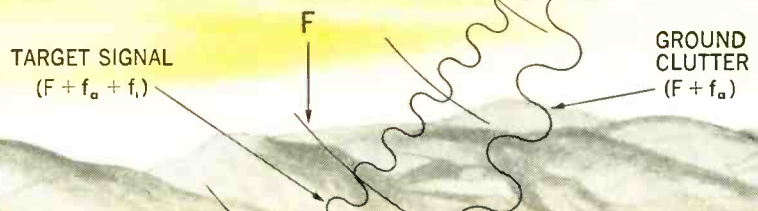
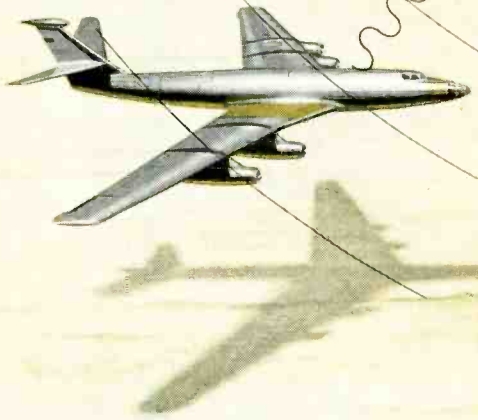








CW INTERCEPT RADAR

Continuous Wave Airborne Intercept Radar is superior to pulse radar for detecting low-flying targets. Even using special techniques, pulse radar echoes from low-flying targets are obscured by ground clutter. However, the unique character of Doppler-shifted frequencies distinguishes the target signal from ground clutter.

The intercept radar locks on and tracks the target Doppler frequency by means of an automatically positioned narrow bandpass filter. This bandpass filter also rejects most of the noise, clutter, false signals and interference, thereby assuring top system performance.

This CW intercept radar is one of the many interesting developments engineered in Raytheon's Maynard Laboratory.

PROFESSIONAL ASSOCIATION WITH A FUTURE

Raytheon has excellent openings for qualified engineers and physical scientists with BS or advanced degrees. Positions are available in systems, development, design or manufacturing engineering of complex electronic equipments. Please write Donald H. Sweet, Government Equipment Division, Raytheon Company, 624 Worcester Rd., Framingham, Mass.

Engineering Laboratories: *Wayland, Maynard, Sudbury, Mass.; Santa Barbara, Calif.*
Manufacturing Facilities: *North Dighton, Waltham, Mass.*

RAYTHEON

Excellence in Electronics

GOVERNMENT EQUIPMENT DIVISION

LAND

SEA

AEROSPACE

Circle 501 on "Opportunities" Inquiry Card

Books

(*Continued from page* 50)

author considers the energy principles and characteristic curves in conjunction with common conductors, combining the elements of newness with something already known to the reader.

Dictionary of Guided Missiles and Space Flight

Edited by Grayson Merrill, Capt. USN (Ret.). Published 1959 by D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J. 688 pages. Price $17.50.

This unique dictionary defines and explains the most commonly used terms in the guided missile and space flight fields today. Reflecting the works of leading professionals, it brings to these endeavors, unsurpassed in technical complexity, an instrument to further the team work needed of many disciplines.

Terms defined include current and historical missiles and spacecraft; their systems used for guidance and control, propulsion, armament and launchings; the components that make up these systems; and all related terms from aerodynamics, astrodynamics, electronics, astronomy, and physics. Included are terms for types of antennas, circuits, radar systems and propellants, as well as the important laws, relationships, equations, space environments and concepts which govern the utilization in design.

Illustrations and discussions are provided for important terms where better understanding will result, and make this book both a source of exact definitions and also a more detailed explanation. A comprehensive cross-referencing plan is included.

Proceedings, 1959 Electronic Components Conference

Published 1959. Copies may be purchased at $7.50 each from any of the four sponsoring organizations; AIEE, 33 W. 39th St., New York 18; EIA, 11 W. 42nd St., New York 36; IRE, 1 E. 79th St., New York 21; and, WENA, 1435 So. LaCienega Blvd., Los Angeles 35, Calif.

These proceedings contain copies of all available papers that were presented at the above mentioned conference held in Philadelphia on May 6, 7, and 8, 1959. Subjects covered include high speed data processing, transmission devices, extreme environments, states electronics, electronic materials, micro-miniaturization, and semiconductors.

What you can Earn in 250 Different Careers

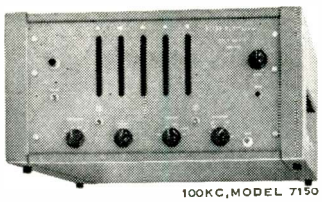
By Ben Puchaski. Published 1959 by Chilton Co., Book Div., Chestnut & 56th Sts., Philadelphia 39, Pa. 175 pages. Price $2.95.

Model Radio-Control

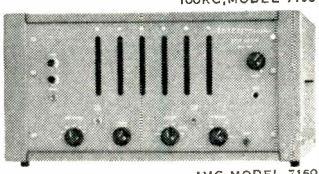
By Edward L. Safford, Jr. Published 1959 by Gernsback Library, Inc., 154 W. 14th St., New York. 11. 192 pages, paper bound. Price $2.65.

* * *

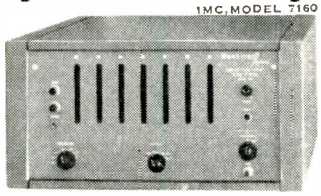
The right counter for every purpose



100KC, MODEL 7150



1MC, MODEL 7160

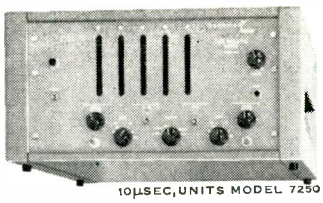


10MC, MODEL 7170

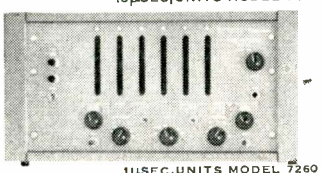
EPUT® METERS

Long considered standard equipment for making rapid, precise frequency measurements, Berkeley EPUT meters are now available with over twenty standard modifications designed for an ever-broadening variety of applications. Most EPUT meters are equipped to make period measurements of low frequency signals.

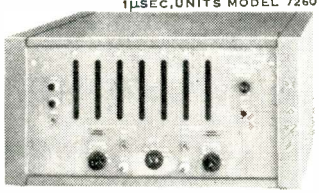
5210 PORTABLE 100KC



10μSEC, UNITS MODEL 7250



1μSEC, UNITS MODEL 7260

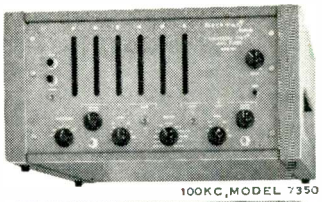


0.1μSEC, UNITS MODEL 7270

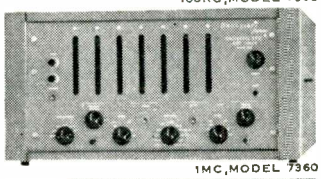
TIME INTERVAL METERS

The full line offers meters of four degrees of precision ranging from a tenth of a millisecond to a tenth of a microsecond. Versatile 7000 Series instruments feature selectable sensitivity for noise discrimination, trigger level adjustable over a wide range, slope selection and very high input impedance.

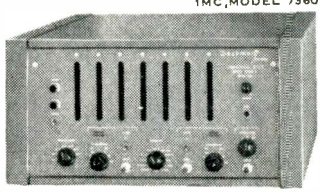
5220 PORTABLE, 100μSEC UNITS



100KC, MODEL 7350



1MC, MODEL 7360

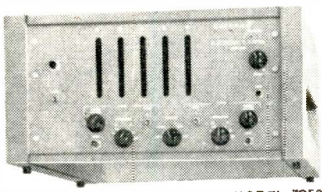


10MC, MODEL 7370

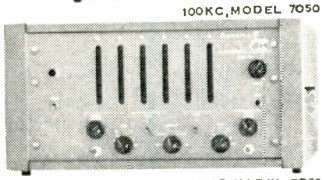
UNIVERSAL EPUT AND TIMERS

Combining the functions of an EPUT meter and time interval meter in a compact economical package, these instruments are widely preferred as general purpose laboratory equipment for precise frequency and time measurement. Universal instruments feature as many as ten distinct operating functions.

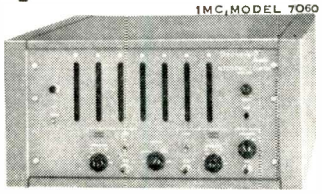
5230 PORTABLE



100KC, MODEL 7050



1MC, MODEL 7060



10MC, MODEL 7070

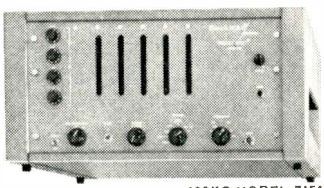
GATING COUNTERS

The counting interval of these instruments can be accurately controlled by a broad variety of input signals. Widely useful as a systems building block, several of these units will perform as EPUT meters or time interval meters when operated in conjunction with an independent source of time signals.

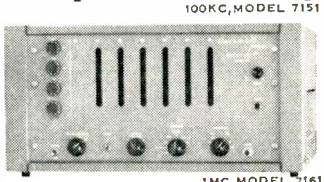
MODEL 5804

INDUSTRIAL TOTALIZING COUNTERS

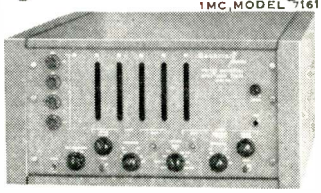
Berkeley makes rugged counters with top speeds from 125 cps to 10,000 cps and capacities up to one billion counts. Model 5805 utilizes miniature magnetic amplifiers for long-term trouble-free operation.



100KC, MODEL 7151



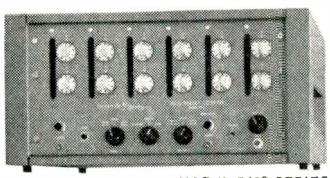
1MC, MODEL 7161



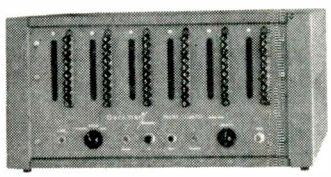
1MC UNIV., MODEL 7351

PRESET EPUT METERS

These instruments will create direct digital indications of rotating speed, flow, pressure, temperature and similar physical quantities in any desired units —for example, rpm, gals/sec, psi, etc. Direct indication is made possible by a counting interval variable over a wide range in small increments.



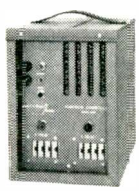
MODEL 5420 SERIES



MODEL 5440 SERIES

COUNTER-CONTROLLERS

Counters which deliver output signals when selected numbers are reached are widely used for precise control of diverse operations. Output signals may be relay closures, sharp voltage pulses or changes in dc level. 5400 Series instruments operate at speeds up to 40,000 counts per second and deliver output signals at one or two preset totals. 5800 Series controllers utilize miniature magnetic amplifiers for maximum reliability in industrial control applications. Operable at speeds up to 5000 counts per second, these units are obtainable with from 1 to 12 preset points.



MODEL 5820 SERIES

Write for Catalog C706.

Beckman®

Berkeley Division

2200 Wright Avenue, Richmond 3, California

a division of Beckman Instruments, Inc.

T4-1

With cap in place, this cartridge equals the length of two standard flashlight dry cells. Unit may be recharged hundreds of times.

Commercial Rechargeable Cells

THE nickel-cadmium storage battery has been adapted to small-sized sealed rechargeable battery cells which can be used in hundreds of industrial, consumer and military applications.

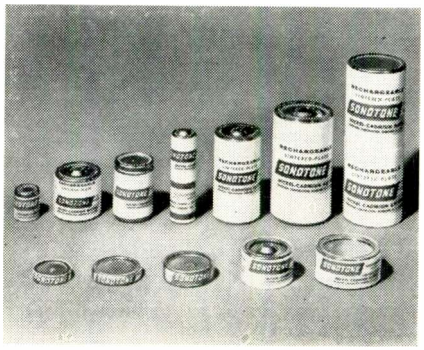
These new battery cells manufactured by Sonotone Corp., Elmsford, N. Y., can be recharged thousands of times—in fact, in many uses, the original cell will outlast the product in which it is used. The units provide a dependable, portable source of electric power for devices ranging from space satellites to children's toys.

The new Sonotone cells also open the door to new applications previously considered impractical because of the limitations of conventional batteries.

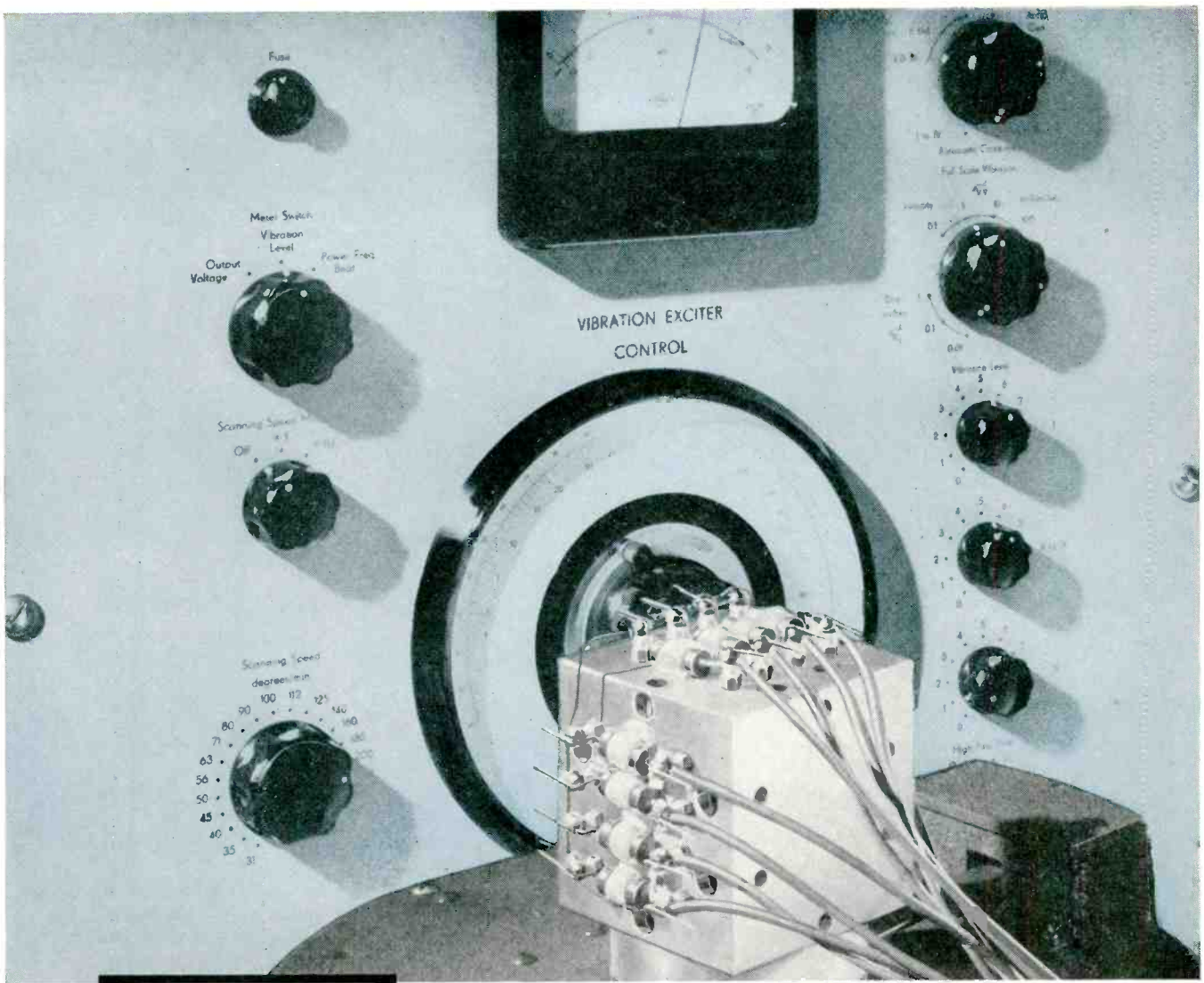
The present line of the new sealed battery cells includes a variety of sizes and shapes, of which the smallest is ¾ in. in diameter, less than ¼ in. long and weighs only ¼ oz.

Through development of these cells, Sonotone has introduced a unique consumer product bearing its name—a long-life flashlight battery cartridge which can outlast hundreds of standard flashlight batteries. This cartridge consists of two sealed cells combined with a transformer-rectifier charger. The components are housed in a sturdy metal case with a removable cap. When the battery capacity is exhausted, the cap is removed and the cartridge is plugged into any 110-volt AC house outlet. After an overnight charge, the battery is again ready for use. The Sonotone cartridge

(*Continued on page* 141)



Sintered-plate, nickel - cadmium battery cells are available in 12 different sizes. All sizes are 1.25 volts. Minimum size is ¾ in. x ¼ in., rated at 75 ma-hrs.



Composite photograph illustrates Kemet Company's aluminum block "shake table" (foreground) and frequency control panel (rear).

KEMET
TRADE-MARK

CAPACITORS WITHSTAND SEVERE VIBRATION TESTS WITHOUT FAILURE!

In addition to severe tests involving low and high temperatures, high humidity, electrical overload and salt spray, "Kemet" solid tantalum capacitors are regularly subjected to rigid vibration tests on a routine sampling basis.

During these tests, which are a part of MIL-C-3965B, the frequency is automatically scanned from 10 to 2000 cycles and back in twenty minutes and the capacitors are subjected to twenty-four such cycles; twelve in each of two perpendicular planes. Acceleration and displacement are automatically controlled during each portion of the test. The electrical leads shown in the photograph provide continuous automatic monitoring for open, short and intermittent circuits in the capacitors on test.

In addition to excellent performance on the standard 15g test, "Kemet" solid tantalum capacitors have withstood 45g acceleration on similar vibration tests.

Kemet Company — supplier of a complete line of solid tantalum capacitors — is not dependent on other suppliers for the mining or processing of tantalum. Kemet Company maintains a complete environmental laboratory which includes vibration testing equipment.

Write today for FREE
"ELECTRONICS PRODUCTS ENGINEERING BULLETIN"
This four-page folder provides performance curves, operating characteristics and specifications.

KEMET COMPANY

DIVISION OF UNION CARBIDE CORPORATION

OFFICES: 11901 Madison Avenue, Cleveland 1, Ohio

Circle 41 on Inquiry Card

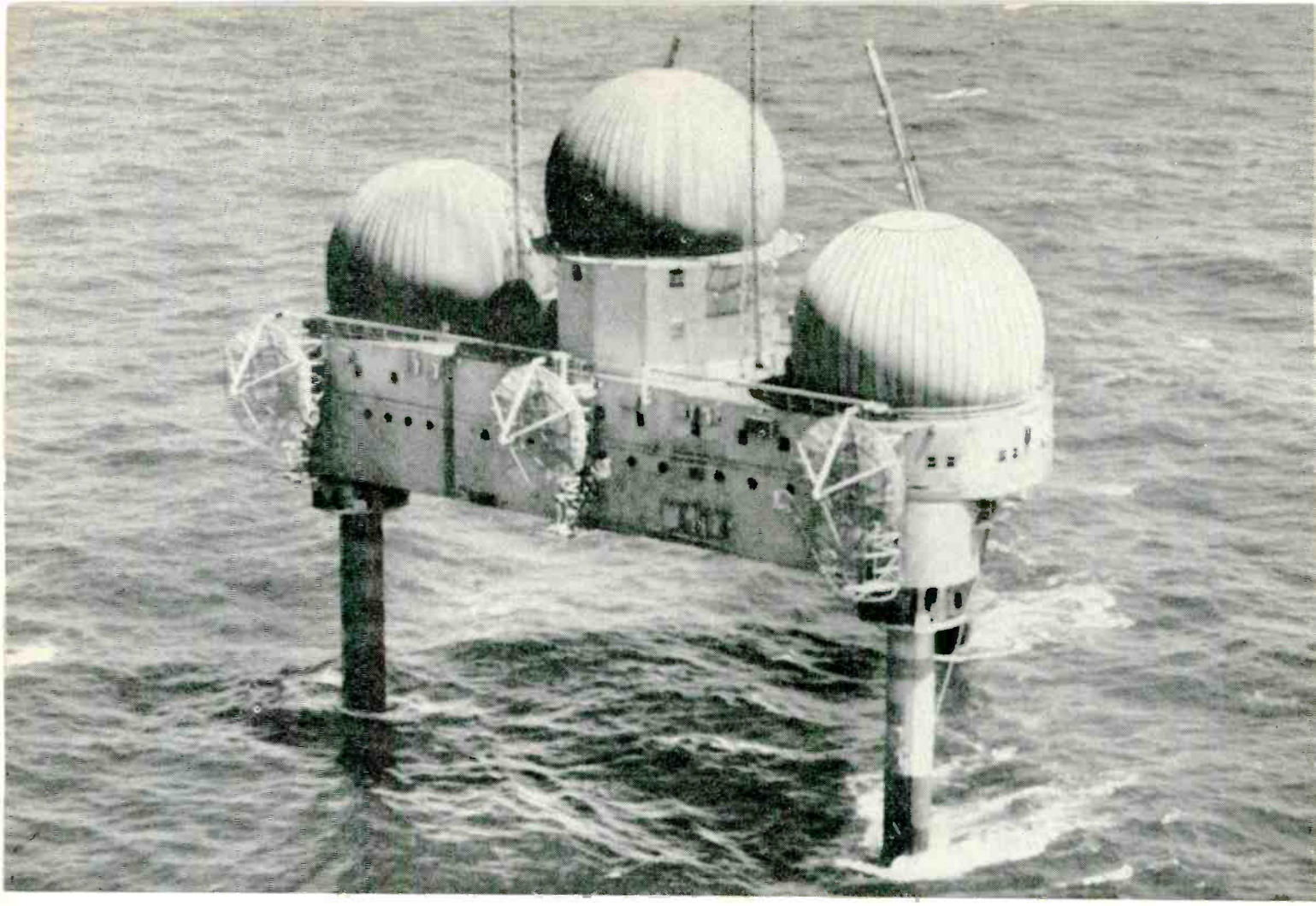


PHOTO COURTESY U. S. AIR FORCE

OFFSHORE INSTALLATION of the Texas Tower Defense System — radar network that helps safeguard the nation's shorelines. Each of the three domes houses radar antennas that constantly sweep the horizon to detect, identify and plot approaching aircraft. Electronic instrumentation in the center dome includes the Bendix AN/FPS-20 radar unit with Tung-Sol/Chatham's VC1257 hydrogen thyratron tube, Tung-Sol/Chatham development.

Tung-Sol/Chatham VC1257 replaces four tubes in *Bendix* Texas Tower radar set!

Engineer points out Tung-Sol/Chatham VC1257 installed in Bendix AN/FPS-20 radar equipment.

The Texas Tower and other key defense systems have required more and more powerful radar equipment. Bendix Radio, to keep pace with this need, replaced four bulky modulator tubes in its AN/FPS-20 radar unit with a single Tung-Sol/Chatham hydrogen thyratron.

Tung-Sol/Chatham's VC1257 features vastly superior power-handling ability, up to 33MW. An internal hydrogen reservoir promotes long life and permits optimum pressure adjustment for a variety of operating conditions. In Bendix AN/FPS-20, the VC1257 provides 7.7 microsecond pulses of 13,500 volts and 700 amperes at a pulse repetition rate of 360 pps. Output pulses need no synchronization as with multiple tube operation.

Hydrogen thyratrons, exclusive Tung-Sol/Chatham development, are available to designers for a variety of pulse modulator applications—1KW (miniature) to 50 MW. All offer benefits in operating efficiency like those gained by Bendix. For complete data, contact: *Tung-Sol Electric Inc., Newark 4, N. J.*

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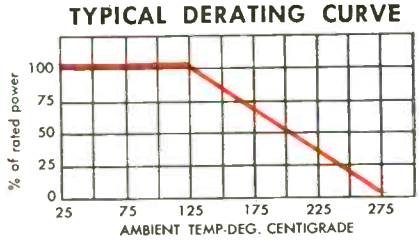

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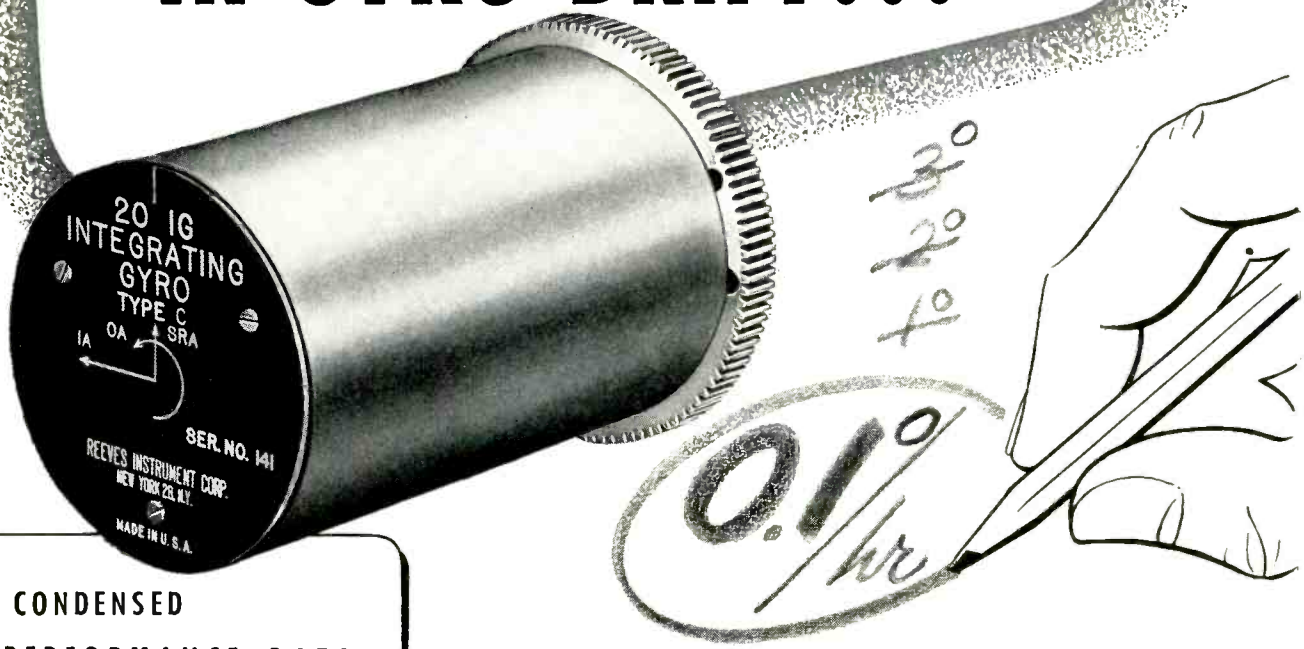

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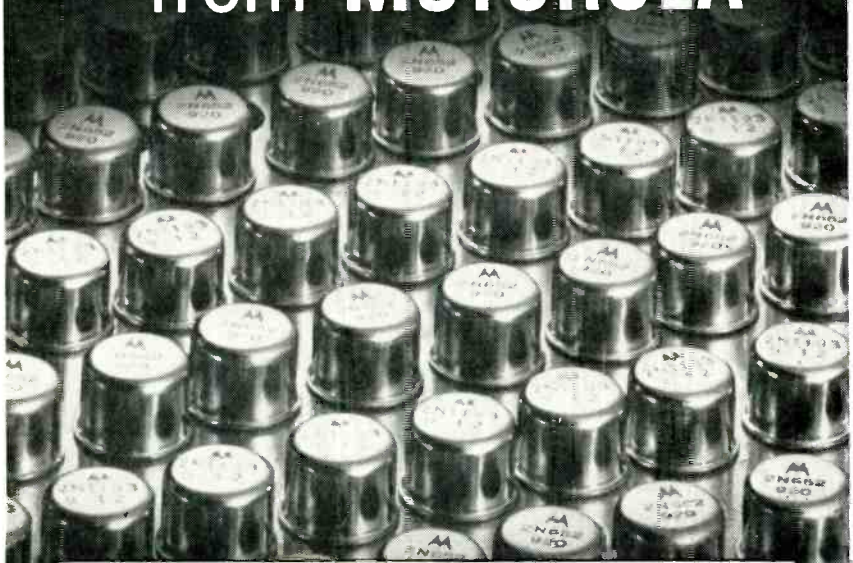

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			Min.	Max.
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2N651	45	30	50	125
2N650	45	30	25	70
T_j = 100°C Operating & Storage			P_C = 200 mw	

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			Min.	Max.
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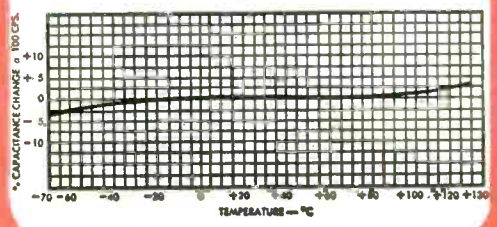
0.27	.400 x 1-3/8
0.47	.500 x 1-1/4
1.0	.562 x 1-5/8
2.0	.750 x 2-1/8

TYPICAL CAPACITANCE VS. TEMPERATURE



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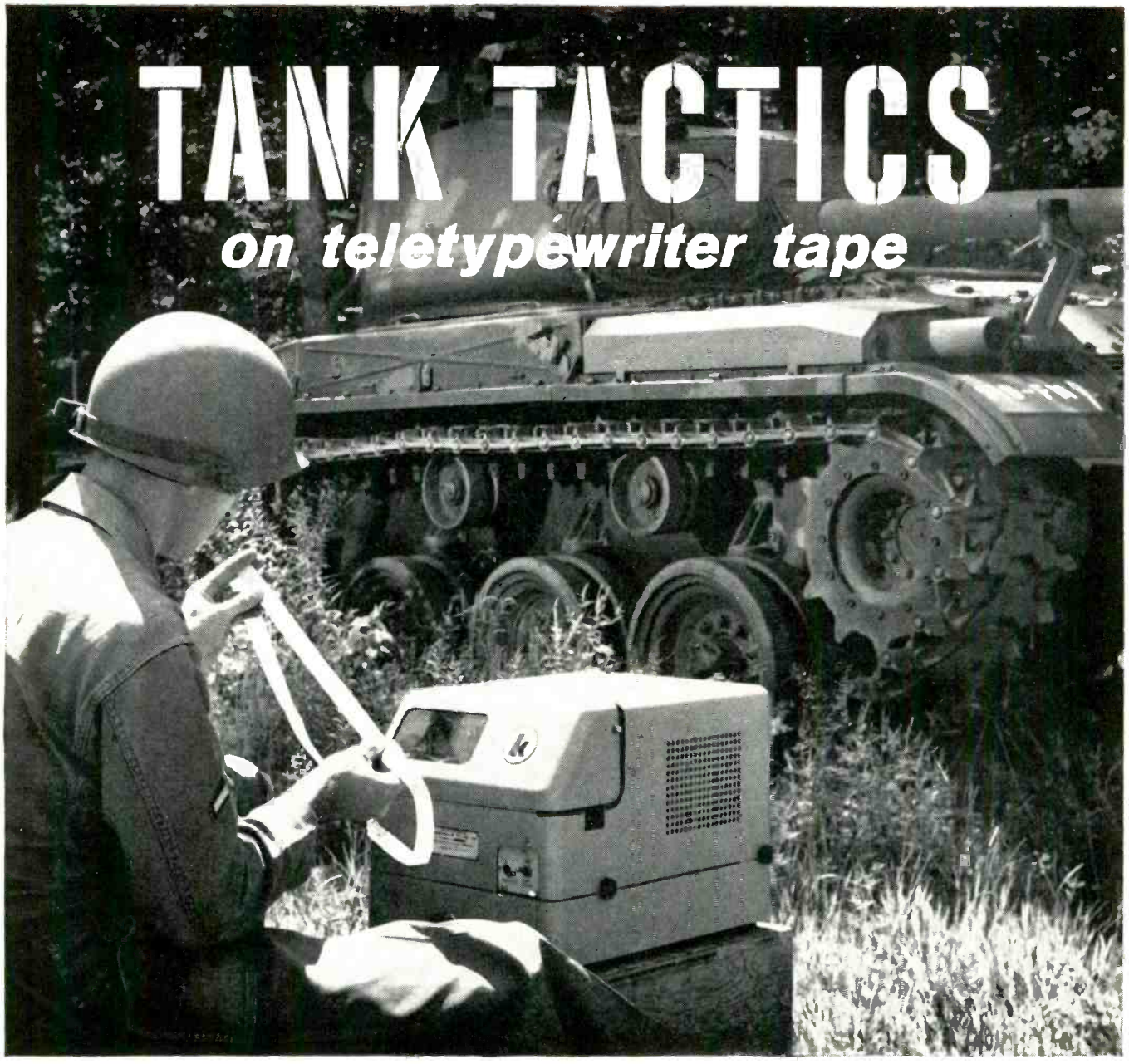

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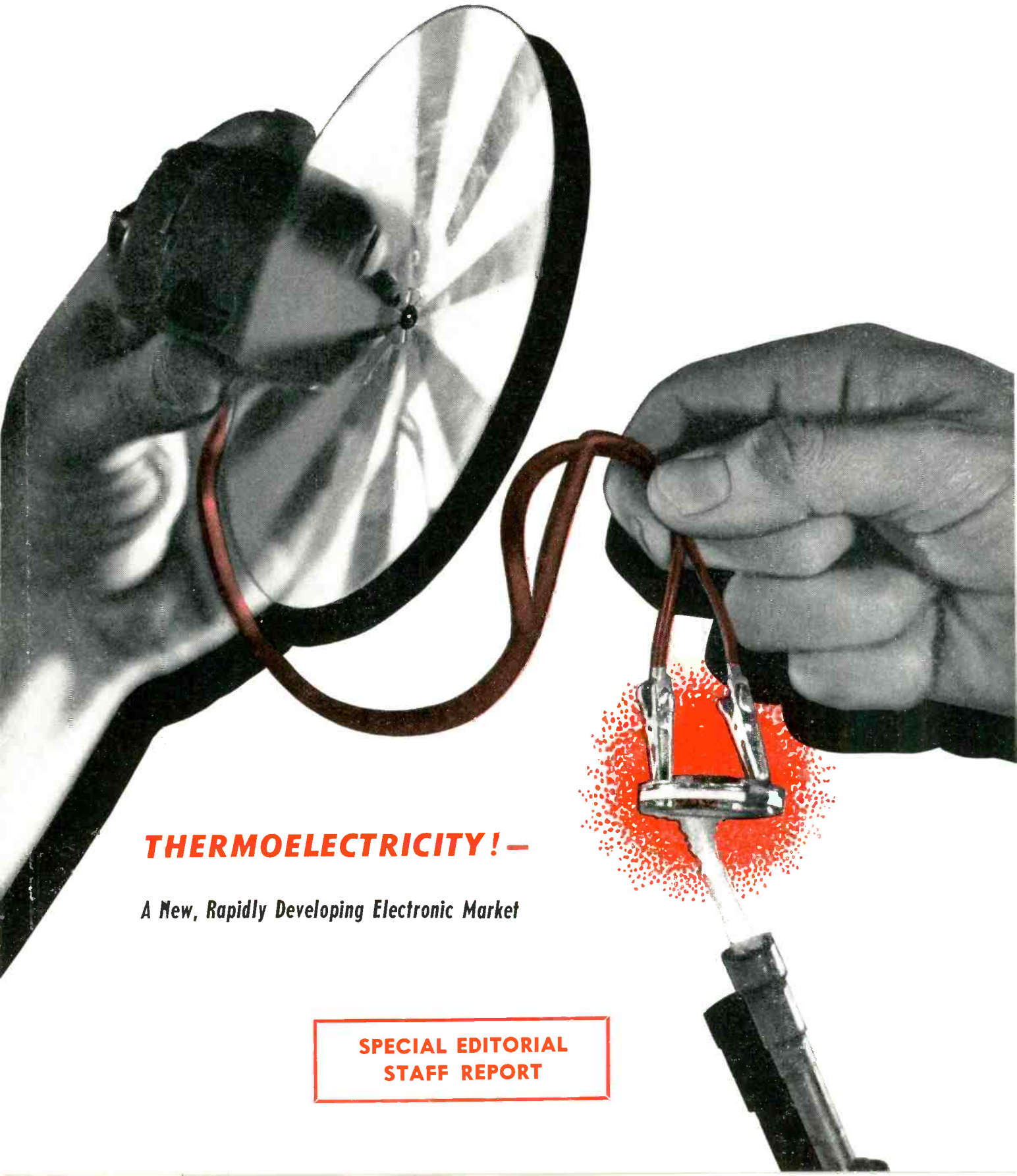


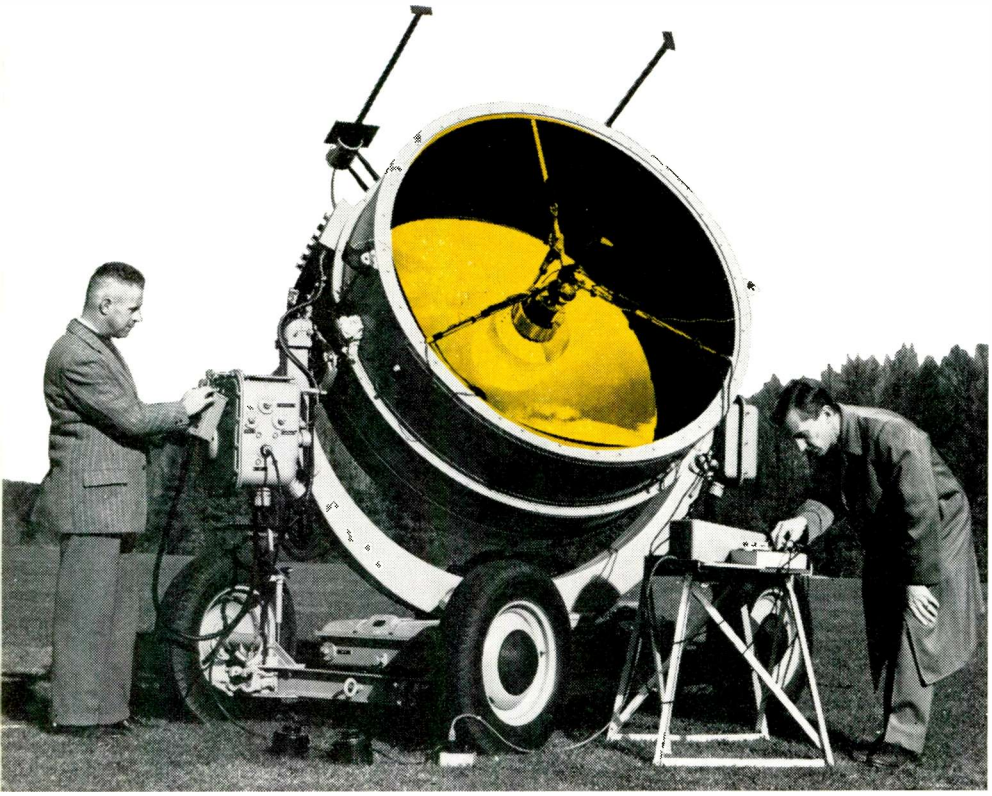
THERMOELECTRICITY! —

A New, Rapidly Developing Electronic Market

SPECIAL EDITORIAL
STAFF REPORT

The century-old thermoelectric principle is no longer a curiosity relegated to the back of the physics books. New materials and methods of fabrication are producing laboratory devices which prove the feasibility of thermoelectricity for power generation and cooling. Readily adapted to a host of new situations, the devices may furnish auxiliary power for satellites, control the temperature of critical electronic equipment, or efficiently utilize "unconventional" power sources such as solar and nuclear energy.

THERMOELECTRICITY— State of the Art



By CHRISTOPHER CELENT
Assistant Editor
ELECTRONIC INDUSTRIES

Fig. 1: K. G. Hernqvist (right) and F. H. Corregan (left) test RCA's experimental thermionic generator in a solar furnace at the David Sarnoff Research Center, Princeton, N. J. The device converts heat to electricity without moving parts.

THE practical, direct conversion of heat to electricity is approaching reality. Research on thermoelectric materials and the fabrication of the materials into working devices has progressed to a point where many scientists are predicting devices which could be competitive with some commercial devices within a couple of years. Already these devices are considered practical by the military for equipment in which reliability, ruggedness and simplicity are prime considerations. Government support for the program, already substantial, is expected to increase. Electronic Industries presents here a brief outline of thermoelectricity, some of the problems involved in building these new devices, and the work being done by a few of the larger companies having thermoelectric research programs.

Thermoelectricity

There are essentially three interrelated thermoelectric effects: the Seebeck, Peltier, and Thompson effects.

The Seebeck effect describes the voltage produced in a loop of dissimilar conductors when the junctions are maintained at different temperatures.

The Peltier effect is based on current considerations and refers to the heat absorbed or given off at the junctions when an external source is used to send current through the loop.

The Thompson effect says that when an electric current is passed between two points of a homogeneous conductor having a temperature gradient there is a net absorption or generation of heat in addition to the Joule heat. Since the Thompson effect is usually small compared to the others, it is generally disregarded in thermoelectric considerations.

Although these principles have been known for quite some time, (Seebeck effect in 1821, Peltier effect in 1834) there has been little application except for precise temperature measurements. The efficiencies of known materials were too low for practical applications and the development of electromagnetic machines diverted attention from thermoelectricity for power generation.

The Russians included a program of thermoelectric generator and refrigerator development in their first 5 Year Plan. Published Russian literature and first-hand reports indicate they have had considerable success in developing devices. One, a kerosene powered generator for powering radio equipment, seems particularly adapted to conditions in the more remote sections of the U. S. S. R. A book written by a prominent Russian scientist, Prof. A. F. Joffe,

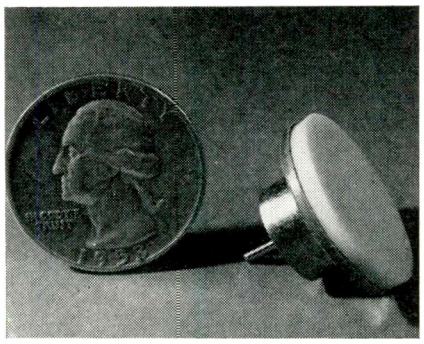


Fig. 2: High vacuum thermionic converter has special ceramic insulators developed by the General Electric Co. Coefficient of expansion of metal and ceramic parts are the same. Device operates from any heat source, nuclear or conventional.

"Semiconductor Thermoelements and Thermoelectric Cooling," is referred to by many in the U. S. as the "Bible of Thermoelectricity."

The thermoelectric value of a substance depends on three material properties: The Seebeck Coefficient (formerly thermoelectric power), expressed in volts per degree K, the specific electrical resistivity, ρ, in ohms-cm, and the specific thermal conductivity expressed in watts/cm deg K. These are not absolute values but are functions of the temperature. Fig. 13.

The three characteristics are combined to give a "figure of merit," $Z = \frac{S^2}{\rho K}$ for thermoelectric materials, which is a rough comparsion of the relative value of the material for Peltier cooling and for power generation. Both the efficiency of a thermoelectric power device and the Coefficient of Performance (COP) for a Peltier refrigerator are also functions of the Carnot efficiency so the temperatures of the

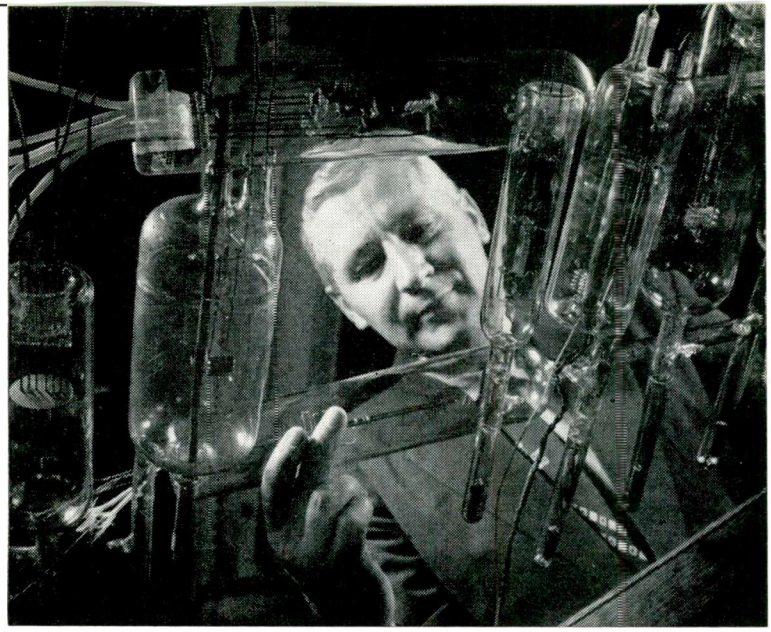
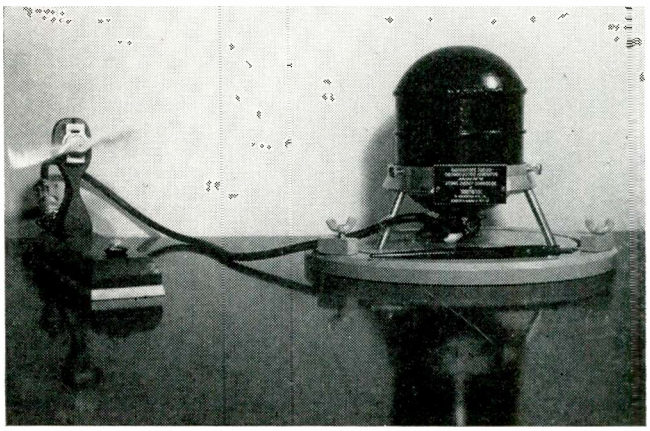


Fig. 3: Dr. Volney C. Wilson, G.E. physicist, inspects one of the experimental thermionic converters he developed. Research aims at efficiencies of over 30% for these devices.

hot and cold junctions are significant. A high value of Z is usually considered necessary for high efficiency.

A high value of Z requires a high value of S and low values of ρ and K. S is obviously an important variable since it is present in the second power, however various techniques have been developed, such as doping, which have produced materials with a relatively high value of S. On the other hand, not too much is known about the mechanisms of thermal conductivity and this factor remains the toughest single variable to adjust. S, ρ, and K are not independent properties; each is related by more fundamental parameters. In an oversimplified picture, they are all related to the number of free electrons. The thermal conductivity is related by the fact that part of the heat is carried by the free electrons and part by vibrations of the crystal lattice. The electronic part of thermal conductivity is inseparably related to the electrical conductivity by the well known Wiedmann-Franz relationship so that both increase in the same manner with increasing number of free electrons. A large thermal emf is associated with a large change in entropy with temperature.

Fig. 4: SNAP 111, Produced by Martin Co. under the A.E.C.'s Systems for Nuclear Auxiliary Power Program, can deliver more power in 280 days than 1450 lbs of conventional batteries.



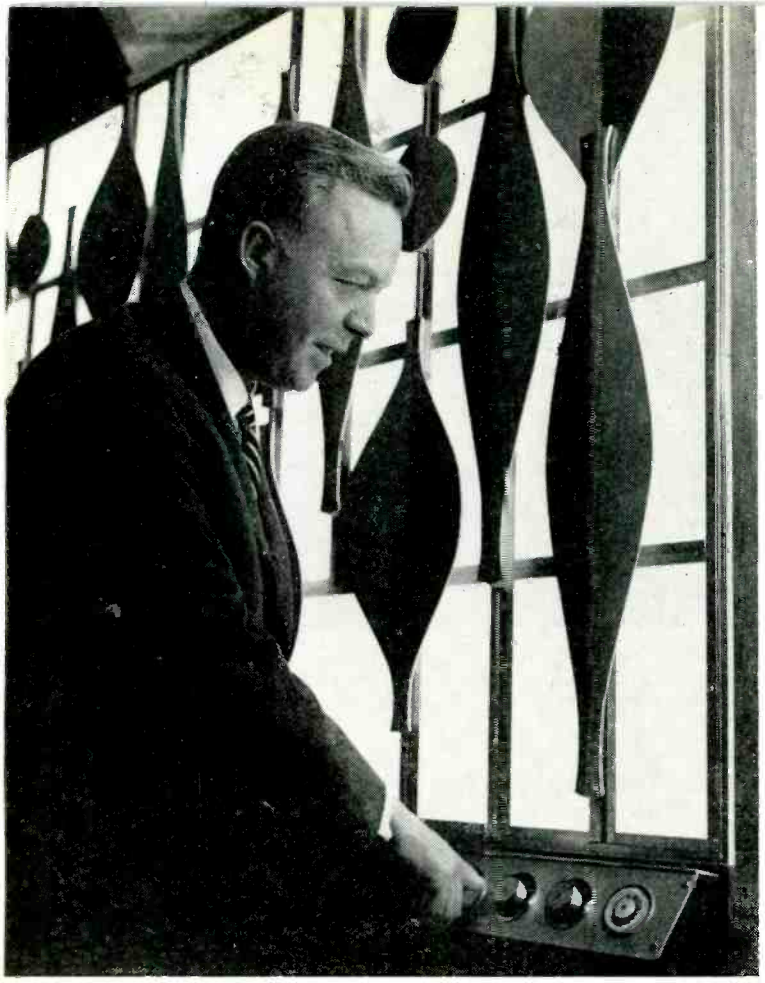


Fig. 5: Chris J. Witting, V.P. of the Consumer Products Group, Westinghouse Electric Corp., adjusts controls on a hot-cold-light panel. "Mobile" is an electroluminescent screen incorporating thermoelectric heat control from 55° to 120° F.

Thermoelectricity *(Continued)*

Some semiconductors such as bismuth telluride and alloys of zinc antimonide and bismuth antimonide have been developed which have relatively high thermal emf's and have moderately low electrical resistivity and thermal conductivity. The properties vary depending on the temperature range. Some semiconductors seem to be efficient enough to offer promise for thermoelectric refrigeration and for low temperature thermoelectric power generation however with many their efficiency drops off at elevated temperatures which limits their applications in power generation.

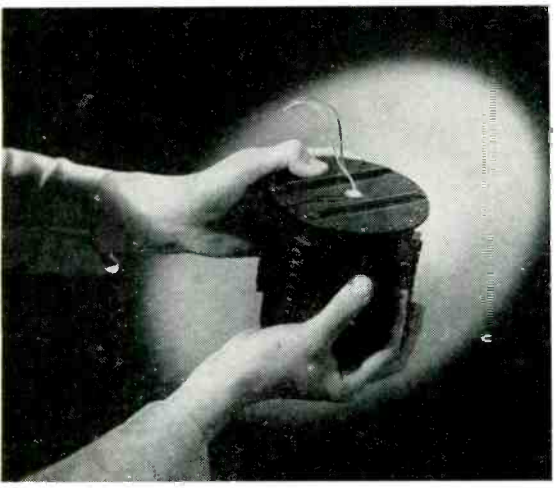


Fig. 6: 5 watt TE generator built by Minnesota Mining and Manufacturing Co. is about the size of a qt. fruit jar. Efficiency is about 6%. Cooled by air it uses an isotope heat source. Semi-conductors used here are in pilot plant production.

Transition Metals

Scientists at the Westinghouse Research Laboratories have been investigating a class of materials which theoretically offers efficient thermoelectric power generation operating in the 2000°F range. With these materials they have reported efficiencies in the neighborhood of 10% and they anticipate eventual efficiencies in the 20% to 30% range.

These materials, the "transition metals," are a group of elements lying near the center of the periodic table. They include such common metals as manganese, iron, copper, and nickle. The particular family which shows great promise is the mixed valence compounds of the transition metals. These compounds are characterized by the presence of ions of the same transition metal with different degrees of electrical charge.

Several possibilities exist for the improvement of materials besides the doping for optimum Seebeck coefficient already mentioned. One is the improvement of crystal structure. A second possibility is the use of alloying additions to reduce the lattice component of thermal conductivity. The composition of the thermoelement from one end to the other could be varied to secure optimum conditions at both the hot and the cold junctions. A fourth possibility is to use liquids as thermoelectric materials either by carrying known materials beyond their melting points or by searching for special liquid materials. Liquids, properly encapsulated, may be able to operate at higher temperatures than solids.

The major effort in thermoelectric research has been aimed at improving known materials and searching out promising new ones. One approach has been to learn more about the mechanism of electron motion so that by proper doping S and ρ may be more closely controlled.

Once good materials become available, it becomes necessary to learn the techniques of preparing the material in commercial quantities. A thorough study of junction fabrication is also necessary to reduce such problems as contact resistance.

The research programs have produced a number of working devices. Some of these devices have been demonstrated publicly. The electrical and physical characteristics of a few of these devices are listed in table 20.

The Thermionic Converter

The thermionic converter is similar in some respects to the vacuum tube diode. The cathode here is the hot junction; the anode is the "cold" junction. The interelectrode space is a vacuum or is filled with a gas at low pressure.

Heat applied to the cathode lifts electrons over the work function barrier at the cathode surface. The electrons travel through the interelectrode space and fall down a lower anode work function barrier. If the anode and cathode are connected by an external circuit, the difference in potential can be made to do useful work. The potential energy of the electrons at the anode is the contact difference of potential.

For high efficiency thermionic devices, the space-charge effects must be reduced or overcome and the

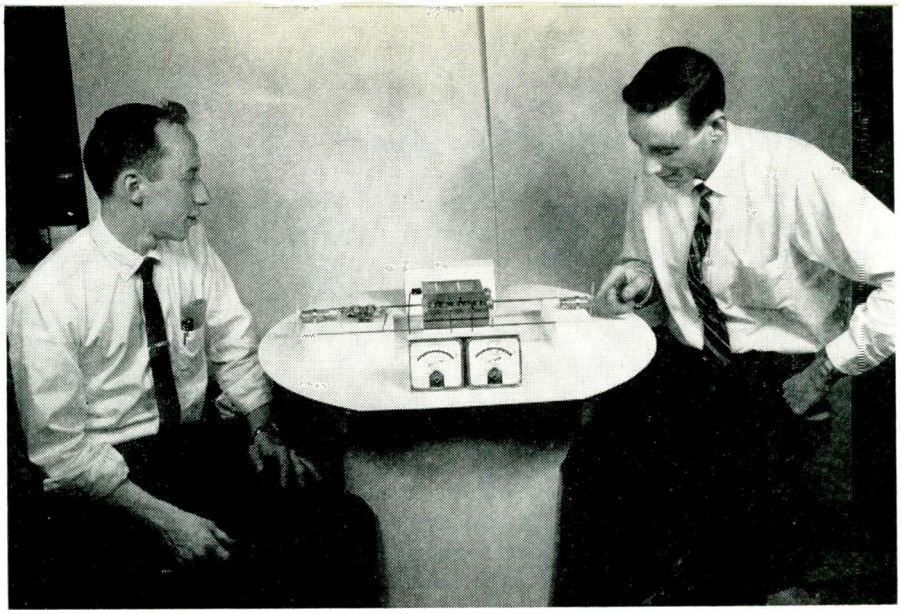


Fig. 7: A 150° F temp. difference produces several amps at ½ v with this generator built by the Delco Radio Div., General Motors Corp. It has 20 bismuthtelluride elements.

difference between the high work function of the cathode and low work function of the anode must be significant. The spacing of the electrodes gives the thermionic device an advantage by reducing the thermal conductivity problem. The anode of course, must be cooled to remove the heat resulting from the electron energy drop and to prevent emission or back current.

Several methods have been proposed for reducing the space-charge problem. A thermionic converter built by Dr. J. E. Beggs of the General Electric Research Laboratories has electrodes spaced less than 1/1000 in. apart which markedly reduces the space charge effect.

A second method involves introducing an accelerating force in the interelectrode space which forces the electrons to move to the anode. It involves a high voltage source and a magnet which are not power consuming, however at high emission current densities, impractically high voltages and magnetic fields may be required.

A third technique neutralizes the space-charge effect with positive ions. A thermionic device developed by Dr. Volney C. Wilson of the G. E. Laboratory uses cesium gas in the interelectrode space. The cesium vapor partially ionizes and neutralizes the space charge effect. In addition, the cesium coats the electrodes favorably affecting their work functions. Another experimental device using this technique is described in the June 1958 issue of The RCA review.

The U. S. Government through the Military agencies and the Atomic Energy Commission is giving substantial support to research on materials, methods, and device development. The present military support is estimated at around $3,000,000. As the program gains momentum the support will probably increase. It is expected to be around $40,000,000 in 1961. Today there are over 80 companies promoting study in the field. Many of these companies while supporting the programs of such non-profit organizations as The Franklin Institute in Philadelphia and Battelle Memorial Institute, have no separate effort of their own.

The A.E.C.

Since 1956 the A.E.C. has had a development program pointed toward simple, long-lived nuclear powered generators. The two main areas of investigation are: the nature of the nuclear heat source and the thermodynamic conversion system necessary to convert the heat to useful energy.

Besides substantial support for fundamental work on materials and for solid state research, the AEC has let a number of contracts for working devices. A thermoelectric generator, built by the Martin Co. with thermoelectric materials supplied by the Minnesota Mining and Manufacturing Co., is one such device. The SNAP III device used polonium—210 as a heat source.

Polonium-210 was used because of the very low gamma radiation associated with its radioactive decay and because of its immediate availability. Other isotopes are being developed, Cesium-144 for example, which will provide longer life, greater efficiency, and a lower weight per output ratio.

Radiation damage studies are being made at both Oak Ridge and at Los Alamos. A device has been produced at Los Alamos which utilizes uranium carbide as a heat source. One element of the thermocouple is ionized cesium gas (plasma). With a 2 sq. cm. surface, the device developed an open circuit voltage of 3.8 v.

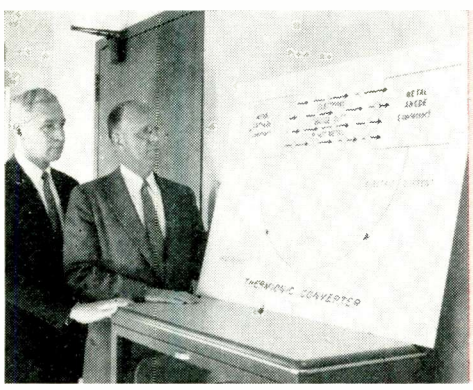
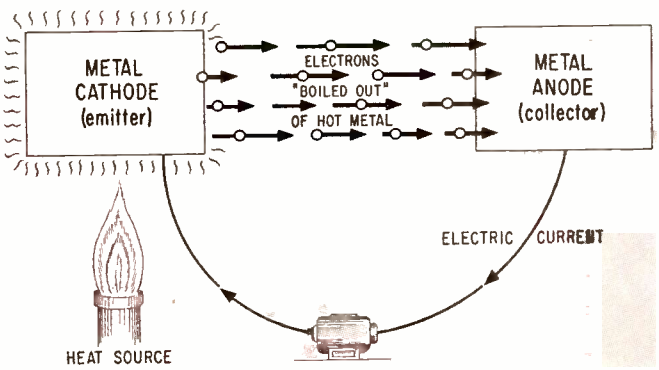


Fig. 8 (left): Dr. V. Wilson (left) and Dr. Guy Suits, G.E. Vice President and Dir. of Research, inspect chart, Fig. 9 (right) depicting operation of the thermionic converter. Operation is similar to a vacuum tube diode. Ionized cesium gas helps reduce the space charge.



Thermoelectricity *(Continued)*

and a short circuit current as high as 120 a. The laboratory predicted that a research reactor using a device of this type could be in operation within two years.

Naval Research Laboratory

The NRL is concentrating on providing services for other groups and filling gaps in the overall government program. They are working on establishing reliable measurement techniques to verify the properties of materials developed at various activities. Among their projects is the construction of a research instrument for careful measurements of thermal conductivity. A simple, rapid comparator has been constructed which matches unknown materials against a carefully measured specimen.

The Laboratory is providing valuable information service work. Included are quarterly reports on the "state-of-the-art", and the assembly of a complete bibliography on thermoelectric development.

Curtiss-Wright

The company has a research program on thermoelectric materials guided by M. Telkes who is extending her previous work on materials.

General Motors Corp., Delco Radio Div.

The company is engaged in long-range research and has developed an experimental unit using thermoelectric elements developed by Merck & Co. The thermoelectric generator was displayed at the "World Congress of Flight," at Las Vega, Nevada, April 12, 1959. See Fig. 7.

Nortronics

The company is developing low capacity Peltier devices, and continuing materials studies in connection with the development of a device of demonstrated utility for cooling infrared detector cells.

Westinghouse Electric Corp.

Westinghouse has one of the largest privately supported thermoelectric research programs in this country, in addition to a very large government supported effort. Included are basic research and a wide range of material and device development for both refrigeration and power generation.

Fig. 10: Ceramic-type thermoelectric materials are prepared by Westinghouse in this special furnace (on a laboratory scale). Materials could operate in the 2000° to 3000° F range.

Dr. Maria Telkes is often credited with "kicking off" the thermoelectric program in the U. S. with her work at Westinghouse in the 1930's. Using a zinc-antimony and lead sulfide pair, she observed efficiencies ranging from 7 to 10% in the 70°F to 800°F temperature range. Her experiments were the first to use semiconductors for this purpose, although they were not then known as a separate class of material.

Westinghouse is investigating three main categories of thermoelectric material: semi-conductors, metallic compositions, and mixed valence compounds. One semiconductor material, indium arsenide phosphide, was recently described by Dr. R. Bower, Westinghouse research physicist, in a paper before the American Physical Society at M.I.T. This three element compound has good thermoelectric properties in the temperature range between the ranges where conventional semiconductors and the high temperature operating mixed valence compounds operate most favorably.

Mixed valence materials development stemmed from a theory advanced by Dr. C. Zener of the Research

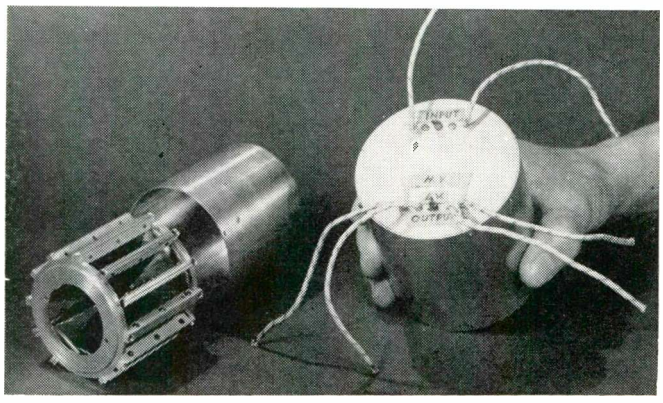


Fig. 11 (left): Close-up view shows construction of a 50 mw thermonuclear generator developed by Mound Laboratory for the U.S. Signal R&D Labs., Fort Monmouth, N. J.

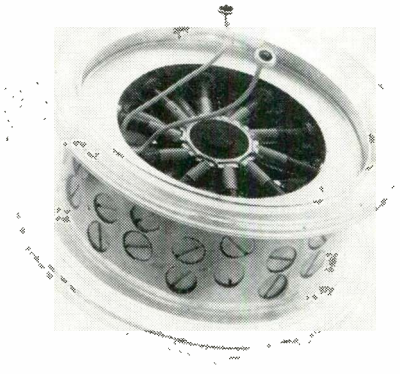


Fig. 12 (right): Thermonuclear generator. Heat producting elements are in the center. Thermoelectric elements radiate from the center like spokes on a wheel.

Laboratory to help explain the atomic structure of the so-called transition metals. Further study led to the investigation of the unique electrical properties of the mixed valence compounds of the transition metals. Research is continuing on such mixed valence crystals as lithium doped nickel oxide. A mixed valence material which will operate at reasonable efficiences up to at least 1500°C is predicted.

Dr. Robert Heikes who is heading the group working on mixed-valence compounds is scheduled to deliver a paper, "Materials for Thermoelectric Applications," at the Technical Conference on Elemental and Compound Semi-conductors (The Metallurgical Society of AIME) at the Statler Hotel in Boston, Aug. 31, 1959.

Mixed valence materials offer several advantages. They are in abundant supply, the cost is relatively low, thermal stability is good and the materials are relatively insensitive to radiation damage or to poisoning by trace impurities. The materials do not require preparation to extremes of purity.

Consumer type devices are being developed. A thermoelectric refrigerator was recently demonstrated and several devices like bottle warmers, thermoelectric controlled blankets and combination heating, cooling, and lighting panels have been advertised as probable applications of the principles. See Fig. 5.

A considerable variety of other materials have been studied and many of them have been subjected to considerable development. Some materials surveyed to a point of definite conclusions are listed in Table 1. Other materials subjected to a more thorough development are presented in Table 2. See Fig. 24.

Westinghouse was recently awarded a contract by the U. S. Navy to design, construct, test, and furnish a 5 kw thermoelectric generator. Although intended primarily as a small-scale prototype of a shipboard installation, it may be used directly as a movable or a portable power source. The heat source will use one of the standard Navy fuel oils or diesel oil. The cold junction will be maintained with a heat converter using either fresh or sea water.

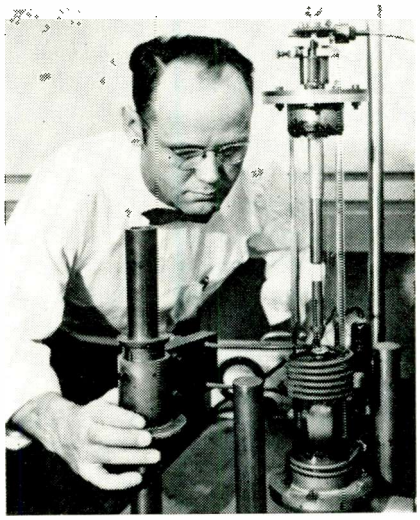


Fig. 13: Research scientists at the National Bureau of Standards use this furnace to grow large single crystals by the Kyropolos technique. The crystals are used to study the thermoelectric (and other) properties of materials.

National Bureau of Standards

To help solve the problems posed by semiconducting materials and provide data for their effective application, the Bureau conducts a program of solid state research sponsored in part by the Dept. of Defense. The program deals with the electrical, thermal, optical, mechanical and magnetic properties of the materials, either separately or in combination. Such studies allow the potentialities of a material for practical application to be evaluated.

The interest in thermoelectricity has stimulated the study of oxide semiconductors, especially oxides of the transition metals. Titanium dioxide was chosen as a prototype of this class and also as an example of a high-temperature semiconductor.

The program of research on the materials includes: crystal growth and sample preparation (See Fig. 13), measurement of electrical properties, including conductivity, Hall effect, magnetoresistance, and thermoelectricity, and further development of solid state theory.

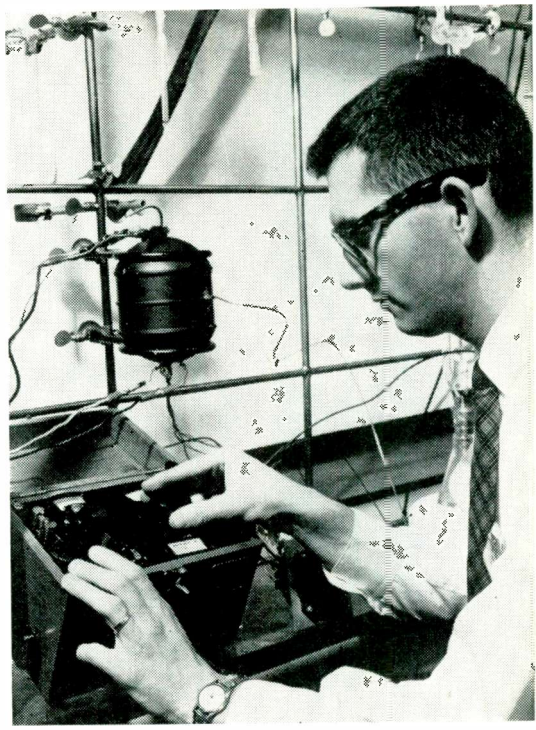


Fig. 14: Engineer at the Martin Co., Nuclear Div., tests radioisotopic "battery" which won 1958 Miniaturization Award sponsored by Miniature Precision Bearings Inc. The Martin Co. is working on a 100 watt generator which will use strontium-90.

General Electric Company

Work is being done on thermoelectricity in three main laboratories of the GE Co.: the Research Laboratory, Schenectady; the General Engineering Laboratory, Schenectady; and Electronics Laboratory, Syracuse. The Company is working on both thermionic and thermoelectric devices.

Under study are metallic alloys and hydrides; borides, carbides, and nitrides; oxidic semi-conductors; intermetallic semiconductors, and liquid semiconductors, junction applications and generator design.

GE scientists are attempting to expand the list of material parameters which can be expected to have an effect on thermoelectric efficiency. They have added to the list such properties as: optimum band gap as determined by ambipolar heat conductivity, atomic mass fluctuations, and melting points.

The Electronics Lab has developed a high tempera-

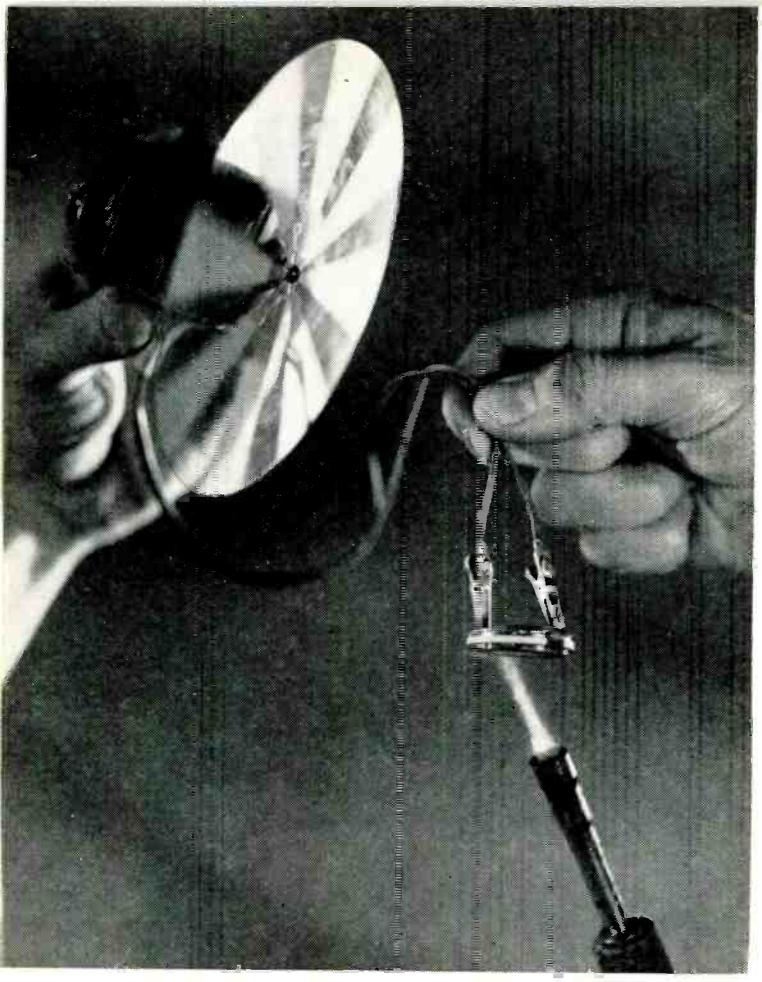


Fig. 15: Thermionic converter drives a small motor. Converter employs special cathode and anode materials which have appropriate "work functions". Electrodes are about 1/1000 inch apart. General Electric Research Laboratory.

Thermoelectricity *(Continued)*

ture thermal diffusity apparatus for Army Ordinance which promises to yield valuable data on thermoelectric materials.

In connection with the work, a valuable study is in progress on encapsulation. The study is an outgrowth of previous successful development of high temperature ceramic vacuum tubes using Fosterite and related mineral materials for the cylinder walls. Encapsulation is obviously necessary for liquids and may also be necessary for solids to prevent oxidation and to inhibit evaporation at high temperatures.

The encapsulation program has produced at least one very important result. A considerable improvement in performance was found at higher temperatures over the performance predicted from extrapolation of available data to higher temperatures.

The government-supported work on thermoelectric power generation at G.E. has some special requirements. The heat must be removed by radiation into the air or upper atmosphere as would be expected in space vehicles. This imposes special design problems, and calls for rather unusual characteristics in the material. The weight and size of the radiating element frequently determines the size of the system. In this application output for a given weight or given size generator will not coincide with the maximum efficiency that can be achieved.

With respect to materials development, the G.E. program has shown that Z ($S^2/\rho K$) may not always be a useful guide. Using hypothetical examples, it has been shown that high thermal conductivity may be more favorable than low thermal conductivity in some situations. The cataloging of materials requirements for various design situations is an important project of the G.E. Labs.

The Schenectady Lab., recently announced the development of several "thermionic" converters. One device developed by Dr. Volney C. Wilson of the G.E. Laboratories, has cesium vapor in the space between anode and cathode. When the gas partially ionizes, it neutralizes the space-charge that would otherwise block the flow of electrons from cathode to anode. The cesium also coats the electrodes, affecting their "work functions"—the amount of energy needed to free the electrons from the surface of the material.

A thermionic converter built by James E. Beggs, also of the GE Laboratories, has flat discs spaced less than 0.001 of an inch apart. A vacuum is maintained in the space between the electrodes. The extremely close spacing helps solve the problem of the space-charge effect. This converter will operate at 1500°F, compared to 3000°F for the gas-filled type, making material requirements easier to meet. A special ceramic insulator having the same coefficient of expansion as the metal parts was developed so that the tube would not crack apart when heated.

Efficiency of the gas filled converter is about 8%. Efficiencies of 30% and better, depending upon the details of particular design, are expected.

The General Electric Atomic Power Equipment Department (APED) has completed an experiment with a thermionic converter using a radioisotope heat source. Gold was used as the radioactive source material. The converter was designed primarily for space vehicle auxiliary power applications. The experiment indicated an extremely high power to weight ratio potential. A power pack generating 100w, lasting more than a year, and weighing less than 25 pounds is possible with this system. The device operated at temperatures up to 1700°F on the "hot side" and 800°F on the "cool side."

The experiment demonstrated the ability of a thermionic converter to operate under the conditions actually encountered in a space vehicle such as a high vacuum, high temperature, and under gamma radiation. With further development, a multi-hundred watt, radioisotope thermionic converter could be ready for use in one to two years.

Dr. W. J. van der Grinton of GE points out in a paper delivered at the IRE Convention last March that some of the limitations due to temperature may be removed by combining thermionic and thermoelectric elements in a single converter—thermionic at the hot end and thermoelectric at the relatively cooler end.

Some conclusions of GE: optimum performance of a single material cannot be expected to cover a wide temperature interval and the narrow temperature interval of best performance is likely to fall close to the melting point of the material if it is truly optimized. Intelligent cascading or segmenting of ma-

terials on the other hand will yield optimum efficiency, heavy atoms and large atomic mass fluctuations among the major constituents of the material are preferred.

Minnesota Mining and Manufacturing Co.

MMM has been active in the development of thermoelectric material since 1950. Activity has been devoted to materials, joining, designing and testing of prototype thermocouple devices for practical applications employing temperatures up to 900°K.

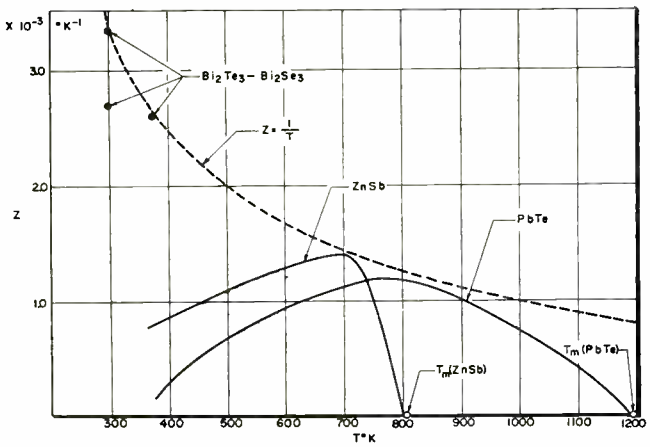
The company's activities include the theoretical treatment of thermoelectric phenomena. Surveys of materials have been made in which intermetallic compounds and alloys have been produced, evaluated for thermoelectric properties, and adjusted by modifications of compositions to improve the figure of merit for the various temperature ranges encountered in practical device design. Alloys have been examined for compatibility with the chemical properties of semiconductor elements. Thermocouple elements have been tested, under operating conditions, for service life. Sublimation, creep or plastic flow and compound decomposition have been studied. Processes and equipment are being developed for volume production of dimensionally and electrically reproducible thermocouple components.

The company has made available two intermetallic compound systems, and several thermoelectric generators are in production. These generators, listed in Fig. 20, are primarily demonstration and study models. The company is planning to introduce several additional models, including some having commercial applications during 1959. The new units could conceivably range in power from ½ w. to several thousand watts.

The company produced the doped lead telluride thermoelectric elements used by the Martin Co. in the SNAP III, a proof of principle device produced for the AEC. This device, demonstrated by the AEC on January 13, 1959, uses Polonium-210 as the central heat element. See Table 20.

A furnace device built by a manufacturer of gas heating control devices from thermoelectric elements supplied by 3M has been in operation for over 5 years presenting tangible evidence that thermoelectric devices can be maintenance free for long periods.

Fig. 16: "The figure of merit is temperature dependent. The narrow interval of best performance may fall close to the melting point (T_m) if the material is truly optimized," G.E. Company.



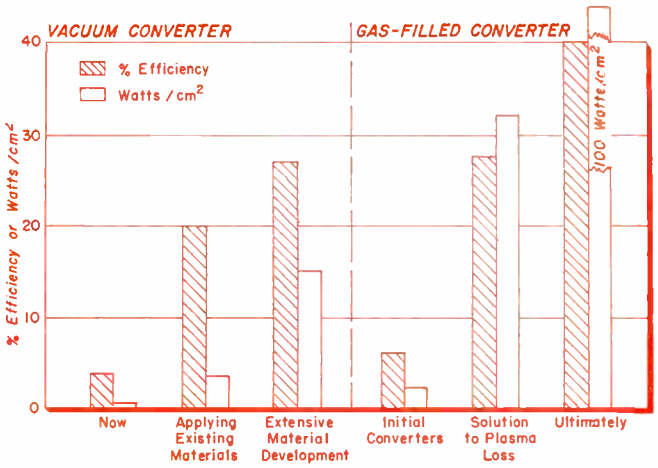


Fig. 17: The substantial research efforts of companies like General Electric (chart by Dr. Wilson of G.E.) indicate the "ultimate" column is feasible. At 40% efficiency, thermionic devices could effectively compete with conventional equipment.

Radio Corp. of America

RCA has a thermoelectric program at the Sarnoff Research Laboratory under Dr. Fred Rosí. Until recently the work was directed almost exclusively toward refrigeration materials, particularly bismuth telluride. Emphasis has been on alloying to produce three and four element materials. The results include the largest reproducible temperature drop reported (65° C from room temperature and 68° C by grading). Recent work on other materials has been in the field of 111-V semiconductors. Dr. Linnenblad at the Princeton Laboratories is working on device problems especially on the problems connected with consumer type equipment. RCA has built a full-size refrigerator and a variety of cooling panels.

The company recently received government sponsorship (Bureau of Ships and Air Force's Aeronautical Research Laboratory) for research on materials in the 300° C to 1000° C range utilizing flame, solar, and nuclear heat sources.

A thermionic device, produced by the laboratory is shown in Fig. 1. Here the fuel source is concentrated solar heat.

RCA recently started production and sale of thermojunctions for cooling and/or heating applications.

Merck & Co.

This company has sponsored research in thermoelectric materials for several years.

A process has been developed for the large scale production of n and p type bismuth telluride for thermoelectric cooling and power devices operating at temperatures between 250° K and 350°K. The process, now operating on a pilot plant scale, has a capacity of about 50 kg. per month. Materials produced are rods with a diameter of 10 to 20 mm. A maximum temperature difference of 65° C measured between the hot and cold junctions of a thermoelectric couple made from Merck material leads to a calculated figure of merit of 1.85×10^{-3} per degree C with a hot junction of 330° K.

Merck is also developing processes for the large scale production of lead telluride, lead selenide, and alloys of these two compounds as well as for the production of ternary alloys of bismuth telluride itself.

Thermoelectricity *(Continued)*

The lead compounds are being developed for power generation devices operating at intermediate temperatures 300 to 900° K. Both n and p types are under study. These materials will be available in research quantities shortly.

The company is doing basic research in new compositions in an attempt to achieve a further improvement in the figure of merit. New materials are being studied for the 200° to 1000° K temperature range.

The company supplied the thermoelectric materials for the device demonstrated at the World Congress of Flight April 12, 1959, by the Delco Radio Div., General Motors Corp.

Servomechanism Inc.

Extensive work on high temperature electronic components led this company into a thermoelectric research program. The company had developed facilities for refractory materials preparation and property measurements. A particular skill in hot pressing techniques has been combined with a chemical method for controlling very precisely the stoichiometry of oxides. Work has begun on a new area of materials which indicate promise for thermoelectric development. Some proprietary materials are promising in the 1200° to 1300° F range.

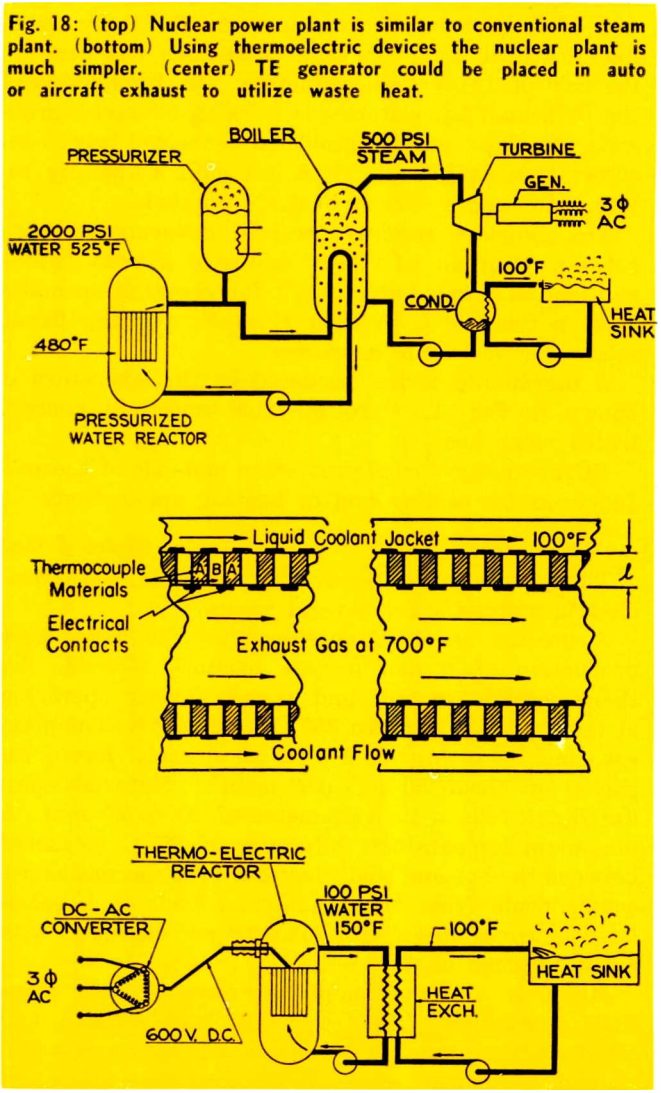


Fig. 18: (top) Nuclear power plant is similar to conventional steam plant. (bottom) Using thermoelectric devices the nuclear plant is much simpler. (center) TE generator could be placed in auto or aircraft exhaust to utilize waste heat.

Whirlpool Corp.

Whirlpool Corp. engineers, concentrating on material evaluation and device consideration have thoroughly analyzed the materials requirements for a wide range of refrigerating systems.

They conclude generally that substantial improvements over existing materials are required to make Peltier cooling competitive with most commercial devices. For room panel cooling and special applications not particularly suited to mechanical systems the prospects are somewhat better.

Whirlpool Corp. and the Franklin Institute have developed a successful laboratory item which closely controls liquids below room temperature. The equipment may be used for physical tests such as in ASTM procedures.

Franklin Institute, Laboratories for Research & Development

The Franklin Institute started working on thermoelectricity early in the 1940's. Despite significant advances in technique and theory, the Institute was unable to enlist substantial support for its program at that time.

Some sponsors of the present program are: Admiral Corp., Amana Corp., American Standard Corp., Borg Warner Corp., Carrier Corp., Chrysler Corp., E. I. duPont de Nemours, Fedders Corp., Frick Co., General Motors, Philco Corp., Rheem Mfg. Co., A. O. Smith, Inc., Texas Instruments Incorporated, Whirlpool Corp., Consolidated Mining & Smelting Co. of Canada, Ltd., Electrolux (Sweden), Eastern Industries, Inc., and Linde (Germany).

The program specifically stays away from device development and concentrates on looking for good thermoelectric materials, especially materials for Peltier cooling. The program aims at extending Thermoelectric theory, especially the mechanisms involved in electron motion. The institute is working on instrumentation for the measurement of parameters and also for the preparation of alloys. They are developing special metallurgical and semiconductor techniques for working in this new field.

Bell Telephone Laboratories

The Bell Labs are currently engaged in an exploratory development program in the field of thermoelectric refrigeration. The work thus far has been confined to an investigation of improved materials and the use of these materials in small refrigeration devices for electronic components. None of the devices are in the design stage.

Two Bell scientists, Dr. J. H. Wernick and B. Wolfe, working on thermoelectric materials development looking for improved type devices which could be very useful for cooling electronic components. J. H. Wernick is to deliver a paper "New compound Semiconductors" at the AIME Technical Conference on Elemental and Compound Semiconductors Aug. 31, 1959.

The Laboratories have developed a thermocouple device to power transistor-type amplifiers at remote

relay stations. The device, a mat of dissimilar strands of metals in a glass fibre warp forming a string of series connected thermocouples, has very low efficiencies but is practical since the power requirement is low and the device needs little maintenance.

The Martin Co.

The Martin Co. using lead telluride thermocouples produced by the Minnesota Mining and Mfg. Co. has delivered a proof of principal device to the AEC. The device, SNAP III, delivered to the AEC on 13 January 1959, uses polonium-210 as the central heat element.

Scientists from the company will deliver four papers on thermoelectricity at the June AIEE meeting in Seattle.

The company is at work on a 100-watt generator using the same basic principles as in SNAP III but the radioisotopic fuel will be Strontium 90. An advanced generator of this type, about the size of a kettle drum, could probably supply power for nearly a decade without refueling.

Monsanto Chemical Co., Mound Laboratory

The Mound Laboratory makes sources of alpha particles and neutrons from polonium-210 for the AEC and for industrial and educational users. Original work on thermoelectricity was designed to demonstrate that nuclear heat could be used for this purpose. In 1957 the Laboratory contracted to supply a polonium-powered thermoelectric battery for the U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N. J. The device is listed in table 20. Mound Laboratories also supplied the polonium-210 for the SNAP III project.

Fig. 19: Powdery "mixed-valence" compounds are pressed into pellets for thermoelectric use. Materials are abundant, relatively inexpensive, and can be used at high temperatures. Westinghouse Electric Co.

Fig. 20: The units listed below are experimental. Our scientists disagree only on "when" they will be commercially practical. Thermoelectric generators less efficient than these are already being used in isolated areas of the U.S.S.R.

COMPANY	MODEL	POWER OUTPUT	VOLTAGE	NUMBER OF COUPLES AND THERMOELECTRIC MATERIAL	SIZE PHYSICAL	HEAT AND COOLING SOURCE	JUNCTION TEMPERATURES "HOT" JUNCTION	JUNCTION TEMPERATURES "COLD" JUNCTION	EFFICIENCY	REMARKS
Minnesota Mining & Manufacturing Co.	3M-1E	11 watt Matched load	3.25 V Matched load 6.5 V open circuit	27	6" x 6" dia.	Ceramic "S" Mantle burner Propane or Natural Gas Convective Air Cooling Fins	1100°F	200°F	6.0%	Demonstration & Study Study Model - generation from fluid fuels. Price $15,000
Minnesota Mining & Manufacturing Co.	3M-1F	11 watt Matched load	3.25 V Matched load 6.5 V open circuit	27	6" high 6" dia.	Electrical Cartridge heater, 110 V ac Convective Air Cooling Fins	1100°F	200°F	6.0%	Demonstration & Study Model - study of TE generator in combination with electrical loads. Price $15,000
Minnesota Mining & Manufacturing Co.	3M-1D	5 watt Matched load	3.25 V Matched Load	27	6" high 7 1/2" dia.	Electrical Cartridge heater, 110 V ac Convective Air Cooling Fins	Variable	Variable	5.0%	Demonstration & Study Model designed for ease of control
Minnesota Mining & Manufacturing Co.	Test Kit Model E-8	Variable	Variable	2	---	6 Volt Battery	---	---	---	Designed to demonstrate the principles of thermo-electric heat pump operation
Baso, Inc.	EX 70139-2	0.033 W Matched load	210 MV	P & N Load Telluride	0.6 to 2.5	Fluid fuels, nuclear heat, waste heat Air cooled	1200°F Max.	200°F to 350°F	Overall 1.0% (8% possible)	Experimental Model Available to Manufacturers
A.E.C.	Plasma Thermocouple	---	3.8 V open circuit 30-40 Amps Short circuit	Cesium Gas & Uranium carbide	About the size of a fruit juice can	Uranium carbide Fission Reactor coolant	---	---	----	Experimental device produced by the Los Alamos Laboratory & the Univ. of Michigan
General Motors Corp. Delco Radio Div.	---	---	0.5 V	20	Size of elements 1/2" dia. 1/2" long	---	150° Temperature Differential		---	Exhibited this year at the "Aord Congress of Flight"
The Martin Co. & Minnesota Mining & Manufacturing Co.	Snap III	5.3 W	3.0 V	P & N 27 doped lead Telluride	5# 5.5" high 4.75" dia.	Radioactive polonium - 210 3000 curies	1100°F	400°F	5.5%	Proof of Principle model produced for the Atomic Energy Commission Estimated values for full fuel load
U.S. Army Signal Research & Development Lab. Power Sources Div. Ft. Monmouth N.J.	---	150 watts at 28 V ± 10%	56 V max. open circuit 280 ± 10% operating volts matched load	---	1.3 ft3 (including fuel tank) 35# max. exclusive of fuel	Leaded gasoline fuel source	---	---	---	To be procured this year
Mound Laboratories Monsanto Chemical Co.	---	167 Mil'watts	23.6 V open circuit	18 thermopiles each having 37 thermocouples	---	880 curies of polonium - 210	---	---	0.57%	Constructed for the U.S. Army Signal Research & Development Labs.
Westinghouse Electric Corp.	---	5000 W	---	---	---	Diesel oil or some other standard Navy Fuel Sea or freshwater cooling	---	---	---	A small-scale prototype of a shipboard installation to be built for Bushps, U.S.N.
Ohio Semiconductors, Inc.	TA-11	Max Current Cooling & Heating 40 A		N & P Type Bismuth Telluride	2 5/8"x1 3/4" x 3/4"		Temperature diss. up to 70°C may be obtained			$\bar{z}$ (avg) = ...x10^{-3}K^{-1} For temp. control applications

CrB_2	− 2		21		(400° C)	(400° C)	(400° C)
MoB			50	$Bi_2(Te, Se)_3$ (N)	−210 (100° C)	1.05×10^{-3} (100° C)	0.016 (100° C)
MoB_2			22				
WB	− 5			$(Bi, Sb)_2 Te_3$ (P)	+195 (25° C)	9.0×10^{-4} (25° C)	0.0147 (25° C)
MnB		+ 5					
MnB_2		+ 2					

Thermoelectricity *(Continued)*

National Carbon Co.

The company, in addition to a regular program of thermoelectric research, is investigating carbon products that show particular promise and promising

Participants in the industry program are: American Motors Corp., Carrier Corp., Chrysler Corp., Controls Company of America, Fairchild Engine & Airplane Corp., Fedders Corp., General Dynamics Corp., General Electric Co., General Motors, Lockheed, The Martin Co., McGraw-Edison Co., Monsanto Chemical Co., North American Philips Co., Inc., Ranko, Inc., Robertshaw-Fulton Co., Tappan

Thermoelectricity *(Concluded)*

fessors Joseph Kaye and George N. Hatsopoulos who co-authored "Analysis and Experimental Results of a Diode Configuration of a Novel Thermoelectron Engine," Proceedings of the IRE, Sept., 1958, will be in charge of the program. New York University is also offering a one-week program in thermoelectricity this summer. The U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N. J., sponsored the 13th Annual Power Sources Conference in April of this year. The papers presented at the Conference will be published in September 1959. The Lab, under D. Linden, has an extensive program including devices using chemical, nuclear, and solar heat sources.

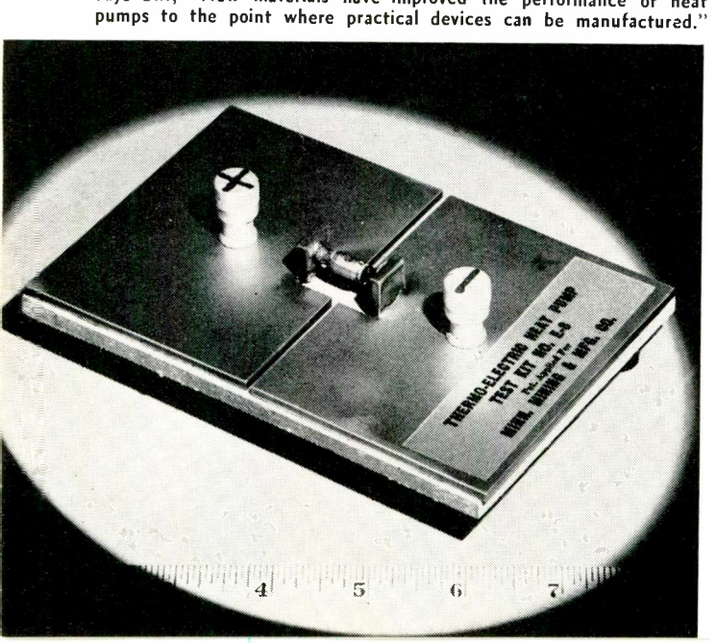
Armour Research Foundation has a thermoelectric research program on high temperature applications and they are investigating materials such as carbides, oxides, and nitrides. Bendix Research Laboratories have a program which includes a broad theoretical study and the application of solar heat to thermoelectric devices.

Power Applications

E. V. Somers of the Westinghouse Research Laboratories, in a paper, "Applications of thermoelectric power," lists four broad power fields in which the thermoelectric process could be applied. The four fields are: waste heat power, auxiliary power, propulsion power, and the central station. Fig. 26 lists the thermal efficiencies that have been obtained in the four power fields.

The middle diagram of Fig. 18 illustrates a device which could be attached to an automobile exhaust. Approximately two feet long and about 1½ inches in dia., it could produce about 75 w with a thermocouple efficiency of 20% and about 150 w with a thermocouple efficiency of 40%. A similar arrangement could be used as a source of auxiliary power in jet aircraft where a thermocouple efficiency of 40% would produce about 40 kw at 90 v in series. The device could be used with standard fuel sources to produce power for propulsion systems; at a thermal efficiency of about 13%, a power level of 34 kw could be produced with a thermocouple efficiency of 40%, and at 6.5%, a power level of 17 kw with a thermocouple efficiency of 20%.

Fig. 25: Thermoelectric test kit, Model E-8, from Minnesota Mining and Manufacturing Co. demonstrates TE fundamentals. (See Fig. 20.) Says 3M, "New materials have improved the performance of heat pumps to the point where practical devices can be manufactured."



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Thermal Efficiency of Power Apparatus

Application	Thermal Efficiency
Waste Heat Power	A Few Percent or Higher
Auxiliary Power— marine vessels, railroads, land vehicles, aircraft	10–20 percent
Propulsion Power— marine vessels, railroads, land vehicles, aircraft	10–25 percent
Central Station Power	25–40 percent

Fig. 26

The bottom diagram of Fig. 18 illustrates a thermoelectric nuclear power plant. Such a plant may operate at thermal efficiencies below those obtained on a conventional nuclear power plant, the disadvantages however may be overcome by the design simplifications. The thermoelectric reactor could also be used as a "topping" unit with a conventional plant to increase the overall plant efficiency.

Acknowledgment

The author wishes to thank Mr. Lee Bennett and Messrs. J. H. Wernick and R. Wolfe for their assistance in obtaining reference material.

New TE Book

As we go to press, a new book on thermoelectricity is brought to our attention. The book, "Thermoelectricity, A Report for Business," by graduate students of Harvard Business School is available (single copies $35.00) from Thermoelectric Assoc., 509 Country Club Dr., Bellefonte, Ashland, Ky.

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What's New . . .

Peltier Thermostating

ALTHOUGH the Peltier effect has been known for more than a century, only recently has its practical application to the design of electronic equipment risen to a position of importance. This recent recognition has been due to new advances in the understanding of solid state phenomena, enabling the construction of transistors and other solid-state devices.

The theory of thermo-electric cooling, however, as developed by Altenkirch and Gehlhoff about 1900 is little changed to date. Prototype devices have been developed by Westinghouse, RCA, and others in the United States, but high cost has limited commercial exploitation.

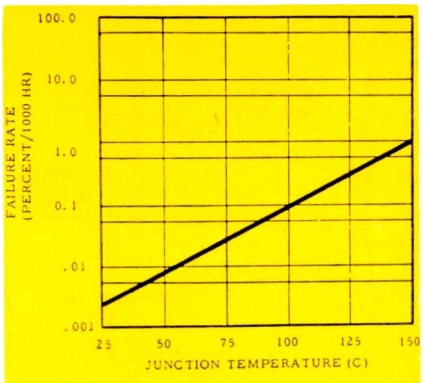
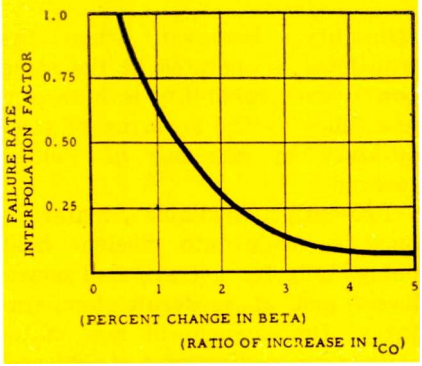


Fig. 1: Failure rate curve for the 2N6577.

Fig. 2: Failure rate interpolation curve.



In the USSR, however, home refrigerators and various small refrigeration units have been produced and are apparently utilized on a large scale. Among the Russian developments are small thermoelectric chambers for biological specimens and thermoelectrically thermostated transistor oscillators. It is in this last area of electronic-circuit temperature control that Peltier thermostating is particularly promising for early application in this country.

Electronic cooling is superior to conventional techniques in thermal efficiency when only small quantities of cooling are required. In addition, of course, Peltier cooling units are thermodynamically reversible and can supply heat more efficiently than resistance heating.

This combination of efficiency and a potentially high reliability, because of the absence of moving parts, allows practical thermostating below ambient temperature. For the first time, it is now possible to construct an efficient cooling unit of only a few watts capacity.

Reliability

Fig. 1, transistor failure rate was developed from industry failure rate curves and experimental data.

Here a failure is defined as a 20% degradation of β and a 2:1 increase of I_{co}. Since the change in these parameters which constitutes failure varies with the circuit application, an interpolation curve was established, Fig. 2.

The failure rate in Fig. 1 is multiplied by the interpolation factor obtained from Fig. 2. In a typical application, reliability considerations dictated a junction temperature of 70° C. This corresponds to a maximum power dissipation of 1 watt at 25° C ambient. By comparison, the manufacturer's maximum recommendation for this transistor is 2 watts, which corresponds to a junction temperature of 100° C. While derating is a very common method of increasing reliability, it requires the use of over-sized components.

An alternate method for increasing reliability is cooling to maintain desired junction temperature.

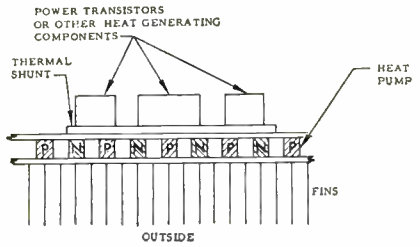


Fig. 3. Power transistor cooling device.

"Heat sinks" have been constructed for many transistors, but the increase in power is rarely as spectacular as the increased volume required for the device.

Conventional cooling systems, with their attendant heat exchangers, have been used in large systems where the increase in weight and volume can be tolerated. Peltier refrigeration, on the other hand, offers decentralized spot cooling without moving parts or fluids. These electronic cooling devices are size-independent in their efficiency and in miniaturized form may be incorporated into heat-generating circuit components.

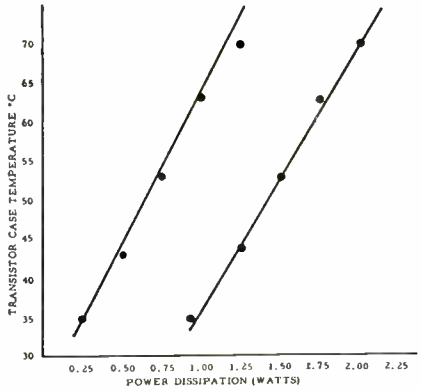
A number of devices have been suggested for the application of electronic cooling. A configuration under consideration by Autonetics, a Div. of North American Aviation, Inc., Downey, Calif., is shown in Fig. 3.

Experimental Investigations

The most effective use of electronic cooling embodies the complete integration of cooling unit and heat generating unit. However, for many practical applications, a useful intermediate step is the construction of a separate, suitably-designed, small, electronic cooling unit. Such a unit was con-

(*Continued on page* 80)

Fig. 4: Peltier cooling effect on the case temperature of a 2N657 Transistor.



What's New . . .

Transistorized TV Features Optical System

A TRANSISTORIZED portable television set has been placed on the market by the Philco Corporation. Called the "Safari," the portable TV set weighs 15 pounds including the battery. It is 8⅜ inches wide, 16⅝ inches high and 5⅝ inches deep. The set employs twenty-one transistors, 14 diodes, and a 2-inch CRT.

In cooperation with the Eveready Company, a special rechargeable battery was developed. The battery can be operated for four hours before recharging is required. Recharging is accomplished by plugging the set into an ac outlet After four hours of operation, about 16 hours are required to recharge the battery fully. An "hours in use" dial for the battery is included in the portable. The set can also be operated directly from an ac outlet.

Optical System

While the transistorized portable is new, the interesting feature of this set is its viewing surface. The set makes use of a two-inch CRT, a special mirror and spherical reflector. With this set-up, the viewing area of approximately 80 inches is considered about the same size as a 14-inch picture tube. Also, this set can be viewed in bright sunlight. The ideal position for viewing is up to four feet away.

The arrangement of the optical system and cathode ray tube is shown in Fig. 2. The diagram also shows the light paths that produce the magnified picture. The light from the arrow head at point "A" on the CRT strikes the beam splitter at point "B" and since this is a reflective surface, it is reflected to point "C" on the spherical mirror. The light at D must pass through the center of focus of the mirror F. The light rays will also pass through the center curvature of the mirror C. The intersection of the light rays AC and AF at point A″ produce the arrow head appearing behind the set and magnified (Remembering your physics, you see a virtual image magnified when viewing from the front).

The beam splitter mirror is designed not only to serve as a reflector but it is also transparent since you look through it to see the magnified image. The ratio of transmission to reflection was chosen to obtain a satisfactory picture under high ambient light conditions.

The chassis has been constructed and laid-out to permit servicing without removal. Also, to facilitate servicing, all components and connections are identified on the printed wiring board. This makes it easy for a serviceman to relate the schematic diagram to the actual circuits and components with very little searching.

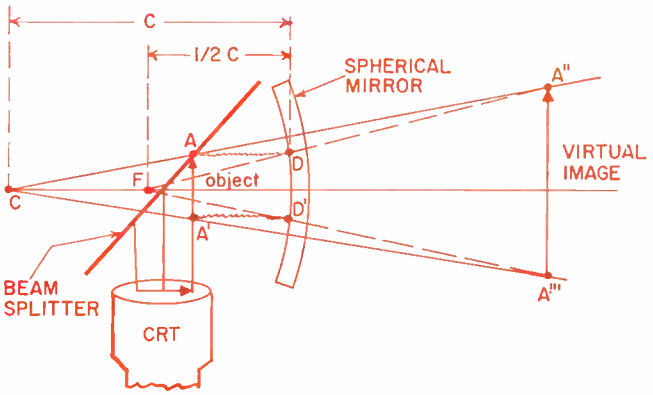


Fig. 2: Sketch shows roughly how the optical system of the Philco transistorized portable enlarges the 2 in. CRT image.

Thermostating

(*Continued from page* 79)

structed for use with a transistor.

Fig. 4 shows the results of measurements to determine the effect of Peltier cooling on the case temperature of a 2N657 medium-power silicon transistor. Curve 1 is the variation in case temperature versus power dissipation without Peltier cooling; Curve 2 shows this variation with Peltier cooling. In both cases a radiator was attached.

This application of Peltier cooling permitted an increase in power dissipation of the transistor by 60%, while retaining the original reliability. However, when the transistor is operated at the same power level, reliability is increased five times by the lowering of temperature by the use of Peltier cooling.

Presently available materials may be made into efficient heat pumps only for use at small power levels and at moderate temperatures. Development of new materials is proceeding at a rapid pace, however, and improvements are anticipated in the very near future in the areas of (1) lower temperatures (through high figures of merit), (2) greater heat pumping capacity, and (3) higher operating temperature.

Page from an Engineer's Notebook

#48 Logarithmic Scales on a Uniform Lattice

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ELECTRONIC data is frequently most logically displayed on logarithmic scales. Such forms are, of course, available, but are special and not as flexible as the uniform lattice widely used in note books.

The possibility of laying out an accurate logarithmic scale on a uniform lattice without extra reference points has hardly been considered. We have found no mention of it in the literature. Inquiries among interested associates reveal that none had used or explored the possibility of such a scheme.

Table 1 shows that a logarithmic decade can be laid out on a 40 division uniform scale with all of the 10 integral and 7 of the 9 semi-integral points falling on divisions of the uniform scale. The maximum error is less than 1.4% of the decade length. Comparable accuracy can be provided on decades of 20, 10, and 5 unit lengths by proper designation of the reference elements.

An additional advantage in this scheme lies in the ease with which related linear scales can be tied to the logarithmic scales for comparative reference—e.g., power and decibel scales on the same lattice. The Volt-Ohm-Watt/dbm Nomograph and the Amplifier Response Record Form are illustrative of typical layouts involving combinations of logarithmic and linear scales on uniform lattice note paper forms.

* * *

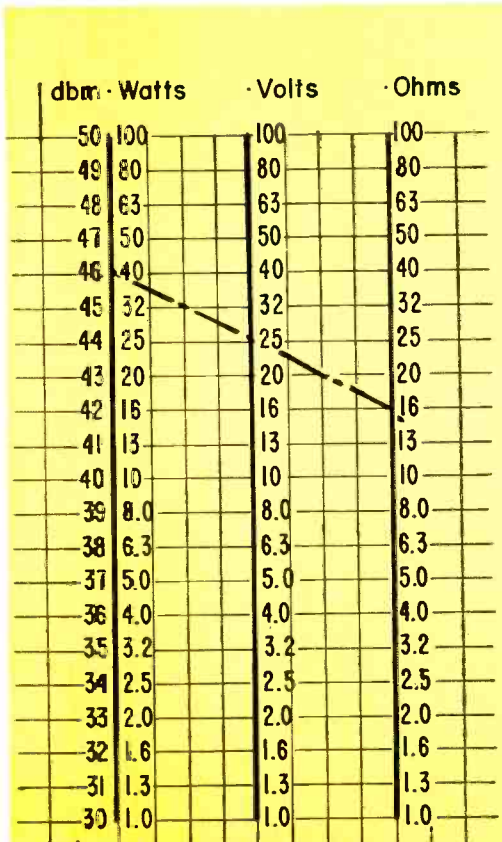


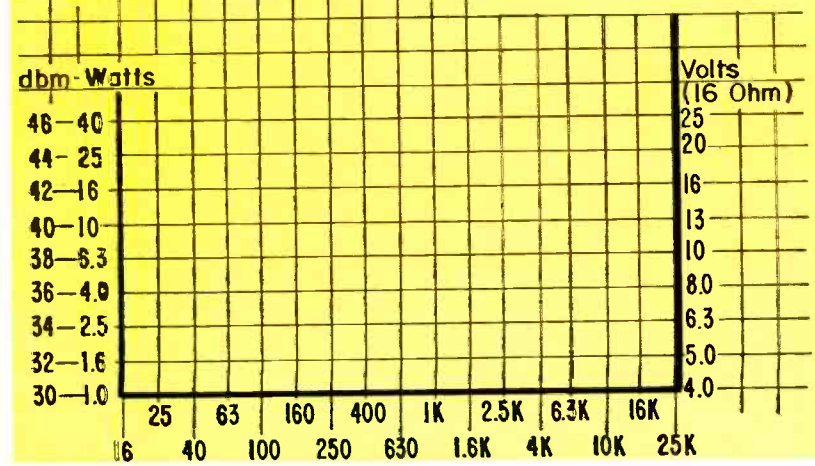
Table 1
DECADE TABLES

40 Units					
100	67	45	30	20	13.5
95	63	42	28	19	13
90	60	40	27	18	12
85	56	38	25	17	11
80	53	35	24	16	10.5
75	50	33	22	15	10
70	47	32	21	14	

20 Units			10 Units		5 Units
100	45	20	100	25	100
90	40	18	80	20	63
80	35	16	63	16	40
70	32	14	50	13	25
63	28	13	40	10	16
56	25	11	32		10
50	22	10			

(Left): Nomograph with logarithmic scales on a uniform lattice — 10 unit decades.

(Below): Amplifier response record form — 5 unit decades used for Frequency and Watts; and, a 10 unit decade for volts.



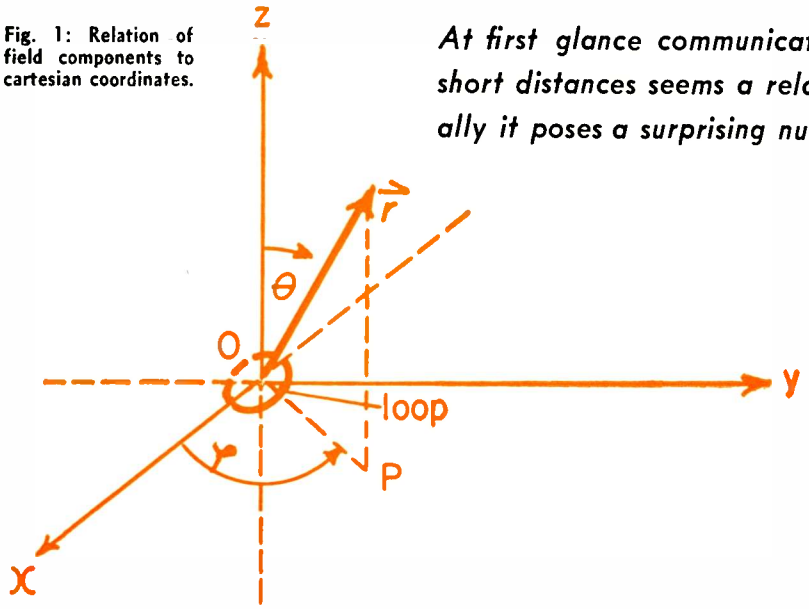


Fig. 1: Relation of field components to cartesian coordinates.

At first glance communication by electromagnetic induction over short distances seems a relatively unsophisticated technique. Actually it poses a surprising number of involved engineering problems.

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OP - Projection of $\vec{r}$ on xy plane
θ - Angle formed by $\vec{r}$ with z axis
γ - Angle formed by OP with x axis

Remote Control by "Near" Magnetic Field

CERTAIN applications of electronic remote control use "near" magnetic field as a medium conveying the modulated carrier to a receiver. This "near" magnetic field, when oscillatory, produces an EmF in a receiving loop as a result of electro-magnetic induction. The induction field is generated by a loop or coil containing oscillatory current of a tank circuit in the transmitter. The transmitting-receiving loop system acts as a somewhat unusual form of air-core transformer with a very high degree of flux stray (extremely low coupling) between the primary (transmitter) and the secondary (receiver) loops.

This manner of operation has been found very advantageous for remote control over distances of a few hundred feet. One typical application is control of garage doors from simple transmitters installed in cars and trucks. This seemingly straightforward industrial design poses a surprising number of involved engineering problems if a selective and reliable solution is wanted at low cost.

Operation based on "near" magnetic field components is advantageous because their size is inversely proportional to the second and third power of distance.

The receiver can be designed for a sensitivity value that will provide a limited range within near field region. The field decays quickly with increasing distance so the geographic area of operation is more clearly limited than it would be for the field decreasing inversely to the distance. The rapid increase of the field magnitude with decreasing distance tends to increase the reliability of operation. This mode of operation also complies admirably with the F.C.C. "low power" rule for certain types of devices.

We should understand the distribution of the "near" magnetic field components caused by the current flowing through transmitter coil in order to establish the range and conditions of directivity for any given remote control problem. It may also prove helpful in tracing interference fields, for instance from television receivers. Formulae for the components of magnetic and electric fields of a loop are available in the literature.[1] We will discuss here the orders of magnitude involved and implications of these formulae.

Assumptions

We assume a loop of small linear dimensions compared to $\lambda/4$. Area of the loop is S.

We assume the loop to be flat, single turn and

carry a current I, equal to the value of ampere-turns of any physical loop considered. This assumption is valid for a distance r from the center of the antenna large compared with antenna dimensions even in the *near*-field zone. The effect of ground is neglected (temporarily).

Basic Formulae

The basic formulae and their derivation are available in the literature.[1] The applicable formulae are:

$$\hat{E}_\varphi = \frac{\eta \beta^2 I S}{4 \pi r}\left(1 + \frac{1}{j \beta r}\right) \exp - j \beta r \sin \theta \qquad (1)$$

$$\hat{H}\theta = -\frac{\beta^2 I S}{4 \pi r}\left(1 + \frac{1}{j \beta r} - \frac{1}{\beta^2 r^2}\right) \exp - j \beta r \sin \theta \qquad (2)$$

$$\hat{H}_r = \frac{j \beta I S}{2 \pi r^2}\left(\frac{1}{j \beta r}\right) \exp - j \beta r \cos \theta \qquad (3)$$

The Equations (1), (2) and (3) represent field components in spherical coordinates, the relation of which to cartesian coordinates is shown in Fig. 1.

Let us define the vectors of electric and magnetic fields as:

$$\vec{E} = \vec{u}_r \hat{E}_r + \vec{u}_\theta \hat{E}_\theta + \vec{u}_\varphi \hat{E}_\varphi \qquad (4)$$

and:

$$\vec{H} = \vec{u}_r \hat{H}_r + \vec{u}_\theta \hat{H}_\theta + \vec{u}_\varphi \hat{H}_\varphi \qquad (5)$$

where $\vec{u}_r, \vec{u}_\theta, \vec{u}_\varphi$. are unit vectors in directions of r, θ and ϕ respectively, while $\hat{E}_r, \hat{E}_\theta, \hat{E}_\varphi \hat{H}_r, \hat{H}_\theta, \hat{H}_\varphi$ are components of vectors $\vec{E}$ and $\vec{H}$ in the directions of chosen coordinates r, θ and φ. These components are considered as phasors, since their values vary sinusoidally in time each with its own amplitude and phase. Meaning and dimensions of symbols used in formulae (1), (2) and (3) are as follows (rationalized *MKS* units): $\hat{E}_\varphi$ in volts/meter—electric field component in the direction φ.

$$(\hat{E}_r = 0 \text{ and } \hat{E}_\theta = 0);$$

$\hat{H}_\theta, \hat{H}_r$ — components of the vector of magnetic field $\vec{H}$ in θ and r directions.

$$(\hat{H}_\varphi = 0)$$

$$\text{Dimension: } \frac{\text{amperes}}{\text{meter}}.$$

η = intrinsic impedence of free space (377 ohms).

I = current in the loop or total ampere-turns for multi-turn loop in amperes.

$\beta = \frac{2\pi}{\lambda}$ = phase propagation constant in $\frac{\text{radians}}{\text{meter}}$.

λ = wavelength in free space (meters).

r = distance from the loop center (meters).

S = loop area in (meters)^2.

Discussion of Equations for Field Components

The mathematical expressions (1), (2) and (3) should reflect in the far field (for very large βr) the well-known vector relationship:

$$\vec{P} = \vec{E} \times \vec{H}$$

where $\vec{P}$ is the Poynting vector in watts per square meter. In addition we can check that in the far region the field pattern corresponds to the well-known pattern of the loop.

For large βr we have:

$$\frac{1}{\beta^2 r^2} \ll \frac{1}{\beta r} \ll 1 \qquad (7)$$

$$| \hat{H}_\theta | \gg | \hat{H}r | \qquad (8)$$

The radial component of magnetic field can thus, as expected, be neglected in the far zone.

When conditions (7) and (8) are taken into account by neglecting $\frac{1}{j \beta r}$ and $\frac{1}{\beta^2 r^2}$ with respect to unity and by setting $\hat{H}_r = 0$ in view of (8), Equations (1), (2) and (3) become:

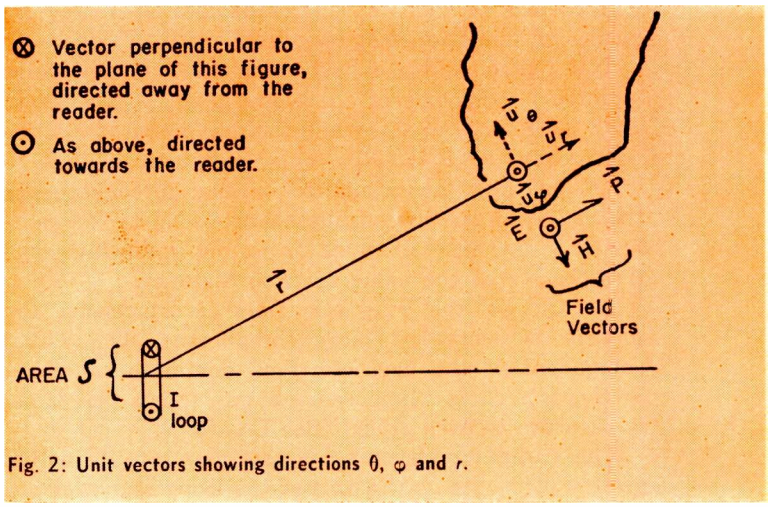


Fig. 2: Unit vectors showing directions θ, φ and r.

$$\hat{E}_\varphi = \frac{\sin \theta}{4 \pi r}(\eta \beta^2 I S) \exp - j \beta r \qquad (9)$$

$$\hat{H}_\theta = \frac{\sin \theta}{4 \pi r}(\beta^2 I S) \exp - j \beta r \qquad (10)$$

Equations (9) and (10) illustrate that in the far zone the electric and magnetic vectors are directed entirely in the directions ϕ and negative θ, respectively. Fig. 2 shows plainly that in this case, $\vec{P} = \vec{E} \times \vec{H}$ ($\vec{P}$ in the direction of positive r) and from (9) and (10) it is evident that:

$$| \vec{E} | = \eta | \vec{H} | \qquad (11)$$

Fig. 3 represents in polar coordinates the plot

$$| \hat{E} | = \eta | \vec{H} = f | \quad (\theta)$$

where:

$$| \vec{E} | = \eta | \vec{H} | = \frac{\eta \beta^2 IS}{4 \pi r} \sin \theta \qquad (12)$$

We note that the pattern in Fig. 3 does not depend on the angle ϕ (rotational symmetry).

It is apparent from the examination of Equations (1), (2) and (3) and (12) that the relationship (11) between the amplitudes of the two fields does not hold in the "near-zone" region. For this reason it appears logical that the term "electromagnetic field" be only applicable to the far-zone region and that magnetic field and electric field components are considered separately in the near field region. Magnetic field can profitably be discussed and calculated in terms of $| \eta \vec{H} |$ rather than in terms of $| \vec{H} |$ in order to maintain the microvolt/meter unit of

"Near" Magnetic Field
(Continued)

field strength for both fields for the sake of practical and computational convenience.

When analysis of radiation properties of a loop is made in a region which can be considered containing both "far-zone" and "near-zone" field components, the following further discussion is of interest.

In the "near-zone" the magnitude of the only existing electric field component $\hat{E}_\varphi$ is considerably lower than the magnitude of $\eta \vec{H}$ at the same location. This fact is of importance when evaluating potential interference caused by communications or remote control devices operating by means of induction magnetic field.

There is no electric field component at any point situated on the axis of the loop (at all points where $\sin \theta = 0$ and $\theta = 0$), while the maximum of electric field occurs at $\theta = 90°$. This statement applies to "far-field" and "near-field" zone alike; in consequence the radiation pattern of the electric field is the same for a given fixed distance from the radiating loop, irrespective of the value of fixed distance.

As far as the magnetic field is concerned the picture is somewhat more complicated. The radial component of the magnetic field dominates at short distances; it is composed of two parts in time-quadrature to each other. (See Eq. (3).)

The radial component is maximum at all points of $\theta = 0$ (points on the axis of the loop) and vanishes for $\theta = 90°$. The radial component of the magnetic field is insignificant in the "far zone". For all the points of the "far zone" (sufficiently large r values)

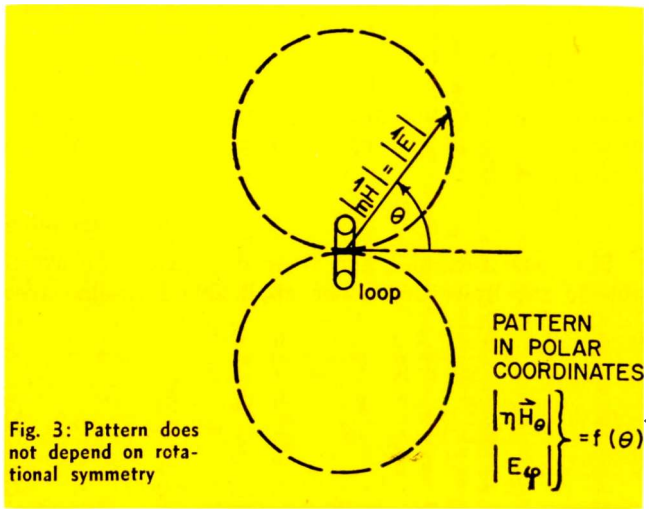


Fig. 3: Pattern does not depend on rotational symmetry

the pattern of the magnetic field corresponds, as it must, to the pattern of the electric field, as stipulated by Eq. (12). In the "near zone" the shape of the pattern is different, the direction of the points of maximum field being the line of $\theta = 0$. In the above remarks, the word "pattern" is meant to be synonymous with the plot of r = function (θ) in polar coordinates for $|\eta \vec{H}|$ = const. The general shape of such plot depends on the value of $|\eta \vec{H}|$ in the near zone.

The polarization of the $\vec{E}$ vector is always linear since only one component $\hat{E}_\varphi$ exists. Polarization of $\vec{H}$ vector is in general elliptical, as is evident from (2) and (3) since the two phasors $\hat{H}_\theta$ and $\hat{H}_r$ are not necessarily in phase. As the "near zone" merges gradually into "far zone" the polarization of $\vec{H}$ gradually becomes linear, as indicated by Equation (10). The examination of Equations (2) and (3) shows that with the decrease of the

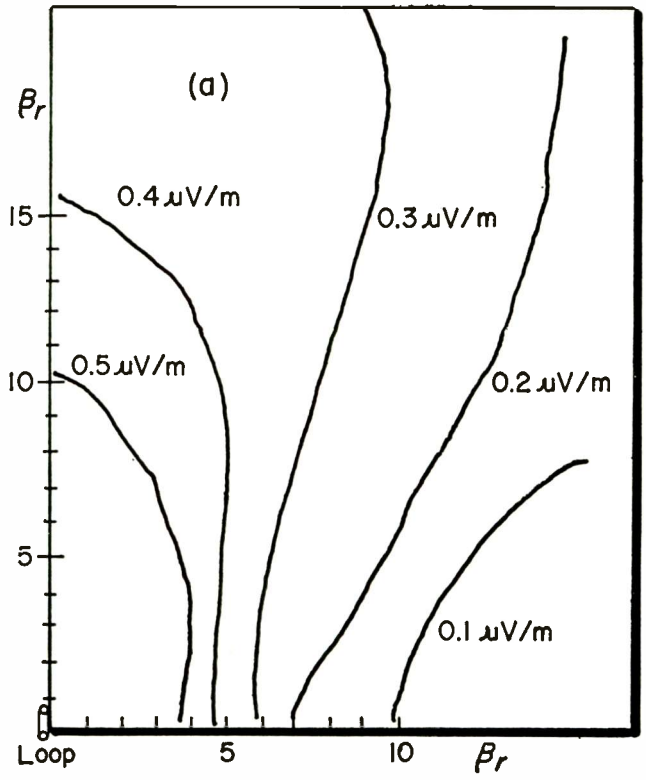
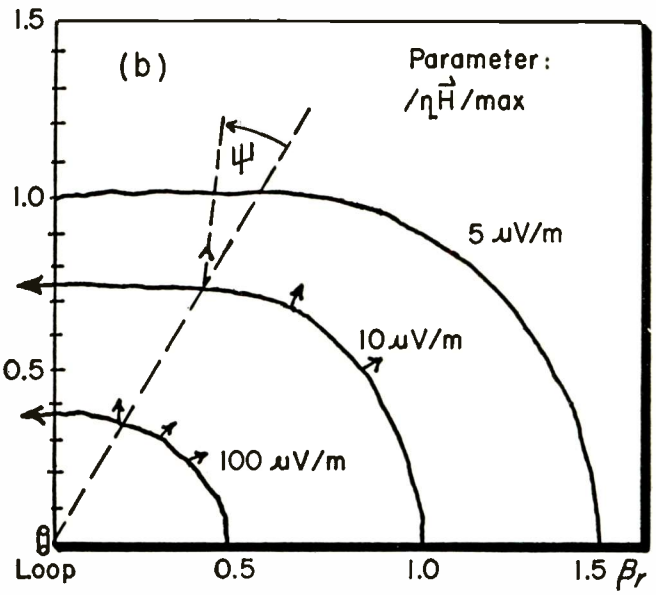


Fig. 4: Lines of equal max. amplitude of magnetic field
(a) $B_r > 1.0$
(b) $B_r > 0.1$
Arrows indicate direction of maximum field
Note that symmetry is maintained with respect to both axis shown



distance r the polarization of $\vec{H}$ again gradually becomes linear. To prove this we can assume

$$\frac{1}{\beta^2 r^2} \gg \frac{1}{\beta r} \gg 1 \text{ for } r \to 0.$$

With this assumption Equations (2) and (3) become:

$$\hat{H}_\theta = \frac{I S}{4 \pi r^3} \sin \theta \exp - j \beta r \qquad (13)$$

and

$$\hat{H}_r = \frac{I S}{2 \pi r^3} \cos \theta \exp - j \beta r \qquad (14)$$

There is no phase shift between the two phasors $\hat{H}_\theta$ and $\hat{H}_r$ representing two mutually perpendicular components of the vector $\vec{H}$. Therefore at low βr values, the polarization of $\vec{H}$ again becomes linear.

Effect of Ground

The above formulae apply to a current-carrying loop in free space. The effect of ground can be considered by means of the well-known "image charge" method. In the case of the loop being located a short distance over infinitely conducting ground every field component at the receiving loop is nearly doubled as long as we consider the distance of the loop over ground as small.

Numerical Example

To illustrate quantitatively some of the points of the discussion presented above, let us consider a numerical example concerning field components originated by a tank circuit coil in a transmitter designed for the purpose of a typical short-distance remote control application (garage door remote control unit). No other transmitting antenna is provided.

In the case of elliptical polarization, maximum value of the vector $\eta \vec{H}$ is computed as well as the angle ψ formed between direction of the maximum vector $\eta \vec{H}$ (major axis of the ellipse) and direction of position vector $\vec{r}$.

All data are represented as functions of the "normalized distance" βr. Such representation is a convenient one since, if $\hat{E}_\varphi$, $\hat{H}_\theta$ and $\hat{H}_r$ are represented as functions of βr, the modulus of every one of these phasors will prove proportional to the third power of frequency for any given value of βr (inversely proportional to the third power of λ). In setting

$$\beta = \frac{2 \pi}{\lambda} \text{ and } \frac{1}{r} = \frac{2 \pi}{\lambda (\beta r)}$$

into Equations (1), (2) and (3), we obtain:

$$\hat{E}_\varphi = \frac{2 \pi^2 \eta I S \sin \theta}{\lambda^3 (\beta r)} \left(-1 + \frac{1}{j \beta r} \right) \exp - j \beta r \qquad (18)$$

$$\hat{H}_\theta = - \frac{2 \pi^2 I S \sin \theta}{\lambda^3 (\beta r)} \left[1 + \frac{1}{j \beta r} - \frac{1}{(\beta r)^2} \right] \exp - j \beta r \qquad (19)$$

$$\hat{H}_r = \frac{j 4 \pi^2 I S \cos \theta}{\lambda^3 (\beta r)^2} \left(1 + \frac{1}{j \beta r} \right) \exp - j \beta r \qquad (20)$$

All field components are proportional to the product of ampere turns and coil cross-section. Typical data assumed for computation of data Fig. 4 are:

Frequency: 310 KC Wavelength: $\lambda = 970$ m.

$$\beta = \frac{2 \pi}{\lambda} = 0.00645 \frac{\text{radians}}{\text{meter}}$$

Coil diameter: 2-3/16 in. corresponds to coil cross-section area:

$S = 24.8 (10^{-4})$ m² Ampere turns: $I = 105$ amp.

Fig. 4 shows the lines of equal $| \eta \vec{H} |$ max. in the horizontal plane. Arrows indicate the directions of φ from which positions of the receiver loop can be established for highest value of the received signal. There is no necessity to provide a similar plot of "lines of equal field" for the electric field because of the simplicity of the Eq. (1) which describes the electric field adequately.

Details of computation of φ and $| \eta \vec{H} |_{max}$ for the elliptical polarization are omitted for the reason of shortage of space.

We notice that Part (a) of Figure 4 shows the tendency to gradual transition to far-field pattern at larger values of βr and lower values of the field.

A numerical calculation of magnitudes of $\vec{E}$ would show that at low values of βr the magnitude of $\vec{E}$ would be below $| \eta \vec{H} |$ by an order of magnitude. Thus, while field measurements in the far field zone conducted by means of a loop antenna and by means of a rod antenna should yield the same results in the microvolt/meter scale, very different results are obtained for two similar types of measurements in the near field zone.

Acknowledgment

The foregoing article is a summary of a report prepared by the author for A.R.F. Products, Inc.

References

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Delayed Tape Recording

AN entirely new field of recorded programming has been opened by the development of an automatic delayed tape recording system for the National Broadcasting Company. The purpose of the new system is to provide a signal delay of up to one hour from the time of the original recording.

It was designed for the relaying of broadcast programs to a time zone one hour behind the area in which the "live" program originated. For instance, if a program is originating from New York at six o'clock and it is also scheduled to be heard in Chicago at six o'clock, the new system would record the original program and "hold" or delay the signal for one hour before it is released to Chicago.

The system was developed by Telectro Industries, Long Island City, N. Y.

System Features

The system, completely automatic, is made up of two high quality tape recorders with a frequency response, at 7½ ips, of 25 - 10,000 cps ±2 db; or 25 - 15,000 cps ±2 db at 15 ips. The dual channel playback pre-amplifier features a signal to noise ratio of better than 60 db below 1% tape distortion.

(*Continued on page* 89)

Analyzing Networks with the Y-Matrix

Small signal analysis of linear active circuits is simplified by applying matrix algebra concepts. This is especially so for circuits consisting of cascaded stages. Transistor circuit examples illustrate applications.

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AN n-terminal network containing passive and active elements may be described by a square Y-matrix of order n. For two or more interconnected networks, a matrix may be derived from the matrices of the network parts. Network quantities such as input and output immittances, and gain may be expressed as functions of the matrix elements and the source and load immittances of the resulting network.

Consideration of the network terminals separately and not in pairs is convenient and allows consistent use of Y-matrix methods in all phases of network manipulations. The use of only one kind of matrix elements, avoiding repeated matrix transformations and multiplications, is of advantage to the circuit designer.

The examples in this article are given for three-terminal networks, but the methods are readily extendable to networks with more than three terminals. Transistor circuits are used to illustrate a possible application of these methods.

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Fig. 1: This three-terminal network is described by Eq. 1.

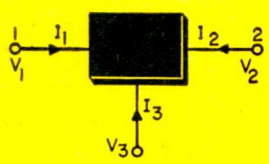
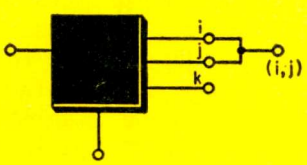


Fig. 2: Interconnecting terminals reduces matrix order.



Network Concepts

Indefinite Y-Matrix

The terminal voltages of an n-terminal network are taken positive with reference to one common outside point, or with reference to one of the terminals. The currents are considered positive when flowing into the terminals.

The three-terminal network of Fig. 1 is described by the following equations:

$$\begin{aligned} I_1 &= Y_{11}V_1 - Y_{12}V_2 - Y_{13}V_3 \\ I_2 &= -Y_{21}V_1 + Y_{22}V_2 - Y_{23}V_3 \\ I_3 &= -Y_{31}V_1 - Y_{32}V_2 + Y_{33}V_3 \end{aligned}$$

In matrix notation:

$$\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} Y_{11} & -Y_{12} & -Y_{13} \\ -Y_{21} & Y_{22} & -Y_{23} \\ -Y_{31} & -Y_{32} & Y_{33} \end{bmatrix} \times \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} \qquad (1)$$

The sum of the currents entering the network is zero and the currents are independent of the voltage of the reference point. As a result, the sum of each row and of each column in the Y-matrix is zero. Such a matrix is called 'indefinite'. The elements on the main diagonal are equal to the sum of the other elements of the corresponding row or column.

When the voltage reference point coincides with terminal 3, V can be considered zero and Eq. (1) can be reduced to the equation for a two-terminal pair network by removing the third row and the third column of the Y-matrix:

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} Y_{11} & -Y_{12} \\ -Y_{21} & Y_{22} \end{bmatrix} \times \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} \qquad (2)$$

Here the input and output voltages have a common reference point and can not be separated; the network should be referred to as a three-terminal network. The voltage reference point may be chosen to coincide with any terminal; the *Y*-matrix of the corresponding network is obtained from the indefinite matrix by removal of the row and column with the same index number as the reference terminal. When terminals are interchanged the rows and columns corresponding to these terminals have to be interchanged also.

For a single transistor, with terminals numbered b, c and e, the Eq. (1) becomes:

$$\begin{bmatrix} I_b \\ I_c \\ I_e \end{bmatrix} = \begin{bmatrix} Y_{bb} & -Y_{bc} & -Y_{be} \\ -Y_{cb} & Y_{cc} & -Y_{ce} \\ -Y_{eb} & -Y_{ec} & Y_{ee} \end{bmatrix} \times \begin{bmatrix} V_b \\ V_c \\ V_e \end{bmatrix} \qquad (3)$$

From this indefinite matrix the matrices corresponding to common base, common emitter, and common collector configurations may be formed by crossing out the row and column corresponding to the common terminal. This may only be done when the operating conditions are equal for the different configurations, because the indefinite matrix elements are a representation of a transistor at certain constant operating conditions. Changes in bias conditions and temperature will change the matrix element values.

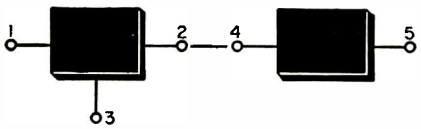


Fig. 3: A basic example in applying the Y-matrix method.

When, e.g., the *h* parameters for a common emitter configuration are given, the indefinite *Y*-matrix may be found by a transformation of the given parameters. Using the notation of Eq. (3)

$$\begin{bmatrix} h_{11e} & h_{12e} \\ h_{21e} & h_{22e} \end{bmatrix} \text{ becomes } \begin{bmatrix} h_{bb} & h_{bc} \\ h_{cb} & h_{cc} \end{bmatrix}$$

This transformed into common emitter y parameters gives

$$\begin{bmatrix} \dfrac{1}{h_{bb}} & \dfrac{h_{bc}}{h_{bb}} \\ \dfrac{-h_{cb}}{h_{bb}} & \dfrac{h_{bb}\,h_{cc} - h_{bc}\,h_{cb}}{h_{bb}} \end{bmatrix}$$

The indefinite *Y*-matrix is now formed by adding a third row and column, making the sum of the elements in each row and column zero. From any other given set of transistor parameters the *Y*-matrix is formed by the appropriate matrix transformation.

Reducing Matrix Order

When two or more network stages are interconnected the matrix of the resulting network is generally of an order higher than that of the network stage matrices. Reduction of the matrix order is equal to reduction of the number of network terminals. There are two possibilities for reducing the terminal number: by interconnecting two terminals; or, by disconnecting one terminal.

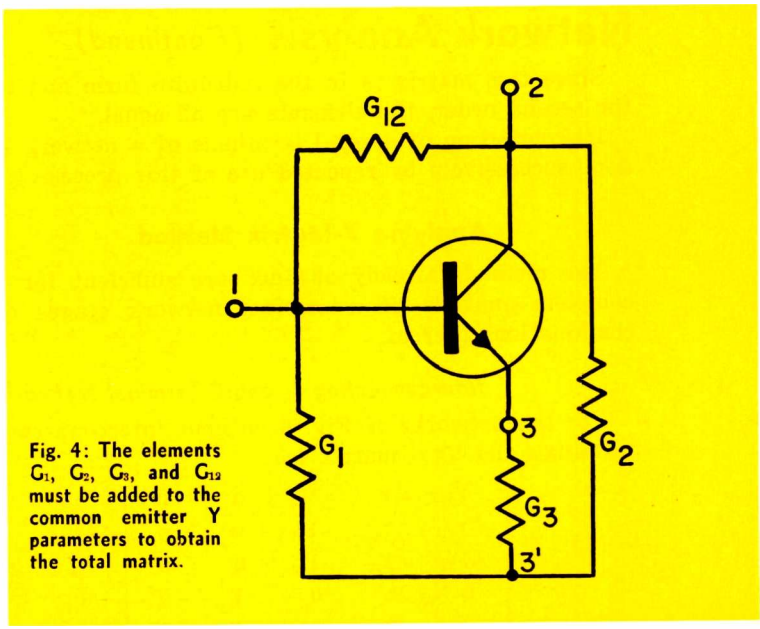


Fig. 4: The elements G_1, G_2, G_3, and G_{12} must be added to the common emitter Y parameters to obtain the total matrix.

Interconnecting Terminals

When in Fig. 2 terminals i and j are interconnected and replaced by one terminal (i,j) the following substitutions are to be made in the network equations:

$$V_{(i,j)} = V_i = V_j$$
$$I_{(i,j)} = I_i + I_j$$

The resulting changes in the matrix elements are:

$$\left.\begin{aligned} Y_{k,(i,j)} &= Y_{ki} + Y_{kj} \\ Y_{(i,j),k} &= Y_{ik} + Y_{jk} \\ Y_{(i,j),(i,j)} &= Y_{ii} + Y_{jj} + Y_{ij} + Y_{ji} \end{aligned}\right\} \qquad (4)$$

This amounts to adding the rows and columns of the *Y*-matrix corresponding to the two terminals. Interconnecting more than two terminals requires repeated addition of rows and columns concerned.

Disconnecting Terminals

Disconnecting terminal k of a network requires substituting $I_k=0$ in the equations and eliminating V_k. The matrix elements of the new network become:

$$\left.\begin{aligned} Y'_{ij} &= Y_{ij} - Y_{ik} \cdot (Y_{kk})^{-1} \cdot Y_{kj} \\ Y'_{jj} &= Y_{jj} - Y_{jk} \cdot (Y_{kk})^{-1} \cdot Y_{kj} \end{aligned}\right\} \qquad (5)$$

For a three-terminal network with indefinite matrix

$$\begin{bmatrix} Y_{11} & -Y_{12} & -Y_{13} \\ -Y_{21} & Y_{22} & -Y_{23} \\ -Y_{31} & -Y_{32} & Y_{33} \end{bmatrix}$$

the indefinite matrix after disconnecting terminal 3 is:

$$\begin{bmatrix} Y_{11} - Y_{13} \cdot (Y_{33})^{-1} \cdot Y_{31} & -Y_{12} - Y_{13} \cdot (Y_{33})^{-1} \cdot Y_{32} \\ -Y_{21} - Y_{23} \cdot (Y_{33})^{-1} \cdot Y_{31} & Y_{22} - Y_{23} \cdot (Y_{33})^{-1} \cdot Y_{32} \end{bmatrix}$$

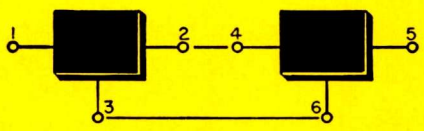


Fig. 5: Method of interconnecting two three-terminal network stages.

Network Analysis *(Continued)*

Since this matrix is in the indefinite form and of the second order, the elements are all equal.

Disconnection of several terminals of a network is done successively by repeated use of this process.

Applying Y-Matrix Method

The methods already outlined are sufficient for a complete analysis of n-terminal network stages or combinations thereof.

Interconnecting 3- and 2-Terminal Networks

For the networks of Fig. 3 without interconnected terminals the total matrix is:

$$\begin{bmatrix} Y_{11} & -Y_{12} & -Y_{13} & 0 & 0 \\ -Y_{21} & Y_{22} & -Y_{23} & 0 & 0 \\ -Y_{31} & -Y_{32} & Y_{33} & 0 & 0 \\ 0 & 0 & 0 & Y_{44} & -Y_{45} \\ 0 & 0 & 0 & -Y_{54} & Y_{55} \end{bmatrix} \quad (6)$$

Interconnecting terminals 2 and 4 results in adding the rows and columns 2 and 4. When terminal 3 is chosen for the common terminal, the matrix, after deleting row and column 3, becomes:

$$\begin{bmatrix} Y_{11} & -Y_{12} & 0 \\ -Y_{21} & Y_{22}+Y_{44} & -Y_{45} \\ 0 & -Y_{54} & Y_{55} \end{bmatrix}$$

With terminal 2-4 disconnected and substituting

$$Y_{44} = Y_{45} = Y_{54} = Y_{55} = Y$$

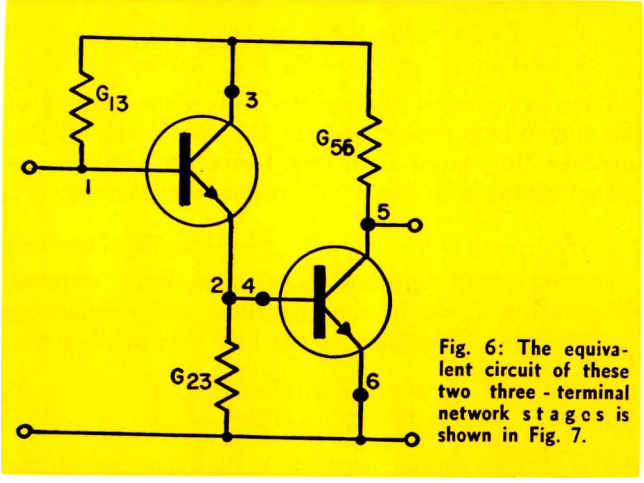


Fig. 6: The equivalent circuit of these two three-terminal network stages is shown in Fig. 7.

we have:

$$\begin{bmatrix} Y_{11}-Y_{12}\cdot(Y_{22}+Y)^{-1}\cdot Y_{21} & -Y_{12}\cdot(Y_{22}+Y)^{-1}\cdot Y \\ -Y\cdot(Y_{22}+Y)^{-1}\cdot Y_{21} & Y-Y(Y_{22}+Y)^{-1}\cdot Y \end{bmatrix}$$

This matrix corresponds to the three-terminal network formed by the interconnected networks of Fig. 3; with 1 and 5 as input and output terminals, respectively, and 3 as common terminal.

When in Fig. 3 the terminals 3 and 5 are also interconnected the following matrix is derived from Eq. (6):

$$\begin{bmatrix} Y_{11} & -Y_{12} & -Y_{13} \\ -Y_{21} & Y_{22}+Y_{44} & -Y_{23}-Y_{45} \\ -Y_{31} & -Y_{32}-Y_{54} & Y_{33}+Y_{55} \end{bmatrix}$$

For the network with 3 as common terminal and substituting

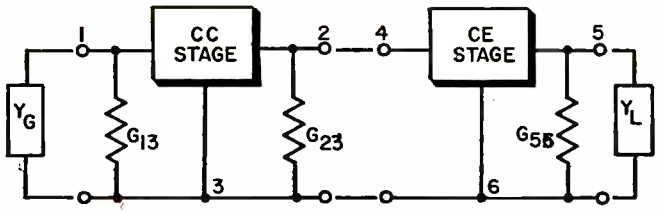


Fig. 7: Equivalent circuit of the three-terminal stages shown in Fig. 6.

$$Y_{44} = Y_{45} = Y_{54} = Y_{55} = Y$$

we have:

$$\begin{bmatrix} Y_{11} & -Y_{12} \\ -Y_{21} & Y_{22}+Y \end{bmatrix}$$

Or with 1 as common terminal:

$$\begin{bmatrix} Y_{22}+Y & -Y_{23} & -Y \\ -Y_{32} & -Y & Y_{33}+Y \end{bmatrix}$$

These calculations are useful in a single stage transistor circuit when the total network matrix is to be derived from transistor parameters in combination with admittance values of the two-terminal circuit elements. For the circuit in Fig. 4, the total matrix, after adding the elements G_3, G_1, G_2, and G_{12}, respectively, to the common emitter Y parameters of the transistor, becomes:

$$\begin{bmatrix} G_1+G_{12}+Y_{11}-Y_{13}\cdot(G_3+Y_{33})^{-1}\cdot Y_{31} & -G_{12}-Y_{12}-Y_{13}\cdot(G_3+Y_{33})^{-1}\cdot Y_{32} \\ -G_{12}-Y_{12}-Y_{23}\cdot(G_3+Y_{33})^{-1}\cdot Y_{31} & G_2+G_{12}+Y_{22}-Y_{23}\cdot(G_3+Y_{33})^{-1}\cdot Y_{32} \end{bmatrix}$$

Interconnecting two 3-Terminal Networks

The total matrix for the network of Fig. 5, before interconnecting terminals is:

$$\begin{bmatrix} Y_{11} & -Y_{12} & -Y_{13} & 0 & 0 & 0 \\ -Y_{21} & Y_{22} & -Y_{23} & 0 & 0 & 0 \\ -Y_{31} & -Y_{32} & Y_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & Y_{44} & -Y_{45} & -Y_{46} \\ 0 & 0 & 0 & -Y_{54} & Y_{55} & -Y_{56} \\ 0 & 0 & 0 & -Y_{64} & -Y_{65} & Y_{66} \end{bmatrix}$$

After interconnecting of terminal 2 with 4, and 3 with 6:

$$\begin{bmatrix} Y_{11} & -Y_{12} & -Y_{13} & 0 \\ -Y_{21} & Y_{22}+Y_{44} & -Y_{23}-Y_{46} & -Y_{45} \\ -Y_{31} & -Y_{32}-Y_{64} & Y_{33}+Y_{66} & -Y_{65} \\ 0 & -Y_{54} & -Y_{56} & Y_{55} \end{bmatrix}$$

With 3-6 as common terminal and after disconnecting terminal 2-4, the matrix is transformed into:

$$\begin{bmatrix} Y_{11}-Y_{12}\cdot(Y_{22}+Y_{44})^{-1}\cdot Y_{21} & -Y_{12}\cdot(Y_{22}+Y_{44})^{-1}\cdot Y_{45} \\ -Y_{54}\cdot(Y_{22}+Y_{44})^{-1}\cdot Y_{21} & Y_{55}-Y_{54}\cdot(Y_{22}+Y_{44})^{-1}\cdot Y_{45} \end{bmatrix}$$

The circuit of Fig. 6, consisting of two three-terminal network stages, with its equivalent circuit, Fig. 7, has a total matrix, before connecting terminal 2 with 4, and 3 with 6:

(Continued at bottom of opposite page)

Delayed Tape Recording

(*Continued from page* 85)

The master control unit has four primary functions and features: (1) It provides an operation sequence relay control circuit for each tape recorder; (2) it generates a stable 25 cps low distortion signal used for an automatic fail-safe indication; (3) dual fail-safe amplifiers and transfer units; and, (4) notched rejection filters to remove the 25 cps signal from the reproduced signals.

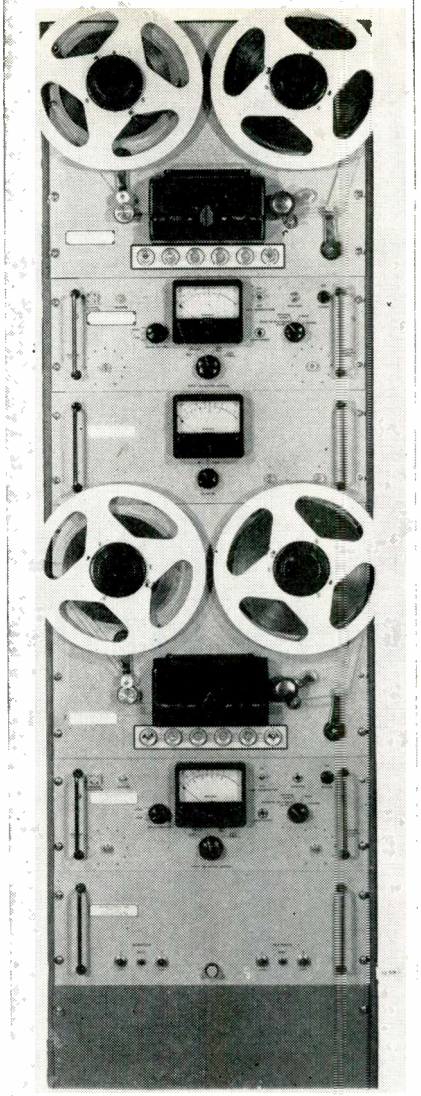
Operation

In actual operation, delayed broadcasting is achieved in the following manner. A four-head assembly is used on each tape recorder with the heads positioned in a play-back, erase, record, and monitor sequence. Now, assuming that the tape has already been recorded during the first cycle, the previously recorded signal would be the delayed program, which, after being picked up on the first head (or the playback head) is erased and immediately re-recorded with the "live" program. The latter may be monitored on the fourth (or monitor) head to check recording quality.

To achieve maximum reliability, two tape recorders are run simultaneously and a 25 cps signal, about 20 db down, is mixed in the record amplifiers with the incoming signal. At the monitor output and the play-back amplifiers, the presence of this 25 cps signal indicates proper functioning of the equipment. If this signal is absent from the play-back, the fail-safe amplifiers are activated and automatically switch the recording to the second unit, continuing the operation without interruption. Before going out, this 25 cps safety signal is removed by notch filters.

A pulse signal is received from the precision time system at 05.00 minutes after each hour, the beginning of each hourly program period. At this point the tape transports are automatically switched to the play-record position by the relay receiving the carrier pulse. The end of the recording period is indicated by a ½ inch length of clear tape placed at a point previously determined to give the correct recording time. As this strip of clear tape goes through the head assembly a light passes through the normally opaque tape and onto a photo cell. The photo cell is activated and a one-shot multi-vibrator sends a pulse signal to another relay which immediately switches the record amplifiers off and sets the tape transports into the rewind position.

Close to the beginning of the tape is a 24-inch strip of clear tape which once again passes the light through and activates the photo cell. The transport then stops, pauses, and goes into the "play" position until the end of the clear tape passes through the head assembly. It then stops and the system is ready to receive a new recording.



This rack houses an automatic tape recording system which delays signals up to one hour from time of original recording.

$$\begin{bmatrix} Y_{11}+G_{13} & -Y_{12} & -Y_{13}-G_{13} & 0 & 0 & 0 \\ -Y_{21} & Y_{22}+G_{23} & -Y_{23}-G_{23} & 0 & 0 & 0 \\ -Y_{31}-G_{13} & -Y_{32}-G_{23} & Y_{33}+G_{13}+G_{23} & 0 & 0 & 0 \\ 0 & 0 & 0 & Y_{44} & -Y_{45} & -Y_{46} \\ 0 & 0 & 0 & -Y_{54} & Y_{55}+G_{56} & -Y_{56}-G_{56} \\ 0 & 0 & 0 & -Y_{64} & -Y_{65}-G_{56} & Y_{66}+G_{56} \end{bmatrix}$$

After connecting the terminals:

$$\begin{bmatrix} Y_{11}+G_{13} & -Y_{12} & -Y_{13}-G_{13} & 0 \\ -Y_{21} & Y_{22}+G_{23}+Y_{44} & -Y_{23}-G_{23}-Y_{46} & -Y_{45} \\ -Y_{31}-G_{13} & -Y_{32}-G_{23}-Y_{64} & Y_{33}+G_{13}+G_{23}+Y_{66}+G_{56} & -Y_{65}-G_{56} \\ 0 & -Y_{54} & -Y_{56}-G_{56} & Y_{55}+G_{56} \end{bmatrix}$$

With 3-6 as the common terminal and after disconnecting 2-4:

$$\begin{bmatrix} Y_{11}+G_{13}-Y_{12}\cdot(Y_{22}+G_{23}+Y_{44})^{-1}\cdot Y_{21} & -Y_{12}\cdot(Y_{22}+G_{23}+Y_{44})^{-1}\cdot Y_{45} \\ -Y_{54}\cdot(Y_{22}+G_{23}+Y_{44})^{-1}\cdot Y_{21} & Y_{55}+G_{56}-Y_{54}\cdot(Y_{22}+G_{23}+Y_{44})^{-1}\cdot Y_{45} \end{bmatrix}$$

For the network with input and output terminals 1 and 5 respectively, and 3-6 as common terminal we have derived the circuit matrix, which is of the form:

$$\begin{bmatrix} (Y_{11})' & -(Y_{15})' \\ -(Y_{51})' & (Y_{55})' \end{bmatrix}$$

With a source admittance Y_G and a load admittance Y_L the circuit quantities are:

$$Y_i = (Y_{11})' - \frac{(Y_{15})'\cdot(Y_{51})'}{(Y_{55})'+Y_L} \quad \text{(Input admittance)}$$

$$Y_o = (Y_{55})' - \frac{(Y_{15})'\cdot(Y_{51})'}{(Y_{11})'+Y_G} \quad \text{(Output admittance)}$$

$$A_v = \frac{(Y_{51})'}{(Y_{55})'+Y_L} \quad \text{(Voltage amplification factor)}$$

$$A_i = \frac{(Y_{51})'\cdot Y_L}{(Y_{11})'(Y_{55})' - (Y_{15})'(Y_{51})' + (Y_{11})' Y_L}$$

(Current amplification factor)

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To properly evaluate VHF and UHF-TV head-end tubes the noise parameters should be known. Conventional measurements give the noise figure at one frequency and one source impedance. Here is a method for calculating the lowest possible noise figure and the optimum source resistance for a wide range of frequencies

Noise Parameters in VHF-UHF Circuit Design

By CHRIS METELMANN
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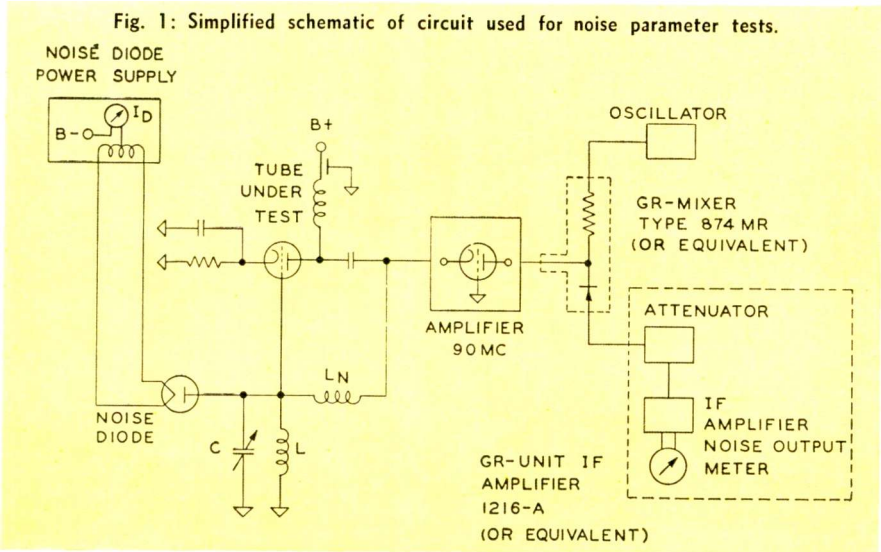
KNOWLEDGE of equivalent noise resistance (R_{eq}) and equivalent noise conductance (G_n) of tubes can help in selecting high-frequency head-end tubes and in designing optimum circuits for these tubes. These noise parameters are useful for calculating the lowest possible noise figure for a wide range of frequencies, and the impedance at which this noise figure can be achieved. This article describes a practical method of determining these noise parameters based on the theoretical background presented by H. Rothe and W. Dahlke of Telefunken in Germany.[1]

First, consider equivalent noise conductance. An electron needs time to travel from cathode to grid and from grid to plate. An electron leaving the cathode sees an accelerating field. It will move toward the grid, but before reaching it, the voltage in the grid may change. When the voltage goes negative, the electron will be decelerated. "Stopping" the previously-accelerated electron effectively induces voltage on the grid tending to charge the grid opposite to its sense of changing. The electron flow acts against the controlling grid voltage. This damping effect introduces a noise voltage on the grid due to the randomness of the electron flow. The magnitude of this effect varies directly with the frequency squared, and is usually described in terms of the transit time conductance (G_t). G_t can be calculated from the geometry of the tube; however, it must be multiplied by a temperature factor β when it is used in the noise equations. The value of the factor β has been given as 5 for oxide cathodes. The equivalent noise conductance (G_n) is identified as being equal to βG_t. It will be shown how G_n can be found experimentally, but G_t and β are not so easily determined; therefore G_n rather than βG_t is used as the noise parameter associate with transit time, in the method described here.

A second source of noise is the equivalent noise resistance referred to the grid (R_{eq}). This part of the noise originates in the plate, and one can visualize this noise by thinking of the single electrons hitting the plate like raindrops hit a roof. The random nature of this

Fig. 1: Simplified schematic of circuit used for noise parameter tests.



action produces continuous noise. This noise may be referred to the grid circuit by assuming an equivalent noise voltage at the grid, represented by the random thermal noise of a resistor as expressed by

$$e^2 = 4kTBR \qquad (1)$$

The factor 4kTB includes temperature and noise bandwidth considerations. With this expression, the noise on the plate can be considered equivalent to that generated by a resistor in the grid.

Noise Parameter Measurement

How are these two noise parameters measured? The circuit in Fig. 1 consists of the tube under test in a grounded-cathode circuit and a second stage amplifier in a grounded-grid circuit. The feedback coil L_n is adjusted for lowest noise figure, and the plate of the noise diode is connected directly to the grid of the tube under test. The condenser C is set at a number of positions at which the noise is measured. This is done by heating up the filament and measuring the diode plate current for the point where the output noise is doubled. First, the reading of the noise output meter with the noise diode unheated is noted, then 3 db of attenuation is inserted (½ the power). Then the filament of the noise diode is heated until the reference reading is reproduced on the noise output meter. For this setting of C, the plate current of the noise diode is recorded. After returning filament heating of the noise diode to zero, and removing the 3 db attenuation, the circuit capacitance is changed to a new setting and the procedure repeated.

If a curve is drawn through the points of noise diode current vs. capacitance, a parabola (Fig. 2) is obtained. The ordinates of this curve can be transformed from noise diode current to input conductance (G_{tot}) by $G_{tot} = 20\ I_D$. The minimum value of input conductance, the lowest point of the parabola, is taken as the noise parameter G_n ($G_n = 20\ I_{D\ min}$). If the capacitance scale along the abscissa is translated so that the capacitance coordinate of the lowest point of the parabola (where $I_{D\ min}$ occurs) becomes zero, the

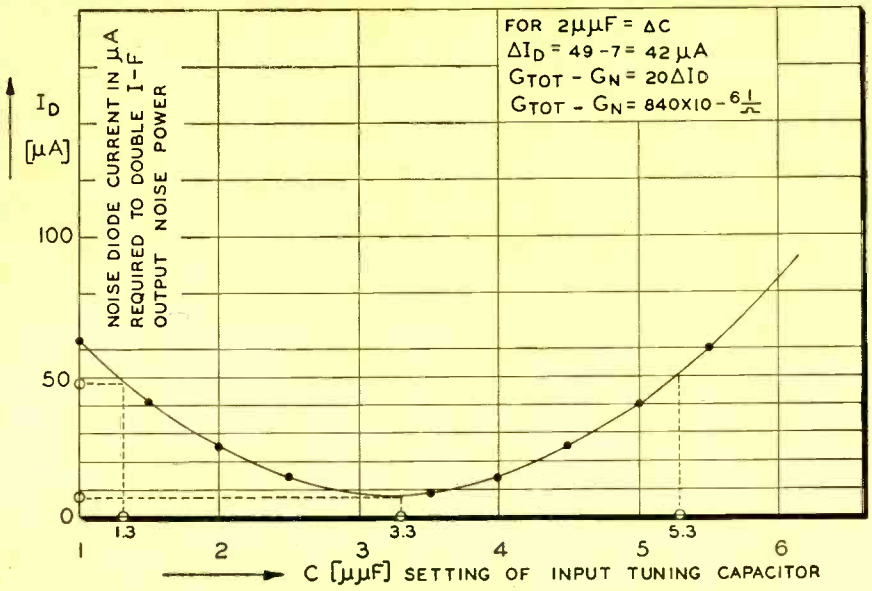
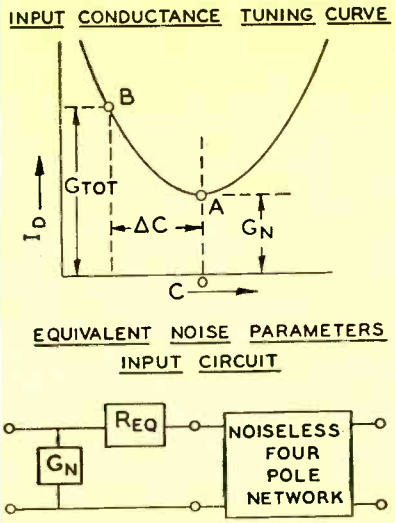


Fig. 2: Input conductance tuning curve is a parabola.

Fig. 3: G_n & R_{eq} are picked from the curve; $R_{s\ opt}$ & $F_{1\ min.}$ are calculated.



G_N = $20I_D$ MINIMUM AT POINT A (MINIMUM INPUT CONDUCTANCE AT FREQUENCY f_0)

G_{TOT} = $20I_D$ AT DETUNED POINT B

ΔC = CHANGE IN TOTAL INPUT SHUNT CAPACITANCE BETWEEN A AND B

I_D = NOISE DIODE CURRENT TO DOUBLE NOISE OUTPUT OF TUBE UNDER TEST

$$G_{TOT} - G_N = \omega^2 \Delta C^2 R_{EQ}$$

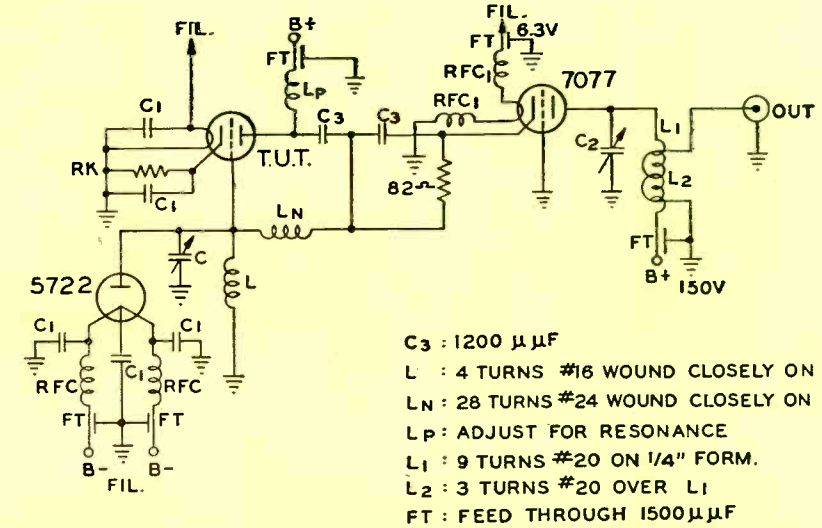
$$NF_1 - 1 = 2\frac{f}{f_0}\sqrt{G_N R_{EQ}}$$

$$R_{S\ OPT} = \frac{f_0}{f}\sqrt{\frac{R_{EQ}}{G_N}}$$ (IF CIRCUIT LOSSES ARE NEGLIGIBLE)

f = ANY FREQUENCY IN MC.

f_0 = FREQUENCY USED FOR MEASUREMENTS IN MC.

Fig. 4: Circuit components must have right characteristics at test frequencies.



C : 1-8μμF LIN. C VARIABLE AIR

C_1 : CERAMIC DISC. .008μF

C_2 : CERAMIC TRIMMER 1-10μμF

C_3 : 1200 μμF

L : 4 TURNS #16 WOUND CLOSELY ON 3/8"

L_N : 28 TURNS #24 WOUND CLOSELY ON 1/8"

L_P : ADJUST FOR RESONANCE

L_1 : 9 TURNS #20 ON 1/4" FORM.

L_2 : 3 TURNS #20 OVER L_1

FT : FEED THROUGH 1500μμF

RFC : OHMITE Z-144 OR EQUIVALENT

RFC_1 : ~¼ OF #32 WOUND ON 1/8" FORM

Noise Parameters

(Continued)

scale then gives directly ΔC, the difference from the capacitance at $I_{D\ min}$. In terms of the new coordinates G_{tot} and ΔC, the parabola can be expressed by the equation

$$G_{tot} - G_n = \omega^2 (\Delta C)^2 R_{eq} \qquad (2)$$

By substituting in this equation the coordinates G_{tot} and ΔC of some point on the parabola other than the vertex, and using the value of G_n previously determined along with the known frequency of measurement, the noise parameter R_{eq} can be calculated.

Using the Curves

Knowing these two noise parameters, the lowest possible noise figure for every frequency can be calculated; also the source impedance at which this occurs. The formulae used to calculate the optimum source impedance ($R_{s\ opt}$) and minimum noise figure ($F_{1\ min}$) are:

$$R_{s\ opt} = \frac{f_o}{f}\sqrt{\frac{R_{eq}}{G_n}} \qquad (3)$$

$$F_{1\ min} = 1 + 2\frac{f}{f_o}\sqrt{R_{eq}\,G_n} \qquad (4)$$

The value of f_o is the frequency at which G_n has been measured (MC), and f the frequency (MC) at which the values of R_s opt and $F_{1\ min}$ are to be determined. Fig. 3 summarizes the equations and procedures used to determine G_n and R_{eq} from the experimentally determined curve, and to calculate $R_{s\ opt}$ and $F_{1\ min}$.

Test Circuit Problems

It may not be obvious that the noise match just mentioned poses a problem for the circuit designer. It is not too troublesome to calculate the values of the components for the circuit, knowing the desired source impedance. But the components used must have the required characteristics at the test frequency. The r-f chokes must be self-resonant at the test frequency to have a high impedance, and the optimum circuit configuration must also be determined. The circuit used in our case is shown in Fig. 4.

One reason for using this circuit was the ease in adjusting for lowest noise figure by changing L_n. By this method, a lowest R_{eq} and G_n is found. It is difficult to be sure that the values are truly a measure of the tube noise independent of the effect of losses in the test circuit. Fortunately, estimates of G_n and R_{eq} may be made in other ways to check the measurements.

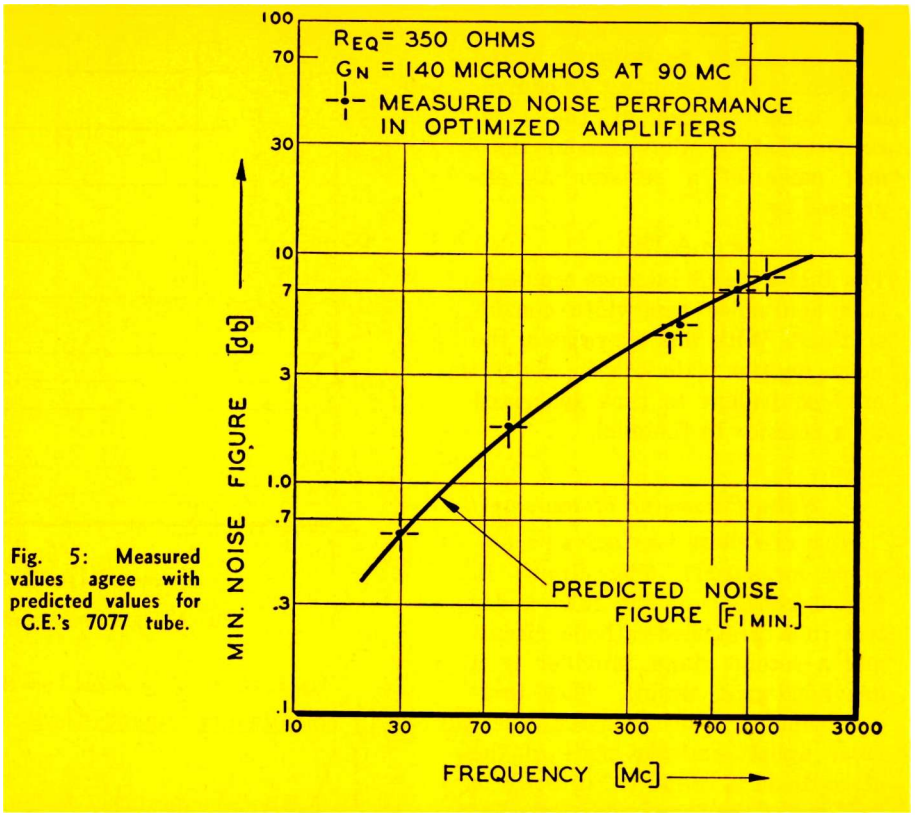


Fig. 5: Measured values agree with predicted values for G.E.'s 7077 tube.

Checking Results

G_n may be calculated by the formula $G_n = \beta G_t$, where G_t is calculated from the tube geometry and β is taken as 5 for oxide cathodes. There is an empirical relationship between R_{eq} and gm which states that $R_{eq} \times gm = 2.5$. Furthermore, it is possible to measure the noise figure at power match. Power match occurs at a certain impedance (R_{sm}) which is independent of frequency and can be measured. Using the values of R_{eq} and G_n as determined at the frequency f_o, the frequency f at which $R_{s\ opt}$ equals the measured value of

Table 1

R_{eq} and G_n at 90 Mc under Published Typical Operating Conditions

Tube Type	R_{eq} ohms	G_n μmhos	E_b Volts	R_k ohms	G_m μmhos	I_b ma
6AM4	260	600	200	100	9,800	10.0
6AN4	250	550	200	100	10,000	13.0
6BC4	260	540	150	100	10,000	14.5
6BC8	600	320	150	220	6,200	10.0
6BK7A	240	520	150	54	9,500	18.0
6BN4	420	390	150	220	6,930	9.0
6BQ7A	435	290	150	200	7,040	9.0
6BS8	390	330	150	220	7,300	10.0
6BZ7	490	350	150	220	6,800	10.0
6CE5*	650	1200	200	180	5,700	11.0
2CY5*	525	640	125	150	6,640	10.0
6201	600	320	250	200	5,300	10.0
7077	350	140	150	82	10,000	6.5
PC86	170	710	175	125	9,800	10.0
PCC88	280	540	150	220	15,000	12.0
E180F*	120	1160	150	82	19,000	15.0

* Pentode or tetrode measured in triode connection.

Table 2

R_{eq} and G_n at 90 Mc for I_p = 15 ma; R_k = 68 Ohms

Tube Type	R_{eq} ohms	G_n μmhos	E_b Volts	G_m μmhos
6BC8	340	520	135	9,600
6BK7A	355	580	130	8,700
6BQ7A	460	520	135	8,500
6BS8	345	530	120	9,800
6BZ7	420	540	120	8,800
6BZ8	385	700	165	10,000
PCC88	180	820	100	13,800
2CY5*	370	700	100	9,900
6BC5*	455	1500	150	9,500

* Pentode or tetrode measured in triode connection.

R_{sm} can be determined by using formula (3), $R_{s\ opt} =$

$$\frac{f_o}{f}\sqrt{\frac{R_{eq}}{G_n}}.$$

If the noise figure is measured at this frequency, the measured value should coincide with the value calculated by formula (4),

$$F_{1\ min} = 1 + 2\frac{f}{f_o}\sqrt{R_{eq}\,G_n}\ .$$

Finally, the circuit can be optimized to give the lowest possible noise figure ($F_{1\ min}$) at any frequency, and this noise figure compared with $F_{1\ min}$ as calculated from measured values of R_{eq} and G_n.

Fig. 5 shows the relationship between predicted and measured minimum noise figures for General Electric's 7077 ceramic tube. These data show that the minimum noise figure, as predicted from R_{eq} and G_n noise parameter measurements, agree with measured values of noise figures from 30 to 1200 MC.

This comparison of noise figures reveals nicely the difference between conventional noise figure measurements and the use of the noise parameters. Conventional lab measurements check the noise figure at one frequency and one source impedance. Nothing else is known beyond this point. In the method described by Rothe and Dahlke, two noise parameters are measured at one frequency and one impedance, and knowing these two parameters, the lowest possible noise figures and the optimum source resistance for a wide range of frequencies can be calculated.

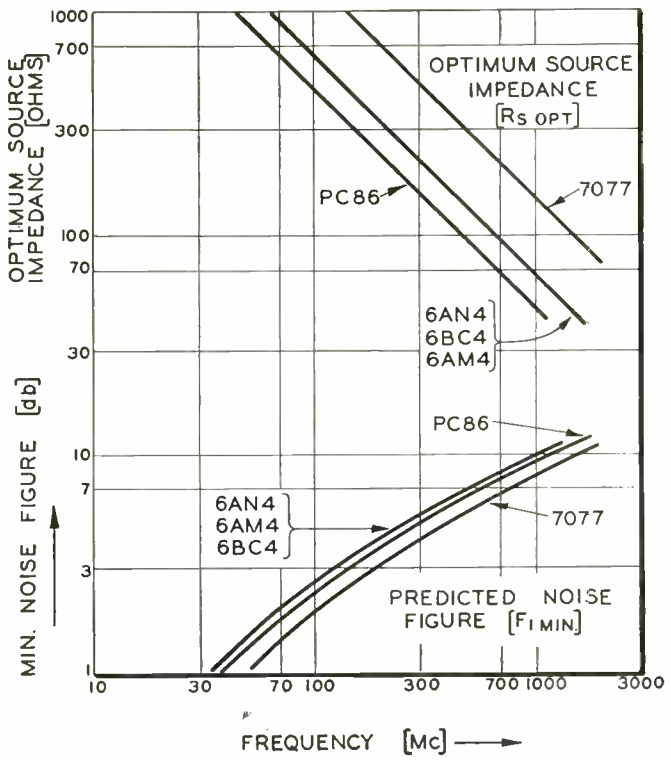


Fig. 6: Predicted min. noise and optimum source impedance for several tubes.

Values for Some Tubes

Fig. 6 shows the predicted noise figure and the optimum source impedance of a number of UHF tube types, as determined by this method on small samples of commercially available tubes.

Knowledge of the two noise parameters, R_{eq} and G_n, provides a tool for evaluating VHF and UHF-TV head-end tubes for noise. Values of R_{eq} and G_n for a number of tube types are shown in Table 1 as measured under published typical operating conditions, and in Table 2 using 68 ohms cathode resistance with the plate voltage adjusted for a plate current of 15 ma. in each case. The data given in Tables I and II were taken on a number of tubes (usually 20) to be sure the values were representative values at the time of manufacture. Changes in production conditions may result in changes in the noise parameters.

References

1. Rothe, H., and Dahlke, W., "Theory of Noisy Fourpoles." *Proceedings of the IRE*, Volume 44 (June, 1956), pp. 811-818.
2. Wallman, H., MacNee, A., and Gadsden, C., "A Low Noise Amplifier." *Proceedings of the IRE*, Volume 36 (June, 1948), pp. 700-708.

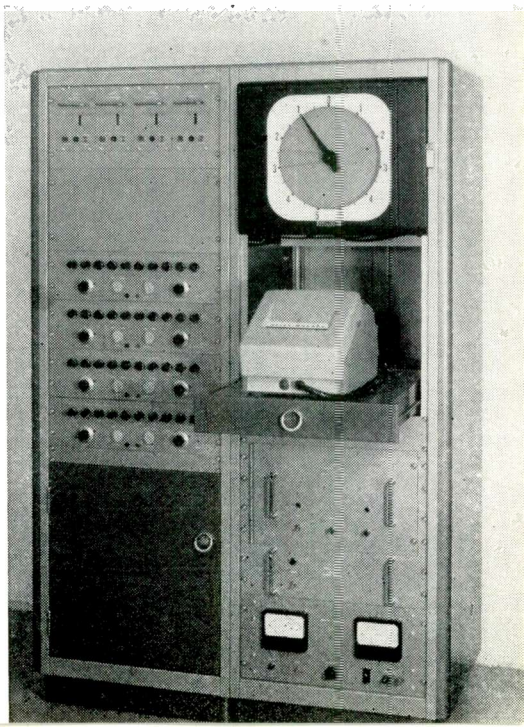
Strain Gauge Output Recorder

A SIMPLE, reliable and economical method for recording in digital form the output of strain gauges is provided by this new data recording system by Datex Corp., Monrovia, Calif.

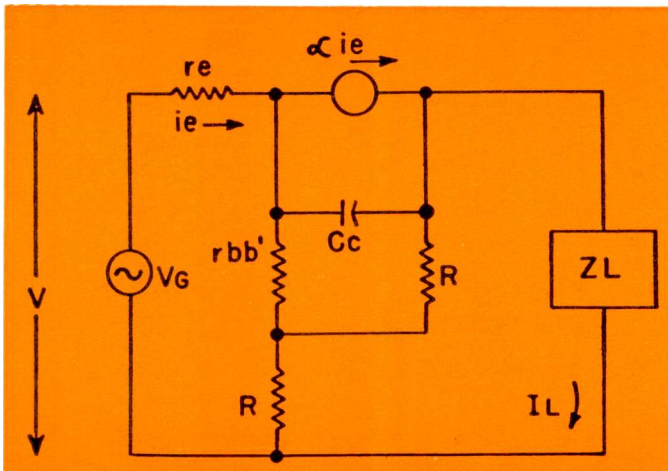
The system consists of four input scanners, a shaft position encoder, four strain gauge control chassis, a system control chassis, two power supplies, a self-balancing potentiometer, and a Datex-Monroe Data/Log printer.

The system provides for selection of up to 40 strain gages and is expansible in modules of 10 points up to a capacity of 100 points or more. The input selectors sequentially select strain gage transducers and present the data to the potentiometer for measuring.

The potentiometer rotates an encoder to a position corresponding to the magnitude of the input variable. The encoder data is stored and translated to decimal code by the control chassis which includes facilities for recording two decimal digits of point identification and sign, and three decimal digits of encoder data via the Data/Log printer.



Data/Log records the magnitude and point identification of variables on paper tape.



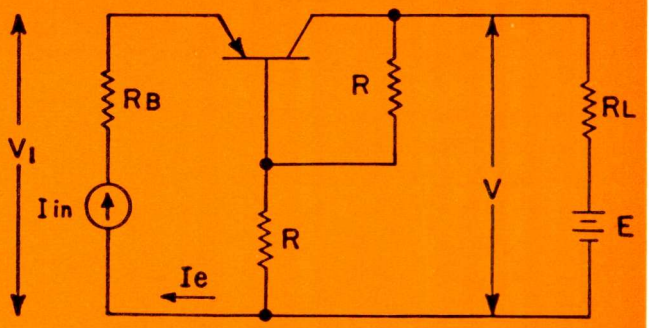


Fig. 11 (left): Voltage doubler equivalent circuit.

Fig. 12 (above): Low frequency voltage doubler circuit.

Designing Transistorized Video Amplifiers

In an easy to follow step-by-step procedure, this article gives engineers the background to design practical receiver video amplifiers to given requirements. Two types of three-transistor circuits are described.

By R. G. SALAMAN*
Colorado Research Corp.
Broomfield, Colorado

Part Two of Two Parts

* Mr. R. G. Salaman was employed by Westinghouse Electric Corp.'s Radio-TV Division in Metuchen, N. J., when this article was written.

A PRACTICAL circuit of the voltage doubler type amplifier is shown in Fig. 13.

Voltage doubler stage:

From the dc conditions for a 2N247, Ie max. = 2 ma., V max. output = 2 V ce = 70V

$$R_L \geq \frac{V}{2\ Ie\ R} = 18 \quad fK$$

If R_L = 18 K

$$R = \frac{V\ R_L}{4\ Ie\ R_L - 2V} = 315\ \frac{K}{I}$$

With a load capacitance equal to 15 mmf.

Z in low freq. = ½ ZL = 9 K in parallel with 30 mmf.

Common collector Stage: With a 2N247 and a high RL = 1K, Z in ≈ 76K. Base bias resistors which produce the nominal 2 ma emitter current and have a parallel impedance of the order of 15K are used to swamp out the load impedance variation on the second detector. The output impedance of the stage is calculated to be of the order of 400 ohms at the high end of the video spectrum.

Common Emitter Stage: The experimental method of finding the values of R_L, Ce and Re shown previously was used. It will be remembered that a plot of R_L vs. gain for a fixed Rs and other quantities adjusted for correct and maximum bandwidth quickly indicate the value of R_L for maximum gain.

Values for Ce and Re were 0.0012 mfd and 270 ohms when R_L = 10K, Bw = 3.5 MC and C_L = 30 μμf. Bias resistors are made much greater than the input impedance and a large (4.7K) fully bypassed emitter resistor is used for temperature stability. It must be remembered to choose a large enough bypass condenser to tie the low emitter impedance to ac ground.

As Ie in the common emitter and voltage doubler stages are the same, and the input resistance of the common base stage is about the same as that needed for maximum efficiency of the common emitter, direct coupling is indicated. Shunt-series peaking can now be added to provide the maximum bandwidth obtainable for the amplifier.

Cascade Push-Pull Amplifier

The required drive can be obtained by another method utilizing one-half the battery voltage needed for the voltage doubler. See Fig. 14.

A common collecter impedance transformer is used to drive a common emitter amplifier which supplies the cathode of the CRT with 50 vP-P. A portion of this voltage is used to feed another common emitter stage which feeds 50 vP-P in the opposite phase to the grid of the CRT. No shunt collector peaking can be used in the first stage as this would upset the pass-band of the signal to the second stage. If shunt peaking is desired, a high resistance divider can be used to supply the second stage directly from the CRT cathode. This type of coupling provides a source of trouble in that the impedance is so high that stray pickup is possible. The collector resistor tap method provides slightly better gain bandwidth.

Cross coupling in the cathode-ray tube is evident but minimized by tapping up high on the first collector load resistor and reducing the second stage gain by introducing emitter feedback.

Video Amplifiers

A common collecter driving a common emitter stage provided 80 vP-P on the cathode of a CRT. Using 2N247's, the common emitter transistor was supplied with a static collector emitter voltage of 45v and an emitter current of 4.5 ma. The load resistor was 10K and the stage provided a gain of 40 with a 3.5 MC bandwidth. Also, a single 2N247 common emitter stage driven by a transistor second detector supplied a 50 vP-P 3 MC signal to a picture tube.

Conclusions

The performance of a 3 transistor amplifier gives 4 times the gain with the same bandwidth, source impedance, and voltage output as a vacuum tube amplifier. The power requirements are less than one tenth of a vacuum tube amplifier. With the rapid advent of better transistors, a one stage amplifier can be expected in the near future.

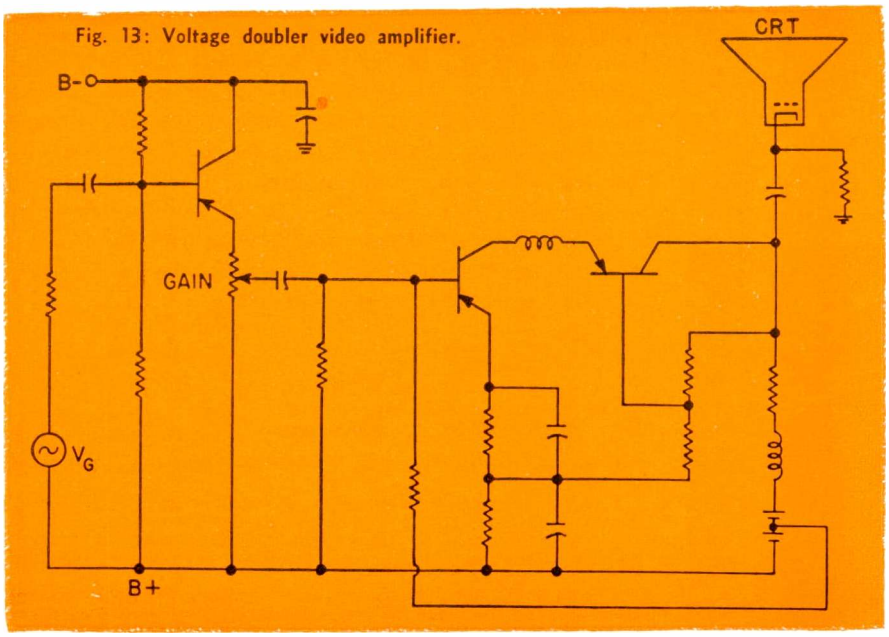


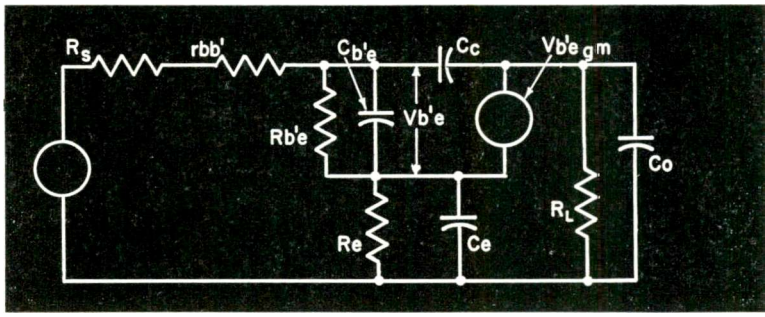
Fig. 13: Voltage doubler video amplifier.

PERFORATED PAGES!

In response to many reader requests the pages in the main editorial section have now been perforated. This will enable readers to easily remove material for their reference files. If the copy of Electronic Industries you receive already has pages removed that you want, please let us know. We'll be glad to provide the missing pages.

ADDITIONAL NOTES

Maximum gain and linearity with a specified bandwidth and minimum power dissipation are desirable characteristics of the video amplifier. As the transfer function of the complete amplifier is too complex to serve any useful purpose each variable can be viewed separately with the others held constant to give a rough understanding of the operation of the amplifier.



For a rough understanding of the operation of the amplifier, each variable can be viewed separately with the others held constant.

Maximum Aperture

It is desirable to obtain as much output aperture as possible as this will increase the linearity of the portion utilized. Linearity is of great importance as usually the sound i-f is also amplified in the video amplifier and any nonlinearity results in modulation which must be removed in the limiter. Therefore, a transistor with a high breakdown voltage must be utilized and the maximum collector-emitter voltage chosen. Once this is accomplished the proportion between R_L and Ie is established:

$$R_L = \frac{Vc\ max.}{2\ Ie} \qquad (1)$$

This condition must always exist for the maximum utilization of aperture.

Low Frequency Gain

The low frequency gain of an uncompensated amplifier with no emitter peaking is

$$G = Vb'e\ g_m\ R_L \qquad (2)$$

As

$$g_m = Ie/26 \qquad (3)$$

it is seen by equation (1) and (2) that the low frequency gain is only

Video Amplifiers

(Continued)

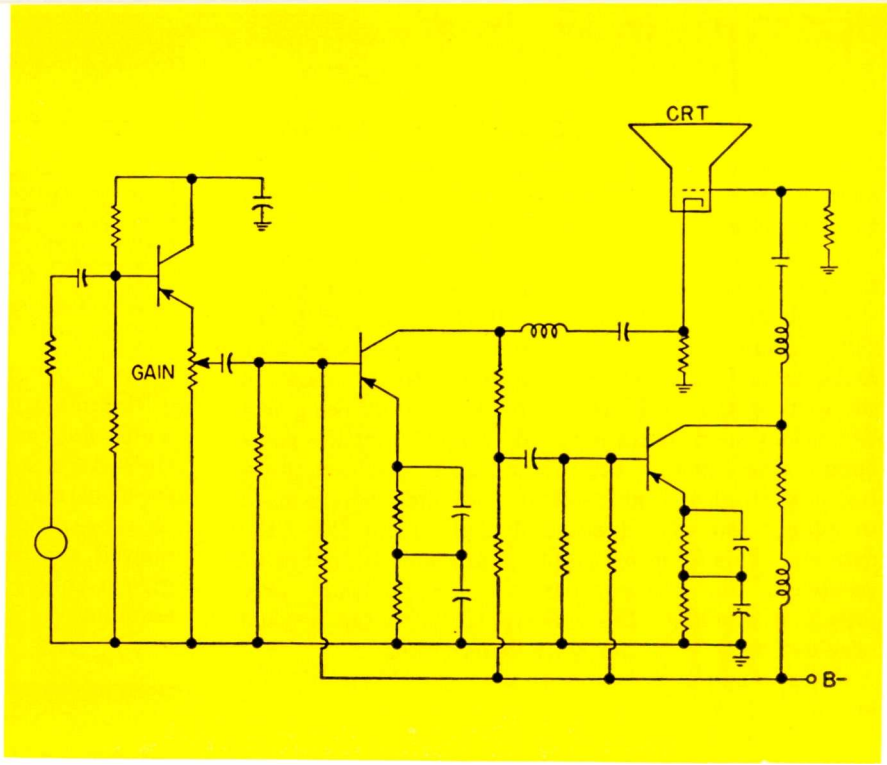


Fig. 14: (right) Cascaded push pull video amplifier.

dependent on Vb'e. Rb'e varies inversely with Ie allowing Vb'e to vary depending upon the remaining series impedance. This will be an inverse proportional variation if Rb'e is being driven from a current source.

When Re is added the gain is easily shown to be

$$G_{LF} = \frac{Vc/2\ Ie}{\frac{1}{\beta}(Rs + Re) + \frac{26}{Ie} + Re} \qquad (4)$$

The equivalent circuit (Fig. 1) suggests that as Ie varied from a high to a low value the associated variation in Rb'e will increase the gain linearly at first and then at low Ie result in a constant value of gain (when Rb'e is high and the rest of the circuit looks like a voltage source). As any unbypassed emitter resistance adds a component β Re to the effective input impedance, it is expected that a lower emitter current would be needed for the gain vs. Ie curves to flatten.

Bandwidth Considerations

When bandwidth is being restricted by Rb'e and Cb'e, the addition of Ce increases the gain bandwidth whereas if only R_L Co is being compensated, Re and Ce are both needed to conserve gain bandwidth (see Part I).

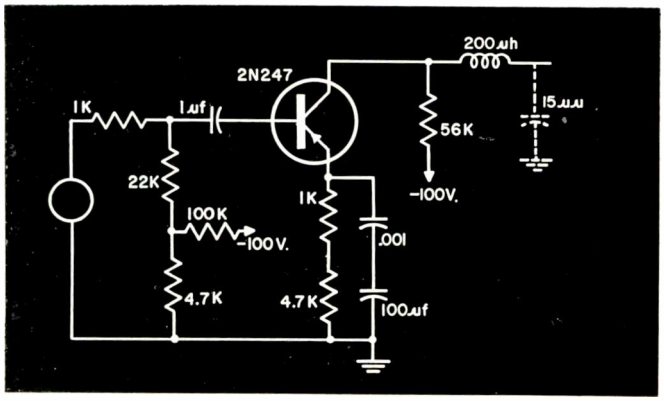
The time constant of Rb'e and Cb'e is constant when Ie is varied and at high currents the feedback impedance due to Cc is small compared to Rb'e. Therefore, at large values of Ie, the portion of Re Ce needed to compensate for the b'e impedance is constant for various values of emitter current. Re, however, must be changed to compensate for the change in load impedance. As Ie is lowered, it is observed that Re must be varied inversely with Ie to maintain a constant bandwidth because R_L is simultaneously raised. It will be remembered that because Rb'e is inversely proportional to Ie the gain varies inversely with Ie when Re is constant. Now it remains constant as Re is also varied inversely with Ie to maintain constant bandwidth; gain bandwidth remains constant.

At low values of emitter current, Rb'e becomes very large and the reflected impedance due to Cc dictates that emitter peaking is needed earlier than before. A typical experimental plot of Re vs. Ie indicates that for the particular circuit values used, the break point occurs at about 0.6 ma. As Re must be increased faster than R_L beyond this point a decrease in gain is expected.

A plot of gain vs. Ie will quickly determine the value of R_L at which the decrease in gain bandwidth occurs and the amplifier can be operated at this point with maximum linearity and output aperture and minimum dissipation. When the plot is made, Ce and Re are always adjusted for maximum and constant flat bandwidth; R_L is determined by formula (1).

Maximum gain was obtained in the experimental circuit in figure with an aperture of 100 volts and a dissipation of only 40 mw. The linearity was within 10% for a 60 volt output signal.

Linearity is within 10 per cent for a 60 volt output signal.



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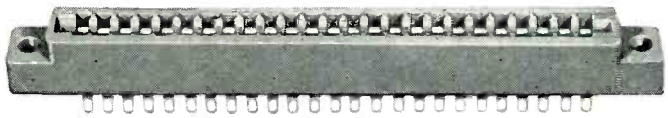
3. Paul F. Hille, Jr., and Jack Avins, Design of Video—Amplifier Peaking Circuits for Optimum Transient Response, *RCA LB—No. 930.*

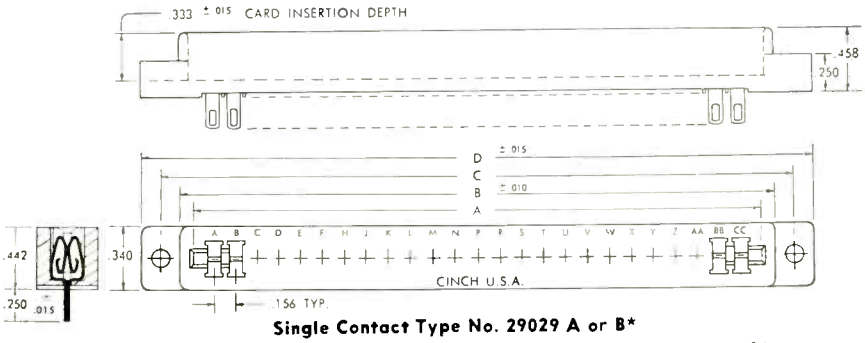
4. Victor H. Grinich, "A Transistor Video Amplifier Having 80 Volts Output," The Cincinnati Section of Radio Engineers, April 13, 1956.

UNIVERSAL *double action* CONTACT MOLDED PRINTED WIRE EDGE CONNECTORS:

SINGLE AND DUAL CONTACT TYPES



Single Contact Type No. 29029 A or B*



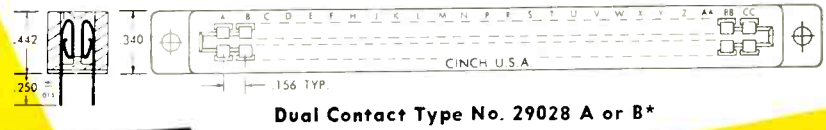
Single Contact Type No. 29029 A or B*

Made in 6 through 25 contacts inclusive. Designed for nominal 1/16" printed wire board, either single or two sided copper. A polarizing contact made of brass, Sel-Rex gold plated, can be placed in any contact position. Insulation material is of glass filled Diallyl Phthalate (Type GDI-30 per Mil. M-19833). Contacts are of Beryllium Copper or Phosphor Bronze with Sel-Rex gold plate .00003 minimum. Terminals are mounted on .156" centers. Mounting holes are .128" dia.

Insulation is among the best available from both the electrical and mechanical standpoints.

Contacts are especially designed for minimum printed circuit card wear, low insertion force and positive contact with the printed wire board.

The lack of sharp radii in the contact design makes it possible to offer this contact in either Beryllium copper or Phosphor Bronze. Due to the use of heavier material in the contacts the tails are more rigid than those in similar connectors that are presently available.

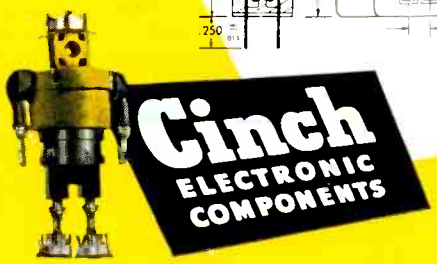


Dual Contact Type No. 29028 A or B*

Made in 12 through 50 contacts in multiples of two. Designed for nominal 1/16" printed wire board, copper clad on both sides.

Contacts, polarizing contact, insulation and mounting holes are the same as described for No. 29029.

*A—Phosphor Bronze Contact *B—Beryllium Copper Contact



ORDERING INFORMATION

In ordering use base number, 29029 or 29028, followed by the number of contacts, then contact material and then the letter indicating position of the polarizing contact. For example 29029-12-A-E, or 29028-16-B-E.

Contact tail as shown available now, wire wrap and dip solder type contacts in the near future.

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VOLTAGE BREAKDOWN:	AC RMS	DC
Sea level (adj. terminals)	2500	3800
Altitude 3.4 HG. 50,000 ft. (adj. terminals)	900	1200
Altitude 1.3 HG. 70,000 ft. (adj. terminals)	600	850
VOLTAGE RATINGS:		
Sea level (adj. terminals)	830	1270
Altitude 3.4 HG. 50,000 ft. (adj. terminals)	300	400
Altitude 1.3 HG. 70,000 ft. (adj. terminals)	200	280
RECOMMENDED WITHSTANDING VOLTAGE:		
Sea level (adj. terminals)	1870	2850
Altitude 3.4 HG. 50,000 ft. (adj. terminals)	675	900
Altitude 1.3 HG. 70,000 ft. (adj. terminals)	450	640

Current Rating 10 Amperes

Contact resistance at 7.5 amperes measured with nominal thickness printed wire board.	0.0027 Ohms Max.
Insulation resistance	5000 Megohms Min.
Insulation resistance (immediately after 96 hours at 90-95% R.H. and 40°±2° per method 103A of Mil-STD-202A	100 Megohms Min.

Single Contact Type No. 29029

BASE NO.	NUMBER OF CONTACTS	DIMENSIONS A	B	C	D
29029	6	1.098	1.239	1.531	1.785
29029	7	1.254	1.395	1.687	1.941
29029	8	1.411	1.552	1.844	2.098
29029	9	1.567	1.708	2.000	2.254
29029	10	1.723	1.864	2.156	2.410
29029	11	1.879	2.020	2.312	2.566
29029	12	2.036	2.177	2.469	2.723
29029	13	2.198	2.333	2.625	2.879
29029	14	2.348	2.489	2.781	3.035
29029	15	2.504	2.645	2.937	3.191
29029	16	2.661	2.802	3.094	3.348
29029	17	2.817	2.958	3.250	3.504
29029	18	2.973	3.114	3.406	3.660
29029	19	3.129	3.270	3.568	3.816
29029	20	3.286	3.427	3.719	3.973
29029	21	3.442	3.583	3.875	4.129
29029	22	3.598	3.739	4.031	4.285
29029	23	3.754	3.895	4.187	4.441
29029	24	3.911	4.052	4.344	4.598
29029	25	4.067	4.208	4.500	4.754

Dual Contact Type No. 29028

BASE NO.	NUMBER OF CONTACTS	DIMENSIONS A	B	C	D
29028	12	1.098	1.239	1.531	1.785
29028	14	1.254	1.395	1.687	1.941
29028	16	1.411	1.552	1.844	2.098
29028	18	1.567	1.708	2.000	2.254
29028	20	1.723	1.864	2.156	2.410
29028	22	1.879	2.020	2.312	2.566
29028	24	2.036	2.177	2.469	2.723
29028	26	2.192	2.333	2.625	2.879
29028	28	2.348	2.489	2.781	3.035
29028	30	2.504	2.645	2.937	3.191
29028	32	2.661	2.802	3.094	3.348
29028	34	2.817	2.958	3.250	3.504
29028	36	2.973	3.114	3.406	3.660
29028	38	3.129	3.270	3.562	3.816
29028	40	3.286	3.427	3.719	3.973
29028	42	3.442	3.583	3.875	4.129
29028	44	3.598	3.739	4.031	4.285
29028	46	3.754	3.895	4.187	4.441
29028	48	3.911	4.052	4.344	4.598
29028	50	4.067	4.208	4.500	4.754

Circle 49 on Inquiry Card

New Products . . . for the Electronic Industries

AC VOLTMETER

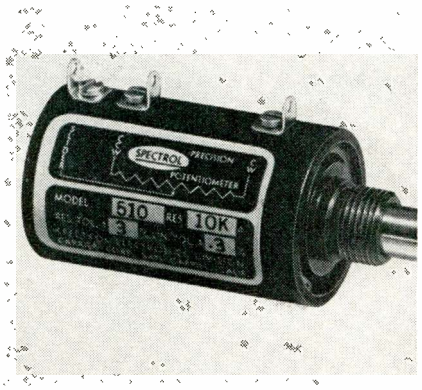
A pocket-sized ac electronic voltmeter, Model 332, is for applications where space is limited and sensitivity not too important. Panel-mounted, it uses a 2½ in. meter and has a barrel

2 in. in dia. and less than 4¾ in. long. Basic range is 0. to 100 mv RMS. Input impedance is 1 megohm, parallel by 10 $\mu\mu$f adding almost no load to the circuit. It can be provided with any voltage range up to 300 v RMS. Frequency response is 20 CPS to 20 KC, ±2%. Accuracy is ±3% of full scale deflexion. Metronix, Inc., Chesterland, Ohio.

Circle 197 on Inquiry Card

PRECISION POTENTIOMETER

A ⅞ in., 10 turn, precision wirewound potentiometer, Model 510, is available in ranges from 25 to 120 K ohms. Standard linearity tolerance is ±0.25% with tolerances of ±0.1% on



special order. It will operate over a −55°C to +105°C range. Up to 46 additional terminals can be added to the standard unit for special applications. Sleeve bearings at both shaft ends are standard. Shaft diameter is ¼". 1K, 5K, 10K, 20K, 30K, 50K, and 100K values are stock items. Spectrol Electronics Corp., 1704 So. Del Mark Ave., San Gabriel, Calif.

Circle 199 on Inquiry Card

SWEEPING OSCILLIATOR

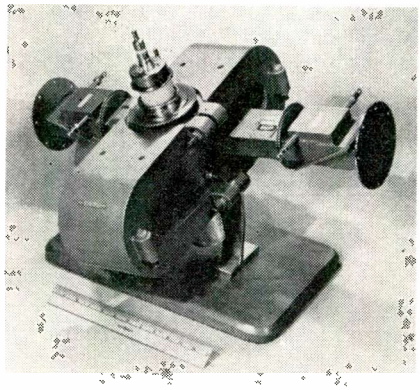
Ligna-Sweep Model SKV covers a frequency range of 200 CPS to 11.0 MC, provides sweep widths from 20 KC to 10 MC on its variable sweep bands, and from 2 KC to 20 KC on its

fixed frequency bands. Four ranges of sweep width are provided using 4 separate oscillator and sweep circuits. Other specs: sweep rate, 0.3-30 CPS in 3 ranges, 30 CPS, and line lock; sweep voltage, approx. 5.0 v. at low impedance out; r-f output: approx. 1.0 v. RMS into 70 ohms; audio, approx. 1.0 v. RMS into 600 ohms. Kay Electric Co., Dept. EI, Pine Brook, N. J.

Circle 201 on Inquiry Card

S-BAND AMPLIFIER

Rated at 3mw peak, 15 kw average power output, the QK622 is an S-band power amplifier stage with wide r-f bandwidth. Tube supplies full power over an operating band of 2900 to 3100 MC at efficiencies over 70%. Operating life is over 1000 hrs. at rated power. Other characteristics: pulse

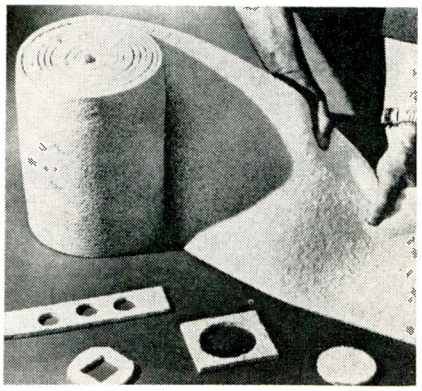


duration, 10 μsec; duty cycle, 0.005; pulse voltage, 50-55 kv; peak anode current, 65 a; efficiency, 70%; r-f input, 475 kw. It can be operated at reduced peak power level as a driver stage. Efficiency is retained at a peak power output of 600 kw and gain of 10 db. Raytheon Mfg. Co., Waltham 54, Mass.

Circle 198 on Inquiry Card

FIBROUS SILICONE RUBBER

A new silicone rubber product, Cohrlastic FSR, is a form of silicone rubber, fibrous in nature, somewhat resembling sponge and foam in properties. It is a mat of silicone rubber fibers oriented in a completely random manner. Some properties are: high permeability, good tear resistance,

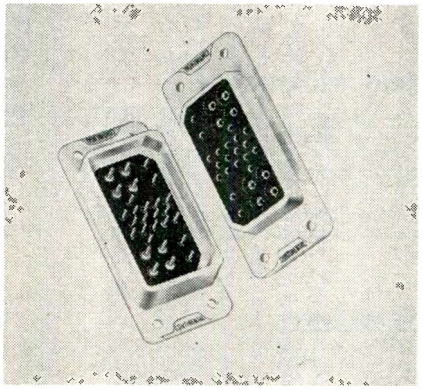


good tensile strength, density in the range of 20 lbs/cu. ft., good compression-deflection characteristics, useable temperature range −65°F to 500°F. It is available from pilot plant equipment in sheets ¼ in. thick, 9 in. wide and 6 ft. long. The Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.

Circle 200 on Inquiry Card

RECTANGULAR CONNECTORS

Series 2000, heavy duty rectangular connectors, are available in 3 contact arrangements for power applications requiring combinations of coaxial and conventional contacts, contacts for #16 and #18 AWG wire, and 41 contacts for #18 AWG wire. Closed entry contacts with leaf spring pro-



vide reliability and maintain a low mv drop under constant and uniform insertion pressure. Body is blue Orlon filled Diallyl Phthalate (MIL-M-18794, Type SDI-5). Current rating is 7.5 a for 0.058 dia. solder cup. and 10 a for 0.076 dia. solder cup. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 202 on Inquiry Card

New Products . . . for the Electronic Industries

PANEL METERS

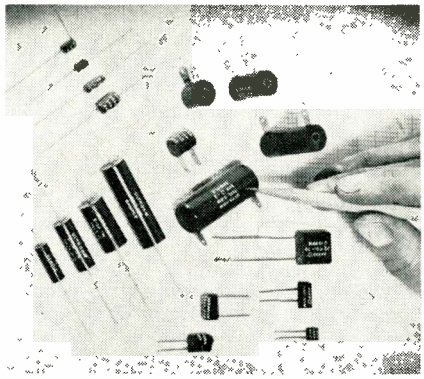
Series of current and voltage panel meters combine high sensitivities with extreme overloads. The 700 Series are available in up to 23 ranges in one model, with full-scale sensitivities

to 0.20 microamps. The combination of low resistance (2 mv drop on the one microamp range) with ability to withstand overload surges of 100,000%, makes these meters most sensitive and rugged. Overload protection of better than 1,000,000% on all ranges is available on special order. Greibach Instruments Corp., 315 North Ave., New Rochelle, N. Y.

Circle 203 on Inquiry Card

WIREWOUND RESISTORS

Special precision wirewound resistors with any specified temperature coefficient between −25 and +6000 ppm/°C are available in values of 10 ohms to 3 megohms. The resistors have

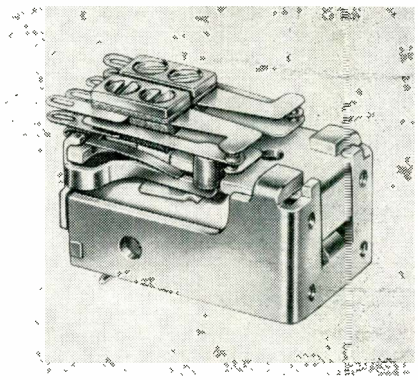


application in telemetering, zener diode, and other circuits requiring positive temperature compensation. In bridge circuits, they can be used to accurately measure temperature. They are available with solder lugs and axial, radial printed circuit, or special leads. Meet or exceed all applicable Mil specs. Ultronix, Inc., 111 E. 20th Ave., San Mateo, Calif.

Circle 205 on Inquiry Card

MINIATURE RELAY

The type TQA is a miniature relay for dc operation at sensitivities from 20 to 100 mw. For negligible shock and vibration, 15 mw per pole is available. Contact assemblies forms A, B

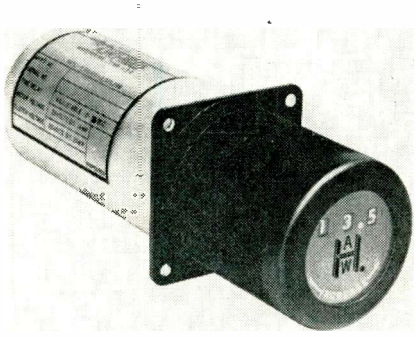


or C, up to a total of 18 springs. Contact rating with resistive load at 28 vdc, or 115 vac: silver contact, 3 a; palladium or gold alloy, 0.5 a. Contact life: 100,000 operations, min. Operating temp.: −55°C to +100°C—available, −65°C to +125°C. Shock: to 50g. Vibration: up to 10g, from 10 to 500 CPS. Comar Electric Co., 3349 W. Addison St., Chicago 18, Ill.

Circle 207 on Inquiry Card

TIME DELAY RELAYS

Precision Time Delay Relay for Military applications. Units have a 2¼ in. round housing extending less than 4½ in. behind the panel. Only the setting knob is exposed. Time delays from 1/10 to 30 sec. in 1/10 sec. increments are set with the full dia. knob. Time delay setting read

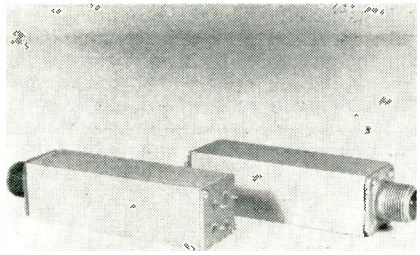


on the 3 digits, in the front of the knob, are internally illuminated with white or red lighting. Accuracy is ±1% from 24 to 29 vdc using the company's dc timing motors. Featured is a load isolation circuit to avoid switch closure prior to the adjusted time delay period. The A. W. Haydon Co., Waterbury, Conn.

Circle 204 on Inquiry Card

COAXIAL RELAY

A high speed coaxial relay for input applications in data system and other relay applications. Hermetically sealed, coil impedances to 6000 ohms, low contact resistance and operating rate up to 500 closures per second are some features of the unit. Pull in and release time less than 1 msec. Operat-

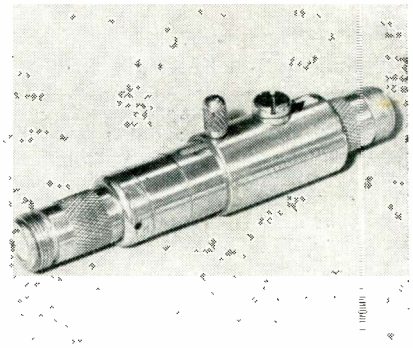


ing currents to 0.5 a resistive, also can be used on inductive devices with contact protection. Contact capacitance is less than 1 uuf. Operating life at low power approaches 20,000 hours at 60 closures per second. Dimensions 1 x 1 x 4½ over all. Electronic Computer Company, 618 Maple St., Conshohocken, Penna.

Circle 206 on Inquiry Card

ATTENUATOR

A Coaxial Variable Attenuator is designed with physically fixed input-output connectors. The attenuator is operated with a smooth sliding motion. Specifications are: 1000-6000 megacycles; attenuation range is 18-40 DB; voltage standing wave ratio is below 1.5. Radar Design Corpora-



tion, Pickard Drive, Syracuse 11, New York.

Circle 208 on Inquiry Card

See page 134 for additional New Product Announcements

New Tech Data for Engineers

Fluorocarbon Resins

Teflon Fluorocarbon Resins for electrical and electronic systems takes the properties of the material, suggests important design considerations in electrical and electronic systems, and reviews specific applications in which these resins solved a design problem. It also shows how TFE-fluorocarbon resins can provide cost savings through ease of assembly or reduction in weight or size. Tables and graphs document the story. E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

Circle 160 on Inquiry Card

Silicone Rubber

Silicone rubber selector chart, CDS-145, is available from the Silicone Products Dept., General Electric Co., Waterford, N. Y. This publication is designed to assist designers and engineers in selecting the proper type of silicone rubber for their particular requirements. The publication contains comprehensive data on applications, typical properties, primary classes and standard industry and military specifications.

Circle 161 on Inquiry Card

Cabinet Racks

Catalog 59 from Par-Metal Products Corp., 32-62 49th St., Long Island City 3, N. Y. contains 28 pages of illustrations, descriptions, technical specifications, and prices of cabinet racks, rack type slide assemblies, Type "C" and Type "A" racks, and utility desk assemblies. Complete information is supplied on accessories, fittings, panels, and roller trucks for use with Par-Metal housings.

Circle 162 on Inquiry Card

Cable Ties & Straps

Technical Bulletin, TR2, from The Thomas & Betts Co., Elizabeth, N. J., describes the Ty-Rap line of cable ties and straps. Included are tool applied and self-clinching types for normal mounting, overhead mounting, reusable mounting, and special conditions. Also included is a description of a special installing tool for ties and straps.

Circle 163 on Inquiry Card

Public Address Equipment

Bulletin 258A, describes public address equipment manufactured by Electro-Voice Inc., Buchanan, Mich. It contains information on compound diffraction projectors, paging units, outdoor speaker systems, P. A. accessories, and selected E-V microphones.

Circle 164 on Inquiry Card

Connectors

An 8-page, 3-color brochure from The Deutsch Co., 7000 Avalon Blvd., Los Angeles, Calif., gives a brief description of design data on the DS miniature electrical connector plus detailed instruction on contact crimping, insertion, and removal. Drawings and data are included.

Circle 165 on Inquiry Card

Microwave Test Equipment

Six-page, 2-color, Bulletin 200, available from Polytechnic Research and Development Co., Inc., 202 Tillary St., Brooklyn, N. Y., describes a variety of microwave test equipment with illustrations and specifications on more than 50 different models of coaxial and waveguide frequency meters. Featured are the PRD Pacemaker line of frequency meters to cover a range of 0.1 to 40 KMC with accuracies to 0.0001%. Specifications are given for precision direct reading, heterodyne, UHF, calibrated, and frequency standard multiplier type frequency meters.

Circle 166 on Inquiry Card

Wire & Cable

Brochure from Inso Electronic Products, Inc., Wire and Cable Div., 1200 Commerce Ave., Union, N. J., presents in tabular form data on their miniature type "E" hook-up wire, sub-miniature type "EE" hook-up wire, and shielded and teflon jacketed cables (600 v. and 1000 v. service). Included is a graph showing number of insulated conductors per sq. in. vs wire size-AWG.

Circle 167 on Inquiry Card

Recording Heads

Illustrated 4-page brochure plus data sheets give specifications, outline dimensions and general information on magnetic tape and drum heads. Also included are design sheets with spaces for electrical and mechanical parameters to aid in the design of a tape or drum head. General Transistor Western Corp., 6110 Venice Blvd., Los Angeles 34, Calif.

Circle 168 on Inquiry Card

Coaxial Terminations

Detailed specs. for Model 535 coaxial terminations are presented in a 2-page, 2-color bulletin, No. 46, from Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md. Model 535, frequency range dc to 10 KMC is available with Type N, C, SC, BNC and TNC connectors, both male or female. Two-color graphs show typical VSWR vs. frequency for each type of connector.

Circle 169 on Inquiry Card

Transformer Winder

Data sheet describes improved Model 150AM which multiple winds heavy duty transformer and bobbin coils to finished form without pounding. Complete technical data given includes dimensions, wire and coil sizes wound, tensions, gears, winding range and speeds, new 5 H.P. motor, set-up time, counter, brake, tailstock and various special features. Offered by Geo. Stevens Mfg. Co., Inc., Pulaski Rd. at Peterson, Chicago 46, Ill.

Circle 170 on Inquiry Card

Magnetic Circuits

Model MC-1, Magnetic Circuit is described in a bulletin from Ohio Semiconductors, Inc., 1035 W. Third Ave., Columbus, Ohio. It was designed for applications such as choppers, analog multipliers, power meters, phase detectors, and other electronic functions. Typical circuit applications are illustrated.

Circle 171 on Inquiry Card

Switches

A 4-page catalog describes 8 high temp. thermal and 7 waterproof switches. Photographs, dimension drawings, specs. and characteristics are included for plug, probe, and surface types of thermal controls for critical government and industrial applications and waterproof switches for use in applications requiring conformance to government standards or military specs. Control Products, Inc., 306 Sussex St., Harrison, N. J.

Circle 172 on Inquiry Card

Systems Management

Bulletin 5900-SMD, 24 pages, covers the Systems Management Div. of Western Gear Corp., Box 182, Lynwood, Calif. The publication details the engineering, manufacturing, research, testing and organizational capabilities of the company in each of those fields. Products and systems designed by the company are illustrated.

Circle 173 on Inquiry Card

Silicon Regulators

New Parameter News, Vol. 1, No. 5, April 1959, from Texas Instruments Incorporated, Box 312, Dallas, Texas, illustrates the circuit applications of diffused silicon regulators. The bulletin contains background information on Zener diodes, regulator design method, and numerous applications. It includes calculations, curves, and component values.

Circle 174 on Inquiry Card

after routing, clip and save

a continuing series on technical topics of specific interest to engineers

Folio 59-5 REFERENCE DATA FILE SANGAMO

Important factors in specifying toroidal inductors

The powdered molybdenum permalloy toroidal inductor is finding increasing use in today's complex electronic equipment. Excellent magnetic stability, superior temperature stability, high Q values, and small physical size are but a few of the outstanding features which explain the popularity of molybdenum permalloy toroids. To fully realize the advantages of these inductors, the components application engineer must accurately specify those parameters which are of critical importance in a given application. "Under-specification" may result in a component which fails to give adequate performance in the circuit. "Over-specification", on the other hand, may result in a component of extremely high cost. An understanding of the factors involved in the design and manufacture of toroidal inductors at Sangamo will enable the components application engineer to effectively judge the consequences of his specification in relation to the cost and performance of the final product.

THE EQUIVALENT CIRCUIT of a toroidal inductor is illustrated in figure 1.

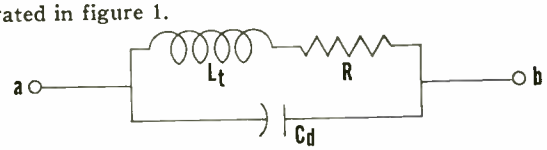


FIGURE 1

L_t is the so-called "true inductance" of the toroid and is assumed to be constant at all frequencies. R represents the sum of copper losses and core losses which increase with frequency. C_d, the distributed capacitance, approximates the capacitance between turns of the winding and between the winding and core. Due to the fact that the dielectric constant of the insulation on the windings and on the core itself is not constant with frequency, the distributed capacity will also vary with frequency. This variation, however, is usually small and may be neglected in the following discussion.

THE APPARENT INDUCTANCE (L_a) is the equivalent inductance between terminals (a) and (b). As might be expected, the apparent inductance varies with frequency. If R is neglected the expression for L_a becomes:

$$L_a = \frac{L_t}{1 - \omega^2 C_d L_t}$$

Inductors for single frequency or resonant circuit applications are usually specified in terms of apparent inductance. The standard tolerance on L_a is 1% or one turn whichever is greater.

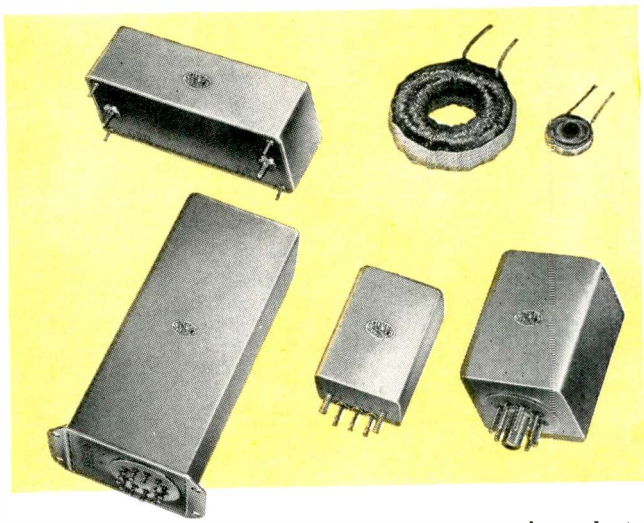
THE Q FACTOR is usually specified in lieu of R since most applications are concerned with the ratio of inductive reactance to equivalent resistance. The accepted method of specifying Q is to set a limit on minimum Q at the operating frequency or over a range of frequencies. Normally, the Q of a given design at a given frequency will vary some 20% between units. Where direct current flows through the inductor it may sometimes be desirable to set a limit on the d-c resistance as well as on Q. Analysis of the equivalent circuit, assuming constant R, shows that:

$$Q_{equiv} = \frac{\omega L_t}{R} - \omega R C_d - \frac{\omega^3 L_t^2 C_d}{R}$$

From the above equation one may deduce that anything which increases the distributed capacitance must necessarily reduce the Q.

DISTRIBUTED CAPACITY becomes most important in wide band or multiple frequency applications, since C_d will determine the variation of L_a with frequency. The majority of users do not find it necessary to specify C_d. Where C_d must be specified, the accepted method is to set a limit on the maximum allowable distributed capacitance. An alternative method of specifying C_d is to set a tolerance on the apparent inductance to be measured at two different frequencies (usually corresponding to the upper and lower frequencies encountered in a given application). The design engineer controls the C_d by varying the method of winding the inductor. In decreasing order of capacity he may choose 1) random continuous windings; 2) progressive winding, or segmented winding. Unfortunately, winding costs increase as distributed capacity decreases. Wax or varnish impregnation will increase the distributed capacity. In applications where it is necessary to insure that L_a be reasonably constant over a wide frequency range, it is also usually desirable that L_a be reasonably constant with temperature and with time. These features are best achieved using a stabilized core, a low capacity winding, and an unfilled hermetically sealed enclosure. In this way, the undesirable effects of impregnation may be avoided.

REQUIREMENTS FOR STABILITY OF INDUCTANCE with temperature, with a-c voltage level, and with direct current are additional factors which will influence the cost and the size of a given inductor. Temperature stabilized cores are available only in certain core sizes and are, of course, more expensive than the standard unstabilized cores. High values of a-c voltage and direct current will lead to larger cores and increased cost.



The Sangamo design engineering department is ready to discuss your inductive components problems. Typical examples of specialty components designed and produced by Sangamo are described in engineering bulletin series IC-260. Address: Sangamo Electric Company, Inductive Components Section, Springfield, Illinois.

SC-59-4

SANGAMO ELECTRIC COMPANY, Springfield, Illinois

--designing towards the promise of tomorrow

Circle 50 on Inquiry Card

New Tech Data for Engineers

Defense Systems

A revised edition of a 32-page, 3-color brochure, "Sylvania Electronic Systems for National Defense" from Sylvania Electronic Systems Div., Sylvania Electric Products Inc., 63 2nd Ave., Waltham, Mass. The brochure outlines the company's electronic systems including such projects as the airborne electronic countermeasures systems, "electronic shield," for the B-58 "hustler" supersonic bomber; the airborne electronic defense subsystem for the B-52 long-range bomber; the MOBIDIC (mobile digital computer) for the Army; the UDOFT (universal digital operational flight trainer) for the Navy; new radar systems of an advanced type, and other projects in countermeasures, advanced communications, and reconnaissance systems.

Circle 175 on Inquiry Card

Toroidal Inductor

Two-color data sheet gives detailed technical data on Arnold Magnetics Series 781 miniature toroidal inductors. Plug-in design is for use in printed circuits. Hooked pins on periphery allow stack-mounting of up to 12 units on a single screw. Units have inductance values ranging from 1 mh to 7 h, in a useful frequency range of from 100 CPS to 80 KC. Units are encapsulated, hermetically sealed, and meet MIL-E-5272A and MIL-T-27A. Arnold Magnetics Corp., 4613 W. Jefferson Blvd., Los Angeles 16, Calif.

Circle 176 on Inquiry Card

Coaxial Cables

Brochure, "Engineering Data for Coaxial Cables," "E502ED," is a complete data sheet listing numerically all known RG type coaxial cables and their characteristics. Data shown includes impedance, capacitance, dielectric, size and type of conductors, jacket materials, shields, diameters, weights and other pertinent information. Standard Wire and Cable Co., 3440 Overland Ave., Los Angeles 34, Calif.

Circle 177 on Inquiry Card

Heat Dissipator

Test Report No. 414, 22-pages, covers the subject of properly cooling transistors using Type TO-3 transistor heat dissipators. The report includes: descriptions of test techniques, tabulated data, heat dissipator and transistor assembly methods, curve plots and illustrations for engineering reference. Engineering Dept., International Electronic Research Corp., 145 W. Magnolia Blvd., Burbank, Calif.

Circle 178 on Inquiry Card

Design Manual

A 94-page, 8½ x 11, engineering design manual TA210G, from TA Mfg. Corp., 4607 Alger St., Los Angeles 39, Calif., describes a line of standard clamps, line supports, brackets, and shims in a variety of shapes and sizes. Included are installation techniques for all types of electronic, hydraulic and mechanical harnessing problems, and information on standard extreme high and low temp. insulating materials plus data on chemical resistance. Over 400 illustrations are used. Weight charts on popular items are included.

Circle 179 on Inquiry Card

Potentiometers

A 28-page technical catalog gives specifications, diagrams and general information on DeJur's complete line of single turn, precision wirewound potentiometers. Diameters include ½ in. micro-miniature to 5 in. high resolution. A series of sine-cosine, and wirewound trimming types are also included. Electronic Sales Div., DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 180 on Inquiry Card

Terminals

Catalog No. 31, 24 pages, contains detailed dimensions and drawings of nearly 400 terminals and electronic hardware items. The catalog describes a wide range of molded and teflon-insulated terminals, terminal boards, handles, tooling and miscellaneous hardware. Included is Lerco's line of mil-spec instrument control knobs. Lerco Electronics, Inc., 501 S. Varney St., Burbank, Calif.

Circle 181 on Inquiry Card

Silica Glass

Information on Vycor brand 96 per cent silica glass which withstands high temperatures and thermal shock is available in bulletin B-91 from Technical Products Div., Corning Glass Works, Corning, N. Y. The 8-page bulletin details physical properties and visible, ultraviolet and infrared transmittance characteristics. Applications, charts, and tables are included.

Circle 182 on Inquiry Card

Tape Recorder

An 8-page, 2-color, brochure describes the PS-200 magnetic tape instrumentation recorder. The brochure outlines specs. of the 7 channel, 250 w., 65 lb., recorder/reproducer. Precision Instrument Co., 1011 Commercial St., San Carlos, Calif.

Circle 183 on Inquiry Card

Transistors

Data sheets on 2N1136, 2N1137, and 2N1138 high gain power switching transistor series are available from Bendix Aviation Corp., Red Bank Div., Long Branch, N. J. Included are characteristic curves, tabulated data, and performance notes. The data sheets show typical converter circuits.

Circle 184 on Inquiry Card

Use of Lab Instruments

How to select and use electrical measuring instruments in experimental laboratories is outlined in, "Electrical Measuring Instruments in the Experimental Laboratory," by J. H. Miller. The 8-page reprint describes and explains the type, range, and ratings of instruments and accessories used in standards, power, and electronics labs. Included are: instrument accuracy and effects of overloads; dc and ac measurements; typical instruments and accessories such as voltmeters, ammeters, wattmeters, multipliers or series resistors, shunts, current and potential transformers; and the taking of data. Reprint No. Z-32. Weston Instruments Div., Daystrom, Inc., 614 Frelinghuysen Ave., Newark 12, N. J.

Circle 185 on Inquiry Card

Wing Nuts

Specification sheets on a complete line of zinc alloy low wing nuts are available from Gries Reproducer Corp., 125 Beechwood Ave., New Rochelle, N. Y. Low wing nuts are used where a non-snagging industrial fastener with minimum top clearance is essential.

Circle 186 on Inquiry Card

Instrumentation

Short-form catalog, No. 101, Instrumentation Systems Engineering, from Systron Corp., 950 Galindo, Concord, Calif., describes the company's standard instruments, custom instrumentation, and system engineering, facilities. Specifications on all equipment are included.

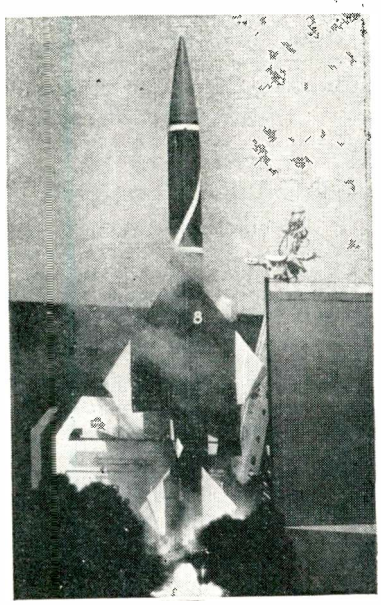
Circle 187 on Inquiry Card

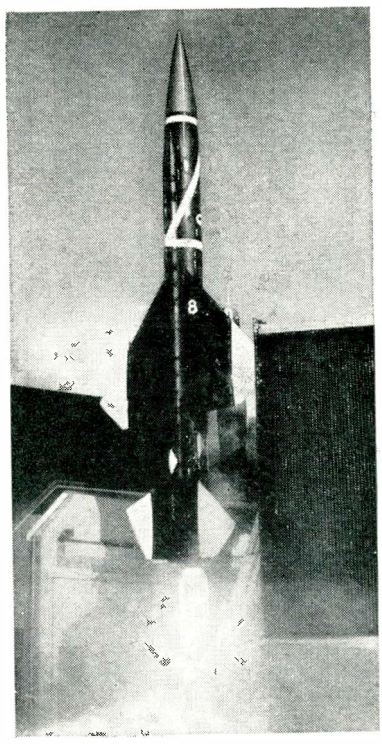
Coaxial Cable & Connectors

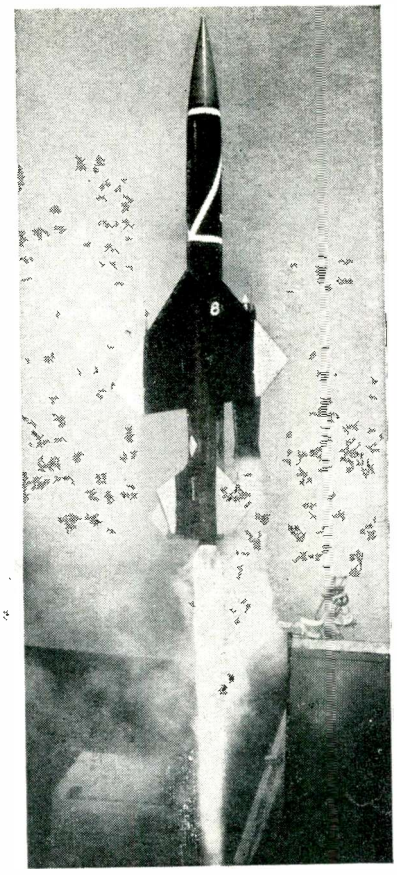
An 18-page, 2-color catalog, No. 591, from Prodelin, Inc., 307 Bergen Ave., Kearny, N. J., contains information on the company's "Spir-O-line" line of coaxial cable and connectors. Included are mechanical and electrical properties, military nomenclature, curves of attenuation vs frequency, and power ratings, efficiency and phase shift, and installation procedures.

Circle 188 on Inquiry Card

BORG® ...a world of ideas... *that work*







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Boeing Airplane Co. needed special potentiometers for the guidance systems of their deadly Bomarc surface-to-air missiles. The necessary potentiometers had to withstand severe vibration and shock and still retain uncanny accuracy within extreme tolerances.

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JANESVILLE, WISCONSIN

Circle 51 on Inquiry Card

New Tech Data

(*Continued from page* 102)

Tables and Formulas

Booklet, B-3677D, "Convenient Tables and Formulas," published by Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa., includes 120 pages of tables, formulas, and graphical symbols summarizing electrical data, properties of materials, heat transfer and steam information, measurements, and other subjects.

Circle 189 on Inquiry Card

Hi-Fi Tubes/Transistors

A bulletin, PA-218, from CBS-Hytron, Parker St., Newburyport, Mass., discusses the use of vacuum tubes and transistors in high-fidelity applications. The 4-page bulletin traces the history of high-fidelity tubes and attempts to separate fact from fiction in claims made for such tubes. Problems related to the use of variable reluctance phonograph cartridges and magnetic tape playback heads are defined, and various hum-bucking and hum reduction arrangements for vacuum tube circuits are discussed. The bulletin also discusses some of the new hi-fi tubes and outlines the properties of transistors which make them ideally suited for high quality audio equipment.

Circle 190 on Inquiry Card

Counting and Control

The complete line of reliable, high speed electronic counting and control equipment is featured in illustrated catalog No. 5920 from Freed Transformer Co., Inc., 1726 Weirfield St., Brooklyn, N. Y. Included are totalizing counters for unit counting, preset counters for semi-automatic or fully automatic control applications, preset interval generators for timing applications, and modular counters—specifically selected and constructed from sub-units—for virtually any counting and automatic control application.

Circle 191 on Inquiry Card

Laminated Plastics

More than 50 industrial Formica laminated plastic grades are described in a Designer's Fact Book from Formica Corp., 4614 Spring Grove Ave., Cincinnati 32, Ohio. The manual contains a comparator chart itemizing the qualities of Formica's most popular grades; a listing of materials by military spec. number, plus designer's information on all standard and special grades manufactured by the company. Each product is illustrated with a photograph showing its primary function. The book suggests other uses for each product. Specification sheets give information on physical and electrical characteristics.

Circle 192 on Inquiry Card

New Tech Data

Cathodes

How to select the best cathode for an electron tube is discussed in an article "What Cathode is best for the Job," reprinted by Superior Tube Co., 1614 Germantown Ave., Norristown, Pa. Two types of cathodes and four forms of sleeves are illustrated and the advantages and disadvantages of each are discussed. The article also illustrates and describes four forms of disc cathodes: standard, miniature, subminiature and narrow neck. Tables list the chemical analysis and the physical and mechanical properties of 11 base metals used by the company in the production of cathodes. The group of 11 cathode materials includes both active alloys and passive alloys.

Circle 193 on Inquiry Card

Ultrasonics

"Ultrasoundings," a quarterly illustrated review of ultrasonic progress from Acoustica Associates, Inc., Dept. P, 26 Windsor Ave., Mineola, L. I., includes several feature articles describing ultrasonic cleaning applications in industry and informs users how to get the most from this fast-growing industrial processing technique. The publication also includes brief descriptions of new developments by Acoustica.

Circle 194 on Inquiry Card

Signal Dropouts

Methods of reducing signal dropouts in magnetic tape are discussed in "sound talk," Bulletin No. 37, from Minnesota Mining and Mfg. Co., Dept. E9-200, 900 Bush Ave., St. Paul 6, Minn. The 4-page bulletin, "Reduction of Dropout Errors in Magnetic Recording Systems," is illustrated with photo-micrographs of common types of coated-in tape flaws, photographs showing the effect of small dust specks on recorded data tracks, a cutaway view of 3M's new precision reel, a photograph of a modern tape coating machine, and diagrams pertaining to the dropout problem.

Circle 195 on Inquiry Card

Galvanometer

The basic theory, application and specifications of the Type 7-370, computing galvanometer are described in Bulletin 1605A from Consolidated Electrodynamic Corp., 360 Sierra Madre Villa, Pasadena, Calif. The instantaneous-watt galvanometer is designed to perform the 3 basic functions of addition, multiplication and subtraction, permitting calculation of power factor, average power, and other multi-variable problems from a single moving trace.

Circle 196 on Inquiry Card

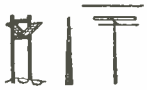
Circle 54 on Inquiry Card

Circle 55 on Inquiry Card

Circle 56 on Inquiry Card

International Electronic Sources

Up-to-the-minute abstracts of articles appearing in the leading foreign electronic engineering journals



ANTENNAS, PROPAGATION

Tropospheric Scatter Propagation and Equipment, J. Fieguth. "Proc. AIRE." January 1959. 8 pps. The paper deals with propagation of VHF and UHF signals beyond the horizon, and briefly describes its nature, which is quite different from tropospheric, stratospheric, and ionospheric propagation. Several different theories exist, attempting to explain the phenomena of over-the-horizon propagation, and although complete agreement on the contribution of the various factors has not been achieved, the expected signal at the distant receiver can now be calculated with a fair degree of accuracy. (Australia.)

CIRCUITS

Synthesis of Relay Circuits for Permutations Fixation, I. S. Daniluk. "Avto i Tel." March 1959. 9 pps. Working conditions of relay circuits determining the order of n contact closings in form of n^2 Boolean functions are formulated and corresponding circuits are given. The circuits under consideration are analyzed. (U. S. S. R.)

High-Speed Push-Pull Magnetic Transistor Amplifier for a Servodrive, V. S. Volodin, E. D. Larin, M. A. Rozenblatt and G. V. Subbotina. "Avto i Tel." March 1959. 8 pps. Possibility of designing a high-speed amplifier for a servodrive based on both magnetic amplifier and transistor one is expounded. (U. S. S. R.)

A Simple Pulse Generator and a Pulse Distributor Employing Transistors, Hermann Stierhof. "Rundfunk." Apr. 1959. 10 pps. In an earlier article, the author has already confirmed the suitability of transistors for video applications. The present article deals in particular with the problems of pulses used in television. The author first describes the function and behaviour of some basic circuits used in pulse technique, such as blocking oscillators, switching transistors and mono- and bi-staple multi-vibrator circuits. (Germany.)

A Temperature Constant 8 W Transistor Amplifier for High Class Reproduction Units. "El. Rund." April 1959. 3 pps. Transistor amplifiers for stereophonic reproduction units, which would have the same or better results as those of valve amplifiers, must be based on carefully developed circuits. As the measurement results of the described twin amplifier demonstrate, it is quite possible today. (Germany.)

The Image Impedance Parameter Theory as a Simple Means for the Realization of Crystal Band Filters in Branching Circuits, W. Poschenrieder. "Nach. Z." March 1959. 7 pps. The conditions which must be met during the realization of band pass crystal filters in branching circuits are derived by means characteristic impedance functions. (Germany.)

Formulae for Amplitude Equalizers, P. Amstutz. "Cab. & Trans." April 1959. 5 pps. This paper deals with simple formulae for the attenuation and phase shift of balanced bridged-T amplitude equalizers, having a characteristic impedance equal to half that of the series branch of the T network obtained by removing the constant resistances. From these relationships are defined complementary equalizers, the sum of the transfer exponents of which is a constant real quantity. (France.)

An Outline of Low Pass and High-Pass Four-Terminal Ladder Network Theory, J. E. Colin. "Cab. & Trans." April 1959. 19 pp. The paper by Mr. Colin deals with the properties of four-terminal networks, studied by the image parameter method. A study of two main network types, called "G" and "S" by the author, is extended to other four-terminal networks. (France.)

Synthesis of Attenuation Equalizer Networks by an Adjustment Method, J. Legras. "Cab. & Trans." April 1959. 29 pps. A preliminary study of the forms of the functions representing the attenuation of some constant impedance equalizer types as functions of frequency allows to determine which variation laws for this attenuation correspond to physically realizable networks. (France.)

Synthesis of LC Networks, J. T. Allanson. "E. & R. Eng." May 1959. 3 pps. A method if outlined for synthesis of certain voltage transfer functions by means of asymmetrical, balanced LC networks terminated at the load end by a resistance. (England.)

COMMUNICATIONS

The Properties of a Symmetrical Slow-Wave System with Three Channels, L. N. Deryugin and N. V. Trunova. "Radiotek." Mar. 1959. 12 pp. The paper studies symmetrical slow-wave systems with two rows of serrations (combs) which are located between parallel planes or in a rectangular waveguide. An analysis is made of the effects of the middle channel and the outside channels formed by the additional coupling apertures between cells on the dispersion characteristics, the coupling impedance, and the position of the nodes of the electric field. (U. S. S. R.)

The Peak Busy Hour in Telephone Systems, G. Bretschneider. "Nach. Z." April 1959. 6 pps. The traffic requirements during the

REGULARLY REVIEWED

AUSTRALIA

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 Electric 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 Uebertragung
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 Electrotechniczne

USSR

Avto. i Tel Avtomatika i Telemakhanika
Radio. Radio
Radiotek. Radiotekhnika
Rad. i Elek. Radiotekhnika i Elektronika
Iz. Acad. Bulletin of Academy of Sciences USSR.

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peak busy hour are a useful measure for the capacity of telephone systems. No uniform definition of the peak busy hour is in existence. Lately, the statistical definition gains in importance. Its suitability for the statistical nature of telephone traffic is investigated. Model tests give a decision in its favor. (Germany.)

Radio Telemetry, Part II—Techniques, P. Rohan. "Proc. AIRE." January 1959. 12 pps. This paper introduces the methods used for obtaining information on the behaviour of missiles and missile installations in flight and describes the apparatus carried by the missile and the ground equipment used for receiving and processing the information. (Australia.)

Printed Circuits Applied to Broad-Band Microwave Links, R. Rowland. "El. Eng." May 1959. 6 pps. This article describes how printed circuit techniques may be applied to the design of base-band and i.f. equipment for broad-band microwave links and discusses the advantages to be gained thereby. (England.)

Signal/Noise Ratio in Pulse-Code Modulation Systems—Use of the "Ideal Observer" Criterion, J. W. R. Griffiths. "J. BIRE." March 1959. 4 pps. In order to determine the relation between the output and input signal/noise ratios of a p.c.m. system, it is necessary to determine the probability of error in selecting a single pulse in a background of noise. This reduces to a problem in statistics which requires the use of a criterion for deciding as to which of two possible probability distributions a particular sample belongs. (England.)

COMPONENTS

Interrelation of Radioactive Relay Parameters, A. G. Vasiliev and K. S. Klempner. "Avto i Tel." March 1959. 3 pps. Transient processes in radioactive relays are considered. Relations for main parameters of radioactive relays are presented. (U. S. S. R.)

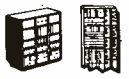
About Realization of Pulse Servosystems Optimum Weight Function, V. P. Perov. "Avto i Tel." March 1959. 9 pps. Simple technique of approximate realization of pulse servosystems optimum weight functions is suggested. (U. S. S. R.)

Double-Tuned Transformers Steady-State and Transient Response, J. B. Rudd. "AWA Tech." #4,1958. 40 pps. An analysis is given of the equally loaded, double-tuned, transformer for any degree of coupling; the steady-state characteristics of insertion loss, insertion phase shift and envelope delay are derived. An approximate, simplified, analysis of the narrow band case is given for comparison. (Australia.)

The Performance of Pyrolytic Carbon Resistors, R. H. W. Burkett. "Brit. C. & E." April 1959. 5 pps. The factors affecting the performance of pyroltic carbon resistors are described, and a performance of these resistors is related to them. The main factors are carbon film thickness, moisture permeability and thickness of the protection, operating temperature and the quality of the ceramic substrate. An optimum range of resistance is proposed, within which the performance of this type of resistor is very much better than suggested by the specifications at present in use. (England.)

Transistors and Cores in Counting Circuits, F. Rozner and P. Pengelly. "El. Eng." 3 pps. May 1959. The square loop magnetic core and the transistor are now well accepted circuit element in digital computer. In this article it is shown how the two elements can be combined to form non-critical reliable counting circuits. (England.)

Retangular Hysteresis-Loop Magnetic Cores as Switching Elements. J. F. Kaposi. "El. Eng." May 1959. 6 pps. Magnetic cores with approximately rectangular hysteresis loops can be used as switching or storage elements because they possess two stable states of remanent magnetization. (England.)

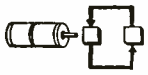


COMPUTERS

A Small Universal Digital Computer Using Magnetic (Ferrite) Elements, Called "LEM-1," Yu. A. Makhmudov. "Radiotek." Mar. 1959. 11 pp. The paper studies certain problems involved in the design and construction of a universal digital computer using contactless magnetic elements (ferrites) and long-term capacitive memory elements. The computer was designed in the Laboratory of Electrical Simulation of the VINIPI of the Acad. Sci. USSR under the direction of Professor L. I. Gutenmakher. (U. S. S. R.)

Electronic Programme-Controlled Computers, V. A. Los. "Avto i Tel." April 1959. 10 pps. Design principles of electronic programme-controlled computers are expounded. (U. S. S. R.)

Systematic Survey of Angle or Linear Displacement Digitizers, A. D. Talanzev. "Avto i Tel." March 1959. 15 pps. The paper discusses many of the techniques now in use for converting analog information representing mechanical motion, rotation or displacement into digital form. Digitizers are classified by the ways of quantization and by the methods of coding. (U. S. S. R.)



CONTROLS

Concerning Absolute Stability of Certain Control Systems, Yu. S. Sobolev. "Avto i Tel." April 1959. 5 pps. The paper deals with comparison problem of absolute stability of automatic control systems. Some examples are presented. (U. S. S. R.)

Dynamics of Electric Servomechanism Vibration Loop Under Free Oscillation Conditions, I. N. Krutova. "Avto i Tel." April 1959. 15 pps. Vibration loop with two parallel control channels is considered. The channels are comprised by one and the same feedback. Loop motion is described by three first order equations. (U. S. S. R.)

Compensation of Continuous Automatic Control System by Means of Delay Elements Filter, Wang Sin-Min. "Avto i Tel." April 1959. 10 ps. Calculation of delay elements filter for compensating continuous automatic control systems is considered. Filter parameters are determined for some instances. (U. S. S. R.)

Design Principles of Contactless Systems or Remote Control with Exponential Converters, V. A. Ilin. "Avto i Tel." April 1959. 5 pps. Design principles of new signal time separation systems of remote control are described. Formulae to determine main parameters of the systems under consideration are presented. (U. S. S. R.)

Analysis of Pulse Magnetic Elements Operation in Contactless Devices of Remote Control, I. V. Prangishvili. "Avto i Tel." April 1959. 13 pps. Operation of pulse magnet elements with rectangular hysteresis loop is analyzed when the elements are fed with sinusoidal voltage of industrial frequency. Some relations are deduced. Calculation of a single element and pulse relay is described. (U. S. S. R).

Integral Criterion to Choose Optimum Parameters of Automatic Control Systems with Overshoot, A. I. Tupitsyn. "Avto i Tel." April 1959. 9 pps. Combined integral criterion is considered that permits to determine optimum parameters of automatic control systems when overshoot is given. Formulae to find approximate solution time are deduced. Some examples are presented. (U. S. S. R.)

GENERAL

Motor Speed Stabilization Circuit Has Three-Winding Transformer, O. B. Rossenbauli and R. N. Rodin. "Avto i Tel." March 1959. 5 pps. A-c and d-c motor speed stabilization circuit is considered. The circuit has a special three-winding transformer. The theory of the circuit suggested is applied to independent excitation d-c choke drive. (U. S. S. R.)

Concerning the Simulation of Nuclear Power System, B. Ya Kogan, Ya A. Nechaev and F. E. Tranin. "Avto i Tel." March 1959. 6 pps. Possibilities of application of analog computers to solution of nuclear power systems problems are considered. Solution of some kinetic and poisoning problems of a nuclear reactor with analog computer is given. (U. S. S. R.)

On the Problem of Electric and Electronic Watches, S. Hildebrand. "El Rund." April 1959. 4 pps. Watches have for centuries been mechanically driven. Recently an electric source of power has been used in place of the usual spring. For this purpose the mercury-oxide cell has proved especially satisfactory. (Germany.)

The Rate of Pumping-Down in High Vacuum Systems, Th. Kraus. "Vak. Tech." March 1959. 5 pps. The rate of pumping-down in high vacuum systems depends on a number of gas producing processes which mainly take place on solid surfaces exposed to the rarified atmosphere in the volume. If in the bell jar a certain gas producing process exists which varies with time, then kinetic considerations lead to the following formula for the pumping time for a given pressure. (Germany.)

An Approximation Method for the Processing of the Spherical Aberration of Objective Lenses by the Methods of Communication Art, F. Below and H. Grabke. "Rundfunk." 3 pps. When correcting the spherical abberation of photographic objectives, the deviation of the focal point by the height of incidence of the light beam is corrected in such a way that the image plane lies as much as possible in the Gaussian focal plane. (Germany.)

Generators and Storage Devices for Functions of the Forms, A. Haug. "Nach. Z." March 1959. 6 pps. During the treatment of mathematical problems by means of electrical analog computers, the frequently occuring relations between two or more quantities must be represented by an electric analogy. Methods for representing the functions $y = f(x)$ are first described and compared with one another. Subsequently methods for the realization of functions of the type $z = f(x, y)$ are treated. (Germany.)

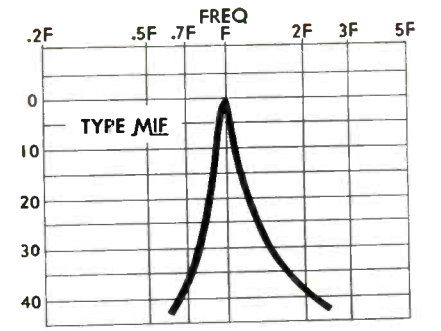
Electronic Simulation of the Dynamic Behaviour of Nuclear Reactors, A. Birkhofer and H. Reimann. "Nach. Z." March 1959. 8 pps. The dynamic behaviour of nuclear reactors can be approximated by seven simultaneous differential equations. These basic equations are simulated by an RC-network

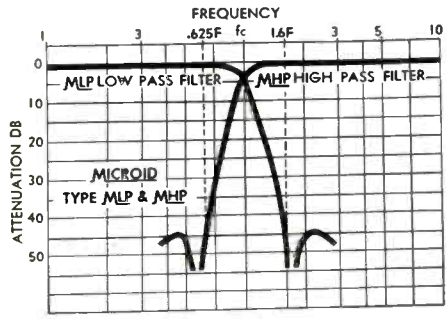
THE SHRINKING MAN'S FILTER

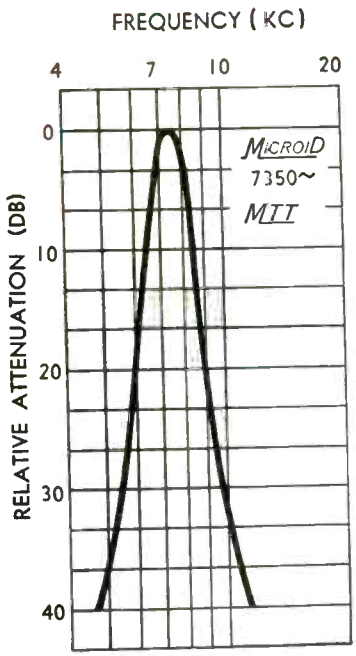
Although worlds apart in purpose, practitioners of the art of head shrinking and Burnell & Co. miniaturization engineers are both expert in reducing to size. For example, Burnell's new microminiature *MICROID* filters are particularly valuable in transistorized circuitry and only a step away from micromodule use. Range of the new Type *MTT* band pass filter is 7.35 kc to 100 kc, band width 15% at 3 db and +60% −40% at 40 db. Size is 1/2"x19/32"x15/16", weight .3 oz. Types *MLP* and *MHP* cover 5 kc to 100 kc with a standard impedance of 10K ohms. These are microminiature counterparts of the popular Burnell TCL and TCH low pass and band pass filters. The band pass filter results when cascading a TCL with TCH filter. Size is 3/4" x 1/2" x 1".

Type *MIF* microminiature interstage filters are designed for a wide variety of applications. Input impedance is 10K ohms, output to grid with a voltage gain of approximately 2:1. The 3 db band width is nominally 8%. Ranging from 7.5 kc to 100 kc, these interstage filters are provided in the same case as Type *MLP*.

Fully encapsulated, the new *MICROID* filters provide less weight, more reliability and exceed MIL specifications. We'll be glad to design and manufacture to your specifications in any quantity. Write for special filter bulletin to help solve your circuit problems.







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in the feed-back path of a symmetrical DC-amplifier with zero point stabilization. (Germany.)

Logical Combination as a Unit on Information Processing, K. Steinbuch. "Nach. Z." April 1959. 7 pps. The efficiency of information processing systems can be measured in "combination units." In doing so all combinations have to be eliminated which are only needed for sequential control. (Germany.)

INDUSTRIAL ELECTRONICS

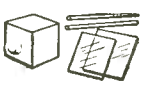
Mathematical Problems Automatic Control of Milling Machine, I. I. Eterman. "Avto i Tel." March 1959. 6 pps. Automatic control of a milling machine with the help of a digital computer is considered. The computer structure and parameters are studied. Formulae for processing data in control pulses are presented. (U. S. S. R.)

Synthesis of the Control Unit of a Servo-system Optimum from the Viewpoint of Its High-Speed, Sun Tsjan. "Avto i Tel." March 1959. 16 pps. Switching surface is determined for the second order astatic servo-system optimum from the viewpoint of its high-speed. The system is described with the third order differential equation. U. S. S. R.)

An Auxiliary Control Equipment for Copy Milling Machines, H. H. Reinsch. "El. Rund." April 1959. 2 pps. Complicated milling jobs such as are more and more needed in modern production can seldom be carried out economically or not at all with older copy milling machines. (Germany.)

Automation and Remote Control of Oil and Gas Pipe-Lines, J. R. Schopper. "El. Rund." April 1959. 3 pps. Automation and remote control from a central point are more and more being introduced for oil and gas pipelines together with their pumping and pressure reducing stations. (Germany.)

A Practical Approach to the Maintenance of Industrial Instruments, W. A. Seatherton. "Brit. C. & E." April 1959. 5 pps. The overall efficiency of an instrument system in an industrial plant is very much dependent on the type of maintenance organization that is established. The basic principles of instrument maintenance outlined in this article, although drawn largely from experience gained on boiler house instrumentation, nevertheless provide a good basis for instrument maintenance in industrial plants generally. (England.)



MATERIALS

Mica, A Material in High-Vacuum Technique, Werner Espe. "Vak. Tech." March 1959. 10 pp. A comprehensive review of the application of mica in high vacuum technique is given whereby in turn the following items are discussed in detail: a) Natural sources, mining and chemical compositions, b) Fabrication, c) Physical and chemical properties, d) Degassing, e) Surface treatment, f) Sealing of mica to glass and metals, g) Applications in detail. Finally the process of making synthetic mica and its properties are discussed. (Germany.)

The Use of Linearly Polarized Microwave for Non-destructive Testing of Materials, A. Dietzel, et al. "El. Rund." April 1959. 2 pp. Anisotropic ranges in a solid influence its solidity. The local distribution of those ranges in low conducting, non-transparent solids can be derived from the change of the polarization

state of linearly polarized microwaves that radiate material under test. (Germany.)

Recording of Diameter Irregularities in Wires and Cables, I. Eyraud & P. Perrier. "Cab. & Trans." April 1959. 7 pp. The device described in this paper allows continuous recording of diameter variations of substantially cylindrical wires and cables. It comprises a recording head which can rotate around the axis of the sample, the diameter variations of which are to be measured, an amplifier and a recorder. The recording head includes a photoelectric cell illuminated by two parallel light beams obtained from a point light source through a condenser. (France.)

MEASURE & TESTING

On Reproducing Periodic Signals of Arbitrary Shapes Using a Gated Oscilloscope, V. A. Vol. "Radiotek." Mar. 1959. 7 pp. The paper studies the problems associated with the error of reproducing individual points of signals by means of a gated oscilloscope. The paper also discusses the conditions governing the selection of a scanning step. The following specific topics are covered: 1) transmission of an arbitrary signal through a linear converter; 2) transmission of an arbitrary signal through a square-law converter; 3) selecting the scanning step for the gated oscilloscope. (U.S.S.R.)

The Application and Further Development of the Test-Line System, Hans Springer. "Rundfunk." February 1959. 11 pp. For some time, nearly all television studio centres have mixed certain signals provided for operational and supervisory purposes with the video signals. By means of these "test lines" it has been possible to carry out investigations and experiments. By means of a newly developed control unit, the white level transmitted in the test lines is used as reference level in order automatically to maintain constant the video input signal of the television transmitters. (Germany.)

On the Longitudinal Oscillations of Magnetic Tapes, E. Belger and G. Heidorn. "Rundfunk." February 1959. 5 pp. The authors examine more closely the character and causes of longitudinal tape oscillations by means of the noise sidebands of a wanted tone that they cause. From the position, size and shape of these sidebands it is possible to gain information regarding the mechanism of these oscillations. (Germany.)

RADAR, NAVIGATION

Storage Processes for Improving the Signal-to-Noise Ratio of Approximately Periodical Signals, Particularly for Radar, H. Meinke and K. Rihaczek. "Nach. Z." April 1959. 5 pp. It is shown that during error containing measurements of random time processes the measurement error is not reduced according to a square root law when the number of averaged measurements is increased but that the error increases when the measured values vary noticeably during a storage period. (Germany.)

The Storage of Radar Pictures with Band-Width Compression, H. Groll and H. Vollrath. "Nach. Z." March 1959. 8 pp. The paper describes the development of magnetic tape recorders for recording bandwidth-compressed radar pictures with a bandwidth of up to 100 kc/s at a tape speed of 76 cm/s. (Germany.)

Tacan Data Link, E. Roessler. "Nach. Z." March 1959. 5 pp. Summary of the articles published in Electrical Communication. (Germany.)

Radio Direction Finding in Three Dimensions, F. Adcock. "Proc. AIRE." January 1959. 5 pp. Methods of determining the direction of propagation of radio signals, in three dimensions, using spaced aerial systems are discussed and a direct reading system is proposed. The errors caused by the proximity of the earth are indicated. (Australia.)

SEMICONDUCTORS

The Breakdown Voltages of Germanium Transistors, R. E. Aitchison. "Proc. AIRE." January 1959. 3 pp. (Australia.)

Accurate Measurement of Transistor Cut-off Frequency, Yasuo Tarui. "El. Eng." May 1959. 4 pp. An equipment is described for the quick and accurate measurement of current gain of high frequency transistors in the frequency range between 1 to 20Mc/s. (England.)

Transistor Junction Temperature, Continuous Measurement In Class C Circuits, H. Sutcliffe and J. Matthews. "E. & R. Eng." April 1959. 2 pp. A circuit is described which can be interposed between the driving source and the output stage in class C transistor circuits in order to measure the temperature-dependent base leakage current. The circuit permits a continuous measurement of junction temperature without disturbing the normal operation of the class C circuit. (England.)

SOURCES

TELEVISION

The Television Coverage Situation in Bavaria with the Opening of the High-Power Station on the Ochsenkopf. "Rundfunk." February 1959. 3 pp. The paper describes the development of the Bavarian television transmitter, network from the opening of the first station, on 1st November 1954, on the Wendelstein, until December, 1958, when the Ochsenkopf station came into service. (Germany.)

A Contribution to the Planning of Television Studios, G. Stump and U. Stepputat. "Rundfunk." Apr. 1959. 4 pp. The article describes a regional studio of the NDR at Hamburg. For the first time, a layout has been designed in which all the technical rooms are accommodated in the immediate vicinity of the studio, so that the unit as a whole, is a self-contained production centre, feeding a picture signal of 1 V and a sound signal of 1.55 V to the final control room. (Germany.)

Planning and Building of the Television Tower on the Ochsenkopf, Gunther Jauch. "Rundfunk." February 1959. 4 pp. Wall thicknesses of the tower were chosen in order to increase stability. Owing to the wide base of the tower, the foundation on to granite was comparatively easy. By using prefabricated wood panels as shuttering, it was possible to complete three stories of the transmitter building before the start of winter. (Germany.)

The Load Specification and Building Methods Adopted for the Television Tower on the Ochsenkopf, Fritz Staiger. "Rundfunk." February 1959. 4 pp. The article begins with a description of the site of the building, the special construction of the tower being pointed out. It gives the dimensions of the reinforced concrete tower, which were determined by the operational requirements, as well as the arrangement of the platform. (Germany.)

Technical and Economic Problems Connected with the Ochsenkopf Transmitting Station, Eugen Kessler. "Rundfunk." February 1959. 4 pp. Since the new television transmitting station on the Ochsenkopf operates in Band I, a large and heavy aerial had to be taken into account from the start. The author describes considerations for reducing the stress on the tower structure due to the aerial. (Germany.)

$$\Delta G = \Delta G / e n_i \mu_p \mathcal{E}$$

THEORY

Analytical Representation of Time Functions with an Unlimited Spectrum, I. T. Turbovich. "Radiotek." Mar. 1959. 6 pp. An analytical representation is proposed for a time function having an unbounded spectrum. This representation is a sum of time functions with bounded spectra. In the resulting series of functions, the mean-square value of each successive term is appreciably smaller than the preceding value; this makes it possible to use approximate methods when computations are performed using this series (for example, the small-parameter method). The coefficients of the resulting series are easy to compute from the values of the approximating functions at discrete instants. (U.S.S.R.)

On A Certain New Method for Solving Problems in Electrostatics, E. L. Burshtein, M. L. Levin, Yu. V. Polyak. "Radiotek." Mar. 1959. 2 pp. This is a paper criticizing an article by L. A. Druzhkin titled "Distribution of the Electrical Charge on Linear Plane Closed Conductors"; this paper appeared in Radiotek, March, 1958. The letter by the three authors indicates that the derivation by Druzhkin is erroneous and that the method and the results are fundamentally incorrect. (U.S.S.R.)

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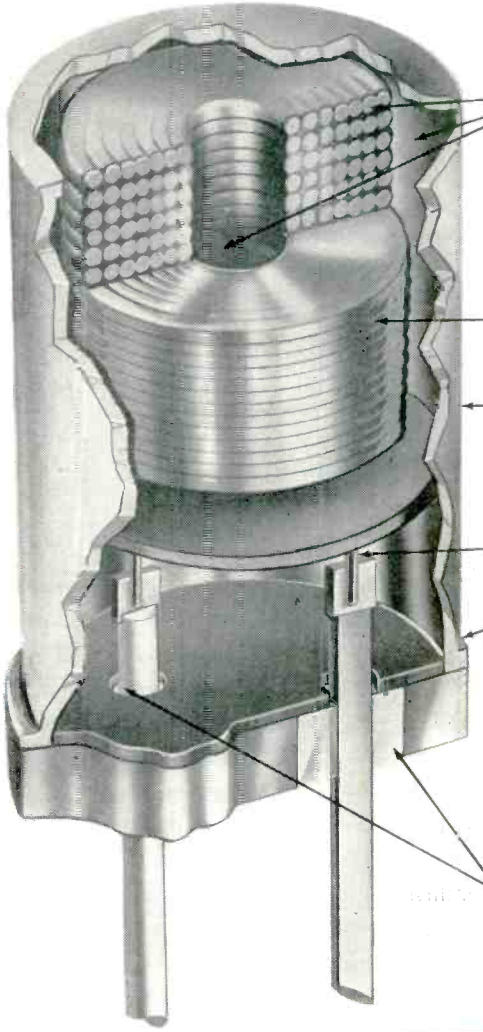

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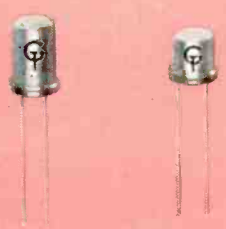
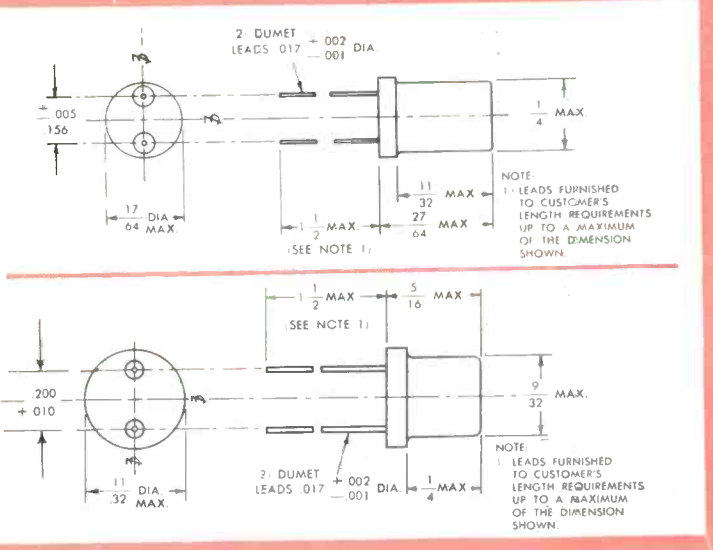
Power Rating	¼ watt continuous in free air (increased dissipation possible with heat sink)	⅓ watt continuous in free air (increased dissipation possible with heat sink)
Temperature Range	—65°C to +125°C	—65°C to +125°C
Maximum Operating Voltage	250V, DC	500V, DC
Temperature Coefficient of Resistance	±20 parts per million/°C	±20 parts per million/°C
Dielectric Strength	500V rms, winding to case	1000V rms, winding to case

Construction — Terminations: — Welded



ACTUAL SIZE



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SOURCES

On the Problem of the Distribution of Electrical Charge on Linear Plane Closed Conductors, L. A. Druzhkin. "Radiotek." Mar. 1959. 2 pp. This is a letter to the editors in which the author rebuts the criticism of his article but essentially repeats the original mistake. (U.S.S.R.)

Switching Circuit Machine Analysis, P. P. Parkhomenko. "Avto. i Tel." April 1959. 12 pp. Algorythms of the machinization of the switching circuits structural analysis and of the sequence determination of their elements action are presented. The realization of algorythms in a special logical machine is described. (U.S.S.R.)

TRANSMISSION

The Rate of Transmitting Information, the Transmission Capacity of a Multipath System, and Reception According to the Method of Linear-Operator Transformation, I. A. Ovseevich, M. S. Pinsker. "Radiotek." Mar. 1959. 13 pp. Estimates are obtained for the rate of transmitting information and the transmission capacity for a multipath system; these estimates become precise equations for Gaussian channels. It is established that in the Gaussian case the rate of transmitting information over a multipath system remains unchanged if the output signal is some linear function of the input signals to the channels. The paper derives the transfer coefficients for the filters which determine the form of this linear function. (U.S.S.R.)

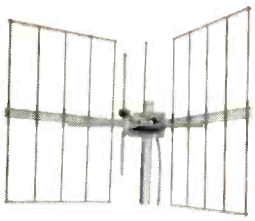
On Computing an Optimum Smooth Transition, A. L. Fel'dshtein. "Radiotek." Mar. 1959. 7 pp. The paper studies a method for computing a smooth transition with optimal properties (a nonuniform transmission line). A comparison is made with a bell-shaped (probability) transition. A list of computation formulas and numerical criteria is given. (U.S.S.R.)

Transmission of Power in Radio Propagation, James R. Wait. "E. & R. Eng." 5 pp. Some remarks concerning the theoretical foundations of the transmission-loss concept are made. It is emphasized that the influence of the ground on the input resistances of the transmitting and receiving aerials must be accounted for. (England.)

TUBES

Electrical Computation of Operating Modes for New Oscillator Triodes, V. A. Khatskelevich. "Radiotek." Mar. 1959. 11 pp. The paper studies the special features of the static characteristics of a number of new oscillator triodes; these features do not permit a direct approximation of the characteristics by a family of parallel equally spaced straight lines. Thus the usual formulas cannot be used for the purposes of computation. A simple computation of the grid current using verified correction coefficients is proposed. A method of equivalent parameters is proposed for computing the plate circuit; this method results in very small errors as compared to precise graphical computation. (U.S.S.R.)

Photoconductors As Electric Circuit Cells, S. V. Svechnikov. "Avto. i Tel." April 1959. 10 pp. Main characteristics of photoconductors of industrial kinds as electric circuit cells are considered as general laws of inner photoelectric effect. (U.S.S.R.)



ENLARGED VIEW OF ONE CORNER REFLECTOR ELEMENT

LONG RANGE REMOTE CONTROL

ANDREW engineers regularly solve difficult antenna problems. An example is the 32-element array recently designed for The Trans-Arabian Pipe Line Company for long range communication and control.

REQUIREMENT: A 160 mc antenna system for use at four unattended radio-controlled gas-turbine pumping units located 60 to 100 miles away from the main pump stations along 754 miles of pipeline. Minimum forward gain of 20 db over a dipole and maximum VSWR of 1.5 across 156-174 mc band were required. Existing towers dictated that the design feature minimum weight and wind loading together with maximum mechanical stability.

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Tele-Tech's ELECTRONIC OPERATIONS

The Systems Engineering Section of ELECTRONIC INDUSTRIES • July 1959

SYSTEMS—WISE . . .

▸ In an attempt to better serve the Nation's requirements, the Dept. of Commerce through the NBS is circulating a questionnaire on technical radio broadcast services. They run the gamut from WWV services to request for new services or changes for existing services which users would like to have.

▸ **WQXR, radio station of The New York Times, taking a rather radical step, has cut drastically the amount of advertising on the station and raised its advertising rates. Spot costs up 20%. With more music and fewer interruptions, each spot will have more attention value. Two years ago the station eliminated 189 spots per week. This further reduction withdraws an additional 300 spots.**

▸ More effective educational uses of television, radio, audio-visual materials and other media have received an additional boost with the approval of 53 grants and 5 contracts for support of research along these lines by the U. S. Dept. of Health, Education and Welfare. A total of 69 grants and 11 contracts for research and experimentation have now been approved.

▸ **KCBS wrested the title of World's First Broadcasting Station away from KDKA without a murmur of protest—at least in San Jose, Calif. The station is the direct lineal descendent of one which operated regularly scheduled programs on a continuous basis beginning in 1909. It started as FN before federal control and was issued KQW in 1921. The station became CBS-owned in April 1949.**

▸ The BBC has developed a system for transmitting television news film across the Atlantic by telephone cable. A 30-second film can be shown on the other side of the ocean 90 minutes after it is taken. Although still experimental, it shows promise of being applicable to events of high topical interest on both sides of the Atlantic.

AIRLINES AUTOMATE

Electronic processing rooms are likely to become a familiar sight at airline offices. More and more airlines are turning to integrated automation systems to handle the heavy paper work resulting from booming jet traffic. Effectiveness of computer operations may be a major factor in determining profits.

▸ **A system of wired pay-as-you-see television will be launched by a subsidiary of Paramount Pictures Corp. in a suburb of Toronto, before the end of the year. Famous Players Canadian Corp., Ltd., expects to wire at least 5000 homes for pay-TV in the western suburb of Etobicoke during the fall and winter months. Bell System telephone poles and other facilities will be used in stringing the pay wire into the homes.**

NEW RECORDER

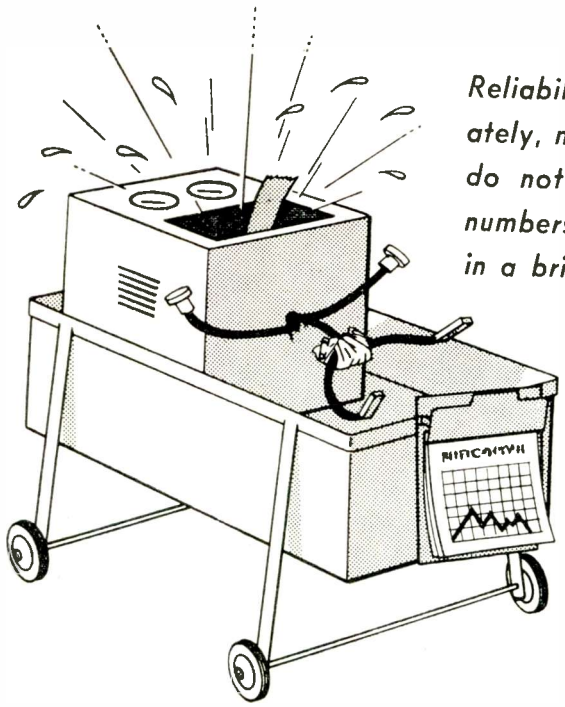
Magnetic disc recording system, developed by RCA, is in use at WDAS, Phila. Pre-grooved aluminum discs can be used up to 10,000 times. Inspecting the recorder: (l to r); Jerry Grove, WDAS; George Weilenmann, RCA; Paul Wildow, RCA; and Frank Unterberger. Large discs are those used previously.

▸ VHF booster construction will not go through a "boom" when and if Congress passes the necessary legislation and full technical specs are received from FCC. Gene Bartlett, General Manager, Mid-America Relay Systems, Rapid City, S. D., largest manufacturer of equipment used by booster operators, said that despite lack of FCC authority, some 200 organizations have bought and installed Mid-America equipment.

▸ **Earth-orbiting radio repeaters hold the most promise for future effective international communications according to Thompson H. Mitchell, President of RCA Communications, Inc. In addressing the Armed Forces Communications and Electronics Association, Mr. Mitchell stated that required techniques are already at hand to begin intensive testing of satellite communications systems within the next few years.**

▸ The Board of Directors of the National Assoc. of Broadcasters is supporting legislation now in Congress to remedy "some of the defects of Section 315" of the Federal Communications Act. This section, among other things, requires radio and TV stations to provide equal opportunity to political candidates.

▸ **Installation and maintenance of electronic equipment has increased 3 times in the last 8 years despite decreases in TV and radio set sales last year, EIA Service committee Chairman, Kenneth H. Brown, reports. The Committee has developed an education plan for impoving service-dealer's ability to cope with some of their problems.**



New equipment presents many problems

Reliability is a very common word to engineers today. Unfortunately, many engineers not familiar with statistics and probability, do not realize that reliability must be associated with actual numbers, tests, and measurements. Here the subject is presented in a brief form for easy understanding with a minimum of math.

System Reliability

What It Is and Why

By JEROME E. TOFFLER
Member of Technical Staff
Hughes Aircraft Co.
Florence & Teale Sts.
Culver City, Calif.

AT present, reliability is one of the most used (and misused) words in the engineer's vocabulary. The statements that a product is "designed for reliability" or "intended for military application" are entirely subjective, and have little real significance—even when the illustration in the background shows a launching of an ICBM, or a remote portion of the Milky Way! Reliability *must* be associated with actual numbers, tests, and measurements. To do this requires some knowledge of probability and statistics—fields in which many engineers are not skilled. An understanding of quantitative reliability is important because the Department of Defense and other contractors are presently putting "teeth" into contractual reliability requirements.

Part 1 of this article covers important definitions and their consequences, treated in a descriptive manner, with mathematics kept to a minimum. Part 2 states a few principles of the theory of random, discrete events (specifically, equipment failures), and briefly outlines the mathematical derivations and required assumptions. This part is intended for those who ask "Why?" as well as "What?" The material is presented at a level which should be understandable to a graduate engineer with an elementary knowledge of statistics.

Part 1

What is Reliability?

A satisfactory definition of reliability must meet at least three requirements:

1. It must be capable of being stated quantitatively; that is, it must be a mathematical formula.
2. It must fully recognize the need for statistical techniques because of the unpredictable nature of failures.
3. It should be related to the common, intuitive, dictionary meanings of reliability, namely: trustworthiness, dependability, and long and useful life.

The following definition, suggested by the EIA Engineering Department, meets these requirements:

> Definition: "Reliability is the probability of a device's performing its purpose adequately for the period of time intended under the operating conditions encountered."

While this definition is probably the best that can be stated without writing a book on the subject, it raises a number of related problems, especially if the "device" is a complex system. The following are typical: What is "adequate performance"? What is the proper role of a human operator? How should component failures be distinguished from "system" failures? What are the proper environmental "operating conditions"? Should "maintenance conditions" be included in "operating conditions"? What is the proper basis for computing time? When does a gradual deterioration become a failure? How many samples should be se-

lected for a test program, or what level of confidence is desired in the results? etc., etc.

The answers to these questions depend to a large extent on system philosophy and are beyond the scope of the present article. They are treated in detail in Reference (1), which is an excellent guide for preparation of reliability reports.

Probability

The key word in the above definition is "probability," which introduces the required statistical element, and also permits the use of mathematical analysis. To the average engineer, the term "probability" recalls a chapter tucked away in the back of a college algebra book, dealing with such subjects as selecting colored balls from urns, coin-tossing, dice-throwing, drawing a "full house," and similar activities whose study seems more appropriate to a gambling hall than a classroom. However, knowledge of this material provides a good background in the fundamentals of discrete probabilities. For many purposes the word "probability" is the same as "relative frequency." The following two statements are equivalent:

1. The probability of a device having no failure in six months is 90%.

2. Of all devices tested, 90%, or 9 out of 10, can be expected to have no failures in six months. (This does *not* mean that every tenth unit will be defective.)

To obtain a mathematical formula based on the definition of reliability, it is necessary to consider "adequate performance" to mean "zero failures." Thus, reliability is the probability of having zero failures in a prescribed time and with a prescribed "mean time between failures."

Stated as an equation:

$$\rho\ (o,\ t) = e^{-t/m} \qquad (1)$$

Where: $\rho\ (o,\ t)$ is the probability of zero failures, with a given m and t.

m is the mean time between failures (also called mean time to failure)

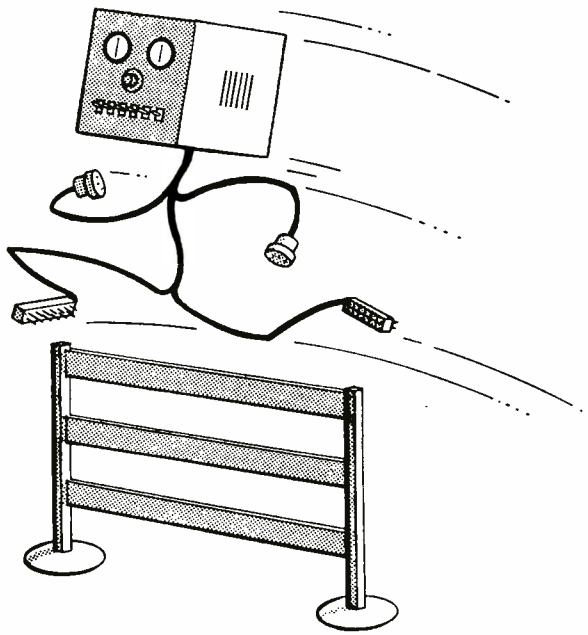
t is the time interval in which zero failures are desired.

$e = 2.718 \cdots\cdots$

The derivation of this formula is stated in Part II, as well as the assumptions involved. It is fortunate that Eq. 1 is exponential. This form is easy to handle mathematically and is familiar to most engineers, since many other natural phenomena obey a similar law. The "mean time to failure" is a figure-of-merit similar to the RC-time constant in a circuit containing a capacitor discharging through a resistor. In particular, the probability that an equipment will operate satisfactorily for a length of time equal to m is $1/e$, or 37%.

Mean Time Between Failures

The determination of the value of m will now be considered. A value must be assigned to m as the result of observing a number of failures on a number of equipments for a period of time, and making the following calculation:



Mid-life equipment has the finest reliability. At this point the "bugs have been ironed-out."

$$\hat{m} = T/F \qquad (2)$$

where: $\hat{m}$ = the mean time between failures *for the interval* T

T = the total operating time for all equipments under test.

F = the total number of observed failures during the tests.

The distinction between m and $\hat{m}$ is that m is the limit which is approached as the total test time is increased indefinitely.

The testing should be performed during the "useful life" of the systems. This is the interval after the initial "debugging" and prior to final "wear-out." Like human beings, systems have a much higher mortality rate during infancy and old-age. The problem naturally arises as to how much operating time or how many failures are required to obtain a valid estimate for the all important m since systems cannot be operated for infinite time or in infinite number. When a statistician is asked this question, he immediately answers with another question, namely: "What is the desired degree of confidence?" At this point someone might ask what is meant by "degree of confidence."

Confidence and Precision

It is important to consider the distinction between *a priori* and *a posteriori* probability. Consider, for example, the problem of poker hands*. The probability, or relative frequency, of a few poker hands is as follows:

One Pair	1760/4165
Two pairs	198/4165
Three of a kind	88/4165
etc., etc.	

The important point is that the above numbers are obtained by mathematical analysis, *not* by observation. It is not necessary to deal millions of poker hands and observe the number of occurrences of certain combinations. The figures listed are exact. There is no question of tolerance or confidence interval. This is *a priori* proba-

* A poker hand in this case means five cards selected at random from a well-shuffled deck.

System Reliability

(*Continued from page* 119)

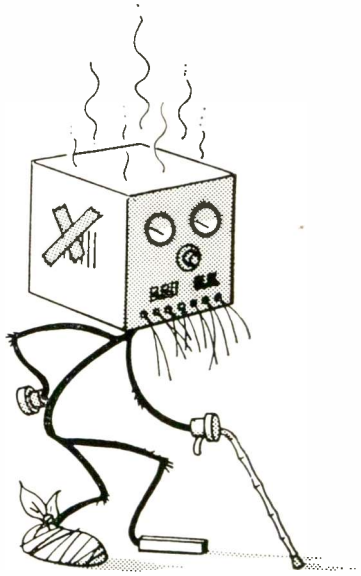
bility, which forms the basis of most gambling games.

On the other hand, consider a complex system operating continuously. Assume that the first failure occurs at the end of six months. Using Eq. 2, the observed mean time between failures is obtained as follows:

$$\hat{m} = \frac{T}{F}$$

$$= \frac{6 \text{ months}}{1 \text{ failure}}$$

$$= 6 \text{ months}$$



Old equipment fails frequently

Assume the equipment is repaired, and that the second failure occurs one hour later. Using Eq. 2 again,

$$\hat{m} = \frac{6 \text{ months} + 1 \text{ hour}}{2 \text{ failures}}$$

$$= 3 \text{ months (approx.)}$$

This is an example of *a posteriori* probability. It is clear that the probability, or relative frequency, of failures is based on observed data and can not be pre-calculated, as in the case of poker hands. It is also clear that a large number of failures must be observed to obtain a reasonable estimate for m. The confidence interval states limits within which there is a certain degree of assurance that the true value is included in the interval. Formulas for calculating confidence intervals are contained in most text books on statistics, for example, Reference (3).

An example will help to illustrate the meaning of confidence interval, and also show the desirability of observing a large number of failures.

Assume the following:

T = 1000 hours
F = 4 failures
} where T and F have the same meanings as previously stated.

The estimated mean time to failure is 1000/4 or 250. The 90% confidence interval is 109 hours to 730 hours. This means that there is a 90% assurance (loosely speaking, probability) that the true value of m is within the above range. There is a 95% assurance that m is between 109 and infinity, or greater than 109. Hence it is seen that four failures were insufficient to obtain an accurate estimate of m with a high degree of confidence, although there can be a high assurance regarding some small minimum value.

Producer's & Consumer's Risk

As indicated above there is always uncertainty regarding the true value of mean time to failure. Accordingly, there are two risks involved:

1. The risk of rejecting a "good" unit, called "producer's risk" and designated by α (alpha).

2. The risk of accepting a "bad" unit, called "consumer's risk," and designated by β (beta).

There is usually no great distinction between good and bad units. However, it is possible to define arbitrarily two values m_1 and m_2 to represent "good" and "bad" units respectively ($m_1 > m_2$). As a numerical example, assume the following:

$$m_1 = 1500 \text{ hours}$$
$$m_2 = 500 \text{ hours}$$
$$\alpha = 10\%$$
$$\beta = 5\%$$

This means that if units are tested in which m is either 500 hours or 1500 hours, approximately 10% of the 1500 hour units are to be rejected, and 5% of the 500 hour units are to be accepted.

The problem is to find a suitable criterion for acceptance or rejections based on the given param-

(*Continued on page* 122)

System Reliability

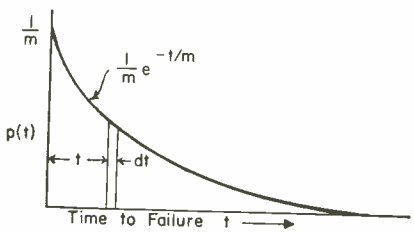
(*Continued from page* 121)

eters m_1 m_2, α, and β. For the problem at hand, the rule is as follows: Accept a unit as "good" if m based on observation of *eight* failures is greater than 875 hours. Otherwise reject it as "bad."

Of course, very few of the units actually tested would have a mean time to failure of exactly 500 or 1500 hours. However, the above sampling plan insures that a unit with m greater than 1500 hours will be rejected with a probability *less* than 10%, and that units with m less than 500 hours will be accepted with probability *less* than 5%. Methods of determining suitable tests for this type of problem are contained in Reference (4).

Exponential Distribution of Time to Failure

The statement is frequently encountered that times between failures are exponentially distributed. This is an interesting and perhaps unexpected result, which is proven in Part II. The distribution is indicated below:



The probability that the waiting time for a failure to occur will be in the interval $t_2 - t_1$ is the area enclosed by the curve between t_1 *and* t_2. It will be noted that the highest probability occurs near zero time, and not in the vicinity of the mean as one might expect. For example, the probability that the waiting time to the first failure is 0 to 5 hours is obtained by finding the area enclosed by the curve between 0 and 5. If the mean time to failure is 1000 hours, the probability that a failure occurs during the first five hours after the start of a test is approximately 0.005; and this probability, although

small, higher than for any other five-hour interval.

Another interesting property of the distribution is that it is independent of the past history of the system (within practical limits, of course). This means that a test can be started any time during "useful life," and the probability of failure during the first five hours of the test is still 0.005, as explained above. The total area under the curve is unity, since there is 100% probability that the waiting time will be between zero and infinity.

Many ingenious plans have been devised for reducing the testing time, such as letting the time depend on the number of failures observed, and making a decision at each failure whether to reject, accept, or continue testing. This is called *sequential* testing. Nearly all mathematical investigation which has been done on test methods and other phases of reliability assumes the exponential distribution of time to failure.

The above material presents only a few of the many aspects of quantitative reliability. Fortunately, the problem is closely related to statistical quality control, a highly developed science.

Reliability Responsibility

Lest equipment designers feel somewhat slighted in being omitted from the above discussion, it is appropriate to conclude with a few remarks for their benefit, before passing on to the derivations. It is important to keep in mind that reliability is basically the responsibility of designers, *not* statisticians. Reliability must be designed into a complex system; it cannot be obtained by testing. No statistician (or anybody else) can predict with certainty when a certain equipment will fail any more than he can predict when a certain tire on a car may blow out. Despite the precise appearance of the equations, the processes are almost entirely random. In fact, it is just this randomness which allows mathematical analysis.

The statisticians, inspectors, testers, purchasing agents, specification writers, etc., are the supporting players in the cast. The

(*Continued on page* 125)

WASHINGTON News Letter

LENGTHY IMPORTANT PROCEEDING—The FCC has just completed its all-important hearings into the allocation of and use of frequencies in the 25-890 MC portion of the spectrum. This will provide the blueprint for its delineation of the spectrum apportionment and usage for the vast array of radio services. These services range from FM broadcasting and TV and tropospheric scatter to the mobile operations for all types of activities including police-fire services, petroleum, telephone companies, utilities, manufacturers, rail-taxi-trucking transportation, and highway construction and maintenance. Analysis of the requirements and positions of the 60-odd organizations and companies, presented in written and oral form with cross-examination only by the FCC Commissioners and staff, will be a tremendous task. It will take months for determinations to be promulgated.

BROADBAND OPERATION—The operational advantages and spectrum-economy phases of the Bell System's broadband plan of mobile radiotelephone operation, as presented by three A. T. & T. officials and one Bell Telephone Laboratories scientist and supported by the U. S. Independent Telephone Association, General Telephone & Electronics Corp. and Lenkurt Electric Co., was a major highlight of the FCC 25-890 MC proceeding. As stated by the A. T. & T. officials, it would mean hands-free mobile telephone usage and interconnection with the long distance dialing network. It would also meet the growing service requirements of land mobile radio users.

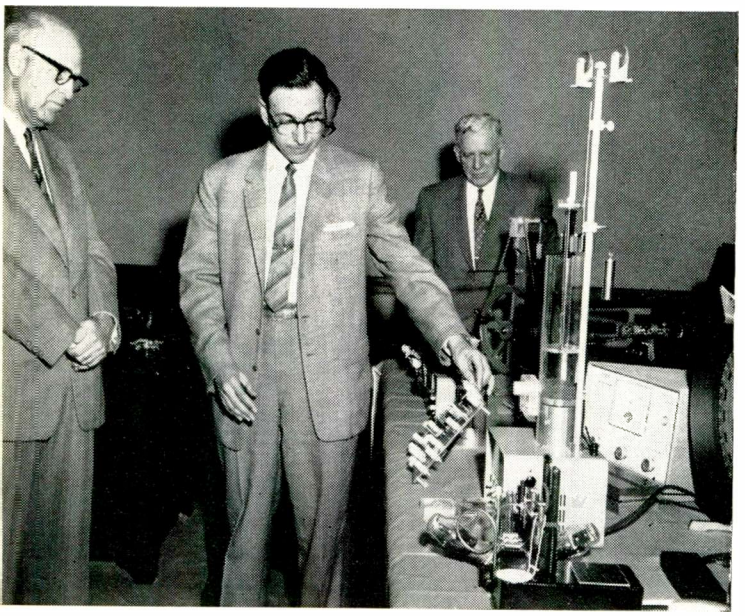
AIR-GROUND SERVICE — While the broadband method of operation was stressed by the Bell System officials as the best means of furnishing public air-ground radiotelephone service, it was brought out that several Bell System companies are ready to begin installation of facilities as soon as frequencies are made available in the 455-456 and 460-461 MC area. These two bands were proposed as an interim measure. It was cited that the air-ground service to be linked into the land local and long distance telephone systems is deemed an essential medium of communications for the air-traveling public.

SATELLITE COMMUNICATIONS — The National Aeronautics and Space Administration plans to place in operation late this year, a transcontinental radio link by use of satellites. This will be the first step in its long-range program to establish a new global system for relaying radio messages, telephone calls and TV programs between continents. The transcontinental link will be between New Jersey and California using a balloon, 100 feet in diameter, orbiting in space to relay radio signals.

National Press Building
Washington 4

ROLAND C. DAVIES

FOREIGN BIDDERS — The Canadian government, acting for Canadian industry, is negotiating with the U. S. for relaxation of the "Buy American" act. Some contracts have been given to Canadian firms, but this has been on an individual contract basis. Presently, foreign bidders must be at least 12 per cent lower on their bid than any U. S. firm to obtain a defense contract.



FOREIGN IMPORTS—Leo A. Hoegh, Director of Civil and Defense Mobilization, made public a "Memorandum of Decision" in which he concludes that imports of heavy electrical equipment are not threatening to impair the national security. The decision is the result of a year long investigation. The investigation was initiated in response to a petition filed by the General Electric Company. The petition was later supplemented by the National Electrical Manufacturers Association.

◀ APPARATUS MAKERS FIGHT

Manufacturers of scientific apparatus used by U. S. high schools have asked Congress to ban the use of Federal funds by high schools for the purchase of "ridiculously low-priced" Soviet apparatus. Dr. Richard Picard (center) is shown describing American-made apparatus to Senator Lister Hill (left).

System Reliability

(*Continued from page* 123)

"stars" in the Reliability story are the designers, at all levels of design from the smallest component to the largest system.

Part 2

Proof of Formula for Probability

The basic assumptions are the following: The probability of a particular event (failure) is the same for any time interval of length t, independent of where this interval is situated and of the past history of the system. This means that the average failure rate is constant, an assumption which is approximately true for complex equipment after it has "settled down"—that is, after the initial period when failure rate is abnormally high, and before wear-out. To be more precise: Whatever the number of events during time (o, t), the probability that during $(t, t + \Delta t)$ an event occurs is $\frac{1}{m}\Delta t$, the probability that no event occurs is $1 - \frac{1}{m}\Delta t$, and the probability that two or more events occur is negligibly small. The problem, therefore, is to find $\rho\ (o, t)$ from these postulathe. The probability of zero failures in time $(t + \Delta t)$ is equal to the joint probabilities of zero failures in time t and also zero failures in Δt.

Thus,

$$\rho\ (o, t + \Delta t) = \rho\ (o, t)\ \rho\ (o, \Delta t)$$

$$= \rho\ (o, t)\left(1 - \frac{1}{m}\Delta t\right)$$

or

$$\frac{\rho\ (o, t + \Delta t) - \rho\ (o, t)}{\Delta t} = -\frac{1}{m}\rho\ (o, t) \quad (3)$$

As Δt approaches zero Eq. 3 becomes the following, due to the way in which a derivative is defined:

$$\frac{d\ \rho\ (o, t)}{dt} = -\frac{1}{m}\rho\ (o, t) \quad (4)$$

Solving this differential equation, and using the initial condition that $\rho(o,o) = 1$, the desired result follows immediately, namely:

$$\rho\ (o, t) = e^{-t/m}$$

Proof of Exponential Distribution of Time to Failure

The statement that a time to failure is t is equivalent to stating that zero failures occur in time t and one failure occurs in the interval $(t,\ t + \Delta t)$, where Δt is very small.

The joint probability of this occurrence is therefore

$$\rho\ (t)\ \Delta t = \left(e^{-t/m}\right)\left(\frac{1}{m}\Delta t\right)$$

or

$$\rho\ (t) = \frac{1}{m}e^{-t/m}$$

This is the curve which is plotted on above.

References

1. "A General Guide for Technical Reporting of Electronic Systems Reliability Measurements," from *Proceedings of the RETMA Symposium on Applied Reliability*, held December 19-20, 1956. Engineering Publishers, New York, N. Y., 1957.
2. *An Introduction to Probability Theory and its Applications*, by William Feller. John Wiley and Sons, Inc., New York, N. Y., 1950.
3. *Quality Control and Industrial Statistics*, by Acheson J. Duncan. Richard D. Irwin, Inc., Chicago, Illinois, 1952.
4. "Life Testing," by Benjamin Epstein and Milton Sobel. *Journal of the American Statistical Association*, September 1953.

Cues for Broadcasters

Eliminating Some Transmitter Capacitors

L. EDWIN RYBAK, Ch. Eng.
WGPA, Bethlehem, Pa.

Transmitter manufacturers consider the possibility that any particular transmitter might be operated anywhere in the broadcast band and their design considerations must, and do, take this fact into account.

Stations have usually experienced fixed capacitor failure. Sad but true, the series parallel combinations do provide a range of capacitance to cover the total broadcast band. However, broadcast stations operate on one fixed frequency.

Engineering and technical personnel trouble shooting such a maze of fixed capacitors and wondering "Which one?" believe there is a simpler and better way of doing things. There is.

By noting the instruction book and determining the values of individual components, it is possible to determine the value of any series, or parallel, or series-parallel combination in each circuit. In nearly every circuit it is possible to reduce the maze of fixed capacitors to one or two components.

Removing original units and replacing them with one or two units of correct value has several advantages. First, trouble shooting is much easier and quicker since there are fewer components to check. Second, the components are provided with increased air circulation and therefore operate at lower temperature, increasing internal heat dissipation ability. This in itself reduces the potential frequency of breakdown, increasing component life. Additionally, capacitors of somewhat higher voltage rating can be installed thus giving even greater reliability.

If exact values are unobtainable two units can be paralleled instead of a series-parallel arrangement. Since capacitors are manufactured with a wide range of tolerance it is probable that exact values even in original arrangement are not possible. The tank coil can be adjusted a few turns to compensate,

$$$ for Your Ideas

Readers are invited to contribute their own suggestions which should be short and include photographs or rough sketches. Typewritten, double-spaced text is requested. Our usual rate will be paid for material used.

with no noticeable loss of efficiency.

The original units can be stored for future use in emergency or replacing if a frequency shift is necessitated by a change in assignment or through sale of the equipment.

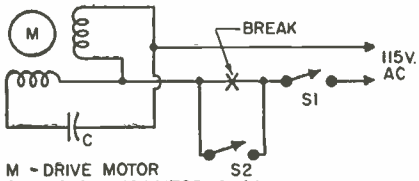
Silent Tape Recorder Operation

ALBERT J. KRUKOWSKI
WSPR, West Springfield, Mass.

As at many radio stations our DJ's run their entire program, playing records, taped commercials, and giving out with the usual gab. One problem that this type of operation presented was how to operate our Magnecord PT-6 Series tape recorders silently, so they could be operated with the mike on. This would eliminate the necessity of shutting off the mike before the tape recorder is started or stopped, and results in much smoother programming.

Our Magnecords, as do many other makes, give out with a loud solenoid click whenever they are started or stopped. The noise is caused by the sudden tension being applied to the linkage by the energizing solenoid, or by the spring return when the solenoid is released. This is purely mechanical and cannot be easily cushioned. We remedied this problem by inserting a lever switch in series with the drive-motor power leads.

In operation, the DJ cues-up a tape and places the function switch in the forward position, this causes the solenoid to energize and places the recorder in standby. The tape



M - DRIVE MOTOR
C - MOTOR CAPACITOR 4 μfd
S1 - PART OF FUNCTION SW.
S2 - DRIVE-MOTOR SW. (ADDED)

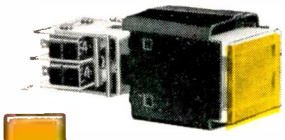
Line is broken and S2 is added

will not start until the drive-motor switch is closed, and when it is closed the tape recorder starts silently as the solenoid was energized previously. The tape recorder is stopped by opening the drive-motor switch. It does so silently as the solenoid remains energized.

This change can readily be incorporated into any tape recorder using a solenoid to engage the tape. On some tape recorders this arrangement will prevent using a running capstan, if the recorder is so equipped, but this is easily offset by using a slightly longer cue and presents no great problem.

UNILITE*

Lights in one color. One lamp. 1" diameter round button.



TWINLITE*

Lights in two colors. Two lamps. Solid or split-color button ¾" x 1". Mounts in rows using barriers.

DUOLAMP*

Lights in two colors. Two lamps. Square button may be split-color. Rugged Military-type construction. Mounts without barriers on .875" centers, both directions.

TREYLITE*

Lights in three colors. Three lamps. Round button is 1" in diameter.

QUADLITE*

Lights in four colors. Four lamps. Mounts in matrix on ⅞" centers, both directions. Also individual flange and barrier mounting.

RE-LAMP FROM FRONT OF PANEL

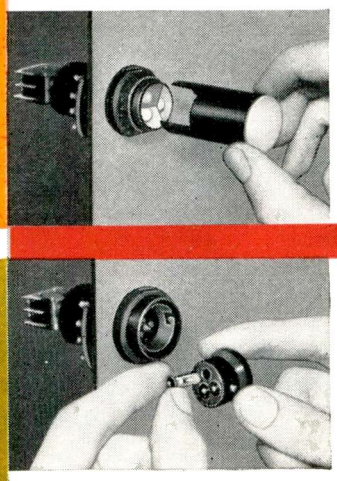
Electrosnap... the only complete line of lighted push-button panel switches you can re-lamp from the front

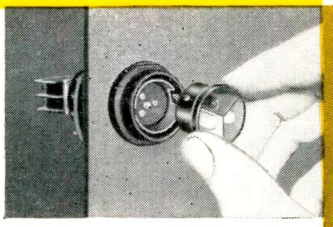
Each of these five types of lighted push-button switches provide both monitoring and switching functions in one compact unit. Each can be quickly and easily re-lamped from the front of the mounting panel. You can change lamps in seconds without disturbing the mounting or the wiring. Re-lamping is this easy: simply pull out the actuator button . . . then reach in and remove the lamps. In some models, the lamps are contained in a separate lamp module which may be readily removed.

ABOVE PHOTOS ½ ACTUAL SIZE.

CHANGE LAMPS IN THREE EASY STEPS

1. Pull out push-button actuator.





2. Pull out lamp module.

3. Replace lamp.

Get all the facts. Write for complete detailed technical literature on these distinctive front-lamping push-button switches.

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44 Reeves Instrument Corporation A Subsidiary of Dynamics Corp. of America —Integrating gyro

PROFESSIONAL ENGINEERING OPPORTUNITIES

Circle number of company on card at right from whom you desire further information.

512 Armour Research Foundation of Illinois Institute of Technology

508 Federal Aviation Agency

502 Federal Electric Corporation an Assoc. of IT&T

513 General Electric Co., Defense Systems Dept.

507 General Electric Co., Advanced Electronics Dept.

510 General Electric Co., Communication Prods. Dept.

508 Link Aviation, Inc., A Subsidiary of General Precision Corp.

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511 Sylvania Electric Products, Inc., Semiconductor Div.

505 System Development Corporation

503 Westinghouse Electric Corporation

63 Revere Corporation of America—Hermetically sealed switch

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50 Sangamo Electric Company — Toroidal inductors

89 Scala Radio Company—Reflector antenna

70 Scintilla Division, Bendix Aviation Corporation—High temperature capacitors

64 Servo Corporation of America—Electromechanical assembly kits

97 Stanpat Co.—Adhesive backed drafting aid

3 Sprague Electric Co.—Power resistors

93 Stromberg-Carlson A Division of General Dynamics Corp.—Telephone relays

15 Sylvania Electric Products, Inc., Special Tube Operations — Traveling wave tubes

30 Sylvania Electric Products, Inc., Semiconductor Division—Transistors

25 Tapco Group, Thompson Ramo Wooldridge, Inc.—Wave-guide switches

7 Vektronix, Inc.—Fast-rise oscilloscope

74 Telechrome Mfg. Corp.—Special effects generator

16 Texas Instruments Incorporated—Switching transistors

22 Trinity Equipment Corporation—Dry air systems

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80 United Transformer Corporation—Miniature filters and inductors

82 Varian Associates, Instrument Division —Strip chart recorders

83 White Dental Mfg. Co., S. S.—Air abrasive unit

56 Zeus Engineering Company—Transistor index

90 Zierick Manufacturing Corp. — Lugs, clips and terminals

Employment—Use the handy card below to get more information on the engineering positions described in the "Professional Opportunities" Section which begins on page 145 of this issue.

Postcard valid 8 weeks only. After that use own letterhead describing item wanted. **JULY 1959**

PROFESSIONAL ENGINEERING OPPORTUNITIES

Please send me further information on the engineering position 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

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JULY 1959

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New Products—July, '59

198 **Amplifier, S-band**—Raytheon Mfg. Co.
208 **Attenuator**—Radar Design Corp.
219 **Capacitors, electrolytic** — Illinois Condenser Co.
214 **Case Machine, glass diode**—Kahle Engineering Co.
217 **Computer, thermistor**—Fenwal Electronics, Inc.
202 **Connectors, rectangular** — DeJur-Amsco Corp.
211 **Delay line, dual**—ESC Corp.
215 **Furnace, laboratory**—Materials Research Corp.
216 **Kits, pressurization**—Trinity Equipment Corp.
203 **Meters, panel** — Greibach Instruments Corp.
201 **Oscillator, sweeping**—Kay Electric Co.
199 **Potentiometer, precision**—Spectrol Electronics Corp.
206 **Relay, coaxial**—Electronic Computer Co.
207 **Relay, miniature**—Comar Electric Co.
218 **Relay, thermal**—G-V Controls, Inc.
204 **Relays, time delay**—A. W. Haydon Co.
205 **Resistors, wirewound**—Ultronix, Inc.
200 **Rubber, fibrous silicone**—The Connecticut Hard Rubber Co.
210 **Terminal, high temperature**—Thomas & Betts Co.
209 **Tester, insulating oil**—Associated Research Inc.
212 **Transformer, isolation**—Hughey & Phillips, Inc.
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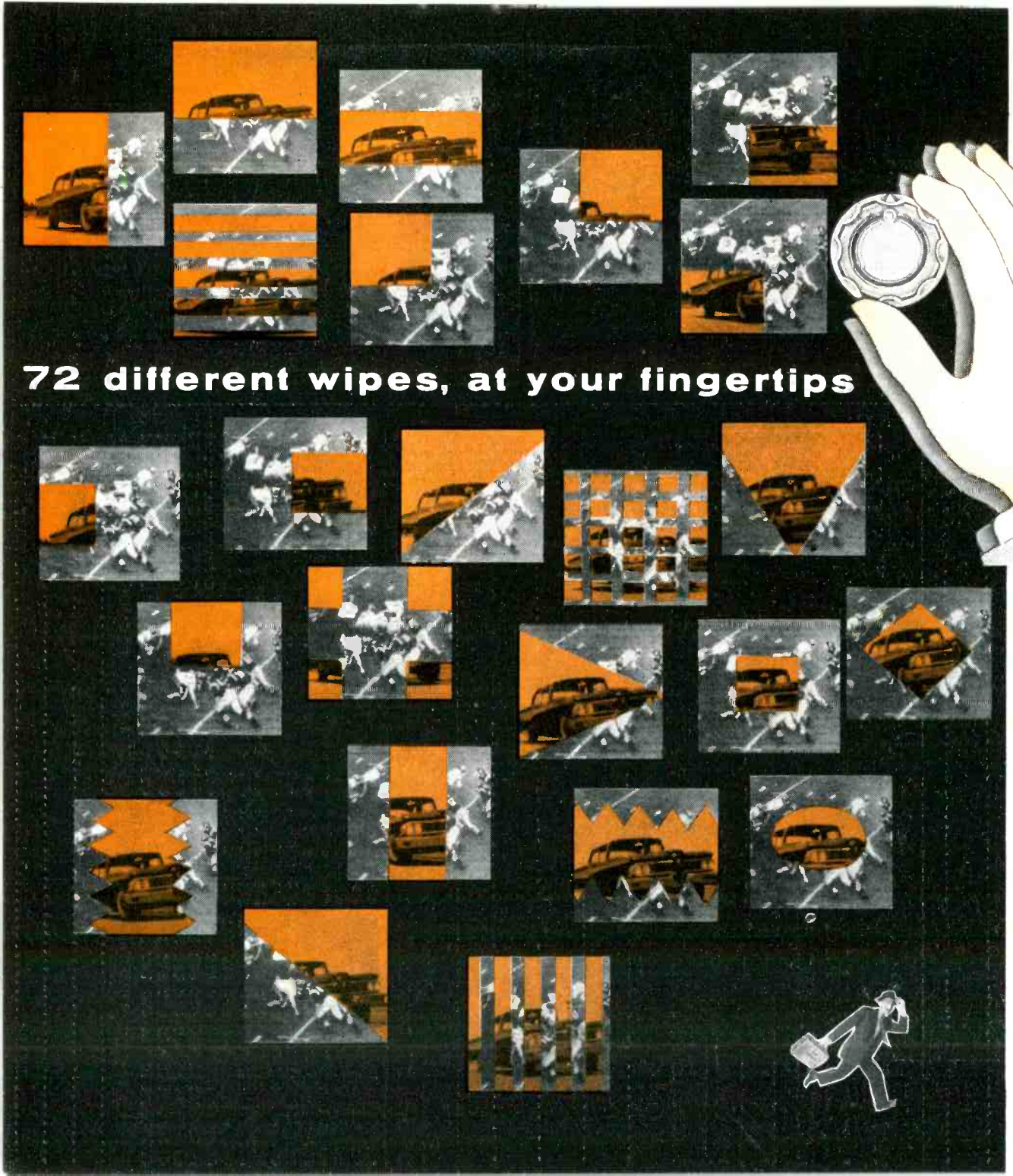
NEW TECH DATA

163 **Cable Ties and Straps**—Thomas & Betts Co.
177 **Cables, coaxial**—Standard Wire & Cable Co.
193 **Cathodes**—Superior Tube Co.
171 **Circuits, magnetic** — Ohio semiconductors, Inc.
188 **Coaxial Cable and Connectors**—Prodelin, Inc.
165 **Connectors**—The Deutsch Co.
191 **Counting and Control** — Freed Transformer Co., Inc.
178 **Dissipator, heat** — International Electronic Research Corp.
195 **Dropouts, signal**—Minnesota Mining and Mfg. Co.
164 **Equipment, public address** — Electro-Voice, Inc.
196 **Galvanometer** — Consolidated Electrodynamics Corp.
182 **Glass, silica**—Corning Glass Works
168 **Heads, recording** — General Transistor Western Corp.
176 **Inductor, toroidal** — Arnold Magnetics Corp.
187 **Instrumentation**—Systron Corp.
185 **Lab Instruments, use of**—Weston Instruments Div., Daystrom, Inc.
173 **Management, systems** — Western Gear Corp.
179 **Manual, design**—TA Mfg. Corp.
186 **Nuts, wing**—Gries Reproducer Corp.
192 **Plastics, laminated**—Formica Corp.
180 **Potentiometers** — DeJure-Amsco Corp., Electronic Sales Div.
162 **Racks, cabinet** — Par-Metal Products Corp.
183 **Recorder, tape** — Precision Instrument Co.
174 **Regulators, silicon** — Texas Instruments Incorporated
160 **Resins, fluorocarbon**—E. I. du Pont de Nemours & Co.
161 **Rubber, silicone**—General Electric Co., Silicone Products Dept.
172 **Switches**—Control Products Inc.
175 **Systems, defense** — Sylvania Electric Products, Inc., Electronic Systems Div.
189 **Tables and Formulas** — Westinghouse Electric Corp.
169 **Terminations, coaxial**—Weinschel Engineering
181 **Terminals**—Lerco Electronics, Inc.
166 **Test Equipment, microwave**—Polytechnic Research and Development Co., Inc.
184 **Transistors** — Bendix Aviation Corp., Red Bank Div.
190 **Tubes/transistors, hi-fi**—CBS-Hytron
194 **Ultrasonics**—Acoustica Associates, Inc.
170 **Winder, transformer**—Geo. Stevens Mfg. Co., Inc.
167 **Wire and cable**—Inso Electronic Products, Inc., Wire and Cable Div.



Telechrome brings to TV broadcasters a vastly improved system for producing a wide variety of dramatic wipes, inserts, keying and other special effects. The superb engineering of the Telechrome Special Effects System provides outstanding reliability and technical performance when used for either color or monochrome TV. Simplicity of pattern selection and wipe speed is provided by manual switches on the remote control unit.

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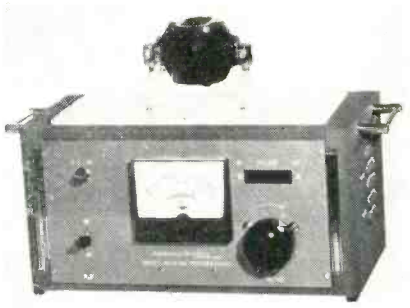
Circle 74 on Inquiry Card

New Products

INSULATING OIL TESTER

High voltage tester of insulating oils used in oil immersed electronic assemblies and oil filled components, Model 4505-A Hypot, weighs 42 lbs. Size is 8½ x 16 x 8 in. High voltage

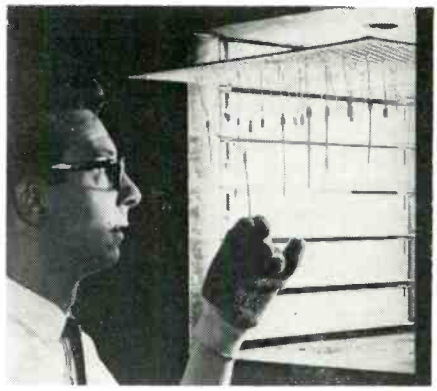


breakdown tests of insulating oils may be made where the equipment is located. Test voltage is continuously adjustable from 0 to 35 kv ac at a 2 kva rating to meet ASTM and Federal specs. Measurement of test potential is made directly at the test electrodes to assure accuracy. Set operates from 110-120 vac. Associated Research Inc., 3777 W. Belmont Ave., Chicago 18, Ill.

Circle 209 on Inquiry Card

HIGH TEMPERATURE TERMINAL

Self-insulated, electrical terminal for high temp. applications in aircraft, missiles and electronic wiring. Teflon is used for the terminal's sleeve, which covers the terminal barrel and a portion of the conductor to be terminated. The use of Teflon allows for applications to 500°F for indefinite periods and to 600°F for short periods. The precise compression in the Teflon and the intimate contact



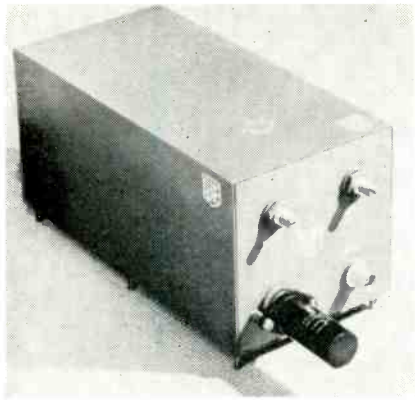
between wire and terminal made by the proper hand or power compression tool remain permanent despite constant high temp. Thomas & Betts Co., 36 Butler St., Elizabeth, N. J.

Circle 210 on Inquiry Card

New Products

DUAL DELAY LINE

Dual Delay Line, Model 71-50, is a relay operated, dual channel delay line, designed to obtain coincidence between two signals of different time and a third reference signal. Char-

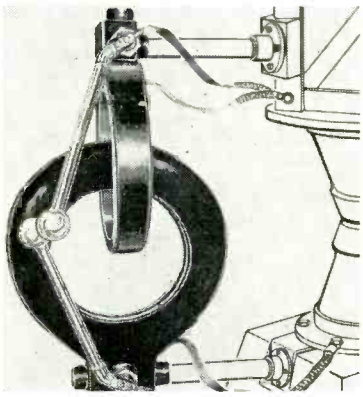


acteristics of the new Dual Delay Line are as follows: Delay, 1 to 1.5 μsec.; independently variable in each channel in increments of 0.05 μsec.; impedance—1000 ohms; output rise-time —0.06 μsec. per channel; dimensions—8 x 4 x 4 inches. ESC Corporation, 534 Bergen Boulevard, Palisades Park, New Jersey.

Circle 211 on Inquiry Card

ISOLATION TRANSFORMER

Tower Lighting Isolation Transformers are available in 3 load capacities: 750, 1750, 3500 w. These transformers provide higher efficiency, improved regulation, additional taps, and epoxy encasement. Designed especially to provide power across the base insulator of a radiator, these transformers may be used wherever 60



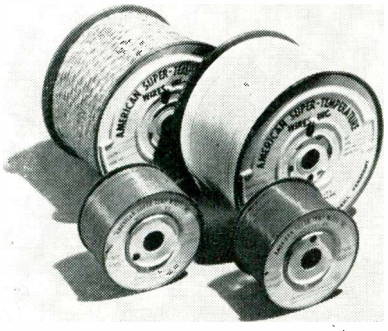
cycle power must be transferred efficiently across two points with very low capacitance or at very high voltages. Hughey & Phillips, Inc., 3200 N. San Fernando Rd., Burbank, Fla.

Circle 212 on Inquiry Card

New Products

HIGH TEMPERATURE WIRE

Lead and hook-up wires and aircraft and circuit wires are insulated with silicone-rubber. Insulations will be available in AWG sizes 4 through 28 and will have temperature ranges

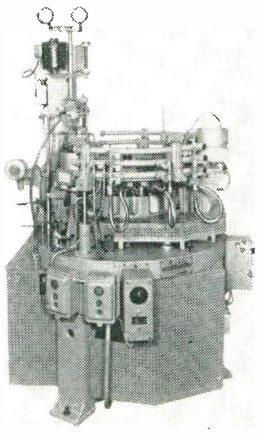


of −55°C to +200°C. Meet MIL-W-16878C (NAVY), Type F for 600 v. service, and Type FF for 1000 v. service; and MIL-W-8777A. Protective jackets can be fabricated in teflon impregnated fiberglass, nylon, dacron, or mixtures of these materials. Jackets are available plain, or with suitable colored tracers for coding. American Super-Temperature Wires, Inc., West Canal St., Winooski, Vt.

Circle 213 on Inquiry Card

GLASS DIODE CASE MACHINE

Automatic two-purpose glass diode body case machine has a capacity of up to 1500 glass body cases per hour. Because it first produces a beaded lead wire, then seals a glass body sleeve over it, the new unit may be used on larger automated production



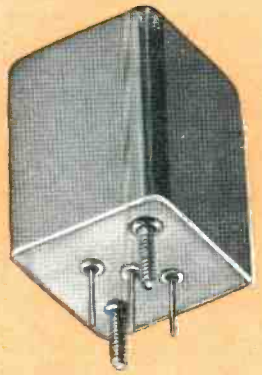
lines to make beaded lead wires alone, or it may be used to produce entire glass body cases. Kahle Engineering Company, 3322 Hudson Ave., Union City, New Jersey.

Circle 214 on Inquiry Card

NEW MINIATURIZED UNITS FROM STOCK...

UTC has led the high Q coil and filter fields for over 25 years. Fresh examples of this leadership are represented in the UTC Minifilters and Miniductors described below. Though greatly miniaturized, the designs are conservative and will provide the exceptional reliability associated with all UTC products.

UTC MINIFILTERS



HPM and LPM case (MIL AG)
1 x 1 x 1⅜"
Weight .....2¼ oz.

BPM case (MIL AF)
¾ x ¾ x 1⅛".
Weight .....1 oz.

Hermetically sealed to MIL-T-27A and MIL-F-18327 Specs.

UTC stock interstage filters have been an industry standard for over a decade. The new UTC miniature filters provide almost the same characteristics in an extremely miniaturized package. Attenuation of these minifilters is only slightly less than their larger counterparts, as is operating level. Special minifilters can be supplied for any frequency above the minimum shown for each group. Straight pin terminals are provided for printed or standard circuits.

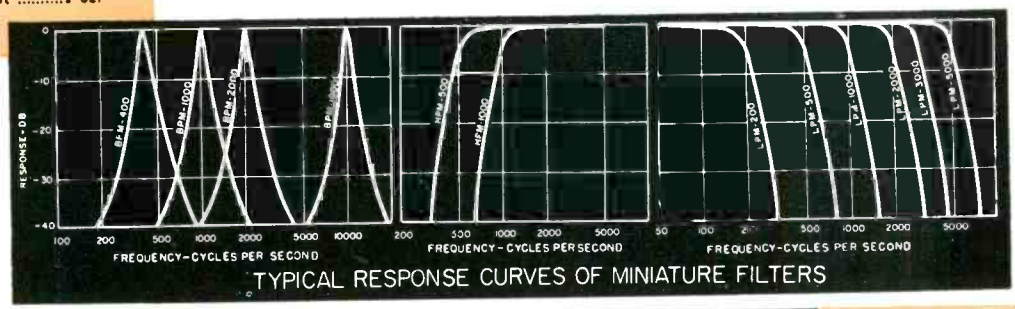
BPM units (band pass) have 2:1 gain. Attenuation is approximately 2 db ± 3% from center frequency, and 35 db per octave as shown. Input 10,000 ohms, output to grid, tapped for 10,000 ohms output to provide flexibility in transistor circuits.

HPM units (high pass) have a loss of less than 6 db at cutoff frequency, and an attenuation of 30 db at .67 cutoff frequency. Input and output 10,000 ohms.

LPM units (low pass) have a loss of less than 6 db at cutoff frequency, and an attenuation of 30 db at 1.5 cutoff frequency. Input and output 10,000 ohms.

STANDARD FILTERS STOCK FREQUENCIES

BPM—400	LPM—200
BPM—1000	LPM—500
BPM—2000	LPM—1000
BPM—10000	LPM—2000
HPM—500	LPM—3000
HPM—1000	LPM—5000

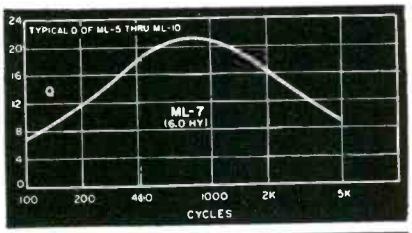


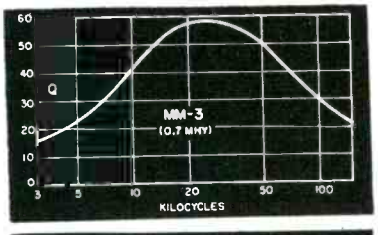
TYPICAL RESPONSE CURVES OF MINIATURE FILTERS

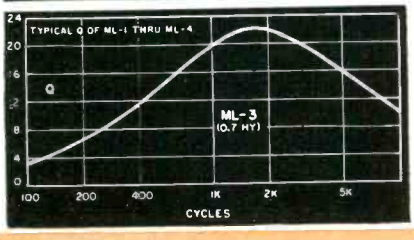
UTC MINIDUCTORS

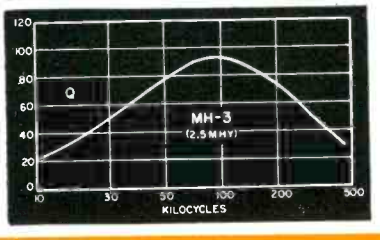
Hermetically sealed to MIL-T-27A Specs., MIL type TF5RX20YY

UTC Miniductors are ideal for transistor and printed circuit applications, providing high Q in miniature form. The ML-1 to 4 units are for medium low frequencies, adjusted to ± 3% at 1 V. 1 KC. The ML-5 thru 10 series are for lower frequencies, adjusted to ± 3% at 1 V. 400 cycles. The MM and MH units are for medium and high frequencies, adjusted to a tolerance of ± 2%. Temperature stability is excellent on all Miniductors, ± 1% from —55° C. to + 100° C. The ML group are in a Hipermalloy shield case . . . The MM and MH coils are symmetrical toroids . . . for high coupling attenuation and low hum pickup. The DCMA MAX. shown is for approximately 5% drop in inductance.









Type No.	Inductance (0 DC)	DC MA Max.
ML-1	.25 Hy.	9
ML-2	.4 Hy.	7
ML-3	.7 Hy.	5
ML-4	1.4 Hy.	3
ML-5	2.5 Hy.	1
ML-6	4.0 Hy.	.7
ML-7	6.0 Hy.	.6
ML-8	10 Hy.	.5
ML-9	25 Hy.	.3
ML-10	60 Hy.	.2
MM-1	3. Mhy.	50
MM-2	5. Mhy.	40
MM-3	8.0 Mhy.	30
MM-4	12.5 Mhy.	25
MH-1	.6 Mhy.	75
MH-2	1.5 Mhy.	37
MH-3	2.5 Mhy.	28
MH-4	6 Mhy.	23

ML CASE
1⅜₂ x 1⅜₂ x 9⁄16 high

MM, MH CASE
9⁄16 Dia. x ¼ high

ACTUAL SIZE

And Special Units to Your Specifications

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"

Circle 80 on Inquiry Card

New Products

LABORATORY FURNACE

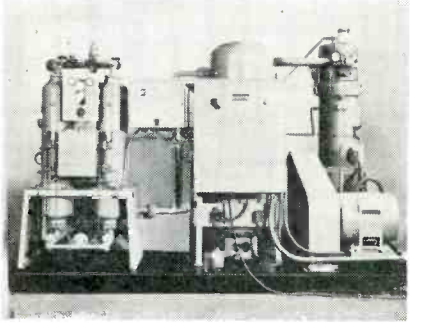
The MRC Model MF-90 multi-purpose furnace provides a complete heat treating and experimental laboratory furnace in one apparatus. It may be used in either a horizontal or vertical

position at temperatures up to 1100°C. A clock motor is mounted for use in the growth of single crystals by the Bridgman technique. Furnace cores may be replaced within 2 min. while the furnace is still at temperature. A cast one piece insulation makes this a clean and simple operation. Replacement cores are supplied in wooden carrying cases. An anticipating controller, variac and ammeter are provided. Materials Research Corp., 47 Buena Vista Ave., Yonkers, N. Y.

Circle 215 on Inquiry Card

PRESSURIZATION KITS

Completely automatic pressurization kits for coaxial or microwave transmission lines use no heat for reactivation. The systems provide dew-points down to −180°F, complete oil repec-



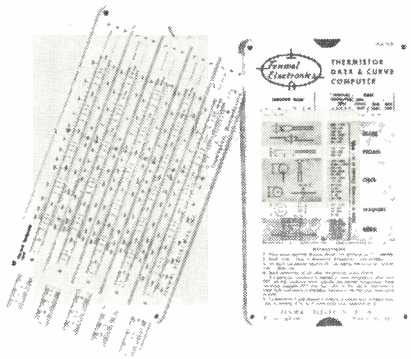
tion, min. maintenance, elimination of electric or steam heating facilities, and virtually no corrosion problems. Trinity Equipment Corporation, Cortland, N. Y.

Circle 216 on Inquiry Card

New Products

THERMISTOR COMPUTER

Thermistor Data and Curve Computer, is a slide rule which reduces lengthly computations to a single slide rule setting. With the thermistor shape desired and its resistance at

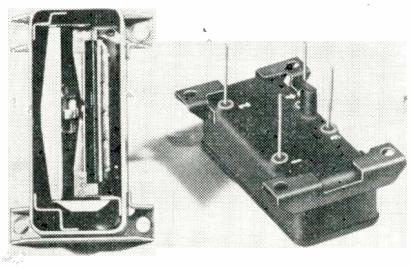


25°C, resistance can be read directly opposite all temperature points on the curve of the appropriate thermistor. Also includes dimensions, dissipation and time constants, max. temp. limits for each of several hundred thermistors. Size is 5 x 8 in. Fenwal Electronics Inc., Mellen St., Framingham, Mass.

Circle 217 on Inquiry Card

THERMAL RELAY

The Type PT thermal time delay may be operated under vibration of 20 g up to 2000 CPS and under shock of 50 g for 11 ms. There is no resonance below 2000 CPS. Operating time delays are 3 to 60 sec. Time delay tolerance is ±5%. Ambient temp. effects are ±5% from −65°C to +125°C. Heater ranges from 2 to 115 v. for delays of 3 to 12 sec. and from 2 to 230 v. for longer delays. Case is 1 3/16 x 2¼ x ¾ in. Weight is 2 to 2¼ oz. Contacts are single pole, single throw, normally open or



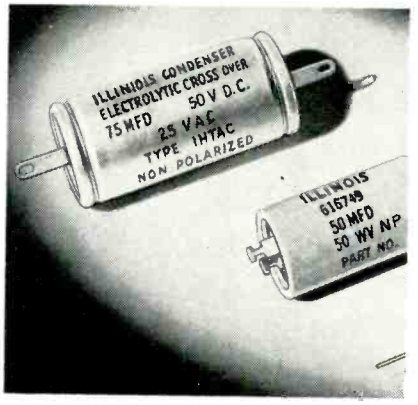
normally closed, 2 a resistive at 115 vac or 28 vdc. Dielectric strength is 1000 v. at sea level and 500 v. at 70,000 ft. G-V Controls Inc., Okner Parkway, Livingston, N. J.

Circle 218 on Inquiry Card

New Products

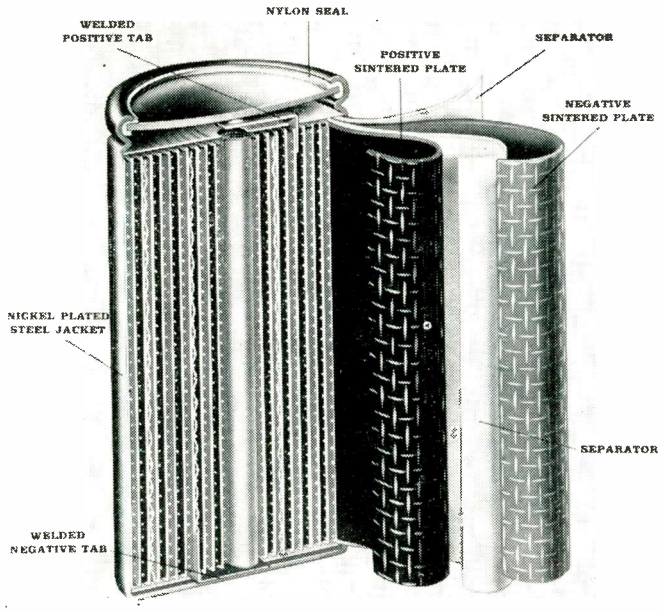
ELECTROLYTIC CAPACITORS

A line of ac non-polarized tubular electrolytic capacitors for cross over audio circuit networks with special design. The units provide virtually uniform capacitance over the entire audio spectrum, with flat characteristics from 30 to 15 KC. High current



carrying capabilities and low power factor enable them to be used in high fidelity high power equipment. Illinois Condenser Co., 1616 N. Throop St., Chicago 22, Ill.

Circle 219 on Inquiry Card



Tightly rolled sintered plates are made of fused metal particles.

Commercial Rechargeable Cells

(*Continued from page* 56)

slips into any flashlight which now uses two "D"-size cells, and lists for $7.95.

Sintered-plate construction permits stable use of the total capacity. The output voltage will remain constant for over 90% of the entire discharge period.

Like its big brothers in the jet aircraft-missile field,

(*Continued on page* 142)

Rechargeable Cells

(*Continued from page* 141)

nickel-cadmium sealed battery cells can operate in extremes of temperature. They may be charged and discharged in temperatures ranging from minus 40° F to plus 160° F. They may also be stored, either charged or discharged, in wide temperature ranges without damage.

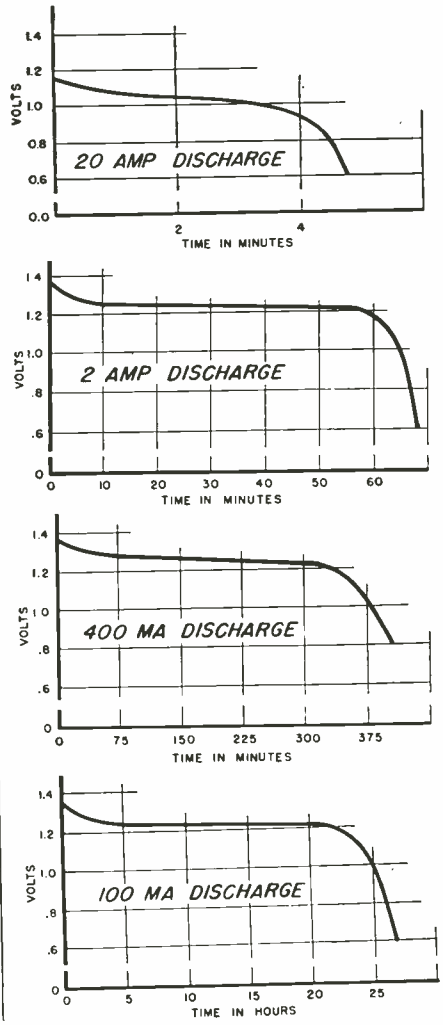
The extremely long life and corrosion-resistant construction virtually eliminate the need for inspection or replacement. No additional water or electrolyte is ever needed because the cell is permanently sealed. It can be charged in place without removal from equipment. In many cases, the battery can be premanently embodied in the product, with a small, inexpensive charger incorporated as an secure sealing allows it to with- integral part of the circuit. The stand overcharging without damage as long as it is charged at the prescribed rate. Cells can be left on this charge for months. They can also be charged from a completely dead condition without harm.

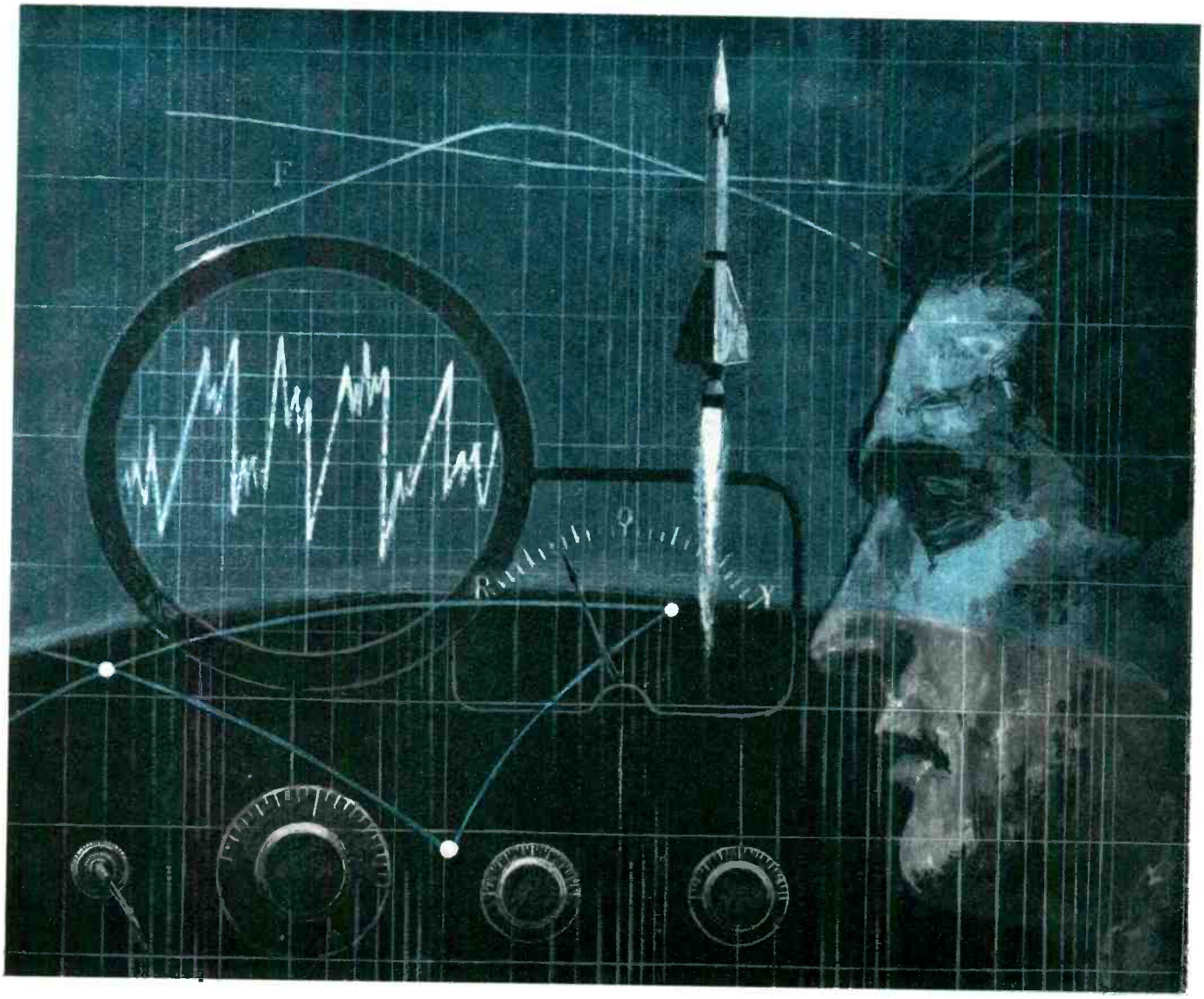
Sonotone sealed battery cells are physically interchangeable with most dry cells without modifying the device in which they are used. The basic sizes can be used individually or in groupings to reach any desired capacity or voltage. Any single Sonotone battery cell has an operating voltage of 1.25 volts. Combinations are available in the standard voltages of 6, 12, 24, 28 and 32 volts.

The cell is built to meet the most rigid military requirements. The tightly rolled sintered plates, composed of fused metal particles, are shock resistant. Internal connections are welded. The case is high strength steel resistant to corrosion. All cells will operate equally well in vacuums or under pressure.

Many applications can use a smaller size sealed cell than is possible with other types, since the Sonotone cell does not need to be replaced after discharge. The capacity is simply renewed by recharging.

Typical constant current discharge curves for the standard flashlight "D" cell.





WE MAKE THE SYSTEMS WORK

Almost unique in the world of the electronics industry, Federal Electric Corporation serves as a complete engineering service organization for the government, for industry and for its parent organization, International Telephone and Telegraph Corporation. A central engineering department, at Paramus, provides a professional staff for systems and application engineering, layout and installation planning, equipment and systems evaluation — and publications services.

Our job is "making the systems work". After complex electronic equipment or systems are designed and built, they must be installed by experts, properly aligned, tuned and tested to assure operation at peak performance. Then they must be continuously maintained to assure dependability. In some cases teams must be provided to operate the equipment, or to train the user to operate it. All this we do — exercising complete management responsibility.

Prime examples of Federal projects are the DEW Line of radar stations across Canada and Alaska and the White Alice communication system in Alaska. In many parts of the world FEC has installed and tested TACAN and ILS systems for military and commercial use. Today Federal is also engaged in engineering operations connected with missile test ranges in Florida and California. From the Arctic Circle to Spain Federal Electric is keeping systems working.

For further information regarding positions in our Systems Engineering staff, at Paramus, and field engineering assignments in the U. S. and abroad, write W. F. Duffy, Professional Placement.

FEDERAL ELECTRIC CORPORATION

An Associate of International Telephone and Telegraph Corporation

Paramus Industrial Park, Paramus, New Jersey

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

EJC Proposes Firm Policy on Eng'g Draft Exemption

The Engineering and Scientific Manpower Commissions of the Engineers Joint Council, 29 W. 39th St., N. Y., has recommended to the Senate Armed Services Committee that a firm policy be established to insure that engineers and scientists and others of high professional skill not be withdrawn from critical occupations in essential civilian activities for military service. Exceptions would be made where critical skills were needed by the military. The EJC also recommended that professional people exempted in this manner be given credit toward military service obligation.

Gen. Lewis B. Hershey, Dir. of Selective Service, commenting on the EMC-SMC proposals said, "I don't think they are saying that we are taking the man out of industry. I think they are saying that he stays in there and gets no credit for it." The EJC concludes that Selective Service will continue occupational deferments for engineers and scientists in essential civilian activities. None the less, they believe, the absence of specific legislative action for this policy leaves the door open for less mature interpretation at a later date. One problem discussed was whether public attitudes have matured to a point of accepting such a concept of civilian service credit.

Consultant Firm Expands

Electronic Consultants, Inc., 89 State St., Boston, Mass., has expanded its services and added a group of international engineering executives as consultants. The firm provides technical market research, reliability studies and programming, and international engineering liaison.

The new consultants are: Lewis M. Clement, Wash., D. C.; John D. Stacy, Glens Falls, N. Y.; and Leon Pololsky, Pittsfield, Mass. The new services are: research and engineering audit, technical management, and financial and feasibility studies in the electronics field.

TV Lures Engineers

Librascope, Inc., Glendale, Calif. manufacturer of computers, controls, and associated components, is sponsoring a new TV program, "Blueprint." "Blueprint" features a space-age format on present and future technical and scientific developments. Dr. Martin Klein is host-emcee for the twice weekly, 13-week duration program.

The Commercial will be confined to acquainting engineers and new job applicants with the advantages of working for the company. Employment Manager, Glen Seltzer, praised the new TV series for its potential in attracting younger listeners who will be the engineers and technical men of tomorrow.

Industrial Site Rises Near Resort Area

A brochure from Lewis Terminals, Inc., 31 W. 20th St., P. O. Box 616, Riviera Beach, Fla., describes a "planned industrial park" located in Palm Beach County. The park is between Cape Canaveral and Miami on the Southeast coast of Florida.

Army Studies "Best Use" for Drafted Engineers

The Army has given its 3,000 man Enlisted Scientific and Professional (S&P) program a thorough going over to determine possible areas of improvement in utilizing those soldiers with scientific, engineering, and professional backgrounds. The program has, over the last 10 years, made the technical experience of over 30,000 professional people available while they served their two-year military service obligation.

The analysis program indicates that personnel management can be strengthened by: adopting personnel standards related to accepted standards in the various professional areas — standards such as those used by the Civil Service Commission; assuring that duty positions clearly require professional level performance in a scientific or engineering specialty, eliminating those that do not; encouraging the assignment of greater professional responsibilities; reducing the frequency of interruption of professional type duties; and providing for local advisory groups to assist commanders in placing and utilizing these soldiers.

Soldiers who meet the new standards will be transferred to the new S&D program. Those who do not, will retain their present S&P titles until discharged from the service.

Norman A. Hess, Small Business Analyst in the Dayton Air Force Depot, inspects products displayed by small firms in DAFD's Procurement Waiting Room. Case is designed to acquaint visiting reps with available items.

In the last few years, many events, not only organizationally, but complexity-wise, have occurred in the coordinated military standardization program. Here, the Signal Corps' participation is reviewed.

Components as viewed by

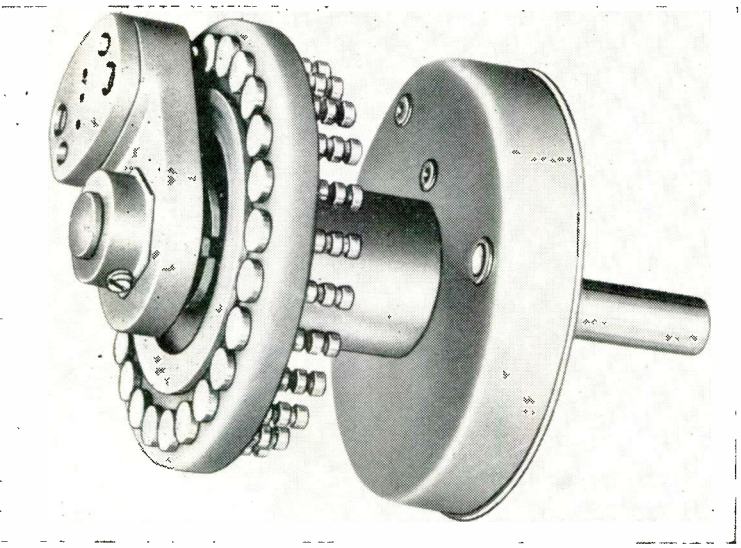
The Military Standardization

PAST standardization problems included such areas as winterization, ruggedization, miniaturization, reliability concepts, and realistic and substantiated requirements. Past effort in military standardization on parts and materials has paid substantial dividends.

However, when today's problems are considered, it is evident that the over-all problem is enormous and that the surface has merely been scratched. The problem is particularly significant for electronic parts and materials, which represent 60% of electronic equipment dollar value and practically 100% of applications and maintenance problems.

Standardization has been practiced in varying degrees for many years by military agencies of the United States; however, experience in two world wars has demonstrated the need for an even higher degree. More so than ever, today's military standardization program on parts and materials involves a multitude of items, many cross-sections of people, and a myriad of functions.

Fig. 1: Standardization study tasks recently concluded or now under way include the development of requirements for necessary types of rotary switches for incorporation in MIL-S-3786.



The military standardization engineer, besides concerning himself with basic problems, must work, coordinate, and correlate his efforts with many others. This group includes those involved in research and development, vending, equipment fabrication, applications, quality control and quality assurance, cataloging and stock management, procurement, field engineering, logistics, inspection acceptance, and international standardization. Further, all military Service and Defense activities, General Services Administration, National Security Agency, Armed Services Electro-Standards Agency, Aeronautical Standards Group as well as industrial and professional standardization groups must be contacted. He must involve himself in such areas as specification engineering, testing techniques, minimum military requirements, characteristics and parameters, reliability prediction and failure analyses, contractual program concerning performance and capability data and a host of other allied activities.

Activities and Operation

Technical phases of Signal Corps' coordinated standardization program on parts and materials are the responsibility of our Branch. (See author's affiliation.) Activities and operations are controlled by various procedural manuals, policies, and directives issued by the Armed Forces Supply Support Center, Army Deputy Chief of Staff for Logistics, and Office of the Chief Signal Officer.

The over-all Defense standardization program, as currently constituted under the Defense Cataloging and Standardization Act, requires achievement of the highest practicable degree in standardization of items and methods used throughout the Department of De-

By BARNEY A. DIEBOLD
Chief, Components and Materials Branch
Standardization Division
U. S. Army Signal Equipment Support Agency
Fort Monmouth, New Jersey

Engineer

fense, and is implemented by Department of Defense Directive 4120.3.

As a primary adjunct to item standardization, the Federal Supply Classification (FSC) system and its Indexes have been developed and adopted by the Office of the Secretary of Defense for use in classifying items of supply identified under the Federal Cataloging Program.

An important management instrument used in the program is the Standardization Plan for each FSC class. The responsible military Department, through its assignee activity, must develop, administer, and maintain a standardization plan for the achievement and maintenance of standardization in that class, collaborating with the other Departments. The plans include provisions for work assignments, or reassignments to other Departments. Projects and criteria, to be accomplished by the three Departments, which are directed toward elimination of unneeded items in the supply system are listed. It directs tasks for further sophistication analyses. The plan also indicates projects for those standardization criteria required to implement and maintain the continuing standardization process and methods for their achievement. Thus, the plan prescribes the subject of the standardization effort responsible for its accomplishment, and the due date by which it must be completed.

Considerations

Projects in the plan must consider such factors as industry practices, procedures for achieving standardization, factual evaluation of benefits to be derived, consideration of logistics requirements, increasing sources of supply, improvement of design and producibility of items of supply, logistics support, conservation of materials, and many others.

Tasks contained are projected on a three-year basis; however, this does not preclude separate initiation of additional projects not originally included. From the FSC assignment responsibilities discussed above, we see that all Departmental participants assist in development of a plan and in completion of the various projects it contains.

Plans are revised one year from the last approval date. The five standardization plans for which Signal Corps has been delegated assignee activity in the parts and materials area have already been approved and are under administration; in fact, all five have been revised or are being revised.

Among the most important products of the program are those in the standardization documents category. These documents must be officially recognized and preserved in proper channels to guide and govern new design and the production of new items of supply, and to restrict procurement to those items designated as standard. Standardization documents are identified in an established series and they directly implement standardization. When discussing the promulgation of new standardization documents, it should be recognized that Signal Corps also is vitally concerned with their revision, amendment, cancellation, supersession, and consolidation.

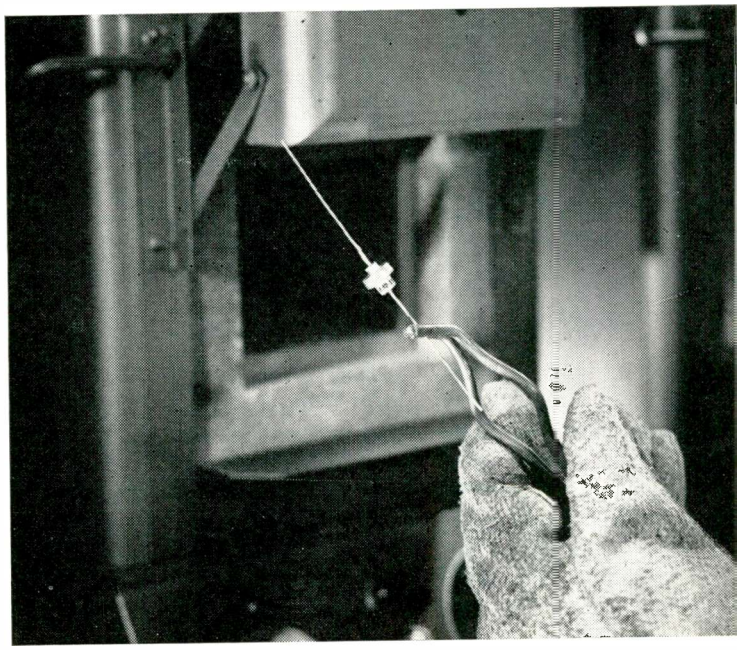


Fig. 2: Tests, requirements, ratings, and dimensions have been established for solid electrolyte tantalum capacitors, MIL-C-55057 (SigC). It provides max. capacity per unit volume, low dissipation factor, stability, and improved life and shelf characteristics.

Signal Corps' accomplishments for the past year in the area of document projects on electronic parts and materials were (as preparing activity) 242 projects initiated, 229 projects completed, and 341 projects currently in process; also, 561 projects were processed as custodian or interested activity.

The basic types of standardization studies are simplification, technical analysis, and engineering practices (engineering standardization).

Simplifications

There are an extreme number and variety of items presently in the Federal supply system. Therefore, the system must be analyzed and the need for such numbers and varieties determined. Items no longer

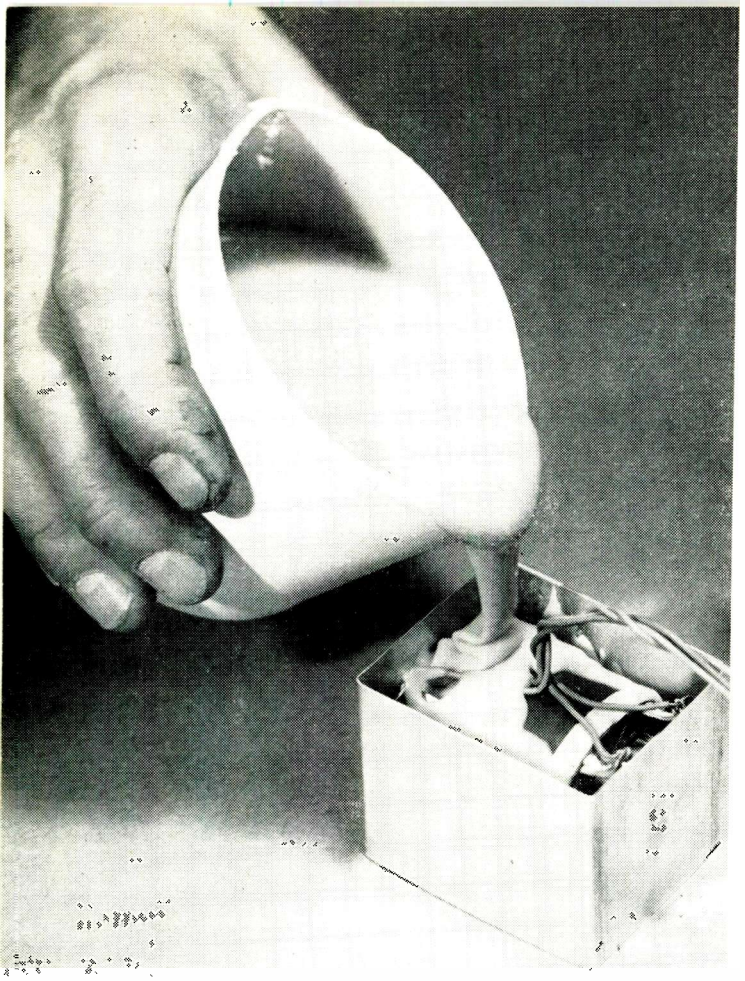


Fig. 3: The Signal Corps is currently working on such projects as Revision to MIL-R-5847 covering high and low temperature resistant silicone rubbers. It will provide for inclusion of a new class of compound having high mechanical strength at high temps.

Standardization *(Continued)*

required, and items whose continual use and procurement can be successfully challenged, are being dealt with appropriately. In parts and materials simplification, a prerequisite for each class, is establishment of technical criteria or guidelines to "beat" against in effecting desired reduction. Manual, electric accounting machine, and automatic data processing techniques are being used in the process. Simplification results, which also obviously affect standardization document areas, are given standardization status codes on supply limitation standards for appropriate action by stock management personnel. As of January 1959, Signal Corps has reviewed approximately 156,170 component part item descriptions, simplification studies, and the results indicate that the over-all savings and benefits to the Government will far exceed the effort expended.

Technical Analysis

Technical analysis is an evaluation of function where a minor design change of an item may suffice to replace several existing items, or a new item by redesign may replace many others. This affords attainment of the maximum degree of interchangeability. Like simplification, results of technical analysis, which are a further refinement or sophistication of reduction or consolidation of parts and materials in the supply system, also will affect standardization document areas and stock management groups.

Engineering Practices

Engineering practices, these concern establishment of basic standardization criteria for description, designation, production, and utilization of supply items. Involved are concepts of dimensional and functional interchangeability; common recognition and exchange through standardized practices, symbols, codes, abbreviations, etc.; development of basic characteristics; and standardization of engineering and production processes, procedures, and practices, etc.

Engineering practices studies are of major importance in establishing standardization document criteria. Since resulting documents are primarily used in design, production, procurment, selection, application, and maintenance areas, Signal Corps does not subscribe to helter-skelter techniques of establishing standardization data. These data, when coupled with already available industrial and military data, establish the substantiated and realistic information required.

These studies and evaluations concern such areas as selection of best engineered, controlled, and fabricated designs; determination of ability to meet physical and performance requirements; establishment of most expeditious, economical, and reproducible test procedures and conditions; firming of minimum military requirements, characteristics and paramaters, reliability prediction and failure analysis data; and all related performance and capability data.

Contractual Tasks

Besides internal standardization studies accomplished on parts and materials, Signal Corps has or recently has had external contractual tasks with J. I. Thompson & Co., Arcs Research & Development Corp., American Machine & Foundry Co., The Machine & Tool Designing Co., Inland Testing Laboratories, Battelle Memorial Institute, Radio Corporation of America, and U. S. Testing Company. Also, U. S. Army Signal Supply Agency is collaborating with U. S. Army Signal Equipment Support Agency in simplification of resistors and capacitors. Following are examples of the 56 contractual standardization study tasks recently completed or currently under way:

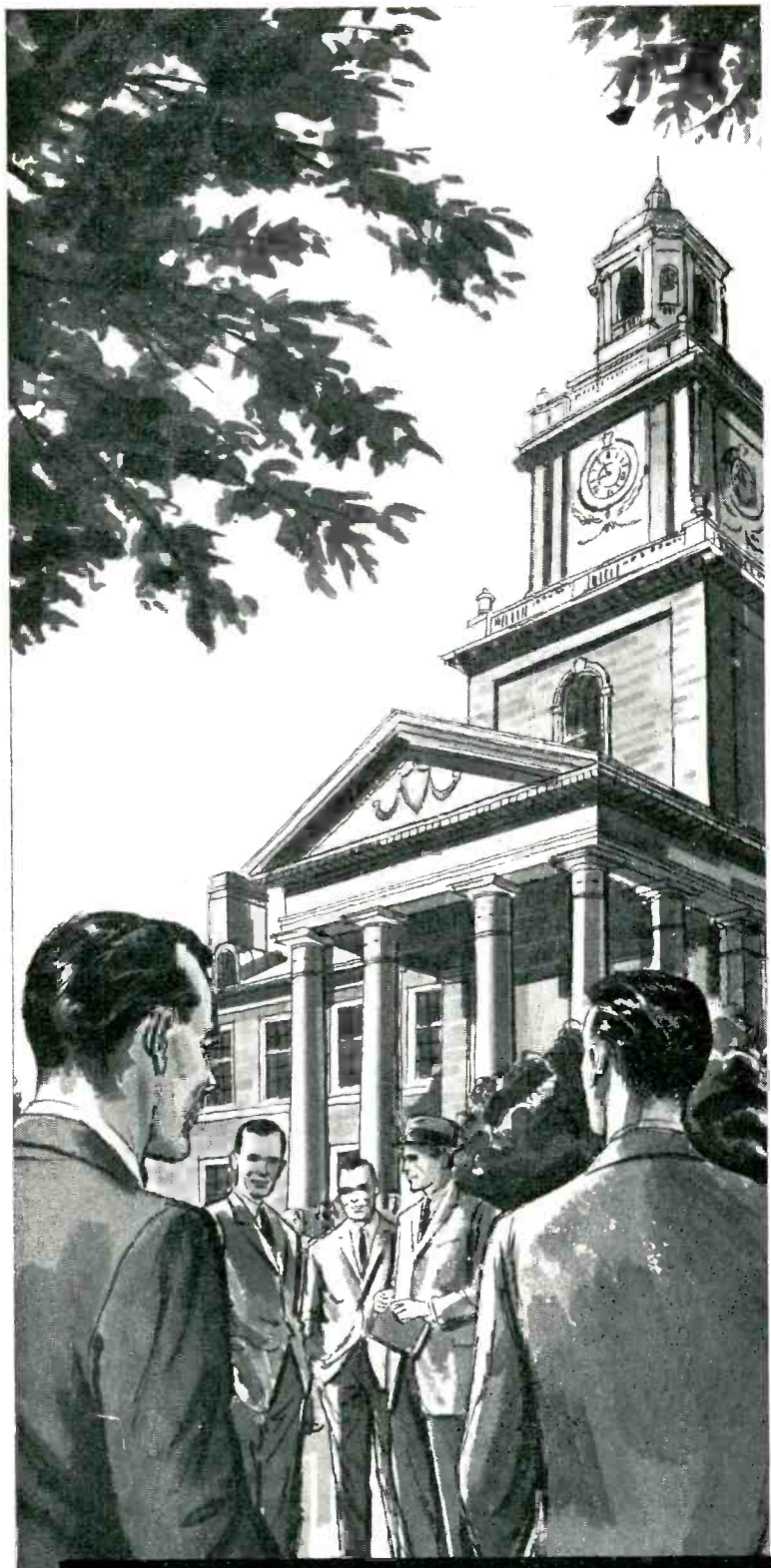
a. *Solid Tantalum Capacitors*—To obtain information for specification requirements for operation from −55°C to +85°C.

b. *Plastic Encased Coils and Hermetically Sealed Coils*—To provide substantiated requirements for military standard for MIL-C-15305A.

c. *Solderability*—Develop realistic test procedure and requirements for solderability of components having wire and tab type terminals. Methods of tests and a number of commercial specifications were investigated and evaluated for applicability.

d. *Transistors*—To establish requirements for noise induced by vibration. Established requirements and techniques will provide basis for modifying existing specifications vibration noise requirements.

e. *Fixed Composition Resistors*—To establish realistic derating curve for MIL-R-11B types. Curve will represent equal performance along its length, i.e., performance in terms of failure rate or equal degradation. (*Continued on page* 150)



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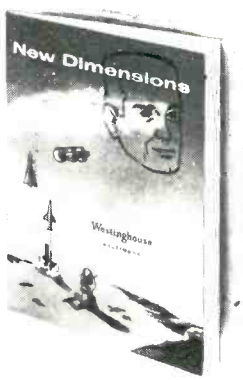
For a confidential interview, send a resume of your education and experience to: Mr. A. M. Johnston, Dept. 930, Westinghouse Electric Corporation, P. O. Box 746, Baltimore 3, Maryland.



Westinghouse

BALTIMORE

Circle 503 on "Opportunities" Inquiry Card

Standardization

(*Continued from page* 148)

f. *Lugs and Terminals*—To reduce number of items in current supply.

g. *Crystal Ovens*—Evaluate representative commercial types selected after screening manufacturers' literature as those most suitable for military use. To use results for requirements for proposed specification to cover new series of 6.3 volt ovens under militay nomenclature.

h. *Light Absorptivity Test for Polyethylene Compounds*—To determine source of variability in present methods used for measuring light absorptivity and carbon black dispersion of these molding compounds. Results for possible modification of light absorptivity test and requirements as specified in Specification L-P-590.

i. *Rotary Switches*—To develop requirements for necessary types for incorporation in MIL-S-3786.

j. *Coils and Transformers* — To reduce number of items in current supply.

k. *Establish Resistor Requirements and Tests*—Whereby failures under long-term life test can be reliably predicted from a short-term accelerated life test which could be run as an acceptance test more readily and more often than present 1000-hour load life test.

l. *Interchangeability of United Kingdom Batteries*—To determine interchangeability characteristics of U. K. and U. S. types for American-British-Canadian (Tripartite) specification action.

m. *Coils and Transformers*—To develop charactertistics of miniature intermediate and radio-frequency transformers for specification tests and requirements.

n. *Resistors*—to determine requirements for specification on fixed film resistors of higher order of reliability than presently available in MIL-R-10509C.

o. *Coils and Transformers*—To re-evaluate environmental test conditions in inductive component specifications to develop group of combined environmental test conditions simulating military field conditions.

(*Continued on page* 152)

"SYSTEM DEVELOPMENT CORPORATION

is currently seeking scientists and engineers in various skill areas. As part of this effort, I have been given the opportunity to tell you something about our organization.

"Let me begin by giving you some general facts about the Corporation: SDC is a non-profit organization chartered to work in fields pertaining to public welfare, the advancement of science, and national defense. The Corporation's name implies its function—the development of systems. Specifically, we are concerned with large, complex information processing systems with a high degree of automation. Development of these systems is accomplished through the application of knowledge in the areas of applied mathematics, engineering, and psychology, to problems of over-all system design, data processing techniques and optimum man-machine relationships.

"Our work is system-oriented, rather than concerned with the design or manufacture of hardware components. As a result of this type of specialization, we have assumed major responsibilities in the development of systems such as the SAGE (Semi-Automatic Ground Environment) Air Defense System and the world-wide Strategic Air Command Control System, and in the integration of the functional responsibilities of these systems with other military electronic support systems.

"Because the scope of our activities is rapidly increasing, we are expanding our staff. In this message I am specifically addressing young engineers with advanced training and proved analytical ability in the areas of weapons system analysis, noise and information theory, ECM, electromagnetic intelligence and allied fields. If you are qualified, and our corporate activities sound interesting to you, we would like to hear from you. Address inquiries regarding our Santa Monica, California facility to Mr. R. W. Frost, 2428 Colorado Avenue, Santa Monica, California. Inquiries regarding our Lodi, New Jersey facility should be addressed to Mr. R. L. Obrey, Box 2651, Grand Central Station, New York 17, N.Y. These gentlemen will see that your letter receives prompt attention and confidential treatment."

David Green

David Green, Assistant Director for Plans, Operations and Management Research Directorate

11-116

SDC

SYSTEM DEVELOPMENT CORPORATION

SANTA MONICA, CALIFORNIA · LODI, NEW JERSEY

Standardization

(*Continued from page* 150)

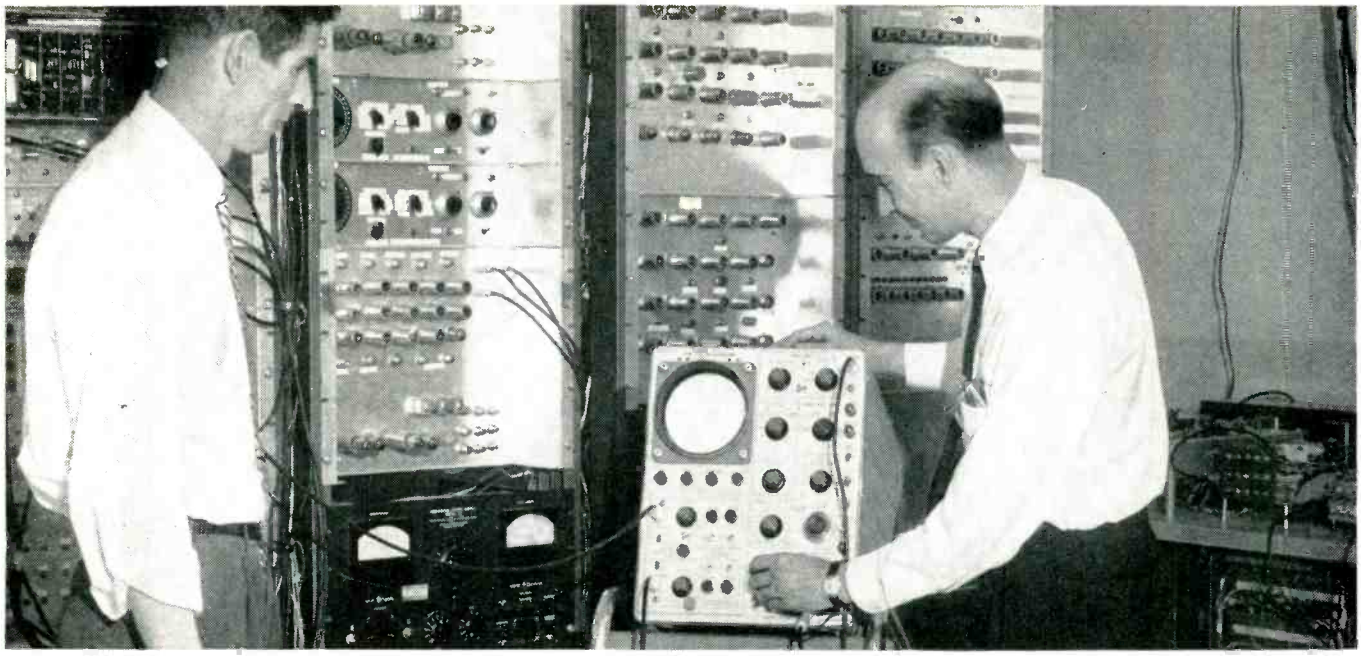
Other Contributions

Signal Corps also contributes through Armed Services Electro Standards Agency to the three-Department program on evaluation of parts and materials for the purpose of establishing and maintaining military qualified products lists (QPL's), or precluding from the lists those products which do not meet specification requirements. Since current Signal Corps policy is to conduct these evaluations at vendor's plant, or at an approved commercial laboratory at vendor's expense, Signal Corps' contribution to the program is of the "in-plant" nature.

Working arrangements between Signal Corps component parts and materials groups and their industrial counterparts are extremely important, mutually beneficial, and have resulted in associations, liaison, and spirit of cooperation so necessary to the program. In this interchange, industry supplies much of the data and information from which standardization documents are processed. In addition to visits to and by parts and materials manufacturers and equipment manufacturers, close liaison is maintained with industrial and industrial-military groups.

Another important phase of the parts and materials program is in the field of international standardization. Signal Corps effort not only involves direct participation in the activities of North Atlantic Treaty Organization, Tripartite (American-British-Canadian), and International Electrotechnical Commission, but in the standardization documents initiated by these groups. These activities are concerned with establishing international agreements to standardize requirements and tests for, as well as specific types of, components and equipments. The military is vitally interested in commercial standardization activities, since adoption of international standards which meet both military and commercial needs provides a quality product at a

(*Continued on page* 154)



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As a NAFEC engineer or mathematician you will have ever-widening opportunities to improve your professional status (both technical and administrative) through a planned career development program. In addition, you will be working with specialists in many other fields.

As a member of the Competitive Civil Service, you will have all the advantages and protections that go with that status. Your pay is good, and starting salary is based on ability and experience. Paid vacations, sick leave and job security add to the real value of your income. *Promotion is from within,* and the Civil Service Retirement Plan is in effect.

For further information, on *your* opportunities in NAFEC, mail this coupon today!

THE ATLANTIC CITY AREA IS GREAT TO LIVE AND WORK IN ALL YEAR 'ROUND!

Placement Officer
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NAFEC, Atlantic City, N. J.

Dear Sir: Please send me an application for employment with the National Aviation Facilities Experimental Center:

I am interested in employment as_____

I have a degree(s) in_____

NAME_____

STREET ADDRESS_____

CITY_____ ZONE____ STATE_____

FEDERAL AVIATION AGENCY

Standardization

(*Continued from page* 152)

reasonable price and makes parts readily available in times of emergency.

In addition to the areas discussed, a progressive standardization group must concern itself with many miscellaneous "back-up" activities. Because parts and materials form the base for the military and communications concept, considerable action is experienced in this area. There is an ever-continuing raft of correspondence containing questions which must be responded to expeditiously. Finally, there are the internal studies and preparations for ensuing standardization actions.

Maintenance on Standardization

Because of the rapid technological advances in the field of electronics, the objectives and accomplishments discussed herein would soon lose their purpose and effectiveness unless maintenance of standardization is energetically pursued. In other words, after standardization has been effected in any given supply area, the results must be maintained. Constant control and review by all concerned are of vital interest to assure use of and adherence to approved standards and specifications. Review as to applicability of existing specifications and standards must be made. New documents must be monitored for their need and impact on existing documents.

Maintenance requirements should not be construed as prohibiting the use of new items for expanding military requirements; however, these items must be monitored for inclusion in the standardization program. Further, it requires the military to continue the review of industrial standards and to coordinate with industrial groups to insure that standard items carried in military supply reflect latest adaptable industrial developments. Constant liaison and coordination with other Defense program areas, such as supply management, research and development, and application engineering is necessary. This also requires the adequate interchange of information and proper orientation of those concerned.

DYNAMIC CAREERS ARE PAR AT LINK AVIATION

To the engineer who wants to get out of the traps, Link - Binghamton offers a clear shot at a good career and good living.

Link Aviation, a leader in flight simulation, has expanded its activities into a wide range of related systems fields, including optical and visual display, radar simulation, and industrial process simulation and control.

The advantages enjoyed by professional men at Link - Binghamton are many. Tuition-paid advanced study. Generous hospital, health and retirement plans. Excellent salaries. And a working atmosphere on a par with the finest.

If your qualifications include experience with radar simulators, automatic checkout equipment, optical systems, electronic packaging, analog or digital computers, contact us at once.

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General
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Corporation

Circle 508 on "Opportunities" Inquiry Card

Personals

(*Continued from page* 46)

Alfred J. Siegmeth is now V. P. in charge of Engineering and Manufacturing at Resdel Engineering Corp.

George F. Breitwieser is now Chief Engineer, West Coast Missile and Surface Radar Dept., RCA. He has also been named Atlas Project Manager for RCA.

Earl I. Anderson has been appointed to the newly created position of Chief Engineer, Home Instruments Engineering, RCA Victor Home Instruments. He was formerly Chief Engineer, Communications Engineering, RCA Industrial Electronics Products.

Stanley J. Rado has joined the Instrument Div., American Electronics, Inc., Culver City, Calif., as Chief Engineer. He was formerly Assistant Chief Engineer at Kearfott Co., Inc., Little Falls, N. J.

Seymour Rosenbaum has been appointed Senior Engineer on the Engineering & development staff of Kulite Tungsten Corp. He was formerly Senior Metallurgist of The Research and Advanced Development Div., Avco Manufacturing Corp.

David Novick has been appointed to the post of Project Engineer at ESC Corp., Palisades Park, N. J. He was previously Senior Engineer, Industrial Products Div., I.T.T.

Philip R. Geffe is now Chief Filter Engineer at North Hills Electric Co., Inc., Mineola, L. I. He was formerly Chief Filter Engineer at Triad Transformer Corp. and Director of Engineering at Hycor.

James J. Carlin is now Production Engineer at Filtors Inc., Port Washington, N. Y. He was formerly with United Aircraft, Norden-Ketay Div.

The appointment of **Charles P. Boegli** as Supervisory Engineer for the Cincinnati Div., Bendix Aviation Corp. has been announced. He was formerly a Project Engineer with the Crosley Div., Avco Mfg. Corp.

Donald B. Harris, formerly Manager of the electron physics section, General Electric Microwave Lab. has joined Stanford Research Institute as a Senior Executive Engineer. **Dr. Don R. Scheuch**, formerly Manager of the weapons systems laboratory, has been appointed Assistant Division Director. **Henry P. Blanchard**, formerly Head of navigation-aids research, is now Manager of the weapons systems laboratory.

MICRO MINIATURIZATION FOR DIGITAL COMPUTERS

12 resistors, 4 capacitors, 4 diodes and 4 transistors...
all are contained in the complete flip-flop circuit illustrated above.

At the Hughes Research & Development Laboratories, dramatic reduction in component size is symbolic of the advances in the digital computer art...advances which are preparing the digital computer for its role as a system control in space.

In addition to developing new digital circuits and components, Hughes engineers are delving into other digital computer space mission tasks such as navigation guidance and control, communications processing and display, vehicle control, mission programming.

An intensive Hughes program in digital computer systems has created openings for creative engineers and physicists with degrees from accredited engineering universities in the following fields:

CIRCUIT and COMPONENT DEVELOPMENT: Digital Computer Analysis, Microcircuitry and Cryogenics, Solid State Physics, Magnetic Storage Devices.

SYSTEMS ENGINEERING: Closed-loop Digital Control, Digital Sensing and Conversion, Radar and Communications Information Processing, Inertial Navigation.

The salary structure for these personnel reflect the exceptional backgrounds required and the unusual challenge of the projects.

Inquire by writing directly to:
Dr. Allen Puckett, Director
Systems Development Laboratories

HUGHES

Hughes Aircraft Co.,
Culver City 51, California

News of Manufacturers' Reps

REPS WANTED

Manufacturer of precision magnetic recording heads designed primarily for instrumentation applications, including digital computers, desires representation in Canada and the United States excluding all of the Rocky Mountain and southwest areas except Arizona and Nevada. Interested representatives are asked to send information on their organization and area of active coverage to Applied Magnetics Corp., P. O. Box 425, Goleta, Calif.

Manufacturer of Teflon insulated wires and cables, including Teflon magnet wire, is looking for representation in the midwestern states and the southeastern states. (R7-1, Editor Electronic Industries).

Manufacturer of complete line of Ultrasonic Cleaning Equipment is seeking representation in all areas. Contact Sales Manager, National Ultrasonic Corp., 111 Montgomery Ave., Irvington 11, N. J.

Marconi Instruments has established a Service Div. for the West Coast in the office of their rep, G. E. Moxon Sales Co., Beverly Hills, Calif.

Texport Co., Dallas, Tex. has been appointed manufacturer's rep for Sonotone Corp. in Texas, Oklahoma, Louisiana and Arkansas.

John W. Bresnaham is now metropolitan St. Louis sales rep for Anti-Corrosive Metal Products Co., Inc.

G. E. Moxon Sales is now rep for Arnoux Corp. in California, Nevada and Arizona.

Bob Gibson has joined E. V. Roberts and Assoc., Los Angeles, as electronic sales engineer.

Howard C. Jappe, Wakefield, Mass., is now sales rep for Phalo Plastics Corp. in Massachusetts, Rhode Island and Northern New England.

Parrish Electronics, Denver, Colo. has been appointed sales rep for Rex Corp.

James A. Mellville, Pittsburgh, Pa.. is now rep in the Pittsburgh, Pa. territory for Lewis-Shepard Products, Inc. Charles M. Bergen is sales and service rep for the company in the Phoenix, Ariz. territory.

Precision Tube Co., Inc., has appointed the Vince E. Johnson Co., Seattle, Wash., as sales rep in Washington and Oregon.

Technical Representation, Glenside, Pa. has appointed William S. Kendrick to its staff of Technical sales engineers.

Irv Brown, Irv Brown Co., Brooklyn, receives plaque from N.E.D.A. as "Individual Rep. of the Year." H. Robert Powell, President of the N. Y. chapter presents the award as Phil Wilk, awards committee chairman, looks on.

Acton Laboratories Inc. has appointed S. S. Lee Associates Inc., Falls Church, Va. as rep in Virginia, Maryland, North and South Carolina, Georgia, Florida, Alabama, Tennessee and Mississippi. Also appointed as rep in the Northern New York state area is D. B. Associates, Inc., DeWitt, N. Y.

Ray J. Deane, Kansas City, Mo. has been appointed rep in the Kansas, Missouri and Nebraska territory for JB Electronic Transformers, Inc.

New reps for Electron Products Co., are: G. E. Arneson & Co., Wayzata, Minn.; Maury E. Bettis Co., Kansas City, Mo.; Bruce Cumming & Associates, Inc., Chicago; Electronic Component Engineers, North Abington, Mass.; Engstrom Associates, Inc., Winter Park, Fla.; Robert Finlay, Ridgewood, N. J.; Electron Products Co., Pasadena; Leo Jacobson Co., Inc., Buffalo; Art Malear & Co., Palo Alto; N. R. Schultz Co., Seattle; George Weinreich Assoc., Dallas; Weller-Rahe Co., Worthington, Ohio; and Electromechanical Products, Agincourt, Ont., Canada.

Babcock Relays, Inc. has appointed the Ed Landa Co., Los Angeles, as rep for California, Nevada and Arizona and Carlson Electronic Sales in northern Illinois, southern Wisconsin, and northern Indiana.

Industry News

Dr. Clarence Zener, Director of the Westinghouse Electric Corp.'s research labs in Pittsburgh, Pa. has been elected to membership in the National Academy of Sciences for "distinguished and continued achievements in original research."

Peter J. Van Benschoten is now Sales Manager of Non-Linear Systems, Del Mar, Calif. He was formerly product engineer.

Donald E. Root is now Administrative Manager, the new Industrial Div. of Cubic Corp., San Diego, Calif.

Phil Gintz, Nuclear Div., American Electronics, Inc., Culver City, Calif., is now in charge of the Radiflo Test Service Dept. He was formerly with the Licensing and Regulation Div., A. E. C.

Dr. Herbert R. J. Grosch is now Manager, Space Program, for International Business Machines Corp.'s Military Products Div. Dr. Grosch will be in charge of the Vanguard Center in Washigton, D. C.

R. Grosch

R. Mottola

Rudolph E. Mottola has been named Sales Manager of the Astron Sales Corp., Distributing Div., Astron Corp., East Newark, N. J.

L. J. Naper, formerly Manager of Lockheed Aircraft's Electronic Assembly Div. has been appointed Manager of Manufacturing of Secode Corp., San Francisco.

Three Lockheed Missiles and Space Div. scientists have accepted appointments to the National Aeronautics and Space Administration's new Research Advisory Committee: Roy Smelt, Manager, Lockheed's Discoverer satellite project and Wayland C. Griffith, Associate Director of Research for Spacecraft and Missiles are on the Committee on Missile and Spacecraft Aerodynamics. Dr. John C. McDonald, Staff Scientist on the Discoverer is on the sub-committee on materials.

(*Continued from page* 161)

Industry News

Dr. Marvin G. Britton is now Development Manager, New Products Div., Corning Glass Works.

Dr. George D. Sands, formerly Chief of the Nuclear Branch of the U. S. Army's Transportation Research and Engineering Command at Fort Eustis, Va., has joined the Martin Company's corporate staff as Director of Scientific Requirements.

G. Sands

R. Krafve

Richard E. Krafve has been elected to the newly created position of Group Vice President, Commercial for Raytheon Mfg. Co. He was formerly a Vice President of Ford Motor Co.

(*Continued on page* 162)

Industry News

(*Continued from page* 161)

Dr. Irving Wolff, Vice President Research, RCA Laboratories is now Chairman of the RCA Education Committee. Russell E. Conley has been appointed Manager, Publications Advertising and Promotions.

Harold S. Green has been named President and Chief Executive Officer of International Telephone and Telegraph Corp. He was formerly Executive Vice President, Raytheon Co.

Philip S. Vincent has been named Manager of Equipment Services for the Remington Rand Univac Div., Sperry Rand Corp.

P. Vincent

D. Hull

David R. Hull, Vice President of Raytheon Mfg. Co., and currently serving as President of the Electronic Industries Assoc. has been elected to the Board of Directors of the Mycalex Corp. of America.

Richard H. Johns has been named Industrial Products Marketing Manager for Autonetics, Div. of North American Aviation, Inc. He was formerly Assistant Manager, Systems Div., Clary Corp.

Mert Goodman has been promoted to Administrative Assistant to Ben Snyder, Pres. of Snyder Mfg. Co., Inc.

Jerry Cain has been made Manager, west Los Angeles Area, Neely Enterprises. Al Oliverio has been appointed Manager of the east Los Angeles Area.

Hugh Robertson, has been elevated from President to Chairman of the Board of Zenith Radio Corp. **Joseph S. Wright** has been elected President and General Manager. **Sam Kaplan** is now Executive Vice President and L. C. Truesdell is V. P. in charge of marketing.

R. H. Andrew has been appointed Manager of Field Sales for the Capacitor Div., P. R. Mallory & Co. Inc.

(*Continued on page* 164)

ELECTRONIC INDUSTRIES Advertisers—July 1959

Industry News

(*Continued from page 162*)

Edward E. McLellan has been appointed Advertising Manager of the Military Electronics Div., Motorola, Inc. He was formerly with the Henry J. Kaiser Companies.

Neil Uptegrove, formerly Manager of Technical Advertising, Allen B. Dumont Laboratories, Inc., has been appointed Manager of Advertising and Sales Promotion of Tung-Sol Electric Inc.

Formation of an Exploratory Development Dept., headed by **Dr. Rabindra N. Ghose**, was announced today by Space Electronics Corp. He was formerly associated with RCA and Ramo-Wooldridge Corp.

Northrop Corporation's Board of Directors has elected **Thomas V. Jones**, President of the company. He was formerly a Sr. Vice President.

Leon R. Noe, Jr., is now Advertising Manager of the SPE Journal, the Society's Official Publication.

G-V

RED/LINE Thermal Timing Relays are available in your area through these local selected distributors:

NEW ENGLAND
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METROPOLITAN NEW YORK
New York, N. Y.
HARVEY RADIO CO., INC.
JUdson 2-1500
New York, N. Y.
HUDSON RADIO & TV CORP.
TRafalgar 3-2900

MIDDLE ATLANTIC
Camden, N. J.
GENERAL RADIO SUPPLY CO.
WAlnut 2-7037
Baltimore, Md.
KANN-ELLERT ELECTRONICS CO., INC.
SA 7-4242
Winston Salem, N. C.
DALTON-HEGE RADIO SUPPLY, INC.
WInston Salem 5-8711

SOUTHERN AREA
Miami, Florida
EAST COAST RADIO & TV CO., INC.
FR 1-4636
Birmingham, Ala.
M. G. ELECTRICAL EQUIPMENT CO.
FA 2-5170

OHIO
Akron, Ohio
AKRON ELECTRIC SUPPLY, INC.
BO 2-8818

MICHIGAN
Battle Creek, Mich.
ELECTRONIC SUPPLY CORP.
WOodward 2-9514

GREATER CHICAGO
Milwaukee, Wisconsin
ELECTRONIC EXPEDITORS
FLagstone 2-2070
Chicago, Illinois
NEWARK ELECTRIC CO.
STate 2-2944
W. Chicago, Ill.
Relay Sales
WEst Chicago 1100

ST. LOUIS
St. Louis, Mo.
INTERSTATE SUPPLY CO.
FL 1-7585

KANSAS CITY
Kansas City, Mo.
BURSTEIN-APPLEBEE CO.
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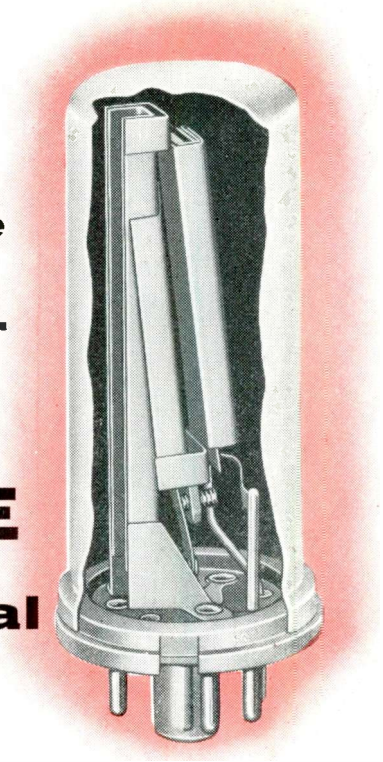
SOUTHERN CALIFORNIA
Los Angeles, California
KIERULFF ELECTRONICS, INC.
ZEnith 7-0271
Los Angeles, California
RADIO PRODUCT SALES
RIchmond 9-7471
Glendale, California
R. V. WEATHERFORD CO.
THornwall 5-3551
VIctoria 9-2471

NORTHERN CALIFORNIA
Oakland, California
ELMAR ELECTRONICS
HI 4-7011

PACIFIC NORTHWEST
Seattle, Wash.
WESTERN ELECTRONIC SUPPLY CO.
ATwater 4-0200

Dependability and long life previously available only in high-cost relays...



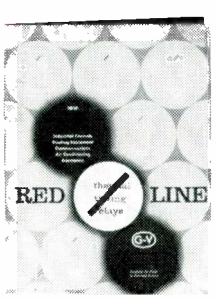
G-V RED/LINE

low-cost thermal timing relays

The sound design, sturdy construction and reliable operation long associated with G-V Hermetically Sealed Thermal Relays is available in a low-cost form, fully qualified for industrial control . . . light and inexpensive enough for electronic and communications circuits.

Delays of 2 seconds to 3 minutes • Energizing voltages - 6.3 to 230 AC or DC.

- **RUGGED STAINLESS STEEL MECHANISM**
  Relay mechanism is of stainless steel, differential expansion type, used in all G-V Thermal Relays. All parts are welded into a single integral structure.
- **SHATTERPROOF—NO GLASS**
  No glass is used in mechanism, encasing shell, or base. This avoids the danger of cracking or breakage in handling and use.
- **STEEL ENCASED HEATERS**
  Heating elements are conservatively designed, wound with Ni-chrome wire on mica and encased in stainless steel, insuring long heater life even when energized continuously.
- **DUST TIGHT ENCLOSURE**
  A dust tight metal shell completely enclosing the relay mechanism and contacts, crimped tightly to the base, provides complete protection for the structure.
- **TAMPER PROOF**
  Time delay intervals are preset at the factory. Thus changes of delay interval in the field which might damage associated equipment are avoided.
- **DIRECTLY INTERCHANGEABLE**
  Directly interchangeable with all other octal-size relays.



G-V

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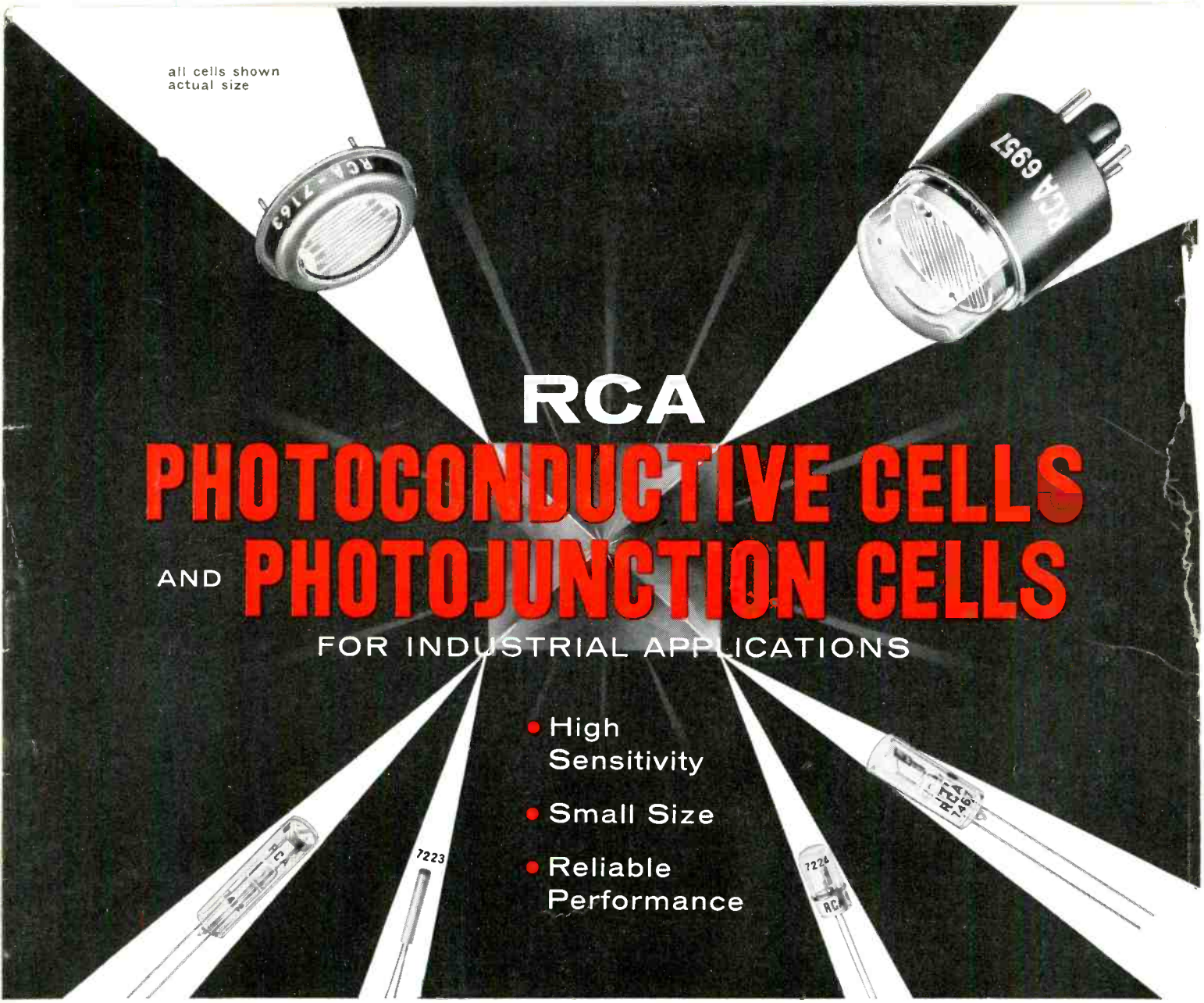
Write for Publication 131.
Circle 2 on Inquiry Card

U. S. PAT. 2,700,084 OTHER U. S. & FOREIGN PATENTS PENDING



RCA PHOTOCONDUCTIVE CELLS AND PHOTOJUNCTION CELLS

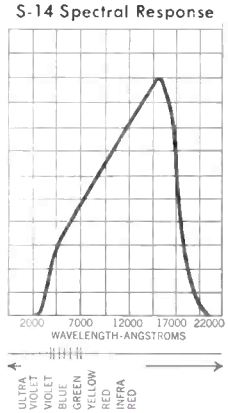
FOR INDUSTRIAL APPLICATIONS

- High Sensitivity
- Small Size
- Reliable Performance

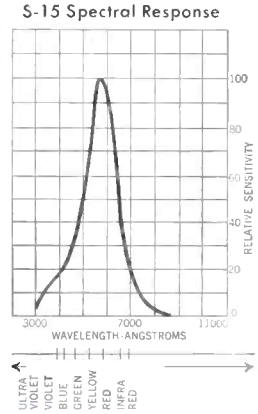
If your control problems involve a light source, look to RCA for the solution. RCA-designed Photoconductive and Photojunction Cells are manufactured under the strictest quality controls to assure dependability and long life. So for applications ranging from street-lighting control to high-speed computers, contact your RCA Field Representative for complete information about RCA Photoconductive Cells and RCA Photojunction Cells. Or for technical data on specific types, write RCA Commercial Engineering, Section G-50-Q, Harrison, N. J.

RCA Type	Description	Spectral Response	Wavelength of Max. Spectral Response	Maximum Ratings Abs.-Max. Values: Voltage Between Terminals	Power Dissipation	Ambient Temperature Range	Characteristics at 25°C: Voltage Between Terminals	Sensitivity: Radiant	Sensitivity: Luminous	Sensitivity: Illumination	Max. Dark Current
			angstroms	volts	mw	°C	volts	μa/μw	ma/lumen	μa/fc	μa
6957	Cadmium-sulfide, head-on photoconductive cell for street-lighting control and other light-operated relay applications.	S-15	5800	250	500	−75 to +60	50	580	1640	4000	20
7163	Compact, cadmium-sulfide, head-on photoconductive cell for street-lighting control and other light-operated relay applications.	S-15	5800	250	300	−75 to +60	50	290	820	2000	40
7223	Very tiny photojunction cell of the head-on type. Employs germanium p-n alloy junction. For computer and sound-pickup-from-film applications. Infrared sensitive.	S-14	15000	50	25	+50 Max.	2.5	0.68*	—	0.2	35
7224	Very small photojunction cell of the side-on type. Employs germanium p-n alloy junction. For sound-pickup-from-film and computer applications. Infrared sensitive.	S-14	15000	50	30	−40 to +50	45	0.52	14	0.7	35
7412	Small cadmium-sulfide, head-on photoconductive cell. For industrial light-operated relay applications.	S-15	5800	200	50	+60 Max.	12	1580	4500	300	0.1
7467	Very small, photojunction cell of the side-on type. Employs germanium p-n alloy junction. For sound-pickup-from-film and computer applications.	S-14	15000	50	30	−42 to +50	45	0.52	14	0.7	35

S-14 Spectral Response



S-15 Spectral Response



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Electron Tube Division — *Harrison, N. J.*

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