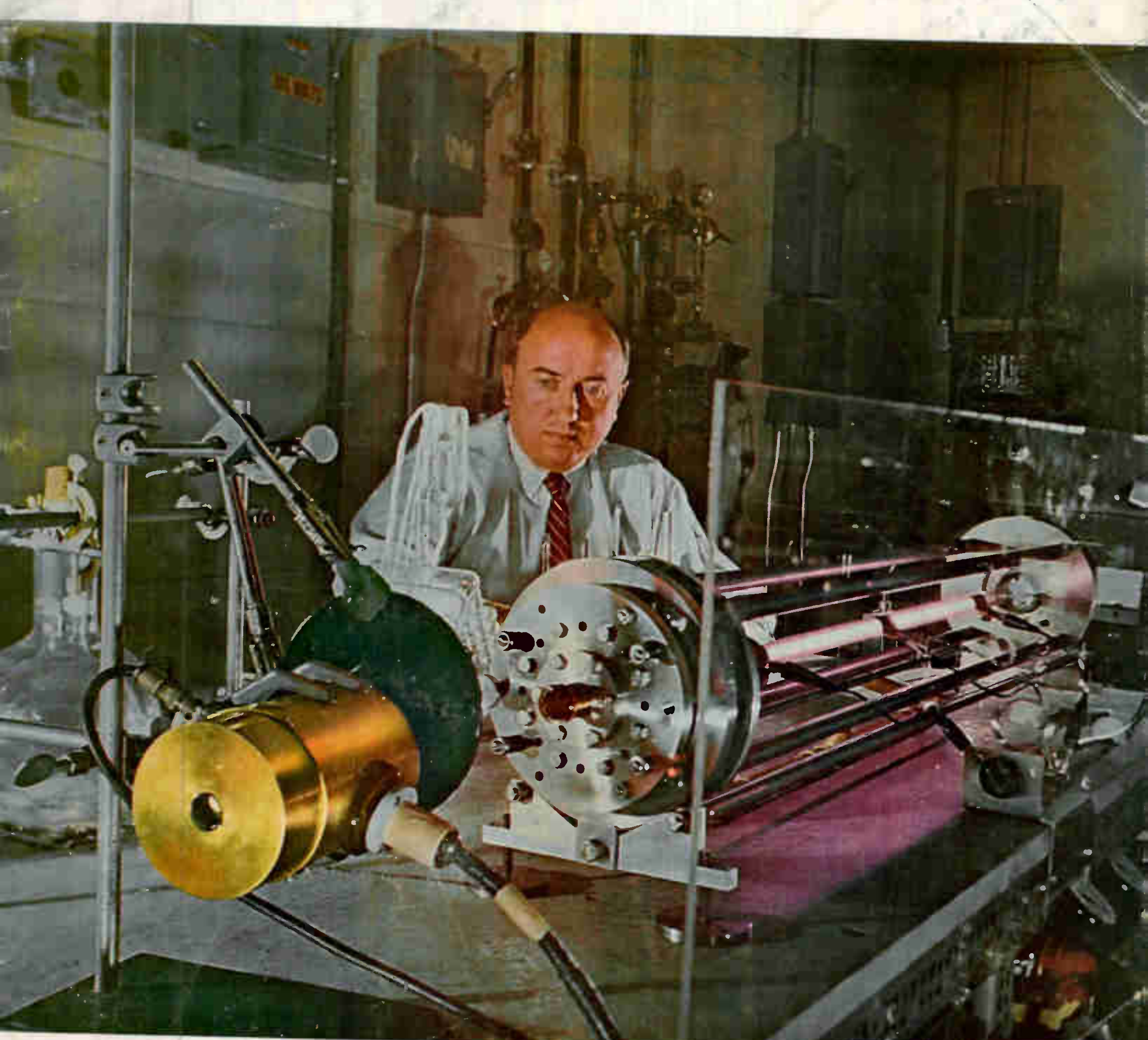
October 27, 1961

electronics

A McGraw-Hill Publication 75 Cents

GASEOUS LASER *(below) puts out coherent infrared when excited by r-f. First article of a series on lasers, p 39*



NUCLEAR FUSION

R-F techniques for C-Stellarator, p 50

SATELLITES

British space instrumentation, p 55

QKB 830 O-TYPE BWO is 1¼ inches in diameter; weighs only 1½ lbs.

provides smaller, lighter X-band signal source

New Raytheon tube combines advantages of backward wave oscillators in rugged compact package ideal for airborne and missile use.

The QKB 830 is especially suitable for local oscillator service in airborne, shipboard, or ground-based equipment such as anti-jam radar receivers. A wide-range tube, it can be tuned from 8.5 to 9.6 kMc by varying a single electrode voltage.

The small size and low voltages of the QKB 830 permit its use as a direct replacement for mechanically tuned klystrons in existing systems. It is also adaptable to many other applications requiring a voltage tunable source having provision for low-voltage pulsed or amplitude modulation.

Write today for technical data or application service to Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts. In Canada: Waterloo, Ontario.

QKB 830 GENERAL CHARACTERISTICS
(Typical CW Operation)

Power Output	15-30mW
Frequency	8.5-9.6 kMc
Voltage Requirements	
Tuning Voltage	150-250 Vdc
Focus Voltage	300 Vdc
Filament Voltage	6.3 V
Shock	50 G's
Cooling	convection
Overall Length	7.5 in.
Weight	1.5 lb. Max.

RAYTHEON COMPANY

MICROWAVE AND POWER TUBE DIVISION

RAYTHEON

CIRCLE 251 ON READER SERVICE CARD

October 27, 1961

electronics

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W. W. MacDONALD, Editor

LAMBDA

Convection Cooled Transistorized Regulated Power Supplies

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0- 34 VDC	5 AMP
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DC OUTPUT (Regulated for line and load)

Model	Voltage Range (1)	Vernier Band (2)	Current Range (3)	Price (4)
LA 50-03A	0- 34 VDC	4 V	0- 5 AMP	$ 395
LA100-03A	0- 34 VDC	4 V	0-10 AMP	510
LA200-03A	0- 34 VDC	4 V	0-20 AMP	795
LA 20-05B	20-105 VDC	10 V	0- 2 AMP	350
LA 40-05B	20-105 VDC	10 V	0- 4 AMP	495
LA 80-05B	20-105 VDC	10 V	0- 8 AMP	780
LA 8-08B	75-330 VDC	30 V	0- 0.8 AMP	395
LA 15-08B	75-330 VDC	30 V	0- 1.5 AMP	560
LA 30-08B	75-330 VDC	30 V	0- 3 AMP	860

Regulation (line) .... Less than 0.05 per cent or 8 millivolts (whichever is greater). For input variations from 105-140(5) VAC.

Regulation (load) ...... Less than 0.10 per cent or 15 millivolts (whichever is greater). For load variations from 0 to full load.

Ripple and Noise .... Less than 1 millivolt rms with either terminal grounded.

Temperature Coefficient .... Less than 0.025%/°C.

(1) The DC output voltage for each model is completely covered by four selector switches plus vernier range.

(2) Center of vernier band may be set at any of 16 points throughout voltage range.

(3) Current rating applies over entire voltage range.

(4) Prices are for unmetered models. For metered models add the suffix "M" and add $30.00 to the price.

(5) Except for LA50-03A, LA100-03A, LA200-03A which have AC input voltage of 100-130 VAC. 105-140 VAC available upon request at moderate surcharge.

AC INPUT 105-140 VAC, 60(5) ± 0.3 cycle(6)

(6) This frequency band amply covers standard commercial power line tolerances in the United States and Canada. For operation over wider frequency band, consult factory.

Size

LA 50-03A, LA20-05B, LA 8-08B	3½" H x 19" W x 14⅜" D
LA100-03A, LA40-05B, LA15-08B	7" H x 19" W x 14⅜" D
LA200-03A, LA80-05B, LA30-08B	10½" H x 19" W x 16½" D

Send for new Lambda Catalog 61

LA118A

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CIRCLE 3 ON READER SERVICE CARD

electronics

October 27, 1961 Volume 34 No. 43

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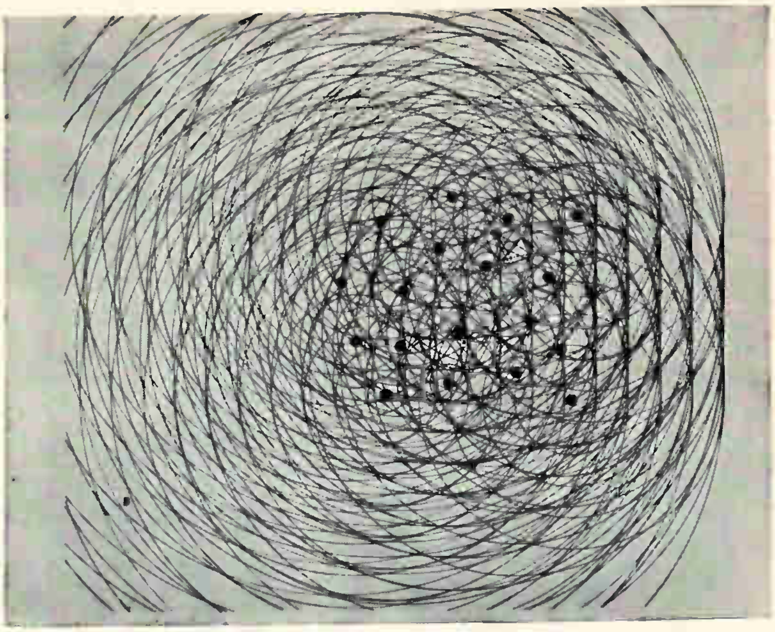
CROSSTALK



COHERENCE is one of the prime characteristics of a laser's light output. It is the characteristic which most distinguishes a laser from other light generating techniques. Once coherence is attained, light may be handled like radio waves. The Westinghouse sketch reproduced here is a conceptual picture of how a laser tunes and reinforces light output into a single, spatially coherent wavefront.

The 19 black circles are ions within the lasing material that radiate light (indicated by the concentric thin circles about each ion) in phase. This in-step radiation produces the developing wavefront that progresses to the right of the drawing.

Principles of laser operation are explained this week in the first part of a four-part series on lasers by Associate Editor Vogel and Assistant Editor Dulberger. The article on p 39 discusses laser materials, materials research and the development of lasers. Applications will be reported next week.

PLASMA BREAKDOWN and ohmic heating circuits described in this issue by C. D. Allen, G. A. Senior and S. M. Zollers, of RCA, are used in the C-Stellarator at Princeton University Plasma Physics Laboratory. This is the fourth article ELECTRONICS has published on the various Stellarator circuits. Our July 3, 1959 issue had a description of the 250-Kc generator by R. L. Gamblin (p 50), ohmic heating was described—also by Gamblin—on Oct. 9, 1959 (p 57), and a megawatt pulsed r-f generator was discussed by H. M. Hill, Jr. in our July 21, 1961 issue (p 70).

Coming In Our November 3 Issue

CIRCUIT DESIGN. For design of a typical transistor amplifier, the gain and stability factors are generally given and a complex mathematical procedure is used to specify component values. These calculations can be greatly simplified by the graphs prepared by D. McLaren of The Martin Co. in Orlando. These graphs are based on computer solutions for the various resistance and transistor beta versus gain and stability factors.

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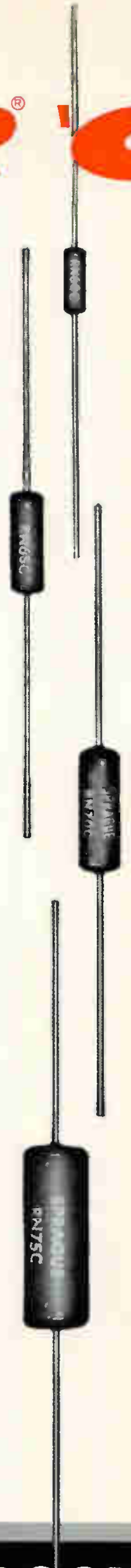
METAL FILM RESISTORS OFFER 5 DISTINCT TEMPERATURE COEFFICIENTS TO MEET ALL CIRCUIT REQUIREMENTS



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COMMENT

Microminiature Component Sales

I have read with great interest your August 4 (p 22) article "Microminiature Circuits: $1.2 Billion in 1965?" However, I am quite puzzled with the level of microminiature component sales estimated for 1960 as shown on the second chart. At $416 million they approach one-half of total selected components' sales of $968 million for 1960.

I can't imagine such a high sales volume for this segment of the components market in 1960. Possibly the answer lies in the definition of microminiature components as applied to 1960 sales.

Please furnish, if at all available, a detailing of components contained in the $416 million figure, or at least an explanation for the extremely high 1960 sales level of such a recently introduced member of the electronic components family.

CHARLES R. O'NEAL
General Electric Company
Owensboro, Kentucky

We got in touch with the information source, and here is his answer:

The primary purpose of the charts was to describe the trend of microminiaturization likely to occur in military electronics. The projections are interpreted to be the ultimate potential values for selected years; whether or not this potential will be realized depends on a variety of factors which are beyond the scope of the projections.

Selected components include semiconductors, resistors, capacitors, quartz crystals, transformers, connectors, and relays. These are the components that have proven to be adaptable to high-density packaging. Such devices are currently being assembled by a variety of techniques and are being marked in quantities today. Advance military planning anticipates that microminiaturization will account for an increasing share as the demand accelerates for extremely lightweight and high-reliability packaged circuits.

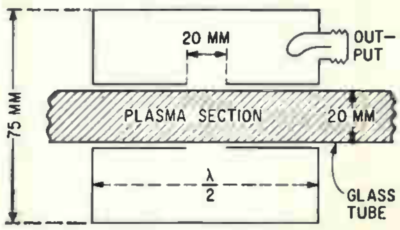
In order to establish a trend for the projection, a rate of microminiaturization was assumed for 1960 and applied to the current level of selected component sales. The projection for 1960 is merely an indication of the rate of penetration by microminiaturization that would have occurred if the full force of high-density packaging had existed.

J. H. RIDDEL
Radio Corporation of America
Somerville, New Jersey

Plasma Engineering

It was very interesting to read the articles in ELECTRONICS about plasma engineering, because we are occupied with plasma amplifiers here.

I was especially interested in the first photo of the second article (August 4, p 33) because it seems to me that Bell Labs uses a microwave cavity very similar to ours



for measuring the shift of the resonant frequency. However, I think it is very difficult to calculate the absolute plasma density from these measurements, so I would be glad if you have any further information about this technique. To help you I enclose a drawing of our resonator.

STURE KRONLUND
Chalmers University of Technology
Gothenburg, Sweden

Mr. Kronlund has been sent the name of the Bell Lab's scientist shown taking resonant frequency measurements of the cavity.

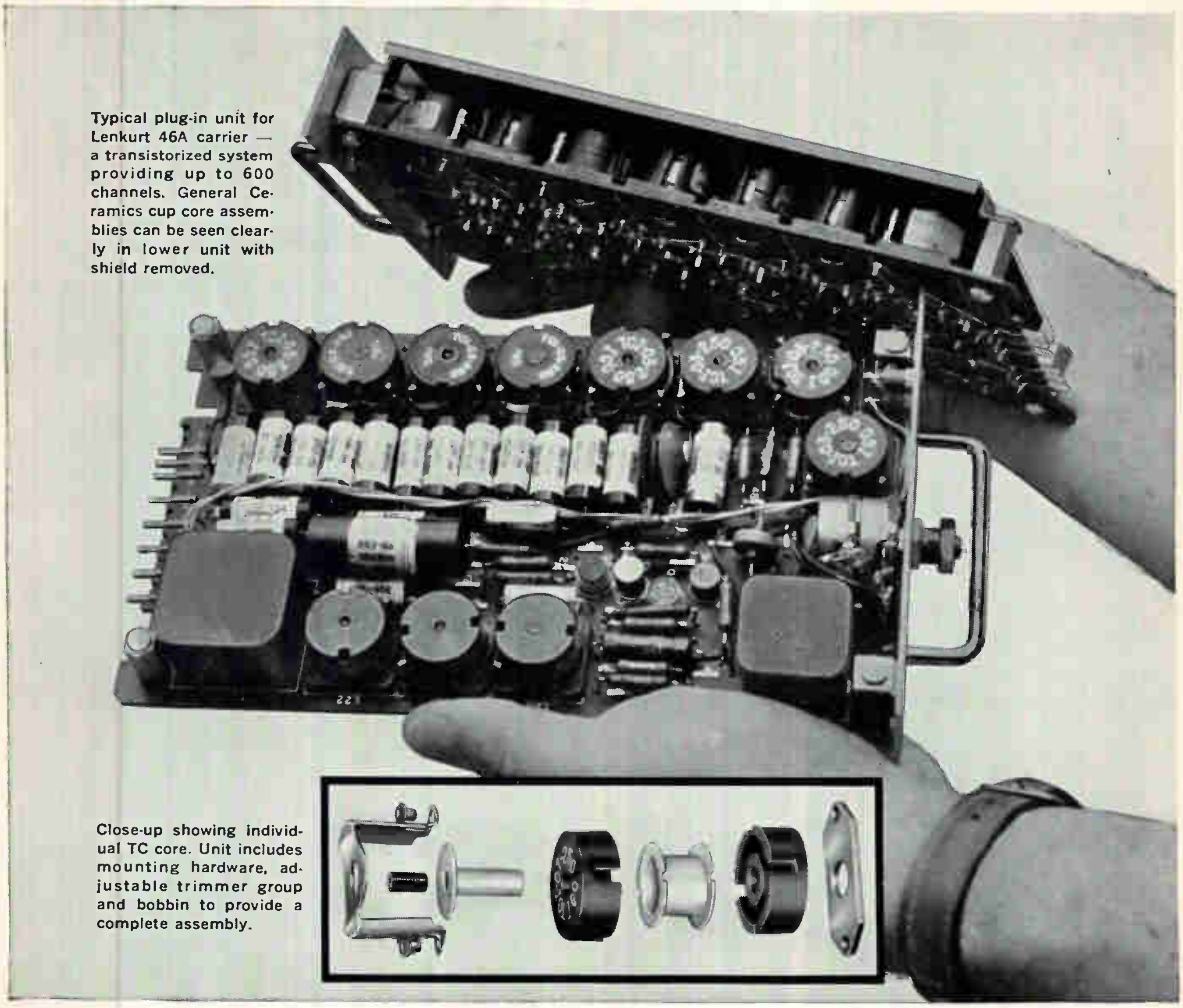
Alumni News

As a faithful alumnus of The Ohio State University, I feel compelled to point out to you that there is no such school as University of Ohio, as mentioned in Crosstalk (Sept. 8, p 4). I am certain that my alma mater is the university which should have received the credit.

J. A. LYTLE
Milwaukee, Wisconsin

Reader Lytle is correct. The name of his alma mater appeared correctly in the article to which *Crosstalk* referred (Sept. 15, p 49).

From the General Ceramics Division of
INDIANA GENERAL CORPORATION



Typical plug-in unit for Lenkurt 46A carrier — a transistorized system providing up to 600 channels. General Ceramics cup core assemblies can be seen clearly in lower unit with shield removed.

Close-up showing individual TC core. Unit includes mounting hardware, adjustable trimmer group and bobbin to provide a complete assembly.

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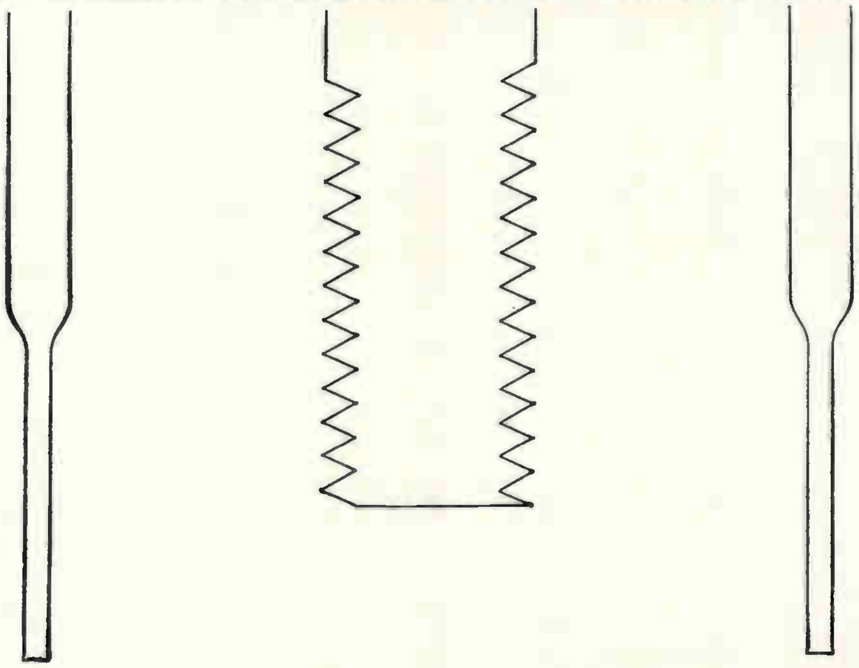

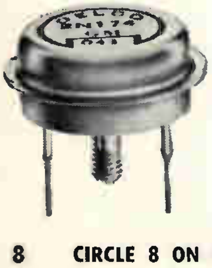

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ELECTRONICS NEWSLETTER

Math Proves Two-Color Perception Theory

SIMPLER COLOR TV, multidimensional color sensory devices, learning machines that adapt to color, new data displays—these and other man-machine developments are expected to flow from mathematical verification of the two-color vision theory advanced by Edwin H. Land, of Polaroid.

Starting with Land's empirical data, Huseyin Yilmaz, a physicist at the new Sylvania Applied Research Laboratory, Waltham, Mass., built a mathematical model of human color perception. It reportedly outmodes the classical three-color explanation.

Yilmaz' theory states that the illuminant to which the visual field is subjected establishes a frame of reference in color space. The brain transforms to its own reference frame by solving equations similar to Lorentz transformations used in relativistic mechanics.

Equations are almost identical to Lorentz'. In place of relative velocity v/c, Yilmaz has relative saturation—saturation of the new frame of reference/maximum saturation to which eye responds.

Sylvania demonstrated by projecting two black and white negatives on a screen. One projection went through a reddish-orange slide, the other through a yellowish-green slide. Several colors produced were not predicted by classical color theory. The work is part of research on information processing. Formulation of human hearing and smell will also be attempted.

IRE and AIEE Consider Merger of Membership

MERGER of two major engineering societies—Institute of Radio Engineers and American Institute of Electrical Engineers—is underway. Boards of directors of both societies last week approved the first steps.

Both adopted resolutions outlining advantages of consolidation and appointed members to a study committee. The committee is to report by Feb. 15, 1962. If society members also vote approval, the merger would be completed by Jan. 1. 1963.

IRE was founded in 1912 and AIEE, in 1884. Interests and activities of the two groups overlap in many cases. Some 6,000 engineers belong to both. World-wide membership of the joint society would be about 150,000.

Orbiting Needle Belt Launched with Midas

AIR FORCE launching of an orbiting needle belt last Saturday immediately triggered a wave of protests from astronomers around the world who fear it might obscure their view of the heavens. One scientist called it "a major intellectual crime".

Air Force defends the project, called West Ford, as important to science. A primary aim is research in space dynamics, another to test effectiveness of orbital scatter. Two such belts could provide communications between any two points in the world. MIT says the widely-spaced needles will not appreciable affect astronomy.

The dipole dispenser was launched piggyback with Midas IV, which will orbit independently. It will be about a month before the needle cloud will spread into a belt circling the earth. Average separation between dipoles will be about 1,200 feet.

Death Ray Wanted

NEXT MONTH, the Air Force's Rome Air Development Center will receive proposals for a design study of a radiation weapon.

The death ray will reportedly be an optical maser's high energy light beam.

ELECTRONICS reported Oct. 13 (p 4) the possibility of using lasers as a missile defense. The series of articles on lasers beginning this week also discusses weapons applications.

Advance Current Primes Memory Steering Diodes

AMPEX Compter Products is producing large capacity ferritecore memory units with cycle times as small as 1.5 microseconds.

Speed is obtained by use of 30-mil cores, high-speed gating circuits and linear-select, partial flux techniques. Currents are 200 ma for read and 100 ma for write. A primer current precedes regular current by 25 to 50 nanoseconds in current steering diodes, enabling lower cost diodes to handle switching.

Units store 2,048, 4,096 and 8,192 56-bit words. Operating modes are clear-read, read-regenerate and split read write. A follow-on prototype cycles in one microsecond. Future types may locate, read and regenerate address cores in 0.6 microsecond.

Bacterial Batteries Create Usable Power

CALIFORNIA company claims it has obtained enough electricity from bio-power device to operate radio beacons at sea. Magna Products, of Santa Fe Springs, reports it has had device models in operation for a year. One type is a cell which contains bacteria feeding on nutrients found in sea water. Second is a fuel cell utilizing organic matter and air. Third is a solar cell containing photosynthetic organisms.

Company says development stems from investigations of bacteria—caused corrosion in oral wells and pipelines at sea.

Nonprofit Satellite Company Recommended

WASHINGTON—FCC-appointed committee of international communications carriers is recommending a nonprofit corporation develop and operate communications satellites for the U.S. The carriers offered to put up $60 million of the $100-$200 million cost. System could be operating in 1965, with limited version in 1964.

Domestic carriers, led by General Telephone and Electronics, asked FCC to extend time for reply to the proposal to Nov. 27. FCC gave them 30 days, to Nov. 12. Several firms want private, rather than public ownership of satellites.

Meanwhile, congressional objections to possibility of a monopoly arising from international carrier operation of satellite system continued. Emanuel Celler, chairman of the House antitrust subcommittee said AT&T is likely to contribute 80 percent of cost and would thus dominate the system. He asked FCC to reject the proposal.

Process Control Bucks Skepticism in Europe

MILAN—Many of the 300-plus scientists and engineers attending the recent International Automation Conference in Turin expressed skepticism about present capabilities of automatic process control.

Cited were the lack of sensing devices able to precisely measure process variables and insufficient knowledge of plant dynamics needed to derive process equations.

Proponents argued that modern high-speed computers now make it possible to consider dynamic optimization of a process. The computer does not have to act upon set points of traditional controllers and exercise static control, they said, but can act directly on process valves, eliminating conventional instrumentation.

Air Launching Would Give Rocket Accuracy

FURTHER INFORMATION on the NAA-Aeronutronic proposal to substitute a B-52 and X-15 for first two stages of Blue Scout launch vehicles has been received. As reported last week, method is aimed at saving two-thirds cost of guided launches and half of current costs for unguided launches.

Aeronutronic says the system would give an unguided mission almost the same accuracy as a guided one of the Blue Scout variety. Company, which builds Blue Scout, did not speculate on use of other vehicles.

Three parts of air launch system would need no more electronics than ground launch. The B-52 would carry compact checkout equipment, X-15 a stable platform and Blue Scout the regular autopilot. Payload for deep space shot is estimated at 50-60 pounds and payload for orbiting at 300 to 800 miles, 50 to 125 pounds.

Educational Electronics Joint Venture Formed

MCGRAW-HILL Book Co. and Thompson Ramo Wooldridge have agreed to jointly develop and produce a wide range of electronic teaching equipment and related programs of instructional materials. TRW is to provide audiovisual, computer and control devices and systems and programming techniques; McGraw-Hill is to prepare the programs. Programs will be designed for school, industrial, commercial, military and home use. Both firms have been active in educational electronics, TRW in hardware and McGraw-Hill in software. The book company is a subsidiary of the firm which publishes ELECTRONICS.

New Lens May Beam 5-Mw of R-F Power

ELECTROMAGNETIC amplifying lens, capable of radiating a 5-Mw beam of microwave power was described at a Chicago IRE meeting last week by W. C. Brown, of Raytheon.

Brown dramatized possible use by picturing a helicopter with a 30 to 50-foot dish antenna. Dish would collect enough energy to drive motor in craft. Brown added that a plane carrying an educational tv station might be kept aloft, pilotless, a month for $5 an hour.

Lens positions an anode—much larger than one used by a magnitron or Amplitron—at the center of the tube with its cathode at the perimeter. Gain builds along the tube's axis, with the space charge spiraling in a fluted helical gear configuration.

In Brief . . .

SEARS ROEBUCK has introduced a private brand 21-inch color tv set priced between $449 and $549.

INTERPLANETARY transportation systems and spacecraft orbits are being studied by Lockheed under $65,000 NASA contract.

FIVE-STORY HIGH sonar transducer, weighing several hundred tons, may be used in Artemis, Navy project in advanced submarine detection system. Transducer would use Arma gyrocompass as north-seeking reference.

AIR FORCE will station six flying communications systems around the world, under Project Talking Bird. General Dynamics/Electronics is supplying single sideband equipment.

ELGIN National Watch has received $4 million in new production orders for Bullpup, Sparrow, Sidewinder and Tartar missiles.

KEARFOTT has been awarded a $2.2 million contract for more than 300 N-1 gyrocompasses, which are used in B-52 bombers.

POST OFFICE in St. Paul, Minn., will be equipped with electronic mail-sorting devices.

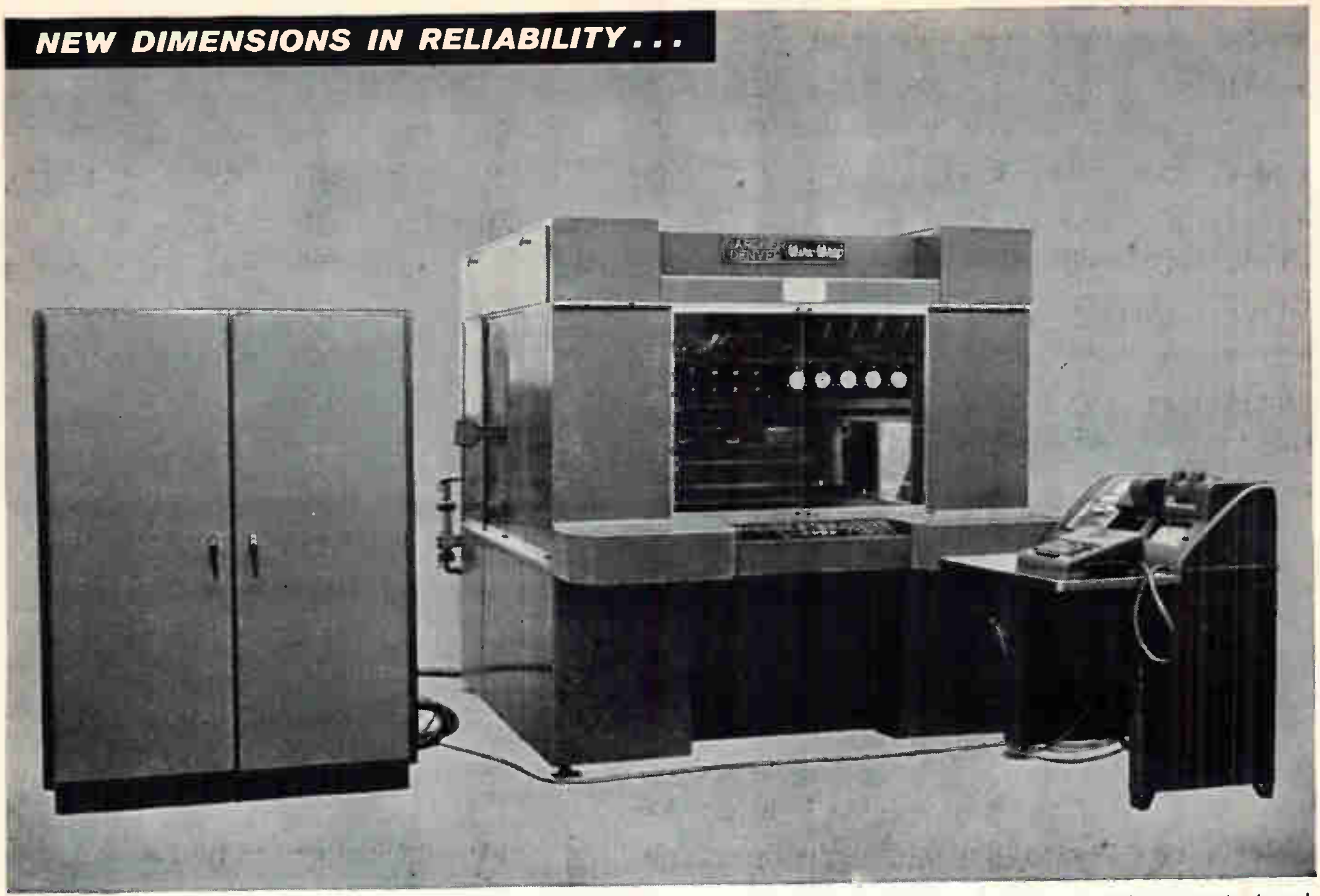
HUGHES has delivered to Signal Corps first of a new helicopter transportable system to direct fire of widely dispersed Nike and Hawk missile batteries.

AUSTRIA reports manufacture of 60,000 tv sets in first half of 1961, gain of 50 percent over 1960. Radio output dropped by 2,000, to 215,000.

AUSTRALIA'S Department of Defense is setting up four edp centers, has bought two of Minneapolis-Honeywell's model 800 computers for one in Canberra.

TWA AIRLINES has bought a worldwide, computer-based reservations handling system from Teleregister Corp., for $6.5 million.

ADMIRAL'S new stereo portable phonograph includes a microphone that allows listener to sing along with records.



Gardner-Denver "Wire-Wrap" machine with control system that utilizes punched cards to wire complex computer boards

Automate complex wiring systems with Gardner-Denver *Wire-Wrap*® Machines

Gardner-Denver has added new dimensions to the reliability of complex electrical connections with automatic "Wire-Wrap" machines . . . for both commercial and military applications.

One machine wires complicated modular boards fast—in almost any pattern you can think of . . . makes literally thousands of connections in a small space. Machines are used for both commercial and military applications.

And these connections are the most reliable in the world —because they're solderless wrapped connections. They're lastingly secure, conquer vibration failure and corrosion. More proof of superiority? Over a billion connections without a reported failure.

If you build electrical equipment that calls for complex connections which must be reliable, write for an appointment with one of our engineers.

Complicated back panel—automatically wired by "Wire-Wrap" machine contains 2480 wires and 4960 connections.

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WASHINGTON OUTLOOK

ARMY has tentative approval to begin production in fiscal year ending July, 1963, of long lead-time components of Bell Telephone Labs' Nike Zeus anti-ICBM system. Preliminary estimates of next year's defense budget earmark $383 million for Nike Zeus (photo). This is $130 million more than the project's current budget.

A final decision on Zeus' future will depend on operational-type tests scheduled for next spring in the Pacific. The Army's current Zeus plan calls for systems to protect six major metropolitan areas. Each would consist of a control center and two missile batteries. Production costs would total about $3.1 billion over the next five years.

PRELIMINARY defense budget for next year also includes funds to begin development of a new tactical ballistic missile, to speed development of Minuteman ICBM railcar system and to substantially increase production of Douglas Aircraft's A-4D attack plane.

The new missile will have a range of about 750 miles and will be deployed by NATO forces. Whether the Army or Air Force will be in charge of development is undecided. A-4D has been tentatively selected as air support plane for Army ground forces until the next-generation TFX fighter is developed under an Air Force-Navy joint project.

EARLY estimates of next year's defense budget total $53.7 billion, some $2 billion over fiscal 1962 appropriation. However, odds are that in January the Kennedy administration will seek a supplemental appropriation for the current year.

Military contract awards for this year add up to at least $24.5 billion—about $3 billion over last year. The services have been authorized to place $25.4 billion worth of orders for production, R&D, and construction.

In the quarter ending September 30, awards went over $6 billion, up about $1 billion from the previous quarter, the heaviest rate of defense contracting since Korea. Over the next two quarters, the rate will be close to $6 billion, then will shoot well over $6.5 billion in the April-June quarter.

This precision DC VTVM is also a wide range, precision ohmmeter and ammeter!

1% accuracy 100 µv to 1,000 volts!

Also 2% accuracy, 1 µa to 1 amp full scale.

Measures 0.02 ohms to 5,000 megohms.

No zero adjustment. Fast warm-up.

Floating chassis. $1,000 worth of convenience for $400!

Haven't you wished for one compact, simple instrument that would make *precision* dc voltage, dc current and resistance measurements over a wide range?

The ⓗⓟ 412A is it! In its VTVM circuit, the 412A uses an exclusive ⓗⓟ photo-chopper instead of old-style mechanical vibrators—no drift, no 60 cps pickup. Input is floating, with resistance increasing from 10 megohms on the 1 mv range to 200 megohms on ranges above 100 mv. Current and voltage ranges have a 10 db sequence for maximum readability and overlap. The ohmmeter is a modified Kelvin bridge eliminating lead resistance error; you measure resistance accurately on hook-up wire sections as short as 6″.

Model 412A also includes a 1 v or 1 ma recorder output, and 3 separate probes. Call your ⓗⓟ rep today for a demonstration on your bench. Price, $400.00.

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ⓗⓟ voltmeter covers 10 cps to 4 MC; accuracy high as ±2% of reading or 1% of full scale. Voltage range 0.3 mv to 300 v, 12 ranges, 1-3-10 sequence. Max. full scale sensitivity 1 mv. Large 5″ true log voltage scale, linear 12 db scale, generous overlap. High stability, high input impedance. Also useful as amplifier for small signals, or to monitor waveforms.

ⓗⓟ 400H PRECISION VOLTMETER—$325
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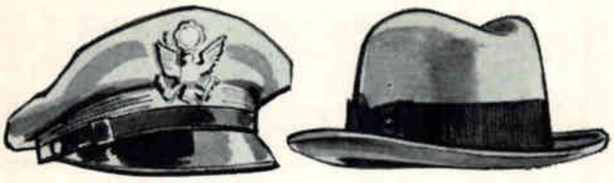

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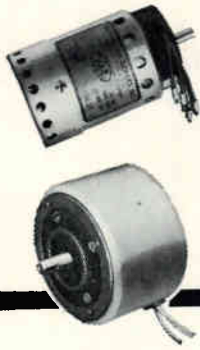

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From 1" to 6⅝" diameters. Power to 1000 VA. Wide frequency range. Low harmonic content. Sine waves with maximum 2% total distortion. Single-, dual- (sine-cosine), three-phase. Dual frequency units, for special applications, produce a combination of frequencies.

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Avail. in Sizes 8, 10, 11, 15 & 18. Damping servo motor generators (tachometers) and temperature compensated, integrating tachometers — supplied as tachometers only or with integral servo drive motor. Special voltages, scale factors and different compensation characteristics can be provided.

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WHO SAID IT COULDN'T BE DONE?

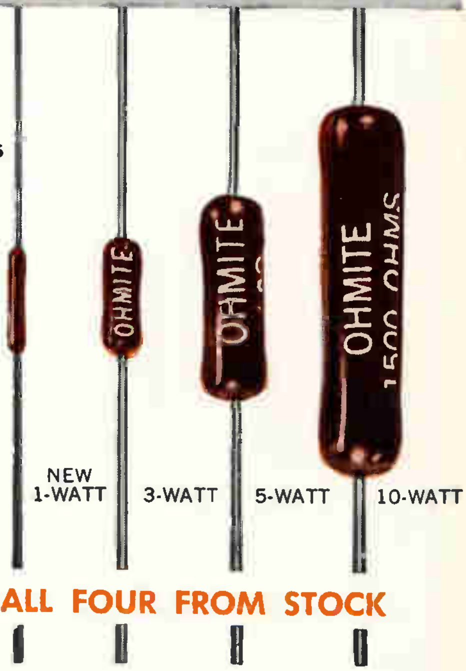
OHMITE'S
NEW ONE-WATT
Vitreous-Enameled Resistor
With Axial Leads

Lots of people thought this tiny "1-watter" was impossible. But here it is. And for the first time in this power rating, circuit designers can get all the advantages of a wire-wound, vitreous-enameled resistor with axial leads—high temperature operation, up to 350°C; ±5% tolerance; low temperature coefficient; low "noise" level; stability; and strong, welded construction.

Construction is the same as Ohmite's 3, 5, and 10-watt sizes—including ceramic core, uniform winding, tough Ohmite vitreous enamel coating, and traditional Ohmite reliability.

Resistance values range from 1 to 6000 ohms. But you can find out all about this *exclusive* Ohmite development by writing for *Bulletin 147. Do it now!*

Now 4 Sizes



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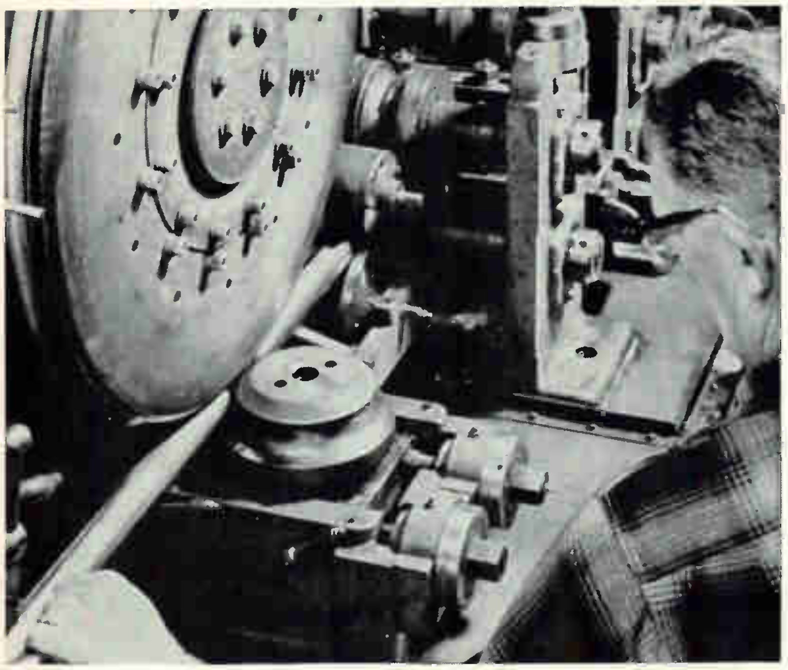
OHMITE

CIRCLE 17 ON READER SERVICE CARD

Chemical Division 3M COMPANY



No hoses, seals or pumps! FC-75 Coolant helps reduce "cube" of new welding transformer by 75%

Electrical resistance welding of tubing has been greatly improved by 3M Brand FC-75 Inert Fluorochemical Liquid Coolant. The Yoder Company has introduced a welding transformer using FC-75 that's only ¼ as large as previous models—yet can raise tube output as much as 60%!

The original water-cooled transformer required hoses, seals, and pumps: FC-75 eliminated these accessories. One water-cooled transformer was a 3 foot cube in size. The new comparable transformer now measures only 9″ x 21″ x 36″! The transformer primaries and cores are submerged in FC-75. As heat builds up, the coolant liquid vaporizes, carries heat to the transformer case, condenses, and returns to the liquid state.

A secondary conductor system is eliminated, secondary impedance is greatly reduced, and current travels directly from the transformer to the electrode. For example, on one size, amperes are up from 41,000 to 51,000, increasing performance. Less input, smaller generator, motors and starters are required.

With FC-75 coolant, the Yoder Transformer can be pushed to capacity, with safe internal temperatures of 300° F! Corrosion and short circuiting are practically impossible. Units designed to take advantage of FC-75 coolant offer you compactness, more efficiency and less maintenance. See the Properties Profile for full specifications. And write us today for more information on FC-75 and FC-43.

PROPERTIES PROFILE on 3M BRAND INERT LIQUIDS FC-75 and FC-43

These unique dielectric coolants possess unusual properties that can prove advantageous to the designer of electrical devices and instruments, as well as to the manufacturer. Increased range of operating temperatures, improved heat dissipation which permits miniaturization, and greatly increased protection from thermal or electrical overload are possible with their use.

FC-75 and FC-43 are non-explosive, non-flammable, non-toxic, odorless and non-corrosive. FC-75 is stable up to 750° F., FC-43 to 600° F. Both are completely compatible with most materials . . . well above the maximum temperatures permissible with all other dielectric coolants. Both are self-healing after repeated arcing in either the liquid or vapor state.

ELECTRICAL PROPERTIES

	FC-75	FC-43
Electrical Strength	35KV	40KV
Dielectric Constant (1 to 40 KC @ 75° F)	1.86	1.86
Dissipation Factor (1000 cycles)	<0.0005	<0.0005

TYPICAL PHYSICAL PROPERTIES

	FC-75	FC-43
Pour Point	<—100° F.	—58° F.
Boiling Point	212° F.	340° F.
Density	1.77	1.88
Surface Tension (77° F) (dynes cm)	15	16
Viscosity Centistokes	0.65 min.	2.74
Thermal Stability	750° F.	600° F.
Chemical Stability	Inert	Inert
Radiation Resistance	25% change @ 1 x 10^8 rads	25% change @ 1 x 10^8 rads

FC-75 and FC-43 have nearly equivalent heat capacities in the liquid and gaseous states.

For more information on FC-75 and FC-43, write today, stating area of interest to: 3M Chemical Division, Dept. KAX-101, St. Paul 6, Minn.

MINNESOTA MINING & MANUFACTURING CO. 3M

Now only from RCA

World's First Silicon PLANAR EPITAXIAL Switching Transistor in the miniature TO-46 Package

RCA announces the 2N1708, first and fastest silicon planar-epitaxial computer transistor in the TO-46 package

PLANAR CONSTRUCTION for excellent stability, high reliability. Collector cut-off current reduced by a factor of 20 to 1 over mesa types. Uniform beta over a wide current range. Maximum storage temperature—300°C.

EPITAXIAL CONSTRUCTION for low saturation voltage and improved switching times.

MINIATURE CASE for extremely high density packaging. Uses same lead arrangement as TO-18 package but requires only 40% of the TO-18 headroom.

BROAD SILICON LINE The new 2N1708 planar-epitaxial transistor is another example of RCA's advanced silicon technology, application-oriented to today's performance and miniature packaging requirements. The 2N1708 complements the other RCA silicon planar switching transistor types: USA 2N706, 2N706, 2N706-A, 2N708, 2N696, and 2N697.

Check the data on these outstanding RCA types. For information on RCA computer transistors and multiple switching diodes, call your RCA Field Representative. All these types are immediately available in quantity. For further technical information, write to RCA Semiconductor and Materials Division, Commercial Engineering, Section J-18-NN-4, Somerville, N. J.

	RCA 2N1708	
CHARACTERISTICS	TEST CONDITIONS	LIMITS
I_{CBO}	V_{CB} = 15 volts; I_E = 0	.025 μa max.
I_{CEX}	V_{CE} = 10 volts; V_{BE} = 0.35 volts; Free-air Temp. = 100°C	15 μa max.
V_{CE} (sat.)	I_C = 10 ma; I_B = 1 ma	.22 volts max.
V_{BE} (sat.)	I_C = 10 ma; I_B = 1 ma	.9 volts max.
t_s	I_C = 10 ma; I_{B_1} = 10 ma I_{B_2} = 10 ma;	25 nanoseconds max.
$t_{\text{"on"}}$	I_C = 10 ma; I_{B_1} = 3 ma; I_{B_2} = 1 ma; V_{CC} = 3 volts	40 nanoseconds max.
$t_{\text{"off"}}$	I_C = 10 ma; I_{B_1} = 3 ma; I_{B_2} = 1 ma; V_{CC} = 3 volts	75 nanoseconds max.

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Competition Stiffens Abroad

WORLDWIDE ELECTRONICS market survey now in progress is pointing out some of the strengths and weakness of U. S. sales prospects in many smaller nations.

Conducted by the Business and Defense Services Administration of the Department of Commerce, the survey so far covers sixteen nations. It concerns itself with the market for U. S. microwave, forward scatter and other radio communications equipment and radar. Nations covered to date range from such heavily industrialized countries as West Germany to Nepal, where telephone equipment in outlying regions is sometimes stolen by hill tribesmen.

On-Spot Surveys

Tougher competition is clearly ahead for the U. S. communications and radar equipment manufacturers, according to the report. Information disclosing this comes from on-the-spot observations by U. S. consular and embassy officials at the request of BDSA's Electronics Division. Primary reasons for the U. S. missing sales are initially higher prices for U. S. products, tariffs unfavorable to U. S. manufacturers and government preference for domestic equipment.

Austrialia, for example, has a protective duty of 45 percent ad valorem on U. S. radar gear. British equipment is subject to a 27½ percent duty. Although imports of radio and radar gear by a government department or branch of the armed forces are duty free, some departments insist on price quotations that include the duty, making that the tender price.

The rising Australian market for transmitting equipment which went from $300,003 in 1959 to more than $2 million last year saw United Kingdom sales in 1960 of $1,870,570; other Commonwealth nations selling $11,124 and U. S. sales amounting to $235,583. Sales figures for components and tubes were in about the same ratios.

In the Federation of Rhodesia and Nyasaland, U. S. radio communications and radar equipment are subject to a five precent duty. Commonwealth imports enter free. In addition, a marked preference is shown for British equipment. Similar conditions prevail in the Union of South Africa where duty on U. S. imports are set at 15 percent as against 5 percent for the United Kingdom.

Swiss Buy in Europe

In Switzerland, where almost all communications are government operated, the marked preference attitude is also evident. In some categories of equipment which Switzerland does not produce, U. S. gear has nearly priced itself out of the market with the result that most broadcast and tv sales go to West Germany. The Netherlands is in second place.

In almost all the nations covered by the survey, consular observers say sales obstacles can be minimized by working closely with local officials, by establishing top-notch sales and engineering branch offices and whenever possible establishing production facilities that form an integral part of the foreign nation's economy.

Sales Reps Needed

The Swiss consular office, for example, says potentialities of the Swiss market can be realized fully only if manufacturers maintain a sales representative in Switzerland. He must be familiar with the needs of Swiss users and the government department that operates the communications systems. The high reputation U. S. products enjoy in almost all the nations surveyed often helps sales prospects if adequate planning is done.

The report indicates that simple communications systems are in demand in economically underdeveloped nations. In nations of higher economic development, more complex communications equipment is required.

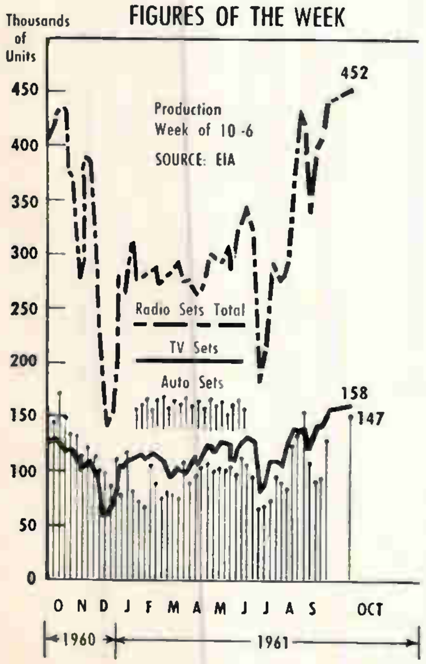
In Mozambique, Kuwait, Nepal

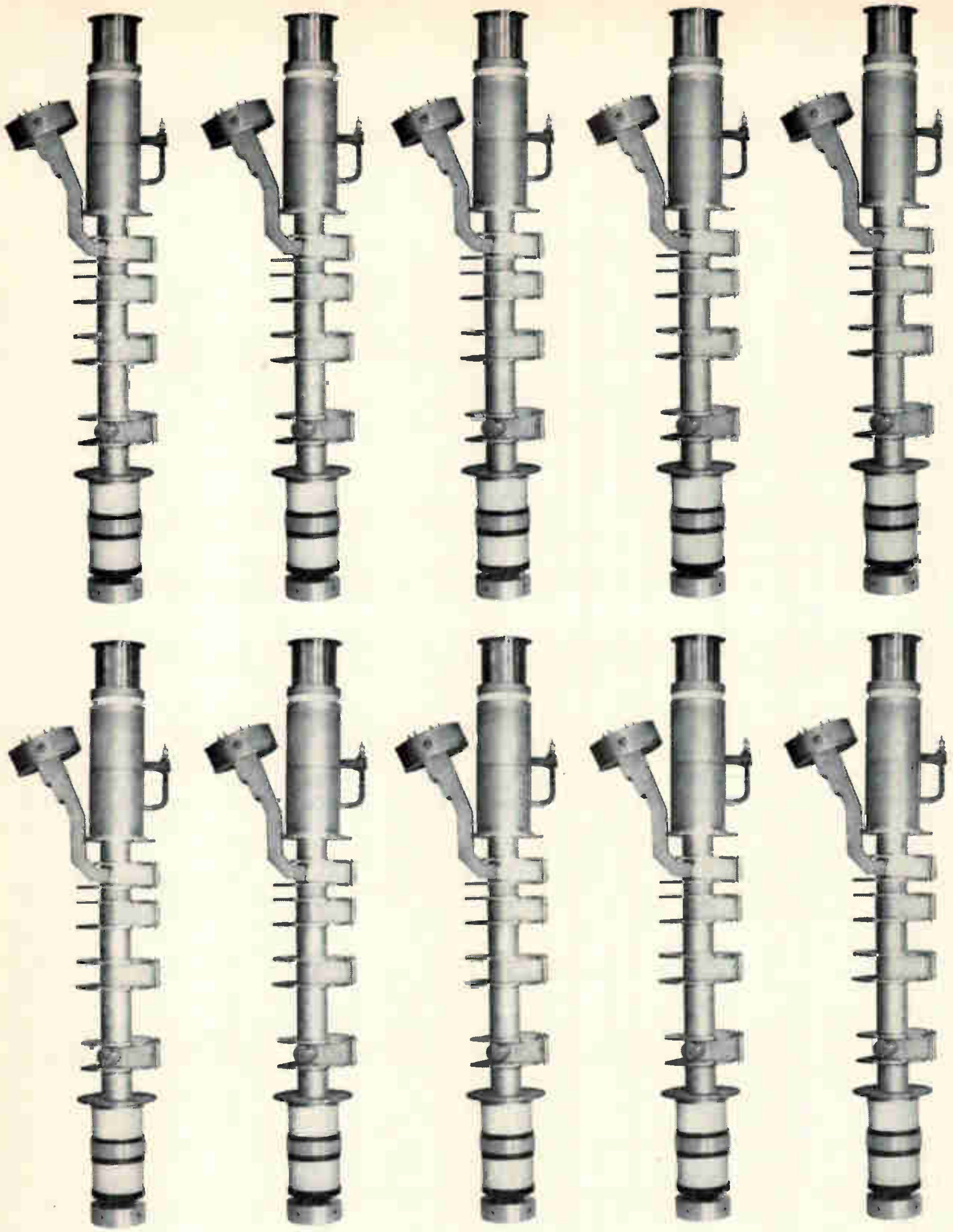
and South Africa, for example, most purchases of communications equipment are confined to two-way radio telephones. The majority of users are municipal, mostly police.

Where U. S. equipment is already in use, the chances for continued sales seem to be improved. In Bermuda, for example, where tariffs are preferential for British equipment some 80 percent of the communications equipment is U. S.

In some of the more economically advanced nations, even those capable of manufacturing their own two-way equipment, U. S. equipment can be sold. One reason for this is that with the onset of more complex operations, spectrum crowding begins to be a problem. New frequencies are authorized before equipment exists locally to meet the new requirements. In the Netherlands, for one, crowding in the low bands has led to new markets for two-way equipment above 400 Mc.

Radar sales and large communications installations abroad are being made mostly for harbors and airports. In many cases, the complexity of a nation's economy is independent of sales possibilities, according to the report. Improved harbor and air terminal facilities in such cases are part of the nation's improvement programs and the electronic equipment used in such operations becomes a working tool aiding the nation's growth.





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ELECTRICAL DATA

Frequency Range	30 Gc-180 Gc (see specific type)
Anode Voltage	1000-4000 volts
Power Output	Up to 20 mw average (depending on frequency)
Beam Current	10 MA
Magnetic Field	2000 gauss
Heater Voltage	6.3 ±10%

MECHANICAL DATA

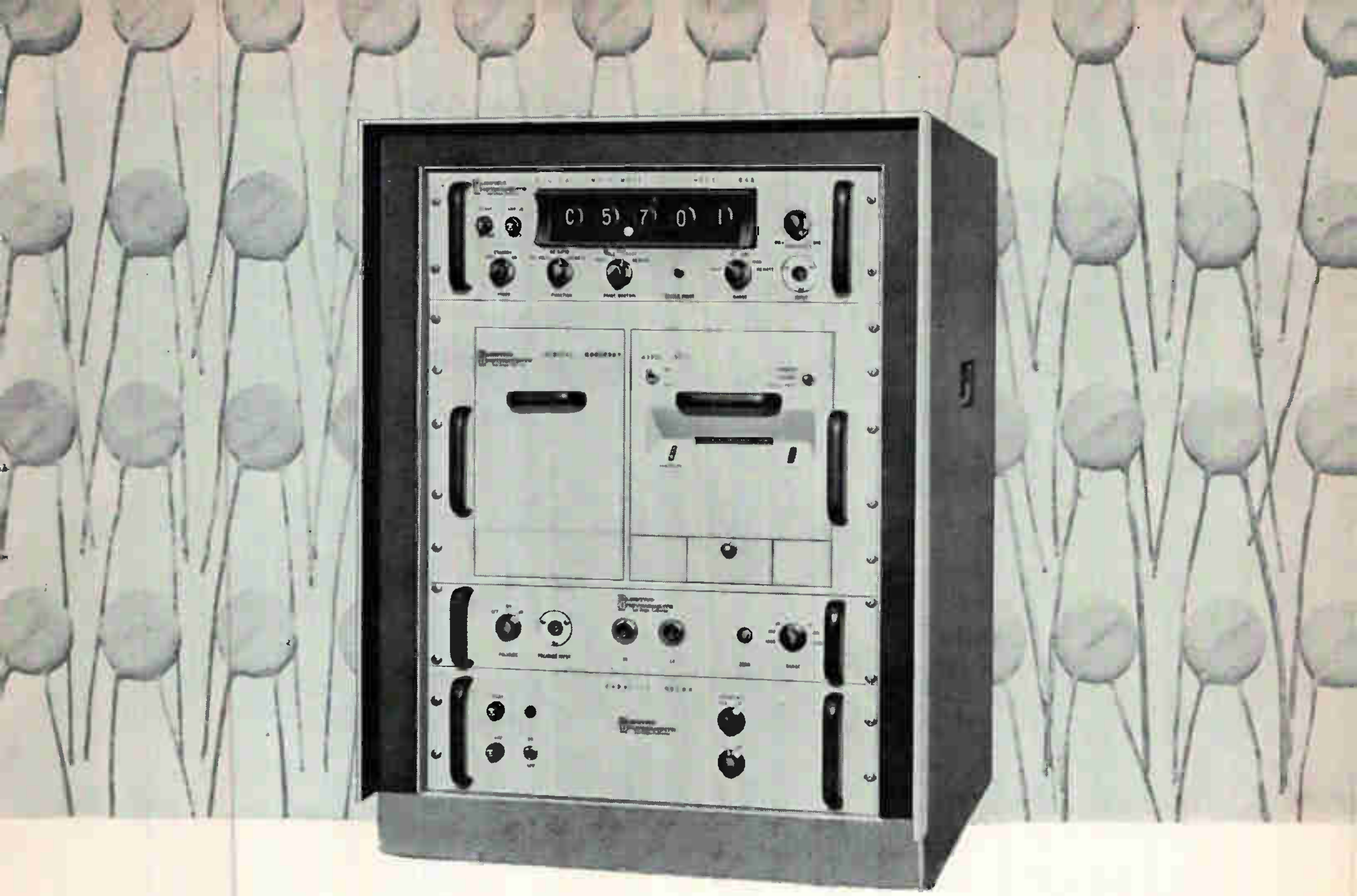
Output Flange	Special adapter to RG-98/U (50-75 Gc)
Maximum Diameter	0.625"
Length	8"
Mounting Position	Any
Weight	5 oz.*

*Without magnet (tube only). Magnets are available.

Red Bank Division

THE Bendix CORPORATION

CIRCLE 25 ON READER SERVICE CARD→



Now measure direct capacitance at 60 readings per minute, dissipation factor to 20%

Capacitors in production quantities can now be tested quickly and accurately with the new high speed, all electronic, EI Model 6150 Digital Capacity Meter.

Capacitance or dissipation factor is automatically measured at 60 readings per minute and higher, and the result digitally presented both visually and in coded form for direct driving of printing devices. Readings are actual values. Possibility of human error has been reduced to a minimum.

Completely Automated Systems—The EI Model 10003 Capacitance Monitoring System, shown above, combines the Model 6150 with a digital printer to provide a simple, low priced, automatic capacitance measuring system.

Applications include production lines of capacitor manufacturers, military component evaluation programs, receiving inspection test areas and other uses where large quantities of capacitors must be tested quickly and accurately.

Ask your nearest EI field engineer for complete information on the new EI Capacity Meter. He is thoroughly qualified to help with your component testing problems.

MODEL 6150 SPECIFICATIONS

Test frequencies: 120 and 1000 cps

Capacitance range: .01 $\mu\mu$fd to 1000 μfd

Capacitance accuracy: .1% of reading ±1 digit referred to the standard capacitor

Capacitance resolution: .01% of full scale

Speed of measurement: less than 1 second per parameter

Dissipation factor range: .01% to 20%

Dissipation factor resolution: .01% $\left[\frac{C_x}{C_{f.s.}}\right]$

Dissipation factor accuracy: .05% + .01 $\left[\frac{C_x}{C_{f.s.}}\right]$% ±1 digit

Internal polarizing supply: 0 to 20 volts dc

Voltage across unknown: 300 mv to 30 mv

Another significant breakthrough in digital instrumentation from

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Engineers: Challenging opportunities now available. Contact Mr. Harvey Fleming.

Britain's Computer Men Seek Sales

By DEREK BARLOW
McGraw-Hill World News

Dozens of computers and system models fill main floor and balcony of exhibition hall as salesmen wait for day's flow of visitors

LONDON—Britain's computer industry is consolidating as emphasis switches strongly from machine development to sales drives. This was the predominant theme this month at the Second British Computer Exhibition. Prominent too was increased activity by U. S. firms entering the British computer market.

Despite the presence of twelve computer manufacturers in the UK, sales are slow. Only some 350 machines are installed compared with over 1,000 on the rest of the continent. Reasons vary from traditional British conservatism to lack of government support.

The industry feels that that situation is on the upturn, but slowly. Indicative is the new government computer investment program of $45-60 million over the next ten years. Program includes installation of EMIDEC 2400's to handle the state pension scheme involving 26 million persons and to control provisioning for 200,000 items of British Army motor transport spares. An AEI 1010 computer will control all Air Force stores.

In general, firms have few installations for the number of computer models developed, a position that may bring some rationalization among manufacturers. Here is how some manufacturers report sales:

- ICT—over 60 orders for their 1301, totaling $18 million.
- English Electric—nine sales of their new high speed KDF 9 a month after introduction.
- Ferranti—total sales exceed 100 machines including three $6 million Atlases.
- IBM—1401 orders top 100.
- Elliott—over 70 sales of the 803, including 10 to U. S.

British computers emphasize the expandable system. Typical is the Leo 111 computer developed by Leo Computers Ltd. Price tag lies between $300,000 to $700,000 according to system complexity. It computes to any desired radix, timeshares up to eight programs, incorporates microprogramed logical control plus an expandable core store of from 2,048 to 34,768 words. Addition and subtraction times are 36.5 and 33.5 microseconds for 10-digit sterling numbers. Character generators display the register contents on a crt screen.

In much the same class is the AEI 1010 parallel machine with an 18 microsecond add/subtract time. A central control unit controls simultaneous operation of up to 34 on-line peripheral units.

Ferranti offers nine machines including Atlas, which performs a million complete instructions a second and has an 0.3 microsecond access time fixed store. Others are the Orion timeshared 36 microsec add/subtract fixed point machine, a small $5,000 Sirius decimal machine with punched tape input/output, the earlier Pegasus 1 and 11 machines, the high speed scientific Mercury machines, Argus process control computer and Apollo for flow automation.

Three new models from English Electric include an anglicized version of the RCA 501 and a new fast, general purpose, parallel machine, KDF9, providing a one microsecond add/subtract time. Feature of the system is a nesting store designed so that incoming data is available on a "last in, first out" basis. The store comprises sixteen registers holding a column of data items. Incoming data joins the column at the top and displaces all other items down one place. Information is transferred out the top. This speeds data location. System also includes time sharing of four programs.

Third model is the process control KDN2, as yet unsold. Designed from standard logic building blocks, this small serial machine is designed as a slave unit operating at 6,000 instructions a second.

Visible at the show was increased emphasis on low-cost simple edp systems. A Creed Ltd. system, priced at $18,000, is completely electro-mechanical. Designed specifically for sales order transactions, pushbutton keyboards record sales orders, retrieve stored data from a punched tape memory system and initiate price calculations.

Another system for sales order and invoicing transactions uses a small time sharing computer developed by Pye Ltd. This provides simultaneous sterling calculations on invoices being prepared by six electric typewriters.

Data links too are on the increase, the British Post Office announcing the granting of type approval to three basic systems developed by IBM, Bendix-Ericson and Automatic Telephone and Electric Co. Currently undergoing final development are associated error detection circuits to reduce the error rate on British post office teletype lines.

Shift registers in the error detector store the transmitted information. Received signals are returned to the transmitter. Any discrepancy between transmitted and received signals stops transmission. The system will reduce the number of undetected errors to one in 10^6 characters.

Trend in computer components and circuits is towards smaller cores and faster circuits with increased branching factors.

Typical is a high-speed logic circuit developed by Mullard with a branching factor of 30 and a delay of only 30 millimicroseconds per stage. The circuit uses alloy diffused transistors.

Another Mullard logic circuit obtains a stage delay of only eight millimicroseconds and a branching factor of three using only one transistor and diode.

Single core per bit memory systems with better than two microseconds cycle time are now being offered by Plessey as standard packages. Store capacities vary from 1,024 up to 16,384 words of 56 bits. Cores are 0.050 inch and access time is 0.35 microseconds.

Under development are 50 nanosecond tunnel diode memories and superconducting stores using continuous film, for missile applications. Typical examples shown by Mullard and Plessey achieve a 300 to 400 a cubic inch component density. Circuits are formed by vacuum deposition. Silicon monoxide and aluminum form the capacitors.

Some eyebrows were raised by RCA licensing agreements. English Electric gets a one-shot manufacturing and sales rights deal for the RCA 501; Compagnie des Machines Bull will revamp and sell the 301; International Calculators and Tabulators Ltd. gets knowhow which apparently will allow it to develop a 301-type machine. Also moving in on longer established firms such as IBM and National Cash are Honeywell—sending its first 800 in January—and Clary, whose DE 60 will be marketed by Block and Anderson Ltd.

Russians Building Huge Radiotelescope

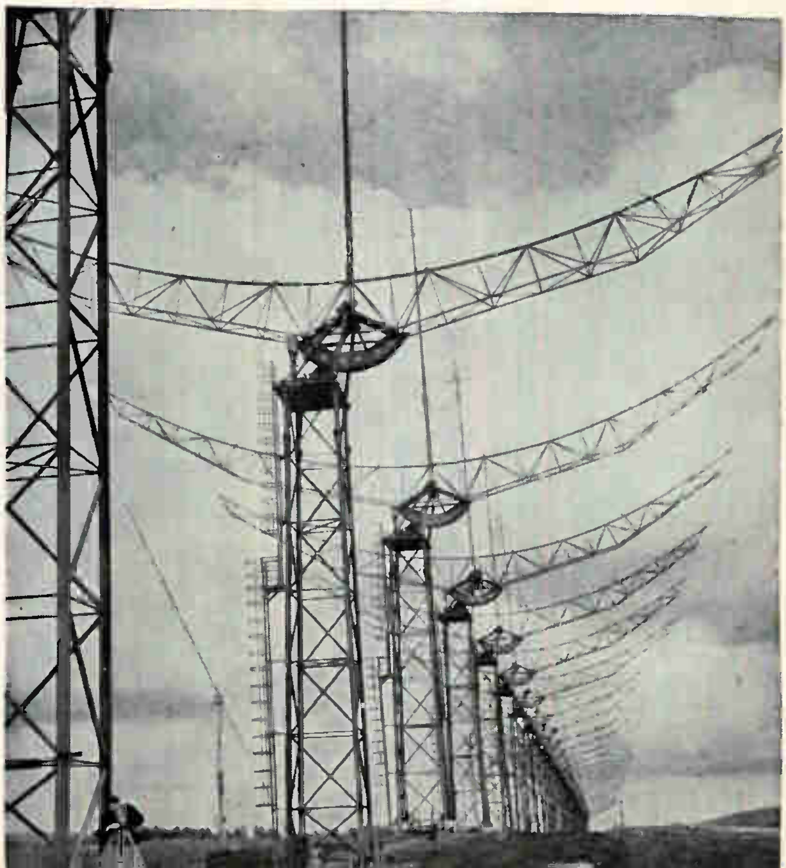
SOVIET UNION is nearing completion of the east-west arm of a large cross-shaped radio telescope. The device is located outside Moscow at the radio astronomy station of the Lebedev Institute of Physics of the USSR Academy of Sciences.

Each arm is one kilometer long and 40 meters wide. An arm consists of 37 towers, spaced at approximately 28.57-meter intervals. Each tower is 22 meters high and supports a 40-meter parabolic truss. The 1-Km-long radio mirror is formed by stringing 430 parallel wires along the trusses the length of the arm.

Each parabolic cylinder arm constitutes 40,000 sq meters of effective surface area. It can be turned toward the required part of the sky at a command from the control panel.

The University of Sydney Radio Astronomy is planning a telescope with longer arms (1 mile or 1,609.334 meters) but not as wide as the Soviet instrument (40 ft or 12.192 meters).

The longer dimensions of the Australian telescope will provide greater resolution than the Soviet device while the greater area of the Soviet telescope will provide greater gain. For this reason, the Soviet telescope will probably investigate natural celestial radiation.



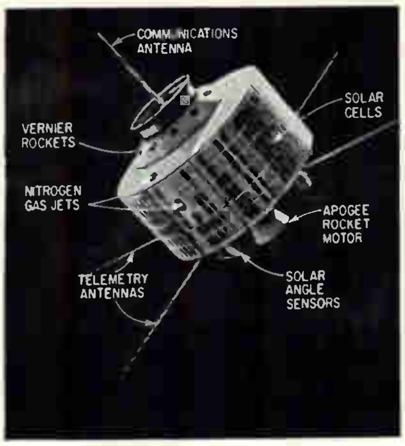
Rocker-like mounts of parabolic arms turn antenna on command from control panel (Sovfoto)

First Synchronous Satellite Goes Up in 62

NASA'S FIRST ATTEMPT to place a satellite into a high-altitude (22,300 mi) orbit, synchronous with the rotation of the earth, will take place during the last quarter of 1962. The satellite will be the National Aeronautics and Space Administration's Syncom, an experimental active communications relay station, to be built by Hughes.

Although ultimately high altitude satellites will hover one spot on the earth, the first series of Syncom satellites will not be in stationary orbit. They will move in an elongated figure-eight pattern 33 deg north and south of the equator over a given longitude over the Atlantic Ocean during a 24-hr period.

To achieve this orbit, a control



system developed by Hughes will be activated after the three-stage Delta vehicle has spun up to about 160 rpm and boosted the spacecraft to synchronous altitude. If all goes well, this should occur off the southeast coast of Africa about 5½ hrs after launch. The apogee rocket motor in the satellite then will be fired to give the vehicle sufficient velocity to place it in a nearly circular synchronous orbit.

The angular velocity of the satellite will be slightly less than the earth's rotation, and Syncom will drift back westward to a specified longitude over the Atlantic. Vernier rockets and gas jets will be fired to achieve near-synchronism with the earth, orient the satellite and adjust the orbit. These control jets can be used during the Syncom's life to correct changes in the orientation or orbit should they occur.

Syncom will be cylindrical, 25 in. high, 28 in. dia., and weigh about 55 lb, excluding the attached solid propellant apogee rocket motor.

Solar angle sensing cells, located on the side of the cylinder, provide information via telemetry, in real time, from which necessary adjustments in orbiting and orienting the satellite will be made by command from the ground.

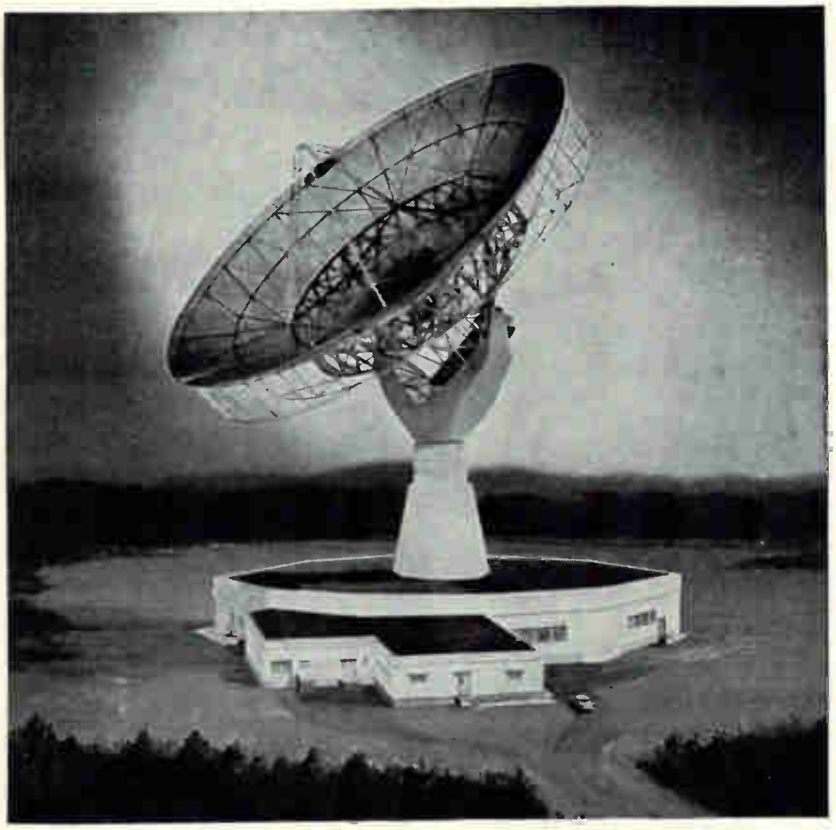
The shell will carry an array of 3,960 solar cells to supply power and to charge nickel-cadmium batteries. The system is designed to provide 20 w of power at 27.5 volts for one year.

Duplicate telemetry and communication systems (including command systems) are provided for redundancy. The communication system operates on a power of 2 w.

A slotted array antenna projecting from one end of the spacecraft will receive and transmit the telephone and telegraph communications. Four whip antennas will be used to transmit telemetry data. These are attached at the opposite end of the spacecraft, projecting outward 90 deg apart in turnstile fashion.

Communication signals, telephone and telegraph, will be sent to the satellite at 7,500 Mc. The signal will be amplified by a lightweight traveling wave tube and retransmitted to the ground on 1,850 Mc. Telemetry will be on 136 Mc. In addition to relaying real-

Haystack Hill Research Antenna



Model by North American Aviation shows how Haystack Hill near Tyngsboro, Mass. will look when completed at end of 1962. The research antenna will serve as test bed for development of large transmitting and receiving equipment for satellite relay systems. As impressive as its size, 120 feet diameter, is its planned precision: Distortion is not to exceed 0.075 inch over its entire quarter-acre of area. Lincoln Labs, which has a major role in design and construction, will manage the facility for the Air Force time data on the attitude of the satellite, information will be telemetered relating to the solar cells, the communication systems, jet reaction system, and spacecraft temperature.

Ground facilities for Syncom will be Army's Project Advent stations. The Army Advent Management Agency will conduct the communications experiments in cooperation with NASA.

Next year will be a big year for communication satellites. AT&T's Tel-Star, active relay, will be launched into an elliptical (600 mi — 3,000 mi) orbit in the second quarter; Army's Advent will be put into a 6,000-mi orbit in the summer; NASA's Relay (being built by RCA) in an elliptical (900 mi — 3,000 mi) orbit in the third quarter; and Syncom in the fourth. A passive Echo 100-ft balloon will go into a 700-mi orbit some time in 1962.

Gamma-Ray Messages Might Work in Space

GAMMA RAYS are a nuisance byproduct of nuclear reactors, requiring heavy shielding for protection of men and sensitive materials. But in space, they may provide a source of communications power "for free". So thinks J. W. Earkens, of Aerospace Corp. Gamma rays in space would not be scattered and absorbed as in the atmosphere. Using gammas from nuclear power systems for spacecraft would avoid special electric power sources and wave generating equipment.

Breadboard Kits Give Students Lab at Home

TAKE-HOME LABORATORIES for electrical engineering students are now on full-scale trial for 200 juniors at MIT. Designed by Prof. Richard D. Thornton, the book-sized circuit kits allow students to do lab work at home and relieve strain on laboratory facilities. Students bring home-wired circuits into the lab for measurements and observation. A three-inch oscilloscope is being developed to supplement the breadboard kit.

CIRCLE 29 ON READER SERVICE CARD→

Molecular electronic computer left has 6.3-cu in. volume, weighs 10 oz. Transistor computer, right, is 150 times larger, 48 times heavier, uses 8,500 conventional components and does same job

Molecular Computer Occupies

By JOHN M. CARROLL,
Managing Editor

DAYTON, O.—LAST WEEK a microminiature general-purpose digital computer using 587 molecular electronic circuits was shown jointly by the Air Force Aeronautical Systems division and Texas Instruments, the contractor.

The experimental unit, built in nine months under a contract to reduce molecular-electronic manufacturing methods to practice, has a 6.3 cu in. volume and weighs 16 oz. It consumes 16 w.

The computer is compared by its designer to the LGP-30. It is a serial, binary, fixed-point machine with a word length of 10 bits and sign. It uses synchronous logic timed by an external 100-Kc clock although pulse shaping is done in the computer. It is addressed by an external digital keyboard or paper-tape reader. The keyboard delivers pure binary input and the clock signals.

Three types of semiconductor networks are used: 382 flip flops, 168 NOR circuits and 37 logic drivers. Flip-flop shift registers provide 16 words of instruction storage and 16 words of temporary storage. The computer is a single address machine using an 8-bit instruction word. Fifteen commands are available. The machine has an accumulator, A and R registers. The A register is in temporary storage.

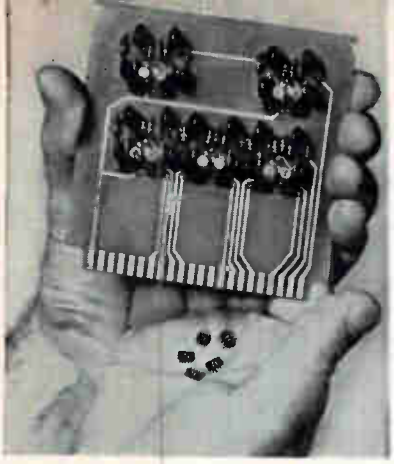
The individual networks, 0.250 by 0.125 by 0.030 in. are assembled by welding eight to 16 together in encapsulated stacks or modules. There are 47 modules each occupying 0.057 cu in. and weighing 0.04 oz. The modules are inserted in a copper grid or matrix that is in turn mounted on a copper or aluminum heat sink 70 cu in. in volume.

Each transistor stage requires about 25 mw. Supply is 10 v. However, using series 51 Solid Circuits, introduced simultaneously with the computer, an improved computer could be built dissipating 2 to 4 mw per transistor and operating from 3 v. Such a computer could operate from 200 to 400 Kc. Using a 6-v supply, operation at 400 to 800 Kc would be possible.

Texas Instruments president P. E. Haggerty said a pulse-code telemetry encoder is under development using both linear and nonlinear circuits that will provide a 50-to-1 size reduction and a 15-to-1 weight reduction over conventional units.

He stated that with 300 standard semiconductor network types available, 12,000 electronic engineers whose work is government supported (10 percent of all such) could be freed from circuit design to tackle problems of cost reduction and reliability at a net savings to the government of $300 million.

According to Harrell V. Noble, technical director of ASD's Electronic Technology Lab, Texas Instruments and Westinghouse Electric are both participating in the Air Force molecular-electronics program. Texas Instruments work deals largely with nonlinear circuits and entails development of manufacturing methods. The work



Five series 51 flip-flop counter networks and equivalent conventional etched-circuit board.

6.3 Cu Inches

has tended to be computer-oriented and, indeed, TI and North American Aviation are known to be working jointly on general-purpose guidance computers using molecular electronics.

Noble said Westinghouse has worked on both linear and nonlinear circuits and in production of dendritic silicon and germanium. The latter technique is said to provide an excellent surface for epitaxial growth.

Also in the Air Force molecular-electronics project, Georgia Tech is cataloging and making mathematical models of solid-state materials exclusive of semiconductors while the University of Michigan is developing mathematical models of Air Force circuit needs.

To the Air Force, molecular electronics includes building up semiconductor circuit blocks epitaxially as well as diffusing circuits into blocks. Motorola is looking into the epitaxial approach.

Others are also working with epitaxy and single, double and triple diffusion.

TI's new series 51 networks are all made from a standard silicon wafer, only vacuum-deposited aluminum interconnections make the difference between the six basic circuit types.

Contained in hermetically sealed packages [illegible] by $\frac{1}{8}$ by 1/32 in., the networks will withstand −55 to 125 C. Power requirement is 2 to 4 mw at 3 v. Six-volt operation is possible. Delay ranges from 75 to 450 nsec. Fan out from 4 to 25 is available.

Business Computers Talk Back

Movable levers of Unicall input unit are placed in positions corresponding to letters or numerals of message to be sent

SPOKEN REPLIES to coded inquiries can be obtained in a few seconds from a new input device operating with a remote real time computer. First public demonstration of this commercially available data set, called Unicall, was made by Remington Rand during dedication of their Univac Engineering Center.

Through joint efforts of Bell Labs, Western Electric and Remington Rand, the data set was designed for use with long distances telephone facilities such as AT&T's Telepac or its Wide Area Telephone Service. Principal application appears to be simplifying and accelerating the updating of changes in inventory, production, distribution and sales in business and industry.

Forty sliding levers on the input unit are positioned to correspond to individual letters or numerals in the message. This selects a unique combination of three audio tones for each message character. Three identification characters precede and one end-of-message or more-to-come character follows each message block.

After setting in the message, the operator dials the computer facility on the set's telephone. The computer's acknowledgement signal trips a character scanning mechanism in the input unit, which reads the coded data into the phone line. Messages of up to 40 characters are transmitted at 20 characters a second. Depressing a more-to-come key enables the operator to send the balance of longer messages on subsequent transmissions.

A 150-word vocabulary designed to meet the needs of the particular application is stored on a magnetic drum at the computer site. When the message is processed, a Univac real-time computing system selects a reply from the drum and sends a verbal response to the inquiring Unicall station. Parallel searching permits simultaneous handling of hundreds of inquiries with a single drum.

Unicall rents for approximately $30, sells for $1,350.

Radio Sounds Alarm and Tunes in Civil Defense

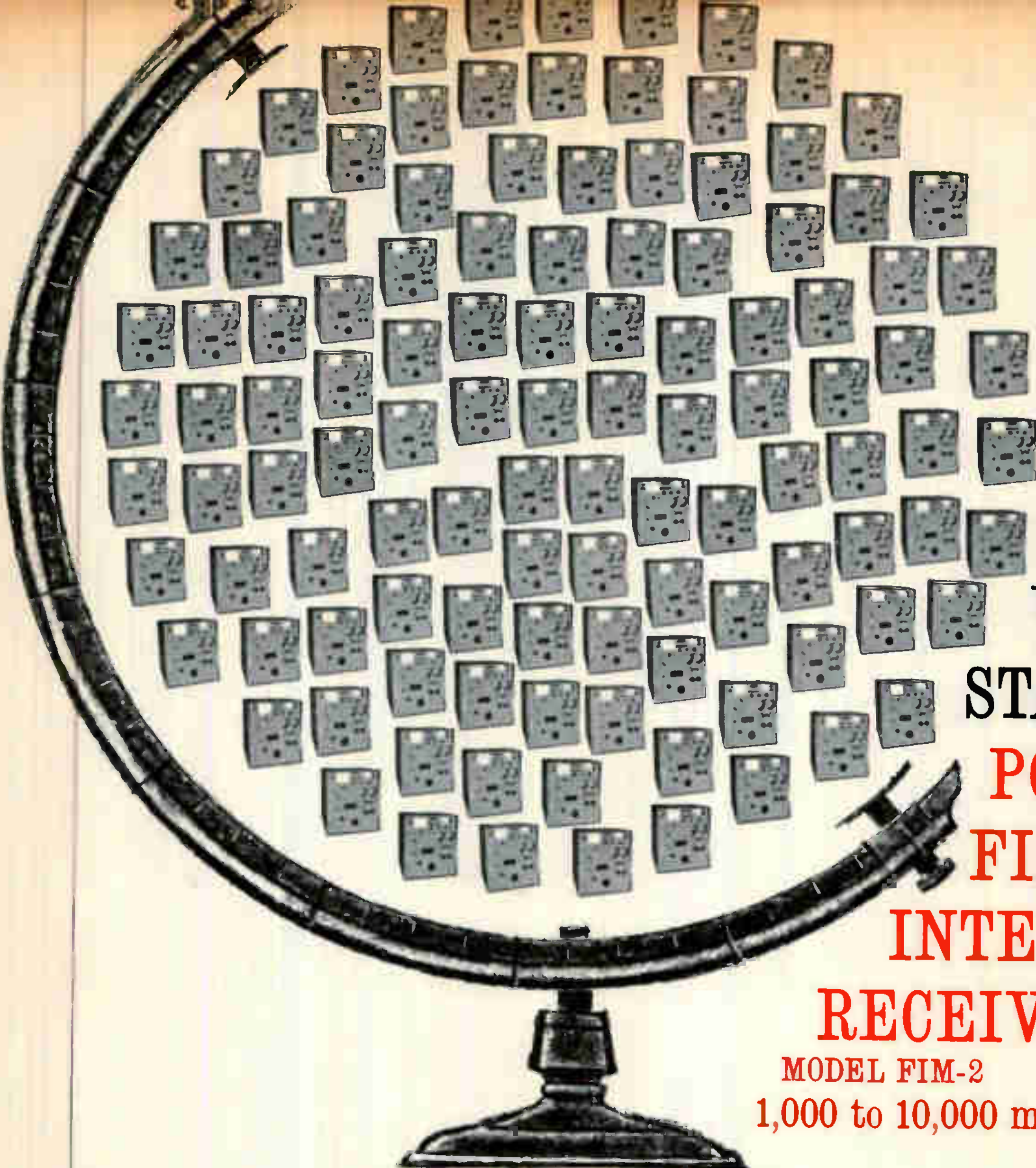
GENERAL ELECTRIC has designed an alarm-radio that will sound a buzzer in case of enemy attack or emergency, then turn on the radio for information. Demonstrated to the government Office of Emergency Planning, the set would be alerted by OEP's proposed National Emergency Alarm Repeater system. A 240-cycle signal on power lines operates switches. Set uses two of GE's Compactron tubes.

Satellite Communications Ground Stations Readied

AT&T EXPECTS work on a $7 million satellite communications center at Andover, Maine, to be completed by December 1. The center will house terminal and tracking equipment.

Construction feature is a radome made of inflated, 1/16th-inch rubberized material. It will be 200 feet in diameter, 160 feet high. The rotating steel and aluminum antenna will weigh 250 tons and be 177 feet long and 94 feet high.

Sylvania reports that site facilities for Project Advent are three weeks ahead of construction schedule and will be completed this month. The facilities will house electronics telemetry, tracking and communications equipment at Fort Dix, N. J., and Camp Roberts, Calif. Sixty-foot parabolic reflectors with multiple feeds will be used for tracking.



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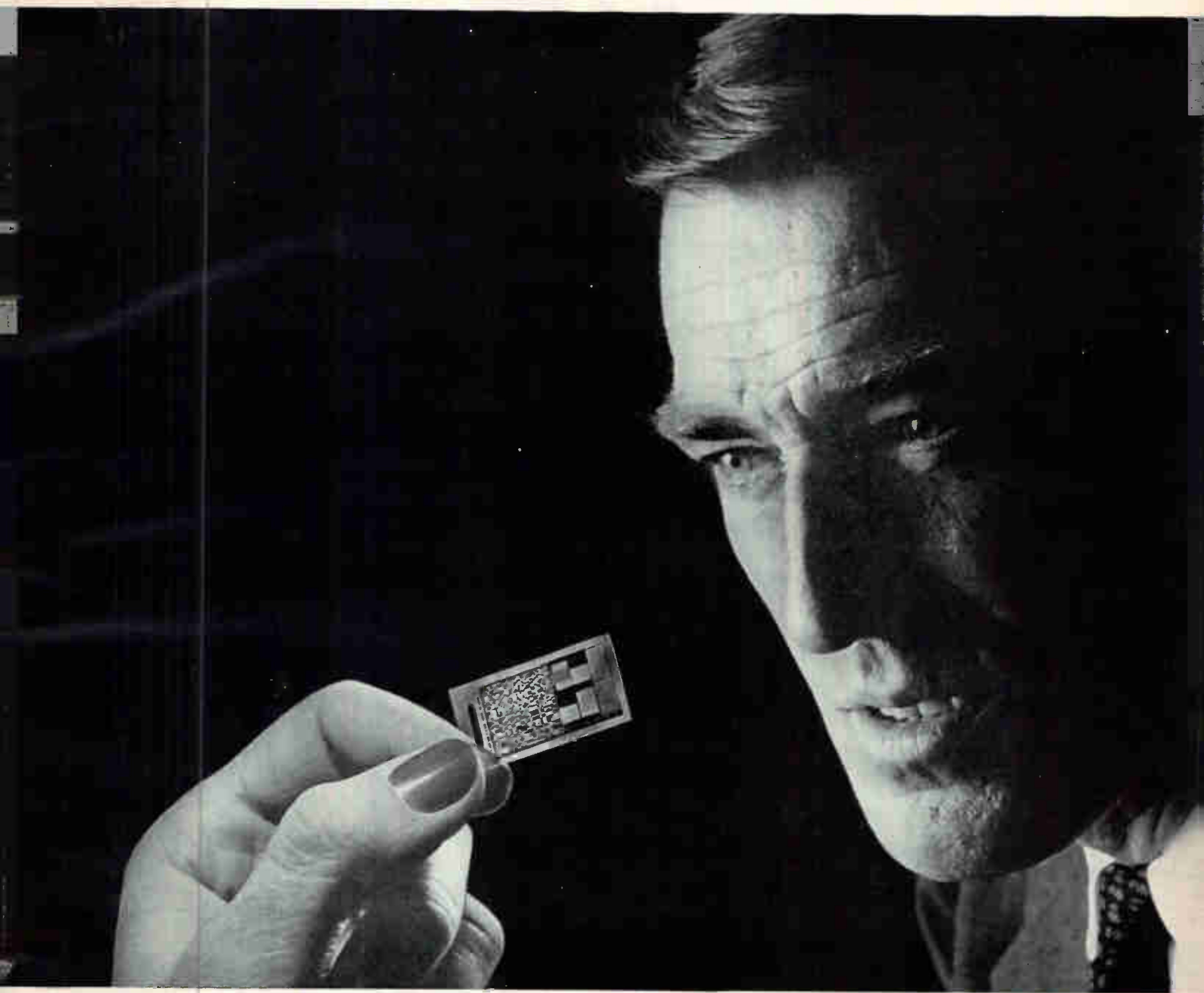

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MEETINGS AHEAD

ELECTRON DEVICES, PGED of IRE; Sheraton Park Hotel, Washington, D. C. Oct. 26-28.

AIR TRAFFIC CONTROL Assoc., ATCA: Deauville Hotel, Miami Beach, Florida, Oct. 30-31.

RADIO FALL MEETING, EIA, IRE; Hotel Syracuse, Syracuse, N. Y., Oct. 30-Nov. 1.

DATA PROCESSING, Automatic Systems, Current Developments, Oct. 30-Nov. 3.

HIGH MAGNETIC FIELDS, International Conf., Air Force Office of Scientific Research; Massachusetts Institute of Technology, Cambridge, Mass., Nov. 1-4.

INSTRUMENTATION Conf., Louisiana Polytechnic Institute, Campus, Ruston, Louisiana, Nov. 2-3.

MAGNETICS, Non Linear, AIEE, IRE; Statler-Hilton Hotel, Los Angeles, Nov. 6-8.

RADIO INTERFERENCE Reduction and Electronic Compatability; IRE, Armour Research Foundation; Illinois Inst. of Technology, Chicago, Nov. 7-9.

EXPLODED WIRE Phenomena, Electrical, Air Force Cambridge Research Laboratories; Hotel Kenmore, Boston, Nov. 13-14.

MAGNETISM & Magnetic Materials, IRE, AIEE, AIP, ONR, AIME; Westward Ho Hotel, Phoenix, Arizona, Nov. 13-16.

MATERIALS and Design Exhibition Conf.; Earls Court, London, Nov. 13-18.

RELIABILITY Symposium, Electronic Systems, IRE, Linda Hall, Library Auditorium, 5109 Cherry, Kansas City, Mo., Nov. 14.

NEREM, Northeast Research & Engineering Meeting, Commonwealth Armory and Somerset Hotel, Boston, Nov. 14-16.

ELECTRICAL MANUFACTURERS, National Assoc., Annual; Plaza Hotel, New York City, Nov. 16.

COMPUTER Conference, Eastern Joint, PGEC of IRE, AIEE, ACM; Sheraton-Park Hotel, Wash., D. C., Dec. 12-14.

IRE International Convention; Coliseum & Waldorf Astoria Hotel, New York City, Mar. 26-29, 1962.

ADVANCE REPORT

May 3-4, 1962, International Congress On Human Factors in Electronics. PGHFE of IRE. Lafayette Hotel. Long Beach, Calif. Papers in the following areas: automatic control. biological science, communications. computers. cybernetics. information theory. mathematics, medicine and psychology. Prospective authors will submit. prior to Jan. 1. abstracts not exceeding 300 words to J. W. Senders. Technical Program Chairman. Minneapolis-Honeywell Regulator Co., 2600 Ridgeway Road. Minneapolis 40. Minn. Initial evaluation of prospective papers shall be made on the basis of the abstracts.

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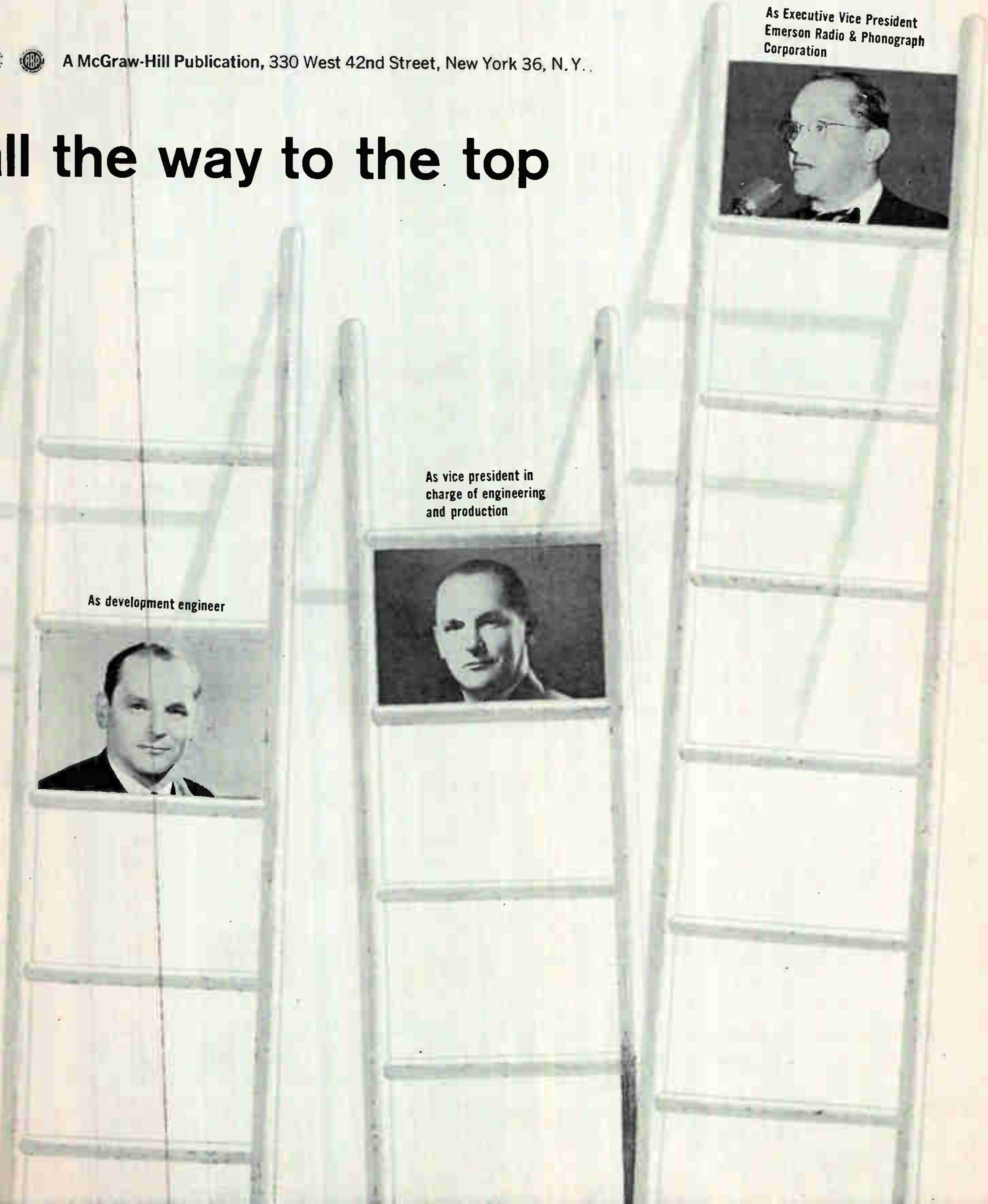

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Total Device Dissipation (case 25°C.)....2 watts
Total Device Dissipation (case 100°C.)...1 watt
Total Device Dissipation (free air 25°C.).0.6 watt

ELECTRICAL CHARACTERISTICS (@ 25°C.)

Characteristics	Conditions	Min.	Max.	
h_{FE}	V_{CE} = 1V. I_C = 150 ma.	40	120	
V_{BE}	I_C = 150 ma. I_B = 15 ma.		1.2	volts
V_{CE}(SAT)	I_C = 150 ma. I_B = 15 ma.		0.5	volts
f_T	I_C = 50 ma. V_{CE} = 10V.	150		mc
C_{ob}	V_{CB} = 10V. I_E = 0 ma.		12	pf
I_{CBO}	V_C = 60V. T = 25°C.		2	μa
I_{CBO}	V_C = 60V. T = 125°C.		150	μa
BV_{CER}	R $\leqq$ 10Ω I_C = 20 ma. pulsed	80		volts
t_r			85	nsec
t_s			100	nsec
t_f			55	nsec

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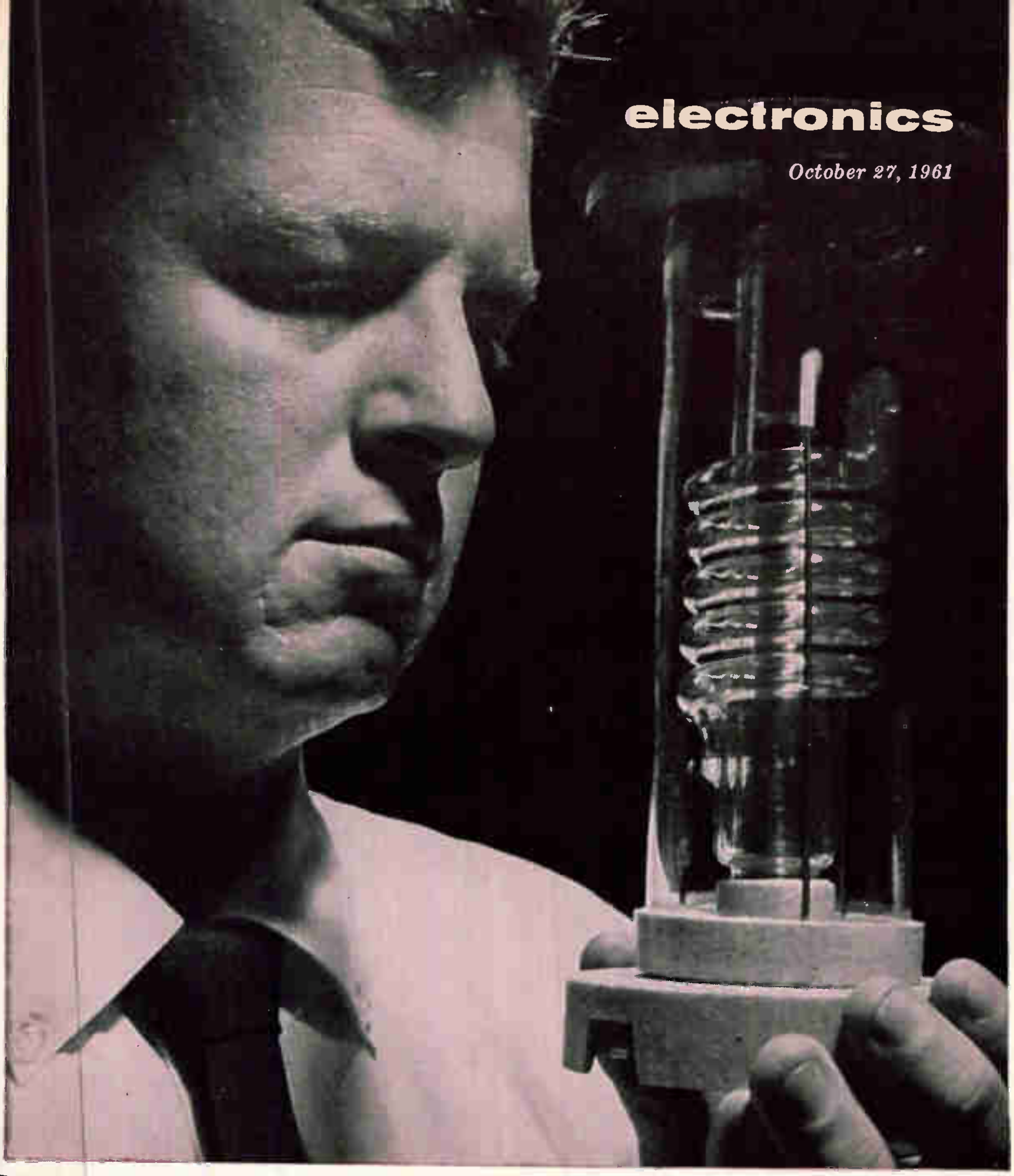


Ruby laser's helix flash tube excites the ruby that it encircles (Minneapolis-Honeywell Regulator Co.)

LASERS:

DEVICES AND SYSTEMS-PART I

Laser generation of coherent light expands available spectrum. Space, military, scientific and communications requirements push device refinement

By SY VOGEL, Associate Editor, and LEON H. DULBERGER, Assistant Editor

←CIRCLE 38 ON READER SERVICE CARD

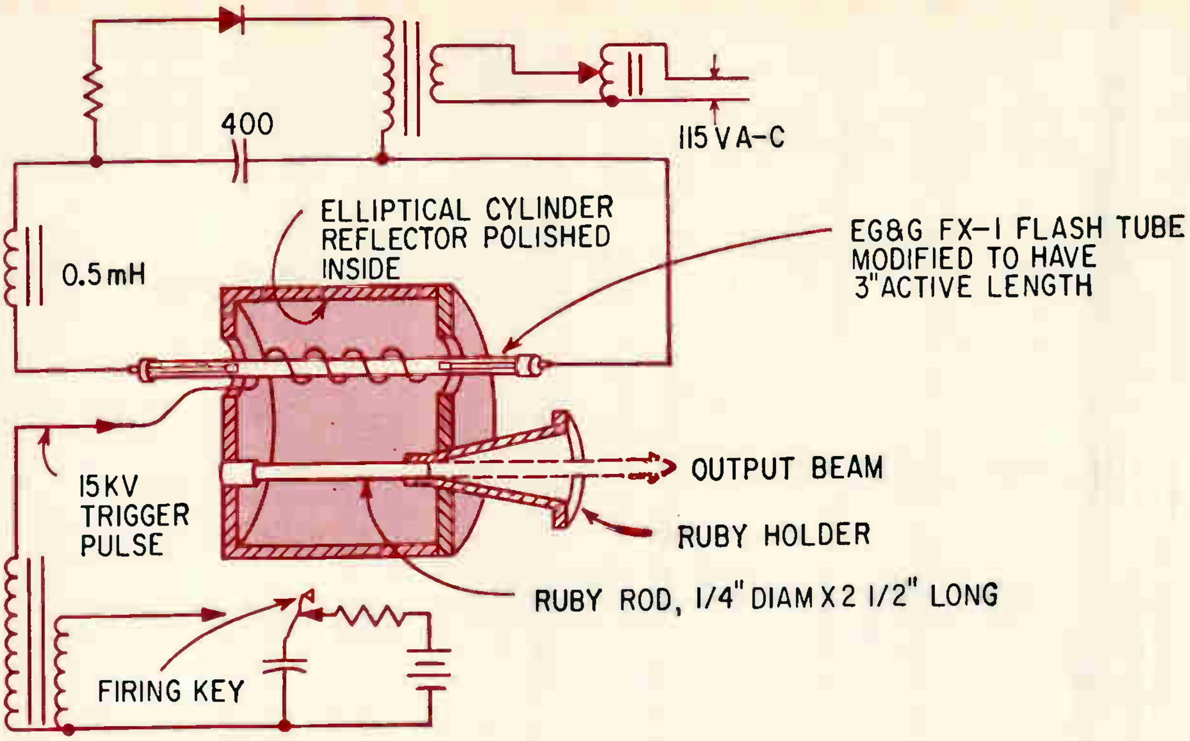


FIG. 1—Flashtube excites Cr^{+++} atoms in ruby to higher energy state. In dropping back to ground state, Cr^{+++} atoms emit coherent light **(***Raytheon***)**

LIGHT AMPLIFICATION by stimulated emission of radiation (LASER) has extended the range of controlled electromagnetic radiation to the infrared and visible light spectrum.

Systems applications of lasers are being explored for communications in space, on earth and undersea. Military surveillance and weapon systems, mapping, medical and computer technology may include lasers in future developments. Spectroscopic research, navigation in space and other applications will be investigated.

Several of the laser's output characteristics are of primary consideration in these applications. The laser provides a coherent light output, in much the same sense that an r-f oscillator exhibits definite time and phase relations in its output waveform.

The output light from a laser is essentially obtained at a single monochromatic frequency. Again the r-f oscillator provides an analogy.

Output is a beam of highly parallel light rays, which permits travel over extreme distances with little divergence. External optics can maximize this characteristic and focus the beam to a cross section of micron dimensions.

Light intensity can reach millions of times that of the sun on a relative bandwidth basis.

With proper focusing and output in the infrared spectrum, a beam hot enough to pit carbon and pierce metal can be generated.

The first operating laser was a solid-state design produced by T. H. Maiman. It employed a synthetic ruby crystal doped with chromium, CR_2O_3 in Al_2O_3. The crystal was machined to optical tolerance, with both ends of the resulting rod silvered to enhance reflection. Bathed in white light from an electronic flash lamp, the green content provided energy to the crystal. This stimulated emission of coherent and monochromatic light, at 6,943A, is described in a discussion of operating principles. Monochromaticity was about five times narrower than that of the ruby's natural fluorescence. Additional development brought this figure to forty times, and then to ten thousand times natural ruby fluorescence. Still greater monochromaticity has been realized with the helium-neon gas laser.

Laser history begins with the maser, (Microwave Amplification by Stimulated Emission of Radiation). Maser amplification was suggested by J. Weber[1,2,3] in 1952. A maser was built by C. H. Townes[4] in 1955. A solid-state version was proposed by N. Bloembergen[5], in 1956.

An extension of maser principles to permit operation in the light spectrum was suggested by A. L. Shawlow and C. H. Townes[6] in 1958. Monochromatic and coherent light were predicted.

The pulsed ruby laser built by T. H. Maiman in 1960 was the first to function[7]. It was followed by a continuously operating gas laser announced in 1961 by A. Javan, W. R. Bennett and D. R. Herriott[8]. They employed a mixture of helium and neon gas excited by an r-f field, and obtained output in the infrared range.

In 1960, P. P. Sorokin and M. J. Stevenson[9] produced laser action with trivalent uranium in calcium fluoride and followed this with other solid state experiments.

During 1961, amplification of light using a ruby laser, driven by a ruby laser oscillator was reported by P. P. Kisliuk and W. S. Boyle[10], and also by P. Leavy[11]. Gains of the order of two times were reported.

The generation of optical harmonics using a laser source directed into crystalline quartz was achieved in 1961 by P. A. Franken, A. E. Hill, C. W. Peters and

G. Weinreich[12]. Ruby laser light at 6,943 A was raised to 3,472 A. No measure of coherence of the doubled frequency was made.

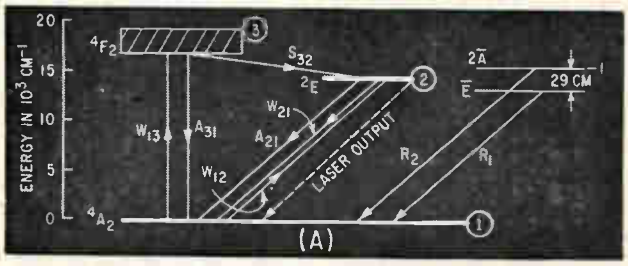
Laser operation requires an active material that will produce stimulated emission of radiation (lase), an excitation source that pumps power into the active material and a resonant structure. Both solid-state and gas of lasers have these characteristics. Functioning of the solid-state lasers developed up to now is essentially the same as that of the ruby laser developed by Maiman.[7, 13] Figure 1 shows the construction of a ruby laser.[14] The active material is ruby, the excitation source a xenon flashtube, and the resonant structure is formed by the ruby rod, whose ends are reflecting mirrors. One end of the rod has a heavy silver coat that makes it an opaque mirror and the other end has a silver coat that makes it a 92-percent-reflecting mirror.

Although the complete physical and mathematical description of laser action is complicated, it is possible to get a simplified picture of laser action by relating this action to the energy-level diagram of the lasing material. Figure 2A shows a simplified energy-level diagram for Cr^{+++} (chromium ion) doped pink-ruby crystal (CR_2O_3: Al_2O_3), the material used in the laser shown in Fig. 1, as well as in Maiman's laser. The heights of black bars 1 and 2 and of the area shown in cross hatching (3) indicate the possible energies that a Cr^{+++} ion can have; energy is in units of 10^3 wavelengths per cm; 1 wavelength per cm ($1cm^{-1}$) is equivalent to 1.9858×10^{-16} erg.[15] In their normal condition (the ground state), the Cr^{+++} ions have zero energy; this condition is indicated by level 1.

If light photons having a wavelength of 5,600 A irradiate the ruby crystal, they will raise the energies of some Cr^{+++} ions to various energy levels lying in the absorption band of energies indicated by 3. Flashtubes supply this irradiating light, along with light comprising many other wavelengths. The left-hand arrow (W_{13}—see legend) going from level 1 to band 3 indicates the increase in energy acquired by a Cr^{+++} ion when it absorbs a 5,600-A light photon; the use of light excitation to raise the energy level of atoms to a higher level(s) is called optical pumping. After short, but finite times elapse (relaxation times), some of the Cr^{+++} ions in band 3 drop back to level 1 (shown by A_{31}) and some drop to level 2 (S_{32}). The rate at which Cr^{+++} ions drop a level of 2 is greater than the rate they drop to level 1. The Cr^{+++} ions in energy level 2 hold their energy for a short time before they drop to level 1. The rate that ions go from level 2 to level 1 (A_{21}) is less than the rate Cr^{+++} ions go from level 1 to level 3. Thus, optical pumping builds up the number of ions having level-2 energies to a greater number than the number of ions having level-1 energies; in other words, the Cr^{+++} populations of levels 1 and 2 are inverted from their normal relation. This population inversion is essential for producing stimulated emission of light.

In dropping from level 2 to level 1, Cr^{+++} ions radiate light. Level 2 (^2E) actually comprises two levels, levels $\bar{E}$ and $2\bar{A}$, which emit radiation lines R_1 and R_2, respectively. If conditions were not completely correct for achieving laser action—for example, if an insufficient amount of excitation were applied—R_1 radiation would be spontaneous radiation rather than stimulated radiation and would comprise a much broader band of wavelengths than the stimulated emission (Fig. 2B and 2C).[13] In both cases, the center frequency of the R_1 and R_2 energy radiated when ions drop from level 2 to level 1 is calculated from $\nu = (E_2 - E_1)/h$ where ν is frequency, E_2 is the energy at the center of level $\bar{E}$ (for R_1) or level $2\bar{A}$ (for R_2), $E_1 = 0$, and h is Planck's constant. The resonating character of laser action enhances radiation at the central wavelength of R_1 and diminishes other radiation. Arrow A_{21} in Fig. 2A indicates the spontaneous radiation of R_1 and R_2 that would be emitted if lasing conditions are not correct. The broken arrow indicates the laser output, which comprises laser radiation at R_1 and spontaneous (incoherent) radiation at R_1 and R_2.

The simplified sketches shown in Fig. 3A to 3E illustrate sequences of laser action. At the instant that pumping light is applied (Fig. 3A), all Cr^{+++} ions are in the ground state; the unshaded circles indicate this state. Optical pumping raises some Cr^{+++} ions to level $\bar{E}$ (Fig. 2A). The black circles in Fig. 3B indicates ions that have been pumped up to level $\bar{E}$; for simplicity, ions pumped to level $2\bar{A}$ are not indicated. Some Cr^{+++} ions drop to level 1, radiating photons that have various wavelengths centered about the central wavelength of R_1. (Consider a photon as being a bundle of light energy that has wavelike properties.) Figure 3C shows one



LEGEND

W_{ab} Energy-change-probability rate due to exciting radiation of frequency ν_{ab}. $W_{12} = W_{21}$
ab level number a to level number b
A_{ab} Energy-change-probability rate with accompanying radiation
S_{32} Energy-change-probability rate without radiation
$^4A_2$ Ground state (0 energy) of Cr^{+++} ions
$^4F_2$ Absorption band of energy levels of Cr^{+++} ions
^2E This energy level comprises sublevels $2\bar{A}$ and $\bar{E}$

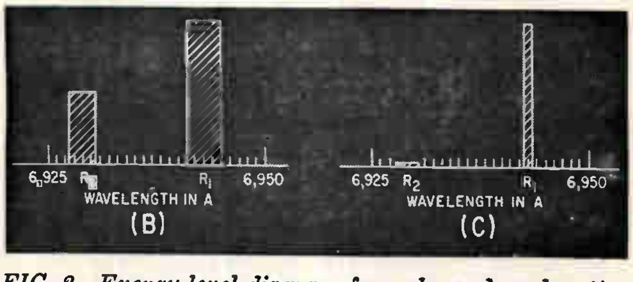


FIG. 2—Energy-level diagram for ruby and explanation of terms in legend (A). Emission spectrums of prototype ruby laser are shown for low-power (B) and high-power excitations (C)

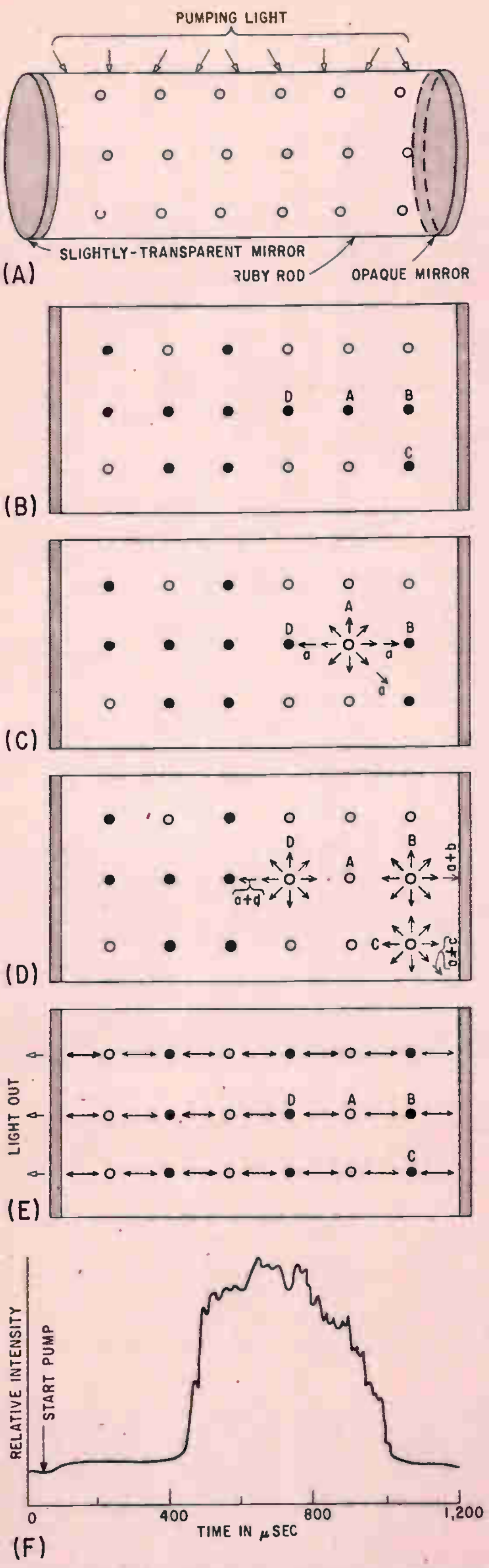
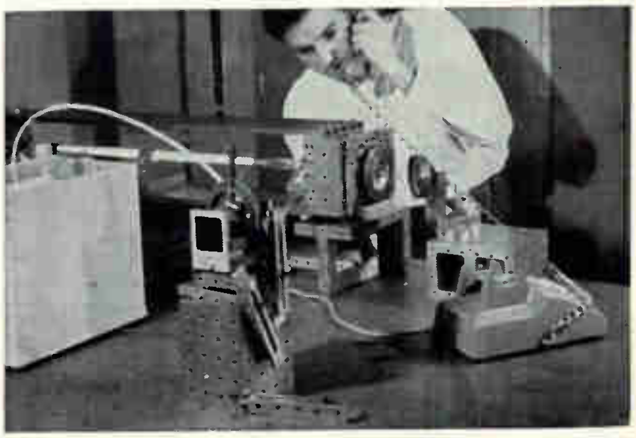


FIG. 3—Sketches (A) to (D) depict the sequence in which ion A spontaneously emits radiation that triggers the stimulated emission in the laser beam (E). A typical laser output pulse is shown in (F)

ion, ion A, dropping to level 1 and spontaneously emitting radiation; in these simplified sketches, ion A is the first ion (and the only one that is shown) to emit R_1 radiation spontaneously, that is, without being stimulated by R_1 radiation. The radiated photon tends to stimulate radiation of the same wavelength from other Cr^{+++} ions of level E that are in its path.[10] This is indicated in Fig. 3C and 3D. Assume that incident radiation a from ion A has the wavelength of the strongest R_1 emission. Incident photon a is reinforced by stimulated photons b, c and d in a precise phase relationship, as indicated by light rays $a + b$, $a + c$ and $a + d$ in Fig. 3D. The opaque mirror reflects $a + b$ back into the ruby cavity, but $a + c$ passes through the side wall and is lost. Thus, the cavity enhances radiation propagated parallel to the axis of the ruby rod and minimizes radiation going in other directions. Due to the amplification caused by photons stimulating the emission of other photons of the same wavelength, rays comprising photons of the center wavelength of the R_1 line, which is the strongest (that is, most prevalent) wavelength, become predominant over other R_1-wavelength rays. This action makes the laser output highly, but not completely, monochromatic.

Since photons traversing other paths than in the direction of the long axis of the crystal escape from the sides of the rod (Fig. 3D), the laser output beam is highly directional. Photon streams reflect back and forth between the end mirrors and emerge from the end mirror that is slightly transparent. Figure 3E indicates the cohering effect of the light field in the cavity in stimulating emission by the ions. To maintain the stimulated-emission process, losses such as those due to radiation escaping from the crystal and losses due to mirror reflection must be overcome by photon amplification. Beam angle of the ruby laser is in the order of 0.01 radian.

Although vast numbers of ions within the ruby crystal are individual radiators of photons, laser action causes them to radiate their energy in step, that is, coherently. The key action of the lasing process that produces in-step radiation is that of an incident photon triggering an ion to emit a photon in phase with the incident photon. If it were not for this action, each excited ion would spontaneously emit a photon, that is, emit a photon at any



Voice modulation of gas laser's c-w output, using a Kerr-cell modulator and a photocell pickup (Bell Telephone Laboratories) time within the relaxation-time range that is characteristic of Cr^{+++} in Al_2O_3. Since the individual radiators radiate (nearly) in step, and since these radiators produce radiation of (approximately) the same wavelength, the laser's output beam has space and time coherence. Consider a point located in the output beam of the laser: since the time intervals between successive peaks in wave amplitude at this point are equal, the beam is coherent in time. Consider two points (or more) in the laser beam that are located in a plane perpendicular to the axis of the beam: since, at a given time, their amplitudes have a certain correlation that will be repeated at regular time intervals, the beam is coherent in space:[17] in other words, if these two points (and other points) in space have equal wave-amplitude peaks at the same times, the beam has space coherence. Researchers have shown that ruby-laser wavefronts form planes that are perpendicular to the direction of propagation, thus exhibiting space coherence.[18] However, space coherence is far from perfect.[19] Since spectral line widths have been about 1,000 Mc, time coherence is not very good, either.

Ruby lasers have not yet produced c-w outputs and typical prf rates have been in the order of several pulses per minute. Each output pulse contains large-amplitude spikes (Fig. 3F) which result from the inability of the pump to supply energy level 2 at a fast enough rate to keep up with the rate at which these ions drop from level 2 during the stimulated-emission process.[14] There appears to be no fundamental obstacle to eventually achieving c-w operation despite some problems. Among these problems are the relatively large amount of pumping power required and internal heating effects. Over-rapid emptying of level 2 is another possible difficulty, since laser action ends when the ground state and E-level populations are equal, or nearly equal.[20] Cooling of the ruby and pump and the use of more efficient and powerful pumps are among the refinements being tried in efforts to achieve c-w operation.

The gas laser invented at Bell Telephone Laboratories provides continuous operation at several infrared wavelengths, 11,180 A, 11,530 A, 11,600 A, 11,990 A and 12,070 A; the strongest of these is the 11,530-A output line.[8, 21, 23] The main difference between the way the gas laser (see cover) functions and the way solid-state lasers function is the method by which they are excited and pumped into an inverted-population condition. Helium, at a pressure of 1 mm of Hg and neon, at a pressure of 0.1mm, are sent into the laser tube, whose ends comprise flat, parallel and semi-transparent mirrors. A 30-Mc r-f generator produces an electrical discharge through the gas mixture, thus raising the energy of ground state (0 energy) He atoms to the 2^3S energy level (Fig. 4). These He atoms collide with Ne atoms that are in the ground state and energy exchanges between He and Ne atoms take place. Due to the collision, the internal energy of the ground-state Ne atom increases to the $2s$ level, which comprises four sublevels, and the internal energy of the 2^3S He atom drops to zero. This collision process produces $2s$-level Ne atoms rather than $2p$ or $1s$ level Ne atoms because the energy-exchange process is such that the least possible amount of change in the total internal energy of the colliding atoms occurs; in other words, since the energy of the $2s$ levels is nearly equal to the 2^3S He level, a 2^3S He atom readily transfers its internal energy to a $2s$ Ne atom, with little of the 2^3S He atom's internal energy being converted to kinetic energy. Building-up the $2s$ Ne population produces a sufficiently large inverted population between levels $2s$ and $2p$ to achieve laser action.

Soon after optical-pumping raises the population of the $2s$ level above the population of the $2p$ level, the light field that is built up inside the laser-tube cavity becomes coherent and stimulates coherent emission of $2s$ level atoms throughout the tube. Suppose optical-pumping conditions were incorrect and the relative populations of levels $2s$ and $2p$ were not inverted. Then it would be more likely that the spontaneous radiation emitted when a $2s$ atom drops to the $2p$ level would be absorbed by a $2p$ atom, rather than stimulate a coherent cascade of photons from $2s$ level atoms.

Level $2s$ comprises four sublevels and level $2p$ comprises 10 sublevels. These are 30 possible transitions in which atoms in level $2s$ may drop to level $2p$ and radiate infrared, but only five of these transitions have thus far been stimulated emissions. The $2s_2$ to $2p_4$ energy change produces 11,530 A, the strongest stimulated emission.

An atom of an impurity gas such as argon, which has

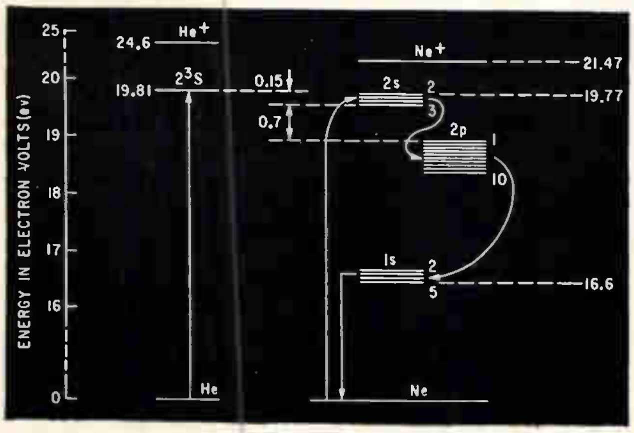


FIG. 4—Energy levels of helium and neon. Arrows represent transitions, with the arrow between 2s and 2p being the transition producing the gas laser's output

TABLE: OPERATING LASERS

Laser Material[a]	Where Developed	Output Spectral Lines (A)[b]
He-Ne	Bell	11,180, 11,530, 11,600, 11,990, 12,070
Ruby (0.05% Cr ion)	Hughes	6,943
Ruby (0.5% Cr ion)	Varian & Bell	7,009, 6,934, 7,041
CaF_2 (0.05% U ion)	IBM	25,000
CaF_2 (0.1% Sm)	IBM	7,082
BaF_2 (U ion)	MIT	27,000
$CaWO_4$ (Neodymium ion)	Bell	10,600

(a) Doping material is shown in parenthesis; (b) Output wavelength varies with temperature

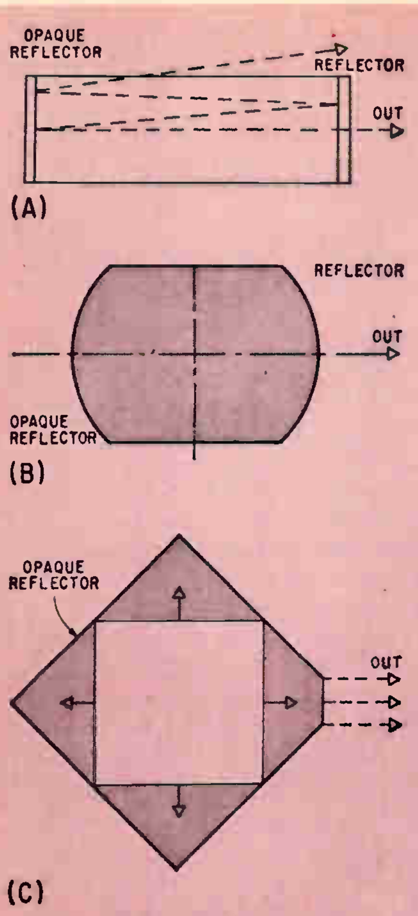


FIG. 5—Structures are flat and parallel mirror (A), confocal (B) and total-internal-reflection (C) resonators

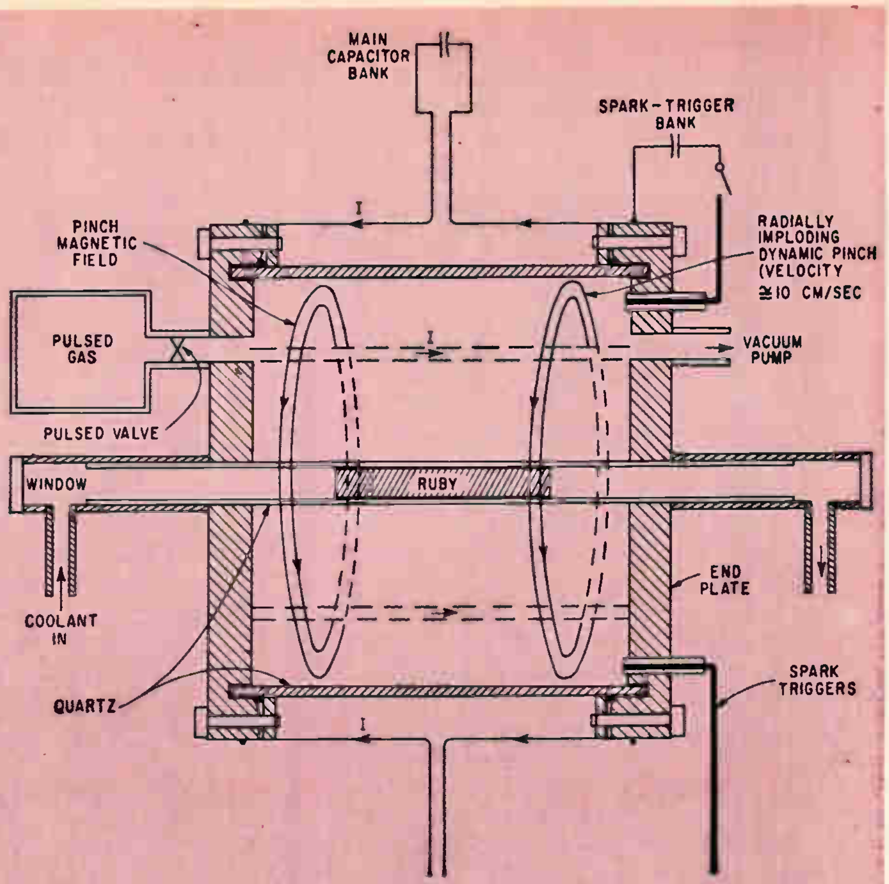


FIG. 6—This laser-excitation source (UCRL) uses pinch effect to generate an extremely intense pulse of light

an ionization energy that is less than that of the 1*s* level (the 1*s* level comprises four sublevels), decreases the population of the 1*s* level when it collides with a 1*s* level atom. With fewer atoms in the 1*s* level, there is less chance of a 1*s* atom rising to the 2*p* level by colliding with an electron; furthermore, there is less chance of the radiation that is emitted when a 2*p* atom drops to a 1*s* level raising other 1*s* atoms to the 2*p* level. Thus, decreasing the number of atoms having 1*s* energies promotes the process desired for achieving laser action—the process of putting more atoms in the 2*s* level than there are in the 2*p* level.

Laser material and construction are under intensive and continual development in scores, perhaps hundreds, of laboratories. Table I lists materials that have been used in lasers that have worked. The only working gas laser developed thus far is the He-Ne laser. All of the other lasers that are listed use solid-state lasing materials. Fundamentally, all solid-state lasers function the same way as the ruby laser invented by Maiman. However, these materials have different energy-level spacings. The Barium-fluoride and calcium floride lasers resemble each other more than they resemble the ruby lasers.[23] Table percents that are listed show the approximate doping-material weights in percents of the total weights of the crystal host and its doping material.

The resonating structures (cavities) of most lasers have comprised parallel reflecting surfaces at the ends of the cavities (Fig. 5A).[22] The confocal resonator shown in Fig. 5B is formed by two spherical reflectors that are separated by their equal radii of curvature.[23, 24] A confocal resonator has these advantages over a parallel-plane cavity: it has lower diffraction losses; it requires less pumping power; optical alignment of parallel reflectors is critical whereas optical alignment of spherical reflectors is not. Figure 5C shows a cavity geometry that is designed to attain total internal reflection.[22] (See practical cavity constructions on p 66 of this issue of ELECTRONICS.)[25]

Silver mirrors and mirrors comprised of dielectric coatings have been used as end reflectors in both solid-state and gas lasers.[22] A dielectric coating mirror comprises a number of dielectric layers having different optical-matching characteristics. Silver has a lower reflectance than dielectric coatings and causes relatively high losses, particularly when used in ruby lasers, which have high peak powers. Furthermore, silver coatings deteriorate with time and use. After about several hundred output pulses, the exact number depending on the operating conditions, silver mirrors would have to be replaced because their deterioration would begin to significantly reduce the output.[26] Dielectric coatings do not undergo such deterioration.

Many configurations have been developed for deliver-

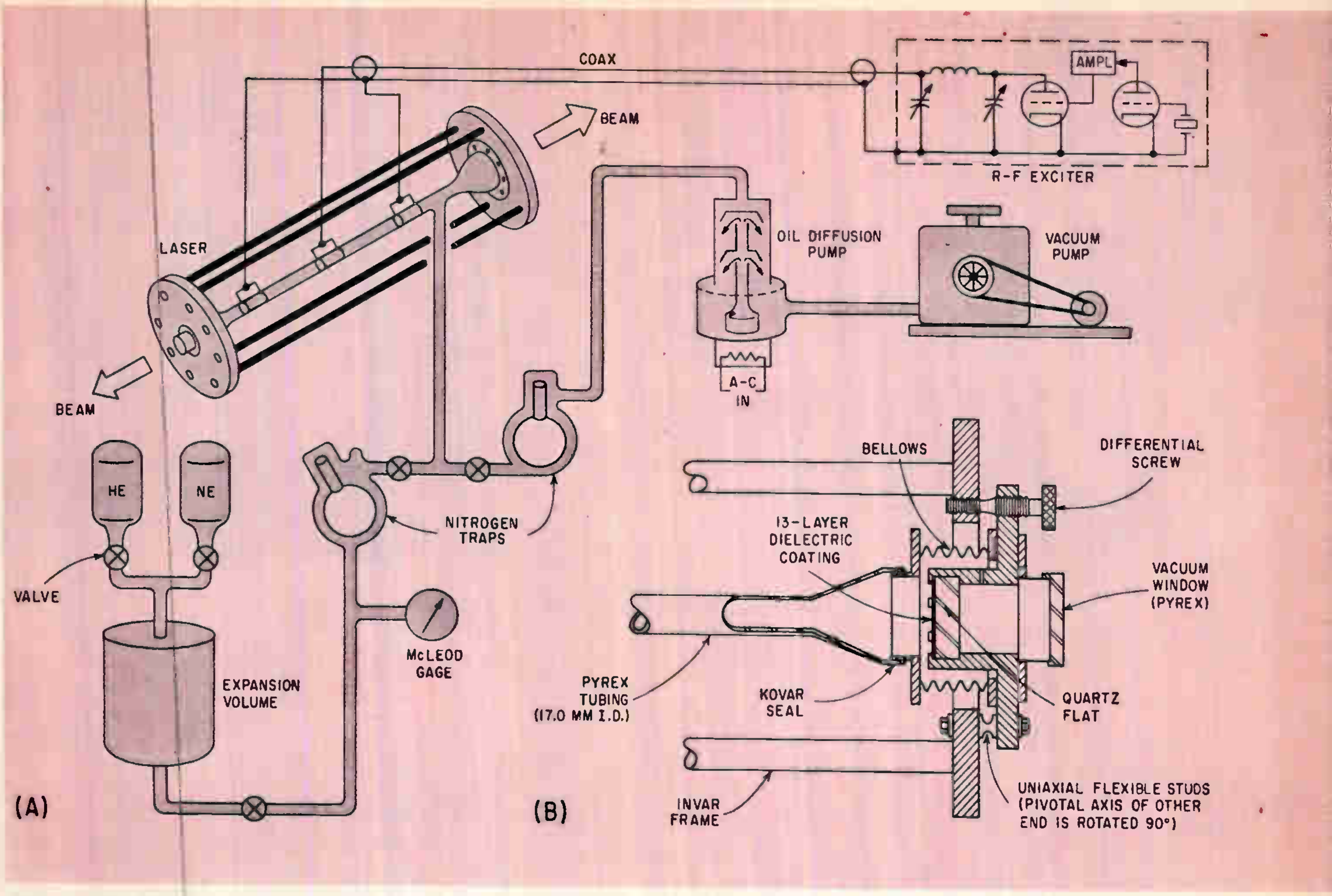


FIG. 7—Raytheon's gas laser system (A) receives excitation power from 28-Mc exciter. The cross section (B) shows the construction of one end of the laser. Other end has a quartz window; otherwise, its construction is identical

ing pumping light to solid-state lasers (ELECTRONICS, Aug. 4, 1961 p 62). Figure 1 shows an efficient arrangement. Mounting the ruby rod and the pumping source, a xenon flashtube, at the foci of a polished cavity having an elliptical cross section, causes all the flashtube's light to hit the ruby rod.[14] Heat dissipation of the flashtube excitation source must not be exceeded. A reasonable upper limit for a quartz flashtube is about 1,000, provided that the flashtube is cooled.[27] A xenon tube provides a continuous spectrum that contains spectral lines characteristic of excited xenon.[28] Since a flashtube's output spectrum is continuous, only a small portion of its output is used in pumping the laser to a lasing level. It is possible to change the output spectrum of a flashtube by varying its temperature, thus improving its laser-excitation efficiency.[29]

Work is going on to develop improved laser-excitation sources producing noncontinuous as well as continuous output spectrums. Figure 6 shows a proposed pumping source that would provide high-intensity excitation pulses.[30] This experimental device uses the dynamic pinch effect to generate optical-pumping radiation for the laser material, a ruby rod. The spark-trigger bank of capacitors delivers triggers to electrodes inside the chamber, which is filled with deuterium gas and a 1-percent concentration of an impurity gas that has a higher atomic number than Deuterium. Simultaneously, the main capacitor bank is switched to the conducting end plates of the chamber. The main bank's discharge produces a tube-shaped axial current that flows in the plasma between the end plates. This current produces a circumferential magnetic field outside the plasma. Since the magnetic field inside the plasma is zero, the inwardly directed magnetic-field pressure on the plasma chamber causes the plasma column to collapse toward the chamber axis, driving a shock wave towards the axis. The collapsing plasma is at its minimum radius at the instant the shock wave reaches the axis; at this instant the inwardly directed velocity of the particles comprising the plasma is converted to random motion, the velocity conversion time being equal to the time required by a sound wave to travel across the thickness of the shock wave. Most of the kinetic energy of the particles is lost by excitation of and reradiation by the highly ionized atoms in the plasma. A computation shows that the plasma can radiate its total energy (2,000 joules) in a μsec, or less. Thus, the ruby rod would receive a pumping pulse that would be about 10^3 times as intense as an excitation pulse from a 2,000-joule xenon lamp, which requires about 1 msec to give up its energy.

Heat affects solid-state lasers more than gas lasers. Tests and observations of extended periods of operation have shown that a ruby laser will not function when it is overheated. Internal heating of the laser material is one of the factors that thus far have prevented c-w laser

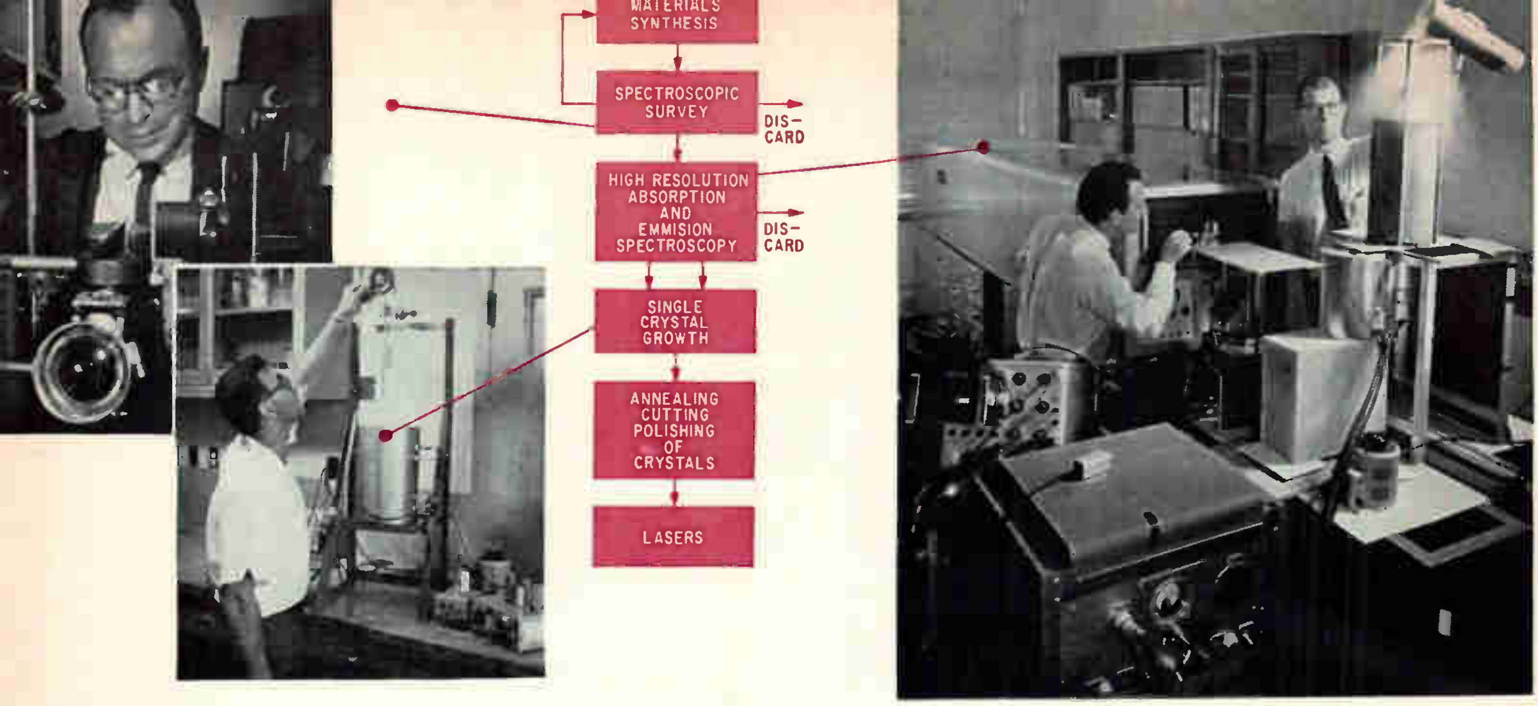


FIG. 8—Research flow chart by RCA. Upper left-hand photo shows measurement of material's emission spectrum. Scientists in right-hand photo are setting up equipment. Lower left-hand photo shows adjustment being made on furnace

operation of solid-state materials, in spite of the use of such external coolants as liquid nitrogen. Since heat transfer requires time, heat may be trapped within the laser crystal for a long enough period to block continuous laser action. Furthermore, heating tends to broaden the widths of radiated spectral lines.[31]

The He-Ne gas laser (Fig. 7) operates at lower power levels than the solid-state lasers developed up to now. Typically, r-f excitation power is 50 watts, although it can be as little as 10 w,[32] and has been reported as high as 80 watts.[21] If too much r-f power is applied, laser action will not occur. The minimum discharge-tube length that is necessary for laser action is about 20 cm.[31] The r-f exciter of the laser shown in Fig. 3 runs at 28 Mc (30-Mc excitation has also been reported[21]). The tube is filled with a mixture of He at 1.0-mm pressure and of Ne at 0.2-mm. The Pyrex discharge tube (quartz tubes have also been used) is mounted on a low-expansion Invar-rod frame. Each of the two end assemblies (Fig. 7B) contains a flexible metal bellows. A differential screw at each end brings the dielectric-coating mirrors into parallel alignment; the differential-screw movement provides a resolution of 1 second of arc. Mirror faces are spaced 1.0-meter apart. Uniaxial flexible studs allow slight positioning adjustments of the end plates. Output windows are sealed with copper gaskets. The window at the end that is not shown in Fig. 7B is a quartz flat. A spring loading (not shown) provides a vernier adjustment of parallelism. Copper-brazed stainless steel is used throughout the construction.

Efforts are being made to improve working-laser materials and constructions.[33] Researchers are looking for better methods to identify and obtain laser materials having high optical quality and proper doping. Making the reflecting mirrors extremely flat is another important problem, since flatness should be in the order of hundredths of a wavelength or less.

Most of the physical characteristics of a material that

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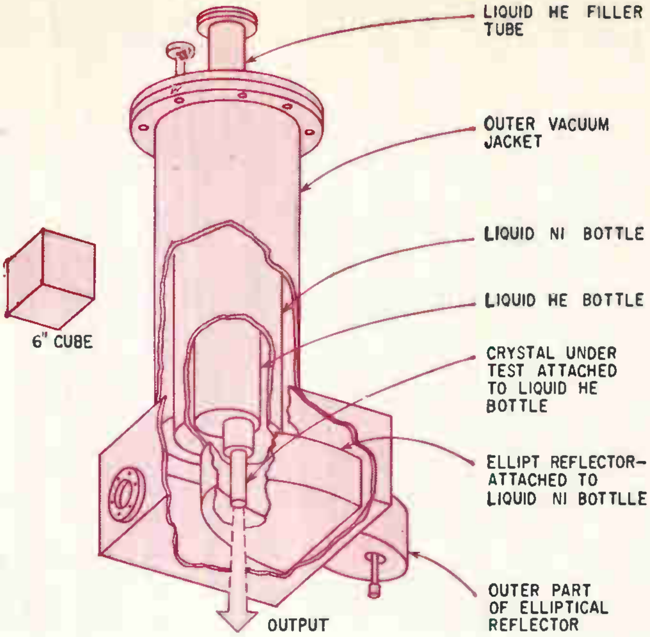

FIG. 9—Adjusting a cryostat laser. This laboratory device tests laser materials and excitation sources. Drawing shows details of the device (Raytheon)

are important, or requisite, for achieving laser action with the material can be ascertained by spectroscopic observations.[31] The basic requirement of a laser material is that it must have a suitable energy-level scheme. These energy levels are ascertained by obtaining absorption and fluorsecent spectra of the material. The flow chart in Fig. 8 outlines the procedures used to find and develop solid-state material that will produce laser action (this RCA research work is partially supported by the U. S. Air Force). Many gases, solids and liquids are being investigated for possible laser action. One gas combination that has been proposed is a mixture of mercury and krypton; an Hg-Zn mixture also looks promising. Single-gas lasers that would use optical pumping to excite the laser gas have been proposed;[6] potassium and cesium are among the materials that have been investigated. Europium, a rare earth, has been mentioned as a likely solid-state possibility. Finding a material that will lase entails much computation and experimentation. Spectra of an element differ for various host materials, percentages of the element,[31] and temperatures. Furthermore, a pumping scheme has to be designed to get the material to lase.

Solid-state-laser operation is strongly dependent on temperature. Crystals that work at room temperature exhibit more output for a given input when cooled. Other crystals do not work at all at room temperature and must be cooled to obtain laser action. Figure 9 shows a laboratory device for investigating materials for laser action.[32] The liquid helium in the inner container can bring temperatures down to 20 K. The pumping-light source is separated from the crystal under test by a glass window that preserves the vacuum in the chamber containing the crystal. Thus, different types of lamps pumps and filters can be tried with a crystal without having to break the vacuum. (The vacuum is broken when a crystal is inserted.) This test configuration, which is called a cryostat laser, will also be used to investigate the effects of temperature on laser operation.

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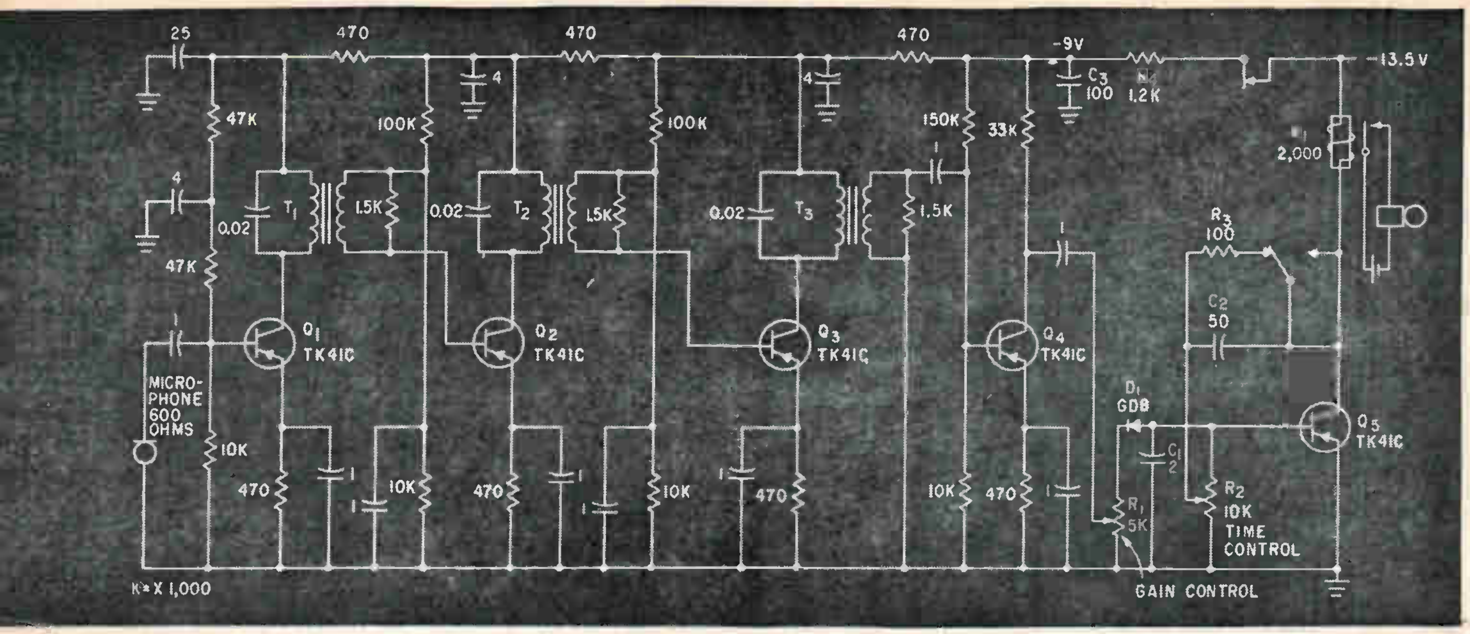


Input to the responder is 13-Kc note of ultrasonic dog whistle

ULTRASONIC FREQUENCY

System uses ultrasonic signal to actuate responder located in predetermined spot.

By M. R. McCANN
I. ALEKSANDER,
Standard Telephones and Cables, Limited, London, England

A SYSTEM that enables a blind person to locate a predetermined position in a given area by aural means can be useful. As an example, the device described here lets a blind person locate the entrance to his house at any time from any point in his garden, which may be as large as 100 yards square.

This system consists of an actuator held by the user, and a responder at the homing point. Prime requirement of the actuator is that it be as simple as possible so as to require minimum maintenance by the user. The most suitable actuator is an ultrasonic dog whistle, which is readily available to blind persons. The responder is a transistorized unit that receives the signal produced by the dog whistle and emits an audible signal for a predetermined period of time.

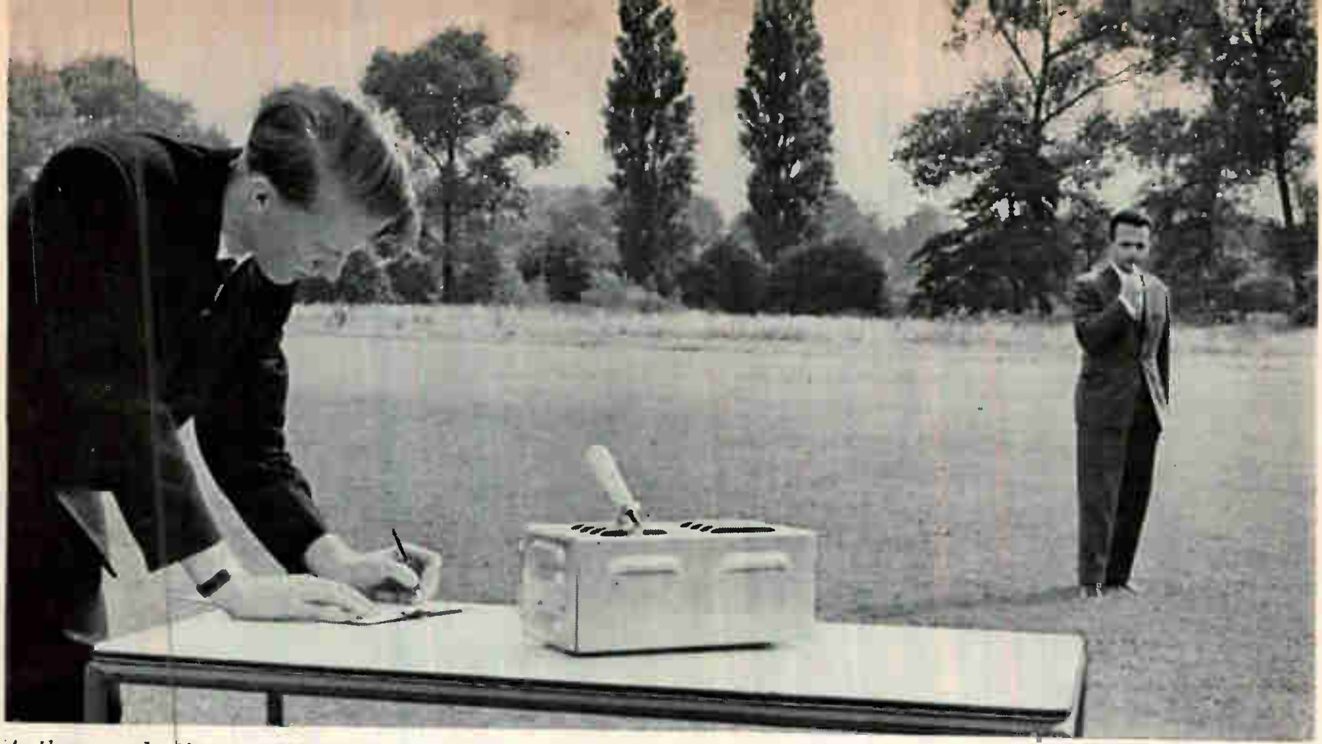
Since the average ultrasonic dog whistle can be tuned to an approximate fundamental frequency of 13 Kc, the primary requirement of the responder is that it contain a sensitive amplifier tuned to 13 Kc. Bandwidth of the amplifier takes into account that too narrow a bandwidth requires too accurate a tuning of the whistle, while too wide a bandwidth produces spurious operation in response to such natural sounds as bird noises. Bandwidth of approximately 2 Kc is the optimum value.

The amplifier output is detected and triggers a monostable relay circuit whose on time can be set. A relay contact actuates an aural signal such as an electric bell or an audio oscillator.

The amplifier has three tuned stages ($Q_1 - Q_3$) as shown in the circuit diagram. Each stage has a bandwidth of 700 cycles, the center frequencies being staggered to 12.5 Kc, 13 Kc, and 13.5 Kc. This provides a reasonably flat response over a total bandwidth of 1.7 Kc. The turns ratio of the transformers is 12.5 to provide interstage matching. A tuning capacitance of 0.02 μf is used in each stage and the primary turns are 125, 120 and 115, providing the center-tuned frequencies of 12.5 Kc, 13 Kc, and 13.5 Kc respectively.

The primary inductance required to tune the transformer to 13 Kc is 7.3 mh. A Ferroxcube former type LA1 wound with 32 swg (standard wire gage) enameled copper wire is used. The 1,500 ohm resistors in the secondaries of the transformers standardize the bandwidth, preventing it from being smaller than the required value. All transistors are STC TK41C.

The untuned amplifier stage (Q_4) gives the responder maximum gain and yet prevents operation of the



Authors conducting experiments to find usable range of the system

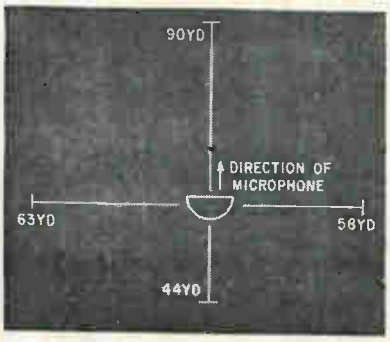
RESPONDER AIDS BLIND

Responder emits audio signal that leads blind person to the predetermined position

device by internal noise in the initial stages.

The detector consists of signal diode D_1 and reservoir capacitor C_1 in the base circuit of the monostable stage Q_5. A 1-v peak-to-peak signal appearing across sensitivity control R_1 causes Q_5 to conduct, energizing relay K_1 in its collector circuit. A changeover contact introduces capacitor C_2 between the base and the collector of transistor Q_5. Charging current of C_2 flows partly into the base of Q_5 and partly to ground through the potentiometer R_2. This provides a maximum time constant of about 25 seconds during which the relay is energized. Potentiometer R_2 is used to make this time constant variable down to a fraction of a second. When C_2 is fully charged, relay K_1 will be deenergized, thus allowing the C_2 to discharge through R_3.

Contacts of K_1 also close a bell circuit and cut the supply to the amplifier, preventing audio feedback from bell to microphone. Capacitor C_3 in the supply line provides a reasonable time constant to the fall-off of signal to the detector thus ensuring that C_1 does not lose its charge before the monostable circuit is securely locked on. Resistor R_4 drops the supply to the amplifier to 9 v and limits current surges flowing into C_3. Sensitivity of the amplifier is such that the relay is triggered with a signal of 0.5 v rms from a Lustraphone LFV/H59 microphone.



Direction of microphone affects range of signal pickup

The system could be extended to cover the identification of more than one point by using several whistles tuned to various frequencies associated with various responders.

Transistors are suited to this application because of their inherent reliability which is the prime factor in any aid for the blind.

The authors thank Standard Telephones and Cables Limited for permission to publish this material, and acknowledge the assistance given by other members of the transistor applications dept. in the experimental work.

The equipment described here was developed to fulfill a requirement of St. Dunstans Institute for the Blind.

R-F Techniques for CONTROLLED

Reaching 100,000,000 degrees K in a plasma discharge is the first step to controlled thermonuclear fusion and the direct production of electrical energy

Plasma breakdown and ohmic heating circuits for the C-stellarator are covered

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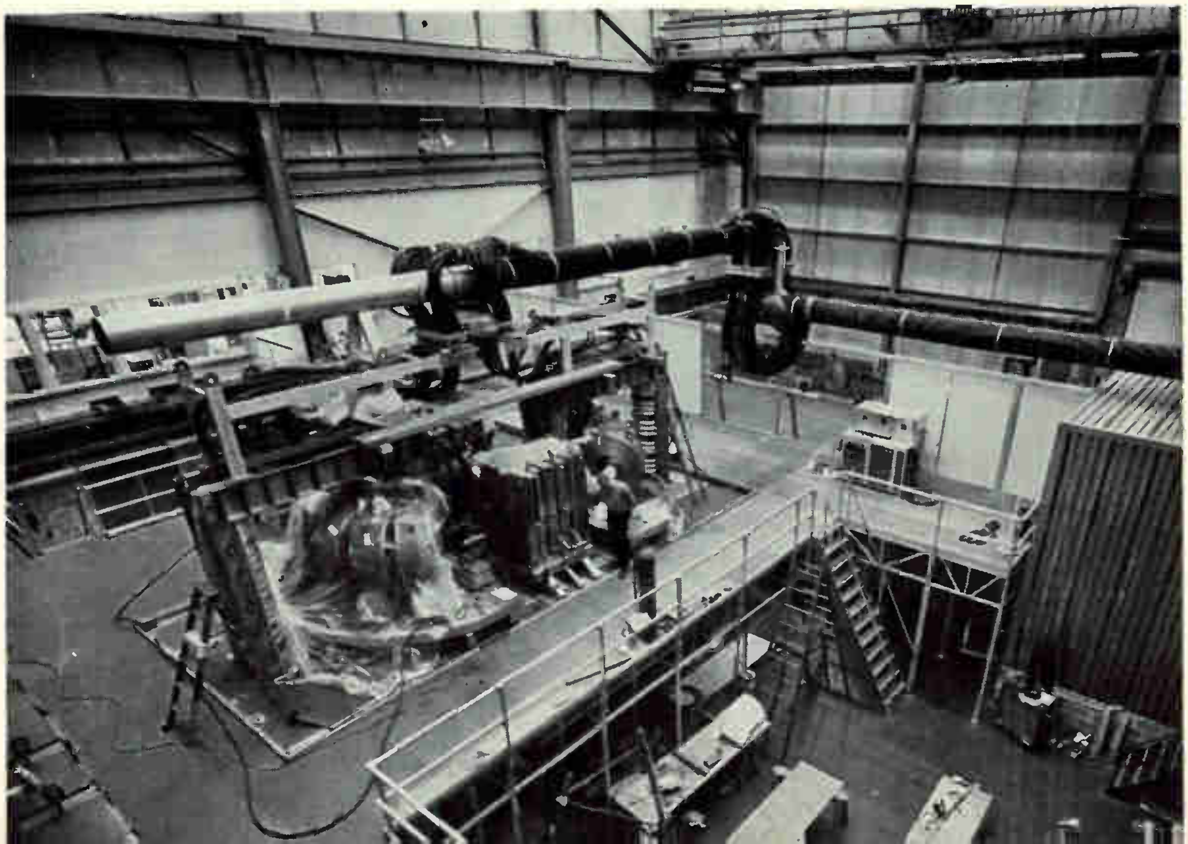
TECHNIQUES for heating confined, fully ionized gases (plasmas) to millions of degrees K are vital to research on controlled thermonuclear fusion. The use of high-power r-f energy to produce such plasma temperatures holds considerable promise[1] and has resulted in a marriage between the disciplines of plasma physics and high-power transmitter engineering. The ultimate goal of this research is discovery of means of controlling thermonuclear fusion and efficiently producing electrical power therefrom[1-3].

In the United States, fusion research is being carried out under Project Sherwood[4] of the AEC. One major approach, pursued at the Princeton Plasma Physics Laboratory (formerly called Project Matterhorn) of Princeton University, has concentrated on the Stellarator concept[5-6]—now in its third generation with the construction of the model-C stellarator facility.

The thermonuclear reaction of interest involves the controlled fusion of a fuel of hydrogen isotopes —deuterium and/or tritium—to form helium, nuclear particles, and a surplus of electrical energy. To produce a controlled fusion reaction, the fuel must be ionized by heating to form a plasma, and then further heated to extreme temperatures. Such heating, coupled with confinement in a given volume for sufficient time, theoretically should cause the ions to collide energetically enough to overcome the strong repulsion forces of their like charges—and thus fuse.

In a sense, there are two tem-

FIG. 1—C-stellarator during construction. The ohmic heating transformers at each end of the device are connected to the isolation transformer through 78 lengths of 1-in. diameter coaxial cables wound around a 2-ft diameter support



THERMONUCLEAR FUSION

perature conditions of concern to fusion research. These are the production of plasma temperatures of millions of degrees K for basic studies of their characteristics and the conditions necessary for fusion collisions, and, ultimately, to achieve a self-sustaining fusion reaction by producing an ignition temperature such that the generated power in the plasma would exceed energy losses. Depending on the fuels involved and the characteristics of the reaction, such an ignition temperature may range from 100 million to 400 million K or more.

The problem of ignition temperature, as well as many others, must be solved before actual production of electrical power can be achieved without a conventional, inefficient heat cycle and with the advantages of cheap inexhaustible fuel (deuterium from sea water), safety from run-away reactions (the amount of reacting material is small) and absence of a disposal problem (ashes of a complete fusion reaction are not radioactive). To date, a successful controlled-fusion reaction has not been knowledgeably achieved, emphasizing the importance of more plasma research.

The C-stellarator shown in Fig. 1 is a research facility and is not intended to produce electric power or sustain a fusion reaction. Its plasma temperatures, of the order of 100 million K, will be provided by three heating schemes using high-power r-f equipment, energized in sequence by a precision timer. The core of the C-stellarator is an 8-inch diameter, racetrack-shaped vacuum vessel with an axial circumference of about 40 feet. A pulsed magnetic field of up to 55,000 gauss, produced by coils surrounding the vessel and energized by 12 generators of 200-Mw d-c output, confines the hot plasma within the vessel. Such confinement increases the probability of fusion collisions and prevents cooling of the hot plasma by contact with the vessel walls. The plasma initially must be at low density, since outward pressure against the magnetic field increases with temperature. The plasma must also be of extreme purity to limit radiation losses from heavier nuclei impurities. Both these requirements are met by the ultra-high vacuum system, which produces initial pressure inside the vessel as low as 10^{-10} mm Hg.

The r-f equipment for the facility consists of three systems. The B, or breakdown system, and the OH, or ohmic heating system, are now installed. The IH, or ionic heating system, is still in the design and development stage.

The B-system output is connected across a ceramic section in the vacuum vessel to ionize or break down the gas to form the plasma. The equipment is rated to produce pulsed power up to 400 Kw peak at a nominal frequency of 100 Kc. Provision is made for altering the frequency up to 200 Kc, with variable frequency envisioned as a future modification. Pulse width of the B system is variable from 0.2 to 10 msec. A 70-Kva c-w mode of operation of this equipment is also specified for possible use in heating the vacuum vessel during the initial bakeout to aid in attaining the highest possible vacuum.

The OH system provides the principal heating of the test gas. Energy is coupled into the plasma by induction, since the use of electrodes that might come in contact with the gas would cool it and probably contaminate it by release of heavy ions. The induced current is expected to produce a maximum temperature of 1 million K by I^2R losses in the plasma. The output of the OH equipment is provided by pulsed operation of six parallel-connected power tubes energized from a capacitor bank capable of 500,000 joules of energy storage. The amplitude of the output is fully adjustable to peak pulse current of 50,000 amperes in the plasma, and in pulse duration from 0.1 to 5 msec. Operation without the power-amplifier tubes is possible with limited amounts of the stored energy being switched by ignitrons in an over-damped discharge.

After experiments with the r-f equipment as initially installed, even greater flexibility is to be provided by modifications. In such future operation of the OH equipment, provision is to be made for feedback control of the pulse shape from the plasma current or plasma

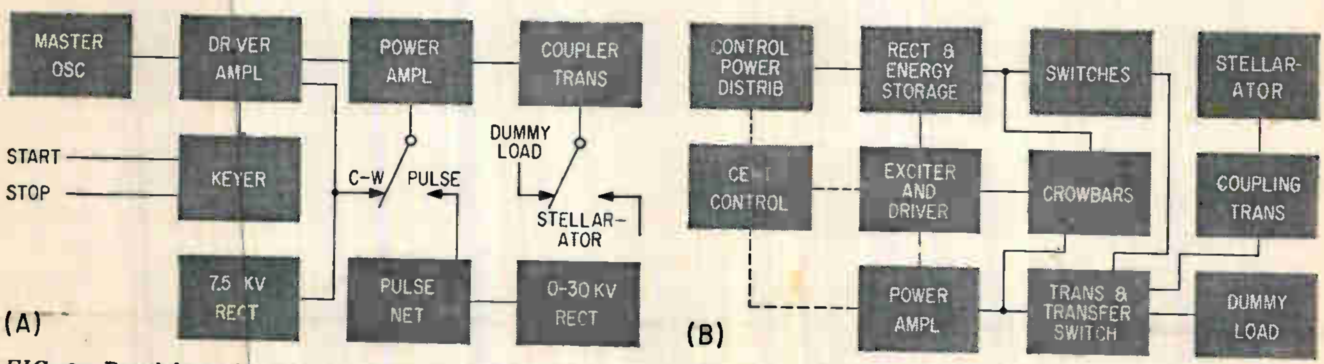


FIG. 2—Breakdown heating system (A) and ohmic heating system (B). Ohmic heating will raise plasma temperature to 10^6 degrees K

voltage. In addition, pulses of 10-Kc sine waves will be available from the push-pull connection of the power amplifier.

The IH system is expected to provide heating from 1 million K to 100 million K. The magnetic-pumping action in this type of heating is described by Spitzer.[7]

For the gas within the C-stellarator to be confined effectively by the magnetic field and to be heated by the r-f equipment, it must first be ionized. Ionization can be accomplished by either a d-c or an a-c voltage pulse; a-c is preferable because it avoids acceleration of particles of high velocities. R-f energy above 50 Kc is satisfactory for ionization and at the same time, produces relatively small net acceleration. Therefore, the B system shown in Fig. 2A operates at a frequency of 100 or 200 Kc, as experimental conditions require.

Three air-cooled stages of r-f amplification are used in the equipment; a master oscillator using a 35T triode, driver amplifier consisting of two 4CX5000A tetrodes in parallel and the power amplifier with two ML-6697 triodes in parallel. The output power is transformer-coupled to the C-stellarator.

The B system operates in either a continuous wave or a pulsed mode. The power output is continuously variable from 5 to 70 Kva in c-w operation, and from 0 to 400 Kw during pulse operation.

The master oscillator operates continuously in both modes of system operation. Its self-excited Colpitts circuit has a measured frequency stability during warmup and long-time operation of better than $\pm\frac{1}{2}$ percent, more than adequate for this application.

In c-w operation, the power output is controlled by adjustment of the grid bias of the driver-amplifier tubes. A motor-driven potentiometer, controllable either locally or remotely at central control, is used to vary the fraction of the bias-supply output voltage that is applied to the driver grids. Since both the driver and the power amplifier operate as linear amplifiers, the output power is directly controlled by this bias adjustment, because it controls the amplitude of the r-f signal effective in causing conduction in the driver tubes. Driver plate power is supplied by a

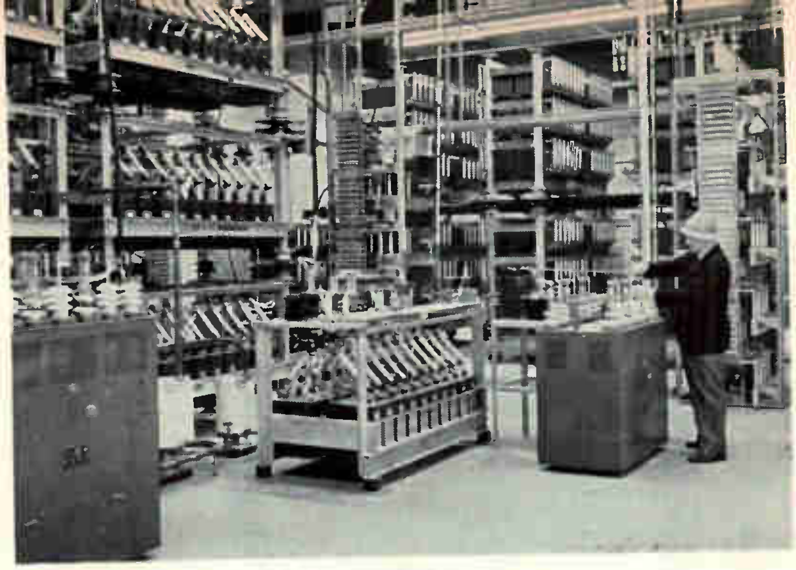


FIG. 3—Ohmic heating energy storage room

7.5-Kv unitized rectifier in both pulse and c-w modes, but the power amplifier is energized from this supply only in c-w. Tube parameters are monitored by conventional meters and by test jacks made available for oscilloscope observation.

In pulse operation, the quiescent bias on both the driver and the power-amplifier tubes is beyond cutoff. The grids of the driver are keyed to reduced bias to permit the output from the continuously running oscillator to be amplified for a duration controlled by trigger pulses furnished by the precision timer in central control. Experiments on previous stellarators indicates that the desired ionization level will be produced within a few milliseconds at 1,000-volt potential across the ceramic section of the vacuum vessel. However, for flexibility in the testing program, two modes of pulsing have been provided; a normal mode, in which the pulse length may be varied from 0.2 to 10 msec at a repetition rate up to 3 pulses per min. and a rapid mode in which the pulse length may be varied from 0.2 to 1.0 msec at a repetition rate of 10 pulses per sec.

The keyer circuit consists of a multivibrator, cathode follower and keying tube. The multivibrator is a conventional cathode-coupled monostable circuit set for a constant 10-msec output pulse. The time at which the pulse is initiated is controlled by the start pulse from the precision timer. The width of the pulse applied to the system may be shortened by the application of a second or stop pulse also generated by the timer. The rectangular waveform generated at the normally ON plate of the multivibrator is coupled by the cathode follower to the keying tube to prevent loading from affecting the multivibrator. The keying tube is part of a voltage divider across the bias power-supply voltage, with the plate of the keying tube grounded and the driver grids connected to its cathode. Thus, the plate-to-cathode voltage of the keying tube is the bias voltage applied to the driver, so that the drivers are able to amplify the r-f signal only when the keying tube is driven to low plate resistance by the positive pulse generated by the multivibrator.

In both the normal and rapid modes of operation, the pulse rise time is 50 μsec, measured at 90 percent of peak value. The time for the trailing edge of the pulses to decay to 5 percent of peak value is 15 μsec, which is only one and a half periods at 100 Kc. Since the required Q's of the tuned resonant circuits of the r-f stages are too high to permit such a short decay time, loading resistors are switched in at the end of the r-f pulse. Hydrogen thyratrons are used as switch tubes to provide loading to the driver output pi-coupling network and to the tuned primary of the output transformer. These thyratrons are fired by the stop pulse, causing the energy in the tuned circuits to be quickly dissipated in the resistors switched in for this purpose. At the same time, feed of further energy is stopped by the termination of the keying pulse.

In pulse operation of the system, plate power for the power ampli-

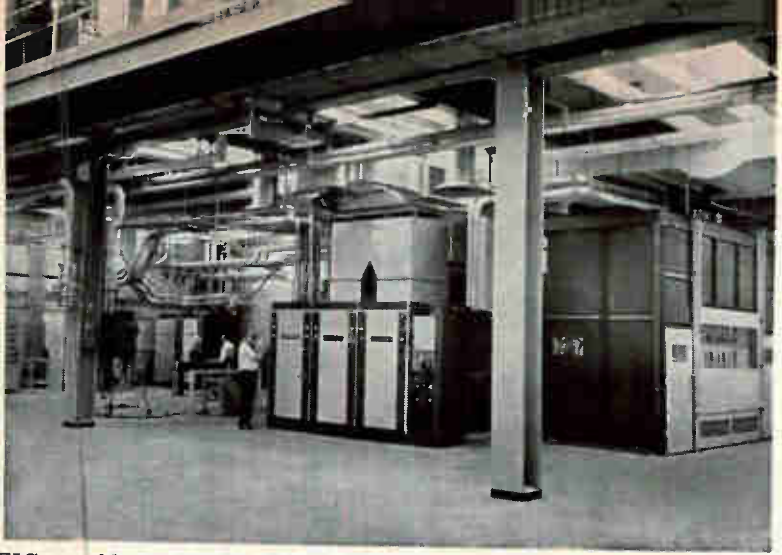


FIG. 4—Ohmic heating driver and power amplifier

fiers is supplied from a 25-section pulse-forming network. In the rapid mode of pulse operation, only five sections of the pulse-forming network are used. The whole line is used in the normal mode. The network is charged from a 3-phase voltage-doubling rectifier to a voltage adjustable between 0 to 30 Kv. When the line is terminated in its characteristic impedance of 300 ohms, it is capable of supplying a constant 50 amperes at 15 Kv for 10 msec.

When ionizing the test gas in the C-stellarator, the load presented to the power amplifier changes rapidly. The 100-Kc impedances are likely to pass through the range of $0.01 + j5.0$ ohms initially, to $1.25 + j1.25$ ohms, and finally to $0.1 + j1.25$ ohms when the gas is fully ionized. Transformer coupling matches the high impedance of the power amplifier tank circuit to this low-load impedance range. All testing has been done into the dummy load provided in the system at a nominal impedance of $1.25 + j1.25$ ohms but operation into the extreme impedances has been thoroughly tested by modifying the dummy load. A motor-operated load-transfer switch connects the secondary of the coupling transformer to either the dummy load or to the C-stellarator.

The power amplifier is the pivotal point of the OH system (Figs. 2B, 3 and 4), since the rest of the design is influenced strongly by the choice of power amplifier tubes. Developmental A15030 super-power beam triodes, having a peak pulse power output rating on the order of 20 Mw. are used. These tubes are designed for a maximum instantaneous plate voltage of 50 Kv and a peak pulse cathode current of 640 amperes per tube.

The small duty cycle (0.01 maximum) means average plate dissipation of the tubes is well below ratings. The 840-ampere peak cathode current, which may be required per tube, is beyond anticipated emission capability at rated filament temperature. Provision has been made to pulse up the filament voltage to raise the temperature to 2,075 C and thus provide the required emission.

Early experiments to be performed require that the OH system produce a pulse of current in the plasma which is fully adjustable in magnitude to a peak value of 34,000 amperes, adjustable in duration from 0.1 to 5 msec, to have the rise and fall of a 5-Kc sine wave and to have pulse repetition rates up to 3 a minute with full pulse width, or 10 pulses per sec with 1-msec maximum duration.

Provision has been made for pulsing the plasma current as high as 50,000 amperes to permit investigation of theoretically predicted instability. Under conditions for obtaining this higher-current pulse, rise time is limited to 0.22 msec and maximum repetition rate is 3 pulses per min.

The large amount of stored energy needed to produce the current pulse requires that the power amplifier tubes be protected from fault damage. A fault-detection circuit is used which is insensitive to the normal voltage pulses appearing at the grids and cathodes of the tubes. The fault-detection circuit reacts to a difference in voltage developed between the tubes when a fault occurs in one of them. The signal developed by the fault-detection circuit is applied to crowbars on the energy-storage banks and on the secondary of the isolation transformer so as to divert nearly all energy from the faulted tube. Tests indicate that the crowbars fire less than 4 μsec after a fault signal occurs.

Drive for the power amplifier is obtained from a cathode follower consisting of twenty-four 4CX-5000A tubes connected in parallel. These have a combined transconductance of nearly 1 mho and peak power-output capability of 400 Kw in this application. The energy for the pulse is obtained from a 5 Kv, 1,000 μf capacitor bank that serves as a plate-power supply for the cathode followers. The 12,500 joules stored in this bank are diverted from a fault in the cathode followers by a single 5555 ignitron crowbar. The cathode follower is driven by a series of class-A voltage-amplifiers, the last of which is a group of four 4CX5000A tubes.

An exciter provides a reference pulse shape and its timing and duration are determined by pulses from the precision timer at central control, or if desired, by a local timer. Provision has been made for the use of feedback to produce the desired shape of current pulse.

Output of the power amplifier tubes is coupled to the plasma through a transformer in the plate circuit. This affords voltage isolation and a choice of two impedance transformations through a tap changer. To reduce lead inductance, the tap changer switch is mounted under oil in the isolation transformer case. This switch also provides for either clockwise or counterclockwise induced current in the plasma at both turns ratios.

Two power-amplifier carriages have been provided with space for five tubes on each carriage, although three tubes per carriage are expected to deliver the required power to the plasma. Each tube is housed in an insulating enclosure containing a gas of high dielectric strength so that voltages nearly twice the maximum instantaneous rating of the tube may be handled. In addition to the tubes, the carriages support the filament transformers, filament voltage controls, insulating water coils and tube fault-detection and indicator circuits related to each of the power-amplifier tubes. Voltmeters and ammeters for filament power, flowmeters for the cooling water for plates and grids, and the water-supply header are mounted on a 9-by-7 foot panel bolted to the front of each carriage.

The connections between the energy-storage capacitor banks and the isolation transformer, and between the isolation transformer and the power-amplifier tube plates are coaxial to reduce lead inductance. This reduces voltage drop in the inductance of the connections and therefore reduces the level of high voltage. The coaxial structure near the tubes must withstand the same voltages as the plates of the tubes themselves. Air was selected for the dielectric for this coaxial line designed to withstand a peak operating voltage of 90 Kv. However, no safe means of connecting the tube plates to the inner conductor of the coaxial line was apparent. Therefore, a transition section was designed to permit the short section of the line nearest the power-amplifier tubes to be operated with the inner conductor grounded and the outer one at high voltage. This arrangement facilitates connecting the tube plates in parallel, since they are arranged in a circle around the line. No operating hazard results from this connection since the entire amplifier is in a shielded enclosure.

A load-transfer switch on the isolation transformer permits connection of the secondary winding to a dummy load or to 78 parallel lengths of RG19A/U coaxial cable. These cables provide a low-inductance connection between the isolation transformer and a pair of transformers mounted so that the vacuum vessel passes through the window of their cores. Thus, the plasma is the secondary winding of these coupling transformers. The coupling transformers are connected with their primaries in parallel, but the single-turn of plasma (the secondary turn common to both transformers) has the induced voltage from the two transformers effectively aiding in series.

Plate supply voltage for the power amplifier is derived from two separate rectifier systems. These rectifiers may be independently adjusted to meet the various requirements of the experiments.

The low voltage supply, rated at 3 Kv, 50 amperes, may be connected to a bank of capacitors arranged in nine groups of 4,500 μf each. With all nine groups in parallel, the resulting 40,500 μf stores the main portion of the energy requirements for first-stage experiments. The groups of capacitors can be rearranged from parallel to series connection by removing a pair of connectors at each group. With the bank so arranged, the total capacitance is 500 μf and may be charged to 45 Kv with a resultant energy storage of over 500,000 joules.

A pair of 9-μf capacitor banks can be charged by a pair of high-voltage rectifiers as high as 60 Kv. The high voltage from this bank of capacitors is applied to the plates of the power amplifier tubes to obtain the desired rate of rise of current in the inductance.

Type 5555 ignitrons are used as high-voltage switches and high-current crowbars in unusual combinations of series and parallel connection. These ignitrons are an example of application of available components to meet requirements outside of their published ratings. The ignitrons are rated for 2,400-volt maximum forward voltage and for 6,000-ampere maximum peak current. It has been found by experiment that these ignitrons will withstand at least 15 Kv in forward or reverse directions and up to 70 ampere-seconds in high-current discharges. Advantage has been taken of these facts in connecting five ignitrons in series to provide a suitable crowbar for the high-voltage capacitor banks. A peak current of 60,000 amperes may be expected, but this is within ignitron ampere-second ratings.

Two switches, each consisting of five ignitrons in series, connect the high-voltage capacitor bank and the low-voltage capactior bank to the plate circuit of the power amplifier tubes. These switches must withstand a voltage of 60 Kv each and pass a peak current of 5,000 amperes. Their operation is controlled by timing pulses from the precision timer.

Crowbars for the nine groups of 4,500-μf capacitors consist of eight ignitrons connected in parallel or series.

The r-f equipment is intended for experimental use by physicists and others who may not necessarily be familiar with its hazards. In addition, large amounts of stored energy must be available to produce the high pulse-power level needed in the experiments. Therefore, the safety requirements of this installation are more severe than for ordinary broadcast equipment. All access doors and panels are interlocked in the conventional way, and the status of the interlock system is summarized at both local and central control. Access to all areas in which conductors that may connect to the stored energy are located is by a system of key interlocks. These interlocks require that all power be turned off to make a key available. This key must be used to unlock a grounding switch which when locked in the safe position, makes available another key that permits entry into the energy-storage area. Emergency OFF buttons are available in various places throughout the building to remove all power if needed. The connection of the B and OH system outputs to the C-stellarator is by motor-operated load-transfer switches that must be cycled to the dummy load positions, in which no output energy can be fed to the C-stellarator, before access is gained to the room.

The authors acknowledge the contributions to the development and design program of the many people associated with it; particularly C. J. Starner, J. Q. Lawson, N. J. Oman and J. H. Roberts.

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Pulse analyzer and counter circuits automatically cover wide transmission band to provide comprehensive analysis of solar x-radiation existing in outer space.

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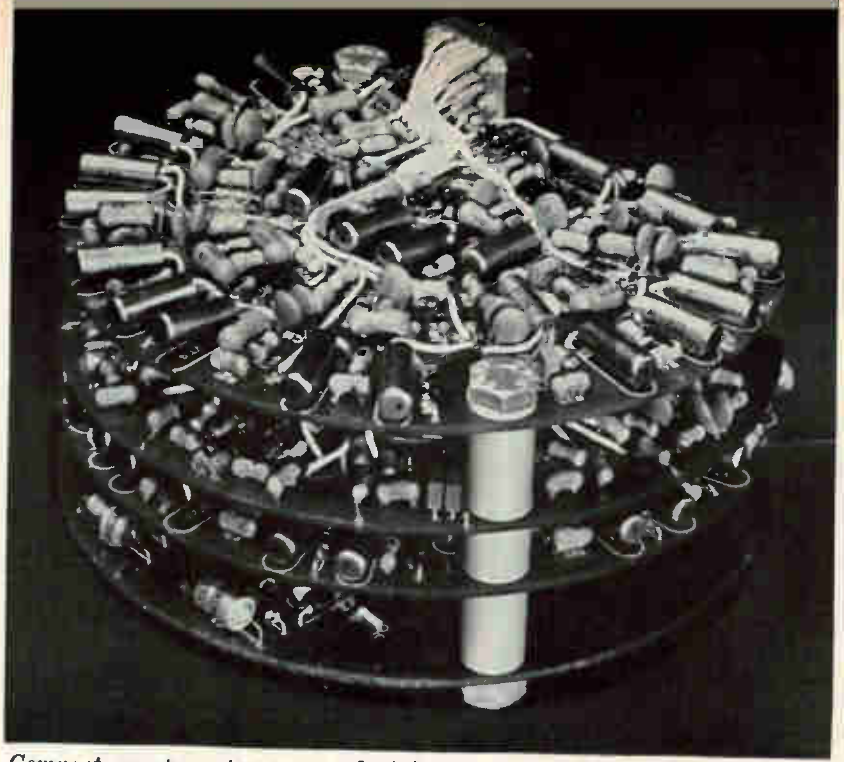


Compact spectrometer uses subminiature components arranged in four stacks on printed circuit boards. Unit is small enough to fit cupped hands

ORBITING SPECTOMETER

Plots Solar X-Rays

ONE EXPERIMENT included in the first British-instrumented Scout satellite is a detailed investigation of solar x-rays in wavelengths between 4 and 14 angstroms. Previous simpler experiments for this band used the transmission properties of an x-ray detector window to define the wavelength, and measured all radiation transmitted by the window. This experiment uses a detector window with a wide transmission band, and the wavelength range is resolved into finer detail electronically.

X-rays are detected by a gas counter that produces pulses whose heights are proportional to the energies of the incident x-rays.

The experiment is carried out jointly by the Departments of Physics at University College, London, and the University of Leicester, under the auspices of the British National Committee on Space Research.

The electronics was designed and built by the Guided Weapons department of Bristol Aircraft Limited, a company of British Aircraft Corp.

Figure 1 shows the basic block diagram of this equipment. Design of the spectrometer is based on two fundamental properties of the detector. The amplitude of the output pulse of the detector is proportional to the energy of the incident radiation; and the rate of the pulses produced is a function of the intensity.

A graph of intensity plotted against wavelength (the radiation spectrum) might be derived by measuring the rates of pulses of selected amplitudes.

This ideal operation cannot be carried out in fact, so a compromise is made. Instead of selecting pulses of a given amplitude, the pulse height discriminator, Fig. 2, selects a range of pulses falling between two limiting amplitudes.

All pulses in the selected range pass through the timing gate (opened for a fixed time) to the counter. The counter registers the average intensity of radiation falling in the given wavelength band.

When this measurement is completed and the results are transmitted or recorded, the level selected by the variable pulse height dis-

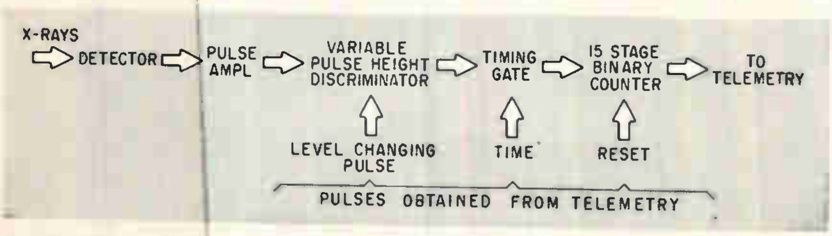
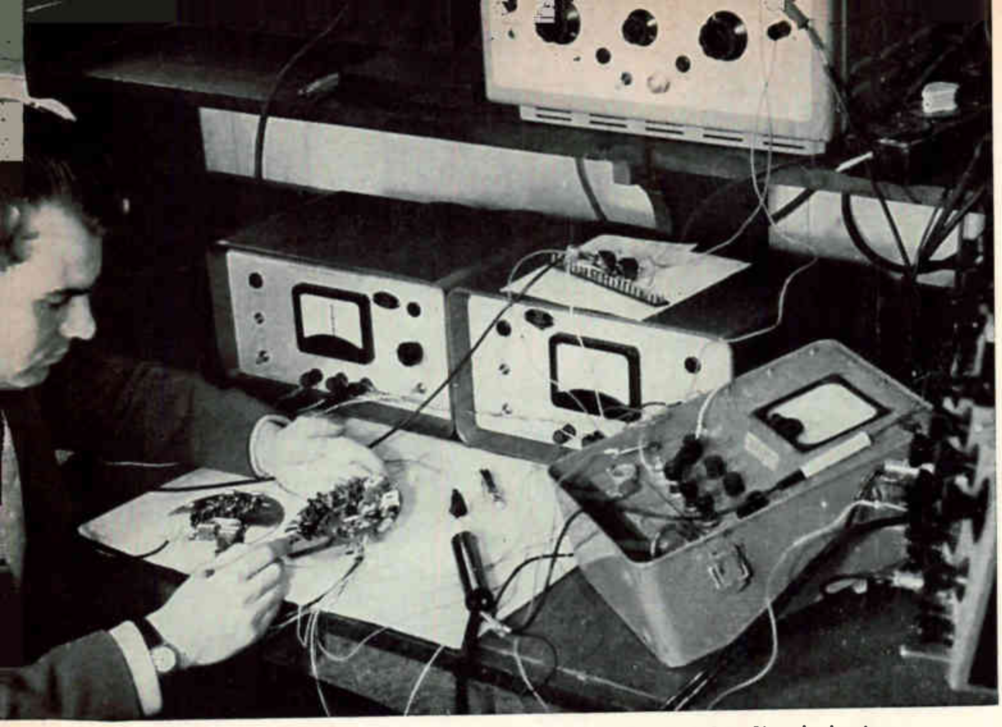


FIG. 1—X-ray spectrometer uses proportional gas counter technique to determine intensity of x-ray emanations. Discriminator and counter circuits define pulses passing in selected range



Technician adjusts wavelength range of pulse-height discriminator

criminator is changed to an adjacent wavelength band. This sequence is repeated five times to cover the full range of wavelengths (Fig. 3A).

It would be interesting to divide the wavelength range in more than five steps, but certain restrictions prevent this. A fine division would produce an enormous amount of data to be transmitted over the telemetry link but this is not the limiting factor. Noise in the system is the most serious limitation, as noise effectively diffuses the limits of selected wavelength ranges.

For example, consider a pulse with an amplitude equivalent to the lower limiting value of one setting of the pulse height discriminator. Random noise, added to the signal, will appear sometimes in the required range, and sometimes in the next one below. Similarly, a pulse which should be just below the level of the required range when noise is present may occur in the range being observed. This introduces uncertainty between successive ranges. In fact, it is convenient to consider that all noise in the system occurs on the boundaries of the pulse height discriminator range.

If the range is made narrow compared with the noise, then the upper and the lower boundaries may overlap, and the acceptance band effectively ceases to exist. The minimum width of the range must be greater than the sum of the noise on each boundary, and so for each setting there will be a pulse amplitude which will occur without ambiguity in the chosen range. To achieve this the number of steps were limited to five and the center of each range gives a definite reading for about 50 percent of the range.

In the pulse height discriminator, Fig. 2, the two trigger units are high-gain amplifiers with transformer feedback biased past cutoff by voltage dividers R_1 and R_2. They are supplied from 5.6-v zener diode stabilizer D_1. Although a lower voltage is required, low-voltage stabilizers have too high a slope resistance at low currents, and the 5.6-v device has a low temperature coefficient. The voltage dividers are set at different values. This difference in triggering amplitude corresponds to the range of the discriminator level.

For low-level input pulses, neither trigger operates. At a slightly higher (predetermined) level the first trigger operates while at high levels, both triggers operate.

By inhibiting gate, Q_7 with pulses from the second trigger, only input pulses within certain ranges can produce pulses at the output.

Level changing is effected by subtracting a known voltage from the input pulse, (Fig. 3A). This voltage is derived from a divide-by-five counter and digital-to-analog converter. Voltage is changed in steps by the initiating pulses applied to the counter.

The pulse amplitude required to operate the first trigger in the lowest step setting must correspond to radiation of 14 A wavelength and the amplitude required to operate

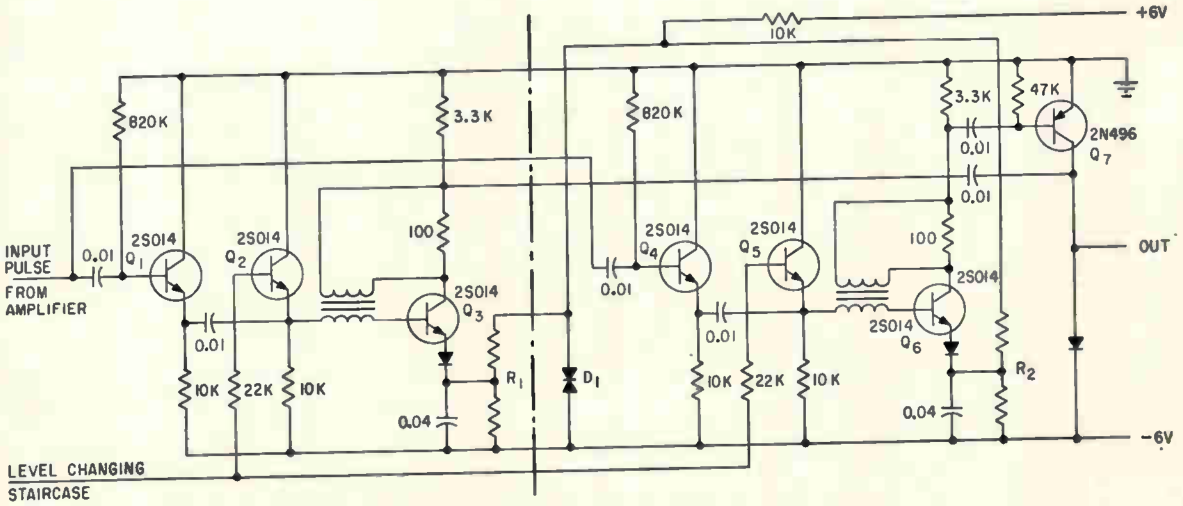


FIG. 2—Pulse height discriminator circuit selects a range of pulses from gas counter

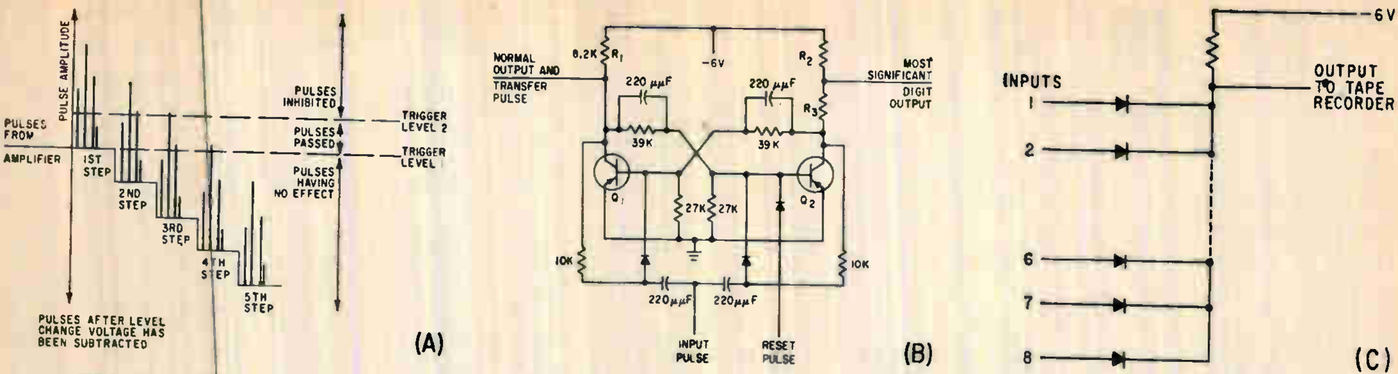


FIG. 3—Full range of wavelengths is divided into five steps. Discriminator determines pulses inhibited, pulses passed, and pulses having no effect (A); typical binary stage of counter is planned to economize in current (B); and most significant digit readout gate (C)

the second trigger in the highest step setting must correspond to radiation of 4 A

By determining the pulse amplitude for these conditions, the amplifier gain can be calculated. This turns out to be about 72 db.

The pulse amplifier is driven from a gas tube that provides a current pulse of about 0.5μa, and is required to work into the pulse discriminator. The gain of the amplifier must be stable over a wide range of temperatures and supply voltage. To attain this, the amplifier comprises three transistor pairs. Each pair has a large amount of feedback for final temperature stabilization. The feedback loop in the last pair includes a thermistor as a temperature-sensitive element. The coupling time-constants are made relatively short to minimize low-frequency noise.

Frequency response of the amplifier must be good, as the input is a random pulse of about 1/2 μsec width. However, the frequency problem is simplified because the gas tube gives a pulse shape that is inherently constant.

High stability and linearity is essential in the discriminator circuit. The rest of the equipment handles pulse signals in binary form and so stability is no longer important. The average rate of the pulses produced by the pulse height discriminator is measured by opening the timing gate for a fixed time and counting the pulses passed in a 15-register binary counter.

Figure 1 shows this timing gate as a separate unit, but in practice the timing signal (or more strictly the complement of it) is applied as an additional inhibit signal to the gate in the pulse height discriminator. Thus this gate is always held closed except for the required timing period.

In designing the binary counter, the power consumed must be low, therefore the stages are graded. Low speeds stages can have higher resistance collector loads and work at much lower currents than the high-speed stages.

The circuit problems introduced by operating at low currents are mainly due to reduction in gain, so transistors with inherently better performance than would be normally required are chosen to allow for degradation. Conventional circuits are possible in the 15-stage counter. A typical stage is shown in Fig. 3B. To economize in current, only the first three stages operate with relatively high collector currents, R_1 and $R_2 + R_3$ are 5,600 ohms; and Q_1 and Q_2, 2N496 transistors. Subsequent stages have increasing values of collector load and OC201 transistors can be used. It is possible to operate the 8th stage and all others with 22,000-ohm collectors.

With low-current operation, the signal currents are comparable with the leakage current. Compensation against changes of leakage current normally consumes a lot of power, so silicon transistors were chosen because of their low leakage current, even though germanium devices can operate over the required temperature range.

Two types of output are taken from the counter. The first is a straightforward 15-bit parallel binary output encoded by the telemetry for direct transmission. The second output is an analog signal that indicates the most significant digit in the counter; this gives bandwidth compression to allow information to be stored in a tape recorder of lower signal capacity.

Figure 3B shows a secondary output taken from the collector of Q_2. This does not give the full voltage swing of the binary. In the 0 state, Q_2 is cut off so the auxiliary output will indicate the supply voltage, but in the 1 state it will indicate a negative voltage depending on the ratio of R_2 and R_3. This voltage is arranged to coincide with the significance of the stage, the most significant stage giving the largest swing and consequently the most positive output voltage in the 1 state. All these outputs are combined in a simple diode AND gate which gives an output voltage equivalent to the most positive input signal present (see Fig. 3C).

Only the last stages have this output because of the high accuracy required to resolve more than eight levels of voltage out of the gate. With this, system compression is attained at the expense of accuracy, but the wide dynamic range of the counter is maintained.

The subminiature components are arranged on printed-circuit boards. Each board is 5½-in. diam. disk to be accommodated in a cylindrical instrumentation container.

The author recognizes the collaboration of R. I. Evans, M. Griffiths and A. F. Spiller of Bristol Aircraft Limited GW Engineering Department, in the design and development of this equipment.

A full paper on this x-ray spectrometer was presented at the British Institution of Radio Engineers, 1961 Convention on Radio Techniques and Space Research, held at the University of Oxford, July 5 to 9.

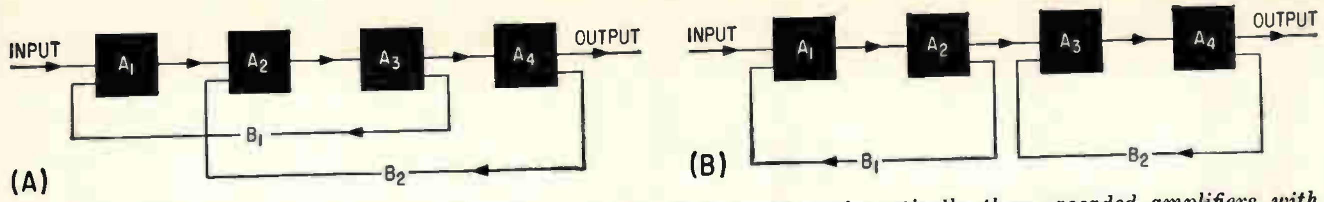


FIG. 1—Interconnected feedback loops (A) are more difficult to treat mathematically than cascaded amplifiers with separate feedback loops (B)

GAIN-STABILITY CALCULATIONS FOR Production Feedback-Amplifiers

Open loop gain from amplifier-to-amplifier in a production run may vary by as much as fifty percent owing to differences in components and supply voltages. This article discusses methods of anchoring the loop gain to within specified limits, using specific amounts of feedback

By A. M. MORGAN VOYCE, System Design Engineer, General Electric Co., Syracuse, N. Y.

WITH THE increasing use of amplifiers as precision devices, the prediction of their gain stability is important to both designers and amplifier end-users. This article describes in detail a method of calculating amplifier gain-stability that is based upon the ratio of closed to open loop gain: a method useful in designing and analyzing the behavior of both solid-state and vacuum-tube amplifiers.

Use of negative feedback to stabilize the gain of an amplifier is described in the equation

$$A_E = \frac{A_L}{(1 - BA_L)} \tag{1}$$

where A_E is the closed loop gain, A_L is the open loop gain, and B is the fraction of output fed back to the input. Factor B is designated a negative quantity since it opposes the input.

Equation 1 shows that as A_L approaches infinity, the value of A_E approaches $1/B$ and consequently the amplifier gain becomes substantially independent of the amplifying elements. In any practical case there is a limit to the value of A_L/A_E that is set by gain-bandwidth considerations, by the Nyquist stability criterion, and by input-output phase relationship of the circuit. There are two distinct methods of overcoming these limitations: interconnected feedback loops (Fig. 1A) and cascaded amplifiers with separate feedback loops (Fig. 1B). The second method is easier to treat mathematically and is therefore more commonly used. Use of voltage or current-derived negative-feedback to improve gain stability can be described as follows:

$$S = (\bar{A}_E - A_E)/A_E \tag{2}$$

where S is the amplifier gain stability, A_E is the required amplifier gain (the closed-loop gain), and $\bar{A}_E$ is the variation in gain from all causes.

The ideal amplifier with perfect gain stability meets the condition $\bar{A}_E = A_E$ (actual gain equals the required gain), so that $S = 0$ error. Since Eq. 2 and 3 may have negative or positive values corresponding to negative or positive gain errors, the gain may be more or less than the required value.

Let the variations in amplifier open-loop gain A_L be described θA_L, where θ is an independent variable between the limits of 0 and ∞. Furthermore, let

$$K = \frac{A_L}{A_E} \tag{4}$$

then $A_L = KA_E$ and Eq. 1 may be written as

$$A_E = \frac{K A_E}{(1 + B K A_E)} \tag{5}$$

and further development yields

$$\bar{A}_E = \frac{K A_E \theta}{1 + B K A_E \theta} \tag{6}$$

It is then possible to substitute the new expressions for $\bar{A}_E$ and A_E in Eq. 2 to get

$$S = \frac{\theta - 1}{1 + B K A_E \theta} \tag{7}$$

From Eq. 1 $B = (A_L - A_E)/(A_L A_E)$ but $A_L = KA_E$ so that

$$B = (K - 1)/K A_E \tag{8}$$

and substituting this value for B in Eq. 7 and ex-

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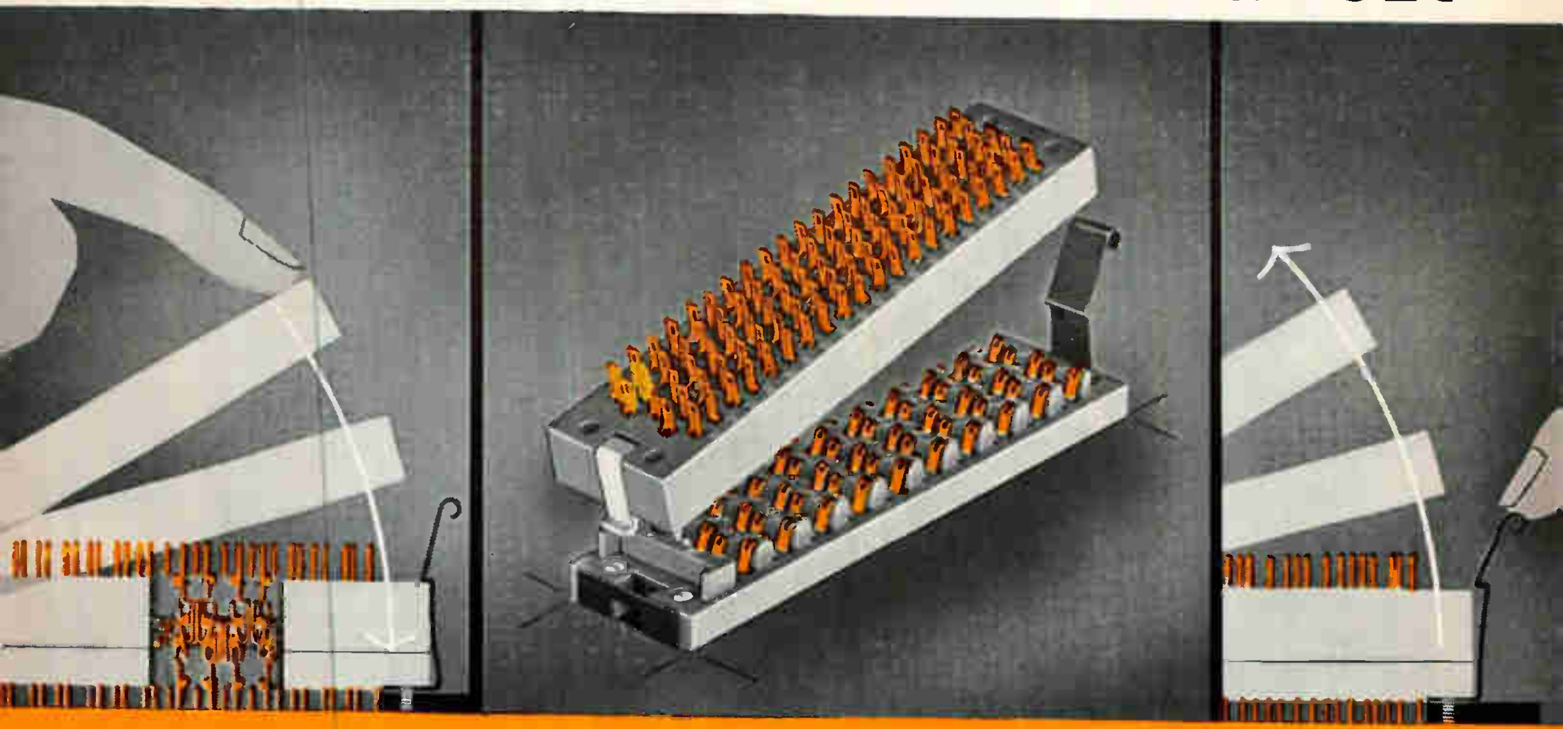

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DOT A DIVISION OF UNITED-CARR FASTENER CORPORATION, BOSTON, MASSACHUSETTS pressing S as a percentage gain change, then

$$S\% = \frac{100\,(\theta - 1)}{1 + (K - 1)\,\theta} \tag{9}$$

Equation 9 is displayed in Fig. 2, with S percent as a function of θ for various values of K. The straight line $K = 1$ is included to represent an amplifier without negative feedback for providing gain stability.

Equation 9, in cartesian coordinates, has the properties: For $\theta > 1$, the curve is in the first quadrant and has an asymptote which is a function of K. For $\theta < 1$, the curve is in the third quadrant making S, the percentage error, negative. The slope of the curve is also greater where $\theta < 1$.

It is also interesting to calculate the value of loop gain for a desired value of gain stability. Rearranging Eq. 9 gives

$$K = \frac{100\,(\theta - 1) - \theta S}{\theta S} \tag{10}$$

A further important property of Eq. 9 is demonstrated in Fig. 2. The curve is asymmetrically distributed about its real origin ($S = 0\%$ and $K = 1$), so that gain errors are not symmetrically distributed about the actual mean value of gain. The error is thus greater for negative than positive values of θ.

Maximum negative error, for any value of K is -100 percent and corresponds to complete loss of loop gain. The maximum positive error however is asymptotic to a value determined by K.

Use of these equations is demonstrated in the following two examples

An amplifier is required to produce a closed-loop gain of twenty with a maximum error of ± 5 percent. During operational periods the open-loop gain may vary by as much as ± 50 percent; what value of loop gain is required to achieve the required gain stability?

In this example, $A_B = 20$, $\theta_1 = +50$ percent $= 1.5$, $\theta_2 = -50$ percent $= 0.5$ and $S = \pm 5$ percent. Thus, for θ_1

$$K = \frac{100\,(1.5 - 1) - (1.5 \times 5)}{1.5 \times 5}$$

Therefore $K = 5.7$. And since $A_L = KA_B$, $A_L = 5.7 \times 20 = 114$. To find θ_2

$$K = \frac{100\,(0.5 - 1) - (0.5 \times 5)}{0.5 \times 5}$$

Therefore $K = -21$.

The negative sign indicates that S is negative so that K can be treated as a positive number. $A_L = KA_E$, hence $A_L = 21 \times 20 = 420$.

The amplifier design is therefore based on the larger value of $A_L = 420$. In operation, the amplifier loop gain can be permitted to vary between the limits of ± 50 percent, resulting in a change in amplification between the limits of 420 ± 50 percent, or 210 to 630 times. The actual amplifier gain, which is preset by negative feedback to produce a gain of 20, will then only vary between the limits of approximately 19.1 and 20.35.

In a second example, a precision amplifier is to be manufactured on a production-line basis, having a

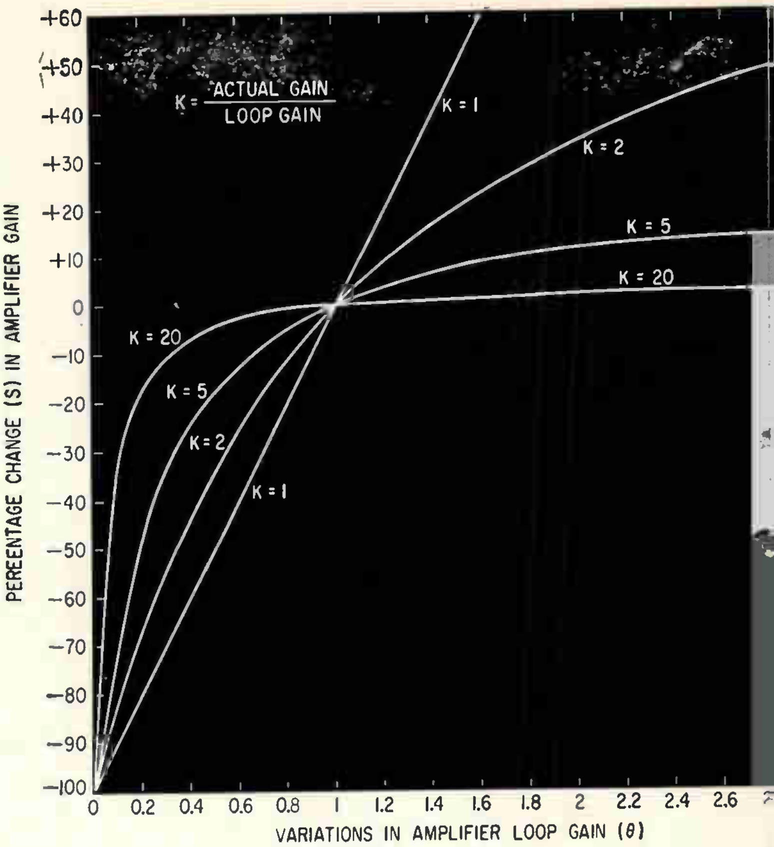


FIG. 2—Stability S is the proportionate change in closed-loop gain brought about by variations θA_L in open-loop gain. Stability against θ is plotted for several different values of K; gain error is greater for negative than positive values of θ

loop gain of 1,500 that is reduced by a single loop of negative feedback to an effective gain of 100. Tolerance limits, from amplifier to amplifier, show differences in loop gain of ± 20 percent (values of A_L between the limits of 1,800 and 1,200). What gain-limits can be expected in production on a sample-to-sample basis?

In this example $A_B = 100$, $\theta_1 = +20$ percent $= 1.2$, $\theta_2 = -20$ percent $= 0.8$, $A_L = 1{,}500$, and $K = 15$.

$$\text{Calculating } \theta_1,\ S \text{ percent} = \frac{1.2 - 1}{1 + (15 - 1)\,1.2}$$

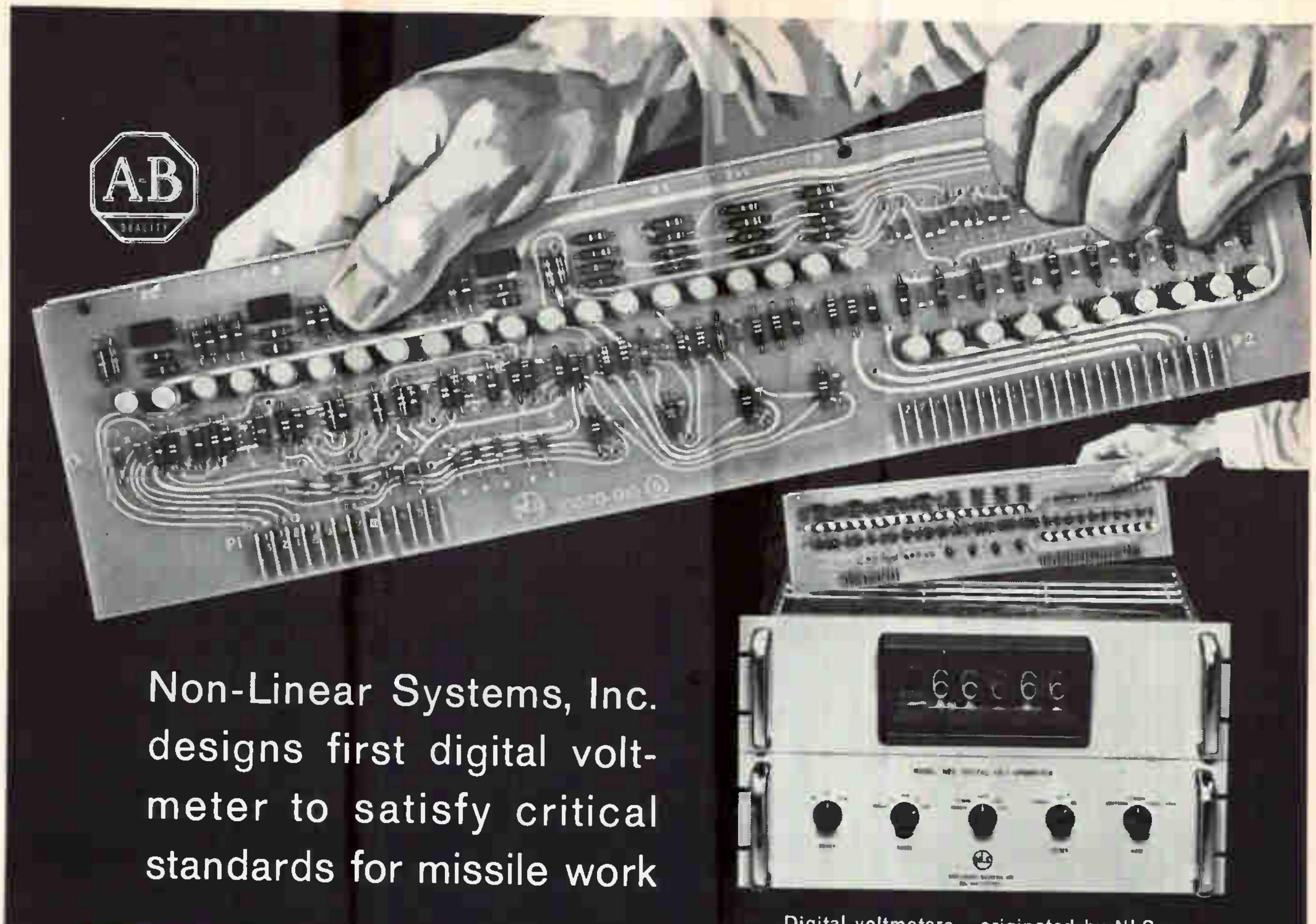
$$= +\,1.2 \text{ percent}$$

$$\text{And for } \theta_2,\ S \text{ percent} = \frac{0.8 - 1}{1 + (15 - 1)\,0.8}$$

$$= -\,1.64 \text{ percent}$$

On a sample-to-sample basis, amplifier gains may therefore be expected to vary between the limits of -1.64 percent to $+1.2$ percent corresponding to amplification factors between the limits of 99.36 to 101.26. Note that the centroid of the limits yield a probable gain of approximately 100.22. If the amplifier samples have a tolerance distribution with a normal Gaussian law then they may be described as possessing a gain of 100.22 with a probable error of the order of ± 1.42 percent, if treated on a statistical basis.

The asymmetric nature of the gain stability equation is demonstrated in the above examples.



Non-Linear Systems, Inc. designs first digital voltmeter to satisfy critical standards for missile work

Digital voltmeters—originated by NLS—permit rapid and accurate voltage measurements. New Series 20 unit—with one plug-in decade board removed—shows the use of Allen-Bradley fixed resistors.

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To satisfy the high standards of consistent accuracy and reliability demanded for missile and weapons checkout, Non-Linear Systems, Inc., developed this digital voltmeter. It uses scores of Allen-Bradley fixed resistors. (For example, the latest Series 20 unit, shown above, contains about 1,000 in each instrument.) "In the selection of A-B resistors," says NLS, "quality and availability have never been a problem."

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CIRCLE 61 ON READER SERVICE CARD

Single Compactron Adapts Receiver for Stereo

By LEO DILLON, Receiving Tube Dept., General Electric Co., Owensboro, Ky.

EXPERIMENTAL compactron has been incorporated into a circuit originally designed for conventional tubes and diodes. The multi-function device is used in a circuit to adapt f-m receivers for stereophonic broadcasts. The only modification to the circuit was changing the value of one component because the compactron had more gain than the tube it replaced.

Although the compactron adaptor is experimental, it demonstrates applicability of these devices to reduce size and complexity of equipment. Because it can perform the functions of two or three tubes, the compactron is expected to lower both material and labor costs. It will probably find use in multiplex converters and new f-m stereo receivers as well as in other equipment.

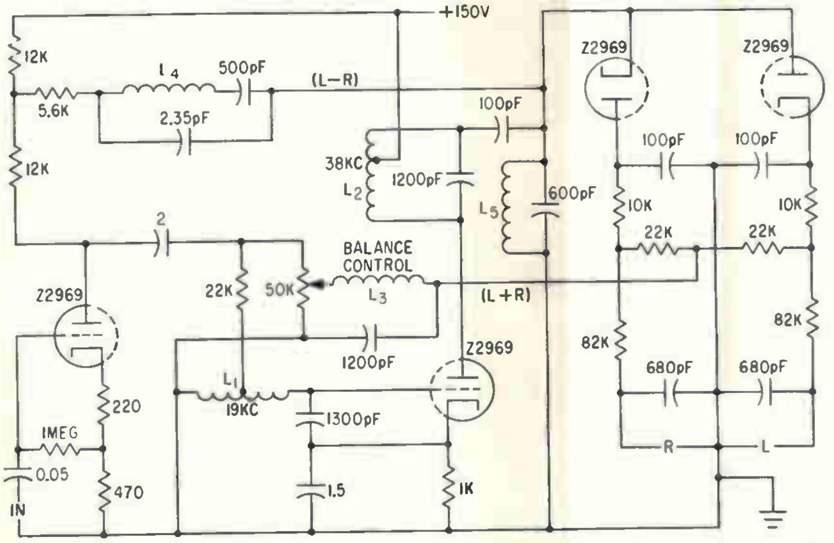
The Z-2969 compactron was under development when the FCC authorized f-m broadcast stations to transmit stereophonic programs. It was used in an adaptor circuit that had already been designed to use a 12AT7 tube and two separate diodes. The Z-2969 contains two similar triodes and two similar diodes.

The composite stereophonic signal contains the normal monophonic signal composed of the left and right signals in the frequency band from 50 to 15,000 cps. A pilot subcarrier at 19,000 cps serves as a control signal for regeneration of the suppressed 3,800-cps subcarrier. The difference of the left and right signals appears as sidebands of the 38-Kc suppressed carrier at frequencies from 23 to 53 Kc ($\pm$15 Kc about the 38-Kc suppressed carrier).

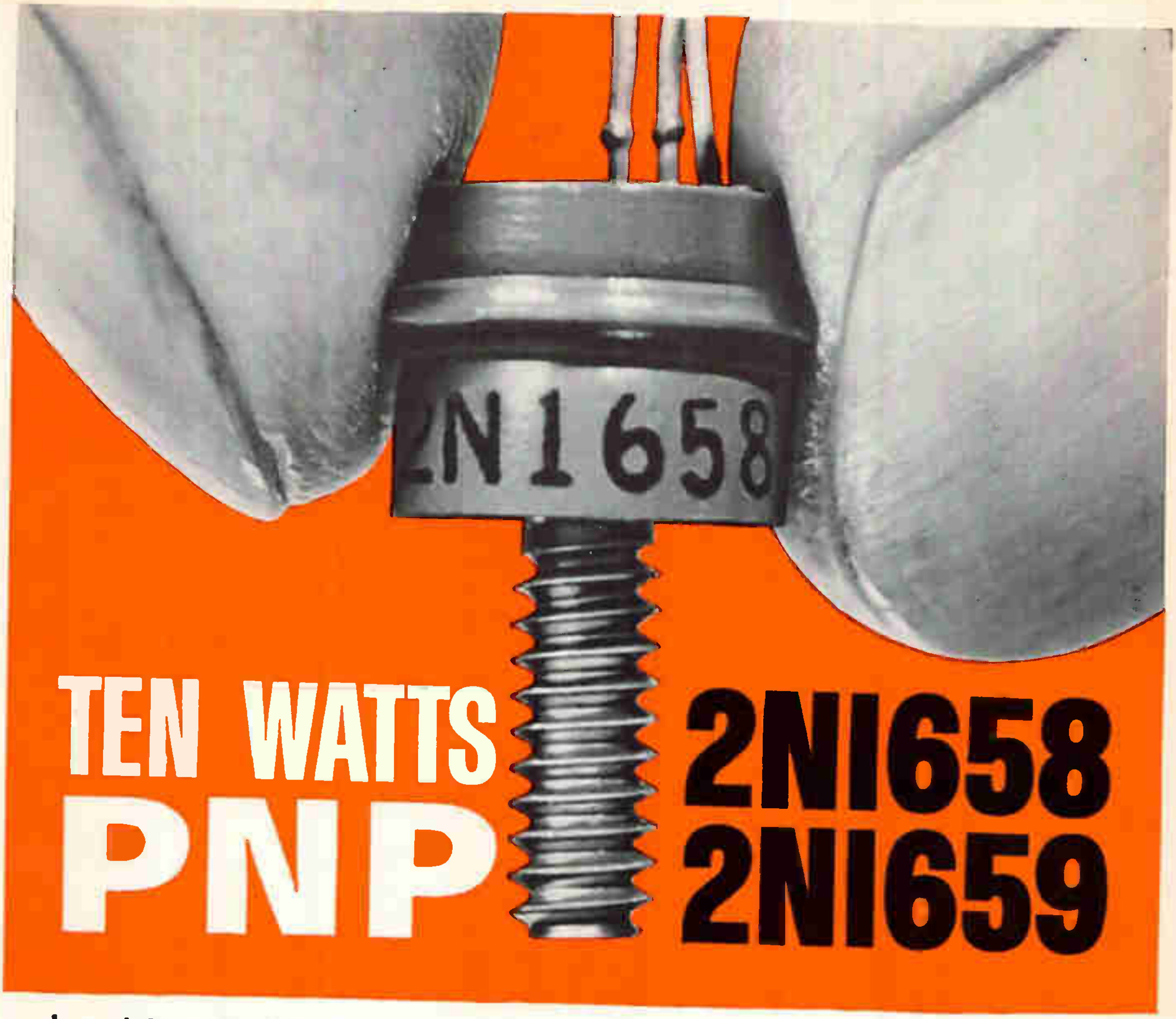
The first stage of the adaptor in the figure is a wideband amplifier. The $(L + R)$ information is applied from the wiper arm of the balance control through a low-pass filter to the matrix circuit. The tuned grid circuit of the other triode section selects the 19-Kc component. Because the plate circuit of this triode is tuned to 38 Kc, it functions as a frequency doubler.

The $L - R$ information is obtained at the junction of the two identical plate load resistors of the first stage. The signal is applied through a bandpass filter and then recombined with its carrier frequency at the output of the doubler to produce a 38-Kc amplitude-modulated signal.

When the 38-Kc signal is applied to the upper diode detector. the $L - R$ information is removed from the positive half of the subcarrier envelope. The detected signal combined with the $L + R$ information in the matrix circuit provides the left output signal. The other diode removes a signal from the negative half of the carrier envelope, which is 180 degrees out of phase with the $L - R$ information. This signal is $-(L - R)$ or $-L + R$ and when combined with the $L + R$ information in the matrix provides the right output



Compactron shown in the photograph performs the functions of two triodes and two diodes in circuit to adapt f-m receivers for stereo



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signal. De-emphasis in each output channel is provided by the series resistors and shunt capacitors.

The only problem encountered in using the Z-2969 was oscillation in the doubler. Voltage developed at the cathode capacitor provides a small amount of positive feedback to the grid. Transconductance in the Z-2969 is about 20 percent greater and plate resistance about 40 percent less than in the 12AT7 triodes, which results in higher gain in the compactron. The problem was easily corrected by increasing cathode bypass capacitance to the value shown in the figure.

To align the adaptor, a signal generator is recommended that can produce a 19-Kc pilot tone and the composite stereophonic signal. With the $L + R$ balance control set at minimum separation, L_1 and L_2 are set for maximum carrier level at either the left or right output jack. With a left-only composite signal applied, the balance control is then set for maximum separation. Readjustment of L_1 may be required for optimum phasing of the reinserted subcarrier. The best settings for both the balance control and L_1 are when channel separation is maximum and distortion is minimum.

Insertion loss of the compactron adaptor is about 6 db. No additional voltage amplification is required if preamplifier gain is sufficiently above that required for monophonic reception to compensate the loss. Channel separation at 1,000 cps is 25 db.

Heartbeat Monitor May Reduce Infant Mortality

FETAL MONITOR indicates heartbeat of a baby several hours before birth. It can provide visual indications and permanent records as well as providing warning signals in the event of fetal distress.

The fetal heart monitor was developed by a team of doctors at Marion County General Hospital and Indiana University Medical Center in Indianapolis. It is hoped that the instrument can reduce the annual stillborn and infant mortality loss of 162,000 lives, which accounts for more than 10 percent of all deaths in the U. S.

The primary factor leading to infant deaths is fetal anoxia—insufficient oxygen during birth. Fetal anoxia is also the primary cause of cerebral palsy or mental deficiency or both in children who survive the anoxic episode.

The instrument provides constant visual and audible monitoring of fetal heartbeat during labor and delivery. It alerts medical personnel to any irregularity in the heartbeat and to heartbeat rates below the dangerous level of 100 beats per minute or above 180 beats per minute.

Fetal heartbeat is conventionally monitored with a stethoscope. However, problems such as interference, loss of sound during contractions (when trouble is likely to occur) or masking of the fetal signal by the maternal heartbeat all limit the usefulness of the stethoscope method.

The heart monitor is about the size of a portable tv receiver. In the early stages of labor, electrodes are attached to the body of the mother and to the fetus, which is still in the womb. Signals from the electrodes are displayed on a crt, and heartbeat rate is indicated on a meter. The signal can also be amplified for audible monitoring, and it can be recorded on a standard electrocardiograph.

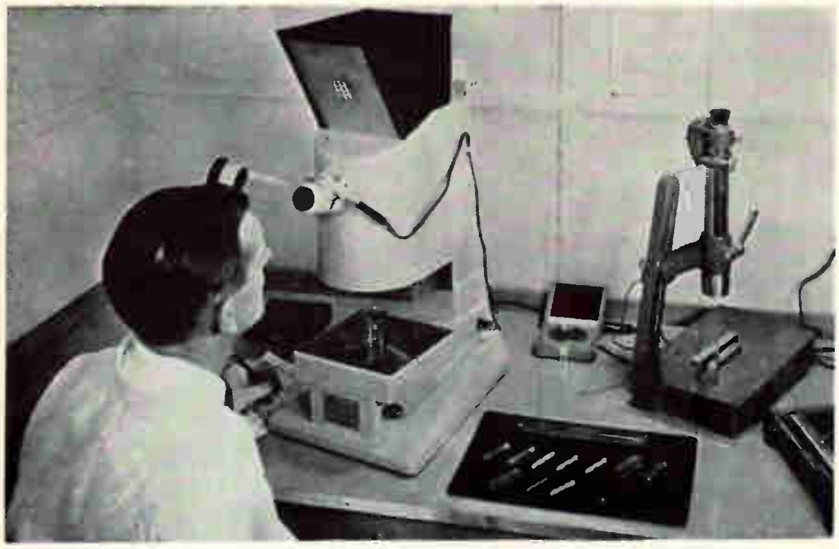
Common birth hazards that might cause the monitor to flash a warning include the cord becoming wrapped around the neck of the baby or the placenta separating from the uterine wall. Both of these conditions can impede the supply of oxygen. They or a number of less common hazards may go undetected long enough to result in death or brain damage. By alerting medical personnel of fetal distress at its onset, they can intervene with the indicated medical procedure, such as oxygen therapy, forceps or a Ceasarian delivery.

The monitor has been used successfully in well over 100 deliveries. As well as routine deliveries, it has been used in several cases of anoxia and once to monitor the delivery of twins both by breech birth.

The research model of the monitor was packaged into a portable unit by Hemathermatrol Corp., and additional units are being produced for observation and use at other medical centers.

CIRCLE 65 ON READER SERVICE CARD

Listing Specs for Optical Quality Ruby



Interference fringes on the optical-interferometer screen check the end faces of a ruby rod for flatness within 1/20 of a sodium wavelength. Instrument at right checks parallelism of end faces to within 1 second of arc. On table are ruby rods and three rough cuts from ruby disc boules

By NELSON B. PIPER, JR.,
Valpey Crystal Corp., Holliston, Mass.

OF THE SOLID-STATE laser materials which have been considered or are presently being developed, synthetic ruby (Cr_2O_3:Al_2O_3) has been the most prominent. (See ELECTRONICS, May 5, 1961, p 88; Aug. 4, 1961, p 62).

Over 90 percent of all ruby rods fabricated to date have been under three-in. length and under ⅜-in. diam. This size range is compatible with the power presently available from most light pumping sources and with the crystal growing techniques of the major domestic supplier of laser-quality synthetic ruby boules. However, larger boule sizes up to 8-in. length and ¾-in. diam. are available.

Nearly 70 percent of all ruby rods fabricated by Valpey have been doped with 0.05-per cent weight CR_2O_3:Al_2O_3 and were oriented such that the optical axis C-axis of the ruby crystal was parallel to the rod axis (0-deg. orientation).

A concentration of 0.05-percent Cr_2O_3 doping appears to be optium. However, other concentrations are being tried to study the effects of doping on the operation of the rod.

Rods oriented to 0 deg display a circularly or elliptically polarized beam whereas a 90-deg oriented rod (C-axis perpendicular to rod axis) display a beam that is definitely polarized in one direction.

When comparing the 0 deg and 90-deg oriented rods for their temperature-vs-threshold characteristics, it is found that the slope of the 0-deg rod is much steeper. Thus, the 0-deg rod is the best choice for operation at liquid-gas temperature and the 90-deg rod is a better choice for room temperature operation.

New growth techniques have helped lower the input power required to stimulate laser action in ruby.

Lower input energy minimizes internal heating in the ruby, thus resulting in a slower rate of threshold rise with time. Originally available, from both American and foreign sources, to the precision fabricator of ruby rods was the conventional ruby boule which displayed optical action at relatively high levels of input energy. American sources now supply ruby-disc boules and sapphire overlays which have been developed specifically for optical applications. The ruby-disc boule yields both 0-deg and 90-deg rods of low strain, low linage (deviation of the crystal's axis) ruby.

Crystal growth developments have now yielded ruby which has lowered input energy levels greatly.

Slow growing of ruby does not necessarily yield a low-strain low-linage material. There is however an optimum growth rate. One important factor affecting strain and linage is the temperature differentials between furnace walls and the ruby-disc boule being grown within the furnace. Temperature gradients within the ruby-disc boule itself must also be controlled closely.

A ruby-disc boule would require no annealing if it were grown under ideal conditions.

A ruby rod with a sapphire overlay has yielded optical action with inputs of only 50 to 80 joules. Basically, the sapphire overlay is a sheath of sapphire which encircles the body of the ruby rod over its entire length.

The sapphire overlay helps focus the pumping light so that its intensity is increased in the center area where it most easily induces optical action. The pumping light which passes through the sapphire wall to the ruby rod in the center is not absorbed and released as heat to the same extent that it would if the rod were solid ruby of the same diameter as the outside diameter of the sapphire overlay. This effect reduces the internal heating, thus helping to maintain a lower threshold level for a longer period of time.

The sapphire overlay effectively increases the conduction cooling area of the composite rod and readily dissipates heat since it is an excellent heat conductor at low temperatures. The overlay also makes it less likely that insulating bubbles form on the crystal's surface.

One type of sapphire overlay is built to the desired thickness on the

jolly well adaptable to temperature extremes!

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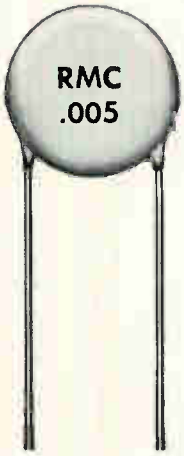

Type JL DISCAPS are engineered for applications where capacitors must exhibit minimum capacity change over wide variance in temperature. Between $-60°$ and $+110°$ C Capacity change is only $\pm 7.5\%$ of capacity at 25° C. Type JL DISCAPS are rated at 1000 V.D.C. and are available with capacity tolerances of $\pm 10\%$ or $\pm 20\%$ at 25° C. Write on your letterhead for information on these and other high quality DISCAPS.

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RMC

RADIO MATERIALS COMPANY
A DIVISION OF P. R. MALLORY & CO., INC.
GENERAL OFFICE: 4242 W. Bryn Mawr Ave., Chicago 46, Ill.
Two RMC Plants Devoted Exclusively to Ceramic Capacitors
FACTORIES AT CHICAGO, ILL. AND ATTICA, IND.

ruby rod by a newly-developed crystal-growth technique. A second type is a sapphire rod that is drilled lengthwise and given an optically-polished inner diameter. The outer diameter of the ruby rod is optically polished until a tight piston fit into the sapphire cylinder is obtained. The second type is used where larger rod sizes (1½ to 3 in. length) are required.

When listing specifications for a ruby rod, it is not enough to state merely that the rod must exhibit laser action. Factors which must be as clearly spelled out as the characteristics of the ruby are details pertaining to orientation, fabrication, tolerances, and surface finish.

To obtain good operating characteristics from a circular ruby rod having flat parallel ends, the following specifications should be considered a minimum: C-axis orientation to within 10 min of arc; end faces polished flat to 1/10 wavelength of sodium light; end faces parallel to 2 sec of arc; length tolerance ±0.005 in.; diameter tolerance ±0.001 in.; ±1 min of arc tolerance on 90-deg angle between end faces and cylindrical surface.

The finish on the rod's body should be specified as either fine ground or clear polished, depending upon the configuration of the pumping light source and its associated optics.

Size of the ruby rod, within limits, and whether the rod is to be square or circular in cross section, is largely dependent on the input power of the light pump, holder design for the rod, cooling techniques, if any, and the associated optics of the pump.

Recent tests were performed on ruby by C. F. Luck, Jr. of Raytheon Company to determine the threshold, polarization effects and beam widths as a function of flatness and parallelism. Three rubies, 2½ in length by ¼ in. diameter, identical in every respect except the controlled deviations were fabricated and then given identical end coatings of silver.

Threshold measurements were made by observing the spiking phenomenon in the output. The voltage applied to the capacitor bank was gradually reduced until only two spikes were observed. This voltage was used to calculate the input

RUBY CHARACTERISTICS AFFECTING OPERATION

Ruby Under Test	A[a]	B[b]	C[c]
Flatness	λ/10	1.0/λ	λ/10
Parallelism (sec)	2	1	15
Relative Threshold	1.00	1.08	1.19
Total Beam Angle (sec) (±2 sec)	19	31	18

a— C-axis orientation of rubies A, B, and C was 0 deg

threshold. The laser used was an experimental version of the Raytheon LH-1. (Laser Head)

The Table shows that flatness directly affects the beam width and that parallelism has considerable effect on the threshold level. Further studies are being made to determine other effects.

Throughout the cutting, grinding and polishing operations measurements of the important parameters must be performed continually. An x-ray diffractometer checks orientation; an interferometer checks flatness; and an autocollimator measures parallelism.

In addition to ruby rods having flat and parallel ends, other configurations and materials have been manufactured or suggested

New Magnet Material For Traveling Wave Tubes

MAGNETIC PROPERTIES of a new permanent magnet material, now being produced by Indiana Steel Products Division of Indiana General Corp., makes it well suited for periodic focusing of traveling wave tubes.

The material, Alnico VIII, has the highest coercive force (Hc) of all the Alnicos, 1,400 oersteds. This is combined with a low temperature coefficient.

With an energy product of 4.2 million, the newest Alnico is also expected to open up design opportunities in other types of equipment, particularly in applications where very short magnet lengths are desired.

High-Density Circuits Use Honeycombs

By CHARLES W. JOHNSON,
Sperry Gyroscope Co.,
Div. of Sperry Rand Corp.
Great Neck, New York

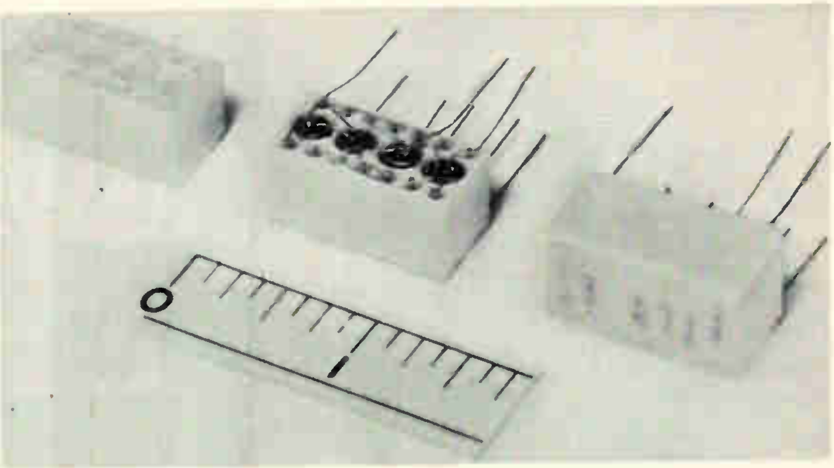
HONEYCOMB ELECTRONIC packaging uses a pre-drilled or cast metal or plastic honeycomb into which the components are inserted. Capacitor discharge welding is used to interconnect component loads on opposing surfaces. After testing, vacuum encapsulation seals the unit. If the encapsulating material is one of the new low temperature curing silicon resins, the final unit may be repaired by adding more resin in the repaired area and curing to a solid mass.

Each component is accessible for insertion, change, or repair, and can be placed in the honeycomb just before welding, thereby eliminating the large cluster of leads that often interfere with the welding electrodes and increase the chances of wrong connections. The honeycomb is essentially a small lightweight jig, which becomes a part of the finished module.

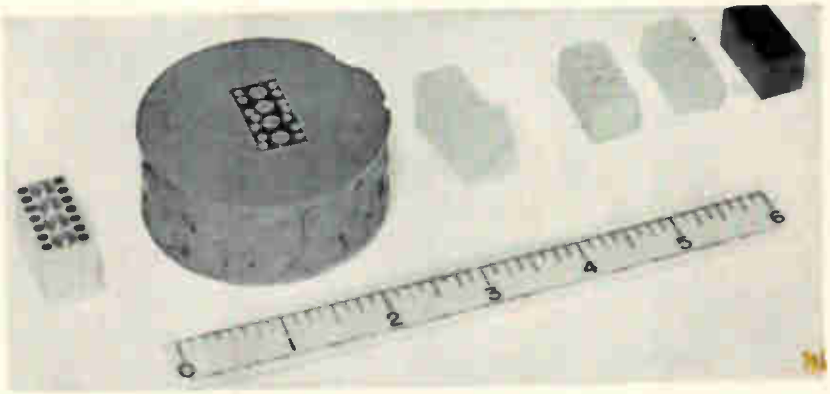
Since the majority of dielectric is in place before final encapsulation, there is a minimal change of distributed capacity caused by this step. If any voids remain after vacuum encapsulation, the resultant loss of heat sinking is proportionally much less than if an entire component were encased in a bubble of air.

Highly filled thermally conductive resins can be used for the honeycomb since voids in the cast or drilled units can be detected beforehand. Thus the reliability of the heat sinking mechanism is improved.

Components are precisely positioned in the honeycomb so there in negligible variations of intercomponent capacity from unit to unit. Feed-through wires can be cast in the honeycomb block and grooves for interconnecting wires can be cast in the surface, allowing cross-overs without shorting and without increasing the overall dimensions of the module.



Components are placed in cast epoxy mold, are welded, then receive final vacuum encapsulation



Aluminum master mold with counterbored holes is used to form a pattern in room-temperature-curing silicone rubber. Room-temperature-curing epoxies, color coded and highly filled for good heat transfer, are cast from the self-releasing rubber mold

Anodized aluminum honeycomb blocks can be used for difficult thermal dissipation problems. Hybridized circuits of sub-miniature standard components and solid state devices are readily handled in the same honeycomb package. After the circuit has been determined, cardboard cutouts (usually 10:1 scale) are fabricated and a layout is made for highest packaging density. Preferably, the higher heat generating components are placed at the corners for maximum heat dissipation.

After the final layout is dimensioned, the aluminum master honeycomb is machined. Counterbored holes give extra strength to the honeycomb and also trap the components in place during insertion and welding. This method permits minimum tangential separations as low as 0.002 inch.

The machined master is then cast in a room-temperature-curing silicone rubber, such as RTV-60, to produce a self-releasing mold from which color-coded epoxy honeycombs are cast.

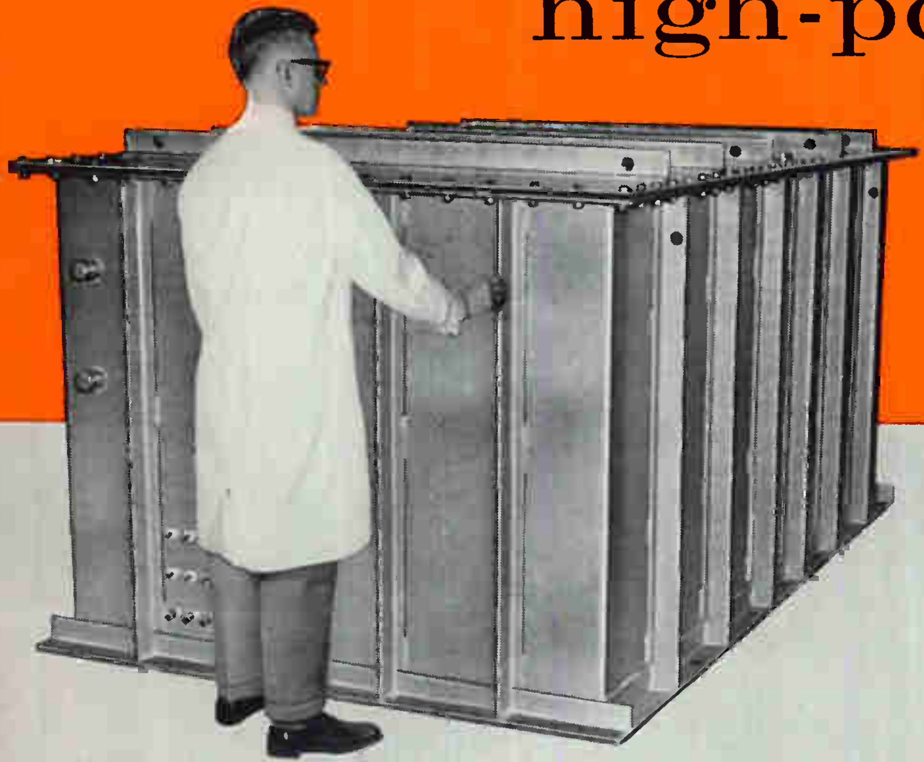
During honeycomb fabrication a series of wiring diagrams are produced for assembling and welding. Typical welding parameters are three to ten pounds electrode force

RAYTHEON TRANSFORMER TALK

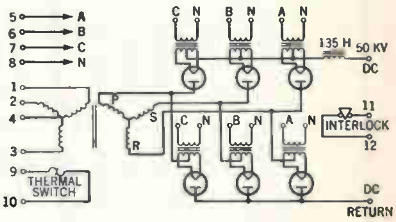
Facts about transformers that have solved equipment design problems • No. 5 in a series.

Power supply for high-power radar

...designed in 1 week delivered in 6 weeks



2½ TON POWER SUPPLY delivers 52.5 kVA, is insulated for 70kV and is capable of withstanding heavy short circuit fault currents.

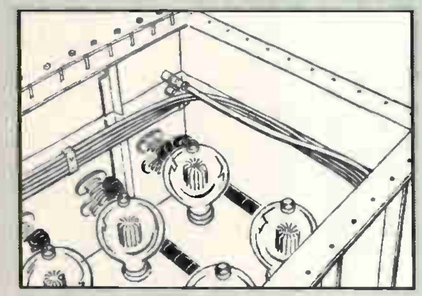


This 52.5 kVA Raytheon power supply was in the field and functioning perfectly just six weeks after the order was received. Actual electrical design work was completed in seven days.

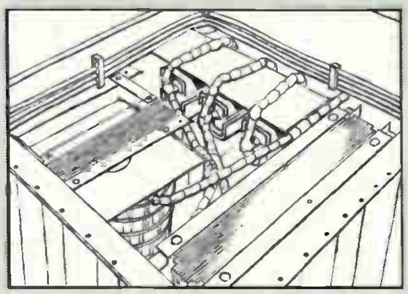
The 2½ ton power supply provides high voltage for a radar modulator in a National Aeronautics and Space Administration System. This three-phase full-wave rectifier supply is capable of emergency operation on single phase which is an unusual feature for a power supply of this size and output.

Raytheon's capability of designing and building high-voltage power supplies can be put to work for you. Write us today for a descriptive folder on the power supply shown here or for a prompt and expert answer to any dc power requirement from 10 to 100 kV. See how Raytheon's unique experience and facilities expedite the *design* and the *construction* of a unit that meets your exact specifications.

Address Magnetics Operation, Microwave & Power Tube Division, Raytheon Company, Waltham 54, Massachusetts



RECTIFIER COMPARTMENT houses six tubes in three-phase circuit. Tubing is for cooling. Entire unit is oil-filled and completely sealed.



MAGNETICS COMPARTMENT—also oil-filled and cooled—includes three-phase plate transformer (lower right), choke (left), and filament transformer stack of six (right).

RAYTHEON

RAYTHEON COMPANY

MICROWAVE AND POWER TUBE DIVISION

CIRCLE 71 ON READER SERVICE CARD

and four to twelve watt-seconds welding energy. All weld areas of the hookup wire are free from bends, thus reducing shorts to the opposing electrode face.

All the welds on a given work sheet employ the same weld schedule, with weld schedules developed by a statistical method.[1]

After all intraconnections are made, the unit is tested statically and dynamically and repaired if necessary.

A final vacuum encapsulation seals the components and a final check is made.

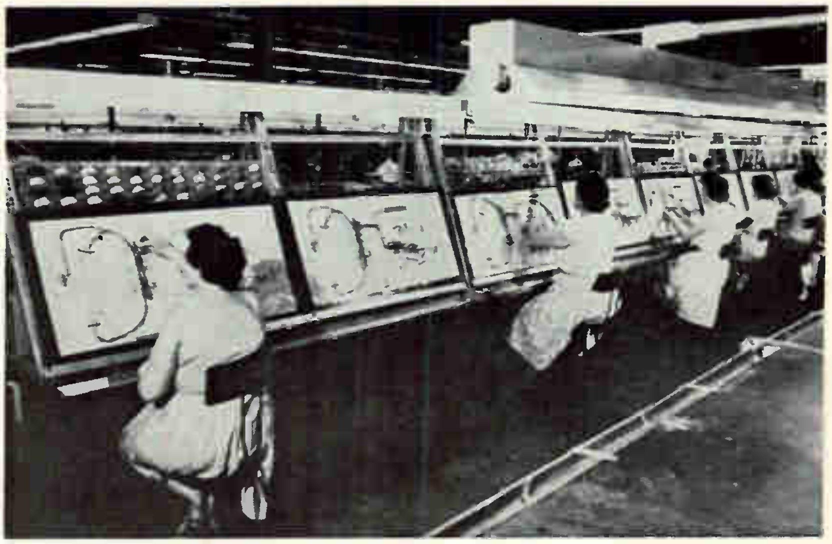
Terminations can be weldable or solderable flying leads, solder terminals, pins, connectors or wire wrap terminals.

The modules can be attached to a chassis with threaded inserts molded in the module, by cementing, by using a retaining plate or by using the lead wires as holding devices.

REFERENCES

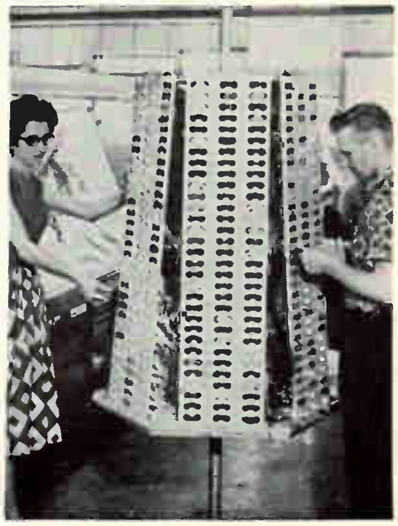
(1) Lloyd D. Armstrong, "Adoption of Welded Electronic Circuits for Missile and Space Vehicles", Presented at Fourth Symposium on Welded Electronic Packaging, Melville, N. Y., March, 1961.

Production Lines for Harness Boards



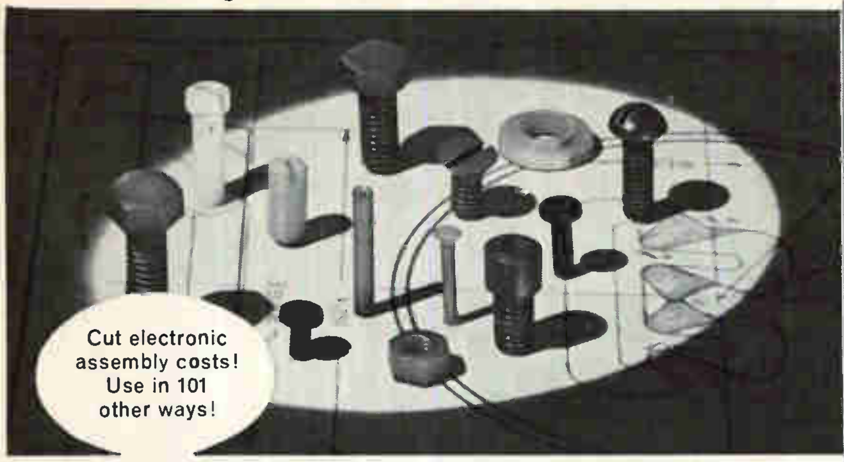
Harness boards are being wired with production line techniques at Pleasantville Instrument Corp, manufacturing subsidiary of General Precision Labs. The technique has produced direct labor savings of approximately 35 percent. Framework to hold the boards is two feet wide by 64 feet long, and can be adjusted to accept boards from 10 × 12 inches to 4 × 8 feet. The line was built by the maintenance department; construction cost, including labor and materials, was approximately $500.

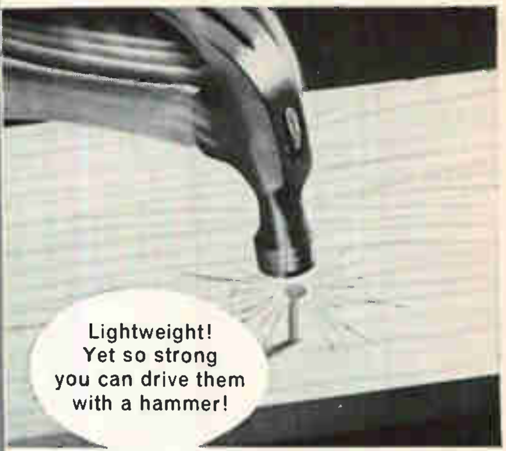
Although harness boards traditionally have been wired from start to finish by the same operator, time studies have shown that it is better to break up the task into 10 or 15 minute work stations. Learning time, in particular, is significantly reduced. As each part of the harness is completed, the board is slid along by hand toward the next sta-



tion. The lazy susan wire holder, photographed at right, is used on the production line to serve two operators. The wire holder, requiring about nine square feet of floor space, replaces a bench that required 32 square feet.

Before you order . . . check NYLO-FAST® FASTENERS!





Have you investigated what NYLO-FAST® Fasteners can do for you? They're colorful, strong—yet 1/6 the weight, chemical resistant, heat resistant, elastic, resilient, and non-conducting! You'll be surprised to discover how many ways NYLO-FAST® Fasteners can serve you—BETTER! Write for complete information.

Immediate delivery from our large stocks which include Nylon, Delrin, Teflon, P.V.C., Lexan, etc. 10 different formulations! Write, wire, or telephone today for the facts!

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METAL PRODUCTS COMPANY, Inc.

CASTLETON-ON-HUDSON 10, NEW YORK

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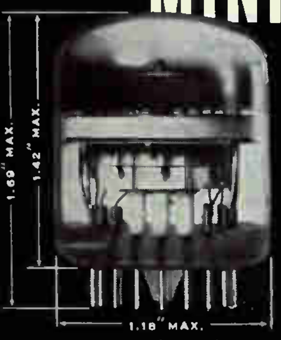
NEW *from Baird-Atomic*

MINIATURIZED COUNTING TUBE

featuring routing guides for simplified bi-directional counting



(ACTUAL SIZE)

DEKATRON® GS10H

- Maximum counting rate sine wave and rectangular pulses... 5,000 p.p.s.
- Maximum anode current . . . 600 μA
- Maximum output at 5 kp/S with a 100 kΩ cathode load resistor and +50 V bias: 35 V
- Access to all ten cathodes

Incorporating a routing-guide system to provide glow direction sensing, this new cold cathode tube reduces the process of multi-stage, reversible, bi-directional counting and selecting to its simplest terms. This means fewer components, resulting in increased reliability and reduced costs. Ruggedly constructed, the GS10H follows the long Dekatron® tradition for reliability and performance.

WRITE FOR THE NEW B/A HANDBOOK OF COUNTING TUBES. PRICE: $1.00

BAIRD-ATOMIC, INC.

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POWER *from*

NICAD NICKEL CADMIUM *Rechargeable Batteries*

SEALED CELLS

DESIGNED FOR

- Low Maintenance Cost
- Instant Efficient Operation
- Durability

NICAD Sealed and Vented Cells make practical the battery operation of many types of equipment not previously suited to dry, mercury, or lead acid types. Capable of sustained or stable voltage over a wide temperature range these NICAD Cells have extremely long life, require little or no maintenance, and are always ready to operate in any position under even the most adverse operating conditions . . . with POWER to spare.

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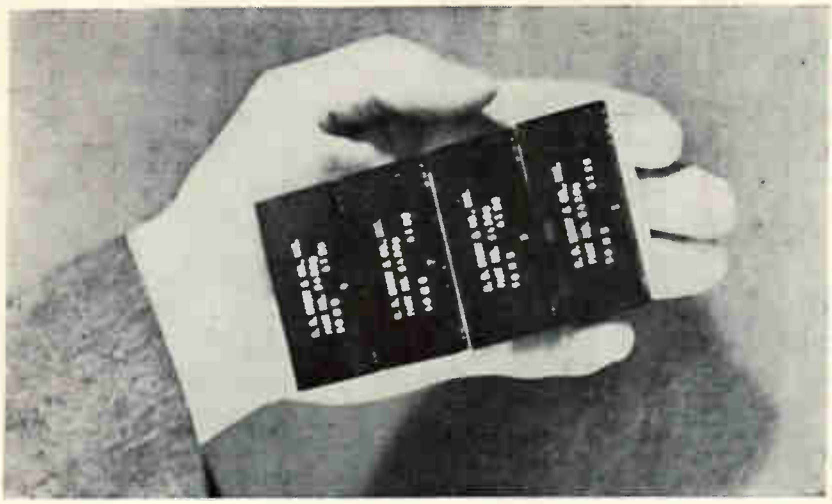
BATTERIES, INC. E-1403 First National Bank Bldg., St. Paul 1, Minn.

NICAD is a trademark of Gould-National Batteries, Inc.

CIRCLE 73 ON READER SERVICE CARD

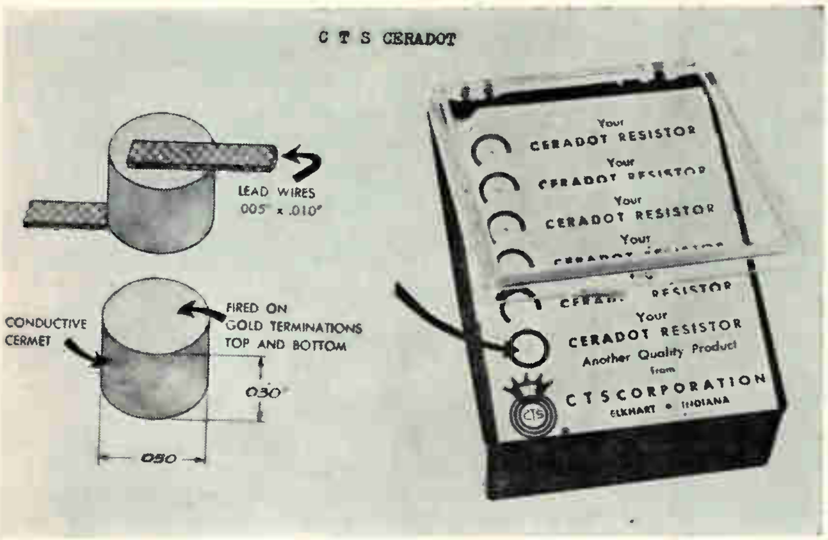
New On The Market



Delay Lines
IN THE NSEC TIME DELAY REGION

RICHARD D. BREW AND CO., INC., Concord, N. H. Nanolines are available in 10 nsec delay increments ranging from 20 to 100 nsec and are epoxy encapsulated. Dimensions are 2.250 by 0.300 by 1.000 in. Delay to rise time ratio ranges from 5 to 1 for the 20 nsec units to greater than 10 to 1 for the 50 to 100 nsec lines. With an impedance of 500 ohms ±10 percent and attenuations less than 0.3 db, the units are suited for use in both breadboard and production models of high reliability apparatus.

CIRCLE 301 ON READER SERVICE CARD



Experimental Resistor Kit
CONTAINS 7 MICROMINIATURE UNITS

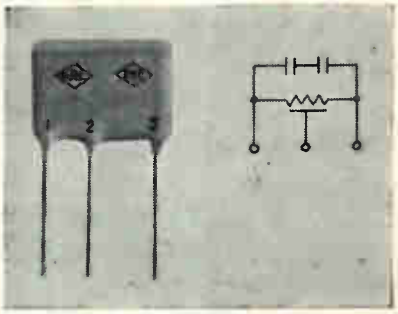
CTS CORP., Elkhart, Ind. An experimenal kit containing 7 microminiature solid cermet (Ceradot) fixed resistors, each with a different resistance value within the range of 250 ohms to 12,000 ohms is offered for $7.00. Each resistor is 0.050 in. diameter by 0.030 in. thick and is without leads. Cermet has inherent high stability and reliability at extreme temperatures and severe environments because it is fired at temperatures over 600 C, producing a rugged hard surface. Gold terminations are fired-on at top and bottom.

CIRCLE 302 ON READER SERVICE CARD

Dielectric Coatings
FOR LASER OSCILLATORS

ADOLPH MELLER CO., Box 6001, Turnkey, Providence, R. I., Dielectric multilayer film able to provide up to 99.9 + percent reflectivity is introduced for use as a reflective coating for laser oscillators. The coating, which can increase output gain between 7 to 1 and 8 to 1, is available on new rods or can be applied to rods already in use. Other advantages include longer life, operation at a lower threshold and negligible absorption. Multilayer coatings can not burn at high energy.

CIRCLE 303 ON READER SERVICE CARD



Multiplex Filters
CUSTOM DESIGNED

CENTRALAB, The Electronics Div. of Globe-Union Inc., 800 East Keefe Ave., Milwaukee 1, Wisc., has available PEC notched T and twin T filters for use in multiplexing circuits. Filters utilize the PEC packaged circuit technique to provide a three lead unit measuring 13/16 in. by 1 3/32 in. that provides 60 db attenuation. Presently, 38 Kc filters are in production but units for other frequencies can be designed. They are available at approximately 20 cents each in quantities of 1,000. Request for samples or additional information should be sent on company letterhead.

Command Receiver

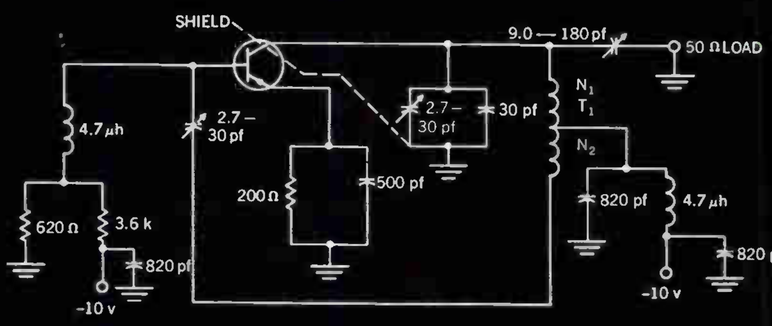
CLEVITE ELECTRONIC COMPONENTS, 3405 Perkins Ave., Cleveland 14, O. New design for a high-altitude balloon command receiver incorporates

DALMESA APPLICATION REPORT NUMBER 1

30 MC OSCILLATOR

CIRCUIT PERFORMANCE CHARACTERISTICS

OSCILLATOR EFFICIENCY	24.7% @ −40°C 22.2% @ +70°C
RF POWER OUT	23.1mw@ −40°C 20.4mw@ +70°C



T_1 #516 AIR DUX OR EQUIVALENT N_1 4 TURNS; N_2 7 TURNS; ALL RESISTOR VALUES ½w 10%

New TI DALMESA Transistors Give IMPROVED HF Oscillator Performance From −40 to +70°C

■ **Solve your industrial communications design problems today with TI's new DALMESA** 2N2188 series. This new germanium alloy diffused mesa transistor family is specifically designed to meet your requirements for high-performance, low-noise, economically-priced transistors for application over the entire communications band from dc to 150 mc. ■ The **extremely low, low-frequency noise corner and high alpha cutoff frequency** offered by new DALMESA transistors result in **low-noise performance over a very wide bandwidth** —the 2N2188 series gives you a typical mid-frequency noise figure of 1.5 db.

■ These new devices also give you **guaranteed gain/bandwidth products of 60 and 102 mc** to assure excellent performance in your IF, RF and video amplifiers. **Increased high-frequency stability** results from the guaranteed maximum **output capacitance of 2.5 pf at 9 volts.** ■ Apply new **DALMESA** transistors to your communications designs today and take advantage of the increased performance capabilities of this new Texas Instruments series. These new 125-mw transistors are **immediately available** through your nearest TI Sales Office or Authorized TI Distributor.

PARAMETER	TEST CONDITIONS	2N2188	2N2189	2N2190	2N2191
BV_{CBO}† AND BV_{CES}	$I_C = -50\ \mu a$	40 v min	40 v min	60 v min	60 v min
BV_{EBO}	$I_C = 0,\ I_E = -100\ \mu a$	2 v min	2 v min	2 v min	2 v min
h_{FE}	$V_{CE} = -6$ v $I_C = -2$ ma	40 min	60 min	40 min	60 min
h_{fe} (at 1 kc)	$V_{CE} = -6$ v, $I_E = -2$ ma	40 min	60 min	40 min	60 min
f_T	$V_{CE} = -9$ v, $I_E = -1.5$ ma	60 mc min	102 mc min	60 mc min	102 mc min
I_{CBO}	$V_{CB} = -12$ v, $I_E = 0$	3 μa max	3 μa max	3 μa max	3 μa max
C_{OB} (at 1 mc)	$V_{CB} = -9$ v, $I_E = 1.5$ma	2.5 pf max	2.5 pf max	2.5 pf max	2.5 pf max
Noise Figures§ (at 1 mc)	$V_{CE} = -5$ v, $I_E = 0.5$ ma	1.5 db typ	1.5 db typ	1.5 db typ	1.5 db typ
Maximum Power Dissipation	25°C Ambient	125 mw	125 mw	125 mw	125 mw

†$I_E = 0$ §$R_G = 1K\Omega$

TRANSISTOR PRODUCTS DIVISION

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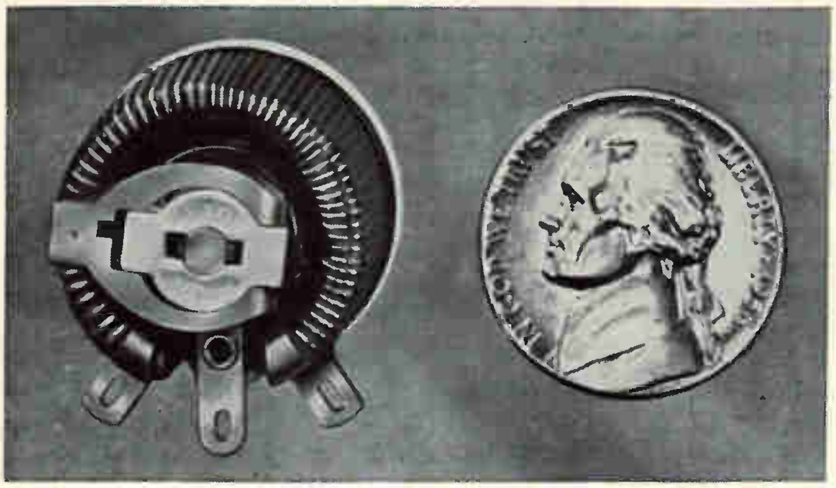
four fixed-tuned emitter bypass Transfilters which permit direct coupling of 455 Kc i-f amplifiers.

CIRCLE 304 ON READER SERVICE CARD

with an oscilloscope to give the junction temperature. A rise in junction temperature may be read directly from a meter in deg C.

CIRCLE 307 ON READER SERVICE CARD



Miniature Rheostat
AVAILABLE WITH TAPERED WINDINGS

OHMITE MFG. CO., 3645 Howard St., Skokie, Ill. Model E miniature rheostat (12½ w) can be supplied with tapered windings where customer needs dictate. Tapered windings consist of two or more sections, each using a successively smaller diameter wire. Possible advantages are: more linear control of certain loads; higher maximum resistance for a given current rating; specific resistance versus rotation curves can be produced.

CIRCLE 305 ON READER SERVICE CARD

Ferroelectric Cells

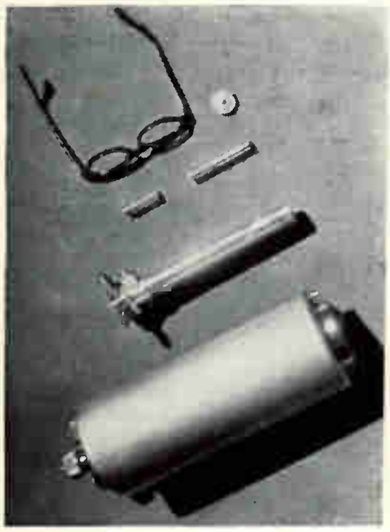
WADDELL DYNAMICS, INC., 4364 Twain Ave., San Diego 20, Calif., is offering ferroelectric memory cells in low-priced experimental kits consisting of 16 cells, individually potted for ease of handling experimentation.

CIRCLE 308 ON READER SERVICE CARD

Dual Gain C-R Tube
FOR RADAR TRACKING

ELECTRONIC TUBE AND INSTRUMENT DIVISION, General Atronics Corp., 1200 E. Mermaid Lane, Philadelphia 18, Pa. Type M1030 12-in., 2-gun crt provides tracking accuracy over a 10-in. diameter useful area with a maximum error of 0.070 in. as compared to 0.150 in. for the conventional types. With additional electrodes providing further electrical correction, accuracy can be improved to approximately 0.050 in. maximum.

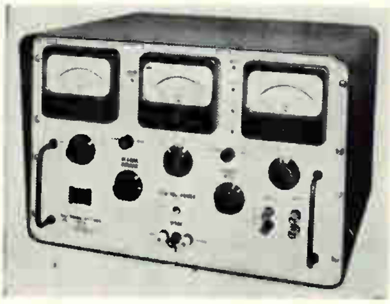
CIRCLE 309 ON READER SERVICE CARD



Infrared Detectors
VERSATILE UNITS

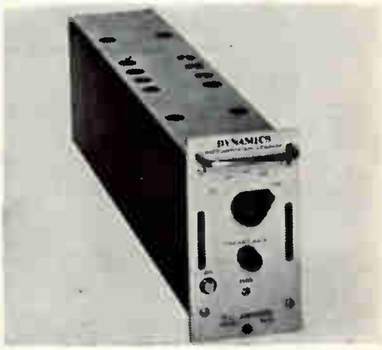
RAYTHEON CO., Foundry Ave., Waltham, Mass., has introduced a line of infrared heat seekers capable of detecting everything from humans to rocket engines. The detectors, covering the band from 1 to 30 microns, are offered in a variety of packages, using combinations of sensing materials and cooling techniques. Useful in military and commercial systems, they are also suited for laboratory spectroscopic work.

CIRCLE 306 ON READER SERVICE CARD



Test Set
THERMAL RESISTANCE

WALLSON ASSOCIATES, INC., 912 Westfield Ave., Elizabeth, N. J. Model 222 thermal resistance tester is designed to accurately measure the junction temperature of semiconductor diodes and rectifiers. In practice, d-c or half wave a-c heating current is applied in the forward direction to the rectifier under test. By interrupting the heating current, the forward voltage at constant measuring current is nulled

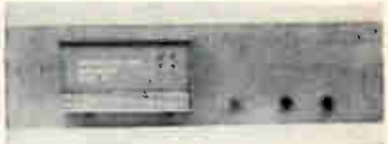


D-C Amplifier
DIFFERENTIAL TYPE

DYNAMICS INSTRUMENTATION CO., 583 Monterey Pass Road, Monterey Park, Calif. Model 2640 chopper stabilized all-transistor amplifier

circuit has potentiometric feedback to minimize noise and realize maximum input impedance. Features include: 10 Kc bandwidth and an output capability of ± 10 v and ± 10 ma. Common-mode rejection of greater than 120 db at 60 cps with 1,000 ohm unbalance in either input lead.

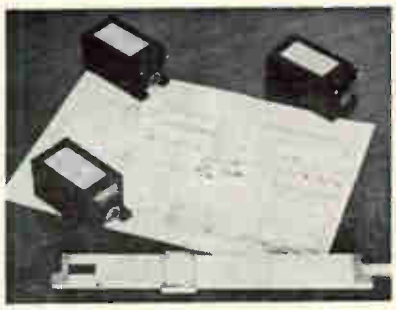
CIRCLE 310 ON READER SERVICE CARD



Converter
ANALOG-TO-DIGITAL

GENERAL DATA CORP., 11602 Ninth St., Garden Grove, Calif., announces a rack-mounted analog-to-digital converter with self-contained power supply. Accuracy is 0.5 percent; conversion time, ½ μsec. Output is 8 binary bits or two BCD in 8-4-2-1 code. Price is $1,250.

CIRCLE 311 ON READER SERVICE CARD



Digital Switches
SEQUENCE TIMING

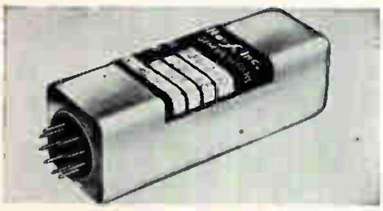
DONNER SCIENTIFIC CO., Concord, Calif. Series 7000 solid state sequence timing switches are designed for space probe and re-entry applications. They feature accuracy to 0.3 percent and initial timing periods adjustable from 0 to 30 sec. Miniaturized packages provide complete circuitry for up to three distant time sequences per unit in less than 10.6 cu in. weighing only 13 oz.

CIRCLE 312 ON READER SERVICE CARD

Round Plug

VECTOR ELECTRONIC CO., 1100 Flower St., Glendale 1, Calif. A 14-pin round plug will aid manufacturers of relays and miniature plug-in circuit assemblies.

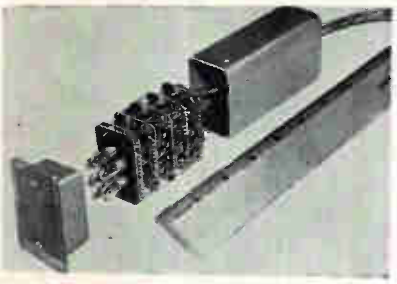
CIRCLE 313 ON READER SERVICE CARD



Crystal Oscillator
TRANSISTORIZED

DELTA-F, INC., 113 E. State St., Geneva, Ill. The DFO-10 series is available at any frequency from 10 Kc to 3 Mc in a package 1 by 1 by 3 in., or from 3 Mc to 100 Mc in a package 1 by 1 by 1¼ in. It has been qualified under all conditions of MIL-E-5400 at 100 Kc. It maintains a frequency tolerance of ±0.005 percent to ±0.03 percent depending on frequency and temperature range.

CIRCLE 314 ON READER SERVICE CARD



Decade Counter
MINIATURE SIZE

ROBOTOMICS CORP., 2422 E. Indian School Road, Phoenix 16, Ariz. Add-Subtract F1503 series 50 Kc miniature decade counter shown with cover removed uses tungsten lamps for bright in-plane display; modular p-c boards and computer type transistors are used. Two strut screws may be removed and boards opened for easy servicing. Grounding one of two control lines reverses count direction. Operating voltage +24 to +30 v.

CIRCLE 315 ON READER SERVICE CARD

Band Pass Filters

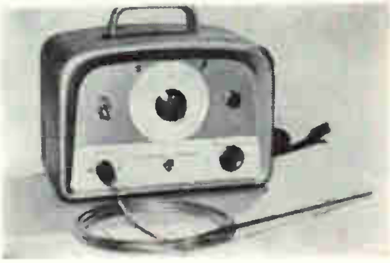
CIRCUITDYNE CORP., 480 Mermaid Ave., Laguna Beach, Calif. Miniature band pass filters covering the frequency range from 255 to 3,655 cps utilize toroid coils exclusively as inductor elements.

CIRCLE 316 ON READER SERVICE CARD

Variable Delay Line
LUMPED CONSTANT

ALLEN AVIONICS, INC., 255 E. Second St., Mineola, L. I., N. Y. Model VLR 15 variable lumped constant delay line features unrestricted settings for its multiple sliders. This independent variability of the sliding taps will be of particular value in those pulse system applications where versatility as well as reliability is of importance. Unit is 2 by 3 by 8 in. long, with extended shaft length of 1⅛ in. Delay is variable from 0 to 1.5 μsec, giving delay/rise time ratios up to 21:1.

CIRCLE 317 ON READER SERVICE CARD



Temperature Controller
ACCURATE TO 0.5 C

OMTRONICS MFG., INC., Box 1419, Peony Park Station, Omaha 14, Neb. Model N-300 Temp-Trol has a sensitivity range from −100 C to +300 C. Unit is readily portable, yet with heavy duty components is actuated through a closed-loop servo control for reliability in all applications, with a rated load of 15 amp on both heating and cooling. Price is $239.50.

CIRCLE 318 ON READER SERVICE CARD

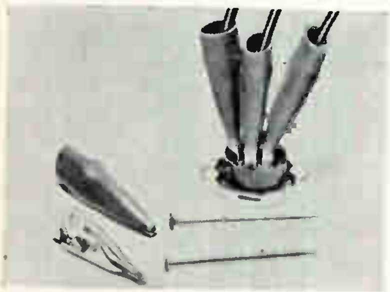
Molded Capacitor

CORNELL-DUBILIER ELECTRONICS DIVISION, Sanford, N. C. The Black Cat all-purpose molded capacitor offers high moisture resistance, wide op-

erating temperature range, and freedom from impregnant leakage.
CIRCLE 319 ON READER SERVICE CARD

Delay Lines
CODING TYPE

COMPUTER DEVICES CORP., 6 W. 18th St., Huntington Station, N. Y., announces a miniature delay line for use in aircraft identification transponders and other iff equipment. Pictured is the model D170. Characteristics of this lumped constant line are: time delay 20.3 μsec, tapped at 1.45 μsec intervals, delay tolerance ±0.05 μsec, temperature stability less than 40 ppm/deg C, rise time 0.50 μsec, attenuation 3 db, and a size of only 4 by 2 by 1 in.
CIRCLE 320 ON READER SERVICE CARD



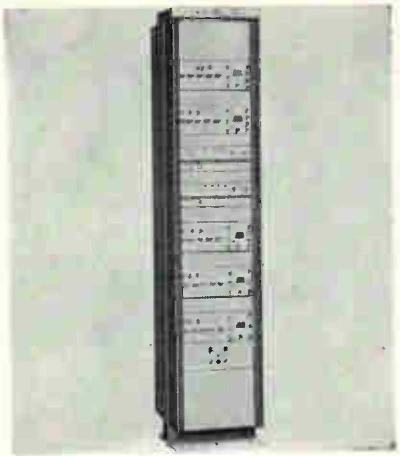
Electric Clip
HAS TINY TIP

MUELLER ELECTRIC CO., 1582H E. 31st St., Cleveland 14, O. The miniscule tip of the Micro-gator clip has been tailored to fit the non-stop shrinkage in size of many electrical and electronic components. Insulator and all, the business end of the inch-long Micro-gator is no larger than a pin head, allowing its use on the smallest, tightest-packed terminals, on printed circuits, and generally where no other clip can possibly fit, according to the manufacturer.
CIRCLE 321 ON READER SERVICE CARD

Precision Solenoid

AR&DA, 135 Main St., Belleville 9, N. J., has available a Synchronoid, which is a precision solenoid packaged in a 1½ in. diameter by 2⅞ in. long synchro case that mounts in a 1.375 in. diameter pilot hole.

CIRCLE 322 ON READER SERVICE CARD



Microwave System
TRANSISTORIZED

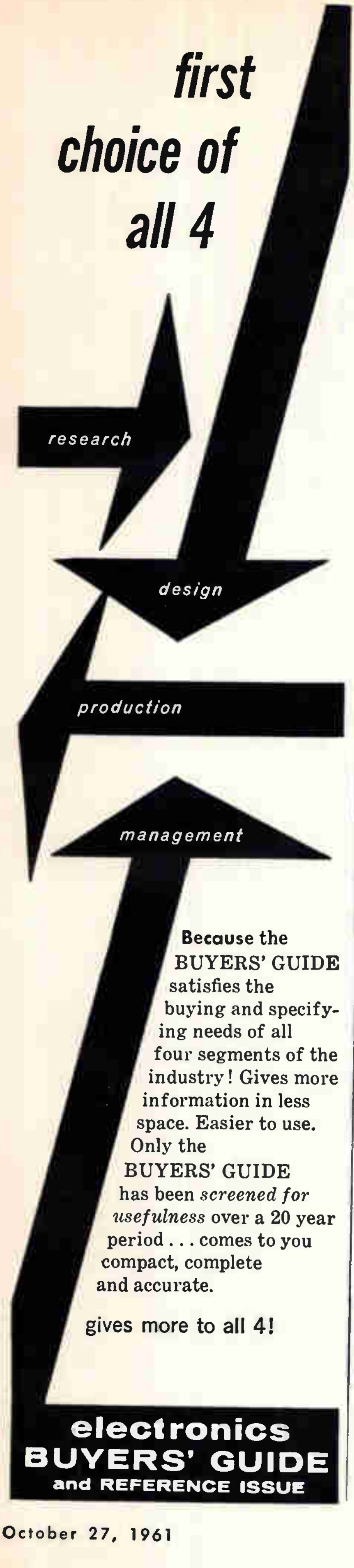
GENERAL ELECTRIC CO., Lynchburg, Va., is marketing an error-reducing transistorized microwave radio relay system that provides a ten-fold increase in transmitter power output but requires 50 percent less power input. Built for high channel capacity and medium to long haul use, the RF-7 transmits at frequencies from 5,925 to 8,400 Mc. The basic equipment can be employed for systems requiring from 1 to 600 telephone channels.

CIRCLE 323 ON READER SERVICE CARD

Static Converters
TRANSISTORIZED

PRL ELECTRONICS, INC., 232 Westcott Drive, Rahway, N. J. The CN line of d-c to d-c transistorized static converters is rated at 100 w. It features short circuit proof operation of −20 to +50 C. Designed to withstand shock and vibration normally found in mobile and aircraft operation. Price range: $70 to $81.25 depending upon input and output voltage requirements.

CIRCLE 324 ON READER SERVICE CARD



PRODUCT BRIEFS

RUBY LASER RODS no silvering. Trion Instruments, Inc., 1200 N. Main St., Ann Arbor, Mich. (325)

INTERFEROMETER SPECTROMETER high reliability. Block Associates, Inc., 385 Putnam Ave., Cambridge 39, Mass. (326)

PULSED KEEP-ALIVE POWER SUPPLY cuts random noise. Burmac Electronics Co., Inc., 142 S. Long Beach Rd., Rockville Centre, N. Y. (327)

PNP GERMANIUM MESA SWITCH ultra-high speed. Texas Instruments Inc., P. O. Box 5012, Dallas 22, Texas. (328)

PULSE & R-F AMPLIFIERS nanosecond rise times. RHG Electronics Laboratory, Inc., 94 Milbar Blvd., Farmingdale, N. Y. (329)

SELENIUM RECTIFIER FLATS large power-handling. Radio Receptor Co., Inc., 240 Wythe Ave., Brooklyn 11, N. Y. (330)

TRANSISTORIZED GAUSSMETER 11 position range selector. Dyna-Empire, Inc., 1075 Stewart Ave., Garden City, N. Y. (331)

TAPPED DELAY LINES small size, fast rise time. Ad-Yu Electronics Lab., Inc., 249 Terhune Ave., Passaic, N. J. (332)

TIME DELAY RELAY instant recycling. Guardian Electric Mfg. Co. of California, Inc., 5575 Camille Ave., Culver City, Calif. (333)

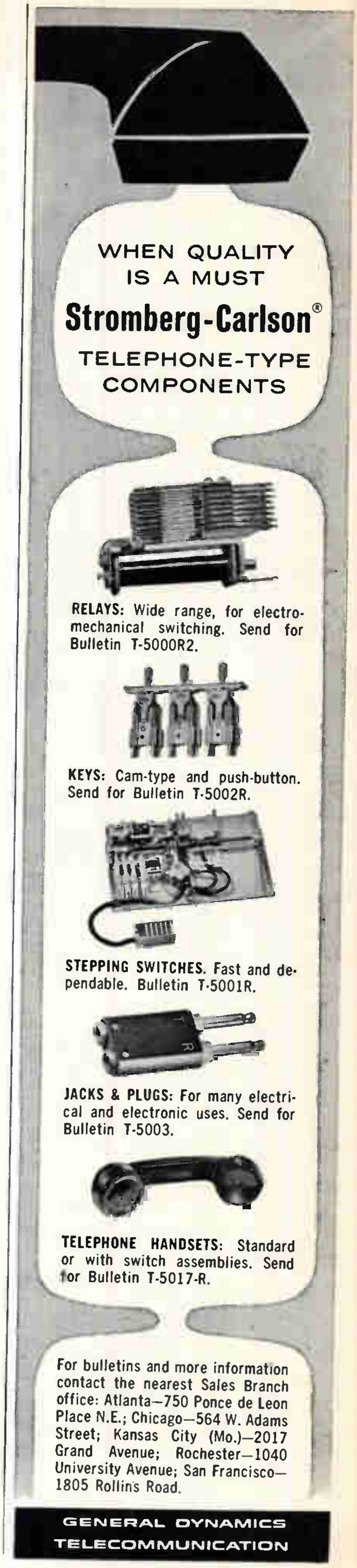
BOOSTER FOLLOWER for operational amplifiers. George A. Philbrick Researches, Inc., 127 Clarendon St., Boston 16, Mass. (334)

ITERATIVE ANALOG COMPUTER compact modular packaging. Donner Scientific Div., Systron-Donner Corp., Concord, Calif. (335)

PRESSURE TRANSDUCERS for missile and space vehicles. Bourns, Inc., 6135 Magnolia Ave., Riverside, Calif. (336)

FILM CAPACITORS hermetically sealed tubulars. Component Research Co., Inc., 3019 S. Orange Dr., Los Angeles 16, Calif (337)

SOLID STATE CHOPPER less than 0.5 cu in. Alpha-Tronics Corp., 1033 Engracia, Torrance, Calif. (338)



Literature of the Week

CRYSTAL CONTROLLED OSCILLATORS Monitor Products Co., Inc., 815 Fremont Ave., S. Pasadena, Calif. A booklet tells how to specify crystal controlled oscillators. (339)

JUNCTION TRANSISTORS American Elite Inc., 48-50 34th St., Long Island City, N. Y. Technical booklet states specifications and curve sheets for a line of Telefunken junction transistors. (340)

INTERROGATORS Information Products Corp., 156 Sixth St., Cambridge, Mass. Interrogators and interrogator systems are the subject of a 16-page booklet. (341)

DIGITAL VOLTMETERS Non-Linear Systems, Inc., Del Mar, Calif. A hard cover book on digital voltmeters is divided into a general section and a catalog section. (342)

PRESSURE-SENSING PACKAGE Taber Instrument Corp., North Tonawanda, N. Y. Bulletin presents model 185/290-2 compact airborne pressure transducer. (343)

TRIMMER CAPACITORS Erie Resistor Corp., 645 W. 12th St., Erie, Pa. Bulletin 314-3 covers the Trimacon line of trimmer capacitors. (344)

TRANSDUCER DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y., has published a technical data bulletin on a miniature high pressure transducer. (345)

CRYSTALS Scientific Radio Products, Inc., 2303 W. 8th St., Loveland, Colo. High stability glass enclosed crystals are discussed in a 1-page bulletin. (346)

POWER SUPPLY Kepco Inc., 131-38 Sanford Ave., Flushing 52, N. Y. Voltage/current regulated power supply is described in a technical bulletin. (347)

SILICONE RUBBER INSULATION General Electric Co., Waterford, N. Y. Bulletin discusses silicone rubber wire and cable insulation for aircraft and missiles support. (348)

STRAIN RECORDING Brush Instruments, division of Clevite Corp., 37th and Perkins, Cleveland 14, O., offers a 20-page booklet entitled

"Strain Recording with Brush Direct Writing Recorders." (349)

GERMANIUM POWER TRANSISTORS Semi-Onics, Inc., 4 Broadway, Lowell, Mass. Series of data sheets describe a line of *pnp* germanium power transistors in the TO-36 package. (350)

TIMING MOTORS The A. W. Haydon Co., 232 North Elm St., Waterbury, Conn. Technical bulletin covers a series of U.L.-approved a-c timing motors. (351)

R-F SYNTHESIZERS Manson Laboratories, Inc., 375 Fairfield Ave., Stamford, Conn. Development of quartz crystal radio frequency synthesizers is discussed in a 16-page booklet. (352)

TRANSISTOR COOLING International Electronic Research Corp., 135 W. Magnolia Blvd., Burbank, Calif., has available a 48-page transistor cooling test report. (353)

REFERENCE CAVITIES Microwave Development Laboratories, Inc., 15 Strathmore Road, Natick, Mass. Catalog CF-61 describes five stock designs of reference cavities covering the frequency range from 9,250 Mc to 9,312 Mc. (354)

ELECTRON PROBE MICROANALYZER Philips Electronic Instruments, 750 S. Fulton Ave., Mount Vernon, N. Y. A 6-page folder provides data and specifications on an electron probe microanalyzer. (355)

RARE EARTH METALS Kleber Laboratories, 2530 N. Ontario St., Burbank, Calif., has available a price list of distilled grade rare earth metals with purities of greater than 99.8 percent. (356)

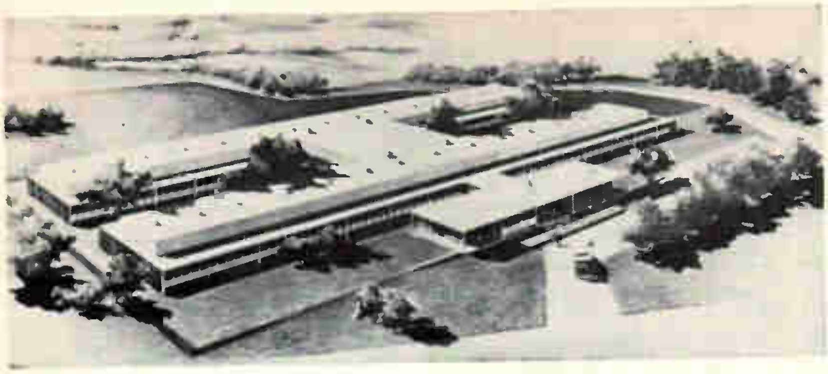
EVACUATING SYSTEMS Vactronic Lab. Equipment Inc., East Northport, L. I., offers a folder on a series of precision evacuating systems and components. (357)

PUNCHED TAPE READER Electronic Engineering Co. of California, 1601 E. Chestnut Ave., Santa Ana, Calif. Bulletin describes model TP-522 punched tape reader for tape duplicating systems. (358)

RESISTORS International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa. Bulletin P-9 deals with a line of power metal film resistors. (359)

Electronics Department in Syracuse, N. Y., to keep pace with rapidly changing customer needs and technologies in the missile and space age, according to Edward F. Herzog, manager-engineering.

Simultaneously announced are the appointments of Kenneth D. Greenhalgh as manager-undersea acoustics systems engineering; L. H. Lynn as manager-ordnance radar systems; and Earl A. Stebbins as manager-marine and ground radar systems engineering.



Fairchild Erecting R&D Center

FAIRCHILD SEMICONDUCTOR, a four year old firm, recently started construction of a $1.5 million research and development center on a nine-acre site in Stanford Industrial Park, Palo Alto, Calif. Scheduled for completion in the spring of 1962, the facility will have 63,000 sq ft of space.

Robert N. Noyce, general manager of Fairchild Semiconductor, a division of Fairchild Camera and Instrument Corp., noted that Fairchild was founded in Palo Alto in 1957.

Gordon E. Moore, Fairchild's director of research and development, said the H-shaped building will have more than twice the space of the present R&D facilities and be fully air-conditioned. He added that 250 employees will move into the new center next spring. The force will be expanded to about 400 by the end of the year. No manufacturing will be done in the new plant.

Today, Fairchild has a staff of 1,700 in three major locations and four smaller facilities. Company manufactures high-performance silicon transistors, diodes and integrated electronic circuits called "Micrologic Elements".

Fairchild's original plant is part of the present R&D Center and a new headquarters and transistor manufacturing plant was constructed in Mountain View in 1959. A third major plant was added in 1960—the diode facility in San Rafael, and a 40,000-sq-ft addition to the main Mountain View plant is nearing completion.

Claus Haake Joins Giannini Controls

GIANNINI CONTROLS CORP., Duarte, Calif., has appointed Claus Haake as research manager of the GCC Research Laboratories in Pasadena. He will be responsible for research efficiency, personnel supervision, staff development and general project coordination.

Prior to joining Giannini Controls, Haake served as senior physicist for Westinghouse Electric researching solid-state physics.

Molecular Dielectrics Appoints Replogle

D. E. REPLOGLE has been named president of Molecular Dielectrics, Inc., Clifton, N. J., a newly formed firm which will explore the molecular sciences for new insulating materials. Molecular Dielectrics was established through the consolidation of Electronic Mechanics, Inc., Clifton, N. J., Mykroy, Inc., Chicago, Ill.; and Mykroy Mfg. Co., Inc., Andover, N. J.

Management of the new firm is being drawn from the three consolidating companies.

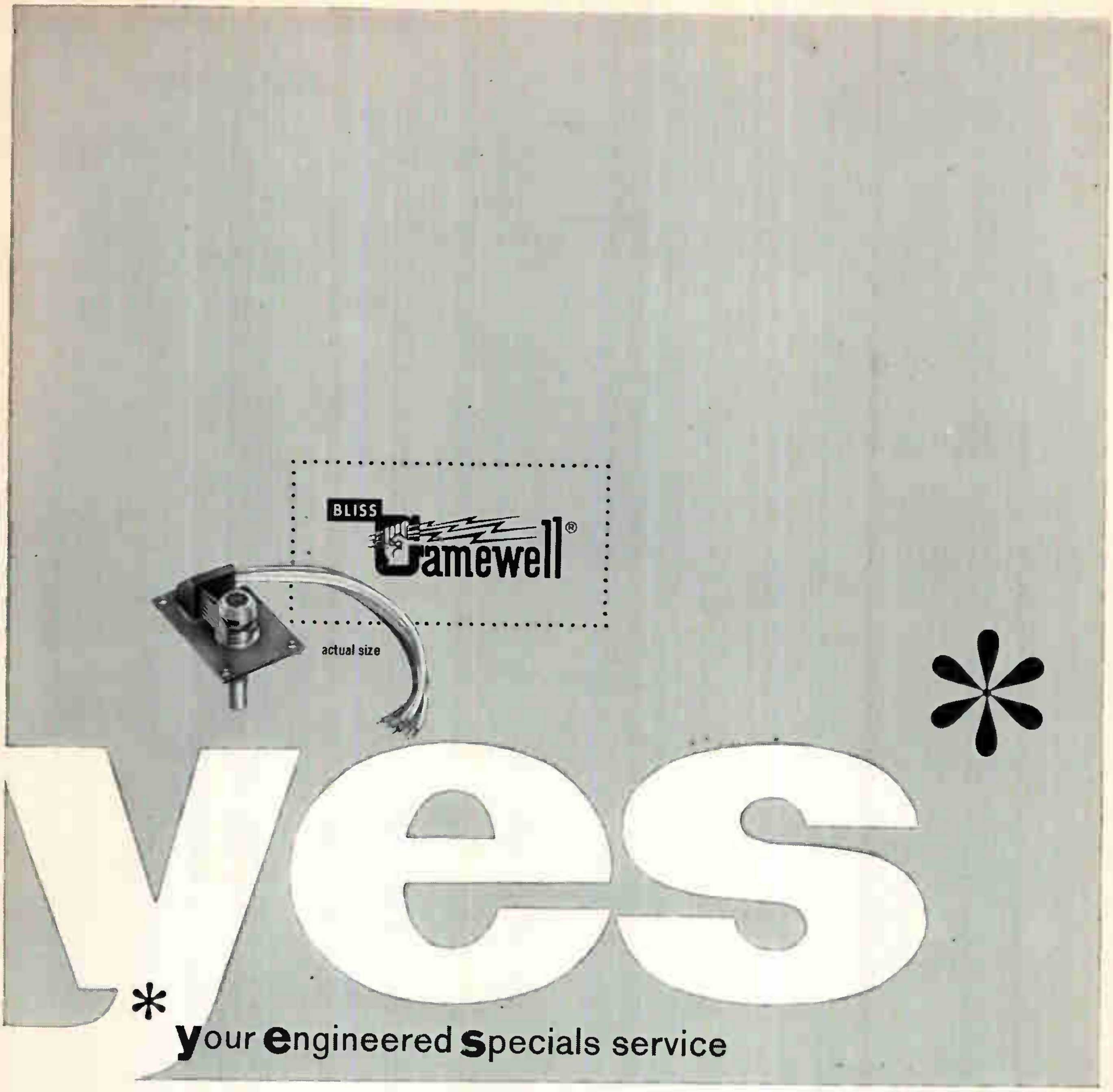
Replogle founded Electronic Mechanics, Inc., 25 years ago in Ridgewood, N. J.

GE's HMED Sets Up Three Subsections

THREE new engineering subsections have been established in the General Electric Company 's Heavy Military

Hycon Mfg. Names John Barnes V-P

HYCON MFG. COMPANY has named John C. Barnes as vice president. He will be in charge of several planned subsidiary developments and a number of special projects



Gamewell made this special completely from scratch. Every part of this rotary switch was newly designed by Your Engineered Specials service to meet a customer's special requirements. The unit provides bi-directional operation at 160 rpm max. It is rated at 28 VDC, 60 ma...has high vibration and shock resistance...and −55° to +150°C. temperature range. Although this design called for only six poles and 11 switching segments, many more could have been provided. ▪ Gamewell's YES service has developed answers to hundreds of special "pot" and rotary switch problems. Interested? Why not write for the full story? **y**our **e**ngineered **s**pecials service.

THE GAMEWELL COMPANY, POTENTIOMETER DIVISION, 1416 CHESTNUT STREET, NEWTON UPPER FALLS 64, MASSACHUSETTS. A SUBSIDIARY OF E. W. BLISS COMPANY

CIRCLE 89 ON READER SERVICE CARD

planned for the orderly expansion of Hycon, according to board chairman and president Trevor Gardner.

Barnes was formerly with North American Aviation's Space and Information Systems division where he held the dual assignment of assistant to the chief scientist and acting director of the laboratories.

Herring Advances At Wyle Laboratories

WYLE LABORATORIES, El Segundo, Calif., has promoted John R. Herring to the new position of manager, engineering and production, West Coast Testing division.

He has been with Wyle since 1954, most recently as director of the program office, in charge of performance of all prime contracts.

Microwave Dynamics Moves to Connecticut

MICROWAVE DYNAMICS, INC., of Plainview, N. Y., has moved to Cheshire, Conn. The move will serve to consolidate its facilities with those of Microtech, Inc., in Cheshire. Both are subsidiaries of Talley Industries, Inc.

Sperry Electronic Tube Hires Noland

JAMES NOLAND was recently appointed engineering section head at Sperry Electronic Tube Division. He will direct the development of advanced types of backward wave oscillators.

Noland was previously employed by General Telephone and Electronic Laboratories.

Clairex Corp. Relocates In New York City

EXPANSION of R&D facilities and technical personnel has been announced by Clairex Corp. as a result of its recent move to new quarters in New York City. A major portion of the 60 percent increase in space available to the firm has been apportioned to advanced studies of photoconductive materials.

Curtiss-Wright Elects Palley

ELECTION of I. Nevin Palley as executive vice president of Curtiss-Wright Corp., Wood-Ridge, N. J., is announced. He joins the corporation from ITT-Federal Laboratories, of which he was president.

Korin Advances At IBM Corp.

INTERNATIONAL BUSINESS MACHINES CORP. has appointed Samuel B. Korin manager, manufacturing equipment development. He was

formerly administrative assistant to IBM's director of manufacturing research.

Morrison Moves Up At Honeywell

S. ROY MORRISON, senior staff scientist at the Minneapolis-Honeywell Research Center in Hopkins, Minn., has been promoted to assistant director of the center. He joined Honeywell in 1955 as a staff scientist.

ANTLAB Announces Two Promotions

ANTLAB, INC., Worthington, O., has announced the promotion of Peter M. Pifer from chief of the electronics department to chief engineer for the company.

Trent E. Davis, a design engineer for the firm, was named to the post vacated by Pifer.

ANTLAB designs and manufactures missile tracking systems, antenna pedestals, microwave receivers, and associated antenna range instrumentation.

Maxson Electronics Names Schwarzkopf

DANIEL SCHWARZKOPF has been named general manager of the Unimax Switch Division of Maxson Electronics Corp. The division is located in Wallingford, Conn.

Prior to joining Maxson Electronics in 1950, Schwarzkopf was associated with the Electrocoil Transformer Co. in New York City.

Form New Company In California

THE FORMATION of Glastronics, Inc., Torrance, Calif., a subsidiary of Radio Cores, Inc., Oak Lawn, Ill., has been announced. Initially, Glastronics will concentrate on the fabrication of beads and bodies for semiconductor diodes.

PEOPLE IN BRIEF

Walter A. Mainberger resigns from National Co., Inc., to join Dunn Engineering Corp. as technical asst. to the v-p for technical operations. **Donald M. Brown** is promoted to product manager for The Electric Autolite Co. electrical products group. **R. A. Alexander** transfers from RCA Victor Co. Ltd., to manager, equipment design engineering, Data Communications and Custom Projects dept. of RCA's Electronic Data Processing div. **Joseph M. Bernstein,** formerly with Automatic Electric Laboratories, Inc., is named staff engineer for systems with Automatic Electric Sales Corp. Simon Stopek leaves Hughes Semiconductors to become a senior engineer at Microwave Semiconductors. Assembly Products, Inc. advances **George F. Quittner** to chief research engineer. **L. Bruce Wilner,** ex-Lockheed Aircraft, now project scientist at Endevco Corp.'s solid state lab. **Allen Gee,** formerly with Texas Instruments Inc. and DuPont Corp., joins technical staff of Hughes Aircraft's semiconductor div. **W. M. "Mack" Turner,** president of Astrometrics, becomes president and board chairman of the newly formed Stellarmetrics, Inc. **Benjamin O. Delaney** is promoted to assistant director of Vitro Laboratories' Silver Spring Lab. **John T. Ralph** leaves Warwick Mfg. Corp. to join Cinch Mfg. Co. as product planning manager. **Thomas E. Buckley** moves up at IBM Corp. to executive asst. to the chairman of the board.

electronics

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

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

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WHAT TO DO

1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *Please print clearly.*
6. Mail to: D. Hawksby, Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

COMPANY	SEE PAGE	KEY #
ERIE ELECTRONICS DIV. Erie Resistor Corp. Erie, Pa.	95	1
ESQUIRE PERSONNEL Chicago, Illinois	112*	2
GENERAL PRECISION INC. GPL Division Pleasantville, New York	112*	3
INTERNATIONAL ELECTRIC CORP. Paramus, New Jersey	93	4
JET PROPULSION LABORATORY California Institute of Technology Pasadena, California	95	5
LABORATORY FOR ELECTRONICS Boston, Massachusetts	79	6
THE MITRE CORPORATION Bedford, Massachusetts	91	7
PAN AMERICAN WORLD AIRWAYS INC. Guided Missiles Range Div. Patrick AFB, Florida	73*	8
PHILCO WESTERN DEVELOPMENT LABS. Palo Alto, California	111*	9
REMINGTON RAND UNIVAC Div. of Sperry Rand Corp. St. Paul, Minnesota	90	10
REPUBLIC AVIATION Farmingdale, L.I., New York	110*	11
TEXAS INSTRUMENTS INC. Apparatus Div. Dallas, Texas	101*	12
UNION CARBIDE NUCLEAR CO. Oak Ridge, Tenn.	95	13

* These advertisements appeared in the 10/20/61 issue.

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electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME ....

HOME ADDRESS..

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

HOME TELEPHONE..

Education

PROFESSIONAL DEGREE(S).......................................

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check)

10271

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

CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines.

	Technical Experience (Months)	Supervisory Experience (Months)
RESEARCH (pure, fundamental, basic)	......	......
RESEARCH (Applied)	......	......
SYSTEMS (New Concepts)	......	......
DEVELOPMENT (Model)	......	......
DESIGN (Product)	......	......
MANUFACTURING (Product)	......	......
FIELD (Service)	......	......
SALES (Proposals & Products)	......	......

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

JPL NEEDS DIGITAL AND RF SYSTEM DESIGNERS

• To apply the results of coding and detection theory to the design and development of advanced digital telemetry and communications systems. To design new information and data handling systems for accepting the monitored outputs of tracking and communication receivers and converting them into IBM 7090 format.

• To design automatic check-out equipment for precision doppler radar. Will have responsibility for systems design and development from specifications throughout fabrication and/or procurement of equipment, evaluation, documentation and training of user.

• To design automatic acquisition subsystem for precision doppler radar. Objective is to minimize the number of radar operators accomplishing detection and acquisition and to improve reliability of this phase of the operation. Work will include acquisition of signal in two angles, frequency and range. Knowledge of both RF and digital equipment is desirable.

• These positions require advanced degree in EE, Physics or Mathematics with experience in above areas.

• Other opportunities exist for electronic engineers and physicists in many areas at JPL. Send complete qualification resume now for immediate consideration. "An equal opportunity employer".

JET PROPULSION LABORATORY
California Institute of Technology
4814 OAK GROVE DRIVE, PASADENA, CALIFORNIA

Electronic Instrument Mechanics

The Oak Ridge National Laboratory
Operated by
Union Carbide Nuclear Company
at
Oak Ridge, Tennessee

Has openings for

Highly skilled electronic instrument mechanics to work with electronic engineers in the development, installation and maintenance of electronic systems. Digital data handling, transistorized pulse height analyzers, analog and digital computer systems are only a few examples.
Minimum high school education, with additional training in electronics and at least three years' experience in installation and maintenance of complex electronic systems.

Excellent Working Conditions
and
Employee Benefit Plans

All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

Send detailed resume' to:
Central Employment Office
Union Carbide Nuclear Company
Post Office Box M
Oak Ridge, Tennessee

TRANSFORMER ENGINEER

With experience in the design and development of Hi-Frequency and Pulse transformers for commercial and military applications.

Ideal opportunity for ambitious man to develop full potential of present small department. Salary—open. Location—Erie, Pa. Call or send resume to Chief Engineer

Erie Electronics Division
Erie Resistor Corporation
645 West 12th Street Erie, Pa.
GL 6-8592

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Where your recruitment program calls for qualified engineers in the electronics industry, there is no more efficient method of reaching them than through the pages of the publication they pay to read.

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(Classified Advertising)

BUSINESS OPPORTUNITIES
EQUIPMENT - USED or RESALE

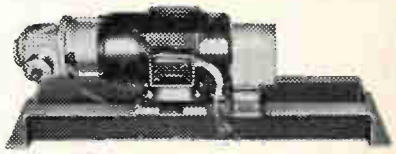
DISPLAYED RATE

The advertising rate is $24.75 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request. AN ADVERTISING INCH is measured 7/8 inch vertically on one column, 3 columns—30 inches—to a page. EQUIPMENT WANTED or FOR SALE ADVERTISEMENTS acceptable only in Displayed Style.

UNDISPLAYED RATE

$2.40 a line, minimum 3 lines. To figure advance payment count 5 average words as a line.
PROPOSALS, 2.40 a line an insertion.
BOX NUMBERS count as one line additional in undisplayed ads.
DISCOUNT OF 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

400 CYCLE GENERATOR SETS



2 KW, single phase, 17.4 amps., 115 volts, 400 cycle electric generator set. Ideal test generator for laboratory use. Manufactured by LELAND for U. S. Navy. Ball bearing construction. Complete with Raytheon Spark Gap Modulator type CRP-10249. Unit is mounted on welded steel base. Dimensions: 43" L. x 18" W. x 20" H. F.O.B. Chicago.

No. ASC400MG Our Price... **$189.50**

Same generator, mounted on base with:

3 H. P. motor, 60 cycle, 1 phase... **$295**
3 H. P. motor, 60 cycle, 3 phase... **$289**
3 H. P. motor, 110 volt D. C. **$275**

FREE CATALOG . . . Hundreds of other equipment bargains . . . write TODAY!

GROBAN SUPPLY COMPANY
1139 South Wabash Avenue, Dept. AS-10,
Chicago 5, Illinois • WEbster 9-3793

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AUTO-TRACK & TELEMETRY ANTENNA PEDESTALS
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Whose Proprietary Rights?

"PROPRIETARY RIGHT" is a phrase that covers a lot of ground. It includes those techniques, methods, processes, layouts and treatments which, taken together, comprise the most important asset of any business . . . the "know-how". We who labor in the electronics vineyard traffic in know-how more than most others. The history of our industry—and its future—are irrevocably tied to the inventive genius of the scientist and the engineer.

In cold fact, the government represents over half the total market of our industry. Billions of dollars of government money are spent annually on electronic systems and hardware, as well as on research and development. We therefore advance the premise that government must conduct itself as a customer in such manner as not to destroy, damage or limit the ability or willingness of the industry to create and supply the products of creative genius, products which stem directly from know-how.

There can be no question that the government, and the taxpayers, are entitled to the fairest and lowest price consistent with quality merchandise. A single source of supply for an important item is admittedly undesirable. There is no question but what the government is entitled to the know-how and patent rights resulting from government-financed development and research. But it is not entitled to the know-how and prior knowledge of the firm undertaking such work. For the government to request that all proprietary rights and data be handed over as a condition of doing business with the government is patently unfair, and dangerous. It is particularly unfair if the government freely dispenses such proprietary information when putting out bids and thereby invites the invention of an item all over again through "reverse engineering."

To what extent must the government possess data and rights to insure the national defense? The question must be answered clearly, for to that extent the government must have the rights and data. Were such data retained by the government for emergency use, little complaint would be heard. Unfortunately such is not always the case. Industry says much proprietary data is being disseminated to bidders for purpose of reprocurement. Furthermore, data is required from subcontractors who must, in turn, require the same data from *their* subcontractors. The result is a passing-down-the-line of data, giving rise to natural speculation that some firms through whose hands the data passes may unjustly benefit from the information therein.

The following factors contribute to the problem:

(a) Government procurement personnel often overspecify data requirements to play it safe.

(b) Businesses, small businesses in particular, are not always fully aware of their rights and can't afford a staff to keep informed.

(c) Although ASPR 9-203 provides protection for proprietary rights, the definition of reverse engineering contained in 9-201(b) dilutes and nullifies this protection.

(d) The all-inclusive demands of MIL-D-70327 for furnishing data in sufficient detail to permit manufacture or reprocurement further dilute the protection.

(e) While it is recognized that the contractor is not required specifically to supply data which is proprietary, it rests with the supplier to initiate action to prevent its inclusion.

So that the question of proprietary rights can be more equitably resolved, we recommend:

(1) That description of contractors' rights be simplified and made more specific.

(2) That the government initiate a program to keep industry informed of procedures by which it can protect itself.

(3) That the reverse engineering clause in ASPR 9-201(b) be eliminated.

(4) That proprietary data required from subcontractors be delivered directly to the government rather than through commercial channels.

(5) That ASPR 9-203 be revised in such manner that the contractor be required to disclose *only* data developed under the particular contract involved.

W W MacDonald

EDITOR