OCTOBER 30, 1959

electronics

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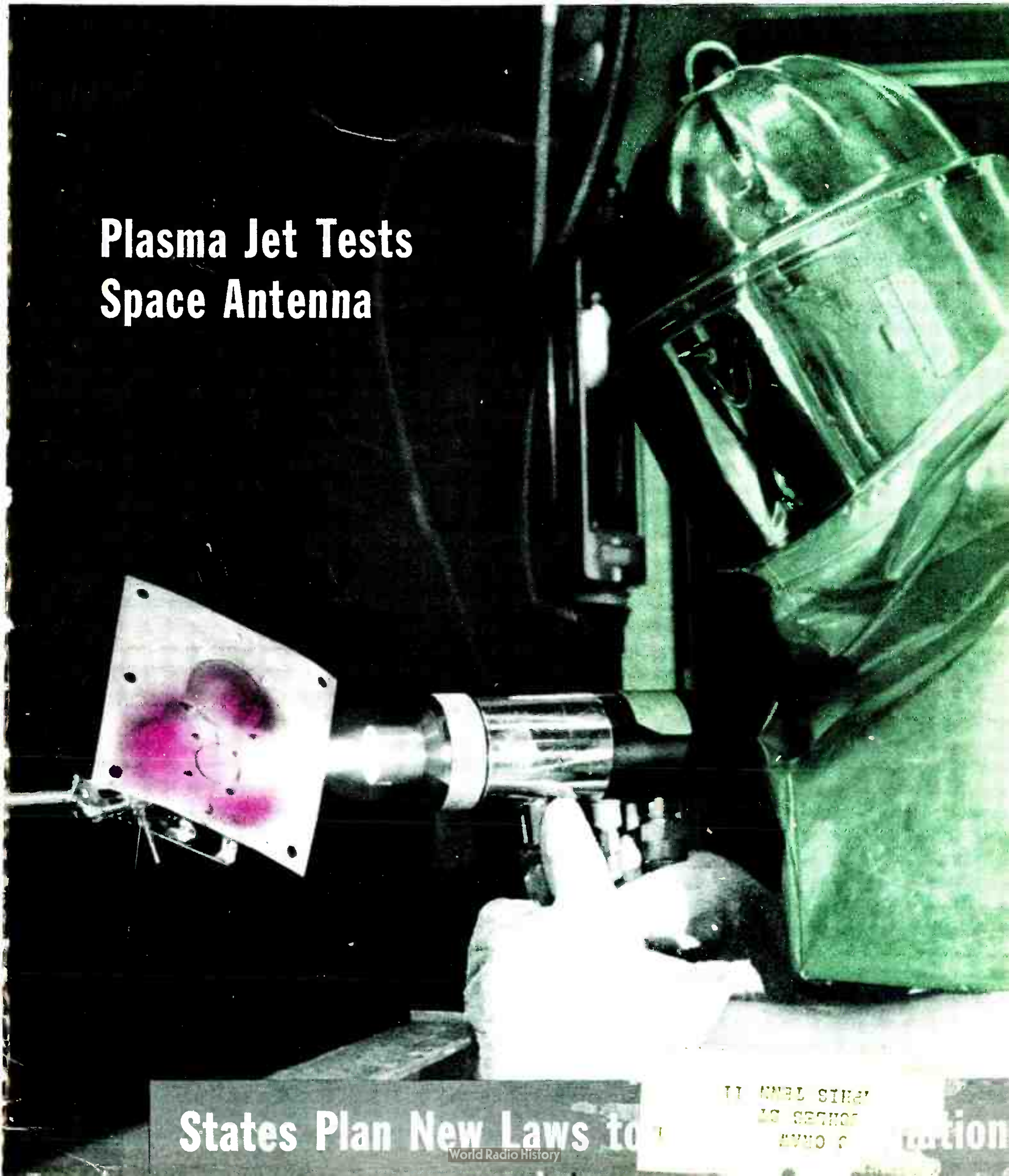
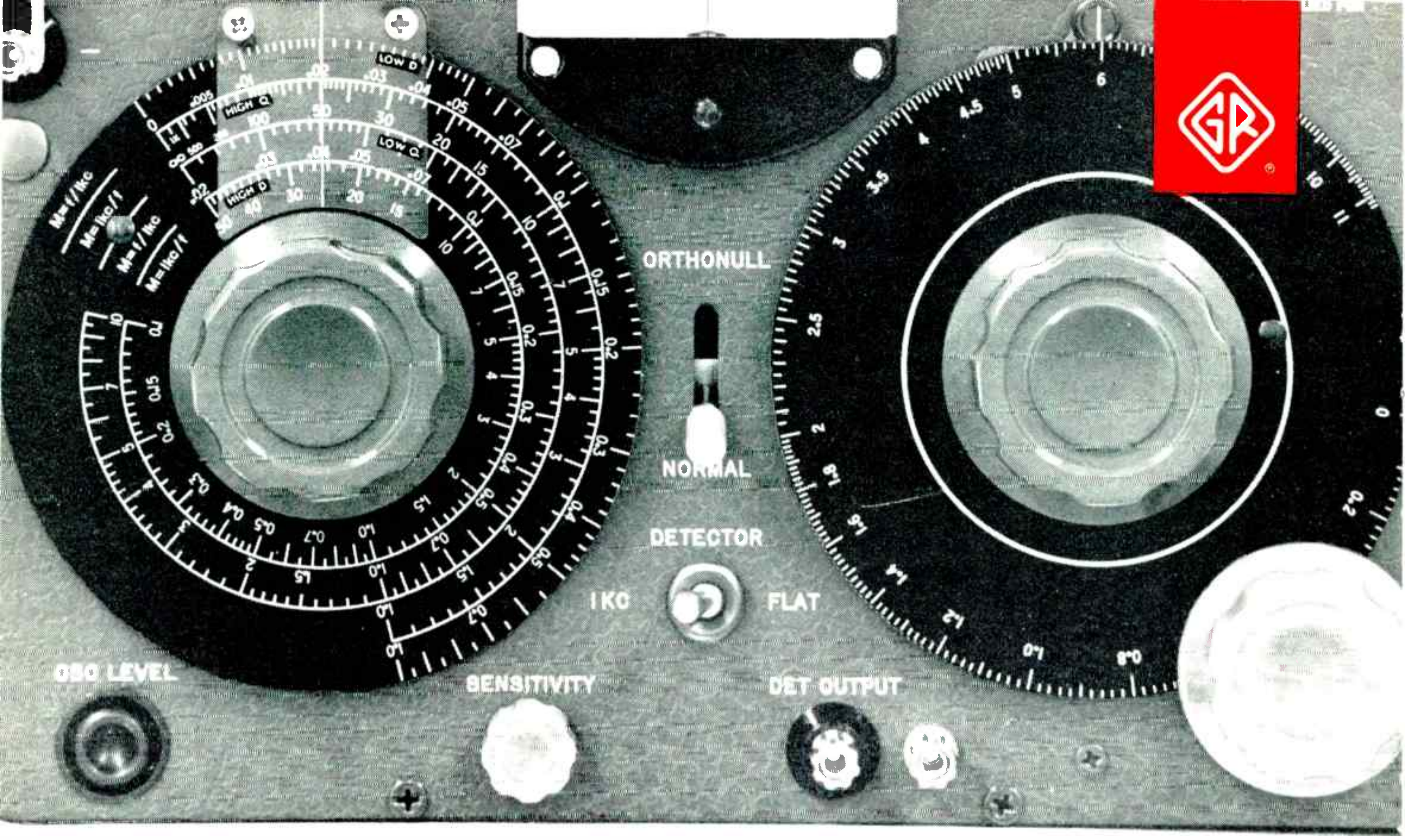


Plasma Jet Tests Space Antenna

States Plan New Laws to ... tion



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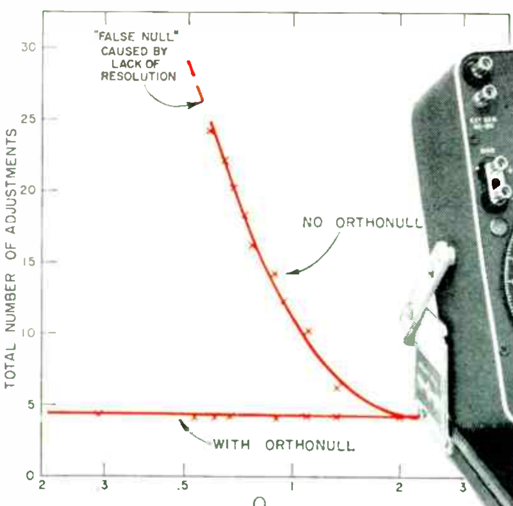
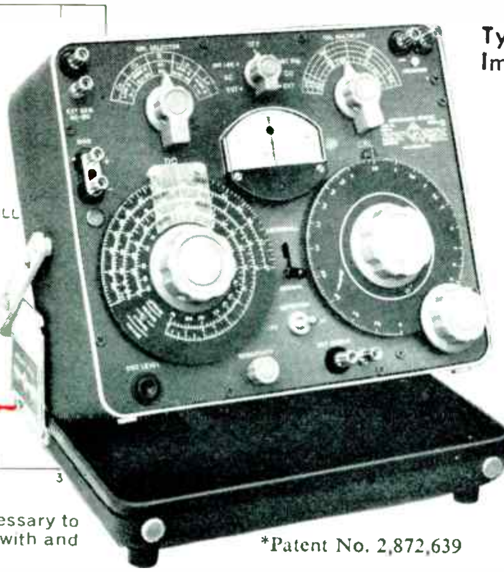


Plot shows the number of adjustments necessary to balance the bridge within 1% for a given Q with and without Orthonull.



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Vol. 32 No. 44

Issue at a Glance

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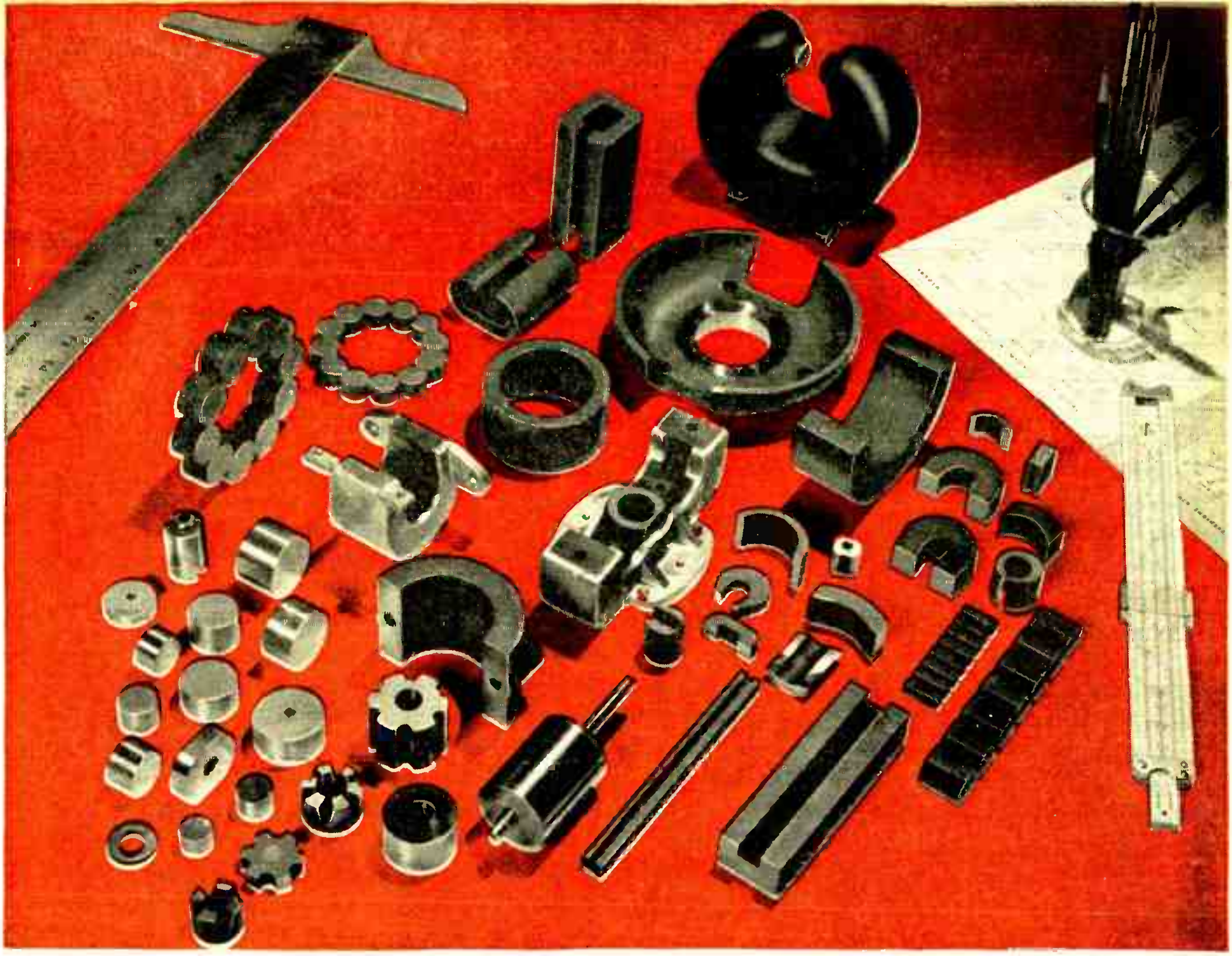

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SHOPTALK . . . editorial

electronics

October 30, 1959 Vol. 32, No. 44

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REGULATING IONIZING RADIATION. Public concern over ionizing radiation—from radioactivity of all types, even from X-ray and fluoroscope equipment—is forcing the adoption of restrictive regulations at state and local levels. Elsewhere in this issue, Associate Editor Leary analyzes the experience of New York State and Westchester County in implementing such regulations.

Electronics has a public responsibility here, because the industry must supply the survey instruments, analyzers and controls which will safeguard public health in this increasingly atomic age. The responsibility has a practical reflection in the increased use of such instruments, and the resultant rising market.

Westchester had to rely on the State Health Department laboratories in Albany for much of the early analysis work. County instruments, we learn, are still not able to keep up with the workload, and more instruments will be needed if the state's wishes—to keep the work at the county level—are to be respected.

County health officials also told us that they wished someone would develop a small and reasonably priced monitor for counting radiation in air samples on a continuous basis. The instrument they're looking for will also be able to give two alarms, one at some fraction of the danger level, the other when the danger level is reached.

Coming In Our November 6 Issue . . .

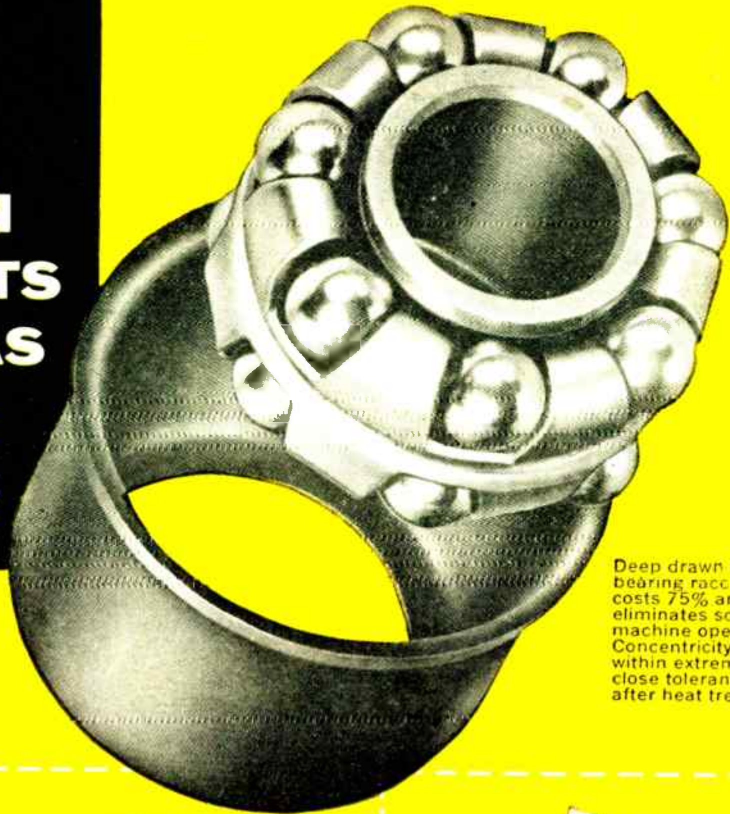
ELECTRONICS PRODUCTION. Each year the electronics industry increases its spending for plant and equipment modernization and expansion. While capital expansion in all U. S. industry is seven percent more this year than in 1958, a McGraw-Hill survey shows that electrical and electronics firms are spending 16 percent more.

Next week Associate Editor Sideris tells how typical electronics companies are raising capital, mechanizing equipment, using new techniques and organizing plant space for greater efficiency. Based on information gathered over the past 12 months, this report is an updating of last year's investigation into plant modernization and production techniques (ELECTRONICS, p 73, Oct. 24, 1958).

TUNNEL DIODES. One of the latest devices to cause a stir in the booming semiconductor field is the so-called tunnel diode, with which the name Esaki is closely associated. A highly-doped *p-n* junction with anomalous voltage characteristics, the tunnel diode is expected to become quite important to electronics, as is the transistor. B. Sklar of Hughes Aircraft Co. in Culver City, Calif., explains the negative conductance property of the tunnel diode by first reviewing what is known about conductors, insulators, pure and moderately doped semiconductors. Then, with the aid of electron-energy-band diagrams, he proceeds to show how heavy doping and quantum mechanical tunneling act to produce the tunnel diode voltage characteristic. Operation of the diode in an amplifier is also described.

INFRARED TRAINER. Learning to accurately fire tank weapons requires practice with erratically-moving targets. A remote-controlled moving target system has been developed that relys on an infrared sensor to detect hits. W. P. Battista of the U. S. Naval Training Device Center, and I. Roth and R. Rachlis of Bulova Research and Development Laboratories, have teamed up to describe this application of infrared detection. Main elements of the system are a control console and target-carrying vehicle. Passive infrared hit-sensing circuits detect passage of rounds through the target which roughly represents the vulnerable portions of an enemy tank. Hits are telemetered back to the control console for score-keeping. Closed-circuit television helps the operator steer the vehicle.

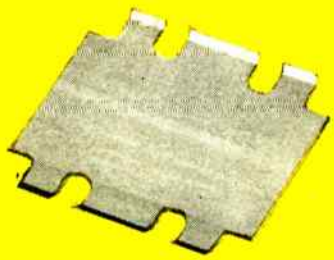
CUT PRECISION PARTS COSTS AS MUCH AS 75%



Deep drawn ball bearing race cuts costs 75% and eliminates screw machine operation. Concentricity held within extremely close tolerance even after heat treating.

Transistor dome has .018 weld flange made from .013 stock, without showing any indentation on reverse side.

Full stock thickness at top of draw on .018 brass case improved watch quality and saved assembly time.



Spring for razor blade dispenser feeds automatically in high-speed assembly machine. Spring steel properties are held during heat treating. Parts are produced free of burrs, without finishing.

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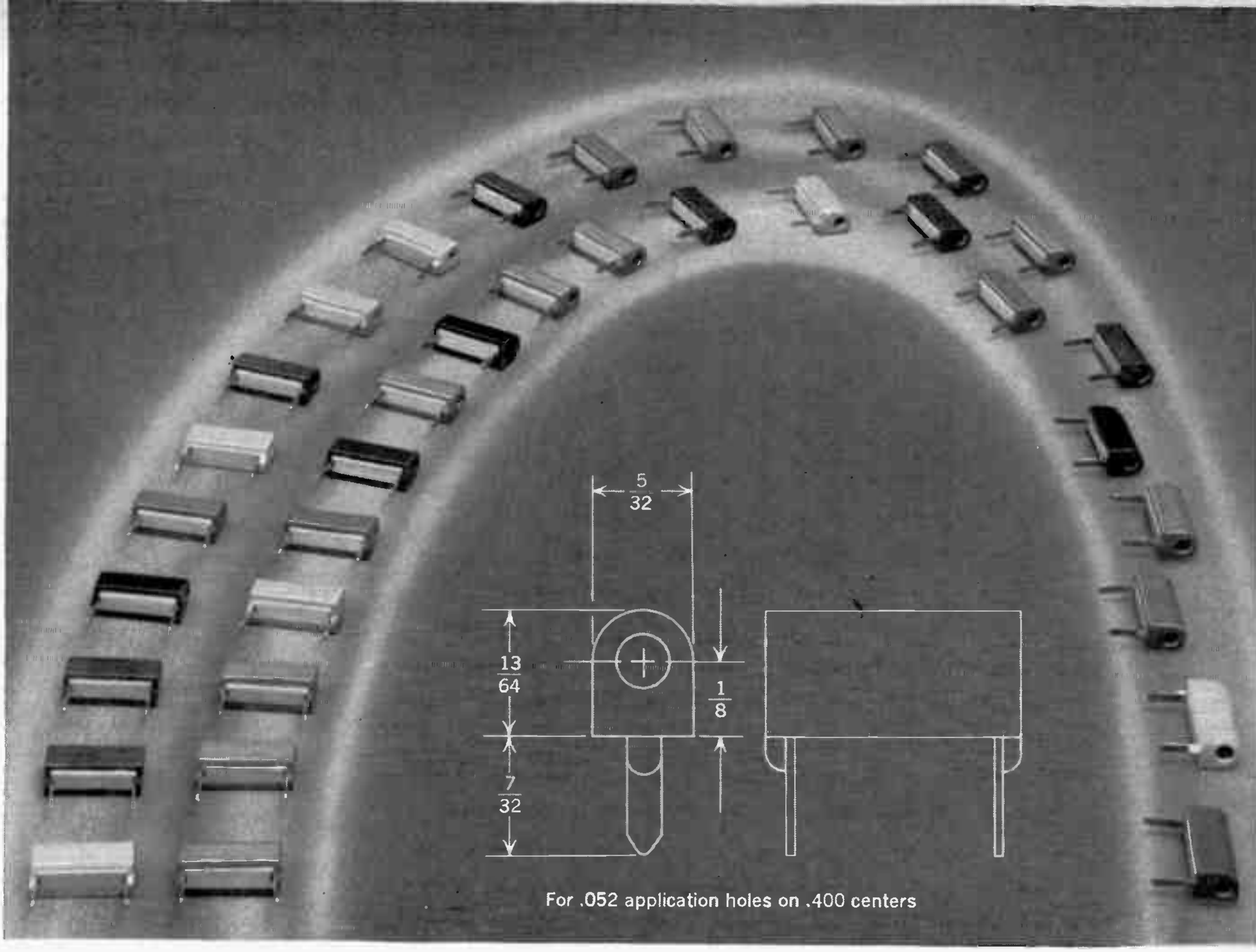

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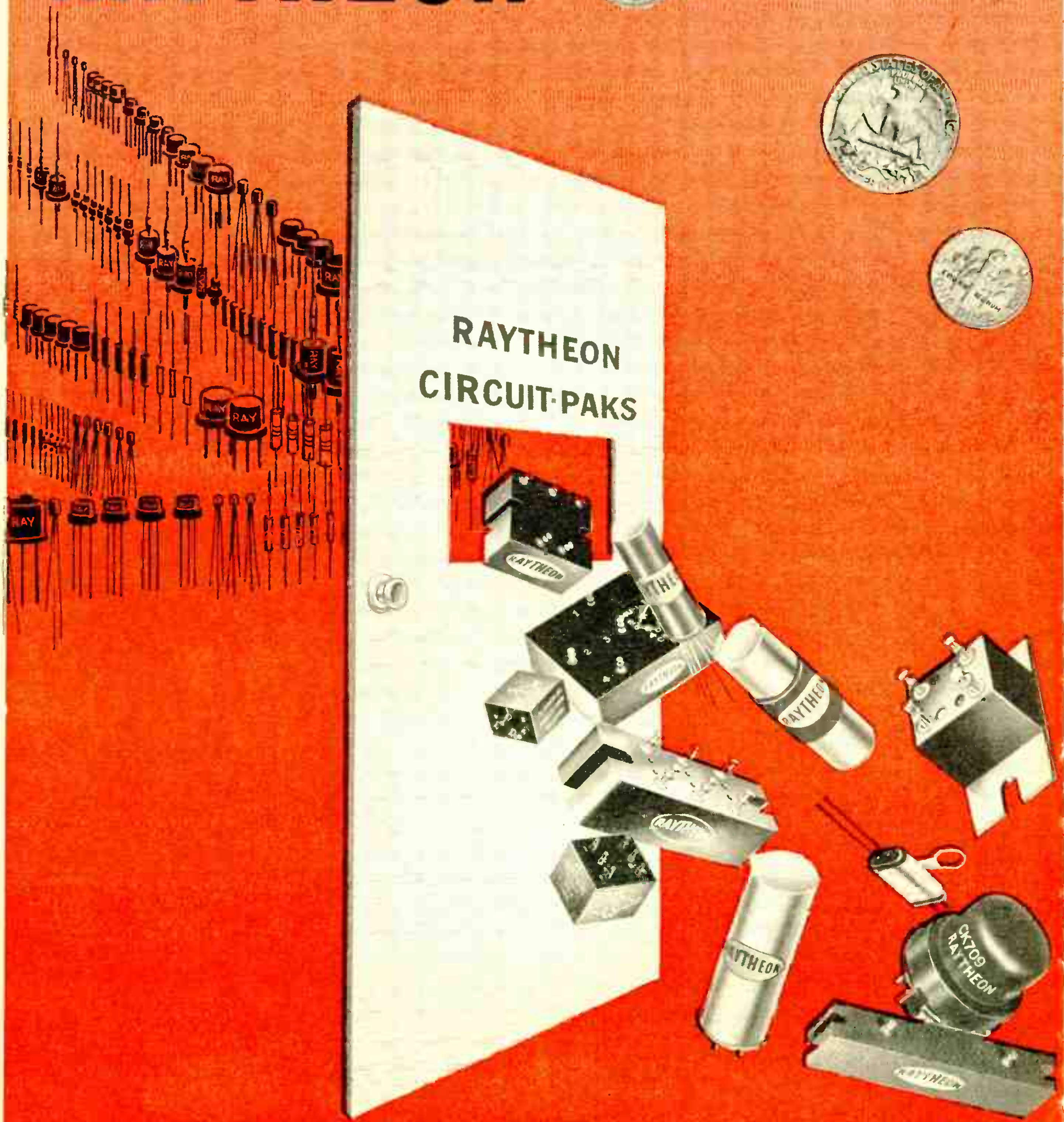

*E PLURIBUS UNUM *(one unit composed of many parts)* aptly describes Raytheon Circuit-Pak.

new word for designers and producers . . .

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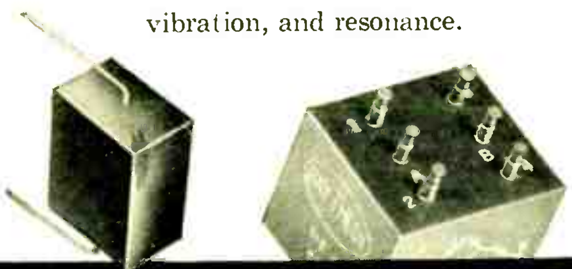

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ELECTRONICS NEWSLETTER

STANDARDS IN SPACE are necessary for international cooperation in exploring the universe, according to John P. Hagen, NASA's assistant director for program coordination. He told the 10th national conference of the American Standards Association last week that standards "must be established on an international basis so that devices built in different places can be mated both mechanically and electrically." Hagen said scientific teams in countries over which an ionospheric satellite passes should be able to contact the satellite and operate it. He cited as another possible international effort an orbiting astronomical observatory, possibly with a man aboard to operate the telescope. This would also require ground teams in many countries to take over satellite operation. "None of this will be possible," says Hagen, "unless a very high degree of standardization is achieved in the electronic circuitry."

U. S. exploration of the moon and planets will start with the sending of scientifically instrumented packages to circle and land on these objects and radio back information. NASA's Hagen says "elementary steps" in the direction of this long-range program have been taken, "but the truly sophisticated work must await the development of larger and more precise launching vehicles."

MARS 1960 SATELLITE PROBE by Soviet scientists is predicted in an East German report originating in Moscow. It says in part: "At the end of September and the beginning of October next year, Mars will be in such a favorable position to the earth—this only happens once every two years and 50 days—that a rocket could circle it without needing much more fuel, which would cut its payload. It is fairly certain that the scientists here will not miss this favorable opportunity." The report also suggests that the Soviets will put a man into space briefly and land him safely "sometime next year."

ROBOTS IN SPACE called "telepuppets" are proposed for building the first U. S. space platforms to be used as launching sites for expeditions to the moon and planets. In a report to the Office of Naval Research, Fred Whipple, director of the Smithsonian Institution's Astrophysical Observatory, Cambridge, Mass., describes such a robot. It will use television "eyes" and remote-controlled hands to "ape the motions of an operator" on earth. The human operator would feel the object touched by the robot by means of feedback from the "telepuppet" fingers. The alternative of humans in space suits constructing the platforms would be extremely dangerous, Whipple says.

ESAKI TUNNEL DIODES with a fundamental frequency of oscillation of more than 1,000 mc have been successfully fabricated by IBM researcher R. F. Rutz in work supported by the Defense Department. The Esaki diode's ability to handle extremely high counting rates is a natural advantage in high-speed computers, says IBM. The company also points out that the device can operate over a very wide temperature range, "withstands nuclear radiation much better than other semiconductor components and is inherently a 'low noise' device that does not interfere with the 'intelligence' of the electrical signal being developed." For more on Esaki diodes, see p 70.

DROP IN ENGINEERING STUDENTS is blamed by Cornell College of Engineering Dean Dale R. Corson on "sputnik fever," which "drove many potential engineers to study science instead of engineering when it hit the United States two years ago." Corson told the Cornell University Council that in the fall of 1958, freshman engineering enrollments were down 11 per cent, and they're down again this year. That satellite and rocket achievements have been engineering feats, not science achievements, has been lost sight of, he declared. Citing increased difficulty in attracting the best engineering teachers, he pointed out that last year the average Cornell engineering undergraduate started at more than $6,000, and it's not uncommon for a Ph.D. grad to enter industry at $12,000.

EXPERIMENTAL FUEL CELL TRACTOR that develops 3,000 lb of drawbar pull, enough to pull a multiple-bottom plow, has been reported by Allis-Chalmers Manufacturing Co., Milwaukee. Electricity is produced by 1,008 cells fueled by a mixture of gases, largely propane. Chemical reactions cause d-c flow through an external circuit connected to a compact controller, which regulates the electricity supplied to a standard 20-hp d-c motor. Driver uses one lever to regulate speed by varying the amount of current going to the motor, another lever to reverse the tractor by changing the polarity of the current flow to the motor.

Guidance subsystem contract for the GAM-87A air-launched ballistic missile has been awarded to Northrop's Nortronics division, prime contractor Douglas announced. Missile system is designed to provide Strategic Air Command with new deterrent force.

PORTABLE TAPE RECORDER that can also be used as a phonograph, medium and shortwave radio, public address system, telephone recorder and continuous tape player, is offered in a 37½-lb package by Japanese firm Nishikura Industry Co. Unit's f.o.b. Yokohama price is $176. Size is 18.1 × 13 × 7.9 inches. Firm says unit can operate from a car battery with an inverter.

Here's an electronics man who's hard to place.

You know him as the man you've got to reach to sell the electronics industry. His company identification badge (symbolized at right) is the most familiar means of telling at a glance (by its code letters—"R", "D", "P", "M") that you may find him in Research, Design, Production, or Management.

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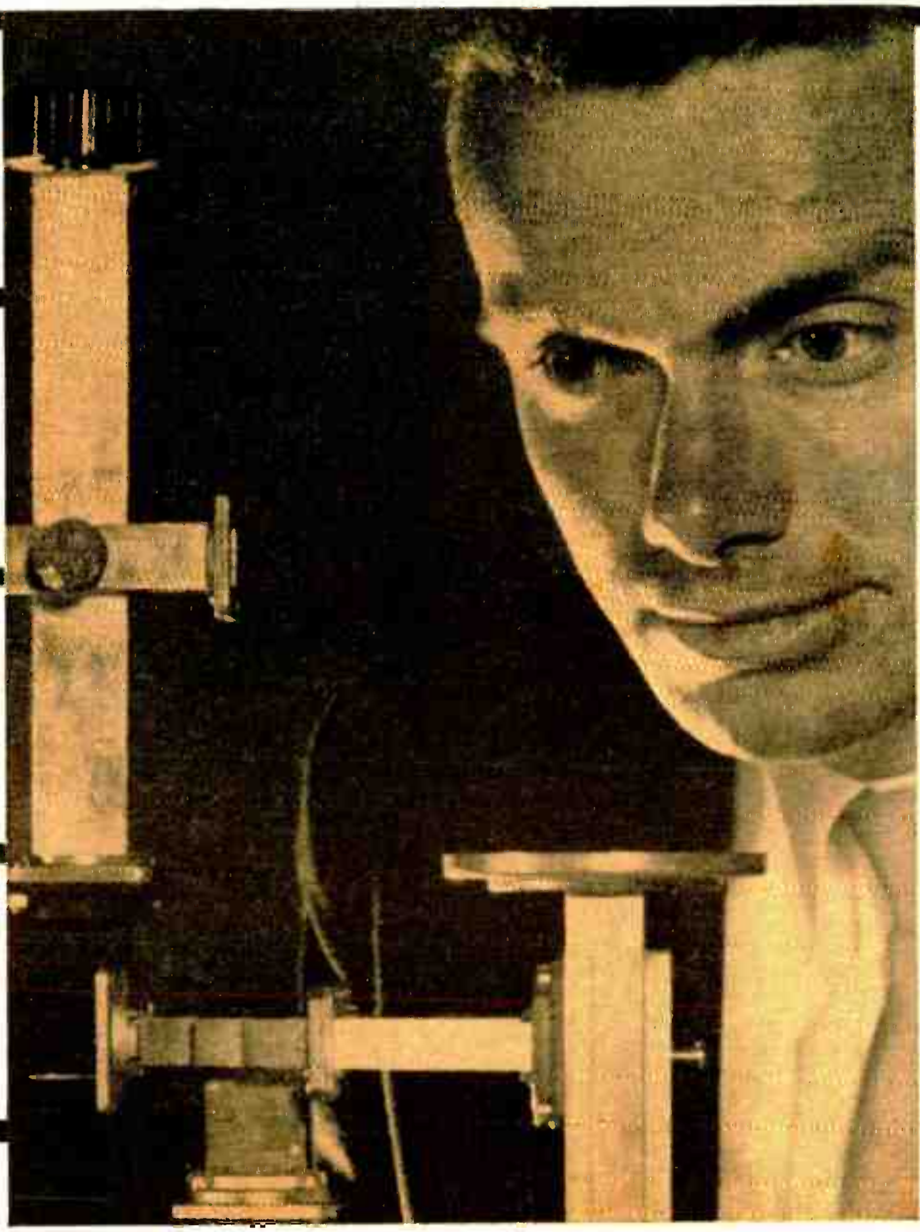

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WASHINGTON OUTLOOK

WASHINGTON—THE PENTAGON has postponed a decision on whether to authorize production of the Army's Nike-Zeus antimissile system until next April. The fiscal 1961 budget, now in the final stages of preparation, will include funds only for continuation of the project at the present level.

For the next five months, the Zeus project will undergo a broad-gaged evaluation by top-level scientific advisers to the Defense Dept. If the verdict is favorable, the Pentagon would send Congress a supplemental appropriation request before next summer to begin production.

The odds are strongly against the Defense Dept. authorizing production of the Nike-Zeus antimissile system. Some high Pentagon officials imply that the upcoming analysis of the project is a token gesture, that the administration has already decided against spending the $10 billion required for an operational system.

Here is a view expressed to ELECTRONICS by one high Defense Dept. official. The view represents the thinking of many in the Administration:

"We must be assured first that Zeus will work. But even then we have to evaluate the necessity of production in terms of the degree of Zeus's potential performance against the threat. If it were a matter of defense against only one oncoming missile on a target, we would buy Zeus.

"The threat", says one Defense official, "is of salvos of ballistic missiles on a target. Even if we could assume Zeus's effectiveness against 80 percent of the enemy's missiles—which is questionable—how much have we really accomplished if 20 percent hit us with thermonuclear warheads? Is this adequate to justify the cost of Zeus?"

- **Defense dept. budget officials have drawn up a new financial plan for** fiscal 1960, outlining the volume of contracts to be awarded during the current year. The new plan shows some $800 million less to be obligated for procurement between September 1959 and June 1960 than had been planned as recently as last May.

Here are some big differences for fiscal 1960 in electronics-laden Defense categories: $180 million less for Navy planes; $380 million less for Navy shipbuilding; $340 million less for Air Force missiles, aircraft and other major equipment.

Some of this can be written off as the budget impact of recently announced cuts, such as cuts in the Air Force's B-58 bomber and cancellations of the F-108 fighter-interceptor and the Navy's Seamaster seaplane. But the largest chunk of the $800 million reduction in this year's contracting plans represents stretchouts or project terminations still to be announced.

- **High-flying telecast project will soon some up for FCC approval.** Project involves a uhf relay station four miles high in a circling DC-7. Educational programs would be beamed through the airborne facility from a transmitter at Purdue University in Lafayette, Ind., to schools within a 200 mile radius. Programs now reaching only 4,000 schools would reach 13,000. A half-channel technique developed by CBS would permit doubling the number of courses without increasing the engineering costs.

Ford Foundation will help underwrite equipment and first year's operation of the airborne educational tv system. Cost: $7 million. Offers to furnish light-weight gear have been made by Westinghouse (which pushed airborne Stratovision in the 1940's but could never get FCC okay), General Dynamics and CBS labs.

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Or, with a simple factory modification offered at no extra cost, the input impedance can be increased to approximately 400 megohms. This insures accurate measurement without loading on most high impedance circuits. In many situations, the 425A thus performs measurements for which expensive electrometers were previously required.

Model 425A also serves as an ohmmeter, measuring resistances from milliohms to 10 megamegohms in conjunction with an external constant current.

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Input Impedance: Voltage Ranges: 1 megohm ± 3%. Current Ranges: 1 megohm to 0.33 ohm, depending on range. (With factory modification, over 200 megohms. Please specify Model H 01-425A in ordering; no extra cost).

Accuracy: Within ± 3% of end scale.

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Ac Rejection: At least 3 db at 0.2 cps, 50 db at 50 cps, approx. 60 db or more at 60 cps.

Gain: 100,000 maximum.

Output: 0 to 1 v for full scale reading, adjustable.

Output Impedance: 10 ohms, shunted by 5000 ohm potentiometer.

Noise: Less than 0.2 μv rms referred to input.

Drift: After 15 minute warm-up, less than ± 2 μv per hour referred to the input.

Power: 115/230 v ± 10%, 60 cps, 40 watts.

Dimensions: Cabinet Mount: 7½" wide, 11¼" high, 14" deep.

Weight: Net 17 lbs.

Price: (hp) 425AR (rack mount) $505.00. (hp) 425A (cabinet) $500.00.

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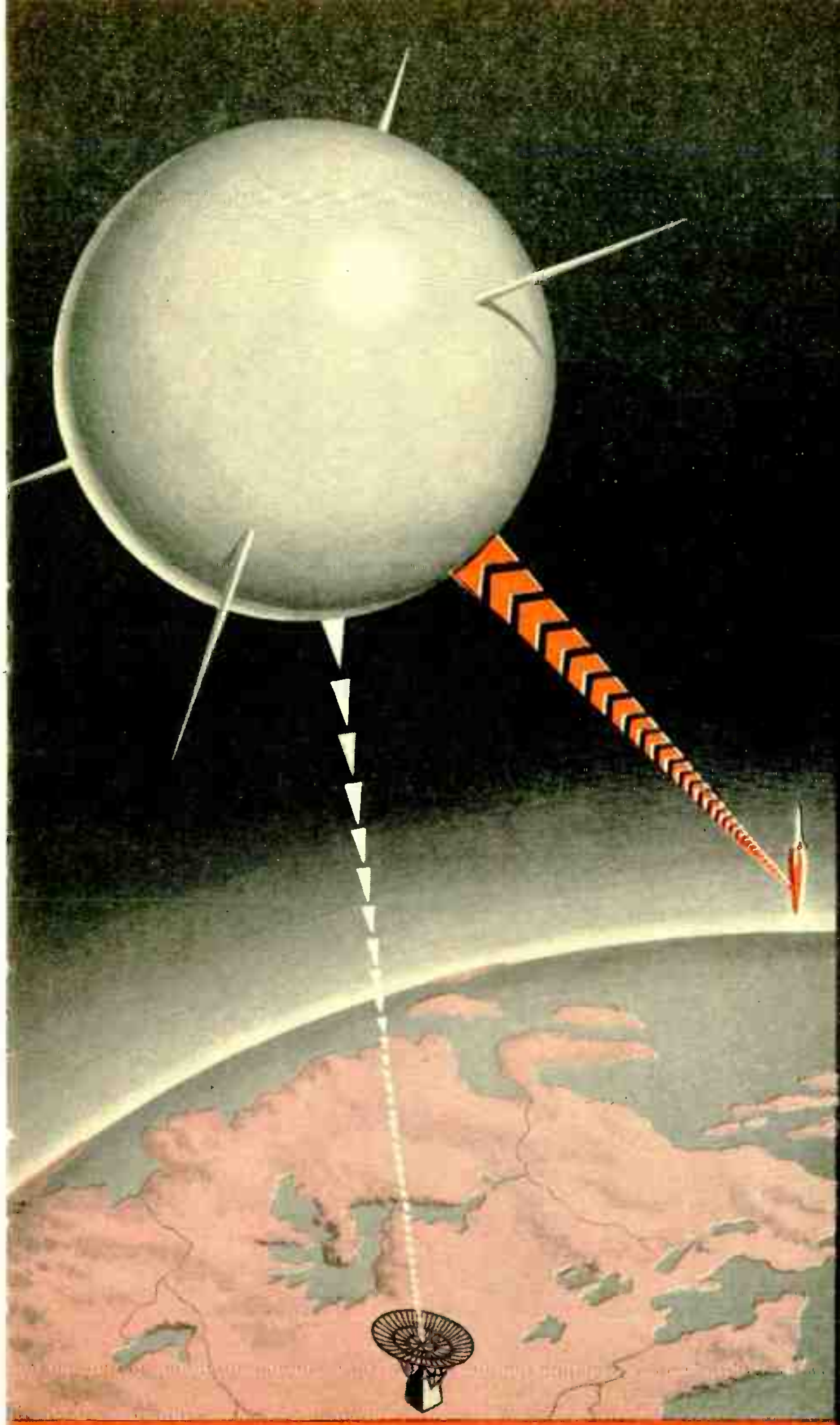
electronics is a member of a select group too—The Audit Bureau of Circulation publications—comprised of those magazines and newspapers whose publishers believe that a reader's interest in a publication is best demonstrated when he pays to receive it—those publishers willing to submit to exhaustive periodic audits in order to prove that their circulation is among those individuals they are pledged to serve, and among screened *selected* individuals ONLY.

The Electronics Man "buys" what he reads in . . .

ABP/ABC A McGRAW-HILL PUBLICATION / 330 WEST 42nd STREET, NEW YORK 36, N. Y.



INFRARED...

new and important uses from Crosley

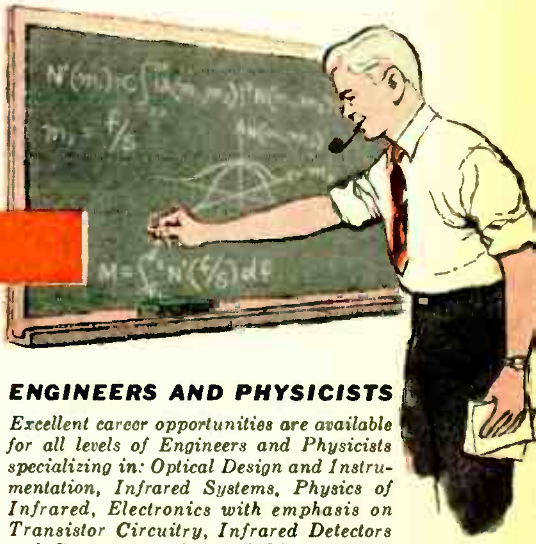
Infrared—which in World War II gave the expert marksman the power to see in the dark—now holds even greater promise. It may serve to provide early warning of approaching ICBM's if they are launched.

Infrared's singular use in World War II triggered a tremendous postwar effort to find other uses for its unique features. This effort, to which Avco's Crosley Division is a major contributor, has produced many applications in both industry and defense to which infrared is ideally suited.

Because they are so important to the national defense effort, most infrared research programs are classified as secret. But in general, Crosley's work in the field points toward new breakthroughs and conspicuous contributions in searching and tracking, anti-ICBM detection, airborne early warning and defense systems, reconnaissance, surveillance, anti-submarine warfare and passive ranging.

As a result of its progress in these areas, Crosley's team of infrared specialists—one of the largest in the country—is gaining the respect of a growing number of contractors.

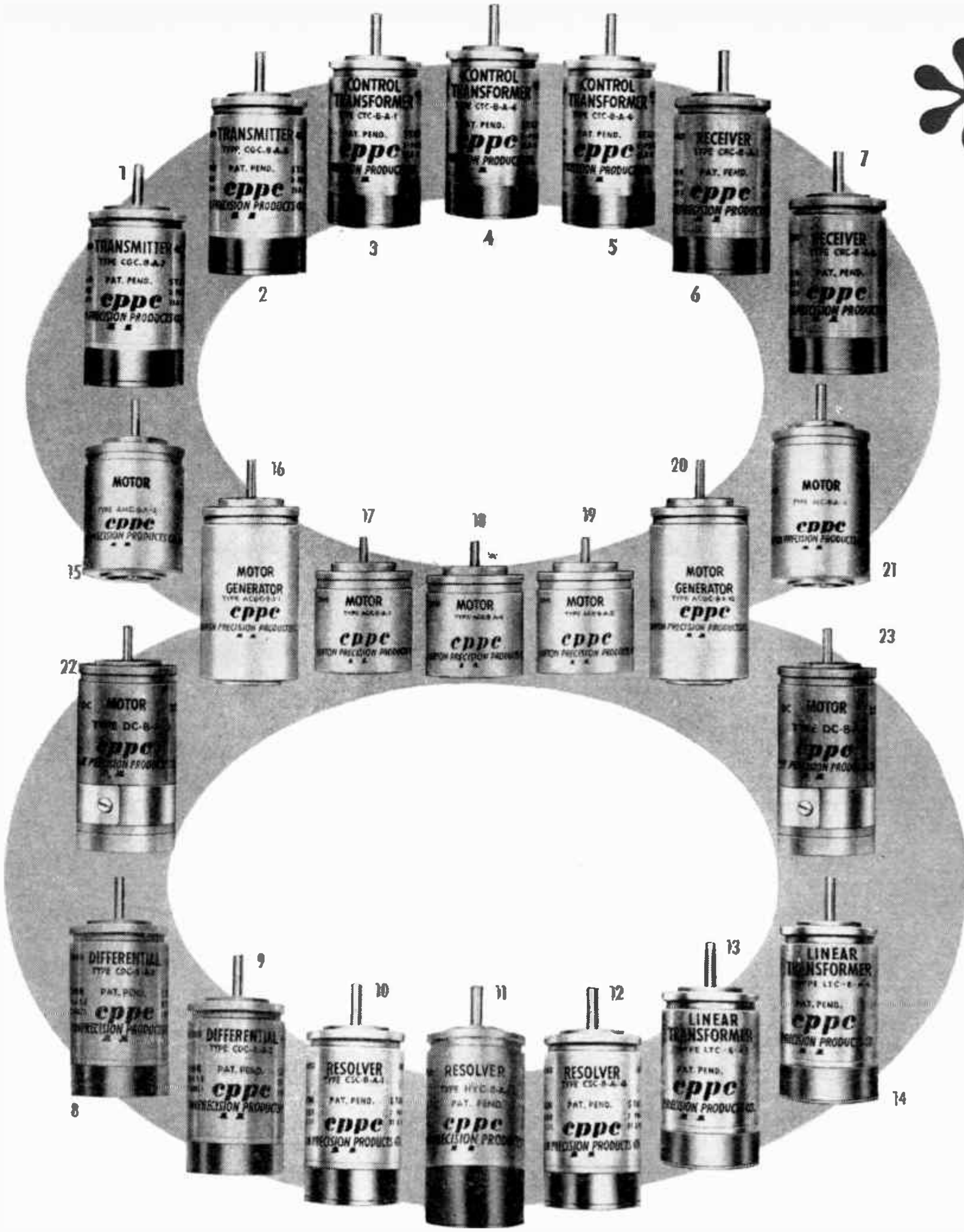
For more information, write to: Vice President, Marketing-Defense Products, Crosley Division, Avco Corporation, 1329 Arlington Street, Cincinnati 25, Ohio.



ENGINEERS AND PHYSICISTS

Excellent career opportunities are available for all levels of Engineers and Physicists specializing in: Optical Design and Instrumentation, Infrared Systems, Physics of Infrared, Electronics with emphasis on Transistor Circuitry, Infrared Detectors and Components, Infrared Measurements and Mechanical Design. For further information, contact: Director, Technical and Scientific Personnel, Avco/Crosley, Dept. E-109, 1329 Arlington Street, Cincinnati 25, Ohio.

Avco / Crosley



TRANSMITTER
CONTROL TRANSFORMER
RECEIVER
MOTOR
MOTOR GENERATOR
DIFFERENTIAL
RESOLVER
LINEAR TRANSFORMER
cppc

Four Texas Companies Merge

FOUR-COMPANY MERGER announced from Texas involves **Houston Instrument Corp., Houston Magnetic Products Inc., Crump Instrument** and the **Instrument Mirror Manufacturing Co.** All firms are situated in Houston.

The merger was accomplished by a transfer of stock followed by a dissolution of the subsidiaries. **Houston Instrument**, the new entity, will manufacture and market industrial laboratory instruments. Present products include X-Y recorders, logarithmic sound and vibration recorders, electronic amplifiers, galvanometer mirrors, magnetic recording heads, gas detectors and special optical systems.

• **Fairchild Camera and Instrument Corp.** has just acquired its fourth firm, is preparing to acquire a fifth company and is planning a two-for-one stock split. Acquisition No. 4 is **Fairchild Semiconductor**, Mountain View, Calif. The plant there will be expanded to 183,000 sq ft. **R. C. Allen Business Machines**, Grand Rapids, Mich., will become the next acquisition if stockholders, voting Nov. 30, give approval. Allen will yield 300,000 shares in exchange for Fairchild Camera stock. Voting on FC&I's proposed stock split will also be done at the November meeting. If the split is approved, Fairchild will exchange 60,000 split shares for the Allen stock.

• Merger of **Orr Industries** into **Ampex Corporation** became effective this month. Announcement of G. I. Long, Jr., Ampex president, reveals that holders of common stock and stock purchase warrants are now entitled to exchange their holdings for Ampex shares on a basis of one share of Ampex for 2.2 shares of Orr.

• **Distribution** has been completed of **Lockheed Aircraft** stock to shareholders of **Stavid Engineering** in accordance with merger agreements signed last month. Stock was exchanged on a basis of 2½ shares of Lockheed for each Stavid share held.

• **IBM's** financial statement for the nine months ended Sept. 30 shows a gross income of $940,896,512 for this year, as compared with $866,011,837 for 1958. Net income for the 1959 period was $101,876,000 after a tax bite of $210,560,050. In 1958 net income was $91,453,043 after taxes of $90,000,200. Net income per share rose 55 cents, going from $5.02 in 1958 to $5.57 in 1959. These net income figures are adjusted to reflect the 2½-percent stock dividend paid in January this year and the 50-percent stock split effected May 5, 1959.

• Report by **Adler Electronics**, New Rochelle, N. Y., for the first half of 1959 shows net earnings of $120,200 before taxes and $67,900 after taxes, based on sales of $3,902,483. Writeoff of continuing development costs are included. Comparable figures last year put sales at $3,902,483 with a net loss of $9,591 for the period.

25 MOST ACTIVE STOCKS

WEEK ENDING OCTOBER 16

	SHARES (IN 100's)	HIGH	LOW	CLOSE
Univ Control	1,004	19 1/4	17 3/8	18 1/2
Raytheon	968	57 7/8	50 5/8	51
Avco Corp	832	14 1/8	13 1/8	13 3/4
Int'l Tel & Tel	757	37 5/8	35 1/4	37 1/4
Sperry Rand	689	22 7/8	21 7/8	22 1/8
Elec & Mus Ind	617	8 1/4	7 7/8	8
Gen Tel & Elec	487	71 5/8	69 3/8	71 1/2
Lear Inc	486	17	15 3/8	15 3/4
Gen Elec	475	78 3/8	76 1/4	77 5/8
Ampex	472	90 3/4	83 1/4	90
Philco Corp	447	27 1/2	25 1/2	26 1/2
Emerson	431	17 3/8	16 1/8	16 3/4
RCA	410	60 1/2	58 5/8	59 5/8
Texas Inst	363	150 5/8	141 1/2	149 1/4
Westinghouse	347	96	93 1/4	96
Burroughs Corp	339	30 1/2	30	30 1/2
Siegler Corp	299	31 3/8	29 1/2	31 1/4
Gen Instr	294	27 5/8	25 1/8	27
Gen Dynamics	294	47 5/8	46 1/8	46 7/8
Zenith Radio	270	106 1/2	99 1/2	103
Gen Precision	267	43	40 3/4	41
Admiral	253	21 1/2	20 1/8	21
Beckman Inst	204	60	56	57
Gen Transistor	186	36 7/8	33 1/2	35 3/8
Litton Ind	181	124 1/2	116 5/8	120

The above figures represent sales of electronics stocks on the New York and American Stock Exchanges. Listings are prepared exclusively for ELECTRONICS by Ira Haupt & Co. investment bankers.

Nuclear-Gear Sales $50 Million

FIFTY MILLION DOLLARS PLUS. That's the current annual rate of nuclear-instrument sales, according to Louis A. Edelman of the Business and Defense Services Administration of the Department of Commerce, Scientific, Motion Picture and Photographic Products division.

The estimate is higher than the $40-million one that has been generally accepted in the past. But Edelman claims he'll prove his point some day next year when he completes the BDSA survey of nuclear-instrumentation manufacturers.

Seeks 100% Response

His survey will report both unit and dollar sales by type of instrument, based on manufacturers' reports of 1959 experiences. Edelman plans to mail a survey questionnaire to every known manufacturer of nuclear instruments. Furthermore, he plans to keep after survey participants until he gets a 100-percent response.

Key factor in Edelman's $50-million estimate is his belief that past surveys of nuclear instruments have not been sufficiently inclusive, and consequently omitted millions of dollars of business.

He takes as his starting point the definition that a nuclear instrument is one which uses nuclear radiation as a source of energy.

This definition covers the three main types of instruments:

1. Health type—devices which detect and measure radiation.

2. Reactor controls—instruments used to measure and control nuclear activity.

3. Process instruments—those used especially for processing, measuring and controlling, thickness and height gages (including isotope instruments).

Wants Special Rating

BDSA's Scientific division is making this survey because it hopes to convince the Bureau of Census that it should give nuclear instruments a special industry rating. Sales of $50 million will be a big factor in winning such a rating, says Edelman.

This "industry recognition" is important because nuclear instruments have no identification under the government's Standard Industrial Classification system. As a consequence, these instrument sales are mixed with those of other industries.

Edelman also desires to establish market bench marks for every nuclear-instrument manufacturer in the country. An individual manufacturer will then be able to determine his portion of the industry total.

Listing Products

Because BDSA is so strongly interested in providing these bench marks of product sales to individual manufacturers, there is no limit to the number of question lines BDSA will use in the questionnaire under preparation.

Any nuclear-instrument manufacturer who wants to make sure a certain product is individually listed should get in touch with Lou Edelman at BDSA, Department of Commerce, Washington 25, D. C.

The survey will be mailed out early next year, but BDSA officials can't pinpoint the exact date.

• **Transistor dollar sales** for the first eight months of 1959 ran 114 percent ahead of similar period in 1958, while unit sales exceeded last year by 95 percent, reports Electronic Industries Association. For the period ended August 1959, dollar sales hit $133.5 million; unit sales, 49.3 million.

FIGURES OF THE WEEK

LATEST WEEKLY PRODUCTION FIGURES

(Source: EIA)	Oct. 9 1959	Sept. 11 1959	Change From One Year Ago
Television sets	181,845	141,146	+43.0%
Radio sets, total	429,245	313,098	+36.4%
Auto sets	136,815	106,741	+47.0%

LATEST MONTHLY SALES TOTALS

(Add 000)

	August 1959	July 1959	Change From One Year Ago
Rec. Tubes, value	$29,974	$29,786	+17.8%
Rec. Tubes, units	35,435	36,394	+16.3%
Pic. Tubes, value	$15,494	$14,684	+ 9.2%
Pic. Tubes, units	832	750	+15.4%

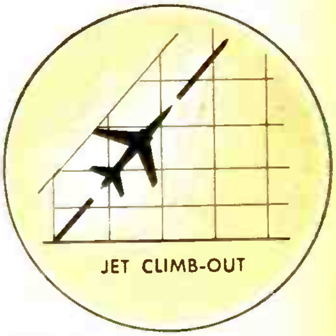
New LFE precision GCA *provides instant control of Jet traffic*

Receiver-transmitter group with separate azimuth and elevation antennas. Indicator Group (shown above) may be located as far as 2 miles away.

Latest in the LFE series of Ground Control Approach Systems is the new ECR (Extended Coverage Radar) . . . a compact, high power, high precision system capable of controlling Jet traffic quickly and accurately on any one of four runways.

Four modes of control are displayed on a single indicator . . . Airport Surveillance (ASR) from 1 to 40 miles . . . Precision Approach (PAR) from 1 to 40 miles . . . and Slant Flight Control (SFC) from 0 to 50,000 feet. Jet climb-out can also be controlled in the SFC mode. Elevation scan is −1° to +30° in all modes. Azimuth scan is 45° in PAR and SFC modes.

The system provides a large volume of instantly accessible coverage in 3 dimensions. Significant benefits include: reduction of contact time required from controller to aircraft . . . allowance for adequate warning time in the event of confusion in aircraft course . . . elimination of interference caused by terrain and precipitation characteristics.



Specific features include: electronically computed pre-determined cursors to indicate elevation and azimuth approach to touchdown . . . also establish center, floor or ceiling of any slant flight corridor. Remote bearing readout provides quick, positive dial indication of center of SFC zone for complete coverage of departure by high performance jets.

The foregoing briefly describes this highly versatile system's many advanced features. It serves to exemplify LFE capabilities for meeting new problems with new concepts . . . from proposal-to-prototype-to production.

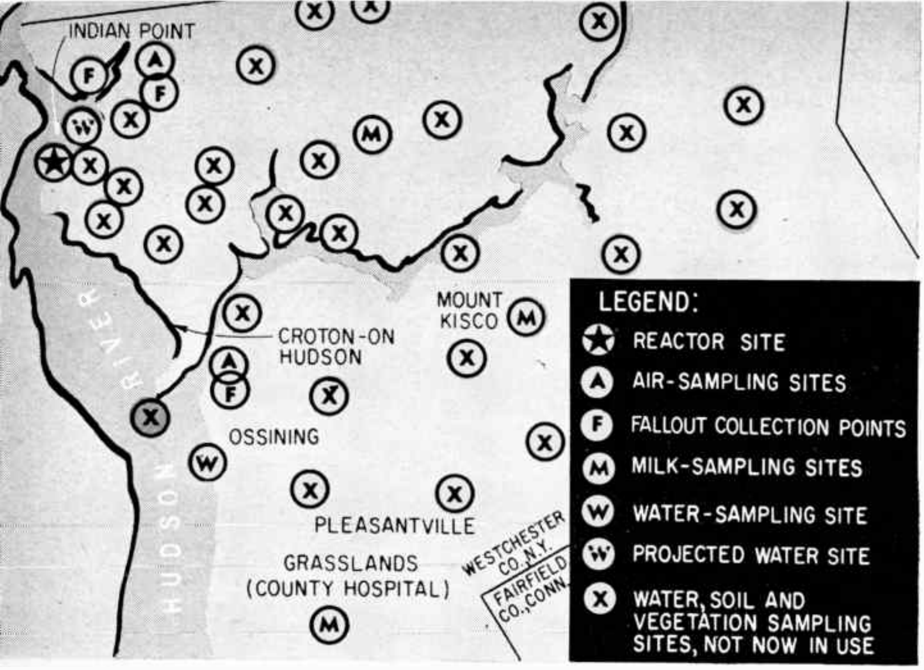
LFE

Leadership from Experience

LABORATORY FOR ELECTRONICS, INC. 1079 COMMONWEALTH AVENUE • BOSTON

ENGINEERS: LFE is growing fast due to the many creative contributions of the engineering staff. Several, out-standing employment opportunities now exist in Radar and Surveillance, Navigation and Data Processing, and in Microwave Instrumentation.

CIRCLE 21 ON READER SERVICE CARD



Upper Westchester sites (left) provide data for radiological analysis. Experience illuminates problems of governing radiation use. One result: bigger market for radiological instruments

Regulating Ionizing Radiation

GROWING INTEREST in radiological techniques—both in medicine and in industry—is now being matched by state and local government interest. Several states have already passed laws regulating the use of any equipment which produces ionizing radiation; others are investigating the situation and readying legislation.

State laws generally become part of the sanitary code, are executed usually by county health departments, state health departments, or state labor departments.

One direct result of this increased interest is that the nation's 50 states and 3,100 counties have suddenly become a big market for radiological instruments. An indirect result is that more users of radiation gear will also be forced into the market for survey instruments and monitoring gear.

Controls

State and local regulation over radioactive materials reaches a step further than Atomic Energy Commission controls. AEC by law concerns itself only with manmade radioactive materials; use of radium, for instance, does not fall within the Commission's purview. But state health and labor officials are definitely interested in use of radium and other natural radioactive materials, and in the use of X-radiation.

County health departments are logical choices for executing laws governing use of ionizing radiation. They usually have on staff one or more doctors, and doctors are the major nonindustrial users of radiation equipment. Labor departments in some states have exclusive control over radiological techniques in industry; in other states, control is shared with health departments, departments of commerce and industry, and whatever department is concerned with issuing licenses (departments of education in many states).

States are not alone in their concern over radiological problems. According to *Nucleonics*, a McGraw-Hill publication, President Eisenhower recently adopted a Budget Bureau recommendation giving more responsibility for radiation safety to the Department of Health, Education and Welfare, and to the Public Health Service; and establishing a Federal Radiation Council from among five members of his cabinet.

New York's Regulations

In June, 1955, the Public Health Council of the State of New York enacted chapter XVI of the State Sanitary Code. This regulates all uses of ionizing radiation which are "not subject to supervision by the New York State Department of Labor."

A couple of its regulations are of especial interest to the electronics industry.

One requires that any installation that has radioactive materials "not in sealed sources" must "provide or have immediately available instruments for detecting and measuring radiation." The regulation defines a sealed source as one "constructed in such a manner as to prevent the escape under normal conditions of any radioactive material."

Another regulation requires that a "radiation safety officer using appropriate properly calibrated equipment" survey radiation installations when placed in operation, when moved, or when any change is made in the installation or its use that might increase radiation level, or at six-month intervals where vibration or other physical conditions may change protective features.

The same rule requires that any unsealed radioactive source must be checked out once a month or oftener; that the air must be regularly monitored if there is a reasonable possibility that radioactive concentrations in the air may exceed permissible dosages, and that all protective devices must be checked at least every six months.

Another regulation requires that all X-ray equipment bear Underwriters' Laboratories seal or meet equivalent standards of electrical and fire safety.

The last regulation in the chapter restricts to doctors, dentists, podiatrists, osteopaths and their nurses the right to use radiation-producing equipment (New York's chiropracters now have a suit pending against the state challenging this limitation). It also restricts the sale, lease, transfer or loan of X-ray or fluoroscope gear to the same people, plus hospitals, infirmaries, medical and dental schools and clinics.

This clause contains two necessary exclusions: one permits the sale of equipment to anyone not intending to use it on human beings, the other allows distributors to acquire it for resale.

Westchester's Problems

Experience of Westchester County, contiguous to New York City on the north, is illuminating. In implementing the state regulation, Westchester is well in the lead of the 56 other upstate counties (the five counties of the City of New York are exempt from the State Sanitary Code, since they have an even stiffer city code).

Westchester also has more problems to worry about. The county has several big sources of radiation: the Indian Point reactor now being built by giant utility Consolidated Edison; the cyclotron at Columbia University's Nevis Laboratories; the labs at Grasslands, the big county hospital. The county health department itself owns a piece of cobalt-60 to calibrate its radiological instruments.

Besides the major sources, there are a number of hospitals and many private physicians who own iodine-131, cobalt-60, phosphorus-32, and gold-198 or 199 in varying quantities. Several hundred physicians and dentists own X-ray machinery and fluoroscopes. And there are two- or threescore industrial installations with which the county is indirectly concerned: the state labor department controls in-plant use, but the county is worried about waste disposal. Burial of contaminated wastes is not permitted in Westchester.

County health officials have several radiological jobs going, and several batteries of instruments.

Instruments

To survey smaller installations (doctors, dentists and so forth) they use a hand-held pistol-shaped ionization chamber made by Tracerlab. They also have a portable alpha-count meter made by Nuclear Chicago, and another portable Nuclear Chicago instrument which counts alpha, beta and gamma radiation.

To safeguard county health against potential farflung damage (either from Indian Point or from other sources such as international tests) the county in close cooperation with the State Health Department has set up a network of collection points (see map) for air, water, vegetation, soil and milk samples. Many of these, after routine operation for a couple of years, have been discontinued. Half a dozen still remain, sampling air, water, milk and fallout.

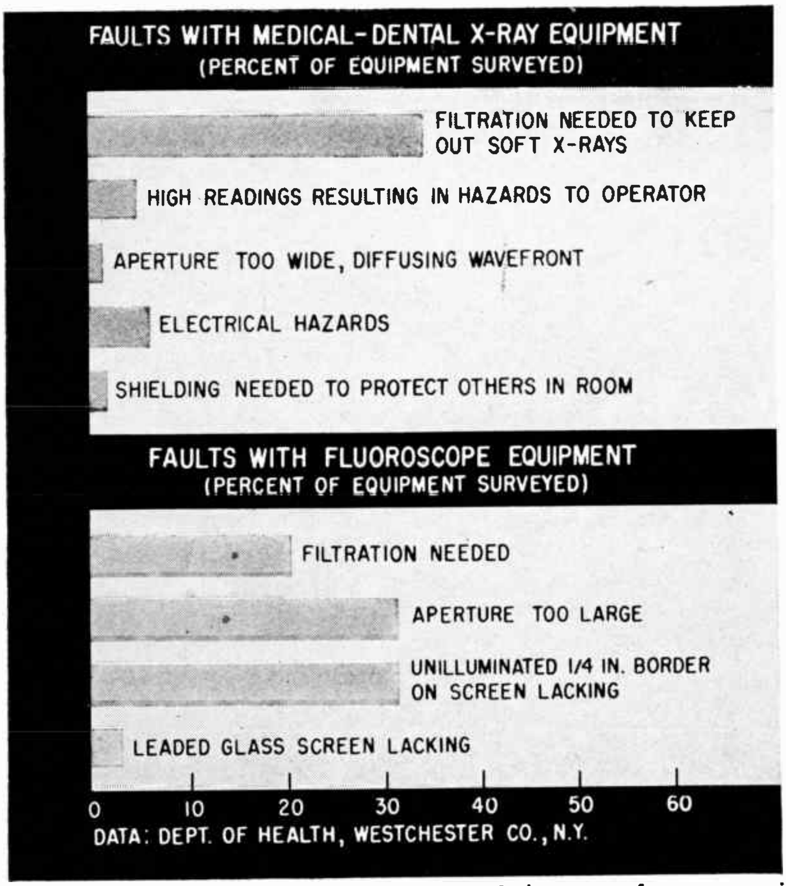
Analysis of samples seeks to count bone-seeking beta sources, such as strontium-90, and soft-tissue-seeking sources like cesium-137.

For field work, county health officers use a Landsverk portable analysis kit designed for food and water analysis. The kit has a Geiger counter, matches samples against comparison standards.

The department also maintains analysis instruments in the county laboratories at Grasslands Hospital. There are two high-speed scaling units made by Nuclear Measurements Co. These have a scale of 1,000 with maximum counting rate of a million per minute, resolution time of 2 microseconds, and a built-in timer accurate to 0.2 sec in 55 min.

With these are used three proportional counter converters, also made by NMC. One has a detection chamber that can accept samples up to 7½ in. in diameter and 1 in. thick. Two have chambers adequate for 2-in. samples and are processed for an alpha background of 1 count per hour. A filter-paper counter converter to accommodate air-sample filters is used with the two latter converters.

The health department also has a raft of civil defense instruments, including Geiger counters, ionization chambers and dosimeters.



Survey of medical radiation gear showed up some faults in manufacture, many in application

FREQUENCY STANDARDS

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

*3⅛" high
400 - 1000 cy.

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.)

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

*3½" high
400 to 500 cy.
optional

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)

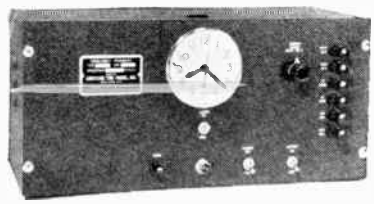
FREQUENCY STANDARD
TYPE 2007-6

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

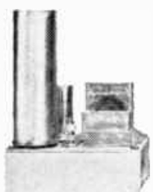
FREQUENCY STANDARD
TYPE 2121A



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)

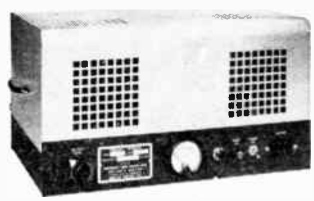
FREQUENCY STANDARD
TYPE· 2001-2



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.

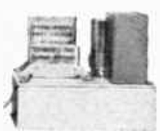
FREQUENCY STANDARD
TYPE 2111C



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.

WHEN REQUESTING INFORMATION
PLEASE SPECIFY TYPE NUMBER

American Time Products, Inc.

Watch Master
Timing Systems

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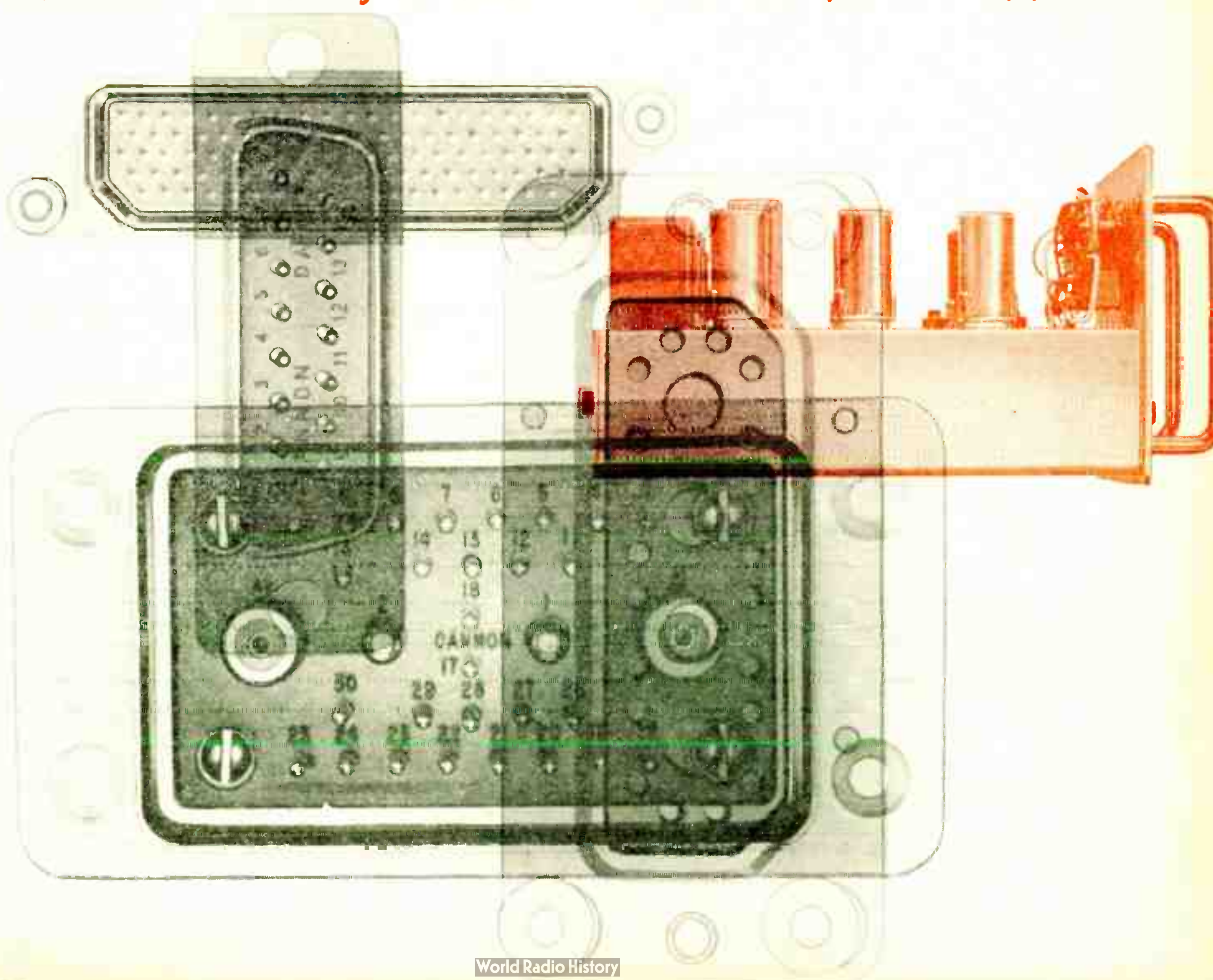
CANNON PLUGS

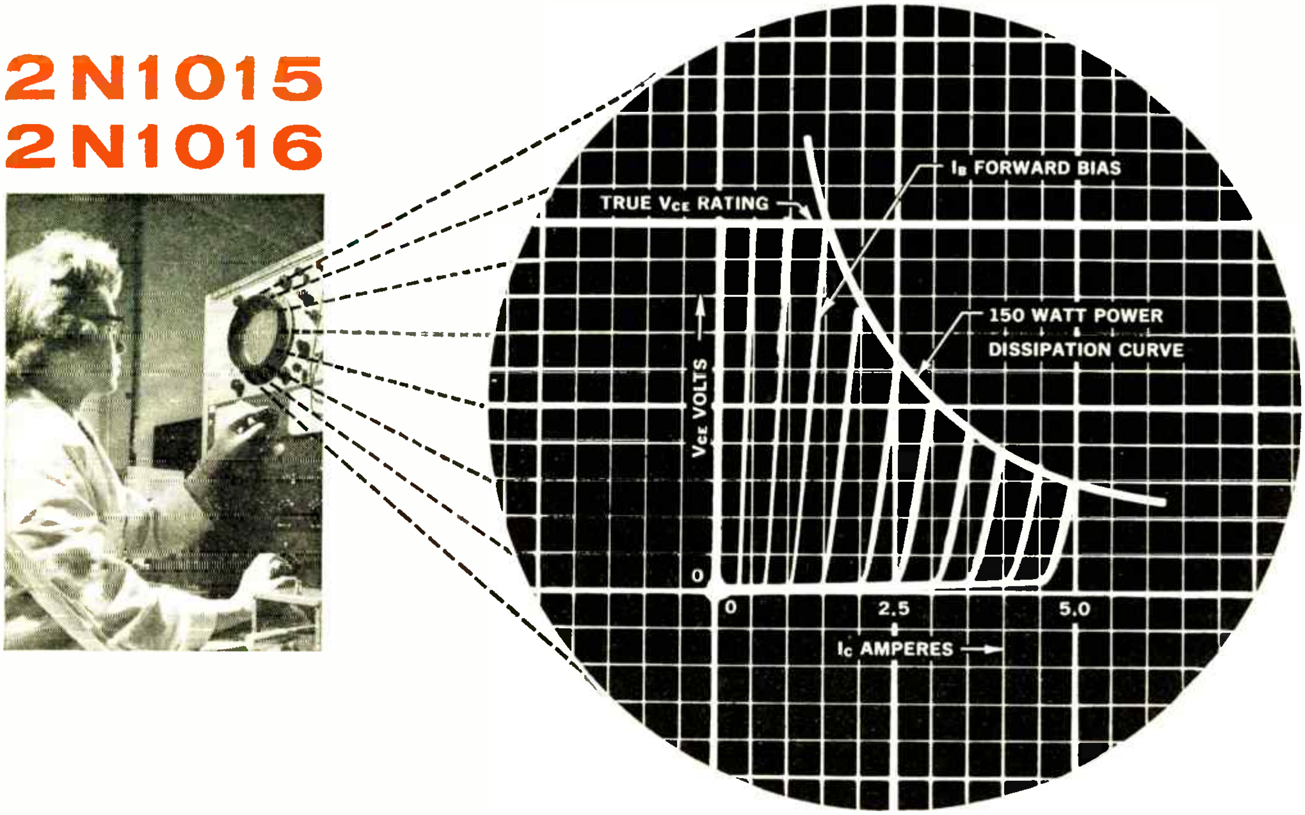
The assembling of highly-flexible electronic systems and sub-systems into a modular package . . . for fast inspection, testing, service, and replacement of components . . . calls for standard-ized-type plugs throughout the system. Reliability and optimum flexibility in shell designs and types of layouts are the design criteria for the more than 18 different basic Cannon Modular and Rack/Panel Plug Series. This Series is available in standard, miniature, or subminiature sizes . . . for standard or printed circuitry. Up to 180 contacts and a varied combination of contacts for control, audio, thermocouple, co-ax, twin-ax, and pneumatic connections. Single or double-gang. With or without shells. The Rack/Panel Series ranges from the tiny "D" subminiature to the heavy-duty DPD Rack/Panel Plug. For further information on Cannon Modular and Rack/Panel Plugs write for Cannon DP Catalog, Cannon Electric Co., 3208 Humboldt St., Los Angeles 31. Please refer to Dept. 00. Factories in Los Angeles, Santa Ana, Salem, Toronto, London, Paris, Melbourne, Tokyo. Distributors and Representatives in the principal cities of the world.

Maximum Flexibility for Modular and Rack/Panel Applications



WESTINGHOUSE SILICON POWER TRANSISTORS

2N1015
2N1016



TRUE VOLTAGE RATINGS

Guaranteed by 100% power testing

This Power-voltage Test consists of testing the transistor in common emitter configuration under all bias conditions in the area defined by the *TRUE* voltage rating of the transistor (V_{CE}); the constant power dissipation curve for the transistor (150 watts); and its rated current (2 amps for 2N1015 and 5 amps for 2N1016).

The voltage at which alpha equals one, and other voltage ratings commonly given for transistors such as V_{CES}, V_{CER}, V_{CEX} and V_{CBO}, are *above* the voltage rating given to these transistors.

Each Westinghouse silicon power transistor has been completely tested throughout its rated voltage-power-current region before shipping. Thousands of transistors performing under all types of operating conditions have proved the validity of this method of *TRUE* voltage rating.

TRUE voltage ratings from 30 to 200 volts give you complete freedom in designing your equipment—you can operate Westinghouse silicon power transistors at the manufacturer's ratings without risking transistor failure. This *TRUE* voltage rating of Westinghouse silicon power transistors coupled with their still unequaled low saturation resistance and low thermal drop makes them an ideal first choice for military, industrial and commercial applications.

Type	V_{CE}*	B (min)	R_S (max)	I_C A (max)	T_j max. operating	Thermal drop to case (max)
2N1015 2N1015A 2N1015B 2N1015C 2N1015D	30 60 100 150 200	10 @ I_C=2 amp	.75 ohms @ I_C=2 amp I_B=300 ma	7.5	150°C	.7°C/W
2N1016 2N1016A 2N1016B 2N1016C 2N1016D	30 60 100 150 200	10 @ I_C=5 amp	.50 ohms @ I_C=5 amp I_B=750 ma	7.5	150°C	.7°C/W

*TRUE voltage rating (The transistors can be operated continuously at the V_{CE} listed for each rating.)

YOU CAN BE SURE...IF IT'S Westinghouse

Westinghouse Electric Corporation, Semiconductor Department, Youngwood, Pa.

Mail Sorting Goes

Electromechanical gear with some electronic control sorts 43,000 letters an hour in Detroit

Photocell detectors and thyratron motor controls are electronics' contribution to postal mail-handling speedup now going on

DETROIT—Last week in the nation's sixth-biggest postoffice here, 12 clerks sat at as many parallel consoles, watching envelopes whisk before them and tapping out on a 10-key board the binary equivalents of 279 destination code numbers. The rest of the job of sorting 43,000 outgoing letters an hour to 279 destinations was done automatically.

The 78 by 9½ ft machine is one of 10 being built for the U. S. Post Office Dept. by Burroughs Corp. of Detroit. The mail sorters and 10 associated operator training setups are being made under a $1,869,000 contract.

Soon a prototype small-postoffice installation will be made by Burroughs in Flint, Mich. The initial engineering on the machine was done for the Post Office Dept. by Rabinow Engineering in Washington, D. C. The machine will cost $115,000 to $150,000 in production quantities.

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Computers in Process Coı

NE\ N I\

At supervisory level, digital computers may soon be controlling , duction lines. New developments make it more feasible than eve,

TOMORROW'S COMPUTER will be more and more adaptable to the control of industrial production processes. Continuous-process industries — notably petrochemicals—are already putting their 24-hr-a-day plants under digital-computer supervision. Cost pressures are driving production managers throughout industry to investigate the feasibility of machine control at all possible levels.

Digital computers will find use at the supervisory level, analog devices work at the control level. Supervising hundreds of analog devices is a job made to order for certain digital computers.

Developments incorporated into systems like the RCA-501, Honeywell 800 and Remington Rand Univac's Larc could materially hasten the entry of digital machines into the production-control field. Control computers such as the input-output processors in these systems are independent entities designed to accept sense information (Is unit *A* busy? When will unit *B* be free to accept data from unit *E*?) and operate effectors. These functions, necessary to a process-control computer, could easily be adapted to production-line requirements.

Entries in the Field

RCA offers the process-control field its model 110, a transistorized digital processor with both core and drum storage. The 110 can take data from cards, paper tape or magnetic tape. It is an adaptation of the input-output controls of the RCA-501.

Analog-to-digital converters and scanners provide the 110 with input from detectors, sensors or monitoring devices. RCA has teamed with industrial-controls manufacturer Foxboro Co. to sell the 110 in integrated systems.

General Electric is active in this area. Digital techniques borrowed from big commercial computers are being toughened up and put to work on the production floor.

GE makes a tinplate-mill data accumulator which integrates and records the number of feet of prime material in a coil of plate, the number of feet of defects such as pinholes, light coating, thin material and so forth. Logging equipment works with an X-ray thickness gage to record on-gage and off-gage totals of sheet rolling mills.

Minneapolis-Honeywell and Philadelphia Electric Co. have joined forces to develop the D-290 computer to run the big utility's electrical generation system.

Thompson - Ramo - Wooldridge's RW300 is receiving a lot of attention from production-control people. The RW300 has been put to work at Texaco's Port Arthur, Tex., refinery to control a polymerization unit, guides the operations of a mechanized rock-blending facility for Riverside Cement Co., Orogrande, Calif., will help run a nuclear power plant for French government utility Electricite de France.

By 1960, Ferranti Ltd. expects to have available a small transistorized computer, 4 ft x 4 ft x 2 ft, designed for plant control. The computer, Ferranti says, will calculate changes necessary in a process, then provide control signals to carry out the required changes.

Big Need: Translation

Automatic recording and monitoring systems will be needed to tie computers to their work and eliminate the middleman stage of taking readings and readying them for machine processing. Consolidated Electrodynamics built such a monitor for Pratt & Whitney to use in the development of the J58 jet engine.

The system measures air and fuel pressure, strain, vibration, thrust and temperatures from test cells, processes and p, for each test in less t. onds.

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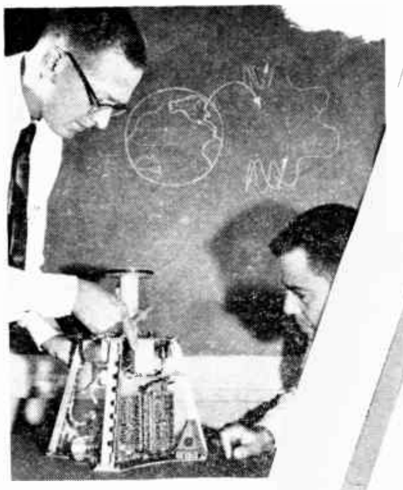
Javelin Prob



Scientists at Lockheed's m check instrument package probe, which will hurl a into the near Van All (2,000 miles up) to obt what particles make special weapons cer Aerolab are conduct

Cl

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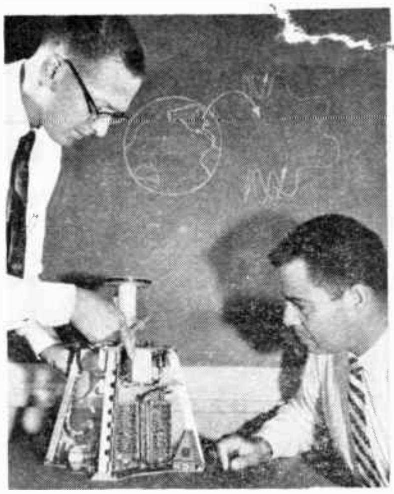
Javelin Probe



Scientists at Lockheed's missiles division check instrument package for the Javelin probe, which will hurl advanced counters into the near Van Allen radiation belt (2,000 miles up) to obtain clearer idea of what particles make up the belt. USAF's special weapons center, Lockheed and Aerolab are conducting the Javelin tests

Mail Sorting Goes

Electromechanical gear with some electronic control sorts 43,000 letters an hour in Detroit

Photocell detectors and thyratron motor controls are electronics' contribution to postal mail-handling speedup now going on

DETROIT—Last week in the nation's sixth-biggest postoffice here, 12 clerks sat at as many parallel consoles, watching envelopes whisk before them and tapping out on a 10-key board the binary equivalents of 279 destination code numbers. The rest of the job of sorting 43,000 outgoing letters an hour to 279 destinations was done automatically.

The 78 by 9½ ft machine is one of 10 being built for the U. S. Post Office Dept. by Burroughs Corp. of Detroit. The mail sorters and 10 associated operator training setups are being made under a $1,869,000 contract.

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Automatic

Pitney-Bowes is studying a code imprinting method that uses phosphorescent dots, while Rabinow Engineering is taking a magnetic-ink approach.

How Mail Sorter Works

Here's what electronics does in the Burroughs mail sorter: One cadmium sulphide photocell scans each of the 279 destination bins. If a full bin is not emptied in two minutes, a time-delay relay shuts the machine off.

One photocell scans the input to each reading console. The photocell fires a thyratron which in turn controls a relay that switches the envelope-feed motor. A bank of eight photocells scans pockets in an endless belt that takes letters from sorting consoles to destination bins.

Four other photocells scan code wheels, also on the endless belt. These 12 photocells shut down the machine if any letter gets misplaced on the belt.

Space Needs Force Spectrum Shakeup

WASHINGTON—HOW TO GET enough radio spectrum space for outer space needs as well as for fast-growing established services is the crux of the problem facing the Administrative Radio Conference of the International Telecommunications Union (ITU) now meeting at Geneva. The conference is expected to last four months.

The problem is not how to divide frequencies among the 100 ITU member countries, but rather how to divide frequencies among the radio services. For example: air traffic control and astronautics users are both crowding for frequency allocations. The conference must even consider providing frequencies for use in outer space.

The conference plans a complete revision of international regulations, including frequency allocations. This will be the first such frequency shakeup since the ITU met in Atlantic City in 1947. Preparatory work has been in progress in the U. S. for over two years.

electronic engineers:

tired of the "bullpen" treatment?

Hughes-Fullerton is recognized as an engineering-oriented organization, where the needs of the creative engineer are given precedence.

Privacy—At Hughes-Fullerton, engineers enjoy private or semi-private offices in new air conditioned quarters.

Creative Atmosphere—Engineers are encouraged to do independent thinking. The many Hughes-Fullerton "breakthroughs" are testimony of this unhampered atmosphere.

Research and Development Orientation—Because the bulk of Hughes-Fullerton projects start from "scratch," engineers have the satisfaction of being in on advancements in the state-of-the-art. At the same time, they can see that the final product fulfills program needs.

Long Range Projects—Hughes was first to develop three dimensional radar. Today this work is encompassing highly advanced data processing systems and electronic display systems.

Growth of Opportunity—Hughes-Fullerton (30 minutes from downtown Los Angeles), has grown from 800 employees in 1957 to 5,000 today. This programmed growth means unusual advancement opportunity. Engineers average age: 31. One out of five has an advanced degree.

It will pay you to investigate Hughes-Fullerton as the place to further develop your career as an engineer—no matter what your experience level.

For additional information please write to: Mr. B.P. Ramstack, Director of Professional Placement.

HUGHES

FULLERTON-RESEARCH & DEVELOPMENT, FULLERTON, CALIFORNIA

MEETINGS AHEAD

Oct. 29-30: Electron Devices Meeting, PGED of IRE, Shoreham Hotel, Washington, D. C.

Nov. 3-5: Mid-American Electronics Conf., MAECON, Municipal Auditorium and Hotel Muehlenbach, Kansas City, Mo.

Nov. 4-6: Automatic Control, National Conf., PGAC & PGIE of IRE, Sheraton-Dallas Hotel, Dallas.

Nov. 5-6: Instrumentation Conf., School of Engineering, Louisiana Polytechnic Institute, Ruston, La.

Nov. 9-11: Radio Fall Meeting, IRE, EIA, Hotel Syracuse, Syracuse, N. Y.

Nov. 9-11: Instrumentation Conf., PGI of IRE, Biltmore, Hotel, Atlanta.

Nov. 10-12: Electrical Techniques in Medicine & Biology, AIEE, ISA, PGME of IRE, Sheraton Hotel, Philadelphia.

Nov. 16-20: American Rocket Society, Annual Meeting, Washington, D. C.

Nov. 16-20: Magnetism & Magnetic Materials, AIEE, AIM, APS, IRE, ONR, Detroit.

Nov. 17-19: Northeast Electronics Research and Engineering Meeting, Annual, NEREM, Commonwealth Armory, Boston.

Nov. 23-24: Solid Facts About Solid State, Symposium, ISA, IRE, Ben Franklin Hotel, Philadelphia.

Dec. 1-2: Circuit Theory, Midwest Symposium, PGCT of IRE, Brooks Memorial Union, Marquette Univ., Milwaukee.

Dec. 1-3: Eastern Joint Computer Conf., AIEE, ACM, PGEC of IRE, Hotel Statler, Boston.

Dec. 3-4: Vehicular Communications, Annual Meeting, PGEC of IRE, Colonial Inn & Desert Ranch, St. Petersburg, Fla.

Mar. 21-24, 1960: Institute of Radio Engineers, National Convention, Coliseum & Waldorf-Astoria Hotel, N. Y. C.

There's more news in ON the MARKET, PLANTS and PEOPLE and other departments beginning on p 78.

This Jones & Lamson Optical Comparator...

At Ace Electronics Associates, Inc. an alert management cut costs, increased production and improved product quality through speedy, precise inspection methods.

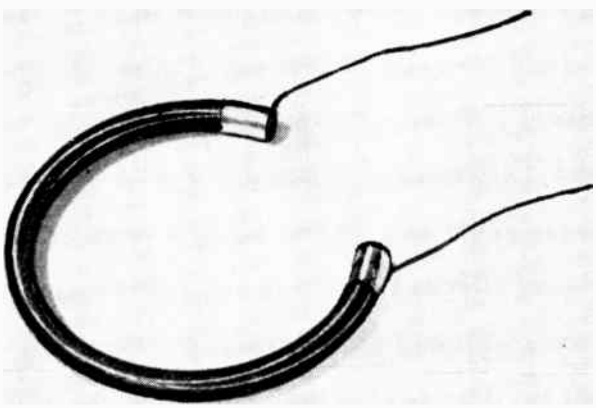
At Ace Electronics Associates, Inc., Somerville, Mass., precision of manufacture is of paramount importance. This young, progressive company, manufacturer of linear and non-linear potentiometers and electromechanical devices, including Acepot and Acetrim, insists that each and every product made in its plant give 100% reliability in the field. The aim is to not only meet, but to surpass its customers' most exacting specifications. This is being done on every piece, every day.

Through stringent quality control procedures tailored to meet unique tolerance problems, manufacturing methods have been constantly improved, costs have been cut to the bone, production has reached new high levels, and product reliability is superb.

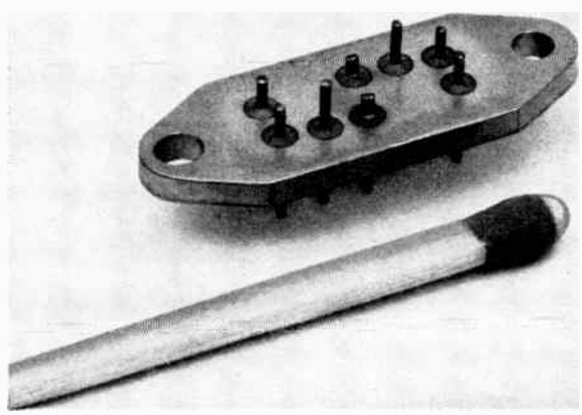
Ace gives much of the credit for this record to the Jones & Lamson Optical Comparator, which is their most important measuring and inspecting tool.

Shown here are a few of the ways in which David St. John, Ace's Chief Inspector, uses the J & L PC-14 Optical Comparator.

These actual case histories, solid proof of the J & L Comparator's speed, precision, versatility and dependability, may suggest ways in which *you* can use a J & L in *your* operations. Write today for Catalog LO 5700, which gives detailed information.



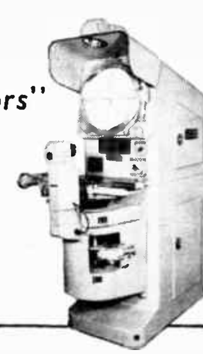
The wound element of the Acepot potentiometer is inspected for conformity to a specific curve giving an electrical quantity at a specific angle. The Comparator also inspects the winding for proper spacing, and its condition at contact point. Inspection is 4 times more precise and 2 times faster than alternate inspection method.



This relay component is inspected to verify the locations of pins to true position within .005″ and perpendicularity within .001″. With the J & L Comparator, even though pins are of different heights, they can be inspected in the same set-up, by varying the focal point. The part is rotated 180° only once. This inspection method replaces a lengthy and difficult mechanical method.

"World's oldest and largest builder of precision optical comparators"

JONES & LAMSON

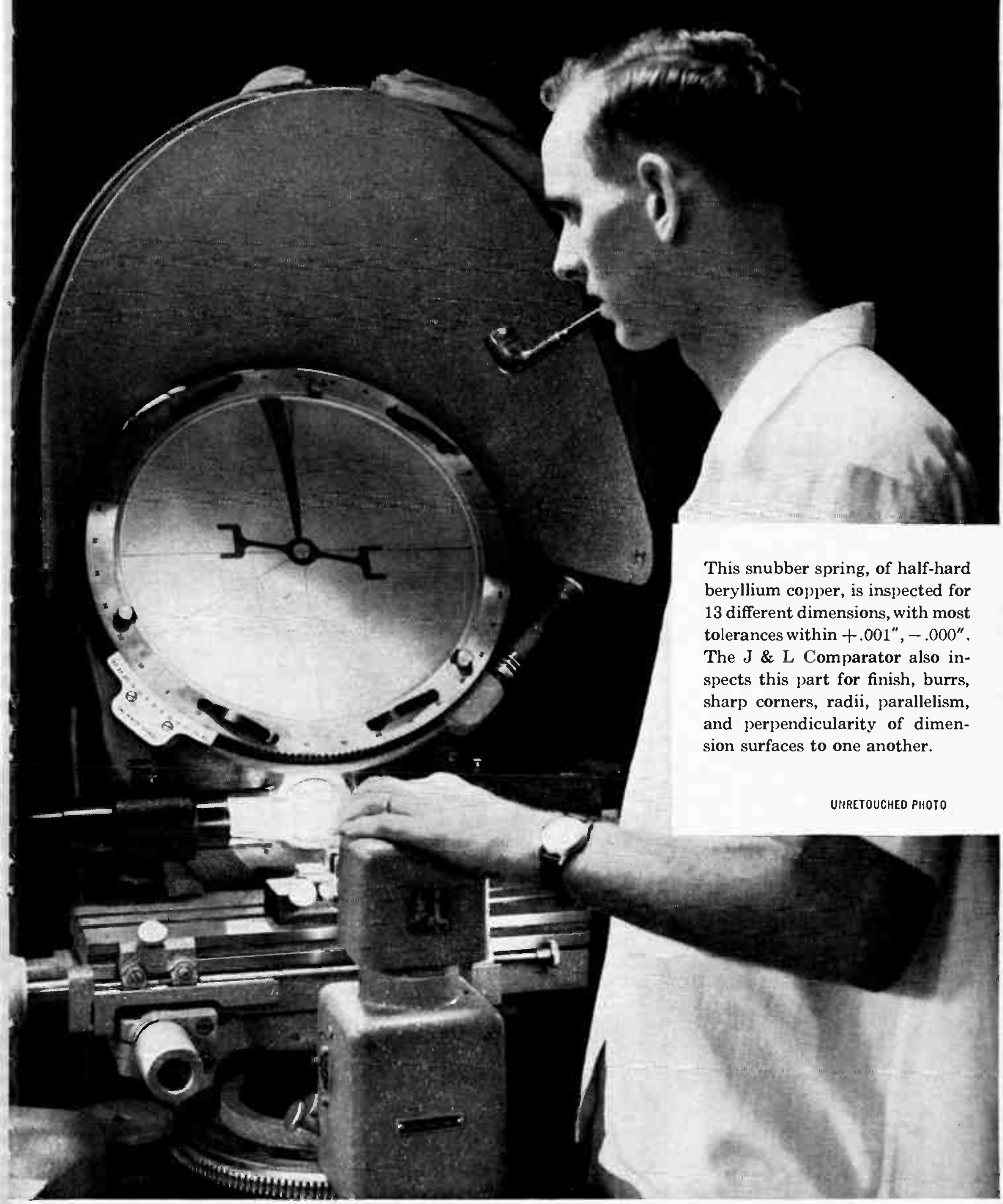


FC-14

JONES & LAMSON MACHINE COMPANY

539 Clinton Street, Springfield, Vermont

. . . Paid for itself in Less than a Week!



This snubber spring, of half-hard beryllium copper, is inspected for 13 different dimensions, with most tolerances within +.001", −.000". The J & L Comparator also inspects this part for finish, burrs, sharp corners, radii, parallelism, and perpendicularity of dimension surfaces to one another.

UNRETOUCHED PHOTO

Tests prove reliability of

Mass production of SCR's is now a reality. The experience, skill and manufacturing knowhow of General Electric's SCR production line is your assurance of dependable quality-controlled SCR's —an assurance unmatched by any other manufacturer.

WHAT THE SCR DOES

The SCR is a miniature semiconductor device that blocks positive forward voltage in its "off" or non-conducting state. However, by applying a small signal to the gate terminal it switches rapidly to a conducting state and acts like a single junction silicon rectifier. It is completely static, arcless and fast. It is almost 100% efficient. It contains no mechanisms subject to wear. As a result, the SCR can switch and control power either faster, more safely, less expensively or more reliably than the many devices it replaces: circuit breaker, relay, thyratron, magnetic amplifier, rotating amplifier and many others. Among the many hundreds of circuit designs are these:

Superior d-c motor operation from an a-c source. Eliminates motor generator sets, tubes or magnetic amplifiers to provide controlled d-c. Replaces mechanical speed and direction changers.

Superior a-c generation from a variable d-c source. First really practical method of using static inverters with ratings of several kilowatts.

Simpler conversion to high frequency. SCR converters are small and efficient. Extends use of high frequency power where desirable, as in fluorescent lighting systems.

Pulse modulators. Compact, yet rugged replacement for hydrogen thyratrons in radar and beacon modulators.

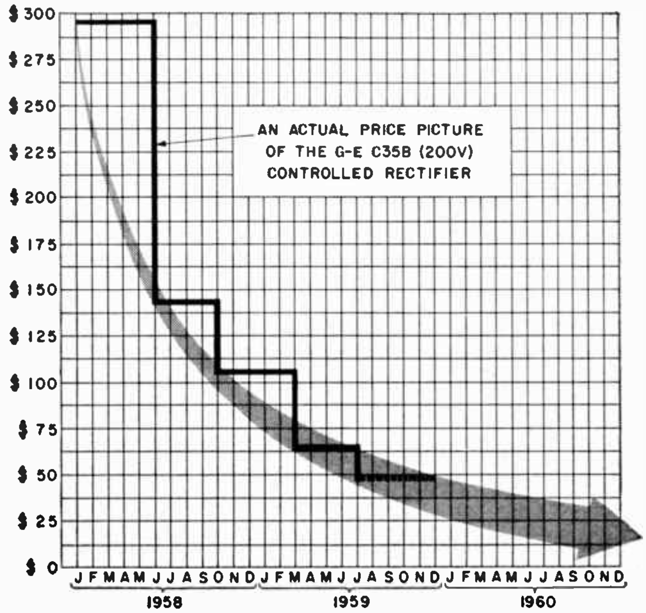
D-c regulation. Control large blocks of voltage with small losses by pulse width modulation. Eliminate bulky rheostats and adjustable d-c generators.

Other applications: Battery charging regulator, transient voltage protection, dynamic braking, constant current supply, static switching, regulated power supply, d-c to d-c conversion, temperature control.

silicon controlled rectifier

Prices again reduced, new circuits developed, customer designs move into manufacturing stage

Prices again have been reduced an average of twenty per-cent on General Electric's Silicon Controlled Rectifier, providing greater values to users. These new prices have been made possible through expanding production and lower manufacturing costs.



GENERAL ELECTRIC
CONTROLLED RECTIFIER PRICE TREND

TESTS AND FIELD REPORTS PROVE RELIABILITY

Reliability of General Electric SCR's has been steadily improved over two years of manufacturing experience. Typical test results point to the reliability achieved to date.

98% survival after 1000 hours of storage at 125°.

97% survival after 1000 hours of operation at maximum ratings at 125°C.

No thermal fatigue failures after 30,000 cycles from 20°C to 135°C and return.

Less than one percent failures experienced by customers (many of which were traced to misapplication).

SCR NOW BEING USED BY MANY COMPANIES

The evaluation stage is passing rapidly into the application stage. Many products incorporating the SCR are being marketed, for the applications are proved, circuits refined and quantity production is a reality. These are just a few of the many cases where an SCR is now doing a job more efficiently, less expensively, faster or more reliably than previous designs:

Power supplies incorporating transient voltage protection (for computers).
Radar modulator.
Static switch to replace mechanical relay for aircraft.
Three phase inverter.
Stage lighting lamp dimming.
Regulated power supply.
Battery charging regulator.
Constant current supply for a magnetic yoke.

SEND FOR DESIGN INFORMATION

Detailed application notes and article reprints are available for the guidance of designers. Your General Electric Semiconductor Sales Representative will be pleased to provide you with complete details. Or write to Section S25109, Semiconductor Products Dept., General Electric Company, Electronics Park, Syracuse, New York. Many local G-E Semiconductor Distributors also stock General Electric SCR units for fast delivery at factory-low prices.

MAXIMUM ALLOWABLE RATINGS (Resistive or Inductive Load)

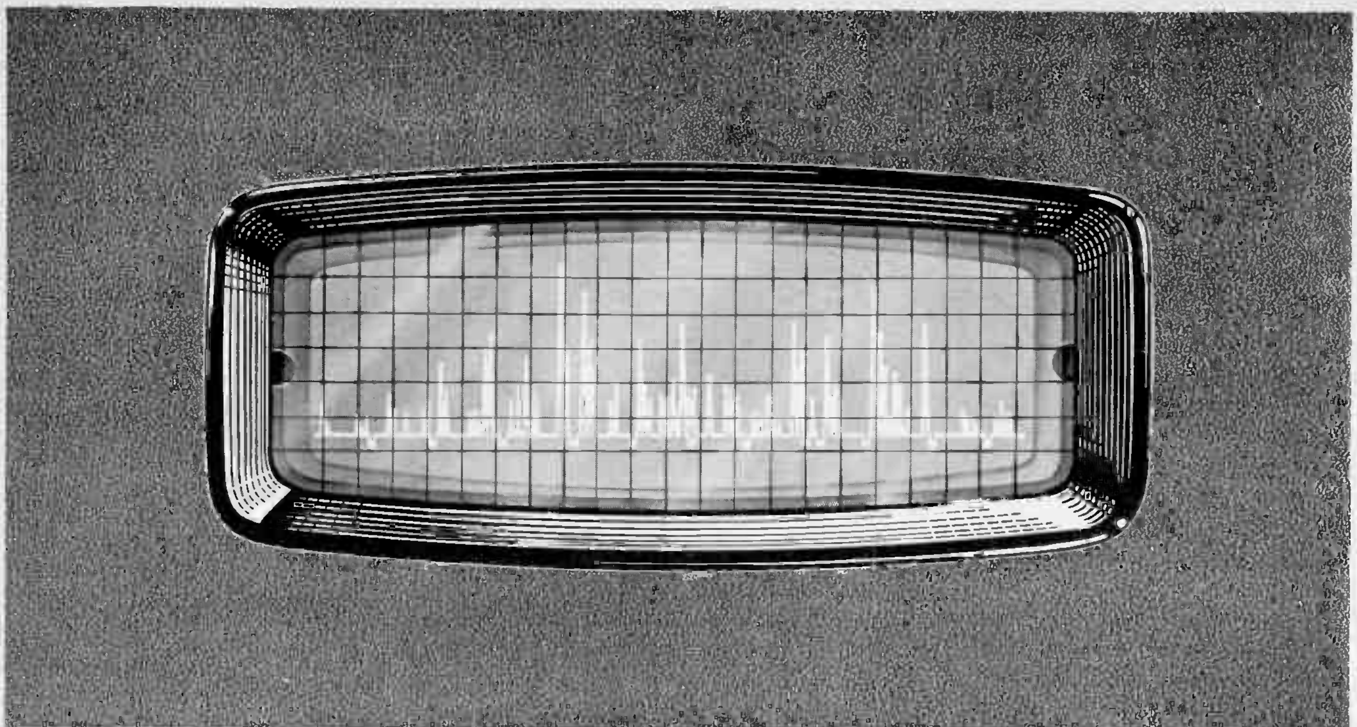
	C35U	C35F	C35A	C35G	C35B	C35H	C35C	C35D
Continuous Peak Inverse Voltage (PIV)	25	50	100	150	200	250	300	400 volts
Transient Peak Inverse Voltage (Non-Recurrent<5 millisec.)	35	75	150	225	300	350	400	500 volts
RMS Voltage (V_{RMS}), Sinusoidal	17.5	35	70	105	140	175	210	280 volts
Average Forward Current (I_F)	Up to 16 amperes							
Peak One Cycle Surge Current (I_{surge})	150 amperes							
Peak Gate Power	5 watts							
Average Gate Power	0.5 watts							
Peak Gate Current (I_G)	2 amperes							
Peak Gate Voltage (V_G) (forward)	10 volts							
Storage Temperature	−65°C to +150°C							
Operating Temperature	−65°C to +125°C							

CHARACTERISTICS (At Maximum Ratings)	C35U	C35F	C35A	C35G	C35B	C35H	C35C	C35D
Minimum Forward Breakover Voltage (V_{BO})	25	50	100	150	200	250	300	400 volts
Maximum Reverse (I_R) or Forward (I_S) Leakage Current (Full Cycle Average)	6.5	6.5	6.5	6.5	6.0	5.5	5.0	4.0 ma
Maximum Forward Voltage ($V_{F\ AVG}$)	0.86 volts (Full Cycle Average)							
Maximum Gate Current To Fire (I_{GF})	25 ma							
Maximum Gate Voltage To Fire (V_{GF})	3 volts							
Typical Gate Current To Fire (I_{GF})	10 ma at +1.5 volts (Gate to Cathode Voltage)							

C-35 Series—lower cost series with ratings similar to above, but for use up to 100°C maximum, with forward current ratings up to 10 amperes.
ZJ-50 Series—a high-current series now in development, and available on a prototype-sample basis.

GENERAL ELECTRIC

Semiconductor Products Department



RACAL presents PANORAMIC RECEPTION

Operators and organisations looking for a first-class Panoramic Receiver will readily appreciate the suitability of the well-known RA. 17 H.F. Communications Receiver as a foundation for equipment of this type. Taking full advantage of the RA. 17 characteristics, RACAL now offer a panoramic unit ideally suited for search, monitoring, bandwatching and spectrum examination.

The RA. 66 Panoramic Adaptor used with the RA. 17 Receiver provides clear visual indication of radio signals with an operational simplicity and reliability which are unique.

With adjustable spectrum-width up to 1000 kc/s, the RA. 81 Panoramic Receiver (RA. 17 Receiver + RA. 66 Adaptor) permits rapid examination of activity in the selected band.

Tuning markers for calibration and for quick adjustment of the receiver to any indicated signal simplify the work of scrutiny and measurement.

For complete technical details, price and delivery write to →

RACAL

RACAL ENGINEERING LIMITED

WESTERN ROAD, BRACKNELL, BERKSHIRE, ENGLAND

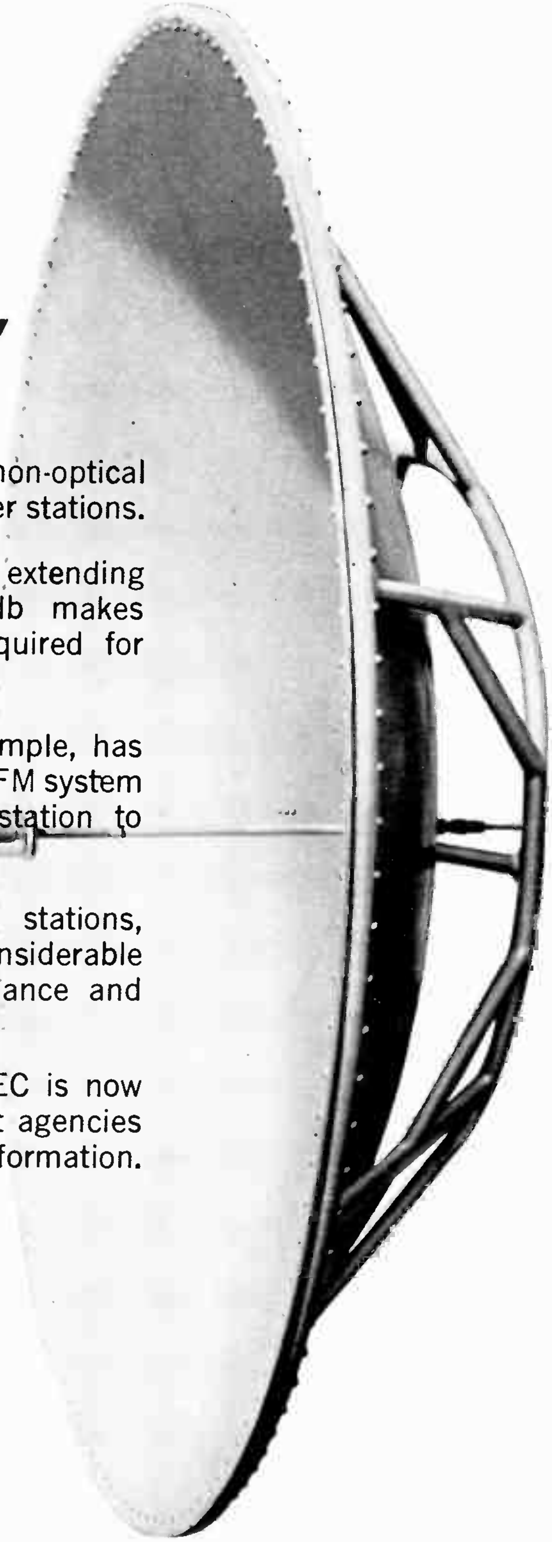
Telephone: **BRACKNELL 941**

Grams/Cables: **RACAL BRACKNELL BERKS ENGLAND**

Overseas Agents in all Countries

RACAL'S SALES ORGANISATION in the U.S.A.

For full details and advice about all Racal equipment, contact **Mr. W. J. Zullo**, our U.S. Representative, at:
Room 409, Esso Building
261 Constitution Avenue N.W.
Washington 1, D.C.
Grams: RACAL Washington, D.C.
or at
104 Highland Avenue,
Somerville 43,
Massachusetts
Phone: Somerset 6-4236
Grams: RACAL Boston Mass.



New from Japan . . .

Important advance in short-haul, multi-channel communications

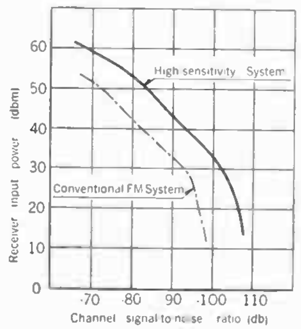
Microwave 60-channel voice transmission over a non-optical path up to 300 MILES is now possible without repeater stations.

NEC's High Sensitivity Reception System, by extending threshold level and improving S/N ratio 10 to 13 db makes this hop with only 1/20 of the power output required for conventional systems.

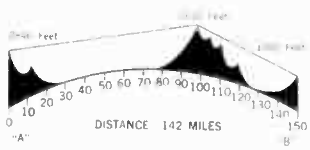
A 100 W transmitter in the 1,800-mc band, for example, has a scatter path of 100—150 MILES. A conventional FM system requires 2 KW output and at least one repeater station to connect the same distance over a non-optical path.

By eliminating high-power amplifiers and repeater stations, the High Sensitivity Reception System results in considerable reduction in initial investment. Savings in maintenance and power consumption are estimated at 40% or more.

Extensive propagation tests have been made, and NEC is now prepared to supply commercial users and government agencies anywhere in the world. Please write for detailed information.



CURVE compares receiver performance of High Sensitivity Reception System to conventional FM.



PROFILE shows how a 100 W transmitter operating at 1,920 mc connects a non optical distance of 142 MILES in one hop Average receiver input level is 75 dbm.

NEC *Nippon Electric Company Ltd.*

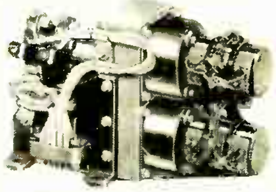
Tokyo, Japan

Electronics / Communications Systems


for control of the future...

...Precision Servo Packages by Bowmar





FOR SYSTEMS OF NAVIGATION, GUIDANCE, TRACKING, COMMUNICATION, DETECTION, RANGING, COMPUTATION

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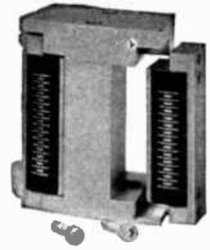
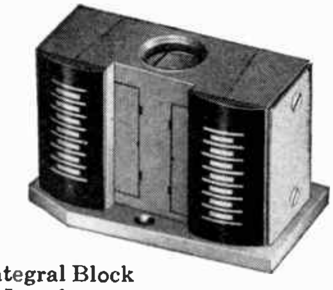
PRECISION ELECTROMECHANICAL CONTROLS AND INSTRUMENTATION, SERVOMECHANISMS, PRECISION MINIATURE GEARHEADS, NAVIGATIONAL COUNTERS, INDICATING DEVICES

CLEVITE 'BRUSH'



"Gap-Mounted."*



Integral Block Interlace.

Magnetic Heads for Digital Recording

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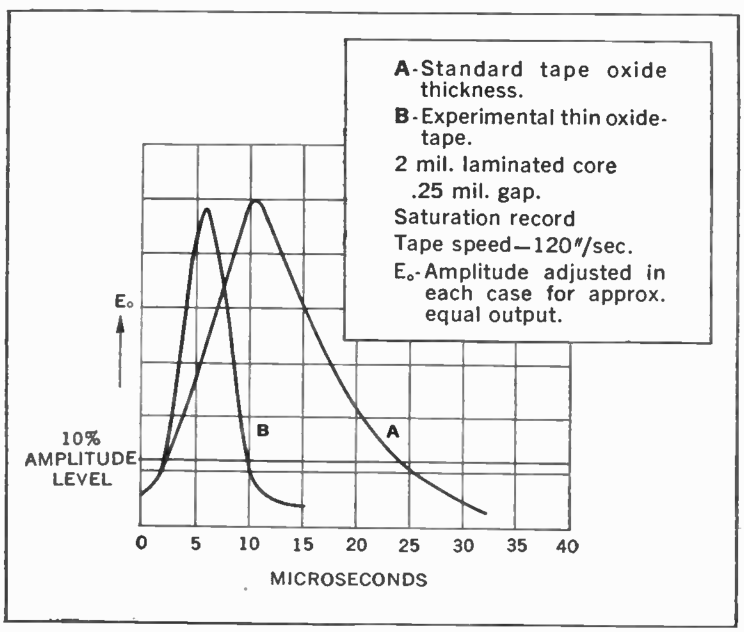

Pulse width comparison—standard and thin oxide tape.

CAPACITY—Five series of Clevite "Brush" multichannel heads give channel format variety for standard tape widths from ¼" to 2". A single block will handle up to 16 channels per inch of media width—an interlaced block up to 32 per inch. Clevite heads read pulse widths down to 1½ mils recorded to saturation on 0.3 mil coating instrumentation tape—approximately 600 pulses per inch with self-erasing saturation recording. More than 300 ppi packing is possible on 1 mil coated drums, operating 0.2 mils out of contact with a 3 mil pulse width on the drum.

ACCESS—Careful choice of material plus unique design and construction techniques enable Clevite "Brush" heads to provide uniform performance at very high processing rates. The heads themselves respond to wave lengths down to .15 mils (1.5 MC at 240 IPS) but standard instrumentation tapes and transports usually reduce the practical repetition rate of saturated recording to approximately 30 KC and 15 KC for RTZ and NRTZ respectively.

RELIABILITY— Clevite "Brush" tape and drum heads hold track width and location to ± 0.001-inch tolerance. Azimuth, contact angle and gap perpendicularity are true ± 0 deg., 5 min. and can be held even closer when required. "Gap-mounted" head (see photo) has lapped bracket and cartridge surfaces for fast replacement without critical adjustment. Redundant and interlaced (see photo) designs provide immediate checking of recorded data and higher output per channel respectively. All multichannel heads available in epoxy or full metal face (to reduce oxide pickup) at no extra charge.

* Patent Pending

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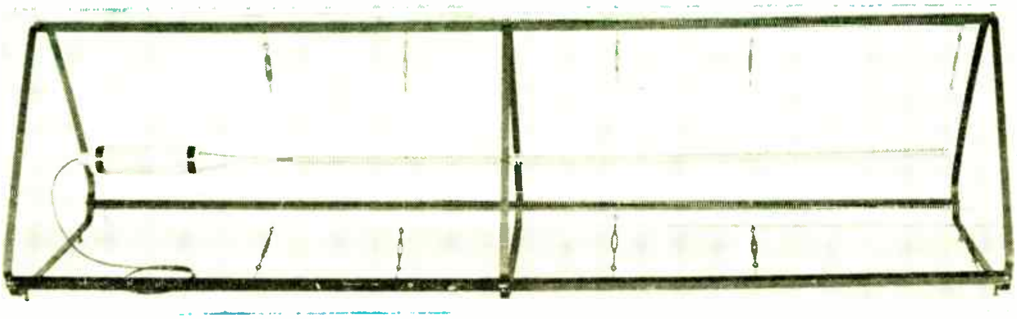


Acoustica's SEFAR transducer, shown here mounted in aluminum angle frame, has capability of extending range of active sonar systems

New Components Head Wescon Developments

From underwater sound to space telemetry, technical presentations in 1959 featured new components and techniques emerging from our industry's research and development laboratories

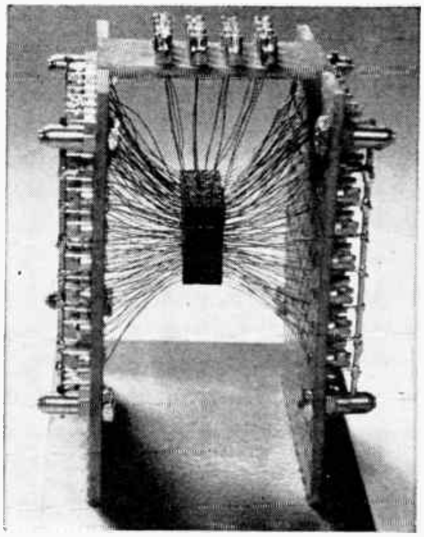
By HAROLD C. HOOD, Pacific Coast Editor, and SAMUEL WEBER, Associate Editor

OUTSTANDING PROGRESS resulting from research and development efforts was reflected in new components and systems introduced at the 1959 Wescon show. Among the new developments described there were: a directive long-range sonar transducer, a high-speed ferrite memory and logic element, a space-probe telemetry system which approaches the Shannon (information theory) ideal, and a maser preamplifier for X-band radar. Detailed discussion of production and circuit design aspects of tunnel diodes also rated high interest.

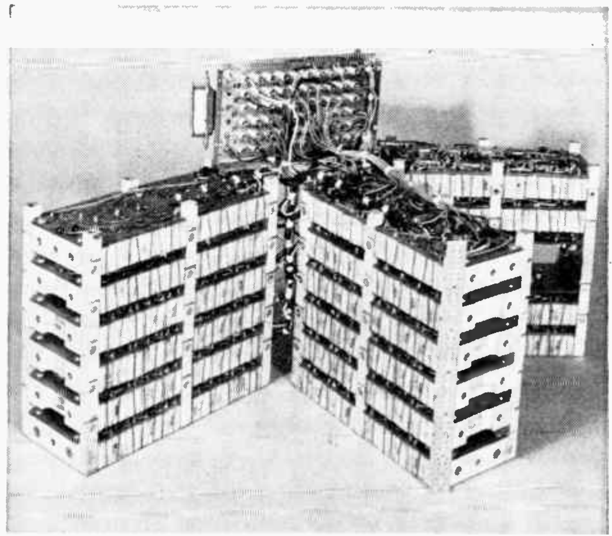
DIRECTIVE SOUND SOURCE—A new directive sound source known as SEFAR promises to extend greatly the detection range of active sonar systems.[1] Presently, range is limited to less than 30 miles.

The device is analogous to a highly directional end-fire antenna array, and consists of three parts: driving transducer, coupling section and waveguide. Heart of the transducer is the waveguide, which is a long thin rod radiating sonic energy into the water. The driving transducer generates compressional waves which are coupled to the waveguide through the exponential coupling section.

Acoustic energy, coupled to the water, is propagated in a concentrated beam centered on the axis of the waveguide. Although the waveguide is long in wave length, its diameter is only a fraction of a wave length. The system works by controlling phase velocity of compressional waves, from a source immersed in fluid. The relation of the phase velocity along the rod to the acoustic velocity in the medium



Biox elements assembled into an experimental 256-bit memory array



Magnesium blocks are used to clamp modules together, forming complete Telebit assembly

determines the directional properties of the transducer. Degree of sharpness of the radiated beam depends upon the effective length of the waveguide.

To achieve the maximum directivity, the phase velocity along the waveguide must equal the sonic velocity in the medium—in this case, water. A series of fins provides inertial loading to the compressional wave and couples energy to the water.

OPERATING FREQUENCY—To obtain long detection ranges for antisubmarine warfare, it is necessary to operate at a frequency considerably lower than that used by conventional sonar systems. Conventional transducers of either the piston or omnidirectional types become large, heavy and expensive when designed for low-frequency, high-power operation. The Sefar transducer is said to be light, inexpensive, and efficient in this operation.

Power-to-weight ratios of over 30 watts/lb are possible in end-fire design. In a prototype built by Acoustica, a 13-ft waveguide for 10 kc was successfully tested.

Tests of the unit show a maximum directivity index of 21 db. At input power levels to 2 kw, sound source remains linear and shows no sign of failure. A maximum efficiency of over 60 percent at 10 kc has been measured.

TUNNEL DIODES—Rising interest in the tunnel diode as a circuit element is reflected in reports from RCA Laboratories and General Electric Co.[2,3] Experimental investigations of this versatile new component indicate high versatility and flexibility.

The frequency range of this device extends well beyond that of transistors. It appears that germanium tunnel diodes are capable of operation at frequencies up to 10 kmc, and the use of other materials, such as GaAs and InSb, would permit operation at even higher frequencies. Also, since the tunneling effect does not depend on minority carrier lifetime, the device is remarkably temperature-independent, and tolerant to nuclear radiation effects.

I-F AMPLIFIER—In the RCA experiments, a circuit for a 30-mc i-f amplifier was designed and tested. Fig. 1 shows the schematic for the circuit. The capacitance of the tunnel diode D_1 is tuned by the autotransformer T_1. The input signal is a current source I_1 with shunt conductance G_1 while the output load is the shunt conductance G_2. These are matched to the diode conductance by the autotransformer.

Capacitance C_o serves as a blocking capacitor for the bias current and a parasitic suppressor to prevent oscillation in the d-c circuit.

To use the diode as an amplifier, it must be operated on the negative-resistance portion of its I-V characteristic. In establishing the operating point—obtained by setting V_o—r_o, the supply resistance, is made very much less than R, where R is the magnitude of the diode negative resistance. Under

Table I—Tunnel-Diode Amplifier Performance at 30 mc

Diode Current μa	Diode Conductance, millimhos	Power Gain db	Bandwidth mc	Noise Factor db
250	−2.7	20	0.2	4.5
300	−3.2	40	0.19	6.3
350	−4.8	27	0.8	8.0

this condition, the capacitance of the diode will resonate with the inductance of the autotransformer plus the isolation inductance L_o in the d-c circuit.

In the experimental circuit, the diode had a peak current of 0.5 ma, a capacitance of 40 $\mu\mu$f, and a nominal negative conductance of 6 millimhos. The amplifier was operated at 30, 66, and 80 mc with stable gains of about 20 db. Table I gives the measured values of gain, bandwidth, and noise. The gain was changed by varying the d-c operating point and the load resistance.

MANUFACTURING ADVANTAGES — GE points up the manufacturing advantages enjoyed by the germanium and silicon diode. It is shown that the semiconductor material used in the fabrication of tunnel diodes does not have to be single-crystal. This holds true even for the part in contact with the junction region.

Tunnel diodes have been made by alloying onto polycrystalline germanium, although their characteristics have not been as good as those using monocrystals. Studies show that it may be feasible to produce tunnel diodes by deposition techniques.

GE experiments indicate that a practical upper limit for germanium tunnel diodes exists at approximately 200 C. One of the most striking features of both silicon and germanium diodes is the wide temperature range over which a negative resistance characteristic is obtained. Experimental units have displayed negative resistance characteristics from 4.2 K to over 400 C.

The GE paper lists many potential applications for the tunnel diode, including the mixer-oscillator circuits shown in Fig. 2, and the uhf transmission line oscillator circuits shown in Fig. 3.

BIAX — Ford Motor's Aeronutronic Division divulged details of its new Biax magnetic memory and logic elements previously reported in ELECTRONICS (p 31, Aug. 28). Operating on a principle of flux interference rather than flux steering, as is used in most multiaperture devices, Biax units are made from conventional ferrite materials, are reportedly an order of magnitude faster than present magnetic devices, and are capable of operation at high temperatures.[4] One prime advantage is the unit's nondestructive READ characteristic.

The Biax memory element contains two nonintersecting orthogonal holes. One production element measures 50 by 50 by 85 mils, and has two 20-mil square holes. Distance between the holes is identical to the distance between the inner and outer walls of each hole. Basic concept is that of flux interference which occurs in the magnetic material between the orthogonal holes.

The flux around each hole must share this common volume of ferrite material, and a change in the flux linkage around one hole causes a change in the flux linking the other hole. Flux interference can be controlled by varying the distance between the two orthogonal holes. The hole spacing in the Biax memory element is chosen so that this interference is reversible, thus providing a nondestructive memory element.

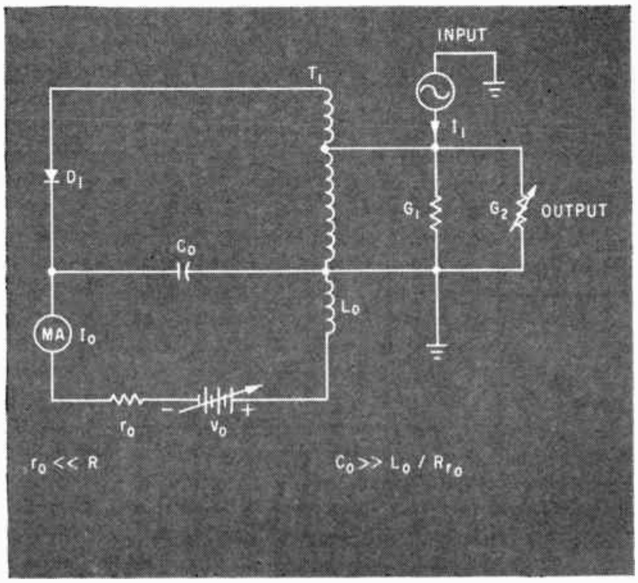


FIG. 1—30-mc i-f amplifier using an RCA tunnel diode

THEORY—The storage hole (upper hole), shown in Fig. 4, contains the conductors associated with writing into the memory element, and the sense winding. The interrogate hole contains conductors associated with reading or interrogation of the element.

Complete magnetic saturation around a given hole can be achieved only if all the domains in the volume between the two holes are favorably oriented. Thus, if an attempt is made to saturate both holes simultaneously, the flux linking each hole is reduced to approximately 7/10 of that which could be attained if one of the holes had no net flux linking it.

A slightly different geometric configuration permits Biax to be used as a logical gating element and as a flip-flop. Two intersecting orthogonal holes result in a magnetization-demagnetization type of operation, completely different from the operation of the memory element.

ADVANTAGES—Aeronutronic claims several advantages of Biax as used for logic applications. ORing of a large number of AND gates, without the problem of poor signal-to-noise ratio, is possible because of the inherent high signal-to-noise ratio (approximately 100) by the Biax AND gate.

Biax is applicable at high speeds because of the small volume of magnetic material employed, and the fact that its operation is not critically dependent upon the shape of the hysteresis loop. A 0.5-μsec cycle time per AND-OR is being used at present.

The use of transistors as output drivers is made possible by the low drive current requirements of Biax logic elements. Transistors may also be used for clock sources associated with logic set-up and logic strobe pulse generation.

INTERPLANETARY COMMUNICATION — Long-distance communications problems associated with

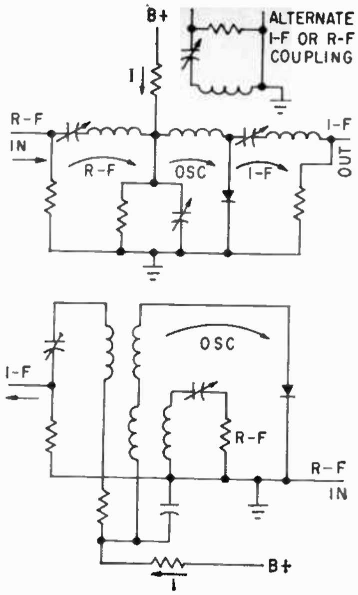


FIG. 2—Use of tunnel diodes greatly simplifies mixer-oscillator circuits

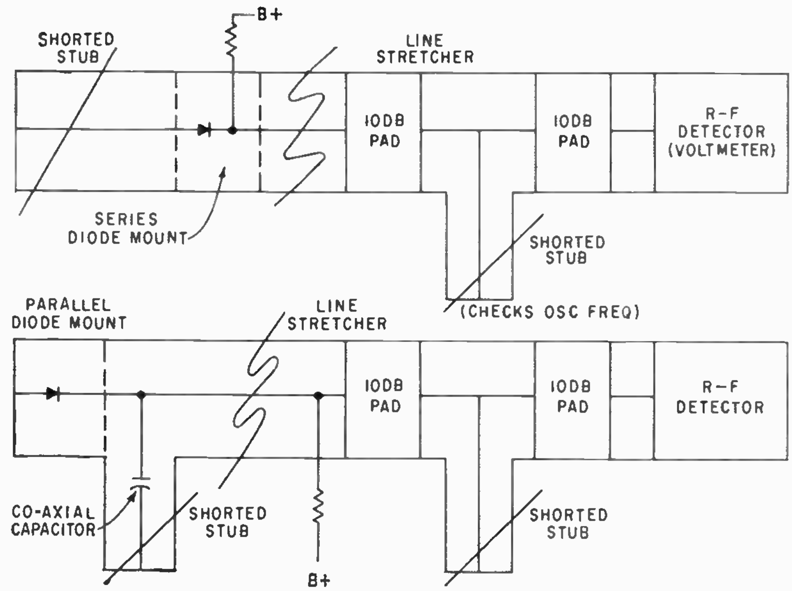


FIG. 3—Uhf transmission line oscillator circuits such as these have oscillated at fundamental frequencies up to 650 mc

space probes and satellites has evoked considerable interest. In a paper on the subject by members of the technical staff of Space Technology Laboratories, it has been pointed out that the Microlock system used in the Pioneer series of lunar probes, although capable of operating to lunar distances with a transmitted power of about 100 mw, suffers from several serious disadvantages.[5] The information bandwidth is fixed, the channel efficiency is low, the analog nature of the telemetry system makes it prone to degradation on retransmission or rerecording and the information must be transmitted in real time.

In an attempt to overcome these disadvantages, a digital telemetry system, called Telebit has been developed. With the same power as formerly used it permits the transmission of eight bits of data per second. On command and for transmission at greater or lesser distances, it can change power and transmit either one bit or 64 bits per second. This system is part of the Explorer VI payload which is producing data from several sophisticated experiments.

TRANSMISSION PROCESSING—The payload accepts information from both analog and digital experiments and processes this information until it is in a form suitable for transmission. The ground portion of the Telebit system consists of several stations located throughout the world. Here, payload transmissions are received and relayed to a central processing station for rapid processing and presentation. A transistorized memory located in the payload permits accumulation of information when nothing is being transmitted. It also commutates several types of input information to produce a time-multiplexed train of pulses containing the data from a variety of experiments.

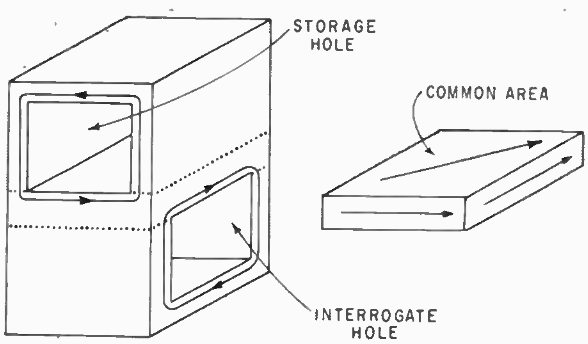


FIG. 4—View of Biax memory element shows flux relationships

Since analog information does not directly lend itself to any simple means of accumulation, conversion of analog data to digital form is necessary and is accomplished by a 64-level digital ramp.

For transmitting the data in the form of binary digits to the ground, a system of biphase modulation is used on a subcarrier which phase-modulates the r-f carrier. This technique has the advantages of providing a continuous carrier for acquisition and tracking from the ground, and an unambiguous resolution of the pulse data through the use of an adjacent pulse comparison biphase demodulator without a ground coherent oscillator.

The Telebit system, it is claimed, approaches the optimum physically realizable modulation system.

MASERS FOR RADAR—The feasibility of using a maser amplifier in an active radar system has been demonstrated at X-band in experiments conducted at Hughes Research Laboratories in Culver City, California.[6] The maser amplifier employed was a reflection type designed for an X-band signal and a K-band pump.

In the experiment a maser cavity was completely filled with ruby material. Al_2O_3, the host lattice, was doped with 0.05 percent chromium as the paramagnetic element and was made to be doubly resonant at both the signal and pump frequencies.

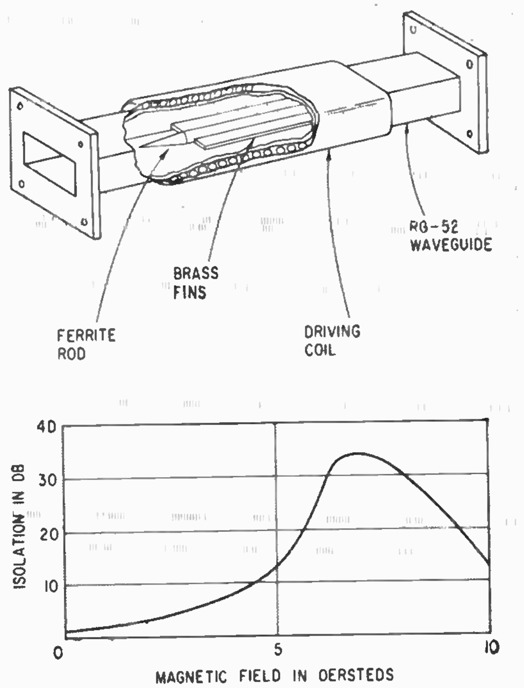


FIG. 5—Ferrite switch designed for use with maser preamplifier and isolation characteristics

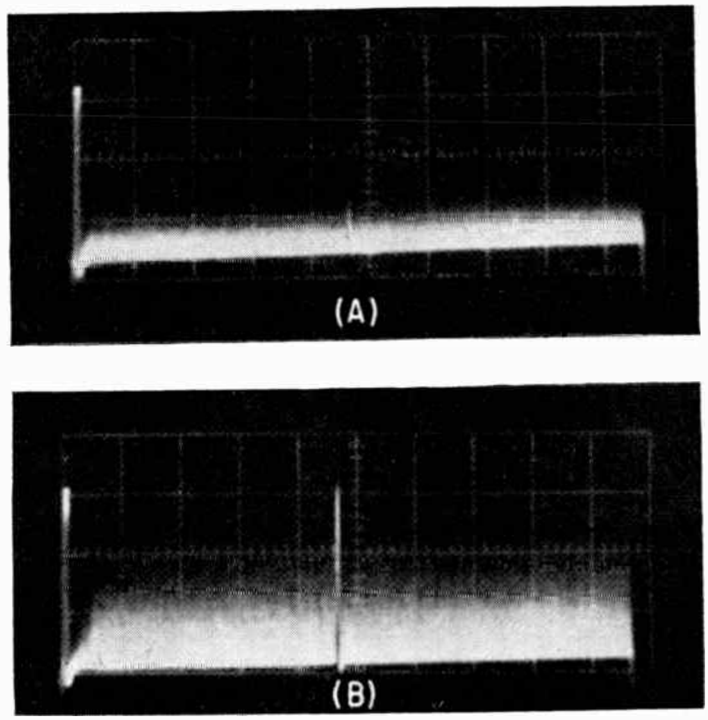


FIG. 7—A-scope presentation before (A) and after (B) maser is connected into radar system

When used as a preamplifier in a radar system, the maser is installed ahead of the receiver mixer and is subjected to the T-R leak-through power of the transmitted pulse. The level of this power ranges from one mw to 10 mw. The maser will not operate as an amplifier in the presence of leak-through pulses greater than 10 mw since this amount of power equalizes the population of the energy levels which are responsible for the gain. As a result of preliminary tests, it became obvious that additional isolation from that ordinarily available for T-R operation was necessary to obtain gain-bandwidth products of 30 mc or greater with the maser.

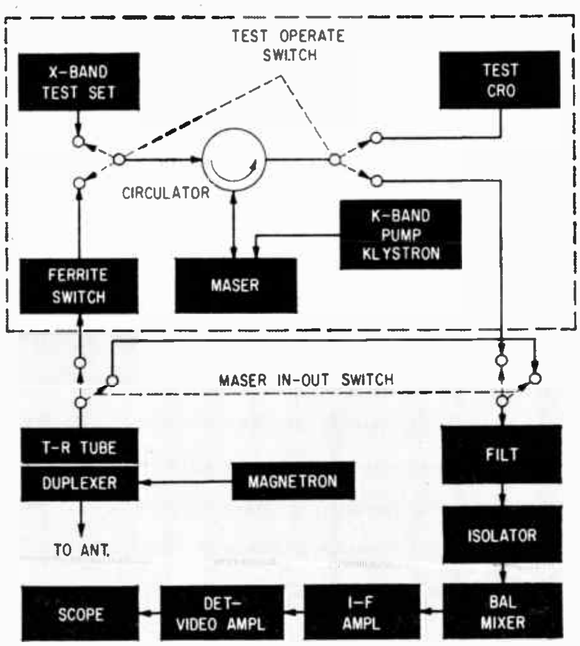


FIG. 6—System block diagram of X-band radar using maser preamplifier

FERRITE SWITCH—The additional attenuation was obtained from an active ferrite switch. This switch is shown in Fig. 5 with a plot of isolation as a function of magnetic field. The insertion loss obtained with this switch is less than 0.25 db and the isolation is greater than 30 db over a 120-mc band. The current pulse driver is synchronized with the radar so that the ferrite switch is activated when the transmitter is on. The block diagram for the system is shown in Fig. 6.

The effects of using a maser as a low-noise preamplifier in the radar system are shown in Fig. 7.

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(1) D. R. Church, Acoustica Associates, Plainview, N. Y., A New Type Directive Sound Source for Long Range Sonar.

(2) H. S. Somers, Jr., K. K. N. Chang, H. Nelson, R. Steinhoff and P. Schnitzler, RCA Laboratories, Princeton, N. J., Tunnel Diodes for Low Noise Amplification.

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(5) G. E. Mueller, J. E. Taber, Space Technology Laboratories, Inc., Los Angeles, Cal., An Interplanetary Communication System.

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Using Low-Frequency

National Bureau of Standards 60-kc standard frequency transmission is monitored by simple coherent detector to check local frequency standards to accuracy of 5 parts in 10^{10}

By **H. F. BURGESS and M. C. JONES,** Sandia Corp., Sandia Base, Albuquerque, New Mexico

RESEARCH AND DEVELOPMENT programs continue to demand greater and greater accuracy in the measurement of frequency and time. To meet this need, the frequency stability of the quartz-type frequency standard has been greatly improved. However, the full possibilities of these improved oscillators can be severely limited by the system of comparison used to standardize them with WWV or other standard frequency signals.

To realize the greatest accuracy from a quartz-controlled frequency standard, periodic checks must be made with a primary source such as the National Bureau of Standards transmissions. If the transmission distance is more than a few miles, serious errors can result from the propagation variations inherent in high-frequency broadcasts.

These errors can be in the order of 3 parts in 10^7 if short-period direct comparisons are used. This figure can be improved somewhat by using one of the methods of comparison that extends over long periods of time or requires a series of measurements. However, in many of these long-period systems, a minor equipment failure can nullify all data that has been collected.

NBS Transmission

It has been shown that if standard-frequency transmissions are made on a frequency below 100 kc the error due to propagation variation is greatly reduced and for many uses can be ignored. In July of 1956, the National Bureau of Standards began an experimental broadcast of a standard frequency on 60 kilocycles. These transmissions originate at the Boulder Laboratories located in Boulder, Colorado and sign the call KK2XEI. The 60-kc service now being offered by the NBS consists of a continuous unmodulated carrier with the call keyed on the hour and at twenty-minute intervals. At the present time transmissions begin at 8:30 AM M.S.T. on Monday, Tuesday, Wednesday, and Friday. Transmissions stop at 3:00 PM M.S.T. on Monday, Tuesday, Thursday, and Friday. Transmission is continuous from 8:30 AM M.S.T. on Wednesday until 3:00 PM M.S.T. on Thursday. Correction factors are issued regularly for each day's transmission.

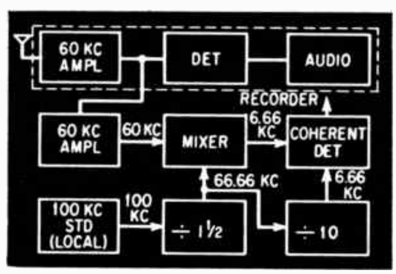


FIG. 1—Upper three blocks are portions of Navy RBL-5 receiver

This signal now provides a primary reference source of frequency that is relatively free of propagation errors. With a minimum of equipment, 100 kc standards can be compared to an accuracy of 1 part in 10` in a single 15 minute reading under adverse receiving conditions. With good reception this figure can be extended to 5 parts in 10^{10}. With an increase in comparison time this figure can be increased.

The first attempt at reception of these signals quickly pointed up several important facts. The high summer static level of this frequency range and the fact that this frequency is a direct harmonic of the power line frequency dictated a narrow-band system. Secondly, the low-level of the received signal made it necessary to operate all comparison equipment on a frequency other than 60 kc. Any attempt to display the amplified 60 kc signal on an oscilloscope resulted in feedback and instability due to radiation from the scope deflection system.

Comparison System

The system developed uses a combination of heterodyne action and frequency division. The actual frequency comparison operation is accomplished at 6.666 + kc. Because of the system used, any error that is indicated by the readout equipment will be the error existing at 60 kc. (Example: a 1-cps difference indicated at 6.666 kc will be an error of 1 part in 60,000.)

The block diagram of Fig. 1 shows the overall plan of the system. The receiving section in the area inclosed with the dotted line is a modified Navy model RBL-5 receiver. This originally consisted of two tuned radio frequency stages followed by a detector and audio section. The input to a third trf amplifier stage is parallel with the detector grid and is used to drive the comparator system. The original detector and audio system is used only for audio monitoring during tuning operations.

The local 100 kc standard signal to be compared is fed to the first divider which lowers it to 66.666+ kc. This signal is then split two

Standard Broadcasts

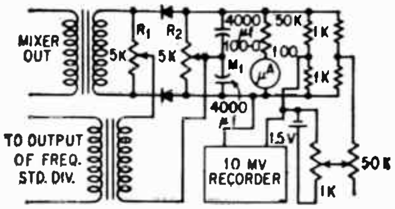
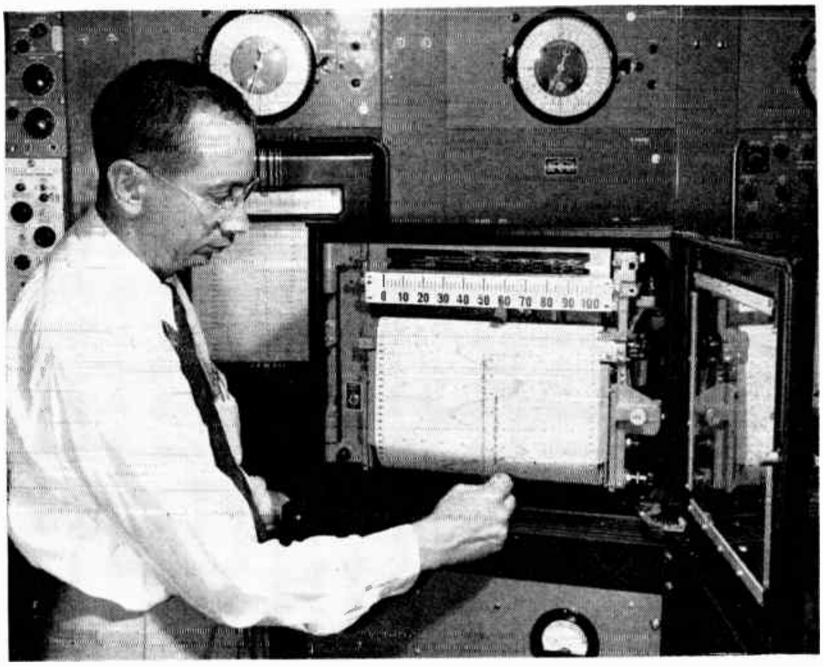


FIG. 2—The coherent detector is of simple design but effectively reduces noise



Deviation is measured with special scale drawn on plastic. This method gives a quick estimate of the frequency of the local standard. Ruler is constructed from information given in Table 1

ways. A portion drives a mixer to be heterodyned with the received 60 kc to produce a 6.666 + kc signal. The remainder of the 66.6 kc is divided again to produce a second 6.66+ kc signal. The result is two 6.66+ kc signals.

Phase Detector

To provide noise cancellation and give the effect of a very narrow band pass, a coherent type of phase detector is used to compare these signals.

The output of this detector is a d-c voltage that rises to a maximum, then passes back through zero to a maximum of opposite polarity and back to zero for each cycle of deviation. A zero center meter is used as an indicator for tuning and a zero center pen recorder produces a permanent record.

The coherent detector shown in the schematic of Fig. 2 is of a very simple type. However, even in this simple form it has the ability to go below the noise level and bring up a usable signal. A good recording can be made on days when the signal is inaudible due to noise. To put the detector in operation resistors R_1 and R_2 are adjusted to the position that gives a zero center meter reading on M_1 when either the received signal or the local standard signal is removed.

Bridge

The bridge shown in the recorder input circuit provides a d-c bias to bring the pen to center scale without biasing the detector diodes. When the detector and recorder are used as shown, this method of detection has the effect of giving a bandwidth of little more than 1 cps. Deviation of the local standard can be computed from the time required for one cycle of trace.

The recording paper travels at a rate of five inches per hour in the present system. Table I shows the length of paper travel for a one-half cycle trace and the corresponding deviation in parts in 10^9. A ruler was constructed from the information in this table and by using it deviation can be read from the chart paper in one simple operation.

Circuits in the system are straightforward. The first divider used to lower the local 100 kc signal to 66.66 + kc is of the locked oscillator type. It consists of an ordinary cathode coupled oscillator with a controlled amount of locking voltage fed to the grid that is normally grounded. Although it is dividing by the odd value of 1.5 it has maintained continuous lock for more than a year.

It has been found that the factor most likely to cause failure in the use of this standard signal on 60 kc is local line noise. Due to the harmonic relation of line frequency to signal frequency, any harmonic generating device such as fluorescent lights can completely cover the signal. However, a high percentage of this type of noise enters the system through multiple grounds. Floating the entire system by means of a line isolation transformer in the 60 cycle supply can mean the difference between no signal and a good recording.

Table I—Recording Paper Travel

Deviation in Parts per 10^9	Recorded Length of One-half Cycle
10	1.160 in.
9	1.289 in.
8	1.450 in.
7	1.657 in.
6	1.933 in.
5	2.320 in.
4	2.900 in.
3	3.867 in.
2	5.800 in.
1	11.600 in.

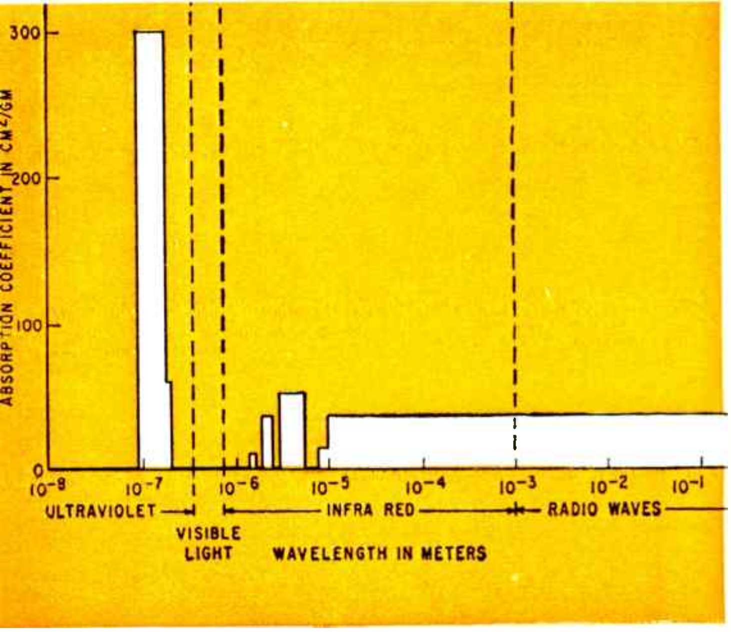


FIG. 1—Absorption bands of electromagnetic energy for water vapor as a function of wavelength

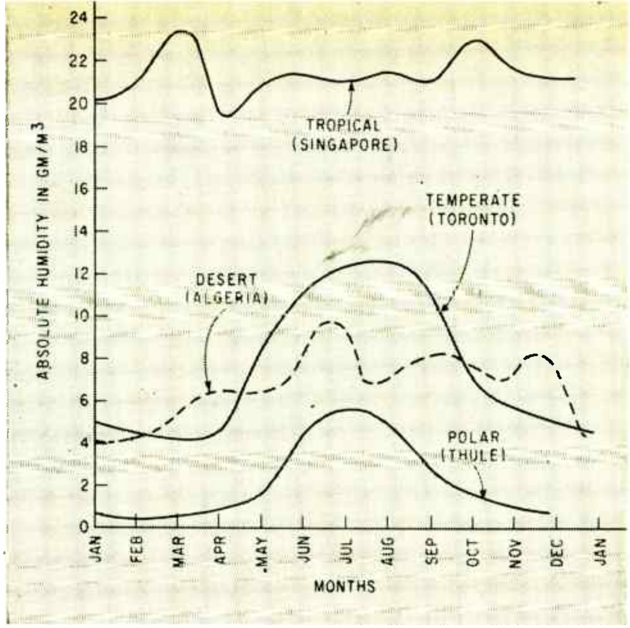


FIG. 2—Typical values of yearly absolute humidity for several different geographic regions of the world

What Designers Should

Are standard humidity tests for electronic equipment realistic? On the contrary, say the authors, correlation of failure rate with sample testing is extremely difficult. Understanding the mechanism of failure in a humid environment can help lick the problem

By A. P. HARRIS and E. W. PARROTT, Military Electronics Standards Agency, Dept. of National Defence, Ottawa, Canada

OF ALL THE ENVIRONMENTAL conditions to which surface electronic equipment is exposed, there is evidence that a combination of heat and humidity is by far the most destructive.

The broad problem of humidity's effect on electronic equipment can be appreciated by examination of the characteristics of water in its various states, the material conditions of humidity and the methods by which it may enter electronic equipment.

Although humidity is not a destructive environment beyond altitudes of 32,000 feet, humidity effects may still be a problem with the electronic equipment of space vehicles. While humidity has always been associated with a ground environment, and sealing has been provided to keep moisture out, one of the problems of space electronics will be to keep the moisture in.

It is the purpose of this article to present some of the problems which face the designers of ground and space electronic equipment.

PROPERTIES OF WATER—An understanding of humidity phenomena begins with knowing the water molecule and the properties of the liquid and solid states.

The water molecule is asymmetric and consists of two positively-charged hydrogen atoms attached to the same side of a negatively-charged oxygen atom. This structure gives the molecule a partial positive charge on one end and a partial negative charge on the other; while the molecule as a whole is electrically neutral, it has polar characteristics which influence its electrical behavior.

Table I is a synopsis of the properties pertinent to the phenomena discussed in this article, particularly the mechanism of entry into electronic parts. Most of these properties change widely with temperature.

In the solid or liquid state, there are always some water molecules with sufficient energy to break from their molecular bonds near the surface and escape. These molecules form a vapor near the surface and produce a measurable vapor pressure. In natural atmospheric conditions, this vapor pressure together

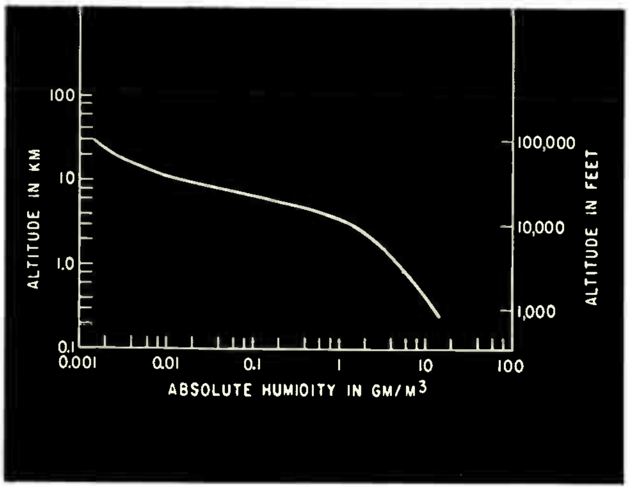


FIG. 3—Absolute humidity as a function of altitude in the Temperate Zone

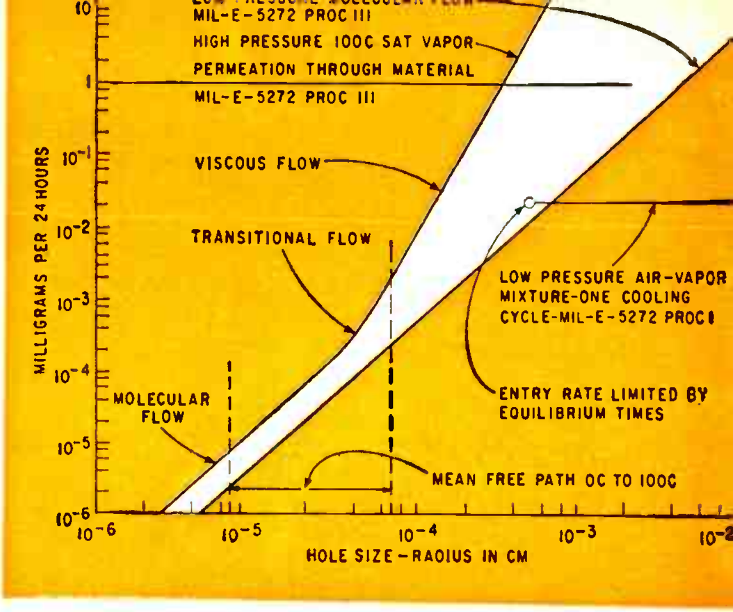


FIG. 4—Predicted rates of entry of water vapor for various hole sizes

Know About Humidity

with the pressures of other gases in the air forms the total atmospheric pressure.

Water vapor has two electrical properties of direct interest. These are: that an increase in absolute humidity will raise the flashover voltage between two electrodes, and that the vapor can absorb electromagnetic energy. In a radiant field the molecule can stretch symmetrically or asymmetrically, deform or rotate. If it rotates, it may do so in several ways as it has three principal moments of inertia. These stretching or rotational movements can occur singly or in combination depending on the frequency of excitation. There are many frequencies and bands of frequencies where vapor can absorb energy from an electromagnetic field and these are shown in Fig. 1, with the amount of energy absorption.

NATURAL HUMIDITY CONDITIONS—Absolute humidity in nature varies widely with geography. As air temperature is the controlling factor, it is highest in warm areas and lowest in cold. Both the rate of evaporation and the ability of air to hold water vapor are lowest in cold regions. At ground level the mean values of absolute humidity range from 0.1 gm/m^3 in polar regions to about 27 gm/m^3 in equatorial regions. Occasional values as high as 32 gm/m^3 have been recorded.

There are many factors which influence the absolute humidity at any given location. Considering only the broadest classifications and typical values, Fig. 2 shows the mean absolute humidity for four areas on a yearly basis. These geographic areas can be classed as polar, tropical, desert and temperate and

Table I—Properties of Water

Molecular weight	18.02
Diameter of molecule	3.4 Angstroms
Mean Free Path	7 × 10^{-5} cm
Liquid State	
Viscosity	0.9 centipoises at 25 C
Surface Tension	71 dynes per cm at 25 C
Absolute Density	0.998 gm per cc at 20 C
Volume Resistance	20 megohms per cm^3
Dielectric Constant	79 at 25 C, 1 mc
Loss Factor^a— 10 kc	2 at 25 C
100 kc	0.3 " "
1 mc	0.028 " "
Vapor State	
Viscosity	98 micropoises at 25 C

Coeff of Diffusion		0.239 sq cm per sec at 25 C
Vapor Pressure—(saturated)		
	0 C	4.5 mm of Hg
	25 C	23.6 " " "
	100 C	760 " " "
Absolute Humidity (saturated)		
	0 C	4.8 gm per meter^3
	25 C	23 " " "
	100 C	598 " " "
Density—(saturated)		23 gms per meter^3 at 25 C
Permeability Coeff.		1.6 × 10^{-10} cgs

(a) conductivity water.

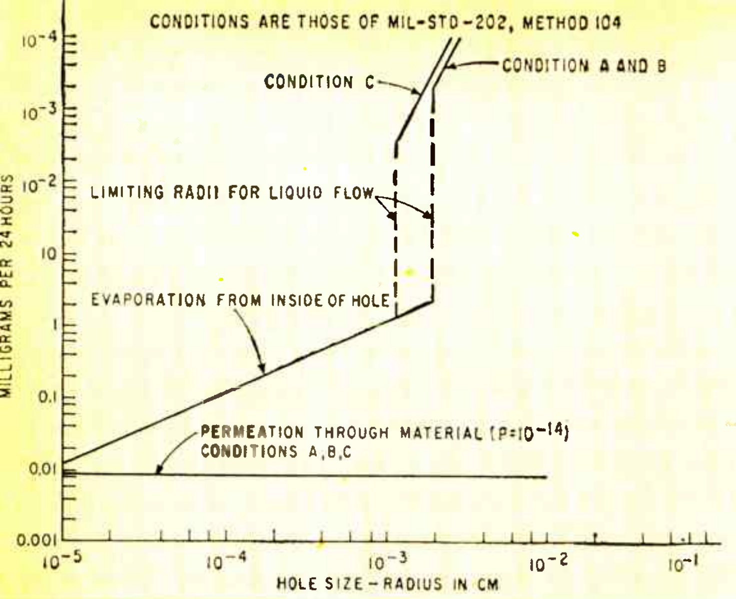


FIG. 5—Predicted rates of entry of liquid water for various hole sizes

the yearly cyclic changes in the areas are evident.

At high altitudes there is low pressure in conjunction with low temperature, and these conditions limit the absolute humidity to extremely small values as shown in Fig. 3.

EFFECT ON PARTS AND MATERIALS—A typical analysis of field failure data, as in Table II, demonstrates that under natural conditions of temperature and humidity the failure rate of conventional ground equipment is higher than for any other environment. Correspondingly the failure rate of electronic and electrical parts under laboratory test, as shown in Table III, shows humidity as a greater cause of failure than most other simulated environments. The humidity test condition here is that of MIL-STD-202 or equivalent.

How does water vapor affect the characteristics of parts to cause this high rate of failure?

When any object is placed in a high ambient humidity, there are three general occurrences: (1) if electromagnetic energy is present there will be absorption of energy in the surrounding vapor; (2) a thin film of liquid water will form rapidly on the object, up to 180 molecules thick; (3) there will be penetration of vapor into the object by various mechanisms which will be described.

The effect of wave energy absorption on the parts is principally a "loading" effect on inductive elements. The formation of films on parts and materials is of greater significance. Because of impurities on the surface, the water film rapidly becomes ionized. This film then provides a conducting path as well as a capacitance effect due to the high dielectric constant. These effects appear in electrical measurements as changes in insulation resistance, surface resistivity, inductance, capacitance, dissipation factor and Q. Surface arcing resistance is lowered. The penetration of liquid or vapor into an organic material can cause dimensional changes, lowering of flexural strength, and in some cases an improvement of impact strength.

How much water absorption, or entry, can electronic parts tolerate before failure occurs?

A MIL-specification RC20 composition resistor will exceed electrical tolerances if the weight of water absorbed exceeds 0.9 gm or 0.2 percent by weight. Most capacitors will show unacceptable performance if the absorption in the dielectric exceeds 0.1 percent by weight. Quartz crystals are particularly sensitive and MIL-specification units will fail if the vapor inside the can is more than 0.004 percent by volume.

MECHANISMS OF ENTRY—Water can enter equipment either by diffusing through a material forming part of the equipment or by entry through a hole in the sealing of the equipment. Moisture can only permeate a material if the molecular spacings are larger than the diameter of the water molecule, which is true of most organic materials.

The rate at which moisture diffuses through the molecular structure of a material is proportional to the exposed area and the gradient of the vapor pressure in the direction of flow.

The time required for the initial wave of moisture to travel into the material depends on the diffusion constant of the material. After a steady state has been established, moisture continues to flow through the material, the amount depending on the permeability constant. Though the mechanical design of a seal may be perfect, moisture may still enter by diffusion through materials. Table IV lists the permeability constants of common organic materials used in electronic equipment.

VAPOR—Vapor will not enter a hole smaller than the diameter of the molecule.

As an environment of 100-percent water vapor exists only under special conditions, the mechanisms of vapor entry into leaks must take into account the presence of air with vapor. There are two general conditions: (1) a low vapor pressure condition where the environment is less than 50 percent water vapor; (2) a high vapor pressure condition where the environment is 50 to 100-percent water vapor.

Each of these conditions has its own mechanisms of entry and the entry rates can be calculated. As there is a 50-50 ratio of air to vapor when air is saturated at 80 C, low pressure processes usually apply at saturation below 80 C and high pressure processes at saturation above 80 C.

LIQUID—An immersion test in liquid water is also a vapor test and water can enter the test sample in either liquid or vapor form.

When the hole radius is greater than 2×10^{-4} cm liquid water will enter, depending on the pressure and the resistance of the channel. The resistance depends on the fourth power of the radius, the viscosity and density of water and the channel lengths. The pressure can be hydrostatic pressure or a pressure differential caused by temperature difference.

With leaks smaller than 2×10^{-3} cm, surface tension prevents a flow of liquid water within the temperature range under consideration. However, the leak channel may fill up with water, and evaporation

Table II—Failure of Military Equipment and Materials Under Various Environments

Equipment and Materials	Temp-Humidity	Dust	Humidity	Radiation	Salt Spray	High temp	Low temp	Temp. Range
Electronic and Electrical Equipment	17	3	10	1	—	14	14	17
Lubricants, Fuels and Hydraulic Fluids	—	1	—	—	—	8	4	11
Metals	10	—	9	—	26	8	5	4
Optical Instruments and Photo Equipment	5	1	3	—	—	—	—	3
Packing and Storage	9	—	9	—	—	—	—	6
Textiles and Cordage	14	—	5	11	—	3	—	2
Wood and Paper	12	1	4	—	—	2	—	5
Total	67	6	40	12	26	35	23	48

Table III—Failure Rate of Electronic Parts in Percent

ITEM	Test Spec	Max No. Samples	Temp-Humidity	Temp Extremes	Temp Cycling	Vibration	Shock	Salt Spray	Life
Resistors, Composition	MIL-R-11	383	3.65	—	0	0	—	—	3.21
Capacitors									
Tantalum	MIL-C-3965	436	14	18	—	4.5	0	—	28
Paper	MIL-C-25								
Plastic Film	MIL-C-25	305	24	—	28.2	11.1	—	8.5	21.6
Inductors	MIL- -15305	204	8.8	8	0	0	—	—	—
Paints, Baked Semi-gloss	JCNAAF-P-201	515	21.9	—	0	—	—	12.5	—
Rectifiers, Selenium	MIL-R-11050	102	30	—	5	3	1.1	36	16.5
Relays	MIL-R-5757	227	30	—	—	55.8	32.5	—	37.9
Connectors, Multicontact	MIL-C-8384	195	18.1	—	5.1	1.9	8	11.2	—
Crystal Units	MIL-C-3098	540	5.3	4.25	—	1.1	0.22	8.4	—

can take place from the end of this "plug" of water. The rate of vapor entry depends on thermal conditions, the channel radius and the permeability coefficient of vapor in air.

With smaller leaks, liquid water does not enter the channel but vapor from the water diffuses through the channel. Effectively this is the same as placing the container in a vapor atmosphere and the same mechanisms of entry apply. The vapor pressure in this case is the saturated vapor pressure corresponding to the water temperature.

When these mechanisms are used to calculate rates of entry under the standard test conditions of MIL-E-5272 and MIL-STD-202 (Method 104), the predicted rates of entry for various hole sizes appear as in Figs. 4 and 5.

HUMIDITY TESTING—What are the actual conditions in the humidity test chamber? To compare these test conditions with natural conditions, and with each other, two standard MIL test cycles have been redrawn to show the vapor pressure in the chamber. Figure 6 shows the vapor pressure conditions of MIL-E-5272 and MIL-STD-202. The maximum vapor pressure conditions in the first case is 232 mm Hg and in the second 200 mm Hg. The corresponding maximum absolute humidities are 244 and 172 gm/m^3.

Cycles with different vapor pressures and timing can produce almost identical entry rates. Steam at 100 C causes entry rates 2,200 times as great as the most severe test cycle. Liquid immersion can produce large entry rates if the hole size is larger than 2 $\times$ 10^{-3} cm. Under the conditions stated, 2 weeks of

Table IV—Permeability Constants of Organic Materials

Material	Range	Average
Laquer	21 –195	69 $\times 10^{-15}$
Varnish	16.8–77.7	36.1 $\times 10^{-15}$
Paints	14.7–71.5	31.1 $\times 10^{-15}$
Polystyrene		8.4 $\times 10^{-15}$
Wax—Hydro Carbon		0.12 $\times 10^{-15}$
Wax—Paraffin		3.1 $\times 10^{-15}$
Rubber—Soft Vulcanized		13.4 $\times 10^{-15}$
Hard		3.1 $\times 10^{-15}$
Gutta Percha		2.9 $\times 10^{-15}$
Chloroprene		5.4 $\times 10^{-15}$
Paper—Kraft		540 $\times 10^{-15}$
Asphalt Sealing Compound		2.3 $\times 10^{-15}$

Note: (1) Units are grams/second/cm/dyne per sq cm
(2) Values are for room temperature, atmos pressure

MIL-STD-202, Method 106 is equivalent to 7 weeks of natural tropical exposure.

DESIGNING AGAINST HUMIDITY—From the knowledge that the absolute humidity reaches negligible proportions above 10 km (32,000 feet), and that space is a dry place, it might be assumed that humidity problems are over for missiles, satellites and space vehicles. This is not quite the case.

A missile with a 5-hour life operating far beyond the humid belt of the atmosphere may have already existed for 3 years, stored in a humid ground environment. Even if the time from production to firing is short, the component parts in units and assemblies will have existed in a ground atmosphere for at least one year and possibly two. A satellite with a one year operational life is expected to have a one year storage life in addition to its life during the production stage.

The components of an interplanetary vehicle with a mission life of two years might be expected to spend equal time in both a humid and humidity-free environment.

In an unmanned satellite or space vehicle, where there is no need for an atmosphere suitable for humans, or where weight and space do not permit special humidifying apparatus, a problem exists which is the reverse of that of the ground atmosphere.

With an outside pressure of zero, if a leak in the seal occurs in the shell of the vehicle, the water vapor will escape with the same mechanisms by which it entered on the ground.

Consider a spherical satellite with a diameter of 1 foot where 50 percent of the volume is air. If this satellite is sealed at 25 C and 50 percent relative humidity, it contains 1.7 grams of water in the air plus an undetermined amount absorbed in the organic materials which make up the sensing apparatus.

If there is a leak of 10^{-3} cm radius, the water vapor in the air will theoretically leak out in 41 days. However, we would expect a release of gases from the internal materials as the pressure falls. These gases would include water vapor, organic gases of high molecular weight from the insulants, and gases from whatever chemical substances are present, such as unsealed batteries.

The effect of zero water content on the performance of electronic parts is not completely known. Insulating materials would certainly change their mechanical properties, sometimes for the worse, while their electrical properties would doubtlessly improve. The condition of sliding contacts would not be benefited and such contacts would suffer electrically from the presence of organic vapors. Any element relying on chemical action for its operation would deteriorate; for example, dry batteries cannot really be dry and operate.

The effect of absolute freedom from humidity on resistance elements and semiconductor devices is not known. Certainly, mechanical changes in the protective insulation used in such elements as deposited film resistors would be harmful.

Note that for MIL-STD-202 the test tolerances permit a difference in test conditions of 154 to 200 mm Hg. This is approximately a 30-percent difference in test severity.

In addition to the wide limits allowed in these two tests, a further variation must be considered arising from the inherent error in the method of measuring relative humidity. The 30-percent variation for MIL-STD-202 can be increased to 37 percent if normal errors in measurement are included.

PREDICTED ENTRY RATES—Knowing the mechanisms of entry, and the vapor pressure in simulated and natural conditions, it is possible to compare their relative severity in terms of the estimated entry of moisture. Table V shows such a comparison between common MIL tests and natural conditions.

For this comparison the following assumptions are made: when moisture enters the container it is completely absorbed by the contents, so that the internal vapor pressure remains unchanged; diffusion calculations are based on material with a permeability coefficient of 10^{-11}; entry takes place through a single hole of radius 10^{-3} cm; the rate of rise or fall in temperature is such that the temperature of the container equals the temperature of the air; allowable tolerances are chosen to produce the most severe conditions.

CONCLUSIONS—From this review of the problems of the humidity environment, several conclusions can be drawn: (1) the physical and electrical properties of water are critically dependent on temperature. Extensive, even radical, changes in its properties can occur over the temperature ranges associated with common military electronic equipment; (2) water in two states is readily absorbed in most materials used in electronic assemblies and will permeate through leaks in imperfect seals in parts and assemblies, even though these leaks are microscopically small; (3) the electrical properties of water are such that even very small amounts will alter the electrical characteristics

Table V—Comparison of Natural and Military Test Conditions

Conditions	Absolute Humidity gm/m³	Vapor Pressure mm Hg		Predicted Entry of Water			
				Through Material[a]		Through Channel[b]	
				Per 24 hrs Milligrams	Total Milligrams	Per 24 hrs Milligrams	Total for Test Milligrams
Test Conditions	Max	Min	Max				
MIL-STD-202							
Method 106	172	18.9	200	1.04	10.4	0.051	0.51
Method 104A & B	Immersion			——	——	——	85[c]
Method 104C	Immersion			——	——	——	1,350[c]
Method 103A	53.7	10.5	58	.6	6	0.033	0.33
Method 103B	53.7	10.5	58	.6	2.4	0.033	0.13
MIL-E-5272							
Proc I	213.8	16.6	232	1.41	14.1	0.071	0.71
Proc III	75.5	10.5	87.5	0.11	15.2	0.06	0.75
100 C Steam	598.0	——	760	8.62		113	
Natural Conditions	Mean						
Tropical—Singapore	25.8	22	27	0.27		0.014	
Temperate—Toronto	14.2	10.7	14.6	0.14		0.007	
Desert—Algeria	9.8	4	11	0.09		0.004	
Polar—Thule	6.5	4.4	6.3	0.06		0.003	

(a). Material assumed to be 1 sq cm, 1 mm thick. Permeabilty constant $P = 10^{-11}$
(b). Channel radius assumed to be 10^{-3} cm
(c). For comparison only as liquid flow applies only to channels larger than 2×10^{-4} cm radius.

of parts beyond acceptable limits; (4) the penetration of water through imperfect seals is largely a function of the water vapor pressure present; (5) the mechanism of vapor entry depends on whether the environment is one of low vapor pressure, or high vapor pressure. Natural humid conditions, with vapor pressure as low as 4 mm Hg or as high as 28 mm Hg cause entry by low-pressure mechanisms; (6) humidity tests produce vapor pressures about 8 times as severe as natural conditions. Such tests should not be regarded as simulation of nature but as leak tests; (7) liquid immersion tests can produce both severe vapor and liquid entry rates; (8) because of the severity of humidity tests, the wide tolerances permitted, the temperature dependence of the electrical characteristics of water, the formation of fugitive water films and possible variation in leak sizes, correlation by sample testing is difficult, sometimes impossible; (9) if humidity testing is regarded as a means to predetermine potential causes of failure rather than simulation of an environment, there are more effective and less time-consuming testing methods; (10) while there is negligible humidity at high altitudes, humidity is still a problem with missile and space vehicles as a large part of their early life is spent in a humid ground environment. Further during their functional life they may suffer from lack of humidity.

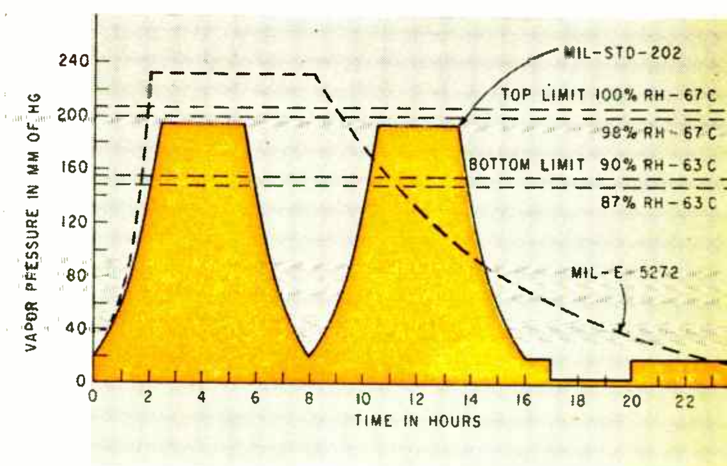


FIG 6—Standard moisture resistance test cycle redrawn to show vapor pressure in the test chamber

Digital Input for Precision,

By setting up the desired output frequency with a four-number digital counter, high accuracy, stability and repeatability are obtained over a wide band

By N. G. ALEXAKIS, Chief Engineer, Digital Instrument Labs, Subsidiary of Telemeter Magnetics, Inc., Los Angeles

OSCILLATORS OF HIGH precision and stability can be made from several relatively simple devices. Quartz crystals, tuning forks and other devices with mechanical resonance can operate at an accuracy of 0.0001 percent or better. When the desired frequency is outside the range of mechanical vibration, harmonics and subharmonics of the fundamental can often be used satisfactorily.

The main limitation of oscillators based on mechanical resonance is that they cannot be shifted in frequency except over an extremely small range. Only the harmonics and subharmonics of the oscillator can be used and it is impractical to cover a wide frequency band with this technique.

One example of the need for precise frequencies over a wide and continuous band is in present-day telemetry systems. Discriminators in f-m telemetry systems operate over wide frequency ranges and calibration is often necessary. Calibration procedures for zero checks and sensitivity checks require precise frequencies. A data-processing installation may have many f-m discriminators. A precision variable-frequency oscillator is desirable and time saving when contrasted with the typical variable oscillator and counter setup.

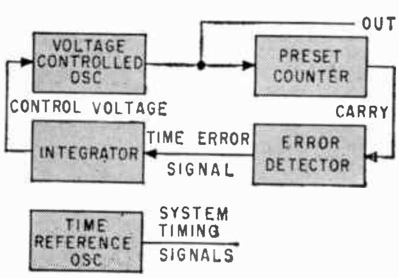


FIG. 1—Operating frequency is set in digitally at the preset counter. Digital servo loop holds the voltage-controlled oscillator at the desired frequency

Digital Servo Loop

A precision variable-frequency generator has been constructed as shown in the block diagram of Fig. 1. The basic elements are a voltage-controlled oscillator, preset counter, timing signal and error detector.

The desired output frequency is set up digitally in the counter. With the frequency set to four digits the accuracy will be 0.01 percent. A calibrated dial, even with a vernier, could not be set to this accuracy without a counter. Digital input also provides excellent repeatability.

The oscillator produces the output signal and also feeds the counter. The length of time needed to reach the number preset in the counter depends on the frequency of the oscillator. A separate timing signal of 1-second duration is developed from a crystal-controlled oscillator and a frequency-divider circuit.

The fixed reference time interval is compared with the variable interval required by the counter. If the variable time is less than the 1-second fixed interval, then the oscillator frequency is too high. If the variable time is greater than the reference interval, the oscillator frequency is too low. These time relationships are illustrated in Fig. 2.

The error signal thus developed is a constant-amplitude pulse of varying duration and either positive or negative polarity. The voltage-controlled oscillator requires a proper d-c voltage to reduce the error to zero. This voltage is derived from the time varying error signal by an integrating circuit.

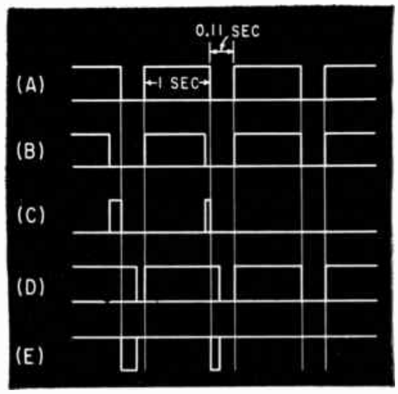


FIG. 2—One-second counting interval and 0.11-second correction interval are generated from crystal controlled oscillator (A); when variable-oscillator frequency is too high, time required to reach preset count is less than 1 second (B); time-varying error signal is derived from *A* and *B* (C); time to count a low frequency (D); error signal from *A* and *D* (E)

Integrator

The integrator circuit consists of a d-c amplifier with capacitance feedback as shown in Fig. 3. The output voltage of the integrator is $E_2 = Q/C$ where Q is the charge into the capacitor. Since C is fixed, the output voltage can be written as $E_2 = K_1 Q$, where K_1 is a constant. The charge is determined by $Q = E_1 t/R$ where E_1 is the amplitude of the error pulse and t is the duration. Thus, since the amplitude of E_1 is fixed, $Q = K_2 t$. Therefore the

Variable Oscillators

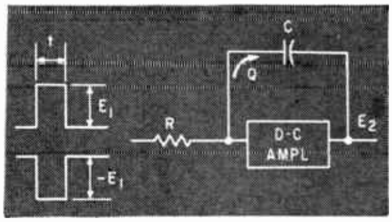


FIG. 3—Integrator circuit is typical d-c amplifier and feedback capacitor

output voltage is $E_2 = Kt$. Output voltage E_2 will be positive or negative depending on the sign of E_1.

The variable pulse width error signal has thus been converted to a variable d-c voltage which is proportional to the error in frequency.

Voltage-Controlled Oscillator

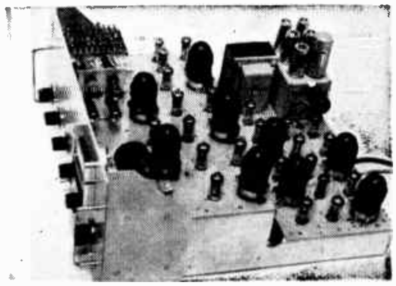
The voltage-controlled oscillator operates from 100 kc to 1 mc. When the counter is set to the desired frequency, extra switch contacts also set the oscillator to the same approximate frequency. The control voltage from the error-detecting circuit is approximately 20 volts and is sufficient to vary the oscillator 10,000 cps. Thus one millivolt of control voltage or noise will cause 0.5 cps frequency change. It is therefore desirable to limit the range of control voltage to reduce noise problems in the circuit.

While the oscillator itself operates only from 100 kc to 1 mc, the complete system operates from 1 cps to 1 mc. The lower frequencies are obtained by frequency division. A filter and gain-control circuit allows a sine or square wave at the output. Output voltage can be set from 0.1 volts peak to peak to 30.0 volts peak to peak in intervals of 0.1 volt. The complete circuit is illustrated in Fig. 4.

The preset counter samples the primary oscillator for one second. A correction interval of approximately 0.11 second follows the count interval. During the correction interval, the time error pulse is fed to the integrator and the preset counter is reset to zero for the next sample.

Since a new correction voltage is generated every 1.11 second, it is only necessary that the voltage-controlled oscillator not drift more than 0.01 percent during this interval. This amount is not difficult to accomplish, even with a simple oscillator circuit. Long term drift is immaterial, as long as it is within the correction range of the control voltage.

The one-second count interval is



Oscillator uses digital servo loop and decade dividers to obtain frequencies accurate to 0.01 percent of desired frequency. Range: 1 cps to 1 mc

derived from a 90-cps crystal-controlled oscillator. The accuracy of any selected frequency is thus tied to a crystal reference. Another signal obtained from the 90-cps oscillator is the 0.11-sec correction interval. The timing signals are routed through various AND and OR gates to perform the sampling and reset functions needed by the system.

Applications

The use of the precision variable-frequency oscillator in f-m telemetry systems has already been mentioned. Another area where oscillators of this type are useful is with automatic test equipment. The various units under test may require widely varying input signals and high precision is sometimes needed.

An advantage of the digital input oscillator is that it can be remotely controlled and operated. Stepping switches can be used to set the counter and the voltage-controlled oscillator.

Another example of possible use is as a secondary frequency standard. With a precision of 0.01 percent over its entire frequency range, the signal generator could serve as a laboratory frequency standard for many nonexacting applications.

In ultrasonics, barium titanate crystals and other types of transducers must often be matched closely for use in arrays. Frequency measurement to four significant figures is typical for many applications.

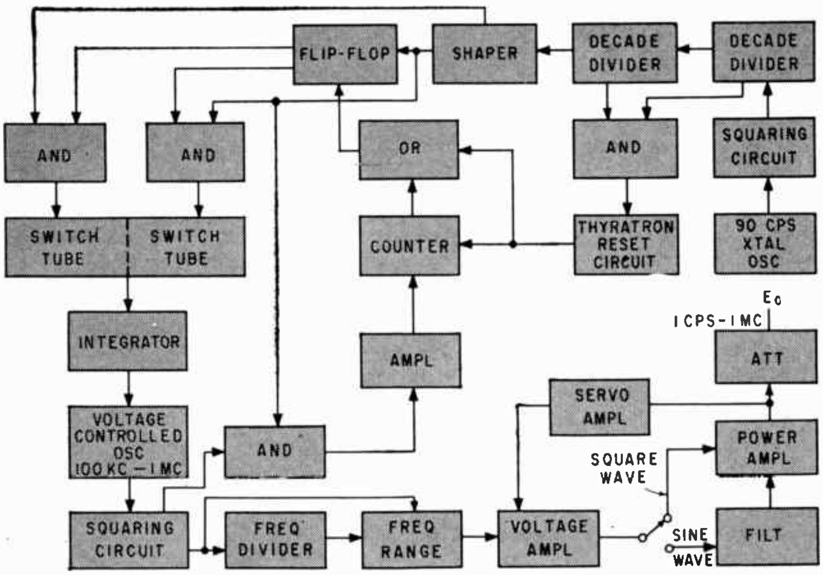


FIG. 4—Complete oscillator system produces square waves or sine waves over frequency range of 1 cps to 1 mc. Accuracy is 0.01 percent of desired frequency

Multiplexing Techniques for

Explorer VII satellite, now orbiting, is using this transistorized 10-channel multiplex system that accepts conventional as well as random pulse inputs. A portion of the system accepts variable impedance inputs

By **OLIN B. KING,** Army Ballistic Missile Agency, Redstone Arsenal, Huntsville, Alabama

SIGNAL-TO-NOISE RATIO is of prime importance in any data link. This ratio is affected by many factors such as bandwidth, transmitter output power, antenna gains and space loss. One of the few parameters which the satellite-link designer may manipulate to obtain improved signal-to-noise ratio is bandwidth. The transmitted bandwidth is a function of the information bandwidth as well as of the type modulation employed. The effective information bandwidth may be reduced appreciably by time-division multiplexing of a number of data channels with the resulting overall system improvements.

A multiplexer must be simple and reliable and moderate accuracy must be maintained over a wide range of environmental conditions. Size, weight and power consumption must be minimized. A 10-channel multiplexer designed for an Army IGC satellite is typical. Eight channels are available for information inputs. Fixed levels are applied to the other two channels. One of these levels corresponds to zero input and the other to 110 percent of information full scale, thus providing for ease of frame identification. The high-level pulse may be used as a sync signal for automatic ground demultiplex if desired. In addition the pulses provide end-point calibration levels each frame which may be used to correct for the effects of drift in subsequent portions of the link. A timing oscillator and its associated amplifier drive a decade ring counter continuously. An analog gate is controlled by each of the counter stages except the second. (This omission of a gate allows the zero pulse each frame). A voltage from a reference source is applied to the first gate to provide the other fixed level previously mentioned. Information inputs are applied to the remainder of the gates. The gate outputs are connected in parallel to provide the multiplexed output.

Counter

The basic counter circuit has been used in a number of applications[1]. The counter, shown in Fig 1, consists of ten modified bistable multivibrator stages, Q_1 through Q_{20}, coupled in the usual ring manner. Each individual stage employs a pnp and npn transistor. Base, load and cross-coupling resistors function as in a conventional Eccles-Jordan circuit. The use of complementary transistors permits two stable states. In one state both transistors are ON or conducting and in the other state both transistors are OFF or nonconducting. A common emitter resistor is used for the npn transistors. The pnp transistors also have a common emitter resistor. Only one counter stage is normally ON. The emitter currents of this stage build up emitter voltages of the proper polarity to reverse bias the OFF stages. Advantages of such a scheme are obvious. In an n stage counter the current drain is reduced by a factor of $n/2$. The number of emitter resistors required is divided by n as compared to conventional circuits. Stability is also improved. The emitter hold-off voltages permit reliable operation to much higher temperatures than possible with other circuits. Ability to accept loading is greatly increased. If the collectors are loaded heavily it is necessary only to increase the size of the appropriate emitter resistor to regain the unloaded stability factor. In such a case relatively equal loads should be placed on every stage to prevent unbalance.

As an accepted practice, power is applied through an R-C network. A series resistor and capacitor couple a differentiated pulse to the first stage upon application of power. This is done to provide an initial set with the first stage ON and all others OFF. The emitter bus presents an ideal input for the count pulses. Count action is initiated by applying a negative pulse to the emitters of the pnp transistors. Such a pulse does not affect the OFF stages but turns the ON stage OFF. The resultant positive step at the npn collector of the turning OFF stage is differentiated and coupled as a pulse to the base of the next stage npn transistor. The time constant of the coupling network should be longer than the duration of the count pulse. This allows the transfer pulse to be present when the count pulse disappears. The transfer pulse turns the next-stage npn transistor ON and the cross coupling network turns the pnp transistor of the same pair ON. Thus the ON stage is shifted one stage to the right. The same action could be obtained by applying a positive count pulse to the npn emitters. It should be noted that no steering circuits whatever are required as in conventional counters.

Satellite Applications

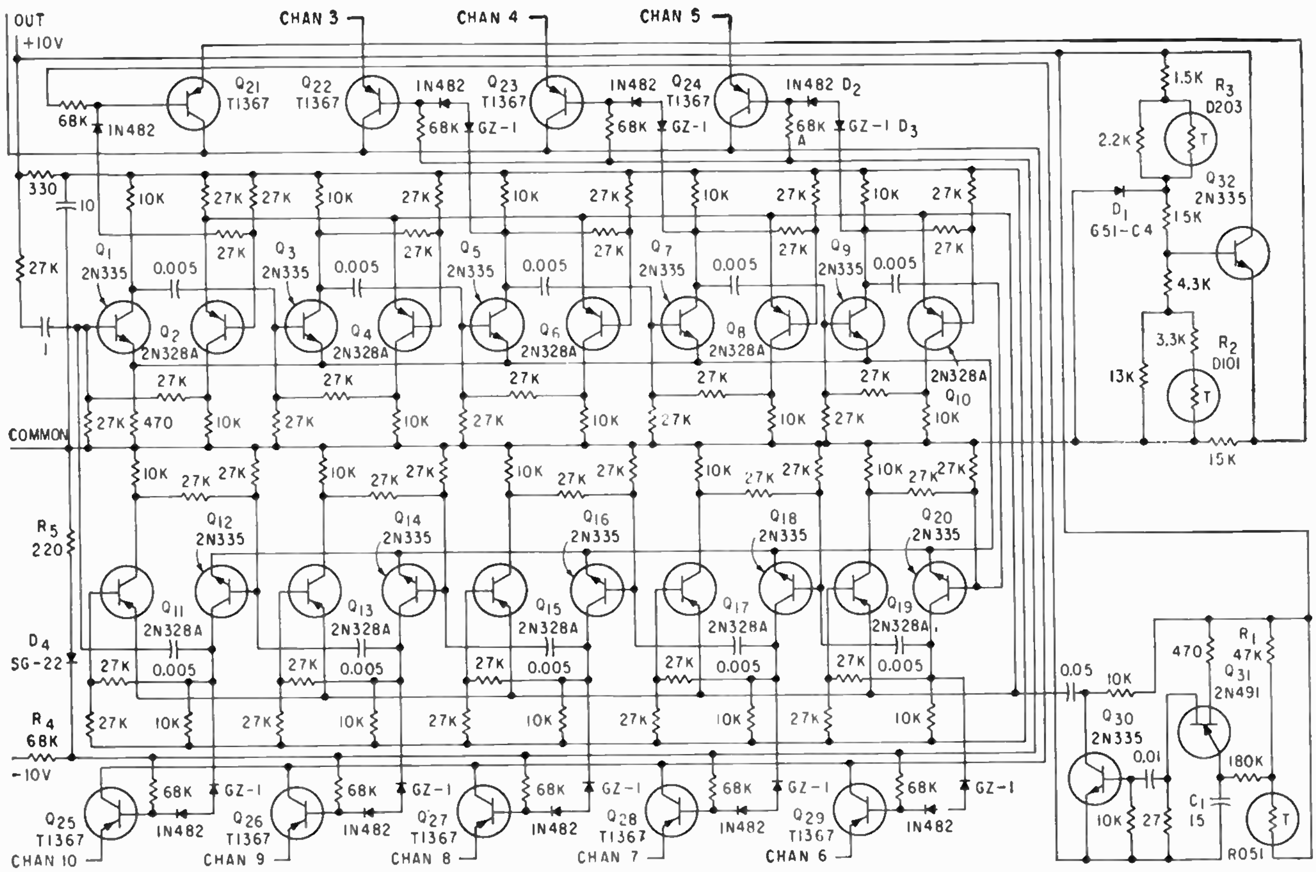


FIG. 1—Ten-channel multiplex uses eight channels for information inputs and two channels for frame identification

This results in saving one or possibly two diodes per stage. Although reset is not required in this instance, this too is easily and economically accomplished with a counter of this type.

Oscillator and Amplifier

The timing oscillator is a relaxation type with unijunction transistor Q_{31} used as the active element[2]. Upon application of supply voltage, current flows through the resistor R_1 and builds up a voltage across capacitor C_1. When the peak point potential of the transistor is reached, it conducts and discharges the capacitor. During conduction, current flows through the base one resistor and develops a positive pulse across it. This cycle repeats itself as long as the supply voltage is present. The frequency is determined by the RC time constants of the unijunction emitter circuit. The thermistor is included to compensate for changes of the capacitor and transistor due to temperature.

Amplifier stage Q_{30} is included to insure sufficient drive to the counter, even after considerable component deterioration. The pulse output is derived from the collector waveform of the amplifier transistor.

The oscillator pulse repetition rate determines the sampling rate of the multiplexer. This rate must either be several times higher than the highest sampled frequency or several times lower. The type of information to be multiplexed must be considered before making the decision. If, as in most satellite cases, the data varies at a slow rate and evaluation of transients is not important, the sampling rate may be low with respect to the modulating frequency. In such a case the multiplexing process does not increase the system bandwidth.

As was previously mentioned, a voltage reference is included and is fed to one channel. This voltage is developed by series regulator Q_{32} controlled by breakdown diode D_1. The major difficulty is obtaining the desired stability within the power limitations. A breakdown diode must be used as the basic element and such a device inherently requires current for satisfactory operation. Unfortunately, diodes in the voltage range where low-temperature coefficient is exhibited have soft knees, that is, considerable current must be passed to drive the diode into the low impedance region where good regulation is obtained. If the allowable current is small, a voltage region must be selected where a sharp knee is found. The higher temperature coefficient must be externally compensated in such a case. Only by such a compromise may satisfactory regulation be ob-

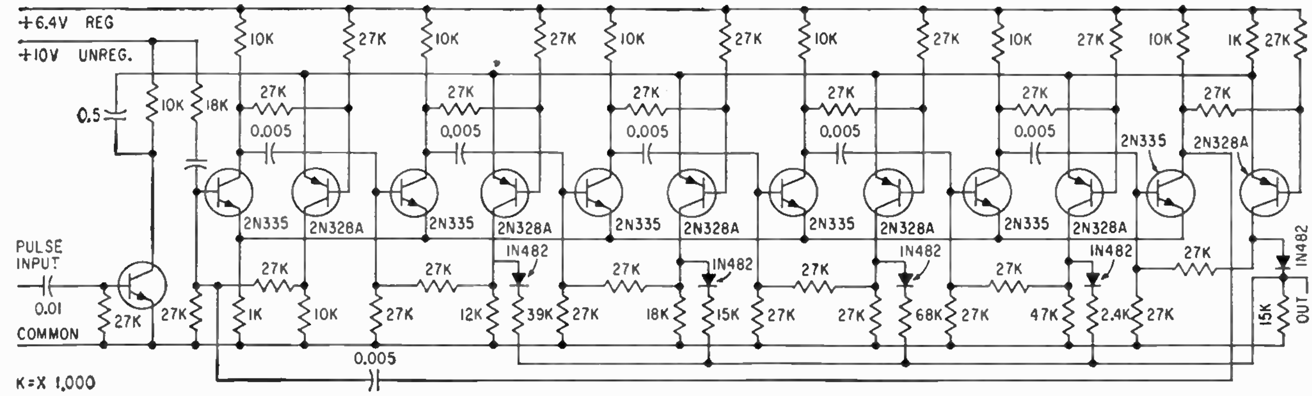


FIG. 2—Pulse converter transforms random information into analog form suitable for multiplexing and provides memory between events

tained under conditions of widely varying supply voltage and temperature while keeping power dissipation low. The resistive network in parallel with diode D_1 serves to divide the diode voltage to the value required at the transistor base. Thermistor R_2 in this network introduces the compensation necessary to correct for variations of diode breakdown voltage with temperature. It also corrects for temperature variation of the base-emitter voltage of the regulator transistor.

Current is supplied to the diode through a resistor-thermistor network as shown. Thermistor R_3 is used to prevent the current drain from increasing at cold temperatures. The diode breakdown voltage decreases in such a case and the voltage across the resistor network increases. The network values are chosen to provide the diode with only the required current regardless of temperature.

The overall circuit provides a 5.5-v reference to transistor Q_{21} with a tolerance better than 1-percent for worst conditions of ± 10 percent supply voltage and temperature from -55 C to $+100$ C. This is accomplished with a total power drain of approximately 20 mw.

Gate

Perhaps the most important circuit in any multiplexer is the gate itself. A wide variety of gate circuits may be envisioned and the choice of a particular one is dependent upon many factors. Items such as sampling and nonsampling input impedance, trans-gate drop, input and output leakage currents, ease of drive and circuit complexity must be considered. In the case in point, overall multiplexing accuracy of the order of 1-percent is adequate and sampling impedance need not exceed 50,000 ohms. This permits the choice of a simple, easily-driven gate circuit. The circuit selected is of the inhibited common-base transistor type. If point *A* of Fig 1 was connected to ground, a large positive voltage applied to the emitter of Q_{24} (for example) will forward bias the emitter-base diode and cause current to flow in the base resistor. If the resistor is small enough to allow sufficient base current flow, the transistor will be driven into saturation, and the input voltage will appear at the output terminal minus the saturation voltage of the transistor.

Thus, the power to drive the switch ON is supplied by the signal source itself. This places a limit on the input imepdance of the gate during sampling. However, transistors are available which meet all other requirements and allow saturation voltages less than 15 mv with a circuit input impedance as high as 100,000 ohms. If lower saturation voltage is desired it may be obtained by inverting the transistors [3,4]. However, the effective beta of the inverted transistor is lower with available transistors and the input impedance must be lowered accordingly. Six-mv saturation voltage and 20,000 ohms input impedance would be typical values for such a connection. For the satellite application, the normal configuration was chosen.

It is evident that for an input signal of less magnitude than the breakdown voltage of the emitter-base diode, the gate proposed would be inoperable. If, however, point *A* were removed from ground and returned to a negative bias equal to the transistor V_{be}, the gate would function for any positive voltage greater than a few mv.

The gate may be placed in a nonconducting state by placing an inhibiting voltage on the base of the gate transistor. This voltage must be larger than the maximum expected gate input voltage to insure that the transistor diodes are reverse biased. In the multiplexer described, the inhibiting voltage is derived from the collector of the appropriate npn transistor of the counter and applied to the gate through diodes D_2 and D_3 of Q_{24} circuit. Diode D_2 serves to isolate the gate from the shunting resistances of the counter during the conducting period. The requirement for breakdown diode D_3 may be understood by recalling that the collectors of the npn counter transistors are not clamped to ground during the *on* time, but rather to the voltage developed across the emitter resistor. This voltage would be sufficient to inhibit the gate for input voltages less than a volt. If, however, the control voltage is coupled to the gate through a breakdown diode, whose conduction voltage is greater than the counter emitter voltage, this source of difficulty is eliminated. The transistors employed in the gates are of the alloyed-silicon type. An alloyed device is used to obtain low saturation voltages. Silicon is mandatory in order that leakage currents be negligible. I_{EO} and I_{CO} for the devices used are typically 5×10^{-10} amperes at ten volts and room temperature. Such leakages allow the gates to have resistances of several hundred megohms even at elevated temperatures. This is more than adequate for the application.

The base resistor of the gate transistors must be returned to a negative bias approximately equal to the transistor emitter-base voltage. This voltage is temperature sensitive and for proper gate operation the bias voltage must track the transistor voltage. A negative voltage is applied through dropping resistor R_4 to forward bias silicon diode D_4. The diode acts as a regulator to maintain a bias voltage approximately equal to the diode-breakdown voltage of the gate transistors regardless of temperature.

All of the gates are connected to a single diode regulator. To compensate for the fact that the diode and transistor forward characteristics do not match exactly, resistor R_5 is placed in series with the bias diode. The potential across this resistor plus the diode potential provides the bias voltage required within a few mv over the range of supply voltage and temperature.

Pulse Converter

Time-division multiplexing as described above is compatible with many data formats. One notable exception exists, however, and it is found frequently in satellite applications. This is the case where information is in the form of random binary or pulse functions. Such is the output of radiation counters or some types of micrometeorite detectors. Obviously a random pulse cannot be reliably detected over a channel which is connected for only a small percentage of the time. Thus a converter must be added to transform the binary information into an analog form suitable for multiplexing and also provide memory between events. This may be done in a number of ways. The simplest methods involve some type of integration and reactive storage. Such an approach destroys the digital nature of the data and if the information rate varies widely over a period of time (as is usually the case) storage element leakage introduces considerable errors. However, use of binary techniques makes possible the conversion of random pulses to quantized analog voltages which retain the digital character of the original input. These binary techniques also provide for infinite memory if required. Simple circuits allow this more sophisticated approach to compete with the cruder methods in all aspects.

Figure 2 shows the schematic of the converter. The input pulses are connected to an amplifier whose output is applied to a ring counter. The outputs of individual counter stages are combined through an adding network to provide an analog voltage as the converter output. With suitable weighting in the adding network, the output voltage relates the state of the counter. It is apparent that the output is quantized into the same number of levels as the counter has stages. So long as the quantum steps are larger than the resolution capability of the data link the digital character of the input information is retained. The input rate, number of quantum levels, and the rate at which the output is sampled must be related in order to prevent ambiguity. The counter must not complete one cycle between output samplings. If the input rate and multiplexer frame rate are fixed, the number of counter stages must be chosen to satisfy this condition. The upper limit on the number of stages is fixed by the resolution of the data link as mentioned above. Should this limit be below that required by the input and sampling rates, the input rate might be reduced by binary division. If the loss of time resolution thus incurred were too great, the only alternative would be to increase the multiplexer frame rate. In the example described, six stages were considered optimum. To facilitate readout, the counter may be reset at the end of each sampling. However, for simplicity the counter may be allowed to operate in a continuous ring manner. In this case the count during any multiplexer frame period may be obtained by subtraction from counts of adjacent frames. The latter choice was made in the example.

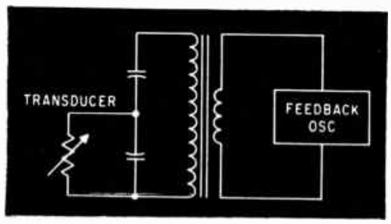


FIG. 3—Resonant frequency varies with impedance of transducer

The basic counter and pulse amplifier circuits used in the converter are the same as in the multiplexer and have been previously described. The adding network may be recognized in Fig. 2. The output from each counter stage is taken from the collector of its pnp transistor. A portion of the collector current of the ON stage flows through a weighting resistor and develops a voltage across a common output resistor. The weighting resistors are proportioned to provide the proper quantum level for each stage. The diode in series with each output isolates the OFF from the ON stages. The collector load resistors are chosen so that the total collector current of each stage is the same.

Impedance Multiplexer

The basic multiplexing idea may be applied to a special case commonly found in satellite instrumentation to achieve even greater advantages. This occurs when the transducers used to detect physical phenomenon have variable impedance outputs[5]. This is the case with thermistors, micrometeorite detectors, and photo cells for example. In the general case the output of such transducers would be connected to suitable conditioning circuitry which would transform the information to an acceptable format, usually a voltage. This conditioning circuitry might be relatively complex with the resulting increase in size and weight and possible decrease in reliability. One of the problems in this area is the difficulty in supplying the reference voltages required in such an application. As previously mentioned, any means of deriving a stable voltage for a long period of time requires a relatively large amount of power. A number of these problems might be eliminated if it were possible to multiplex the transducer outputs directly with no type of conversion.

In most situations a subcarrier oscillator is used between the multiplexer and the transmitter to enable frequency division multiplexing of additional data or to provide wide band gain. A number of impedance controlled subcarrier oscillators have been designed and might be used with a multiplexer if compatibility were achieved. In order to analyze the functions required of

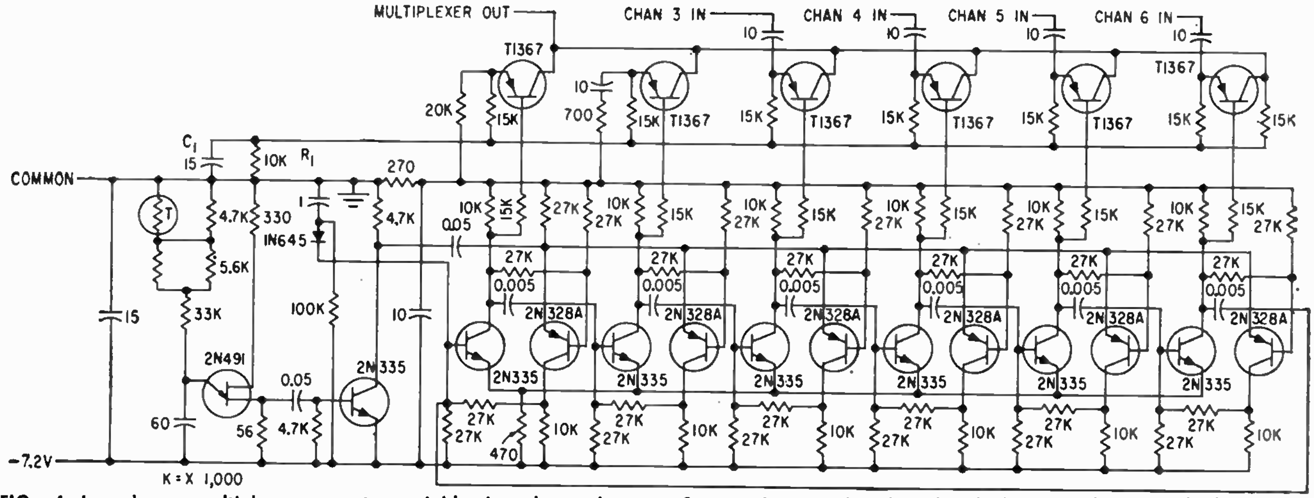


FIG. 4—Impedance multiplexer accepts variable impedance inputs. System inaccuracies introduced by impedance multiplexing are insignificant in a practical system

the multiplexer, the oscillator itself must be examined.

The oscillator demands may be met by a number of circuits. However, a design of the general type described by Riddle[6] seems very well suited for satellite applications. The general method of operation may be understood by considering Fig. 3. The capacitive branch of the tuned tank of a feedback oscillator is split and a transducer is connected across the lower capacitor. Non-rigorously the mechanics of functioning may be followed by observing that as the impedance of the transducer varies, the effective admittance of the capacitive branch varies also. This change in admittance causes the tank resonant frequency to vary and results in a proportionate change in output frequency.

The actual effect of the transducer is to control the current flowing in the capacitive branch. Thus, the quantity which actually must be switched by an impedance multiplexer is an alternating current and the gates used must be bilateral.

Gates

If the transistors are to be used to capitalize upon their inherent advantages as switches, both diodes must be reverse biased during the OFF period to prevent feed-through. A method for accomplishing this is illustrated in Fig. 4. The transducer input signals to the gates are capacitively coupled to prevent any d-c current from flowing through the transducers from the biasing circuitry. The transistor bases are connected to ground through resistor R_1, across which the driving signal is applied at this appropriate time. The input terminal of each gate transistor is returned to ground resistively. A portion of this resistance is made common to all gates as shown. The output terminals of all gates are connected in parallel and also connected by a resistor to the common resistor.

A gate is turned on by applying a negative voltage to its base and bias current flows through both transistor junctions. Thus, both transistor diodes are forward biased and a very low impedance exists between the input and the output terminals of the gate transistor.

Any a-c current or voltage applied to either terminal will appear at the other, provided the peak value of the current is somewhat smaller than the bias current. The bias current flowing in both branches of the ON transistor is drawn through the resistor R_1 to all stages. The voltage across this resistor is of the proper polarity to reverse bias both junctions of the other transistor and satisfy the OFF condition. Thus, the ON stage holds all additional stages OFF. Filter capacitor C_1 serves to maintain the reverse bias voltage during transient switching periods. Offsets due to saturation voltage and leakage current are rendered unimportant by capacitive coupling. The impedance of the ON switch is less than ten ohms and is negligible with respect to the load. The impedance of the OFF switches is in excess of 100 megohms even at elevated temperatures and consequently crosstalk is also negligible.

A schematic of a six channel design is shown in Fig. 4. The first two channels are terminated in fixed resistors to provide the reference functions described in connection with the basic multiplexer. It should be noted that the values of the gate components are flexible and may be chosen to provide an input impedance which provides the desired characteristic when using nonlinear transducers.

Performance

All of the circuits operate from −55 C to +100 C. The data errors introduced are less than 1 percent. Power drain of the basic multiplexer is less than 60 mw, including the reference supply. Power consumption of the complete converter is only 8 mw and that of the impedance multiplexer 18 mw. The equipments weigh only a few ounces each and withstand 25 g's vibration to 2,000 cps and accelerations beyond 100 g's.

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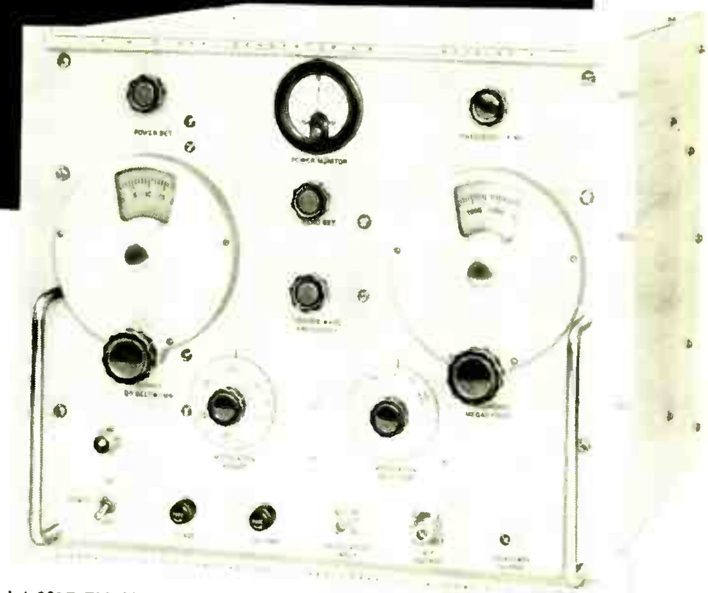

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Tuning:	Separate vernier control for small changes in frequency.
Stability:	Drift not over 5 kc per minute.
Dial Accuracy	1%
R.F. Output—Calibrated	
Level:	Continuously variable 0 dbm to −110 dbm.
Output Accuracy:	Within ± 3 db from 0 dbm to −20 dbm, ± 1.5 db from −20 dbm to −60 dbm, ± 1 db from −60 dbm to −90 dbm and ± 3 db from −90 dbm to −110 dbm.
Source Impedance:	50 ohms, VSWR less than 1.6.
R.F. Output—Auxiliary	
Level:	Non-adjustable, 0 dbm to −5 dbm.
Isolation:	Exceeds 30 db.
Source Impedance:	50 ohms, VSWR less than 1.3.
Modulation	
Internal Squarewave AM:	100% AM modulated by internally generated 800-1200 cps squarewave.
External Frequency Modulation:	Deviation linear within 1% to 2 mc, within 2% to 3 mc. Response within 0 to −3 db, 100 cps to 500 kc.
CW:	CW signals have spurious FM hum and noise of less than 10 kc peak to peak.
AC Power Requirement	117 volts ± 10%, 50-60 cps, 200 watts.
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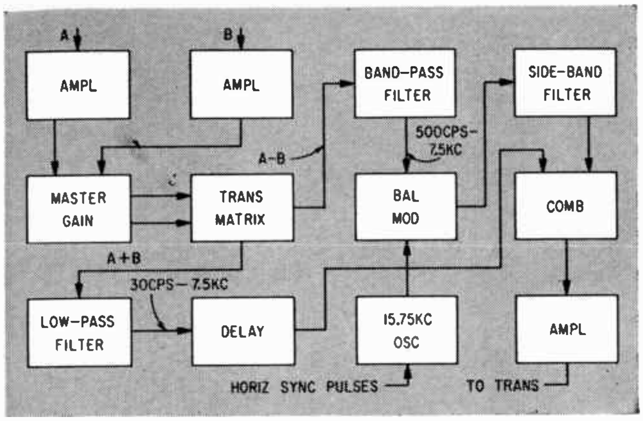

FIG. 1—Conventional tv sound transmitter modified for stereo sound transmission

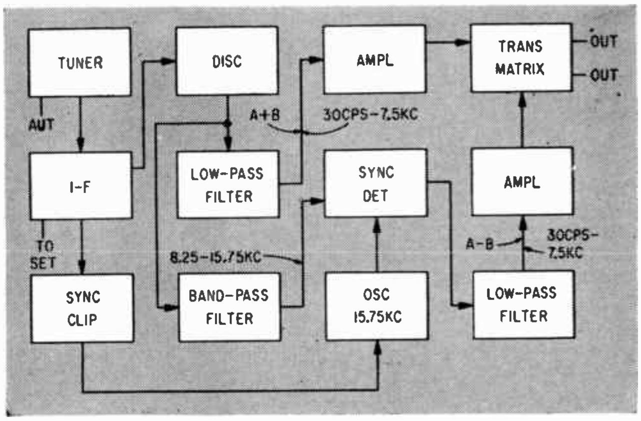

FIG. 2—Conventional intercarrier tv receiver modified for reception of stereo signals

Stereophonic Tv Sound

Multiplexing two audio channels at horizontal pulse frequency permits transmission of stereo over single conventional tv sound transmitter

RECENT BROADCASTING of stereophonic sound for tv programs has required either an a-m or f-m station in cooperation with the regular tv sound transmitter. This technique has pointed up the desirability of transmitting stereo without the use of extra transmitters.

The Philco Corporation has conducted a development program to produce a method of single-station stereo sound broadcasting. Two methods of transmission and reception have been developed. One method uses time multiplexing at the transmitter and receiver; the other, which is simpler, is described in this article. The radiated sound signal is compatible with existing monophonic tv sound, and has adequate bandwidth and track separation of the two stereo channels.

Transmitter

The two audio tracks (A and B) pass through conventional 75-μsec preemphasis circuits and through master gain control to the two-transformer audio matrix as shown in Fig. 1. Sum signal ($A + B$) is limited to 7.5 kc by a low-pass filter; difference signal ($A - B$) is limited at both ends of the audio band, 500 cps and 7.5 kc, by a band-pass filter. Limitation of the low frequencies yields the common low-frequency characteristic of the signal.

A sync separator removes the sync pulses from the composite video signal being supplied to the picture transmitter. The horizontal 15.75-kc sync pulses are used to lock a 15.75-kc sinusoidal oscillator which in turn supplies the carrier to a balanced modulator.

The band-limited difference signal is the other input to the balanced modulator, while the output goes to a lower sideband filter. The filter output is a single-sideband, suppressed-carrier signal in which only the lower sideband of the 15.75-kc carrier exists. Since the audio frequencies below 500 cps have been eliminated, the linear phase characteristics of the sideband filter may be readily obtained through the useful passband while securing adequate attenuation to the upper sideband.

The single-sideband difference-modulated signal is now combined with the sum signal which goes only through a compensating time delay. Delay must be added in the path of the sum signal to equalize the delay introduced in the difference path by the single-sideband filter. The stereo signal is amplified and applied to the conventional f-m sound modulator.

Receiver

The receiver is a conventional intercarrier type modified as shown in Fig. 2. The composite audio signal is removed from the sound discriminator before the deemphasis network. A low-pass filter having a cutoff at 7.5 kc selects the sum signal ($A + B$) and incorporates a deemphasis network. A band-pass filter, 8 kc to 15.75 kc, selects the single-sideband suppressed-carrier difference signal ($A - B$).

The difference signal is recovered by synchronous detection using the 15.75-kc sinusoidal oscillator locked to received horizontal sync pulses. The output signal is filtered by a low-pass filter and deemphasis applied.

The amplified sum and difference signals are then combined in a transformer matrix to yield the separate audio tracks.—L.S.

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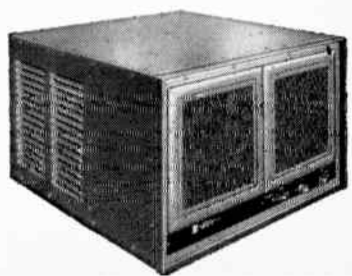

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Nuclear Thermal Pulse Simulator

By D. J. BAKER* and D. E. THOMAS, Thermal Radiation Laboratory, Air Force Cambridge Research Center, Bedford, Mass.

UNUSUAL thermal radiation pulses resulting from nuclear detonations can be simulated with a double-discharge circuit. Simulating these waveforms is required to evaluate atomic bomb alarm systems.

Pulse Characteristics

Pulses from nuclear detonations within the atmosphere rise rapidly to a first maximum, decline to a minimum and then rise to a second maximum. After the second maximum, emission rate decreases, as shown in Fig. 1.

During the first maximum, the surrounding air is heated to incandescence by absorbing the released electromagnetic and kinetic energy. The inner, hotter region of the fireball becomes surrounded by a sphere of luminous, shock-heated air of somewhat lower temperature. While the temperature of this sphere of ionized gases is above 2,300 K, the gases strongly absorb radiation. Thus the core of the fireball is shielded, creating a minimum in the thermal pulse[1]. As the ionized shock front expands and its temperature drops, it becomes transparent and the hotter interior gases again become visible.

Time to second maximum is a function of yield of the nuclear device and can be approximated from $t_{2\,max} = 32\, W^{1/2}$ (millisec), where W is yield in kilotons.

Complex thermal detection systems have been used by the Air Force Cambridge Research Center to obtain quantitative measurements of thermal irradiances from nuclear detonations as functions of yield, time, wavelength and altitude. For operational tests and calibrations of such systems[2], a nuclear thermal pulse simulator was developed.

* Now with Electro-Dynamics Laboratory, Utah State University, Logan, Utah

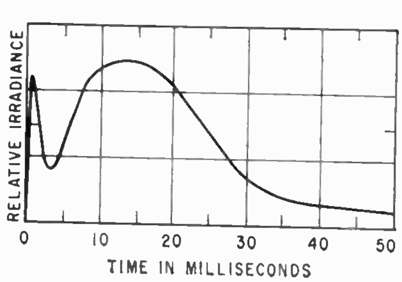

FIG. 1—Plot of thermal pulse resulting from nuclear detonation

Pulse Simulator

Inert gas discharge tubes simulate the thermal source. High intensity light output is obtained by concentrating energy into a short time. This is done by discharging a capacitor through a low-resistance gas column. In the flashtube, gas atoms are ionized by the intense electromagnetic forces of the discharge, and light is emitted by the subsequent recombination of the electrons and ions.

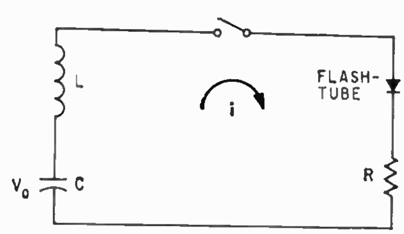

FIG. 2—Equivalent discharge circuit including inductance

Xenon flashtubes provide a continuous spread of energy over the entire visible region of the spectrum extending into the infrared and ultraviolet, upon which are superimposed the broad lines of xenon[3]. Color temperatures sufficiently near that of nuclear detonations were obtained.

Quartz fused into an amorphous and homogenous material makes an excellent envelope for the discharge tubes. It has a low coefficient of expansion, can withstand peak power input of several million watts and makes a good insulator and dielectric. Optical transmission is nearly flat from 0.2 to 3 micron.

Peak intensity of the visible light increases linearly with input energy, $\frac{1}{2} C V^2$, where C is capacitance of the discharge capacitor and V is the voltage to which it is charged. Peak intensity is likely to be highest for a capacitor of small value charged to a high voltage[1]. Peak current in the arc is a function of discharge circuit characteristics and of the voltage to which the capacitor is charged.

Operating voltage range is not rigid, although appreciable overvoltage will cause self-ionization and possible tube damage. Undervoltage can result in erratic or ineffective triggering. For calibration of thermal detectors, the flash source must be discharged at the same voltage for each test, as both intensity and spectral output are functions of discharge voltage.

Generation of the desired waveform is effected by proper design of the discharge circuit. Light duration is approximately a linear func-

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THE FRONT COVER. Antenna for tracking beacons in re-entry vehicle is subjected to arc plasma jet at Melpar, Inc. Tests determine if antenna at 1,500 C maintains constant electrical thickness, low dielectric loss and carbon-free surface. Other re-entry simulation uses require that arc plasma unit generate temperatures to 20,000 C, heat flux intensities to 1,800 BTU/ft²/sec and velocities of about Mach 2

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tion of oscillation period of arc current, since tube resistance is not sufficient to critically damp the current transient. Dynamic resistance of all tubes change over a wide range during conduction. Arc resistance varies inversely as voltage and is also an inverse function of capacitance. With a given tube and voltage, average resistance will be somewhat less with higher loadings. Average dynamic resistance is from 0.5 to 5 ohms.

For a single capacitor discharge circuit, flash duration is about $T = RC$. Adding self inductance affects both peak intensity and light duration, whereas adding resistance reduces only peak intensity. The equivalent circuit containing inductance is shown in Fig. 2. Time to current maximum is $t_{max} = (L/R)\sqrt{1 - 4L/R^2C}\ ln\ (1 + \sqrt{1 - 4L/R^2C})/(1 - \sqrt{1 - 4L/R^2C})$ (sec).

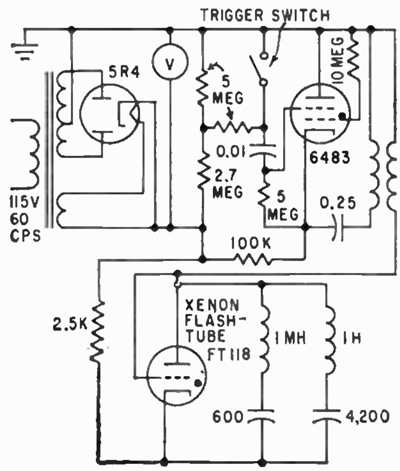

FIG. 3—Pulse simulator circuit uses xenon flashtube

To simulate the two peaks, two capacitor discharge circuits are used. With appropriately chosen circuit constants, simultaneous discharge through the xenon flashtube produced the required pulse.

In the nuclear thermal pulse circuit in Fig. 3, the trigger coil is a small transformer having a high turns ratio. A 0.25-μf capacitor at 150 to 300 volts is discharged through the coil primary to establish the flashtube ionizing grid pulse. For greatest reliability, a high-voltage pulse with a steep wave front should be used. Positive control with either manual or electrical triggering was effected with a Sylvania 6483 cold-cathode thyratron. The circuit shown uses a GE FT 118 xenon discharge tube that emits about 5,000 lumen-sec at a rated input of 125 watt-sec. The tube is operated at its rated 450 volts; however, a charging circuit of 650 volts was used to greatly reduce charging time.

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(3) H. E. Edgerton and P. Y. Cathou, Xenon Flash Tube of Small Size, *Rev of Sci Inst*, 27, p 821, Oct. 1956.
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Plasma Probed At Harvard, MIT

RESEARCH on plasmas will be intensified at MIT under a $500,000 grant from the National Science Foundation. MIT's work in the field dates back to the World War II with the Radiation Lab's development of the TR Box, radar switching device using a plasma. MIT also has research contracts for Project Sherwood, for energy conversion studies and for investigation of high-energy shock waves.

The research will include the reentry problem, plasmas in communications, containment in magnetic fields for fusion and direct conversion of plasma energy into electrical current. Under overall direction of William P. Allis, professor of physics, project will investigate plasma production by microwaves and study of plasma-emitted microwaves, also carbon-arc plasmas operated in very high vacuums.

Simultaneous grant of $300,000 goes to Harvard for investigation of high-temperature gas dynamics. The two institutions will conduct research independently, but interchange information.

Harvard studies under Howard W. Emmons, professor of mechanical engineering, will concentrate on relatively high density gases. Project will be aimed at gas dynamics involved in entry problem, propulsion, combustion, atomic power and astrophysics. Simulated atmosphere of other plants (Mars and Venus) will anticipate problems of entry into those atmospheres.

What Frequency Can Tunnel Diode Reach?

ONE OF THE MOST interesting semiconductor devices to come along in recent years is now known as the Esaki tunnel diode[1].

Leo Esaki observed that in a *p-n* junction of a semiconductor, when there is an internal field, electrons tunnel between the conduction and valence bands. Further, tunneling decreases over a range of forward bias due to the relative displacement, with bias, of the energy band on opposite sides of the junction.

Ever since this tunneling effect was first made known to research, important semiconductor men have been actively investigating the tunneling electron and mechanical techniques for diode fabrication (ELECTRONICS, p 82, June 12). A technical feature story explaining the action and properties of this important development is now being processed by our staff and will appear in next week's issue of this magazine.

How High Up?

Frequency response in the ultrahigh and superhigh frequency bands (uhf is between 300-3,000 mc; shf is between 3,000-30,000 mc) with simple circuitry; low noise figure; ability to operate from near absolute zero to several hundred degrees C; and remarkable resistance to radiation damage. These are some of the features of this development—some actually worked out in devices, all working on paper.

One question being asked this week by many top semiconductor research men is: "How high up in frequency can the tunnel diode go?" And they are beginning to answer this question themselves. How high is up? The frequency is going up steadily, whether for amplification or oscillation, and nothing imposed by the Esaki tunneling process says it will stop. Of course, mechanical techniques of construction are to be solved. And indeed, the principle problem seems to be one of fabrication—the assembly of parts of small dimension.

Semiconductor men are now obtaining a better understanding of

Esaki-diode oscillator mounted in a standard three-pin header. The outer pins are identical. Either one can be used with the center pin

the device and its high frequency response. Last summer, RCA announced a tunnel diode made of germanium that would operate "higher than 1,000 mc and had potential up to 10,000 mc" (ELECTRONICS, p 69, July 10). And on paper, GE admits it can get up to 10,000 mc and beyond.

Bell Laboratories has done a lot of work with tunnel diodes, but so far has not published many of its important findings. Bell is interested in switching devices, and present research uses indium antimonide cooled to a low temperature.

Big Microwave Year

Henry Sommers, one of the key semiconductor men at RCA, feels confident that inside of a year various laboratories will be up to 10,000 mc. At room temperature there may be difficulties in operating around the 10,000 mc mark. But going up higher at reduced temperatures will involve questions of technique.

Just how many of technique problems are solved, the various labs working in this field are not ready to admit, right now. But we can guess. And one thing is sure. Next year will be a big one for microwaves.

One actual report of tunnel diode research at IBM, investigating the Esaki effect as a possible computer element, is reported by R. F. Rutz[1]. Two factors in this development should be noted. First, experimental oscillators have been fabricated from germanium with fundamental oscillations that have reached into the superhigh frequency band: 3,010 mc and 4,020 mc. These are believed to be the highest frequencies of oscillation for the Esaki diodes yet reported. Second, the design approach uses lumped-parameter components—inductance, capacitance and resistance.

Figure 1A, p 72, is a cross section showing construction, and Fig. 1B

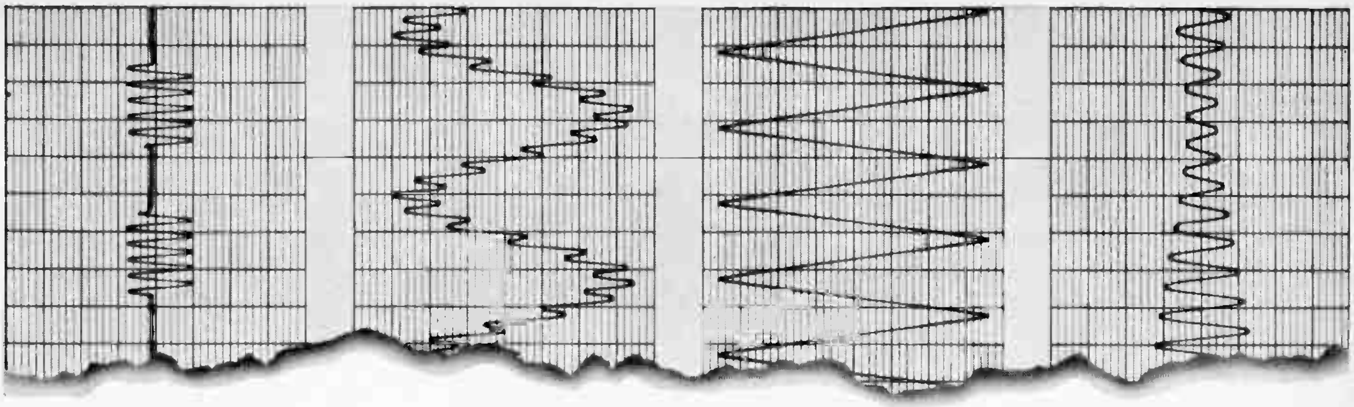
Frequency of the Esaki-diode oscillator developed at IBM is measured by R. F. Rutz. Oscillator, too small to be seen here, is on table between test instruments

gives the simplified equivalent circuit of the semiconductor microwave oscillator.

The IBM unit is a neat and well designed integrated circuit package, putting the tank circuit inside the mount. Eventually these devices will all come to having the circuit and device packaged together.

Integrated Package

According to Rutz's description, the lumped-parameter oscillator, Fig. 1A, consists of a highly doped *n*-type germanium wafer soldered to a mounting tab which serves as one electrode of the circuit. Two tin impurity dots, one doped with gallium, the other with arsenic, are



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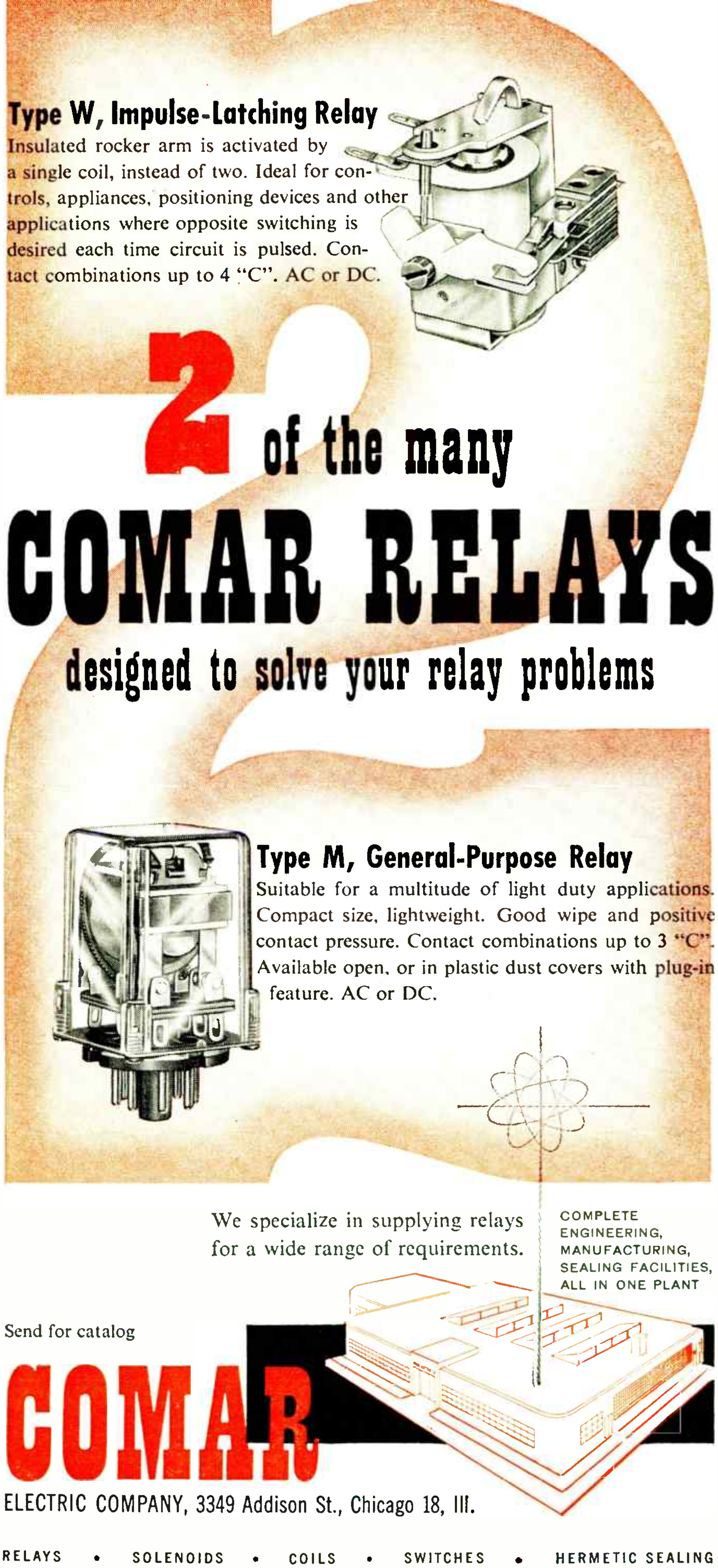


alloyed to the n-type wafer in close proximity. The SnGa dot forms a recrystallized p region which makes an abrupt junction with the heavily doped n material. This produces a negative resistance of the Esaki type when a forward bias in the region of 50 to 350 mv is applied.

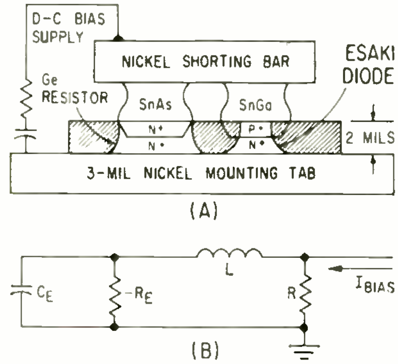
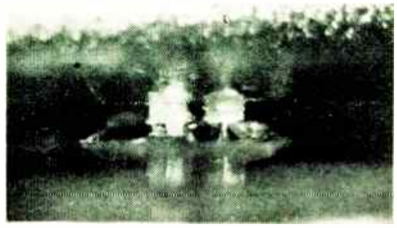


FIG. 1—Schematic cross section of the semiconductor microwave oscillator (A), and its simplified equivalent circuit (B). Experimentally, the frequency increases as the diameter of the Esaki-diode junction area is decreased

The SnAs dot, on the other hand, merely forms an ohmic contact to the n-type wafer. If the resistance between the SnAs dot and the mounting tab is smaller than the absolute value of the negative resistance of the Esaki diode, then the system oscillates at a very high frequency when a shorting bar, which acts as the second electrode of the circuit, is connected as shown. A biasing current then flows through the resistive part of the circuit of sufficient magnitude to produce a d-c voltage across the Esaki diode to make it behave as a negative resistance.

The Esaki part of the circuit is represented in Fig 1B by a negative resistance, $-R_E$, shunted by a capacitance, C_E. The bulk resistance of the diode is not explicitly repre-



Magnified view of the IBM super-high frequency oscillator package. At left is the germanium resistor. At right is the highly-etched Esaki diode, its narrowest dimension is about 0.001 inch

sented in this simplification, says Rutz. The bias resistor, concentrated under the SnAs dot, Fig. 1A, is represented by R and the loop inductance of the circuit is represented by L. A necessary condition for oscillation is that $R < |-R_n|$.

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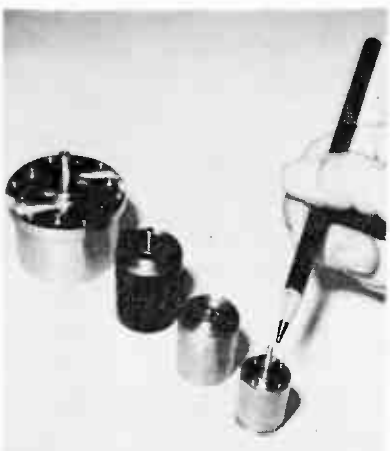
(2) R. F. Rutz, A 3,000-Mc Lumped-Parameter Oscillator Using an Esaki Negative-Resistance Diode, *IBM Journal*, October, 1959

Servos for Space

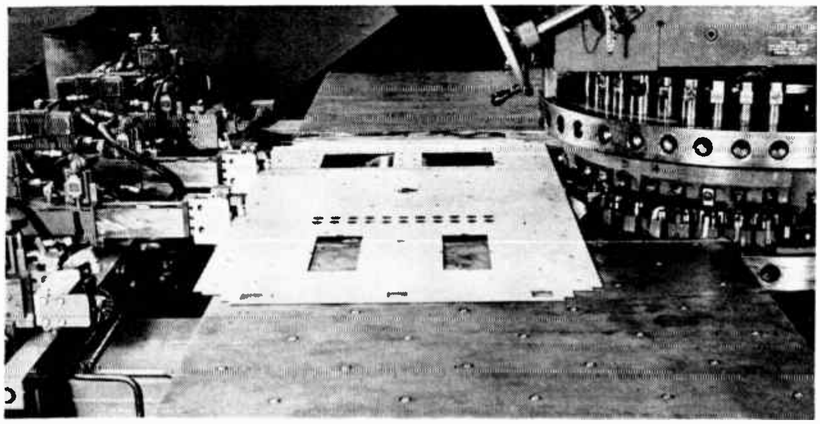


The evolution above shows the past eight years of progress in the design of precision miniature gears for vital electromechanical controls. Developed by Bowmar Instrument Corporation, of Fort Wayne, Indiana, a large producer of precision gear packages, these guidance system control bundles have shrunk down to the diameter of a penny. Now the firm is working on a half-ounce package with a diameter of a pencil

Magnet Wire

ALUMINUM-CLAD copper wire, used in the production of high-temperature magnet wire, is presently available in sizes from 0.003 in. to 0.25 in. dia, according to a Sylvania Wire Technical Information Bulletin. In this application, the wire is anodized to produce a lighter and less bulky magnet wire than a conventionally insulated copper material.

The cladding, an aluminum alloy, equals a cross sectional area of about 40 percent of the composite wire. This aluminum alloy exhibits superior corrosion resistance and can be anodized readily. The material can be considered in all applications requiring long life at temperatures up to 800 F. Resistivity is 38 ohms/cir mil ft at 800 F.



Side view of 100-ton press. Workholders retract when the carriage approaches the turret and reclamp the work when it clears the turret area

Programmer spots punch center coordinates

New Turret Press Is Automatic

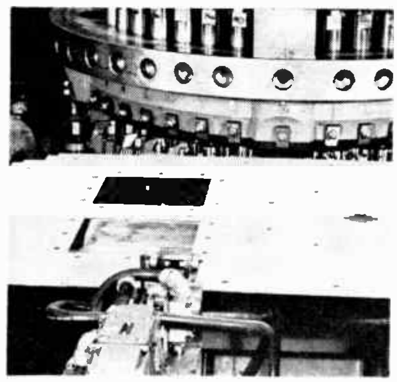
NUMERICALLY-CONTROLLED series of turret punch presses is being introduced by Wiedemann Machine Co., King of Prussia, Pa. Controls were developed by General Electric Co., Specialty Control Dept., Waynesboro, Va. A 100-ton press is in regular production use at the Waynesboro plant.

The 100-ton press' rate is 30 hits a minute, about 4 times the rate of a manually-operated turret press. Hole position accuracy is 0.01 inch from a reference point, generally a corner of the workpiece.

Normal traverse speed in X and Y axes of the positioning carriage is 500 inches a minute. The turret contains 36 sets of tools and rotates at 15 rpm. Workpieces are held by hydraulically-driven arms terminating in disk clamps. These are automatically retracted when the outer edge of the work is being punched.

Loading and unloading are manual. Tool selection and other operations are automatic after punched tape is inserted in the console. The control system is a modified GE Mark III 3-axis closed loop numerical positioning system.

Presses of 15 to 150 tons are planned. The 15-ton press will be ready next fall and will have a rate of about 60 hits a minute and hole accuracy of 0.004 inch. There are no plans to retrofit existing presses, since the speed of operation requires special mechanical design.



Rounded support, partially visible in punched hole at lower left, swings up under workpiece to support it during punching

Tape is prepared on standard typewriter punching equipment, or on an automatic programmer. The Auto-programmer prepares tape from dimensionless half-scale drawings, reducing drafting and programming time by about 75 percent.

Templates are pasted on plastic sheet (Cronaflex) which is placed on the table of a modified Haag-Streit Coordinatograph. Punch centers are manually located by illuminated crosshairs, providing X and Y positioning coordinates.

Tool selection is fed into the console in terms of increments of turret rotation, by means of selector switches. Crosshair location is determined by Fischer and Porter Digi-coders.

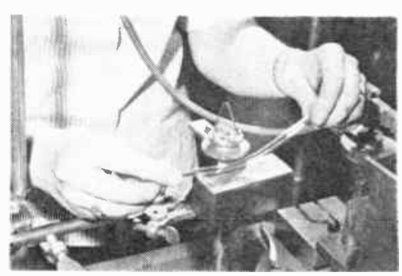
The operator presses foot pedals and the console punches the machine directions on tape. Duplicate tape and a manuscript are produced from the punched tape. A Diazo transparency of the template is used as an assembly drawing after parts identification are added.

Breathing Helps Tube Production

BREATH PRESSURE is used to obtain precise control over the shape of glass envelopes for electronic flash tubes produced at Minneapolis-Honeywell, Heiland Div., Denver, Colo.

Envelopes are made from select Pyrex tubing and formed on heated mandrels. The operator breathes into an attached rubber tube, near the end of the forming operation, causing the envelope to blow out and fill the shape of the mandrel.

A smaller tubing is welded to the envelope, so that the flash tube can be later pumped out and filled with



Mandrel used to form 6 mm tubing into rings. Gas is off to show detail

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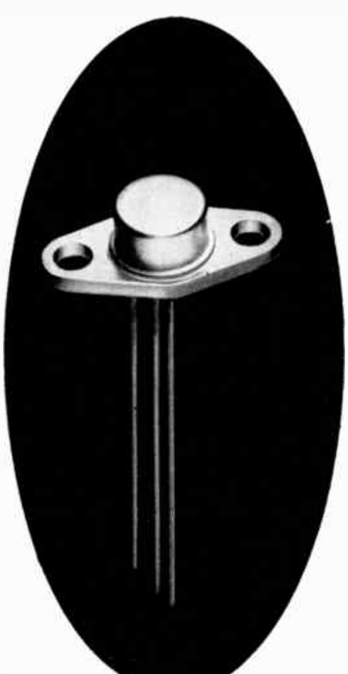
Delco Radio has a complete line of germanium power transistors

HIGH POWER—The conservatively rated 15 ampere stud-mount series leads the field with improved collector to emitter voltages, low saturation resistances, and diode voltage ratings measured at 85°C. The JAN 2N174, MIL-T-19500/13A, and the commercial 2N174 are leaders in the switching versions of this series. Headed by the 2N1100 and including the new 2N1412, other transistors in the Delco Radio high power family have equally impressive performance characteristics.

MEDIUM POWER—The new 5-ampere series in the JEDEC TO3 case includes the 2N1168 and 2N392 for high power gain in low distortion linear applications. The 2N1011 (MIL-T-19500/67 Sig.C), 2N1159, and 2N1160 for higher voltage switching applications complete this series. • The low diode leakage 2N553 series, also in the JEDEC TO3 case, is rated up to 4 amperes. Usage of this series is growing rapidly in a variety of applications—especially in regulators. The 2N297A (MIL-T-19500/36A Sig.C) and the 2N665 (MIL-T-19500/58A Sig.C) are produced from this type, making with the above a comprehensive line for military applications.



MINIATURIZED MIGHT—The new 2N1172 is a mighty mite for a wide variety of usages where the modified JEDEC 30 package, on a functioning miniature diamond base, permits dissipation up to two watts at 70°C.

Write today for engineering data or personal applications assistance in getting these readily available, *proved* transistors to work in your most exacting requirements.

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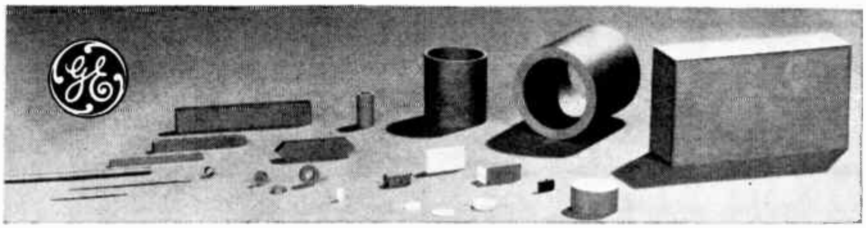
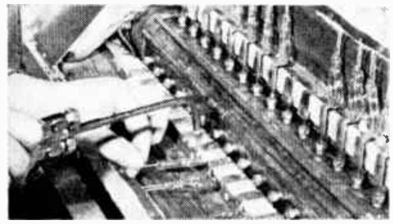
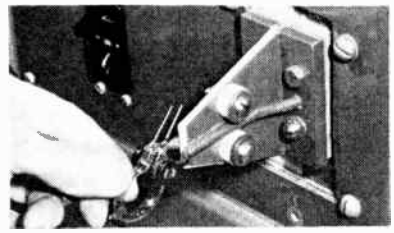


xenon. Before welding, a spot about 1/8 inch in diameter is heated and a hole made by blowing on it.

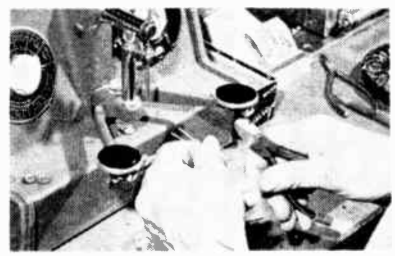
Electrodes are uranium tubing fused to small tungsten rods. Half are used as anodes. The others have a barium getter and nickel screen spot welded on, to act as cathodes. Oxides are removed from the electrodes by sodium hydroxide and a-c, with a small barrel plater.



Tubulation is sealed with torch as flash tubes are removed from vacuum manifold



Barium getter is flashed in induction heater

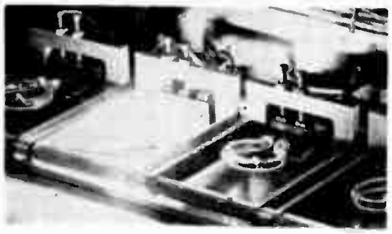


Nickel ribbon is spotwelded to one leg of tube

Electrodes are welded into the shells. Dry nitrogen and hydrogen are flowed through the tube to prevent moisture condensation and contamination. The operator's breath is used to control a Cartesian manostat, which in turn controls gas flow. The gases shape the welded area around the electrode.

As the operator closes the opening of the control hose, gas pressure is applied inside the shell at a set pressure so that the glass does not touch the tungsten, preventing cracking due to differing rates of expansion.

Gas remnants are pumped out via the tubulation and it is welded shut.



Portion of aging and testing rack

The tubes are annealed overnight. Leak tests are performed, the tubes are baked out at high temperature, evacuated and filled. The tubulation is again welded shut and tipped off. The getter is flashed by induction heating.

Pure nickel ribbon is spotwelded around one leg of the tube. Silver paint is applied from the nickel around the backside of the tube, for triggering the flash tube.

Three 6-minute aging and testing cycles are run on each tube. There are 30 flashes per cycle: 25 flashes condition the tubes at 10 percent above operating voltage, the last 5 are test flashes. If any of the 5 flashes are missed, the tube is rejected.

Aluminum Extrusion Houses Module Units

Extrusions will become modular cabinet assembly for electronic control system

ALUMINUM EXTRUSIONS measuring 24.19 by 2.485 inches are being made by Harvey Aluminum, Torrance, Calif., for fabrication into modular cabinet assemblies.

The 6-hole shapes are made of 6061 alloy on a 12,000 ton hydraulic press. End walls are 0.312 inch thick and other walls are 0.25.

According to the firm, the method reduces weight and costs and improves structural reliability. Sections can also be used as passage or storage areas for components, gases and liquids.

On The Market

Wheatstone Bridge transistorized

CALIBRATION STANDARDS CO., 1079 Coronet Ave., Pasadena, Calif. Model WB-100A Wheatstone bridge features ultra-high stability resistors and sensitive readout. All multiplier and decade resistance values are factory adjusted to 0.005 percent tolerance. The instrument is rated at 0.05 percent to cover wide changes in ambient temperature and long-term aging effects. Sensitivity of the null indicator is ±1 mv, providing full-scale deflection for unbalance of 1 percent up to 50 megohms. The 4-in. panel meter is protected against overload.

CIRCLE 200 ON READER SERVICE CARD

Silicon Diodes subminiature

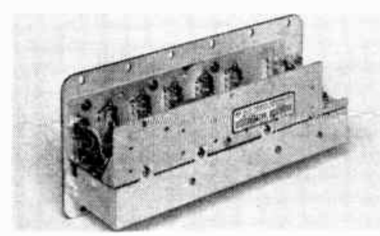
SILICON TRANSISTOR CORP., Carle Place, N. Y., has a series of subminiature silicon circuit diodes guaranteeing a controlled forward specification of 0.7 to 0.74 v at 10 ma. The forward matching characteristics of the STC101 through 108 make these diodes ideal for application requiring ultimate reliability, as well as predictable forward characteristics as in transistor biasing, modulator and clamp circuits. Units are available for immediate delivery.

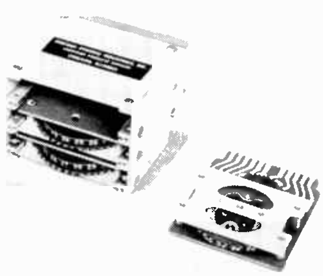
CIRCLE 201 ON READER SERVICE CARD

Command Receiver for missile use

R/S ELECTRONICS CORP., 435 Portage Ave., Palo Alto, Calif. Model 2610 uhf command receiver operates with an input voltage of 28 v d-c at a preset frequency in the range of 400 to 450 mc. Frequency modulation is ±350 kc at 50 cps to 15 kc; sensitivity 7.5 μv for 6 db signal plus noise to noise ratio with 15 kc audio bandwidth; output 3 v rms into 1500 ohms; image rejection 50 db.

CIRCLE 202 ON READER SERVICE CARD





Rotary Switch saves panel space

CHICAGO DYNAMIC INDUSTRIES, INC., 1725 Diversey Blvd., Chicago 14, Ill., announces a miniature highly reliable printed circuit manually operated rotary switch. For fast, simple servicing and lower maintenance costs, the units can be removed and replaced in seconds without unsoldering, disassembling or wire removing. A modular bank of 25 switches can contain up to 500 separate switching circuits. Each switch needs only ½ in. panel space.

CIRCLE 203 ON READER SERVICE CARD

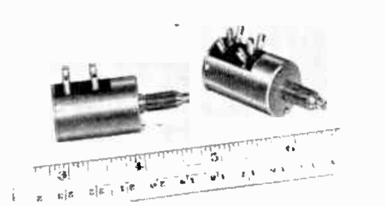
Transformers coil-oscillator

MERCURY TRANSFORMER CORP., 12964 Panama St., Los Angeles 66, Calif. Coil-oscillator inductor features good long term drift. Inductance is 630 mh maximum and 280 mh minimum, with a normal excitation of 10 v rms between opposite ends of the winding between 1,000 and 2,000 cps.

CIRCLE 204 ON READER SERVICE CARD

Dual Trimmer Pot ¾ in. diameter

MAUREY INSTRUMENT CORP., 7924 S. Exchange Ave., Chicago 17, Ill. Model 75-M28 pot's wirewound resistance element is from 25 to 25,000 ohms per cup. Tracking accuracy is 0.5 percent. Unit features completely sealed construction for encapsulation if desired; operates at 1.5 w at 105 C; is built to meet



Hold your frequency under fire (and ice)!

New linear permalloy core keeps filters frequency-stable over a wide range of temperature conditions—at half the cost

Designers of audio filter networks, faced with the high price of components and the need for frequency stability over a wide swing in ambient temperatures, can now benefit from a most significant development—the linear molybdenum permalloy powder core.

The linear cores we've developed are used with polystyrene capacitors. This combination costs as little as half the price of temperature-stabilized moly-permalloy cores and the silvered mica capacitors with which they must be used.

What's more, frequency stability is increased! For temperatures ranging from −55°C to +85°C we have observed frequency stability variations as low as 0.05%. This is considerably less frequency shift than normally expected with temperature-stabilized combinations.

We guarantee the temperature coefficient of these linear cores within a very narrow range! Information regarding sizes, prices and performance behavior awaits your request. Popular sizes, in 125 permeability only, available immediately from stock. *Magnetics, Inc., Dept. E-74, Butler, Pa.*

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applicable sections of MIL-R-19A, MIL-E-5272A, MIL-R-19518, MIL-R-12934B, NAS710.

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VHF Transmitter 360-channel

AIRCRAFT RADIO CORP., Boonton, N. J. Type T-25A is a 360-channel, electrically tuned, crystal controlled, 6 to 10 w vhf transmitter operating on any 50 kc channel between 118.0 mc and 135.95 mc. The 6.3 lb transmitter may be paired with any communications or navigation receiver operating in its frequency band. Unit is designed and certified to FAA TSO C-37 Category A, FCC requirements, and to the rigid environmental requirements of U. S. military agencies. Operation is possible at altitudes to 60,000 ft.

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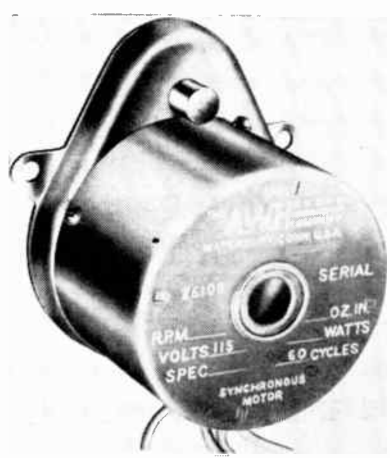

A-C Timing Motors compact, reversible

THE A. W. HAYDON CO., Waterbury, Conn. The 26100 series motors, suitable for both military and industrial applications, are supplied with built-in gear trains offering speeds from 450 rpm down to ¼ rph. They are designed specifically for applications where ease of reversing is the main requirement, and where small size and light weight are necessary. The synchronous characteristic of these hysteresis type motors assures an accuracy on the same order as the power source. Operation can be on single phase supplies, using a phase shift network supplied with one winding, or on two phase supplies. Reversing is accomplished rapidly and conveniently with an spdt switch.

CIRCLE 207 ON READER SERVICE CARD

Vane Axial Blower meets MIL-M-7969A

WESTERN GEAR CORP., 132 W. Colorado Blvd., Pasadena, Calif. Model FV7-1 vane axial blower has an output of 600 cfm at 1-in. water static pressure, 760 cfm free air. Input is 200 v a-c, 400 cps, 3 phase at 1.2 amperes. Motor is a 6-pole, 7,300 rpm unit, designed for 2,000 hr of life. It weighs 4.75 lb and has a low noise level 78 db overall. The envelope diameter shell is 7½ in. by 6 in. long. Motor is equipped with three-phase thermo protection for overload and stall conditions.

CIRCLE 208 ON READER SERVICE CARD

Silicon Transistor low storage time

FAIRCHILD SEMICONDUCTOR CORP., 545 Whisman Rd., Mountain View, Calif. The 2N1252 is a low storage *npn* diffused silicon mesa transistor. It is ideally suited for use in high current saturated switching circuits. Unit features guaranteed storage plus fall times of 150

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In some industries a man is boxed off by his title. In most fields, for example, a management man won't talk the same language as a design engineer.

The Electronics man, however, is not easily pigeonholed. Whatever his title, whatever his department, this engineering oriented man influences the buying and specifying of electronic equipment.

electronics is edited to reach the important areas of the electronics industry . . . the men who, regardless of title, influence the purchase of products, materials and service. *This* is why it pays to advertise in ***electronics*** and ***electronics*** BUYERS' GUIDE.

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Editorial Conference: Friday 9:30 AM

Bill MacDonald, 33 years an Editor, Feeds a Growing Boy

Electronics, like a growing boy, has a voracious appetite — an appetite for information about technical developments, new markets, business potentials . . .

electronics magazine has the job of feeding information to the industry in a balanced editorial diet so that the quality and quantity of editorial will more than meet industry requirements.

Editor W. W. MacDonald inspires respect from his 26-man editorial staff, and justly so. Mac has been, successively, an Associate Editor, Executive Editor and then Editor of *electronics*. Before joining *electronics* he had been Managing Editor of "Electrical Merchandising" and Editor of "Radio Retailing." A senior member of the Institute of Radio Engineers, he has devoted 33 years to editing McGraw-Hill publications.

Mac is responsible for *electronics* editorial. True, he has far more assistance from his highly trained, professionally mature staff than do most business publication editors. Fifteen members draw upon direct engineering experience in the electronics field. Four editors gained electronics experience in the armed services. Four others came to *electronics* with backgrounds in journalism, finance, and marketing. The balance of the staff comprise the Art Director and his assistants.

But the Editor of *electronics* is a perfectionist and never satisfied. He is constantly raising the standards by researching his readers, going into the field, sounding out his staff.

And what does Mac's editorial contribution mean?

That the reader of *electronics* is kept best informed about his industry, and is therefore most apt to progress in it. If your subscription to *electronics* is expiring, if you're not a subscriber, fill in the box on the Reader Service Card. It's easy to use. Postage is free.

electronics / A McGraw-Hill Publication • 330 West 42nd Street, New York 36, N. Y. ABP ABC mμsec at I_C = 150 ma; 35 mμsec $t_r + t_f$ is typical for low-level circuits employing I_C = 10 ma. Five megapulse operation is typical in direct coupled transistor logic saturated circuitry. Unit has a d-c current gain range from 15-45.

CIRCLE 209 ON READER SERVICE CARD

X-Y Recorders modular units

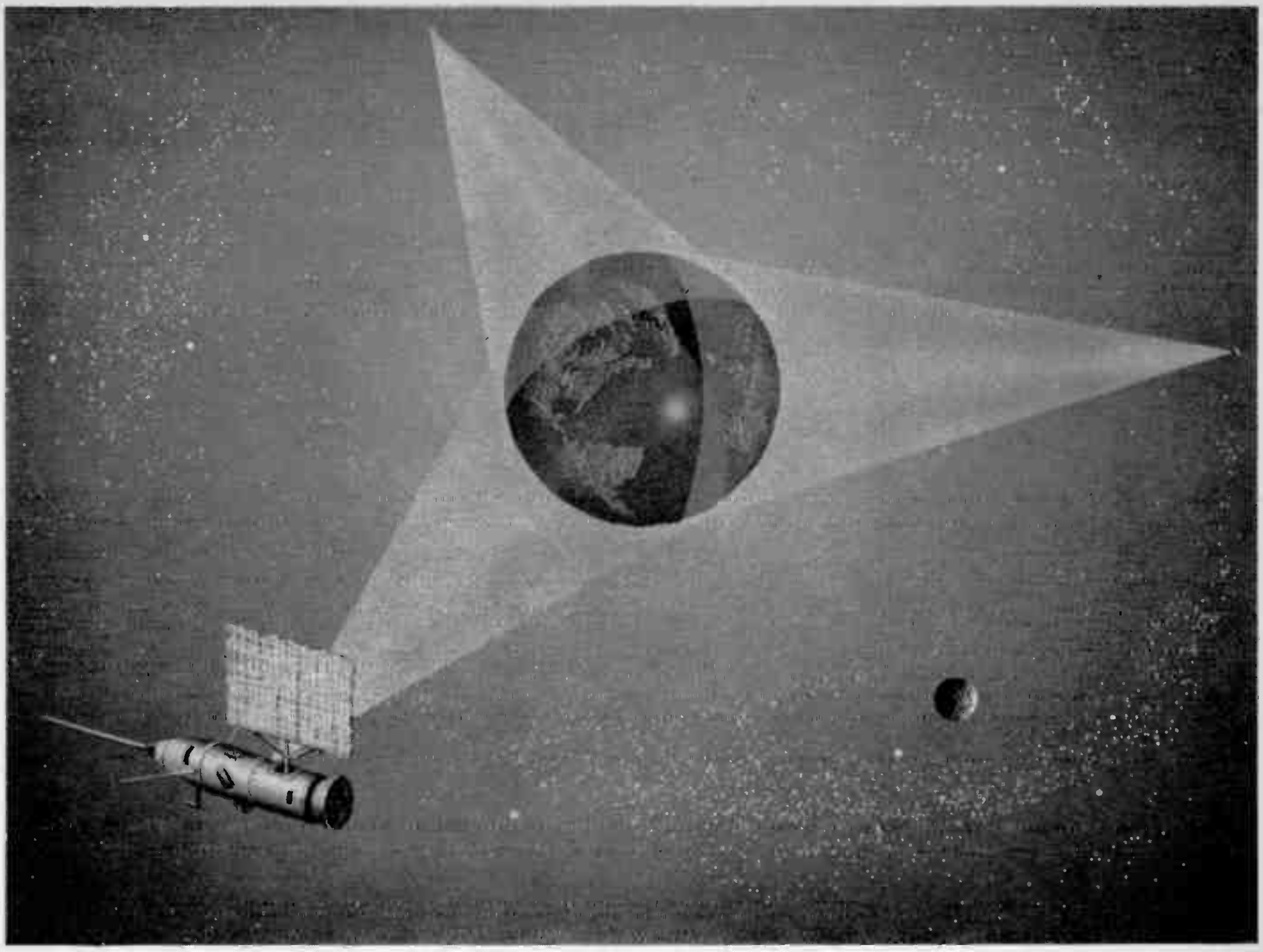
Electro Instruments, Inc., 3540 Aero Court, San Diego 11, Calif. A totally transistorized 11 by 17 in. recorder consists of a basic plotter with separate input modules for general purpose, computer, low-level differential, time base, curve following, and other specialized functions. Featured are faster slewing speeds, greater accuracies, 0.05 percent internal calibration, 10 μv sensitivity, high precision internal Zener diode reference, improved vacuum hold-down system, vernier control between ranges, remote operation of function modules, visible ink supply, front panel gain control and calibrated scales on both axes.

CIRCLE 210 ON READER SERVICE CARD

Permanent Magnets for t-w tubes

The Indiana Steel Products Co., Valparaiso, Ind., announces Indox VI permanent magnets for twt's. The new barium-iron oxide oriented material can be used where greater resistance to demagnetizing fields is required or where magnet length is limited as compared to its area. Typical properties include a coercive force (H_c) of 2,550 oersteds (higher than Indox V), a residual induction (B_r) of 3,200 gauss, and a peak energy product of 2.4 X 10^6.

CIRCLE 211 ON READER SERVICE CARD



Literature of the Week

MATERIALS

Synthetic Mica. Mycalex Corp. of America, 125 Clifton Blvd., Clifton, N. J. Volume 1, No. 1, of *The Mycalex News* contains background information on the company. Also included in the first of a four-article series on synthetic mica.

CIRCLE 225 ON READER SERVICE CARD

COMPONENTS

Components for Military Applications. Ohmite Mfg. Co., 3601 Howard St., Skokie, Ill. Catalog No. 50 is a valuable handbook on U.S. military specs covering such components as fixed power resistors, adjustable power resistors, precision resistors, rheostats, tantalum capacitors, and relays. It makes the MIL-Specs easy to understand.

CIRCLE 226 ON READER SERVICE CARD

Power Packs. Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N. J. Two-color catalog sheet No. 118 describes a line of solid state, miniaturized, high amperage power packs.

CIRCLE 227 ON READER SERVICE CARD

Coil Forms. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass., has available a coil form wall chart containing dimensional drawings and tabular descriptions.

CIRCLE 228 ON READER SERVICE CARD

EQUIPMENT

CRO. Waters Manufacturing, Inc., Wayland, Mass., has available a folder illustrating and describing model 7000-B c-r oscilloscope with a frequency response from d-c to 100 kc.

CIRCLE 229 ON READER SERVICE CARD

Transmitter Adapter. Kahn Research Laboratories Inc., 22 Pine St., Freeport, L. I., N. Y. A 4-page folder illustrates and describes model STR-59-1A all a-m stereophonic compatible ssb transmitter adapter.

CIRCLE 230 ON READER SERVICE CARD

Reflector Antennas. Blaw-Knox Co., P.O. Box 1198, Pittsburgh 30, Pa. Booklet 2556 highlights reflector antennas specially designed and fabricated for celestial study, missile and satellite tracking, and radar control.

CIRCLE 231 ON READER SERVICE CARD

Ultrasonic Cleaning. National Ultrasonic Corp., 111 Montgomery Ave., Irvington, N. J., has available a 12-page ultrasonic cleaning primer for use as a guide by potential users of ultrasonic cleaning equipment.

CIRCLE 232 ON READER SERVICE CARD

Analog Computer. Southwestern Industrial Electronics Co., 10201 Westheimer Road, Houston 27, Texas. A 2-page brochure describes and illustrates the CM-2, a solid-state computing device for mathematical calculations.

CIRCLE 233 ON READER SERVICE CARD

Thermistor Bridge. Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md. A 4-page folder illustrates and describes the model TB-2 precision 1,000 mw thermistor bridge.

CIRCLE 234 ON READER SERVICE CARD

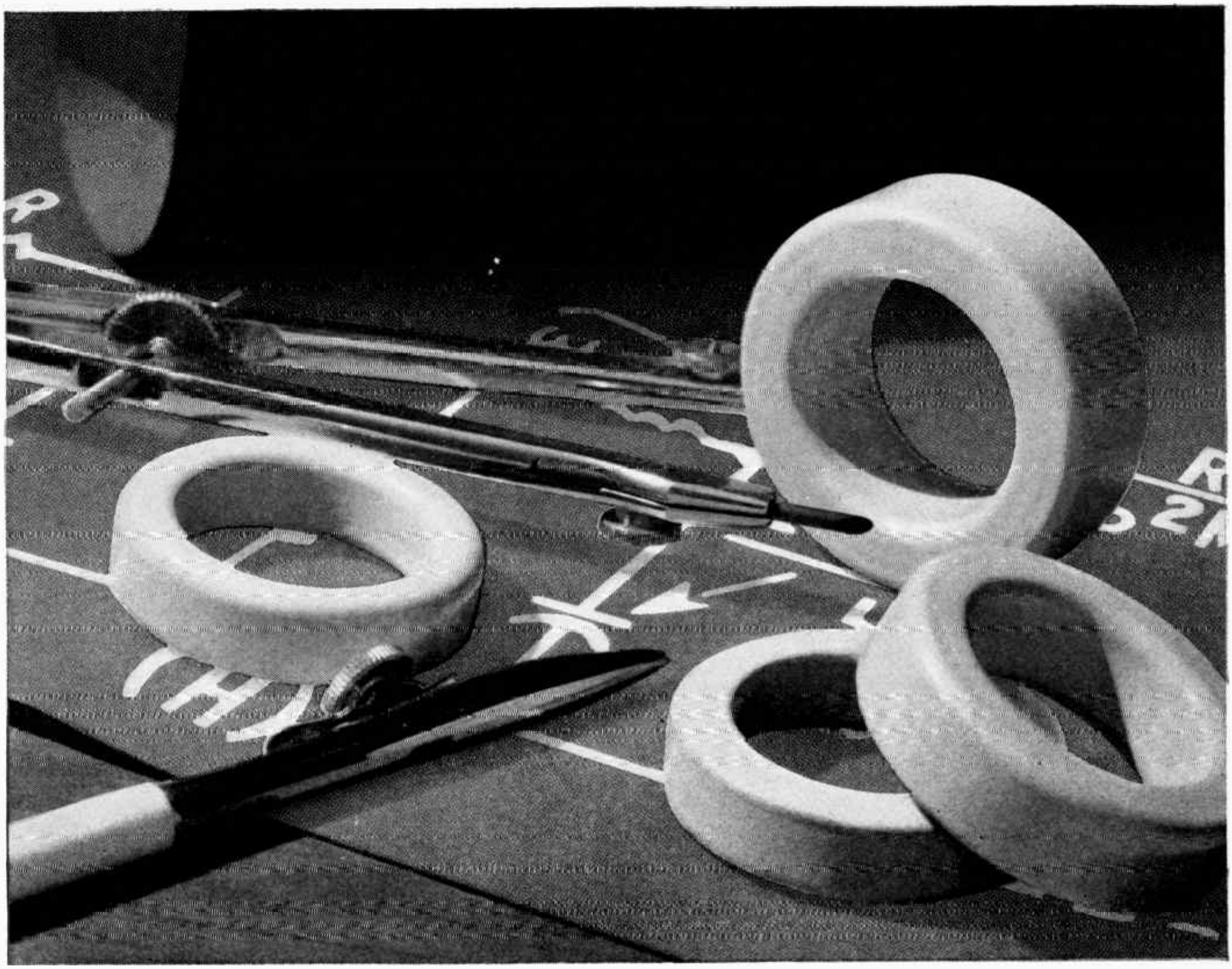
Power Stages. Texas Instruments Inc., 13500 N. Central Expressway, Dallas, Texas. A recent issue of *Application Notes* describes transistorized vhf power oscillators and amplifiers.

CIRCLE 235 ON READER SERVICE CARD

FACILITIES

Component Testing. Astrolab Testing Corp., 11615 McBean Drive, El Monte, Calif., has available a facilities brochure titled "For Proving and Improving Product Performance". It is illustrated with views of lab equipment, testing procedures, processes and report forms.

CIRCLE 236 ON READER SERVICE CARD



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. . . POWDERED PERMALLOY FILTOROID® CORES*

The high permeability and low core loss of powdered permalloy Filtoroid cores can remove design roadblocks for you. You can build extra frequency stability into filter networks with these cores. Their permeability *remains* stable with changes in time and flux levels. Distortion factors are held to a bare minimum. Temperature coefficient of inductance is tightly controlled.

There's extra design flexibility for you, too, in the broad range of Filtoroid cores available. They're made in three standard permeabilities—150, 125 and 60—in sizes up to 1.570″ O.D., all carried in stock for immediate shipment.

Our engineers are ready right now to help you select the proper Filtoroid core for your filter circuits. Write or call for a discussion of your needs, or send for Bulletin G-1.

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transformer laminations • motor laminations • tape-wound cores
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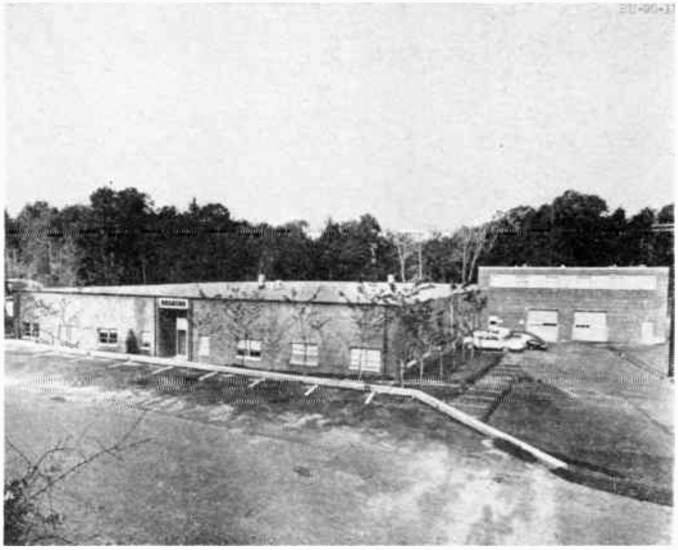


Branson Still Expanding

BRANSON ULTRASONIC CORP., Stamford, Conn., manufacturer of ultrasonic cleaning and gaging equipment, has again expanded plant facilities. Construction has been completed on a 12,000-sq-ft addition to the existing 24,000-sq-ft building built only three years ago.

As another step in a continuing expansion program, the new building houses production facilities needed to meet increasing sales volumes. Also, much larger cleaning systems are now being built, and research and development of new applications demands more space.

Active in the ultrasonics field for more than a decade, Branson has been a factor in the growth of "silent sound" from little more than a laboratory curiosity to an industrial tool essential for many modern production techniques. Vidigage ultrasonic resonance gages, Sonoray flaw detection instruments, and Sonogen ultrasonic cleaning equipment have been repeatedly refined and are currently being marketed by the company.

Branson gaging instruments use sound waves at frequencies beyond human hearing to measure metal and plastic thicknesses from only one surface, test nondestructively for laminar flaws, and determine metal corrosion rates.

In a cleaning system, sound waves at 38 kc are converted into mechanical vibrations by a transducer and transmitted into the cleaning solution. This causes cavitation throughout the volume of the liquid. Any article immersed in this activated bath will, the company says, be quickly and efficiently cleaned without hand-labor or attention.

GR To Conduct Standards Seminar

TOP technical personnel from several primary standards laboratories of the Armed Forces and the National Bureau of Standards will attend a 3½-day seminar (Nov. 17-20, 1959) on standards and measurements of capacitance at low frequencies at the General Radio Co. Laboratories, West Concord, Mass.

Program will feature an introductory meeting, a plant tour with emphasis on the manufacturing of precision standards, six lecture sessions, five workshop sessions on calibration procedures, and conclude with a question-and-answer program-evaluation and future-trends session.

Owing to the specialized nature of the seminar, attendance is being restricted to invited guests only and limited in number to insure maximum effectiveness. Registration and arrangements chairmen are J. C. Gray and L. W. Gorton, respectively.

Name Slocum IRC President

APPOINTMENT of Walter Ware Slocum as president of International Resistance Co., Philadelphia, Pa., was recently announced by Charles Weyl, former president who now becomes chairman of the board.

Slocum was formerly associated with Daystrom, Inc., where he headed several divisions at various times, and was also vice president in charge of operations for the corporation.

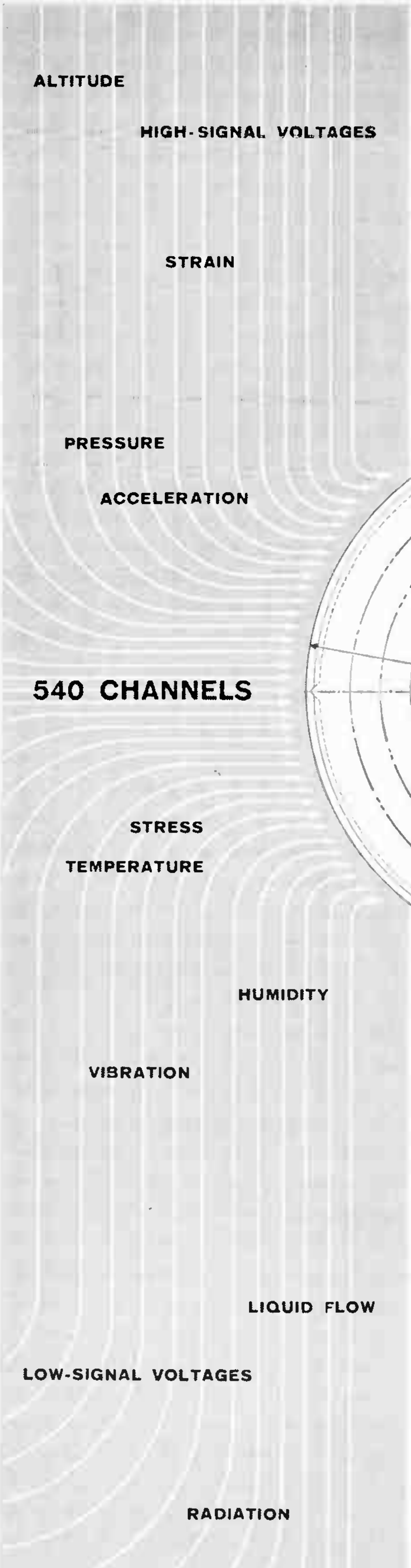
Nichols Joins Conrac, Inc.

NEW ENGINEERING manager of Conrac, Inc., Glendora, Calif., is Charles A. Nichols. He brings to his new post 30 years of experience with several West Coast electronics manufacturers.

Prior to his association with Conrac, Nichols was vice-president in charge of engineering at Hoffman Electronic Corp., Consumer Products Division.

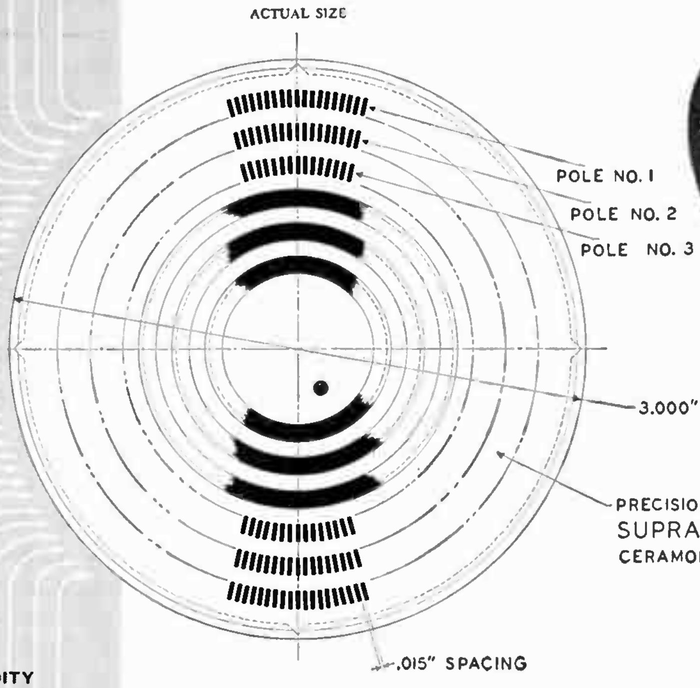
Organize New Company in West

ESTABLISHMENT of Digital Sensors Inc. in new facilities in Los An-



major advance in design:

SUPRAMICA® 555 ceramoplastic commutator plates



MYCALEX SWITCH
TM MODEL CP 499

combine: up to 540 channels . . . long life . . . low noise . . . in a 3 inch diameter

The unique properties of SUPRAMICA 555 ceramoplastic make possible an equally unique standard of performance in commutator switching plates.

Total dimensional stability prevents contact loosening. Thermal endurance of the plate up to 700°F permits long, reliable operation. 1600 hour performance at 600 rpm *without* cleaning or adjustment is normal for MYCALEX commutators of this type. In tests, an additional 4,000 hours were easily obtained after simple brush cleaning. At 1,800 rpm, 200 hours of continuous operation are normal without cleaning or adjustment.

A new low in noise level—less than 1 millivolt, when switching 5 volts into a 150 ohm load—allows the sampling of transducers with peak output as low as 10 millivolts and noise level of 10-20 microvolts, without the use of pre-amplifiers.

And we are now able to include up to 540 rectangular contacts in one three-inch diameter plate.

A letter or telephone call will bring you complete data on MYCALEX commutator plates, switches and matched brush assemblies. Our engineers are ready to design and manufacture plates and complete switches to meet your individual specifications.

SYNTHAMICA® SYNTHETIC MICA
SINCE 1919 MYCALEX® THE INSULATOR
THE FIRST SUPRAMICA® CERAMOPLASTIC

MYCALEX
ELECTRONICS CORPORATION

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Executive Offices: 30 Rockefeller Plaza, New York 20, N. Y.

EXCLUSIVE LICENSEE OF MYCALEX CORPORATION OF AMERICA

CIRCLE 89 ON READER SERVICE CARD

geles, Calif., is announced.

Company is engaged in the development of transducers for the sensing of position, pressure, temperature and acceleration, with outputs compatible with digital systems.

Holland Directs R&D Division

THOMAS E. HOLLAND is director of the recently formed Research & Development Division and vice president of Beckman & Whitley, San Carlos, Calif., manufacturer of instruments and missile components. He joined Beckman & Whitley in 1958.

Previously he has been director of research in the George Washington University Research Laboratory, physicist at the Los Alamos Scientific Laboratory, and member of the Scientific Bureau of Bausch & Lomb Optical Co.

Plant Briefs

Name of Universal Winding Co., Providence, R. I., has been changed to **Leesona Corporation.**

More than $300,000 in new environmental and electronic test equipment has been added to the engineering test department of **Bulova Research & Development Laboratories, Inc.,** Woodside, L. I., N. Y.

A new electronic display equipment manufacturing company has been formed in Redwood City, Calif., under the name **Cetec Electronics Co.** Among its first products will be video monitors for broadcast video work and closed circuit tv systems.

Erie Resistor Corp., Erie, Pa., recently broke ground for a new 20,000 sq ft plant in nearby Waterford, Pa. This location will consolidate most of the personnel and activities of Erie's Electro-Mechanical Division. Target date for completion of the new facility is December of this year.

Ferrodata, Inc., Glendale, Calif., announces the formation of the **Electro-Dynamics Division** for the study and research into extreme reliability of solid state devices.

News of Reps

Chemtronics Inc., Brooklyn, N. Y., manufacturer of chemicals for the electronics industry, appointed **Art Cerf & Co.** for the middle Atlantic States.

Robert O. Whitesell and Associates, Indianapolis. will represent Ohio Semiconductors, Inc., Columbus, in Indiana, Ohio, Kentucky, West Virginia and eastern Pennsylvania.

Fairchild Recording Equipment Corp., Long Island City, N. Y., has appointed **Stan Cluphf** of **Stan Cluphf & Associates,** Denver, Col., as sales rep for the Rocky Mountain territory which includes Montana, Wyoming, Utah, Colorado, southern Idaho, and northwestern Nebraska.

Bruce Copeland has joined the staff engineering department of **Neely Enterprises,** North Hollywood, Calif., electronic manufacturers' reps.

B. B. Taylor Corp. of Baldwin, N. Y., is now the exclusive sales rep for Pacific Electronic Controls, Inc., Monrovia, Calif., in the New York metropolitan area. P.E.C. manufactures a complete line of multiturn and single-turn potentiometers, both linear and nonlinear types.

COMMENT

Electronics in Archaeology

Your article "Understanding Dielectric Materials" (Components & Materials, p 84, Oct. 9) was called to my attention by a graduate assistant. We had recently returned from an archaeological expedition in Egypt and along the Orontes where we were attempting to investigate several putative sites of the ancient Auaris, stronghold of the Hyksos kings of Egypt's second interregnum, and of the Kadesh mentioned by Thutmose III in one of the Karnak inscriptions.

The section on oil deposits (p 87) mentions that tar sands and oil-bearing sandstones might be tapped with the aid of radio or microwave energy, and adds that "properties of composite dielectrics are of interest."

This set me off on the idea that the properties of bone and of human artifacts could conceivably be employed in the detection of ancient human settlements now covered by the sands of centuries.

My hazy recollections of physics tell me that the concentrations of bones which characterize ancient necropolises, the piles of implements and ostraka that usually mark an abandoned city, and even the weapons of bronze or iron—all should be subject to detection by electromagnetic means.

It seems possible that an instrument capable of detecting such subterranean treasures, borne aloft in a plane or helicopter, might be of infinitely greater value to archaeology than all the combined intuitions and reasonable deductions of archaeological researchers.

CALVIN DONELSON
PROVIDENCE, R. I.

Peripatetic reader Donelson gives voice to the appeal of many old and new sciences for "an electronic instrument" to help his research.

Foreign Competition

We are being threatened with an influx of Japanese and Euro-

pean imports which may seriously undermine several sectors of the industry. Japanese transistors, for example, are practically flooding the market. Transistor radios manufactured in Japan may put a big dent in our own ability to market small portables. European analysis instruments are also entering into serious competition with American-made products; and Japan, England, France and Italy are producing computers that may undermine our home-grown computer market.

Your magazine, if in no other way except by publicizing the danger, could and should do something about it.

Electronic Industries Association's attempt to erect stiffer tariff barriers is a step in the right direction . . .

E. R. CARROLL

CHATHAM, MASS.

Complaints about foreign competition are one sign that this is a maturing industry. But a maturing industry need not creak with the illnesses of old age.

Competition with European and Japanese labor is hard to take, but competition is also a source of economic strength. We do not believe that this industry needs to be completely isolated from overseas competition, although some protection is advisable to place the competition on a fair basis.

We've carried articles on Japanese and European industry in order to keep our readers informed; we'll carry more as the news develops.

Inverse Feedback

In Fig. 1 supporting G. E. Fasching's article ("Inverse Feedback Stabilizes Dry-Cell Current sources," p 78, Oct. 9), the value of R_k is shown as 1.68 ohms. It should read 16.8 ohms.

Also, the polarity of bias voltage E_3 should be diagrammatically reversed.

L. F. WILMOTT

U. S. BUREAU OF MINES
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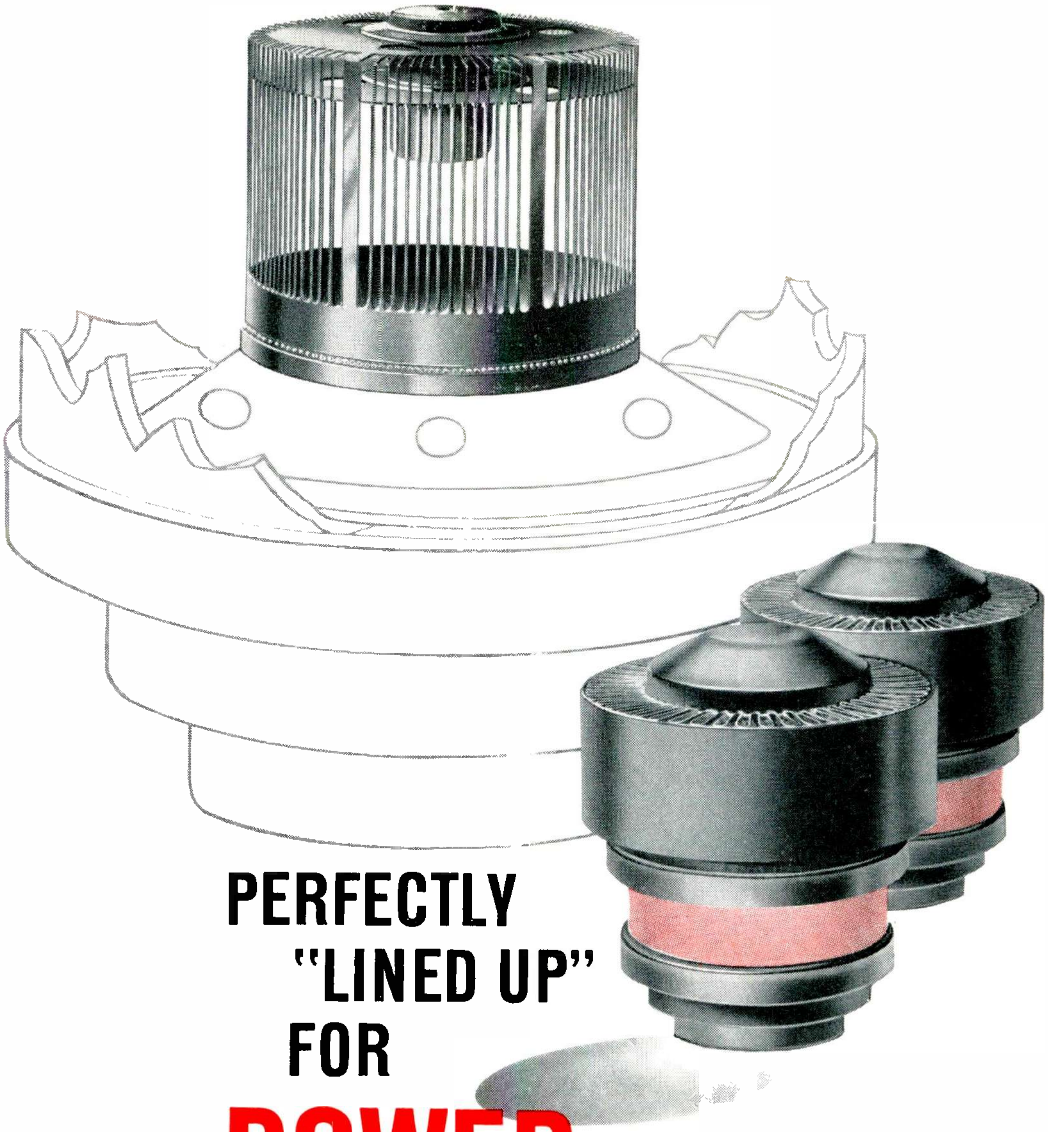

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					at 400 MC	at 1215 MC	at 400 MC	at 1215 MC
A-2572	CW or AM	2500	1250	600	760	450	20	6

Dev. Types	Operation	Max. Plate Volts	Max. DC Plate Amperes During Pulse with 10 μs duration and duty factor of 0.01	Max. Plate Dissipation Watts	Useful Power Output at Peak of Pulse—Watts at 1215 MC	Power Gain at 1215 MC
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*Peak positive

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