August 4, 1961

electronics

Sonar sounds Arctic Ocean bottom directly through ice, p 44

Plasma Engineering, Part II: Measuring Parameters. See p 33

How to compute noise levels in microwave systems. See p 52

A McGraw-Hill Publication 75 Cents

COMPACT C-BAND TWT, QKW 928, utilizes PPM focusing for lightweight construction. VSWR is 1.1 over any 50 Mc channel. Tube is also available with coaxial fittings for full octave (4-8 kMc) coverage.

Raytheon introduces low-cost 12-watt TWT for long-life microwave relay operation

Rugged all metal-ceramic tube for 5,925 to 7,125 Mc range designed for power amplifier service in unattended stations.

The QKW 928 offers a combination of advantages never before available in a traveling wave tube for communications applications.

This 12-watt tube's periodic permanent magnet focusing permits a new, simpler, more compact construction that assures long life and permits a lower cost. The new design reduces external magnetic fields so that two tubes can be mounted in close proximity to each other.

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

QKW 928 TYPICAL OPERATING CHARACTERISTICS	
Frequency Range	5,925-7,125 Mc
Power Output (saturated)	12 Watts minimum
Small Signal Gain	36 db
Helix Voltage	2,600 Vdc
Collector Voltage	2,600 Vdc*
Anode Voltage	2,650 Vdc
Filament Voltage	6.3 Volts

*Can be depressed to 1,400 volts for improved efficiency.

RAYTHEON

RAYTHEON COMPANY

MICROWAVE AND POWER TUBE DIVISION

See us at WESCON—Booth 3410-3412

August 4, 1961

electronics

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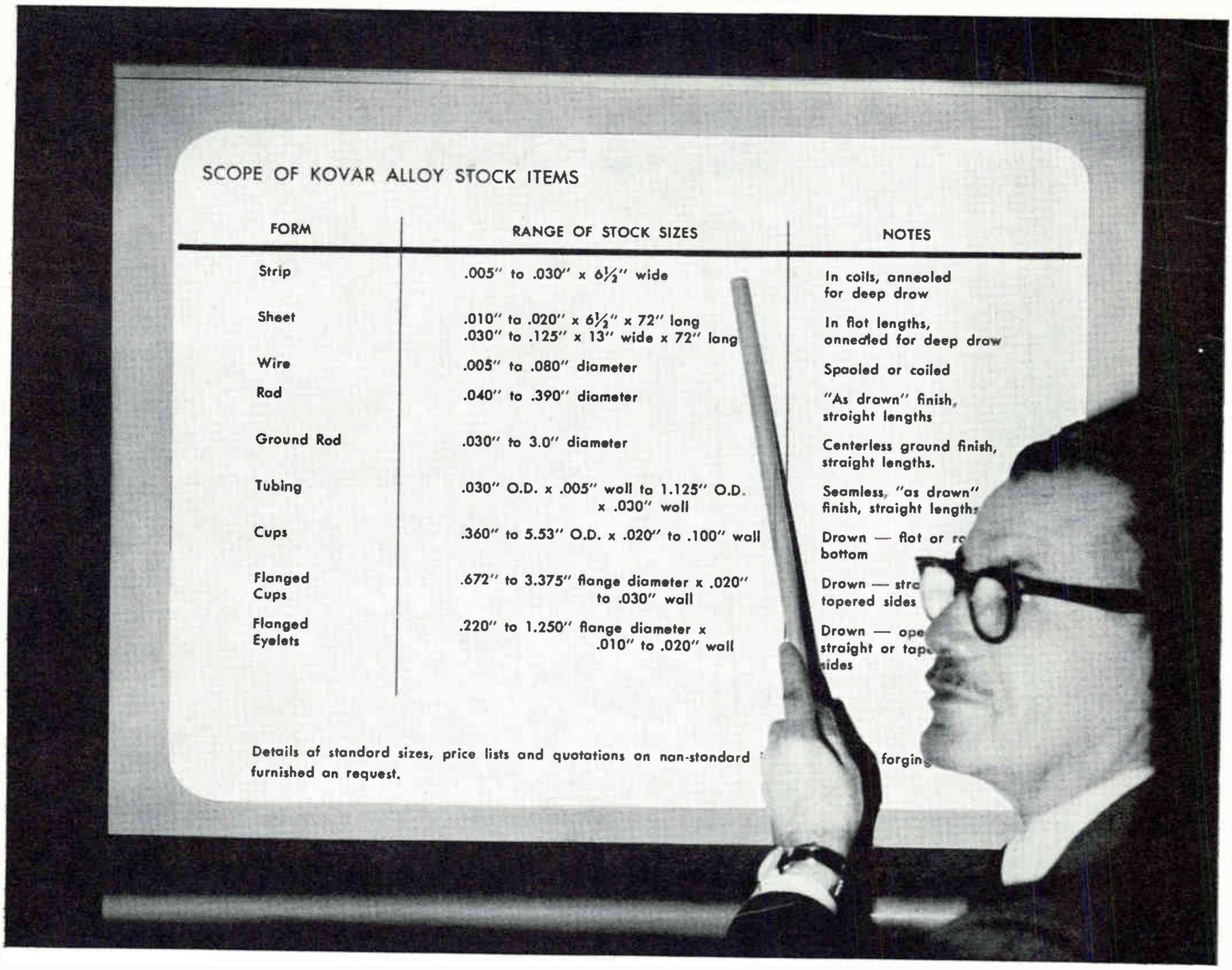
W. W. MacDONALD, Editor



Engineering hints from Carborundum

Check stock forms of KOVAR® Alloy to simplify production problems

KOVAR®, the original iron-nickel-cobalt alloy for making seals with several hard glasses comes in a variety of forms, sizes and parts available as *stock* items for immediate shipment.

The table above summarizes the breadth of these stocks. It does not, of course, cover the wide range of available sizes. For example, over forty sizes of seamless KOVAR alloy tubing are maintained as stock items. Complete, up-to-date data sheets giving specifications, dimensions, surface finishes, tolerances and other details sent on request.

For applications that cannot be served satisfactorily by stock items, specials can be supplied. Complete technical service is offered to help in solving particular processing and application problems. Just write The Carborundum Company, Refractories Division, Dept. E-81, Latrobe Plant, Latrobe, Pa.

THERE IS NO TRUE SUBSTITUTE FOR KOVAR® ALLOY . . . *supplied only by* **CARBORUNDUM**

KOVAR's superiority in making all types of glass-to-metal and ceramic-to-metal seals — and its ability to be easily formed, welded, soldered and brazed — is the result of a stringently controlled manufacturing process based on over 25 years continuous production experience. KOVAR is an alloy of unique and rigidly maintained characteristics. Stock and custom forms, together with complete technological advisory service, are available only through Carborundum.

For permanent vacuum and pressure-tight sealing . . . count on

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LAMBDA

Convection Cooled Transistorized Regulated Power Supplies

VISIT LAMBDA AT WESCON SHOW BOOTHS 3602-3604

LA SERIES

0- 34 VDC	5 AMP
0- 34 VDC	10 AMP
0- 34 VDC	20 AMP
20-105 VDC	2 AMP
20-105 VDC	4 AMP
20-105 VDC	8 AMP
75-330 VDC	0.8 AMP
75-330 VDC	1.5 AMP
75-330 VDC	3 AMP

SPECIAL FEATURES

- Convection Cooled—No internal blowers or filters—maintenance free
- Ambient 50°C
- No Voltage Spikes or overshoot on "turn on, turn off," or power failure
- Short Circuit Proof
- Remote programming over Vernier band
- Hermetically-sealed transformer designed to MIL-T-27A
- Easy Service Access
- Constant Current Operation—Consult Factory
- Guaranteed 5 years

CONDENSED DATA

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

LAMBDA ELECTRONICS CORP.

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

Western Regional Office: 230 North Lake Avenue, Pasadena, California • Phone: Code 213, MUrray 1-2544

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CIRCLE 3 ON READER SERVICE CARD

electronics
August 4, 1961 Volume 34 Number 31

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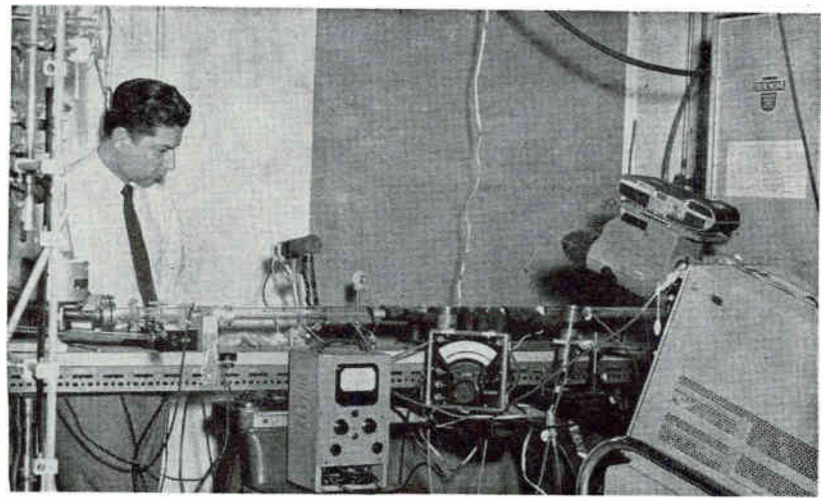
CROSSTALK



SHOCK TUBES and associated equipment shown in the photo above are used in MHD studies at the Franklin Institute, Philadelphia. Ordinarily, strong shock waves ionize the gas (ELECTRONICS, p 47, July 14, 1961). Instead, the Institute uses r-f ionization to permit investigation of subsonic flow. Gas in the tube's low pressure section is ionized and made conductive by an r-f field applied through external electrodes connected to the tank circuit of a 3-Kw, 500 Kc induction generator. External permanent magnets produce a field of about 1,000 gauss transverse to the tube. Interaction of induced currents and field produces an effective drag on gas motion, attenuating the incident shock wave and theoretically altering the gas velocity behind the shock wave toward the sonic value.

Typical measurements made in shock tube studies include velocity and conductivity. Techniques for measuring these and other parameters important in plasma research are described in Assistant Editor Wolff's second article on plasma engineering, on p 33.

Coming In Our August 11 Issue

WITH MORE THAN 35,000 electronics engineers and management men slated to convene at San Francisco's Cow Palace in two weeks to view exhibits by 800 companies, participate in 41 technical sessions, swap the latest operating ideas, and generally talk shop for four days, national industry interest will be focused on recent developments throughout the West. Sales in the 11 western states hosting Wescon this year will fall just short of the $3 billion mark, or about one-quarter of the nation's total.

Aggressive, farsighted R&D programs, responsible in large measure for the area's spiraling sales, have hatched many notable new developments, a cross-section of which are detailed in Pacific Coast Editor Hood's round-up article resulting from several weeks of reportorial rooting throughout the area. You'll learn, for example, what made JPL's recent Venus radar bounce possible, how a brand new one-piece ceramic crt electron gun ruggedizes scope tubes and slashes assembly time, some promising uses of a new superconductor material, how a new wiperless potentiometer uses electro-optical pick-off, details of one of the latest systems for arms control surveillance, and a preview of some of the more significant papers to be presented.

FILMISTOR® 'C'

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

RUGGED END-CAP CONSTRUCTION FOR LONG TERM STABILITY

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EXCEPTIONAL RESISTANCE TO MOISTURE AND MECHANICAL DAMAGE

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SURPASS MIL-R-10509 PERFORMANCE REQUIREMENTS

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

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

Filmistor "C" Resistors are automatically spiralled to desired resistance values by exclusive Sprague equipment. The metallic resistive film, deposited by high vacuum evaporation, bonds firmly to special ceramic cores. Noble metal terminals insure low contact resistance.

The resistance elements, complete with end caps and leads attached are molded in dense, high temperature thermosetting material to form a tough molded shell for maximum protection against mechanical damage, moisture penetration and repeated temperature cycling.

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

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

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COMMENT

Nomogram

Please forgive my delay in responding to the several letters I received through your office regarding the nomogram mentioned in my article "Transformerless Supplies" which appeared on page 56 of the June 26, 1959, issue of ELECTRONICS. I have replied in person to each of the individuals and have enclosed a revised nomogram. I failed to take into account the fact that the current and voltage in an R-C circuit are 90° out of phase. My formula was $C = I_h \times 10^6/2\pi f(117 - E_h)$. It should have been $C = I_h \times 10^6/2\pi f\sqrt{117^2 - E_h^2}$.

FRANKLIN G. KELLY
SPACE TECHNOLOGY LABORATORIES
LOS ANGELES, CALIF.

Platinum Wire

I would like to thank you and the many persons in universities and industry who replied to my request for information [on special wire sources] published in *Comment* of the May 19 issue.

Knowing the limitations of space for publication of letters I perhaps excessively simplified my question. What I am trying to do is to center a platinum wire and also a silver wire of 5 mils diameter down the bore of #22 hypodermic needles. These wires must be insulated from the wall of the needle. The problem at first glance seems simple: pot the wire in epoxy resin in the needle after first fitting the end of the wire with a suitable connector. Believe me, it is not as simple as it sounds; the bare wire drifts during the curing process and shorts against the wall of the needle. Even if the wire is coated with epoxy before starting to pot it, the same problem has continued to plague me. Thus the request for some insulation which would withstand the autoclaving temperatures when needles are sterilized. Trying to obtain a smooth coating of epoxy on a 5 mil wire is, I think, beyond my capabilities or equipment. After more than 150 tries I got one wire suitably coated. The cost of having 500 ft of each type of wire coated is beyond the limited research budget for this work, and 500 ft is the least amount available.

JOHN A. SYKES, M.D.
M.D. ANDERSON HOSPITAL
AND TUMOR INSTITUTE
HOUSTON, TEXAS

Heart Sound Discriminator

I have some comments on the presentation of my article on a heart sound discriminator (p 52, June 16). The copy that I sent to you contained a title page with acknowledgement to Dr. Robert F. Rushmer of the University of Washington School of Medicine whose original idea this was, who supervised the project during the development, and who arranged for support of it through the National Institute of Health. I would appreciate any suggestions you may have in reference to recognition of Dr. Rushmer's part in the project and the financial support derived from the U.S.P.H.S.

RICHARD R. WEISS
SEATTLE UNIVERSITY
SEATTLE, WASH.

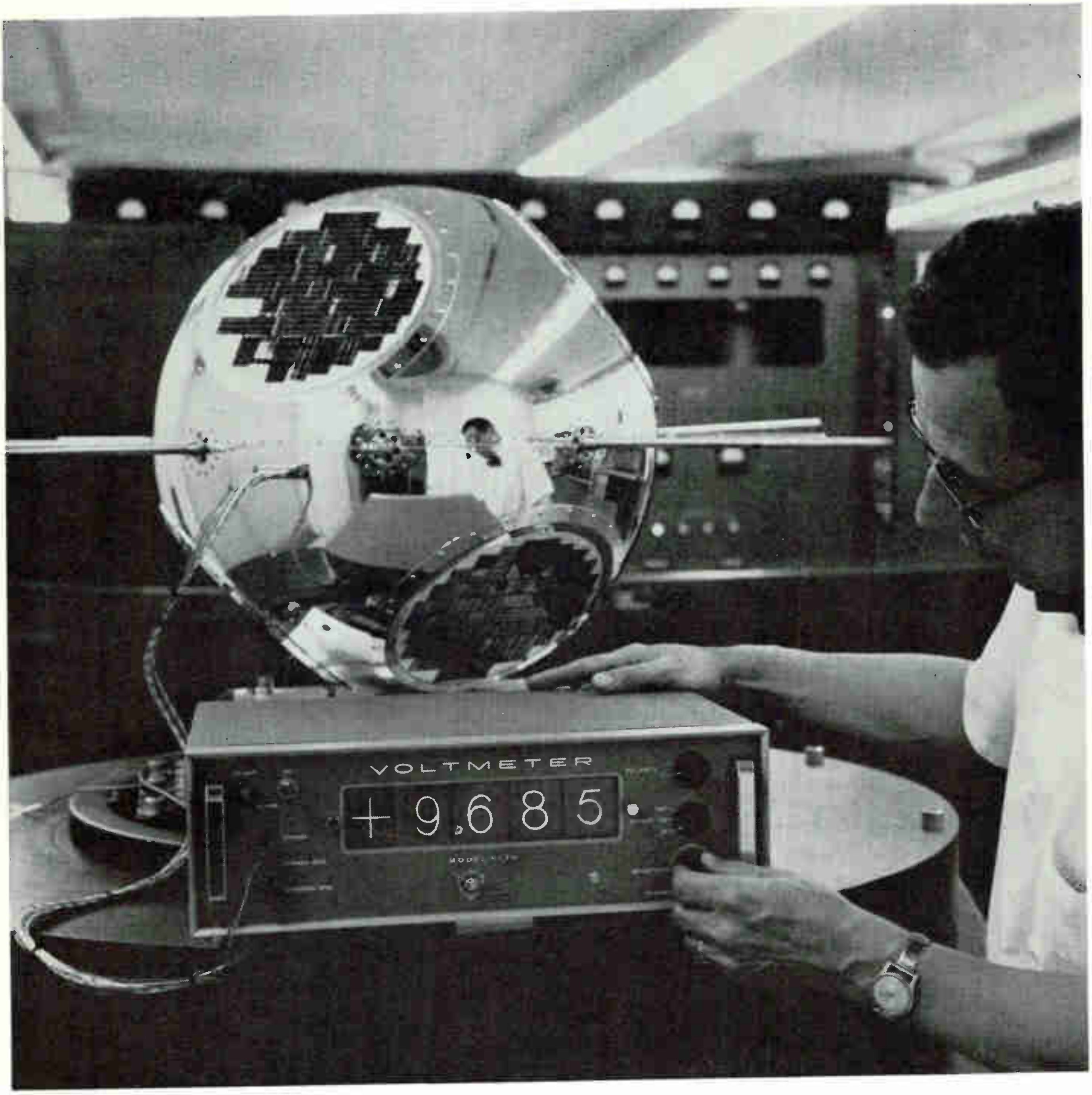
Mr. Weiss's acknowledgement read: "This study was performed in the course of a Training Program in Cardiovascular Research Techniques directed by R. F. Rushmer . . . of the University of Washington Medical School and supported by . . . the National Heart Institute, National Institutes of Health, Bethesda, Md."

Medical Electronics

Our attention has been called to the article "Medical Electronics", Part IV, in the June 23rd edition of your magazine ELECTRONICS.

We have read the article and our therapists are anxious to know if reprints are available. Many times we find the need to use such information when suggesting the use of a hearing aid to our patients. We do not offer the service of hearing aid evaluation, but we feel that the clarity of information in your article may help patients in their selection.

LONNIE K. LEAMAN, R.N.
THE HEARING CONSERVATION
CENTER OF LANCASTER COUNTY
LANCASTER, PA.



NEW DVM CONCEPT!

FAST: *Two readings per second* ***ACCURATE:*** *0.01% accuracy* ***LOW COST:*** *Only $1,580*

In the above test of a satellite's telemetry and solar cells, it was necessary to make 100 accurate measurements every minute. The job was done with the new Cubic V-70 digital voltmeter that reads out four times as fast as any instrument with stepping switches. The V-70 uses ultra-reliable reed relays hermetically sealed in glass for a life expectancy of at least 10 years. It has no moving parts, requires no maintenance, will operate in any position, and is resistant to thermal and physical shock. The V-70 is the only DVM offering 0.01% accuracy and less than 1 second balance time for less than $2,000 (Model V-70, $1,580; Model V-71 with automatic ranging and polarity, $2,200). For details, write to Dept. E-107.

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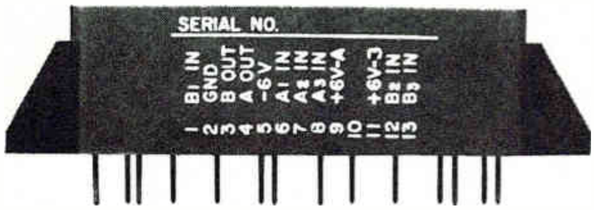
CIRCLE 7 ON READER SERVICE CARD



In less time than it takes light to cross this room, a new product, **DELCO'S NEW** high speed **10 MC** silicon modules, could: (1) correct the course of a missile in flight; (2) make it possible for sonar pickups to track and compute the position of targets with microsecond accuracy; and (3) handle any number of other airborne guidance and control functions that previous modules—due to low speed or environmental or performance limitations—could not handle. Delco Radio's 10mc modules, with a maximum gate-switch speed of 40 nanoseconds, convert data 100 times faster—even under the most extreme environmental conditions.

These **SILICON** modules come epoxy encapsulated, and operate over a temperature range of −55°C to +100°C. And these same reliable **DIGITAL** circuits are available packaged on plug-in circuit cards. These Delco **MODULES** are environmentally proved to: **SHOCK,** 1,000G's in all planes. **VIBRATION,** 15G's at 10 to 2,000 cps. **HUMIDITY,** 95% at max. temp. **STORAGE AND STERILIZATION TEMP.** −65°C to +125°C. **ACCELERATION,** 20G's. Designed for systems using from one module to 100,000, and the module's rated performance considers the problems of interconnection. Data sheets are available. Just write or call our Military Sales Department.

Physicists and electronics engineers: Join Delco Radio's search for new and better products through Solid State Physics.

PIONEERING ELECTRONIC PRODUCTS THROUGH SOLID STATE PHYSICS

Division of General Motors • Kokomo, Indiana

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DEPENDABILITY
RELIABILITY

ELECTRONICS NEWSLETTER

Miniature System Tracks Planet in Daylight

GENERAL PRECISION's Librascope division reports development of a 10-pound passive star tracker sensitive enough to track Venus in broad daylight. Containing no mechanical parts in its light-sensing system, it can track visible or infrared radiation.

The system uses an ITT FW-118 multiplier phototube. When a star is intercepted, the tracker generates an electron image of the target star image focused on the photocathode. Signal pulses from the tube are processed to derive angular error intelligence. This is accomplished by the magnetic fields of a deflection yoke, which sweep the electron image across an aperture plate in front of the first dynode.

Subsystems are synchronized by a master clock, eliminating changes due to ambient conditions. The tracker's output can be either digital, for computer processing, or analog, for servoing in a null-seeking system. Power consumption of the basic device is less than four watts, pointing accuracies are reported to exceed one-half second of arc with 40-inch focal-length optics. The tracker occupies only 150 cubic inches of space.

Solar Cell Converts Blue Light of Space

"BLUE" SOLAR CELL, named for its greater response to the blue region of the light spectrum, is announced by Hoffman Semiconductor. In space, most of the sun's energy is in the blue region. The cell is reported to be 15 percent more efficient than present units, delivering up to 10 watts per square foot, and more resistant to radiation. It has a thinner diffused surface in line with findings that thin junctions better withstand nuclear radiation.

Development of the cell and production processes were expedited by a solar simulator that almost exactly duplicates sunlight in space. Two light sources are used, a xenon tube for light heavy in blue and a tungsten lamp for light largely in the red area of the spectrum. Filters, lenses and a pyrheliometer, which senses total light energy regardless of color content, complete the simulator.

Submerging Seismograph Improves Sensitivity

BACKGROUND NOISES that limit the sensitivity of seismographs are almost eliminated when the instrument is on the ocean floor. The technique was demonstrated successfully recently by Lamont Geological Laboratory, which recorded an earthquake on an instrument three miles underwater near Bermuda.

Lamont performed the experiment under a contract with Air Force Cambridge Research Laboratory, under the Vela-Uniform project. The project is a basic research phase of the Vela nuclear explosion detection program (ELECTRONICS, p 30, June 16).

A seismometer, amplifier, f-m transmitter and batteries were enclosed in a 14-foot long underwater device wtih a nose cone and spike at one end and tail fins on the other. Signals were transmitted to the surface by acoustic telemetering.

Company Converts to All-Welded Modules

ELECTRONIC TIMERS made by the A. W. Haydon Co. of California will use welded modules. The company said it will convert its entire line to production techniques that eliminate all soldering, developed jointly with MIT and Space Technology Labs.

Components are stacked between two Mylar films. Leads projecting through the films are interconnected by resistance-welded nickel ribbon, producing a strong, compact structure. The company said the technique eliminates thermal and mechanical stress on components during production and also cuts down size and weight.

Color Tv Tube Makes Set Five Inches Thinner

AFTER A TWO-MONTH crash development program, Motorola introduced last week a working prototype of their new 23-inch, 90-degree, rectangular color tv tube. Result is a color tv set about five inches shallower than sets using the conven-

FCC Sees Satellite Communications in 1963

EXPERIMENTAL SATELLITE communications system for telephone, telegraph and tv should be operating "sometime in 1963", the House Interstate Commerce Committee was told last week by FCC Commissioner T. A. M. Craven.

The system would relay messages and programs over areas not serviced by land communication lines. Craven said a satellite capable of broadcasting tv directly to home receivers is some 20 years away.

Asked if Russia is trying to develop a similar system, Craven answered: "The information we have is negative".

Earlier, FCC invited the following international communications firms to join a planning committee, in line with a presidential directive (see page 12): American Cable and Radio and its subsidiaries, AT&T, Hawaiian Telephone, Press Wireless, Radio Corp. of Puerto Rico, RCA Communications, South Porto Rico Sugar, Tropical Radio Telegraph, U. S.-Liberia Radio and Western Union. FCC dismissed, without prejudice to future consideration, petitions for consideration from General Telephone and Electronics and GE.

tional round television picture tube.

Motorola says it spent nearly $100,000 developing the tube, but has no plans to manumacture it. Instead they are offering complete production knowhow to any and all tube manufacturers, hoping to provide sales impetus to the color tv market.

Company sales executives estimate the short-necked tube could boost color sales from five percent to 10 percent of the total tv receiver market.

Thin-Film Registers Use Magnetic Transfer

ABSENCE OF INERTIAL elements in thin-film magnetic shift registers allow them to be synchronized with data processing units having widely varying information rates, according to American Systems Inc., Hawthorne, Calif. Digital information is translated through the surface without physical movement or conversion of magnetic information to electrical signals. The company recently demonstrated operational prototypes measuring about one by three inches, with memory capacities of 128 to 256 bits and operating frequencies to 1 Mc.

Numerical Control and Servos Automate Grinder

THREE HUGE automatic roll grinders will soon be in operation at the new hot mill of Great Lakes Steel Corp., Detroit. The machines will dress identical pairs of steel rolls up to five feet in diameter. Built by Farrel-Birmingham Co., Ansonia, Conn., the grinders use a GE numerical control with special closed-loop probe and servo system.

The control system compensates for the fact that, unlike other machine tools, grinders have a cutting tool that is not dimensionally stable and follows the surface of the work. In the new machine, probes first measure the worn roll. The lowest point on the diameter is memorized. Highest spots are knocked down, then the roll is rough and finished ground.

During the grinding operation, probe systems keep the roll aligned and also monitor wheel wear and dressing between passes.

The roll that is most worn is ground first. Its dimensions after grinding are then duplicated on the second roll of the pair. The rolls, used for forming hot steel, must match or strip will not be straight and flat.

Cadmium Telluride Solar Cells May Resist Heat

CADMIUM TELLURIDE maintains its conversion efficiency up to temperatures of 1,200 C and has lifetime and absorption characteristics superior to other semiconductors for solar cells. That's the gist of a report from Armour Research Foundation, which is studying the compound under a Signal Corps contract.

Robert Robertson, physicist in charge of the study, says cadmium telluride should permit satellites to carry fewer solar cells.

Satellites carrying silicon cells required redundant arrays (9,000 cells on Tiros II, 6,000 on Explorer 6), he said, because silicon is relatively inefficient and short-lived above 200 C. The group doing the studying also plans basic research into applications other than solar cells.

One Tiros Camera Fails, But Another Takes Over

CAMERA NUMBER ONE of Tiros III weather observation satellite failed last week after the satellite's 170th orbit. The camera had taken 2,020 cloud cover photographs of "excellent quality" since launch on July 12, NASA reported. A duplicate wide-angle photo system in the satellite was put into fulltime operation. At last report, Tiros III had transmitted more than 3,500 photos, Tiros II has sent 37,000 and Tiros I transmitted more than 22,000.

The heat budget measurement experiments in Tiros III are continuing to operate satisfactorily. These experiments indicate how much solar radiation is reflected by the earth's surface and the earth's surface atmosphere.

In Brief . . .

NATIONAL AUDIO VISUAL Convention was held in Chicago last week. The score: 3,500 delegates, 175 sponsoring firms, 230 booths exhibiting audio-visual aids aimed at educational and industrial markets.

POLARIS MISSILE arming and fuzing development accounts for $4.5 million of $11.2 million in new defense contracts for Avco.

NEW BILLING and collection system developed by New York Telephone Co. will use 17 optical scanning, electronic reading machines from Farrington Electronics.

HALF-MEGAWATT, programmed, regulated d-c power supply for Argonne National Laboratory will be built for $85,000 by Continental Electronics, a Ling-Temco subsidiary. Firm is also building a 5-megawatt r-f driver for the lab's 12.5-Bev proton synchronton.

U. S. NAVY reportedly has begun construction of $100 million trans-Pacific radio station in northwest Australia. Said to be more powerful than the Cutler, Maine, station, it will have a 3,000-foot-high mast.

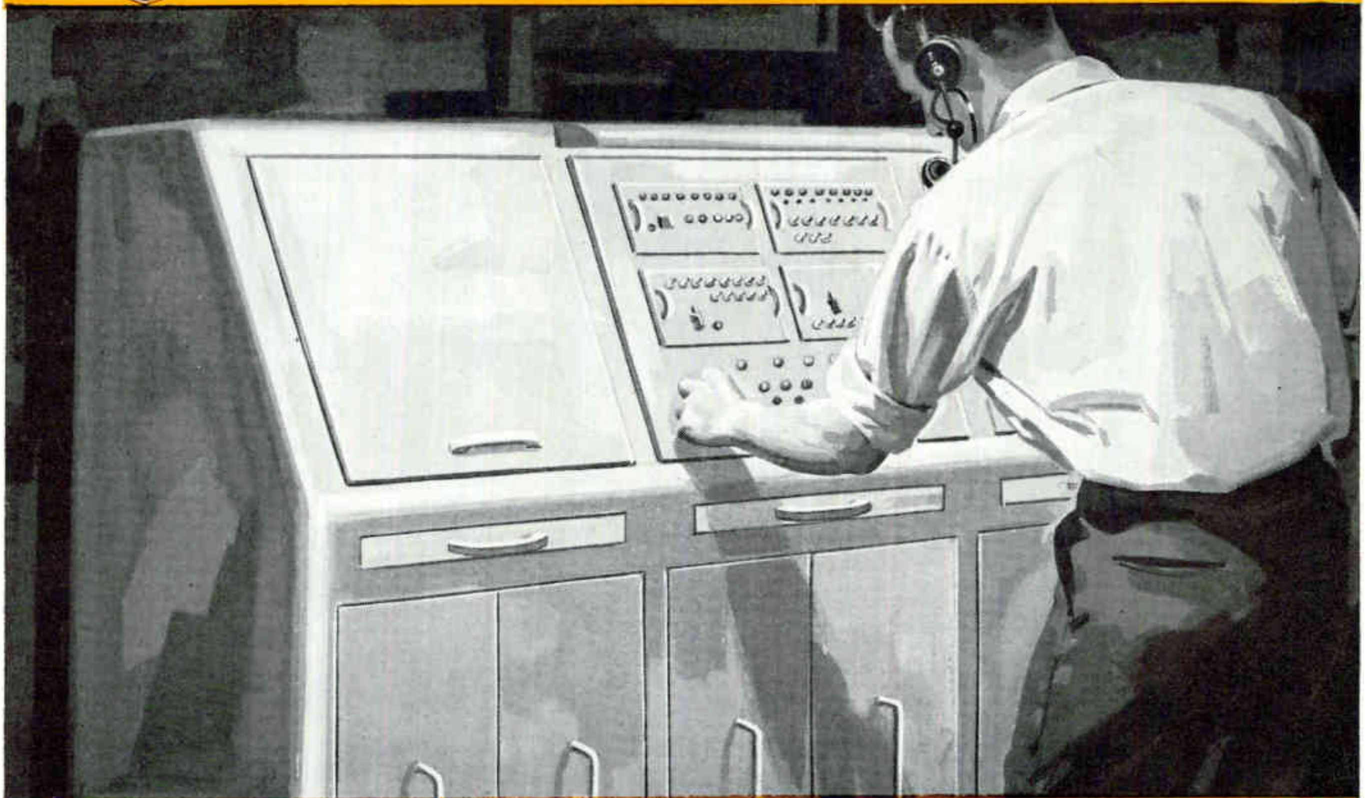
DEVELOPMENT of a Mach-3 airliner by 1970-71 is called feasible in report issued by DOD, NASA, and FAA. Market for 200 such planes is seen.

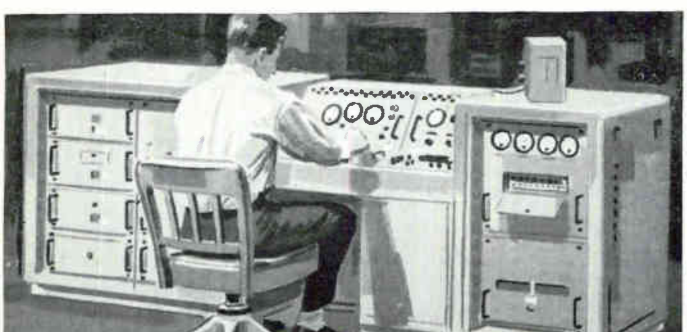
SCIENTISTS from 14 nations, including Russia, meet at Cal Tech next week for International Symposium on Space Age Astronomy.

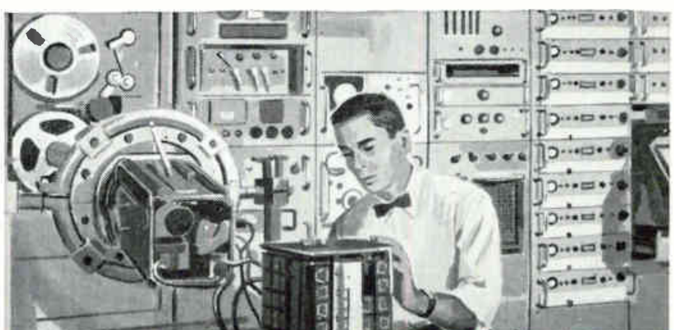
SPERRY RAND announces new input for Univac 490 real-time systems. Input enables Univac to handle posting and records-keeping for up to 4,096 bank tellers.

ON AUGUST 1, phase of time signals broadcast from NBS stations WWV and WWVH were advanced 50 milliseconds to correspond to Universal Time (UT-2).

EIA OF JAPAN reports that the 4th Annual Japan Electronic Parts Show will be in Tokyo, Oct. 17-22.







WASHINGTON OUTLOOK

KENNEDY ADMINISTRATION'S new defense buildup will boost sharply output of combat communications equipment and other tactical military electronics gear. Just a few weeks ago, the Army informally told Congress it needs an extra $101.9 million this year to buy electronics equipment (portable radar and communications systems, photos). Much of this sum, plus funds for the Navy and Marines, is included in the $1.8 billion now added to the current defense budget.

The plan to step up hardware buying and expand the Army bears the imprint of Presidential Adviser Maxwell D. Taylor's thinking. It changes earlier ideas of only a minor hike in hardware production. No extra funds are earmarked for strategic forces.

PENTAGON is authorized to use the added funds only for items which can be ordered and delivered within the next 10 to 12 months. The idea is to crank out extra goods from current production lines. Few if any new suppliers will be brought into the fold in this extra round of buying.

But the new defense plans will boost total procurement this year to close to $17 billion, highest since World War II. This rate will be maintained and possibly increased in the years ahead, barring any arms control agreement or easing of world tensions.

ELECTRONICS INDUSTRY is assured a multi-million dollar chunk of business from development and operation of a satellite communication system. The White House recently laid out requirements that broadened the system's scope substantially. It must provide tv transmission and service to the world, including areas that won't bring initial economic returns. In extending the peaceful space service to under-developed areas, the government commits itself to underwriting a large share of the increased cost, in the next 5 to 10 years.

President Kennedy wants the satellite system in service at the earliest possible date. FCC hurriedly called on the 10 or so international communications companies to form an ad hoc committee to prepare a proposal for industry ownership of the system by October 13.

Additionally, the White House stipulated that: industry ownership and operation is desired, but the government will keep strict controls on the system through NASA and FCC; economic gains from the system must be reflected in rates charged for its use; and ownership of the system must be shared with foreign companies, with no carrier dominating the organization. Competitive bidding must be used in equipment purchases with all records of the joint venture organization available for inspection.

BURGEONING of the electronics industry in the Washington metropolitan area shows up in a new directory of scientific-type organizations located here, just published by the Board of Trade. It lists 190 R&D organizations employing 21,000 persons. Sixty-two firms are engaged in design, development, or manufacture of electronic products and systems, with 9,700 employees.

Here are two new -hp- couplers that can speed and simplify your reflectometer, mixing and power sampling work

Two models:
250 to 1,000 MC,
1 to 4 GC

Higher resolution due to higher directivity
Flat ½ db dual directional coupling
2-octave range for broadband convenience, minimum system reassembly
High power capacity, low SWR that makes permanent installation practical

IN REFLECTOMETER measurement of reflection coefficient and SWR you get better resolution due to new higher directivity, plus the convenience of needing only one coupler for measuring over a broad range, and in both directions.

IN POWER SAMPLING, flat coupling full range eliminates coupling corrections; you have, again, the convenience of one unit for both incident and reflected power, plus high power handling ability, low SWR and low insertion loss making practical a permanent monitoring installation in transmission lines.

SPECIFICATIONS *Model 760D, 250 to 1,000 MC,* mean coupling 20 ± ½ db, coupling variation ± ½ db, minimum directivity 35 db, primary SWR (max.) 1.20, secondary SWR (max.) 1.25, power capacity 50 w CW, 10 kw peak, Type N connectors, price, $200.00. *Model 761D, 1 to 4 GC,* same except directivity > 30 db, primary SWR 1.25, secondary SWR 1.30, price, $185.00.

SINGLE OCTAVE DUAL DIRECTIONAL COUPLERS FOR USE WHERE BROADBAND WIDTH NOT REQUIRED

Model	Range	Minimum Directivity	Primary SWR (maximum)	Secondary SWR (maximum)	Price
764D	216-450 MC	30 db	1.10	1.20	$160.00
765D	450-945 MC	30 db	1.15	1.20	160.00
766D	940-1,975 MC	26 db	1.20	1.30	150.00
767D	1,950 MC-4.0 GC	26 db	1.25	1.50	150.00

Mean coupling 20 ± ½ db; coupling variation ± 1 db, power handling capacity 50 w CW, 10 kw peak; Type N connectors.

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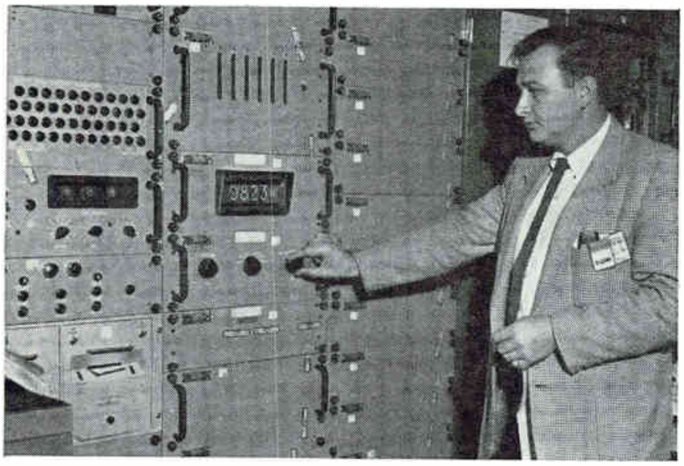
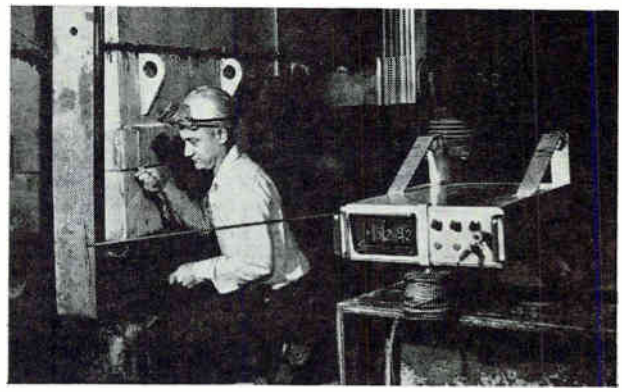
CIRCLE 13 ON READER SERVICE CARD

FINAL PRODUCTION TESTING. Zener diodes are checked by NLS M24s at final testing stations of Hughes Aircraft Company's Semiconductor Division.

CHECKOUT OF MISSILE COMPONENTS. An M24 checks electronic components at Autonetics, a division of North American Aviation, Inc., as part of the High Reliability Program for Minuteman ICBM. The operator is shown measuring resistance. By turning a front panel knob on the M24, she can also measure DC voltage or DC voltage ratio.

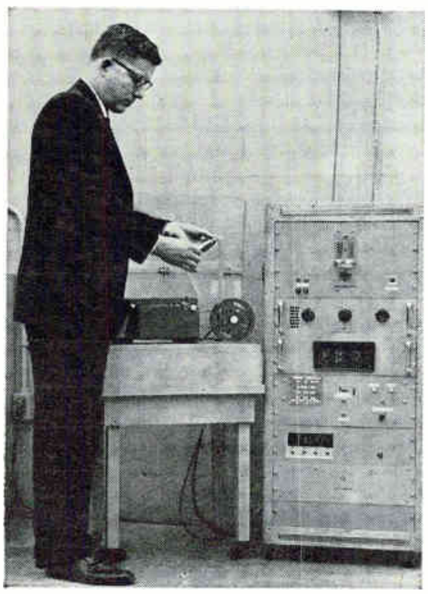


MISSILE PRODUCTION TESTING. An NLS M24 Multi-Purpose Instrument performs an important part in the missile functional test system at Boeing Airplane Company's Missile Production Center in Seattle, Wash. The system automatically applies more than 400 go/no-go sequenced tests to ground-check missile flight reactions from launch to intercept. The M24 and the printout portion of the system monitor application of test stimuli and isolate malfunctions.

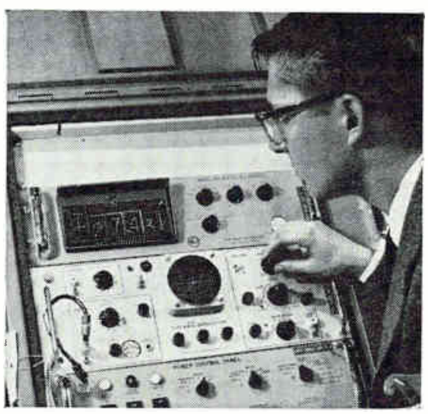


ELECTRO-CHEMICAL ANALYSIS. Savings of as much as $8,000 a year on one particular project are expected to result from use of an NLS 481 DVM at Diamond Alkali Company's plant in Deer Park, Texas. By accurately measuring small changes in voltage and voltage drop, it permits optimizing the efficiency of producing chlorine from sodium chloride brines by electrolysis.

ACCEPTANCE...

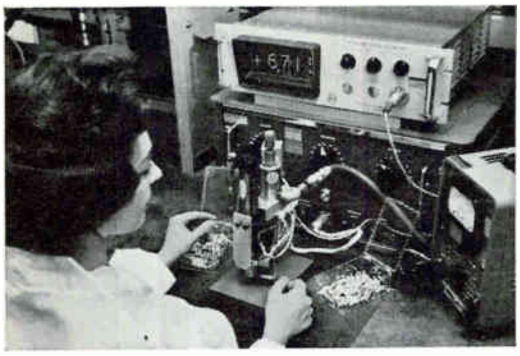


PETROLEUM RESEARCH AND DEVELOPMENT. This precision data logging system, incorporating an NLS V24 DVM, has served Esso Research Laboratories for more than two years in around-the-clock service. The V24 converts millivolt signals to digital form for operating a Friden Tape Punch. The system aids in making pilot plant studies of industrial processes.



MISSILE TRACKING SYSTEMS. The Azusa Test Set, designed by General Dynamics/Astronautics, A Division of General Dynamics Corporation, includes an NLS V35 DVM. This set checks the power and transmitter portions of the airborne package of the system which is used for tracking all missiles launched from Cape Canaveral. Functions of the V35 include monitoring of 28-, 100- and 1,500-volt power supplies; calibrating telemeter transducers; and adjusting Klystron beam, bias and modulator voltages.

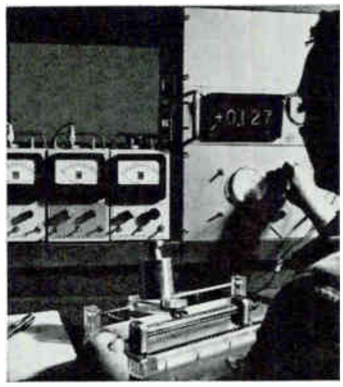
SPACE MEDICINE RESEARCH. In simulated space environment testing, this NLS V34 digital voltmeter is part of a system which detects and records minute changes in body weight, a key factor in determining physiological strain. The unique "No Needless Nines" logic of the V34 permits measurements at pre-selected time intervals with an accuracy of ±3 grams within a range of ±4,500 grams. AMF's Mechanics Research Division developed the overall system under direction of the Air Force's Aeronautic Systems Division at Wright-Patterson AFB in Ohio.



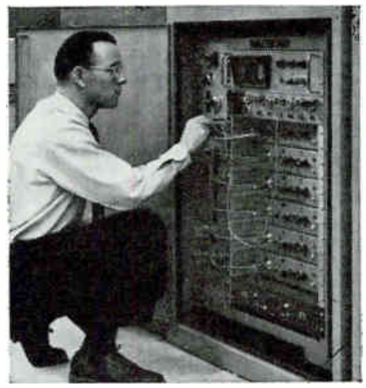
PRODUCTION TESTING. A 481—one of a battery of NLS DVMs—measures Zener diodes for separation into voltage categories at the Semiconductor Products Division of Motorola, Inc. Measuring speed for this operation was doubled by use of the NLS digital voltmeters.

MISSILE CHECKOUT. Two NLS DVMs team up on checkout of equipment for the GAM-77 Hound Dog Missile at the West Coast Laboratories of Mallory Electronics Company, A Division of P. R. Mallory & Co. Inc. The 481 (bottom) calibrates remotely settable timers for the Hound Dog and the V35 (top) is used for final checkout of these devices. "By using DVMs, we are able to eliminate human error in final inspection," said a Mallory executive.

QUALITY CONTROL OF ELECTRONIC COMPONENTS. More than 50 NLS 481 digital voltmeters are used in the Quality Assurance Program at the Semiconductor-Components Division of Texas Instruments Incorporated. The instrument pictured is measuring breakdown voltages of high-reliability germanium switching devices.



MATERIALS EVALUATION. Electronic Chemicals Division of Merck & Co., Inc., uses a 481 DVM to reduce testing time for determining resistivity of single crystal silicon.



A-TO-D CONVERSION IN INDUSTRIAL PROCESSING. A 481 DVM operates an analog-to-digital converter in a variance computer for Saran Wrap production at The Dow Chemical Company's Saran Wrap plant in Midland, Mich.

sign of superiority in digital voltmeters

If you measure or record voltage, consider the broadening applications of digital voltmeters as indicated by these examples. The NLS instruments shown here . . . and the thousands of others in action today . . . tell a story of acceptance that is three-fold:

1. The digital voltmeter—first unique instrument since the development of the oscilloscope and vacuum tube voltmeter—has become a *basic measuring and logging tool* since its origination by Non-Linear Systems, Inc., nine years ago.

2. NLS digital voltmeters have been *proved in use* by many of the most discriminating companies in the electronics and allied industries.

3. Most of these firms have *specified NLS again and again,* some owning more than fifty instruments . . . evidence of the acceptance of NLS, as well as the usefulness of the product it manufactures.

Our point: it makes sense to contact the most experienced manufacturer of digital voltmeters to meet your measuring and data logging needs. Select from the world's most complete line . . . by purpose . . . by price. NLS offers 16 basic models—all with exclusive features—from a low-cost "Industrial" type instrument to a $6,150 all-electronic DVM that makes 200 readings per second. For the most complete and authoritative information available on DVMs, contact your local NLS office or rep, or write NLS.

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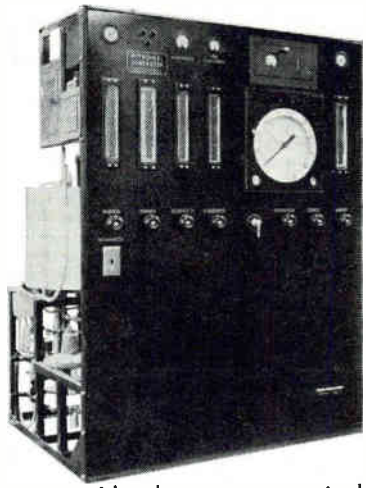

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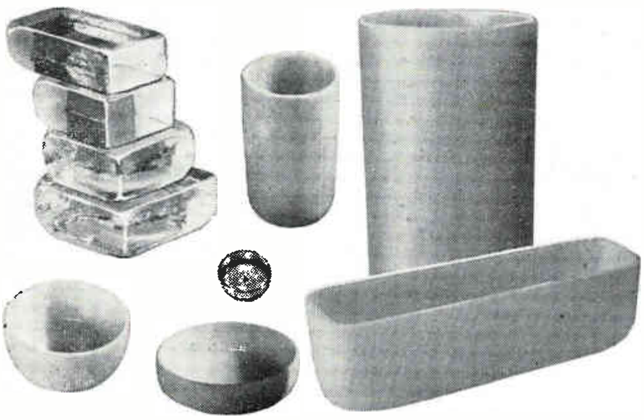

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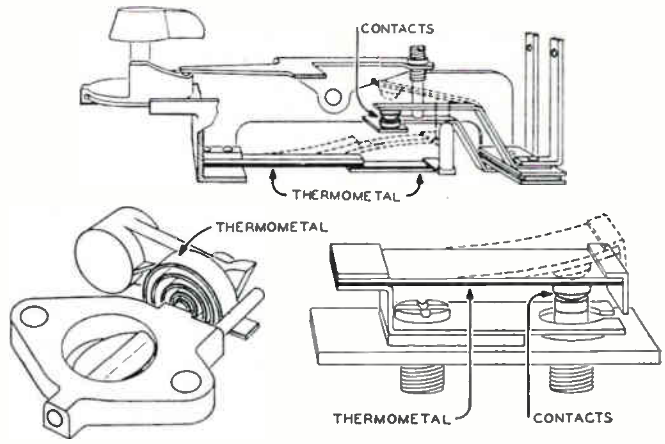

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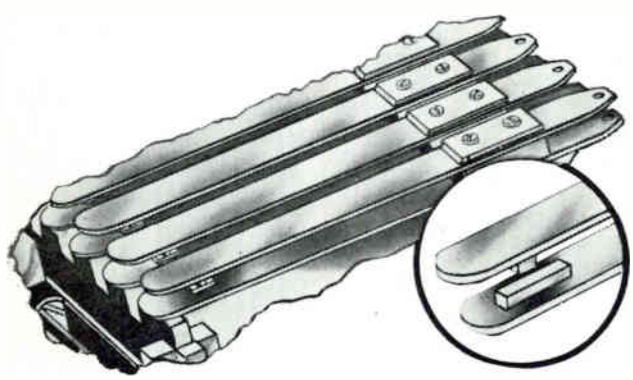

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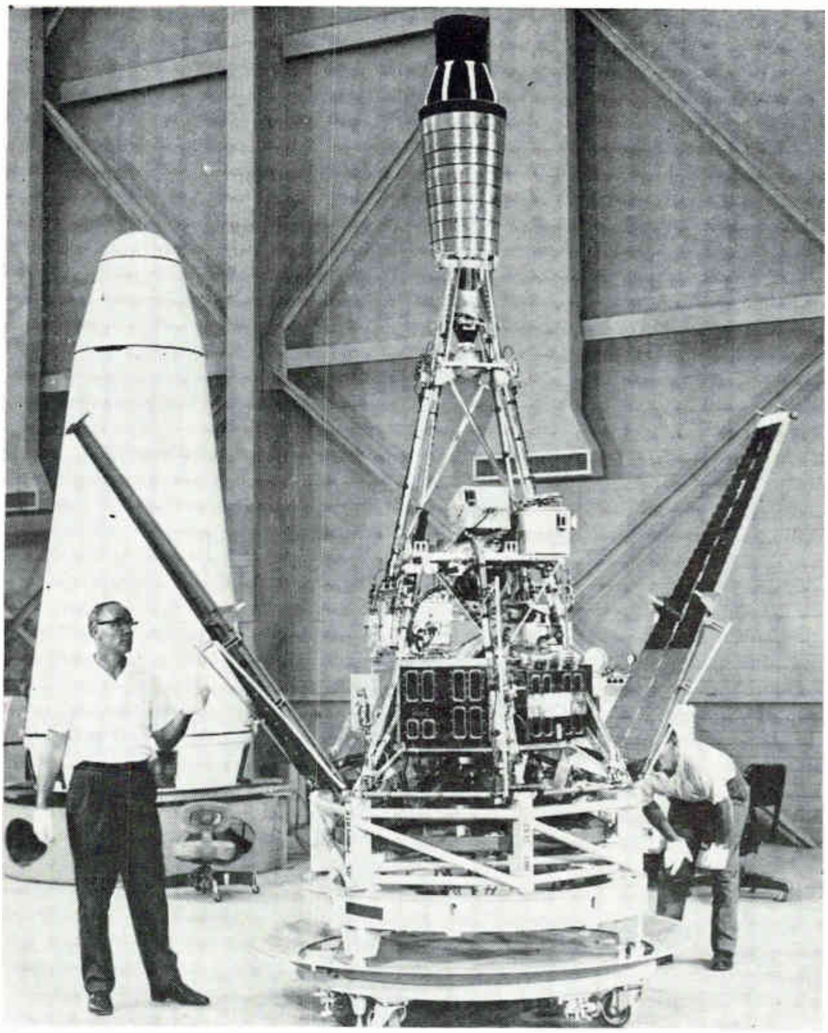
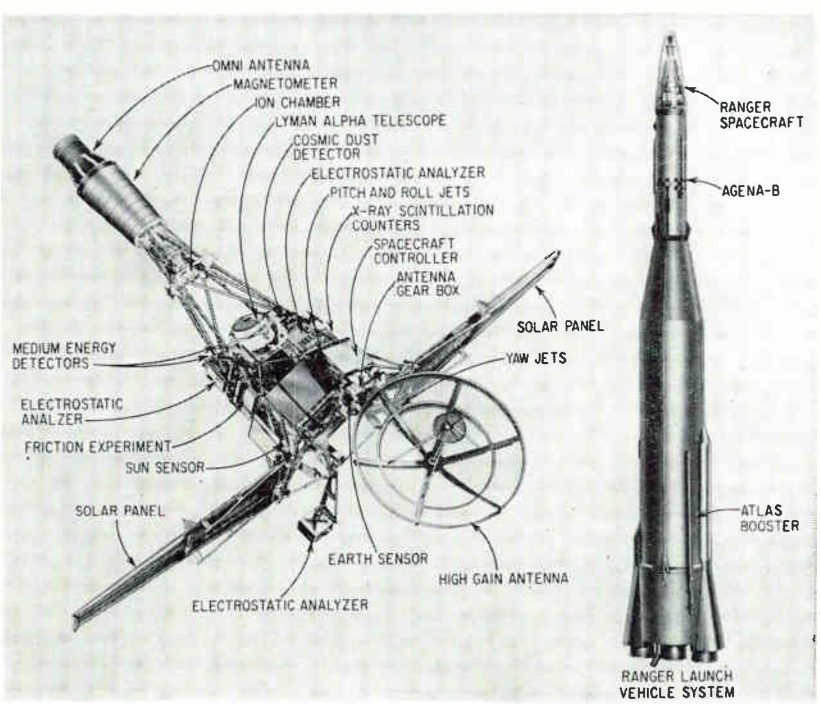


Once in space, solar panels will unfold, lock on to sun, deliver power to craft. Each panel contains 4,340 solar cells



Eight experiments and auxiliary gear (left) are boosted into orbit atop Atlas-Agena B (right)

Ranger: First

TO THE ELECTRONICS INDUSTRY, the importance of the first Ranger space shot is the release of design details of the craft that will be almost standard for a long generation of spacecraft. The hexagonal-shaped configuration will carry standard, or close to standard, electronics and other instrumentation on many missions, the National Aeronautics and Space Administration says.

Primary purpose of the first Ranger shot is to develop and test basic elements of spacecraft technology for later flights (ELECTRONICS, p 24, June 23). These include an attitude stabilization system based on celestial references (the sun and earth), high-gain pointable antenna, advanced communication system, development of components able to operate for long periods in space and calibration of solar cells in space.

As a secondary mission, the first shot will carry eight scientific experiments (described in detail in ELECTRONICS, p 38, Dec. 16, 1960): solar corpuscular radiation experiment, medium-energy-range particle detectors, cosmic-ray ionization rate measurement, triple-coincidence cosmic-ray experiment, magnetic-field experiment, solar x-ray detection, neutral hydrogen geocorona and cosmic-dust detectors.

Since the two-fold mission of the first Ranger shot does not actually involve the moon, the craft will be put into a highly eccentric orbit with an apogee of 685,000 miles, a perigee of 37,500 miles and an orbital period of 58 days. It may burn up on reentering the earth's atmosphere or it could possibly reach earth-escape velocity and go into orbit around the sun.

The craft will be launched by an Atlas-Agena B rocket. The Atlas D booster, guided by radio command, will burn out when the vehicle is about 80 miles high and some 350 miles down the Atlantic Missile Range. During a 25-sec coast phase, the shroud protecting the Ranger is separated by a series of springs. Next, small explosive charges release the Agena (carrying the Ranger) from the Atlas. The Agena pneumatic control system begins a

# of a Line of Space Travelers

By JOHN F. MASON,
Associate Editor

pitch maneuver to orient the vehicle into an attitude horizontal to the earth. The timer then signals ignition of the Agena engine.

At engine start the hydraulic control system takes over, keeping the vehicle horizontal during the 2½ min the engine is operating. The infrared horizon sensor sends corrections to the control system.

At engine cutoff, the Agena is in a near-circular, 100-mi, parking orbit. It coasts for about 14 min. Then the timer again signals the Agena engine to begin a 1½-min burn operation. About 2½ min after shutdown, Ranger is separated from Agena by springs. It should be traveling 23,800 mph.

The Agena guidance is made up of timing devices, inertial reference platform, velocity meter and ir horizon sensing device.

The Ranger craft is slightly more than five feet in diameter at the base of the hexagon and 11 feet long. In its cruise position, with its solar panels extended, it is 17 feet in span and 13 feet long. Weight is 675 lb of which 243 lb consists of electronics (Ranger has 19,520 electronic parts), 144 lb of scientific experiments, 50 lb of solar panels, and 238 lb of structure.

The craft has two radio transmitters (3-watt and ¼-watt, both transmitting on frequencies near 960 Mc), one omnidirectional antenna at the front end of the craft and a high-gain directional antenna 4-ft in diameter at the base of the craft aimed at the earth.

Two solar panels, each about 10 sq ft, contain 8,680 solar cells. Converted energy is expected to provide from 155 to 210 watts.

To determine how much solar energy can be collected, the performance of four specially calibrated solar cells will be telemetered back to earth. A 125-lb silver zinc battery with a capacity of 9,000 watt hours (capable of running the craft for two days) will be carried to run the spacecraft prior to acquiring the sun and in case of solar panel malfunction.

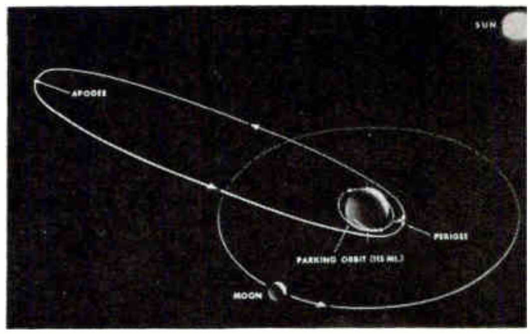
Six electronic boxes on each side of the hexagonal base contain the electronic intelligence of Ranger 1. One of the most important of these instruments is the spacecraft controller that calculates electronically when specific functions should be performed, how the craft should roll and pitch to find the sun, how to find the earth to aim its directional antenna and other functions.

The controller is an electronic solid-state timer. The 1-pps timing reference is divided from a 400-cps power supply. These pulses are accumulated in a storage device. The unit also contains a memory device with a preset series of triggers.

When the accumulated pulses per second match the preset count stored in the memory device, a relay is closed and the controller issues a command for Ranger I to perform. There are ten commands, hence ten channels and ten relays. Here is what each one does and when it does it:

(1)—25 min after the controller was started, which was 3 min before launch—increases the power being sent to the large transmitter from 1.5 watts to 3 watts. (2)—35 min—turns on solar corpuscular detectors. (3)—36 min, 40 sec—extends the electrostatic analyzer package in a small box on a small boom about 4 ft from the spacecraft; also, extends solar panels. (4)—61 min, 40 sec—turns on attitude control system; sends power to the sun sensors, cold gas jets and gyroscopes. Solar panels lock on to sun. (5)—90 min—starts Ranger looking for earth with three multiplier phototubes mounted coaxially with directional antenna.

(6)—118 min, 20 sec—changes the scale factor of a telemetry measurement which informed earth stations of Ranger's wobbling right after separation from Agena; since wobbling is now much decreased, the scale factor is adjusted. (7)—200 min—changes scale factor in one of the radiation instruments to provide a finer measurement. (8)—250 min—transfers data being sent by the 3-watt transmitter from the omnidirectional to the directional antenna. (9)—366 min—reduces rate at which the ¼-watt transmitter sends data. (10)—370 min—turns on engineering experiment to determine friction forces in operating machinery in a hard vacuum.



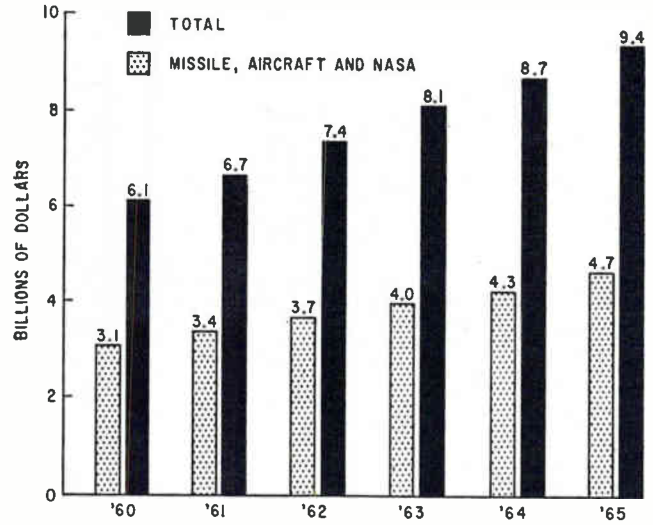
Ranger will first go into parking orbit, then eccentric earth, or solar, orbit

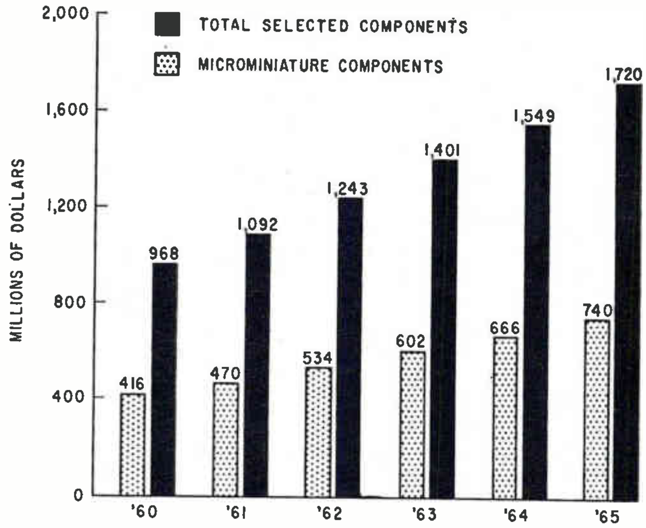
THE JET PROPULSION LABORATORY is responsible to NASA for the design and operation of Ranger. Eighteen subcontractors to JPL provided instruments and hardware:

AMERICAN MISSILE—telemetry encoders, power switching and logic assembly; APPLIED PHYSICS—dynamic capacitor; CONSOLIDATED SYSTEMS—Lyman Alpha telescope; HOFFMAN ELECTRONICS—solar cells; HORKEY-MOORE—spacecraft system test stand; INTERNATIONAL TELEGRAPH AND TELEPHONE—static power converter modules; LEACH—telemetry checkout; LOCKHEED AIRCRAFT — prototype sterilization cart; MOTOROLA—transponders and radio command program.

NORTRONICS—sun and earth sensors; RADIAPHONE—scientific instruments, ground support equipment; RADIATION INSTRUMENT DEVELOPMENT LAB.—channel pulse height analyzers, ground support equipment and decoders, power supplies; SERVOMECHANISMS—electro gating system; SPACE TECHNOLOGY LABS.—scientific instruments, engineering services; SPECTROLAB—Lyman Alpha mirror; STATE UNIVERSITY OF IOWA—radiation detector.

TEXAS INSTRUMENTS—ground support equipment, flight data encoders; UNITED ELECTRODYNAMICS—pole beacon encoders, flight friction and ground test sets. In addition, 1,500 other firms contributed to the Ranger program. The cost of these supplies was to $12 million.





RCA's estimate of mocrominiature sales is based on total electronic expenditures by federal government. At left are expenditures for missiles and aircraft. At right is analysis of selected components

Microminiature Circuits: $1.2 Billion in 1965?

MARKET ESTIMATES of up to $1.2 billion in 1965 for microminiature equipment and components, made recently by RCA, are based on the prediction that significant consumer applications are still a few years away. This is also the feeling of most manufacturers engaged in microminiaturization programs. The general consensus is that use in large volume is coming first in military equipment and then, in three to five years, in consumer products.

However, at least one manufacturer is reported ready to introduce microminiature circuits to consumer markets this year. The manufacturer, Westinghouse, is expected to produce microminiature circuits at a volume level that will make the circuits competitive with conventional equivalents.

RCA announced its market forecast at a meeting with companies cooperating with the Signal Corps and RCA in the micromodule program (ELECTRONICS, p 9, July 21, 1961). The details were given to representatives of more than 50 companies. In addition, RCA announced that it is actively bidding for military contracts that involve high-volume use of micromodules. Micromodules are assemblies of small, standard-sized component wafers called microelements.

RCA's Semiconductor and Materials division estimates the total market at the component and module level as $0.9 to $1.2 billion for 1965. Military applications should account for about 80 percent.

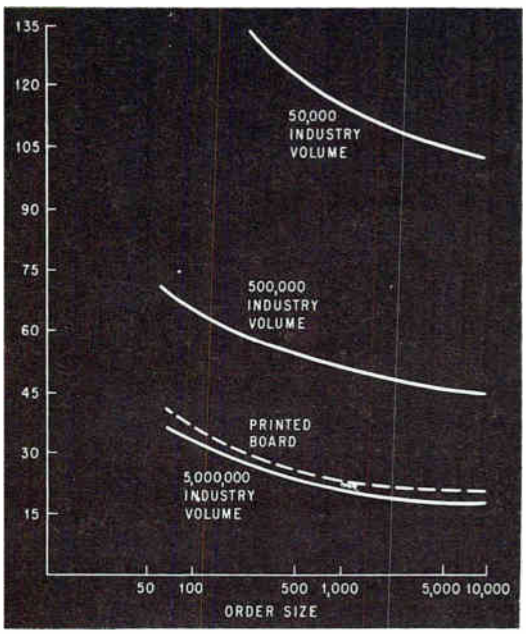
These figures are based on total projected federal electronics expenditures (which include all military procurement, NASA, FAA, AEC, MAPS and the Post Office Department), of $9.4 billion in 1965. Half of this $9.4 billion will be for missiles, aircraft and spacecraft, product groups likely to be miniaturized because of the demand for light weight and high reliability.

On the overall components level, federal expenditures for 1965 are expected to reach $1.72 billion. This figure is for tubes, semiconductors, resistors, capacitors, quartz crystals, transformers, connectors and relays but excludes antennas, microphones and similar items.

These components have been analyzed to find which are likely to be microminiaturized. It is estimated that the expenditures for microminiature components will reach $740 million in 1965.

At present, in the micromodule program, the components (microelements) account for 92 percent of the total module cost. This figure is expected to increase to 96 percent as module assembly techniques improve.

Cost of individual modules vary with circuit complexity and sales volume. At an industry volume of five million units, the approximate cost for a shift register in micromodule form would be a little less



Approximate cost of micromodule shift register is compared to military-type printed circuit equivalent than the cost of a similar unit in military-type printed boards. For an oscillator, volume of a few million units would make the micromodule package competitive in price. For a gate, the printed board version of the circuit would be cheaper even with an industry volume of over five million units.

Engineering and Science Advisory Council Urged

NATIONAL SOCIETY of Professional Engineers, meeting in Seattle, opposed the formation of a cabinet-level department of science within the federal government. Board of directors of the 56,000-member society asked for legislative reorganization of engineering and scientific activities in the White House. A national advisory council was proposed. The council, NSPE said, would serve as liaison between government and the scientific and engineering community and would improve federal interagency cooperation.

Publication of a 148-page study of engineers in industry in the 1960's was announced. One of the findings is that, with the exception of lawyers, engineers are better paid than other professionals in industry. Since 1956, salaries of experienced engineers have increased faster than starting salaries and, since 1953, engineers salaries have gained on production workers. The old complaint that "I'd be better off in the shop" is no longer true, the report says.

GI Plans to Produce Ceramic Semiconductors

GENERAL INSTRUMENT Corporation announced last week the formation of a ferroelectric ceramics department to produce semiconductor ceramics and piezoelectric materials and components by newly developed processes. New products will include thermoelectric devices and thermistors, ultrasonic transducers, ceramic filter elements and other piezoelectric devices. The processes involve doping titanates with lead, zirconium, silica, strontium, magnesium and rare earths.

Air Force Programs $1/3-Billion-Plus For Ground Electronic

Tactical Aircraft Control and Warning System, 412-L, is one of nine large electronic systems USAF will push in 1962

AIR FORCE BUDGET estimate for fiscal year 1962 presented to the House Appropriations Committee earmarked a total of $370.5 million for nine electronic and telecommunications L-systems.

Tactical Aircraft Control and Warning System, 412-L, gets $32 million. A semiautomatic, air and ground transportable system, the 412-L provides detection of air targets, tracking and identification, evaluation of the air situation, and control of manned and unmanned weapons.

Production of equipment for the three tactical units—in Europe, the Pacific and in the U.S.—was begun with 1959 funds. The new $32 million will complete procurement of the data processing gear and will provide communications and ancillary equipment for the last of several sites of the 18-site program. GE's Heavy Military Electronics Dept. is prime contractor (ELECTRONICS, p 29, Apr. 17, 1959).

Continental Aircraft Control and Warning System, 416-L, will get $142.2 million. Function is to provide a control and warning system to detect and track aircraft or air-breathing missiles, identify them and direct and control defensive weapons such as manned interceptors, Bomarc and Nike missiles.

The new money will buy out the complete system, with the exception of a limited number of radars in subsequent fiscal years. Prior years' funds paid for approximately 85 percent of the system. The completed system will include 159 prime radars, 193 gap-filler radars, 26 Sage direction and control centers and identification and control gear. Western Electric is systems management contractor.

North American Air Defense Command (NORAD) Combat Operations Center, 425-L, is slated for an initial $12.3 million. The Center will have a data-processing system and provide displays and communications which will accept, consolidate and correlate data forwarded from command units. Contractors are Burroughs, system hardware; Mitre and System Development Corp., computer programming.

Air Traffic Control Support System, 431-L, for USAF bases where air traffic density is high, is programmed for $10.3 million. Equipment includes ground-based radars with tracking range up to 120 miles; radio transmitters; uhf beacons and direction finders. In prior years 10 surveillance radars have been bought.

The new money will buy eight more area surveillance radars, 85 high-powered transmitters for terminal area control, and miscellaneous radio gear. To complete the program of 26 surveillance radars, USAF is programming four for 1963 and four for 1964. More high-powered transmitters are programmed for 1963 through 1965.

Weather Observation and Forecasting System, 433-L, will need $7.7 million to buy 85 weather radars and 72 data converters. An additional 21 radars will be included in the fiscal 1963 budget. The new radars will extend the range of existing equipment from 65 to 200 miles. Data converters will translate the upper air weather information from electronic sensing devices. United Aircraft is prime contractor.

Strategic Air Command and Control System, 465-L, is programmed for $53.5 million. Development of the data processing, displays and communications gear for this system is essentially complete. New funds will be used to equip the centers at SAC headquarters and at March AFB, Calif. Four hardened sites are called for. Total estimated cost of the system is $355.2 million. Funding through 1962 amounts to $197.2 million. ITT is prime contractor (ELECTRONICS, p 36 Mar. 25, 1960).

Electromagnetic Intelligence System, 466-L, calls for $17.4 million for one of the collection subsystems, AN/GLR-1. Total estimated capital investment will be $215.7 million. $81.6 million is funded through 1962. RCA in association with IBM manages the system.

Ballistic Missile Early Warning System (BMEWS), 474-L, is programmed for $34.5 million to finish buying equipment for the Greenland and Alaska sites and provide a major portion of the tracking radars, computer and associated gear for the United Kingdom site. About 90 percent of BMEWS was paid for in prior fundings. No tracking ra-

Control Systems

dar is scheduled for Alaska. RCA in association with Western Electric is responsible for the system.

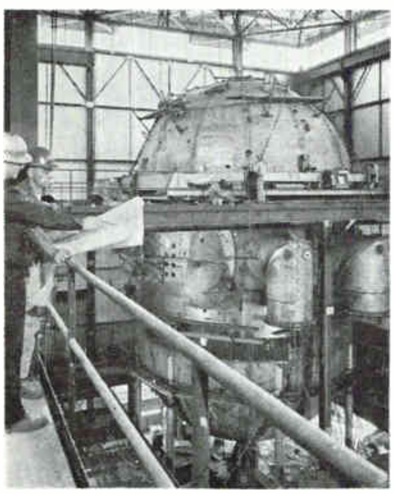
Air Force Communications System, 480-L, is slated for $60.6 million to provide equipment to improve the following elements: capacity, reliability and security of voice and digital transmission in certain vital areas of the world; capability to transmit technical data from the Atlantic Missile Range; and mobile communications to link tactical units with the fixed USAF communications network. ITT is prime contractor.

Germany to Supply Range Communications

AIR FORCE MISSILE test center at Cape Canaveral has awarded a $5 million contract for a 700-mile extension to the underwater communications network serving the Atlantic Missile Range.

Joint contractors are Northrop Corp., Phelps Dodge Copper Products Corp., U.S. Underseas Cable Corp. and Felton & Guilleaume, of West Germany. Cable and repeaters will be manufactured in West Germany. USUCC will lay the cable.

Space Simulator



Environmental chamber nearing completion at GE's Space Technology Center, Valley Forge, Pa., will test manned space vehicles in simulated spatial vacuum, temperature and solar-energy effects

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Kierulff Electronics	1	2		4	5	6	Los Angeles, Calif.
Radio Product Sales	1	2				6	Los Angeles, Calif.
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Peninsula Electronics					5		San Jose, Calif.
Denver Electronics	1					6	Denver, Colo.
Westconn Electronics	1	2					Bridgeport, Conn.
Radio Appliance Co.		2					E. Hartford, Conn.
Westchester Electronics		2					Stamford, Conn.
Capitol Radio	1					6	Washington, D. C.
Electronic Indus. Sales	1	2				6	Washington, D. C.
Electronic Equipment						6	Miami, Fla.
East Coast Radio	1			4		6	Orlando, Fla.
Thurow Electronics	1						Tampa, Fla.
Allied Radio	1	2				6	Chicago, Ill.
Chauncey's, Inc.				4			Chicago, Ill.
Newark Electronics	1	2				6	Chicago, Ill.
Melvin Electronics						6	Oak Park, Ill.
Bruce Electronics			3			6	Springfield, Ill.
Graham Electronics	1	2	3	4	5	6	Indianapolis, Ind.
Radio Supply					5		Wichita, Kansas
P. I. Burks & Co.		2				6	Louisville, Ky.
D & H Distributing						6	Baltimore, Md.
Kann-Ellert Electron.		2					Baltimore, Md.
Radio Elec. Serv.	1				5		Baltimore, Md.
Cramer Electronics	1	2				6	Boston, Mass.
DeMambro Rad. Sup.	1	2				6	Boston, Mass.
Lafayette Radio	1	2	3			6	Boston, Mass.
Radio Shack		2					Boston, Mass.
Radio Specialties		2					Detroit, Mich.
Northwest Radio	1	2		4			Minneapolis, Minn.
Burstein-Applebee		2				6	Kansas City, Mo.
Walters Radio		2				6	Kansas City, Mo.
Interstate Indus. Elec.				4			St. Louis, Mo.
Olive Electronics	1				5		St. Louis, Mo.
General Radio		2				6	Camden, N. J.
Eastern Radio		2				6	Clifton, N. J.
Federated Purchaser	1	2				6	Mountainside, N. J.
Aaron Lippman & Co.		2					Newark, N. J.
Lafayette Radio	1					6	Newark, N. J.
Atlas Electronics	1	2				6	Perth Amboy, N.J.
State Electronics		2		4		6	Whippany, N. J.
Ft. Orange Radio		2					Albany, N.Y.
Federal Electronics	1	2				6	Binghamton, N. Y.
GEM Electronics		2				6	Brooklyn, N. Y.
Radio Equipment		2					Buffalo, N. Y.
Summit Dists.		2					Buffalo, N.Y.
Wehle Electronics	1					6	Buffalo, N. Y.
Lafayette Radio		2					Jamaica, N.Y.
Greylock Electronic		2					Kingston, N. Y.
Peerless Radio						6	Lynbrook, L.I., N.Y.
Bruno-New York		2				6	New York, N. Y.
Electronics Center		2				6	New York, N. Y.
Harrison Radio	1	2	3	4		6	New York, N. Y.
Harvey Radio	1	2				6	New York, N. Y.
Lafayette Radio	1	2	3			6	New York, N. Y.
Milo Electronics	1	2				6	New York, N. Y.
Terminal Hudson Elec.	1	2				6	New York, N. Y.
Higgins & Sheer Elec.		2					Poughkeepsie, N. Y.
Morris Electronics						6	Syracuse, N. Y.
Valley Indus. Elec.		2					Utica, N. Y.
Westchester Electron.	1	2					White Plains, N. Y.
Dalton-Hege Radio	1						Winston-Salem, N.C.
Akron Electronic Sup.		2					Akron, Ohio
United Radio	1		3	4			Cincinnati, Ohio
Pioneer Electronics	1					6	Cleveland, Ohio
Thompson Radio		2		4			Columbus, Ohio

Analyzers Featured at Medical Show

By WILLIAM E. BUSHOR,
Associate Editor

ALTHOUGH TECHNICAL interest in medical electronics is booming throughout the world, relatively few of the advanced equipment concepts have materialized as systems in production. But an upswing in manufacturers' interest was demonstrated at the International Medical Electronics Conference held recently in New York City. More than 60 firms sponsored exhibits.

Among the displays was an ultrasonograph (ELECTRONICS, p 50, Feb. 3, 1961) for detecting brain tumors, breast tumors, gallstones, cancer of the liver and similar conditions. The instrument, called an ultrasono-tomogram by Japan Radio Co., operates at frequencies of 0.5, 1, 2.5, 5 and 10 Mc.

Beltone displayed a decision-making audiometer for testing and measuring hearing abilities of individuals or groups. The instrument consists of an audiometer, modified typewriter and suitcase-sized computing system.

The device varies frequency and gain of pure tone signals in graduated steps. The patient responds to a signal by pressing a button. Information is accumulated in a memory until the instrument can make a decision on the responses. Subject errors resulting from tension or failure to understand instructions are detected. A maximum of 10 tests are given at one frequency, but if the response pattern is recognized before completion of the schedule, the score is printed and the instrument goes to the next frequency.

Ear transducer of Minneapolis-Honeywell's new patient-monitoring system

Decker showed its Pulsesensor, which measures ophthalmic artery pressure (ELECTRONICS, p 52, Jan. 20, 1961). This instrument provides quantitative physiological data for studying cerebral circulatory effects of hypertension, blocks in the main arteries of the neck, drugs, collateral circulation, and physiological and emotional stress. The pulse and systolic information picked up by the device can be recorded or used for programming physical or physiological tests.

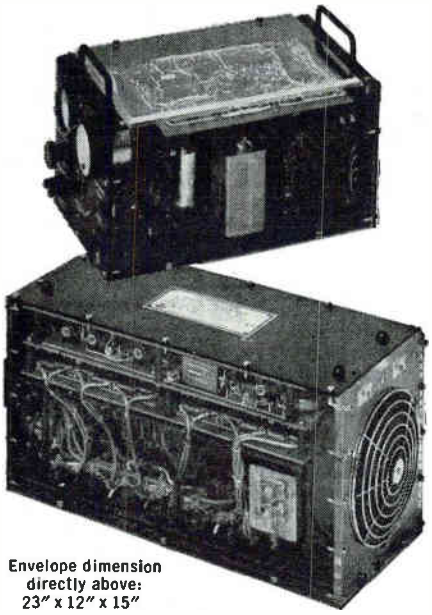
An automatic, all transistor, three-channel, physiological data acquisition and telemetry system is one of Litton's equipments. The subject carries the sensing and transmitting unit. Multiplexed channels are separated and recorded at a remote discriminator.

Electro-Age has an r-f pacemaker providing internal stimulation of the heart and external control of the pulses without through-chest electrodes. The receiver, implanted in the body with electrodes connected to the heart, picks up signals inductively transmitted through the chest wall from an external loop. The loop is driven by a pacemaker whose output pulses can be controlled in rate, amplitude and duration.

An experimental radiocardiograph by RCA uses a transmitter the size of a sugar cube. When the unit is placed against the body, information on heart action is detected and trasmitted to a remote receiver. The receiver converts the data for display on a cathode ray tube or for recording.

The British exhibited a 392-pound model of a working heart. A hydraulic oscillator, it was developed from observations of a klystron tube. Conferees could see first hand how pulsating tubes, representing cardiac arteries, become fatigued and wear out—a condition that can lead to heart attacks.

NOW FROM KIDDE ELECTRONICS!



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Static Power Supplies – Special purpose type static power supplies, 10W to 5KW, 1V to 16KV, dissipative and non-dissipative, regulated.

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MEETINGS AHEAD

Aug. 13-18: Magnetohydrodynamics, Seminar, Penn State Univ., University Park, Pa.

Aug. 16-18: Electronic Circuit Packaging Symposium; Univ. of Colorado, Boulder, Colorado.

Aug. 22-25: WESCON, L.A. & S.F. Sections of IRE, WEMA; Cow Palace, San Francisco.

Aug. 23-Sept. 2: National Radio & TV Exhibition, 1961 British Radio Show; Earls Court, London.

Aug. 23-25: Gas Dynamics Symposium, ARS, Northwestern Univ.; Evanston, Ill.

Aug. 28-Sept. 1: Heat Transfer Conf., International; Univ. of Colorado, Boulder, Colorado.

Aug. 30-Sept. 1: Semiconductor Conf., AIME; Ambassador Hotel, Los Angeles.

Sept. 4-9: Analog Computation, International Conf., International Association for Analog Comp., and Yugoslav Nat. Comm. for ETAN; Belgrade, Yugoslavia.

Sept. 6-8: Computing Machinery, National Conf., ACM; Statler-Hilton Hotel, Los Angeles.

Sept. 6-8: Nuclear Instrumentation Symposium, PGNS of IRE, AIEE, ISA; N. C. State College, Raleigh, N.C.

Sept. 6-8: Space Elec. & Telemetry, PGSET of IRE; Univ. of New Mexico, Albuquerque, N.M.

Sept. 6-13: Electrical Engineering Education, Internat. Conf., ASEE, AIEE, PGE, of IRE; Sagamore Conf. Center, Syracuse Univ., Adirondacks, N.Y.

Sept. 11-15: Instrument-Automation Conf. and Exhibit, ISA; Sports Arena, Los Angeles.

Oct. 9-11: National Electronics Conf., IRE, AIEE, EIA, SMPTE; Int. Amphitheatre, Chicago.

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

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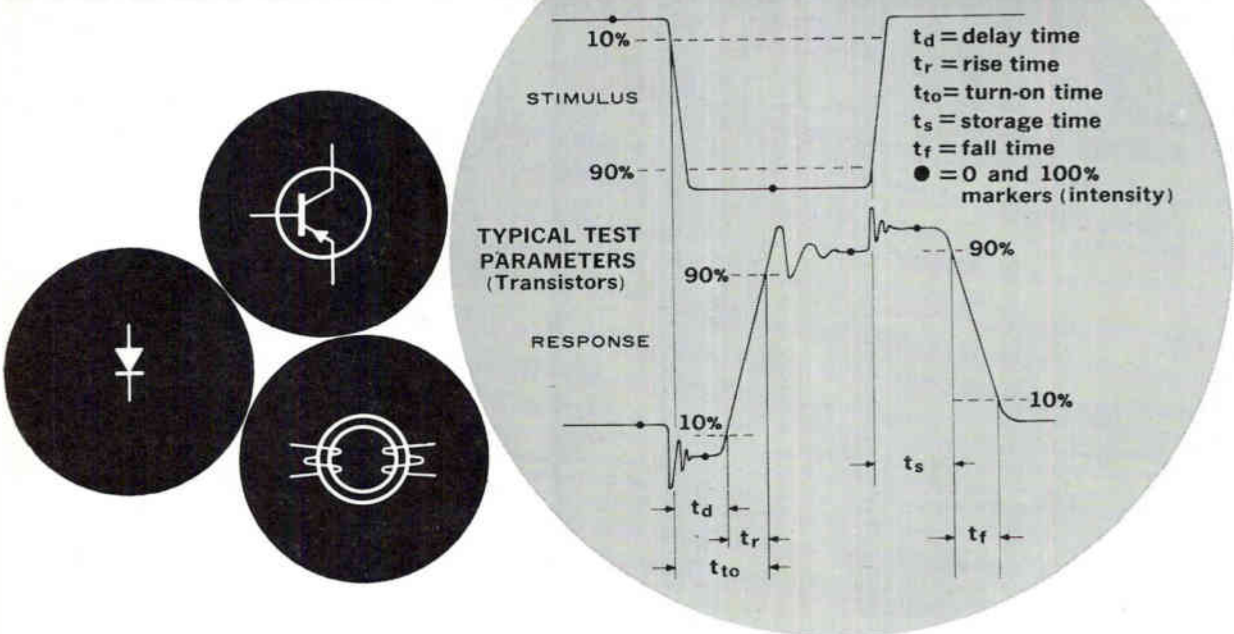
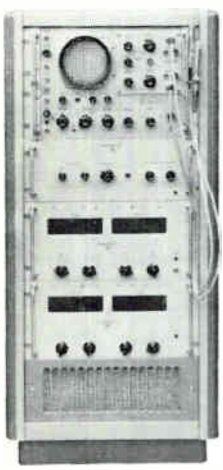


Up to four accurate digital measurements in ¼ second—new automatic convenience for production testing, incoming inspection, quality control of transistors, diodes, magnetic cores, high speed components and circuits!

The Dymec 5844 Automatic Waveform Measuring System provides digital readings of rise, fall, delay and storage time, as well as other dynamic parameters. Go/no-go production testing capability adds further flexibility and efficiency.

With this system you can measure time intervals between any two points chosen from the 0 to 100% level of either stimulus or response pulse. In addition, absolute values can be selected for such applications as measuring diode reverse recovery time. The system also can be used to measure pulse amplitude, pulse area and stored charge. The system is designed for unattended operation with automatic normalizing of 0 and 100% levels on stimulus and response waveforms.



Unique features of the DY-5844

Dual inputs—measure stimulus, response pulses simultaneously, 100 K input impedance for minimum circuit loading.

High accuracy—better than ±3% of full scale, ±0.4 nsec.

Digital readouts—4-digit display for each measurement, plus electrical output for data recording and comparison.

High speed—selected parameters measured in ¼ second. Easily integrated with automatic handling equipment.

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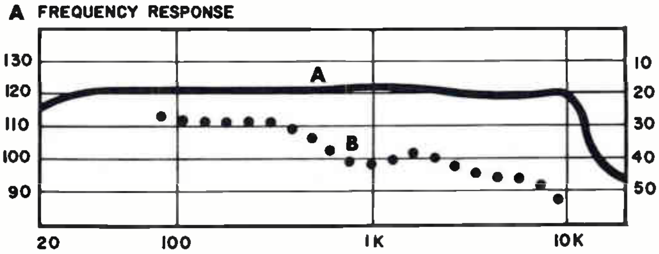

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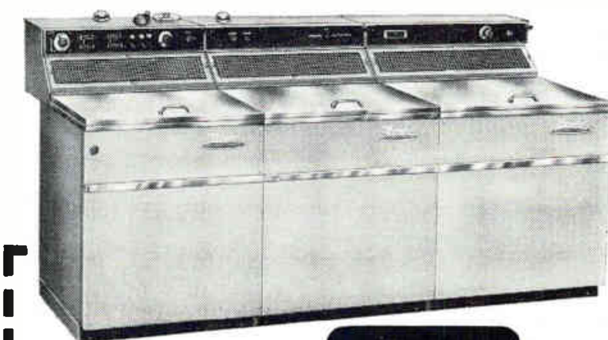

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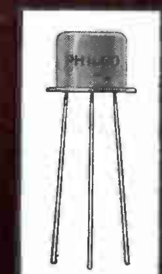

TO-5

ABSOLUTE MAXIMUM RATINGS

Storage Temperature ....−65 to +300°C.
BV_{CER} (R≦10Ω) ....80 volts
BV_{CBO} ....120 volts
BV_{EBO} ....5 volts
Collector Current I_C ....500 ma
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 = 150°C.		200	μa
BV_{CER}	R ≦10Ω I_C = 20 ma. pulsed	80		volts
t_r			85	nsec
t_s			100	nsec
t_f			55	nsec

You would expect Philco, as inventor of industry's most capable germanium logic transistor—the MADT, to design Silicon memory components with extra capability, too. And Philco has done it. The 2N2087, forerunner of a broad line of Philco epitaxial silicon mesa transistors, offers an incomparable combination of parameters that may well be the special design solution you require: maximum BV_{CBO} of 120 V., minimum h_{FE} of 40 at 1V_{CE}, maximum V_{CE} (SAT) of 0.5 V., minimum f_T of 150 mc., maximum C_{ob} of 12 pf., and maximum t_s of 100 nanoseconds.

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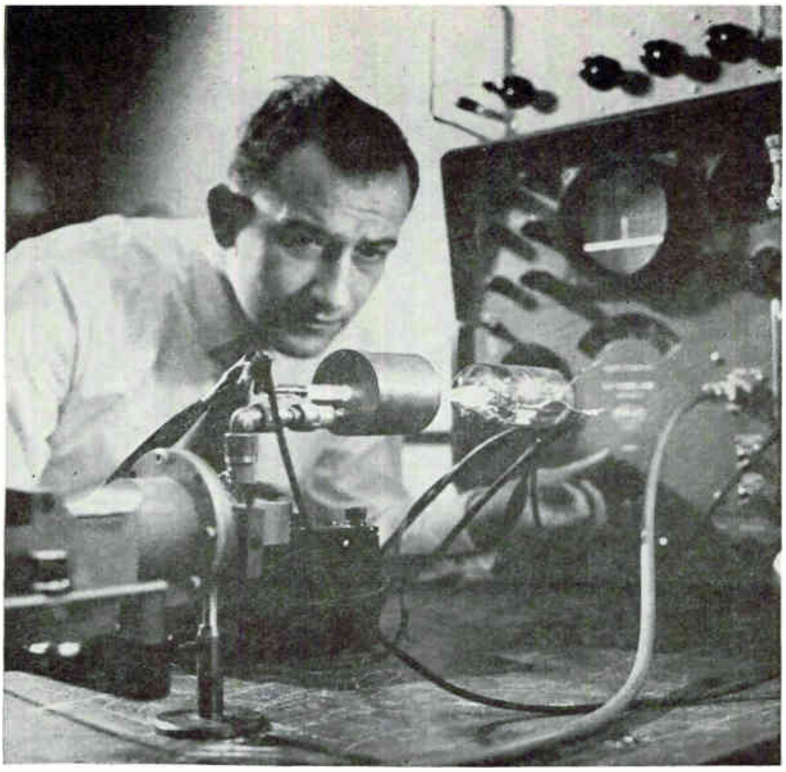
August 4, 1961



Bell Labs' scientist measures resonant frequency of microwave cavity to obtain density of plasma produced by d-c discharge. Density is calculated from frequency shift caused by introducing plasma into cavity

PLASMA ENGINEERING—PART II:

MEASURING PARAMETERS

Electric and magnetic probes, microwaves, photography and spectroscopy are among the diagnostic tools with which plasmas can be studied

By MICHAEL F. WOLFF,
Assistant Editor

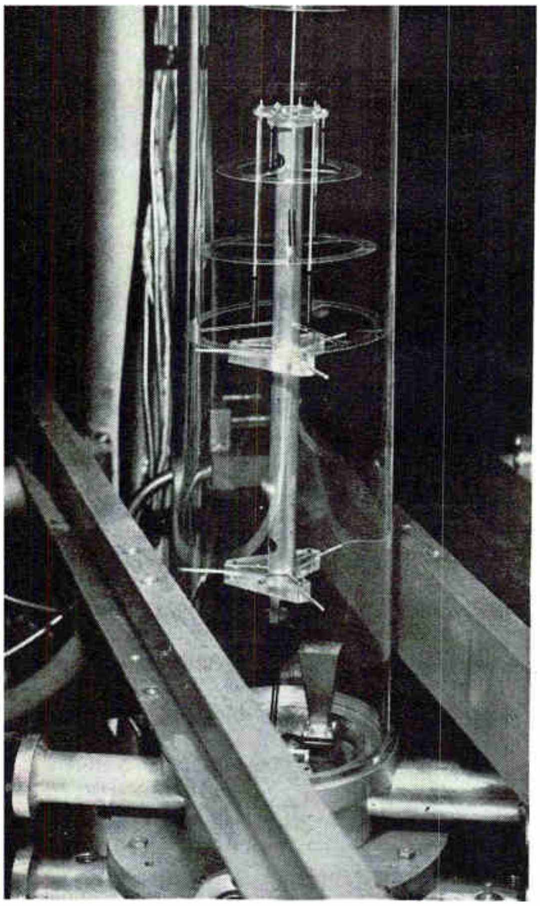
MEASUREMENT OF PARAMETERS such as particle temperature, density and velocity plays a key role in plasma research. For although it is relatively easy to produce plasma (discussed in Part I), it is difficult both to contain plasma and to understand its properties. There is the hope that understanding these properties will lead to the ability to control plasma.

Plasma parameters frequently cannot be measured directly—they are determined by observing the effects they cause. For this reason the term diagnostics is applied to plasma measurements.[1] In much of the present work with high-temperature, transient plasmas, a given technique will not usually provide an accurate measure of a particular parameter. Such diagnostic procedures, therefore, involve measuring a parameter in several different ways and establishing a value only if there is correlation between the results obtained with each technique.

Diagnostic techniques fall into two broad categories: techniques that introduce perturbations into the plasma and techniques that do not. The former involve the use of probes; the latter include observing the radiation emitted from the plasma by photography and spectroscopy.

Electrical Probes—Probes include electrical and magnetic probes which are actually immersed in the plasma as well as beam probes that are fired into the plasma. Most common electrical probe is the so-called Langmuir probe. This is simply a small wire with a potential applied. The potential is varied and the resulting current drawn from the plasma by the probe is measured simultaneously. Commonly, with transient plasmas as well as some steady-state experiments, the probe voltage is swept at rates of 1 to 10 v per μsec and the current-voltage characteristic displayed on an oscilloscope and photographed.[2]

From these measurements electron temperature and density, and plasma potential can be calculated provided the probe dimensions are small compared with the electron and ion mean-free paths and that no magnetic fields are present. (With probe techniques a Maxwell-Boltzmann temperature distribu-



Ballistic target for Litton Industries' plasma accelerator has four independent, concentric targets designed to measure radial mass distribution of the plasma

tion is generally assumed.) When there is a magnetic field, the mean-free paths of the collected particles may become comparable to the probe dimensions and the voltage-current characteristics will be altered. In this case interpretation of data becomes more difficult.

Because a probe draws current from the plasma, conditions in the region of the probe may differ from those elsewhere and the measurements can be misleading. To avoid drawing such large electron currents, a double floating probe may be used.[2,3] This technique uses two probes, ordinarily of equal area, each floating in potential with respect to the plasma and kept at a potential difference relative to each other by an external source. The voltage applied between the probes is varied and the resulting current difference measured.

Plasma potential can also be measured by comparing the characteristic of a Langmuir probe with that of an emitting probe.[4] When the emitting probe is heated so that it is capable of thermionic emission, electrons will leave the probe only when it is negative with respect to the plasma. Thus, the point at which the two characteristic curves merge is taken as the plasma potential.

The electrostatic probe is another type. It is essentially a coaxial probe with two separate unbiased electrodes. By measuring the potential across the electrodes, electric field strength in a given direction can be determined.

A shielded probe loosely coupled to a coaxial resonator having a variable short circuit can be used to detect plasma oscillations.[2] This probe can be used simultaneously as a Langmuir probe to obtain plasma temperature and density.

Magnetic Probes—An important technique for diagnosing plasmas where time-varying magnetic fields exist involves using magnetic probes.[5] These consist of small ceramic rods on which electrostatically shielded hair wire coils a few millimeters in diameter are wound. They are placed in the desired region of the discharge chamber; the induced voltage output of the coil is integrated by an R-C network and displayed on an oscilloscope for a record of the instantaneous magnetic field strength. From these data, information can be obtained about magnetic field pressure, plasma sheath thickness, electrical conductivity of the plasma, and plasma velocity. Conductivity of a fully ionized plasma and pressure can be used to obtain average particle temperature. Integration with R-C networks is used because the induced voltages can reach the kilovolt range.[6]

Probes have been constructed to measure fields as low as a few tenths of a gauss and frequencies to 1 Mc.[7] The 1-Mc coil used at Republic Aviation Corp. for measurements in the vicinity of a discharge is 3 mm in diameter and has 20 turns of fine magnet wire; measured inductance of the coil and leads is 1 μh.

Magnitude and direction of plasma currents can be measured with Hall probes.[8] These probes are typically 1 × 3 mm and have constant sensitivity from steady-state to around 1 Mc. They can be made more sensitive to slowly-varying fields than magnetic coils by pulsing the control current to the element up to around 10 times the normal steady current. As with magnetic coils, 3-dimensional composite probes can be made by using mutually orthogonal elements with the same control current.

Another type of coil which measures current rate of change is known as the Rogowski coil or belt. This is a toroidally wound coil placed in the path of the discharge current. Integral of the induced voltage gives the discharge current. Since transient electrode voltage can be measured during a discharge with conventional resistive dividers, resistivity and, from this, conductivity and electron temperature can be obtained.

Plasma conductivity can also be measured by placing the tank coil of an oscillator coaxial with the discharge tube. Effective inductance of the tank coil and, hence, oscillator frequency are dependent on the conductivity of the plasma inside the tube.

Velocity Measurement—Several techniques are used for measuring the velocity of moving plasma fronts. Two multiplier phototubes a known distance apart can be used to calculate the average velocity of the luminous plasma by recording the arrival time at each location.

Double probes spaced a known distance apart can also be used to obtain the average velocity of the plasma as well as temperature and density distribution. In the system of Fig. 1, probe potential V_o is applied in ½-v increments from −25v to +25v; V_r is read off the dual beam scope, permitting plotting the potential difference between the probes ($V_d = V_o - V_r$) against the total current between the probes ($i_d = V_r/R$).

In shock tubes, pressure measuring transducers and heat transfer gages can be used in a similar manner to take advantage of the pressure and temperature discontinuities accompanying the shock front. Direct measurement of pressure is made with piezoelectric crystal gages, usually quartz or, for low pressures, barium titanate. Sensitivities of 0.01 atm can be achieved with piezoelectric probes.[10] Heat transfer measurements are obtained with coated thin platinum-film resistance thermometers useful up to about 1,000 Btu/ft²-sec.[11]

Plasma velocity as a function of time can be traced on an oscilloscope by means of the velocity profile measuring device shown in Fig. 1. A constant magnetic field is set up perpendicular to the direction of plasma velocity and an emf is induced in the plasma perpendicular to the magnetic field and the velocity. This emf is detected by two probes and the output is fed through a pulse transformer to the oscilloscope.

Velocity of both electrons and ions in a localized area of low-density plasma can be measured with a velocity spectrometer.[12] This is done by directing a narrow plasma beam into a cavity across which a magnetic field is applied. The field separates the particles to either side of the beam, according to charge. Two plates are in the paths of the particles which are then stopped by varying the applied potential. From the potentials applied, particle speed is estimated.

Efficiency of energy transfer to a plasma burst and the momentum of the burst can be determined with a calorimeter-ballistic pendulum.[13] This consists of a cylindrical or conical copper cup weighing about 5 to 10 grams supported by copper and nickel alloy resistance wire. Typically, there will be a temperature increase per pulse of about 4 to 5 deg. Ratio of total energy deposited to total energy available can thus be determined. Assuming an inelastic collision, momentum of the pendulum can be used to calculate the momentum of the plasma which moves it.

For plasma propulsion applications, thrust measurements are important. A ballistic pendulum can give accurate relative values of thrust, but for measuring absolute values a thrust stand is used.[7] This device is essentially an inverted pendulum in which the plasma engine is mounted on a support cradle resting on a flexural pivot. Engine's thrust applies a moment about the pivot point established by the flexure. A thrust stand has been used at Republic to measure thrust below 0.002 lb per pulse per sec.

Material probes contaminate the plasma and are subject to particle bombardment which can evaporate enough material from the probe to cool the plasma and, at high temperatures, destroy the probe. With Langmuir probes, secondary and thermionic emission changes the current-voltage characteristic.

Beam Probes—To overcome these disadvantages, electron and neutral beam probes have been studied for certain applications. The deflection of an electron beam fired into a plasma can indicate the presence of plasma oscillations and stray electric fields. Electric fields due to ion and electron space charge can also be mapped. At Lawrence Radiation Lab an electron beam of 30 to 100 ev kinetic energy has been used to measure space potential in a pulsed 3 to 8 Kev H^+ beam.[14]

Use of a neutral alkali beam as a probe for studying low-density plasmas is being investigated at NYU.[15] The beam, which would be essentially unaffected by the plasma fields, is passed through the plasma in selected directions, and attenuation and change in beam shape measured to obtain electron and ion temperature.

Microwave Diagnostics — Diagnostic techniques based on the interaction of plasma with microwave fields are under extensive development. Active techniques involving the propagation of microwaves in the plasma have the advantage over other probing techniques that perturbations are minimized because of the low power required. Also microwaves do not contaminate plasma as physical probes do. There are also passive microwave techniques that measure the radiation produced by a plasma.

Microwave diagnostic techniques differ from each other primarily in the method by which the microwave field is produced in the region occupied by the plasma.[16] Plasmas can be located in resonant cavities, waveguides and regions in which there are no microwave elements (free-space).

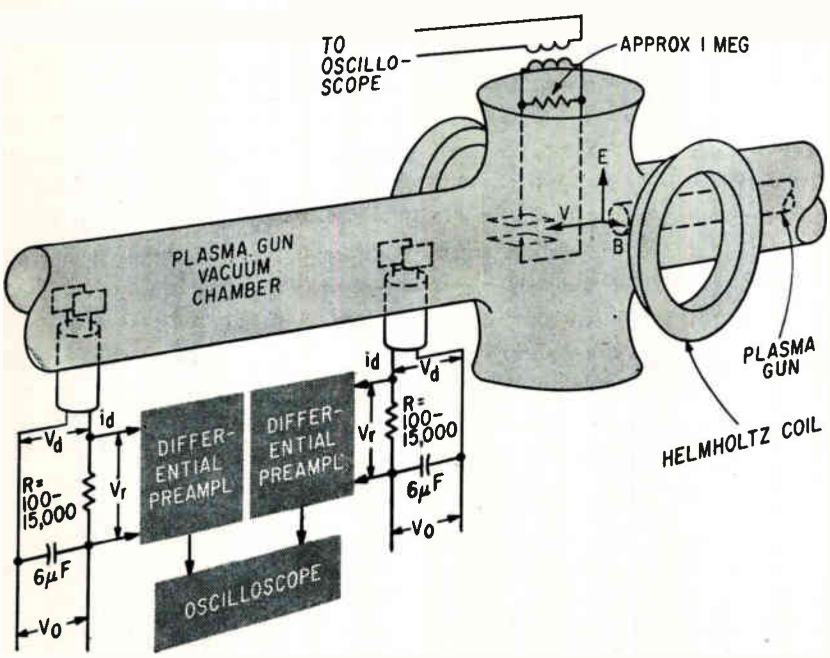


FIG. 1—Plasma gun instrumentation used at Grumman Aircraft Engineering Corp. includes double probes and velocity profile measuring device

Free-Space Techniques—Because of the high electron densities and large dimensions of most fusion plasmas, free-space techniques are most applicable here. These techniques involve passing a collimated microwave beam through the plasma and making phase and amplitude measurements from which certain plasma characteristics can be ascertained. Such techniques are also required for studies of plasma guns and similar devices.

One of the most successful free-space probing techniques is the measurement of electron density and its variation with time.[17, 18] Neglecting magnetic field effects, a plasma can be characterized by three frequency regions. At low frequencies (electron-ion collision frequency ν greater than incident microwave frequency ω) plasma resembles a metallic conductor. At ω less than the plasma frequency (ω_p) and greater than ν, plasma cannot propagate an electromagnetic wave and external waves are reflected at the surface. At $\omega > \omega_p$, however, plasma becomes a relatively low-loss dielectric and oscillations are transmitted.

From the expression $\omega_p^2 = ne^2/m\epsilon_o$, where n is electron density, m is electron mass, e is electron charge and ϵ_o is $1/36\pi \times 10^{-9}$ farads per meter, it can be seen that ω_p^2 is a direct measure of electron density ($\omega_p = 8{,}980\ n^{1/2}$). For the external magnetic field parallel to the electric vector and neglecting collisional damping, ω_p and, hence, n can be determined by measuring phase shift which equals $2\pi d/\lambda\ [1 - (1 - \omega_p^2/\omega^2)^{1/2}]$ where d is plasma thickness and λ is wavelength in free space. (This also assumes a uniform plane wave.)

Microwave interferometer systems are used to determine phase shift. A basic interferometer which can be used to study transient plasmas is shown in Fig. 2. With no plasma present, the attenuator and phase shifter are adjusted so that the reference path signal cancels the transmitted signal, yielding a null output. When a sufficiently dense plasma is introduced into the transmission path, a phase shift occurs and the circuit unbalances. Bridge output is an oscillatory function of density which is displayed on an oscilloscope.[19]

One simplification of the interferometer method is to attenuate the reference path signal so that only transmission can be recorded. This tells whether electron density is above or below cut-off for a given frequency.

A more sophisticated interferometer is known as the fringe-shift or zebra-stripe interferometer. Here phase shift is plotted directly on the oscilloscope in the form of deflected stripes.[20]

Limitations of the interferometer method include:

(1) It is restricted to plasma beams of solid cross-section.

(2) Errors are introduced in the measured phase shift when plasma diameter is not large compared to antenna beam cross-section, and

(3) Measurements are limited by the requirement that ω exceed ω_p; present limit for the technique is $n = 10^{14}$ electrons per cu cm where ω_p is on the order of 100 Gc. In an ir interferometer being developed at MIT, however, researchers hope to measure the dielectric coefficient of plasma by getting phase shift of the ir beam at 200 microns. If the technique works, it would mean densities up to 10^{16} electrons per cu cm could be measured.

Use of the whistler mode has been proposed as a means of propagating inside a dense plasma at frequencies below the electron cyclotron frequency whatever the electron density.[21] The mode was observed over distances up to 125 cm in experiments conducted around 3 Gc on the Zeta thermonuclear machine at Harwell, England by National Bureau of Standards scientists.

Another microwave technique applicable to plasma guns and accelerators is to measure velocity with a c-w klystron source and a magic-T bridge.[7] One arm of the bridge ends in a horn directed at the plasma exhaust. Before the gun is fired the bridge is balanced so there is no output from the crystal detector in the third arm. When a plasma front travels down the gun, reflection from the moving plasma unbalances the bridge. Detector output, viewed on an oscilloscope, goes through a maximum and minimum with every half-wavelength of reflector displacement. Thus, time required for the plasma to move half a wavelength is found.

Electron temperature can be determined by treating the plasma as a black-body and measuring the radiated noise power. A microwave radiometer which allows measurements on transient plasma requiring short averaging times and bandwidths of several megacycles as well as steady-state plasmas is shown in Fig. 3. For transient plasmas, the ferrite switch is left connected to the antenna until the plasma event ends, then switched to the noise source to give a calibration signal at the end of the oscilloscope trace.[19]

Because of theoretical and experimental uncertainties, it is difficult to perform free-space measurements of electron temperature with the microwave noise method. Errors are introduced by such factors as change in plasma area, and reflections. These are more easily controlled when the plasma can be contained in a resonant cavity.

Cavity Techniques—Microwave cavity method is based on the fact that when plasma is introduced in a cavity tuned to one of its resonant frequencies, both the resonant frequency and the loaded Q value change.[22, 23] Since these parameters are related to electron density and collision frequency for momentum transfer, measurement by standard microwave techniques of the frequency shift and change in Q permits calculating the associated plasma parameters.

The cavity method is usually restricted to low electron densities ($\omega_p << \omega$) unless the electric field is directed everywhere perpendicular to the electron density gradient. This condition is met by placing a plasma column along the axis of a cylindrical cavity that oscillates in the TE_{011} mode. In this case densities where ω_p/ω is of the order of 1 or more can be measured. If the radius of the plasma column is less than the free space wavelength of the microwaves, then densities such that $\omega_p/\omega >> 1$ can be measured.

In practice, these cavity meas-

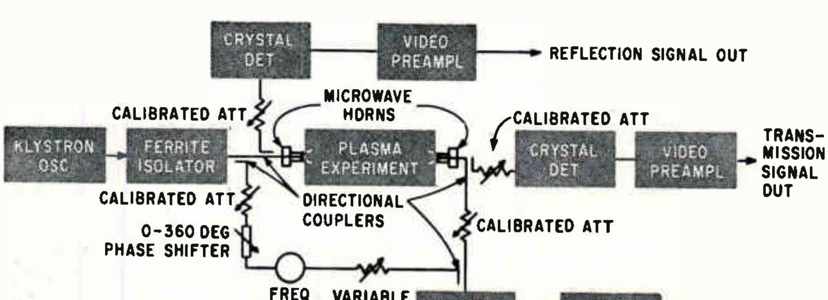


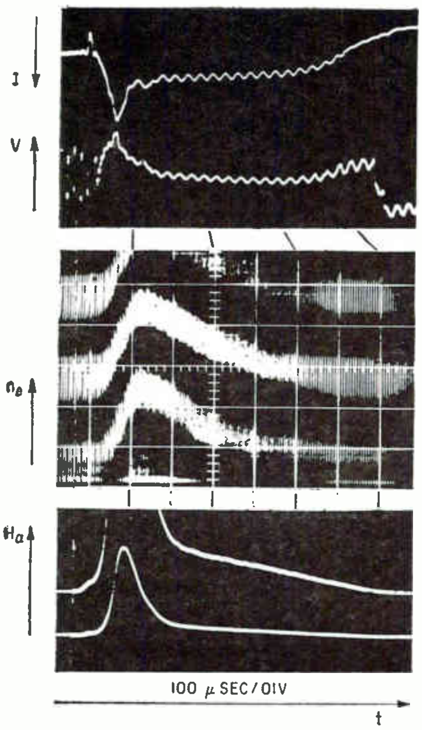
FIG. 2—Basic microwave interferometer can be used for simultaneous measurement of transmission, reflection and interferences[9]

urements have been limited to plasmas whose electron temperatures are in the electron-volt range. Furthermore, their interpretation is greatly complicated if static magnetic fields are present because the plasma is then made nonisotropic. Various mode configurations have been examined, however, for the case of a cylindrical cavity coaxial with a plasma column in a static uniform magnetic field.[24] The TM_{omo} class of modes can be used to study plasmas that are uniform in the axial direction; it is most successful for low electron densities ($n < 10^{12}$ cm^{-3} for 6 -cm radiation). Density distribution over the cavity volume can be obtained by simultaneously measuring frequency shift for several modes.

Resonant cavity technique has found frequent use in studies of plasma decay. Here, pulsed microwave power is used to produce the plasma and measurements are made with a probing microwave field in the time between pulses.

Temperature of a plasma in a resonant cavity can be measured with radiometer techniques because the plasma can be made to act like a black-body. Resonant cavities have also been used for studying dense plasmas ($\omega_p >> \omega$) by assuming the plasma to be an almost perfect conductor.[25] The plasma is assumed to form part of the cavity wall and electron density and collision frequency at the surface of the plasma are related to the amount of detuning.

Figure 4 shows the equipment used at MIT for studying dense plasmas produced by a high-power pulsed microwave gas discharge. The plasma is produced in a quartz tube lying along the axis of a cylindrical resonant cavity by an S-band magnetron that excites the cavity in the TE_{111} coaxial mode. Prior to this the cavity parameters are measured with mercury in the quartz tube. Energy coupled into the cavity from a C-band probing system excites the TE_{011} mode. Resonant frequency of the mode is measured with the cavity wavemeter to obtain the shift in frequency of the probing mode from its resonant frequency when the mercury was present. Change in cavity Q is found by measuring the swr in the C-band waveguide at the resonant frequency of the TE_{011} mode. Continuous energy produced by the klystron between 4.1 and 4.3 Gc is less than 0.25 watt. Electron densities to 2×10^{14} cm^{-3} have been measured.



Oscillographs of plasma current, voltage, electron density and hydrogen α light provide information on a discharge in Princeton University's Stellarator. A programmed voltage pulse has produced a discharge of nearly constant plasma resistance and, therefore, nearly constant electron temperature in the 10-ev range. Electron density trace is taken with 4-mm microwaves where one fringe shift signifies a density of about 10^{13} per cu. cm. High degree of ionization is indicated by Hα light reaching peak value well before electron density peak

Waveguide Techniques — Like the resonant cavity method, electron density and the frequency of collisions between electrons and ions can be measured by confining the plasma in a section of a waveguide transmission line. Both rectangular and circular waveguides are used and the plasma must be introduced such that an appreciable length of the waveguide is uniformly filled along the axis.[16]

Where these conditions can be met, the waveguide system has certain advantages over the resonant cavity technique since plasma parameters can be measured over a greater range and the measurement techniques are simpler.

Waveguide technique has been used to study plasma decay in the presence of a longitudinal magnetic field.[26] Plasma is produced by a pulsed discharge in a glass chamber located in a circular waveguide in which a circularly polarized mode is excited. Phase shift in the waveguide is measured between pulses with a bridge to an accuracy of 0.3 deg.

Photography—In discharges that emit intense light, such as pinches and shocks, plasma shape and velocity can be studied by means of high-speed photography. Single exposures, framed, and streak or smear pictures are used.

Framed pictures are individual photographs taken at short intervals with exposure times on the order of 2 msec to 5 nsec. In a streak camera the image of a slit cross-section is swept across the film, providing a time-versus-position picture that shows one region of the plasma as it changes with time. Thus, while good quantitative data with time resolution often less than 10^{-8} sec can be obtained from streak cameras, the fact that data can only be obtained along the slit makes interpretation difficult.[27] Single-exposure shutters, on the other hand, produce qualitative records but no time continuity in rapid events.

Streak pictures are taken with rotating mirror, rotating drum and image converter cameras. In the rotating mirror camera, light entering the camera is directed onto a mirror driven at several thousand rps by a turbine. (At lower speeds prisms can be used.) This light is then reflected onto a stationary film strip. With some rotating mirror cameras the plasma event has to be synchronized with the angular position of the rotating mirror, while other cameras are capable of continuous writing thereby eliminating the need for camera control of the event. Resolution of 40 lines per mm has been attained and apertures as great as $f/4.5$ and writing rates greater than 3 cm per μsec reported (not on the same camera).[28]

Rotating drum cameras have the film placed on the inside of a drum and it is the film that moves. Although rotating drum cameras are adaptable to fast f numbers, their comparatively slow rotational speed affects the time resolution that can be obtained.[29]

In the image converter camera, light is focused onto the photocathode of the image converter tube and the image then swept across a fluorescent screen and photographed.[30] Advantage of the image converter camera is that light is amplified by a factor of 50 from the anode to cathode, permitting effective *f* numbers below 1. Other characteristics are exposure time between 5 and 200 nsec, writing rates of 66 cm per μsec, and resolution of 15 lines per mm.

Both the rotating mirror and image converter cameras can be used as framing cameras. The former is used for framing by placing separate optical systems between the mirror and film for each frame desired. A series of exposures is taken with the image converter camera by deflecting the electron image to different positions on the fluorescent screen and holding the image at each position during exposure.

Framing cameras can also combine a rotating mirror with a film drum. A camera of this type under construction will have a turbine-driven mirror rotating at 400,000 rpm and a film drum rotating at 4,000 rpm. The camera is expected to take 2,000 frames at 10^6 frames per sec.[31]

Single exposures can be made with the image converter camera as well as the Kerr cell camera. The Kerr cell camera takes a single picture with exposure time of the order of 5 nsec by using a Kerr cell shutter. The Kerr cell contains a liquid such as nitrobenzine through which polarized light passes only as long as a suitable voltage is applied across the two electrodes immersed in the fluid.

Typically, the Kerr cell shutter has an effective aperture of *f*/7 and exposure time of 5 nsec which does not significantly decrease optical resolution. Light gathering power of *f*/7 can be restricting, however, for subjects of low brightness.[28] (With the lenses used, Kerr cell systems generally go above *f*/20.)

High-speed cameras are frequently used to obtain time-resolved spectra. A streak camera can be converted to a spectrograph by placing a transmission grating or prism before the lens, thereby using the camera slit as a spectrograph slit.[32]

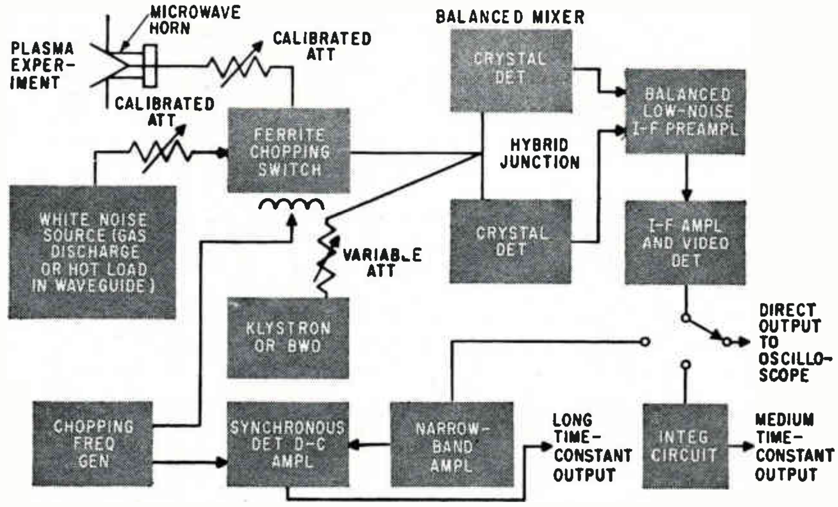


FIG. 3—Microwave radiometer can be used to determine electron temperature in steady-state or transient plasmas[9]

Spectroscopy—Spectroscopy[1, 8] affords a valuable tool for plasma diagnostics since it permits determining chemical composition and parameters such as temperature and density without perturbing the plasma.

Techniques most widely used involve measuring the Doppler broadening, Stark broadening and relative intensities of spectral lines. Equipment includes grating and prism spectrometers, and monochromators. For line widths on the order of one half angstrom or less, the necessary resolving power is obtained by using Fabry-Perot interferometers. By varying the air pressure between the Fabry-Perot plates it is possible to sweep through the desired wavelength range. Because of the low light level in highly ionized plasma and the need for fast time resolution, multiplier phototubes are generally used as detectors rather than photographic plates.

Doppler broadening is an important technique for measuring ion temperature. Assuming a Maxwellian distribution, the broadening of a spectral line into a band of frequencies as a result of random thermal motion of the ions can be directly related to mean kinetic energy, provided there is no ion coherent mass motion.

In machines where large magnetic fields are used to confine the plasma, the Doppler effect is observed simultaneously with the line splitting due to the Zeeman effect. Zeeman splitting provides information about internal magnetic fields. Between 4,000 and 7.000 angstroms polarizers can be used to mask the Zeeman splitting, permitting observation of the Doppler broadening alone.

Ion densities are determined in the case of atoms which exhibit the first-order Stark effect by measuring the Stark broadening of a spectral line. This is caused by the presence of random electric fields that cause a change in the frequency of radiation.

If traces of helium can be added to a plasma then the electron temperature can be inferred by measuring the relative intensities of the singlet and triplet lines. Electron temperature can also be obtained from the intensity ratio of ionized and neutral helium lines.

At temperatures above 10^6 K, most light ions are fully stripped nuclei and discrete spectral lines disappear except for the heavier impurities. Spectroscopic measurements at these temperatures are, therefore, performed on a continuum radiation spectrum consisting primarily of energy lost in the form of bremsstrahlung—radiation emitted by free electrons that are accelerated as they approach other particles.

Bremsstrahlung may be de-

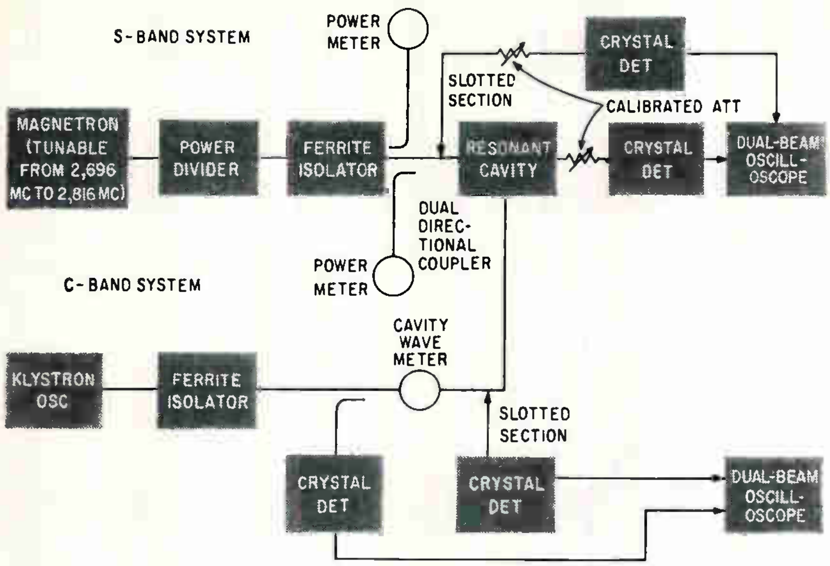


FIG. 4—C-band microwave system is used at MIT to study plasma produced in cavity by S-band system

tected by x-ray detectors, uv and visible light detectors, ir detectors and microwave receivers. Most of this radiation, however, lies in the soft x-ray region and a measurement of the energy dependence of the x-ray intensity is used to determine electron temperature.[33] Intensity measurements are made with scintillation counters combined with multiplier phototubes, ionization chambers (argon and solid-state) and crystal spectrometers. X-ray crystal spectrometers also allow high-resolution examination of plasma line radiation below 20 angstroms.[34]

Measurement of absolute bremsstrahlung intensity in the visible radiation region is used to determine electron density. Intensity measurements are made with 20-percent accuracy by photoelectric techniques and, knowing electron temperature, used to give density.[33]

At high temperatures only plasma impurities give spectral lines. These lines, however, lie in the uv region and are studied by vacuum spectroscopic techniques. Observation of uv radiation can provide information on the existing energy balance in the plasma.

Neutron detection[35, 36] is employed in diagnostics of fusion plasmas because thermonuclear reactions involve the production of neutrons. If it can be shown that neutrons originate from reactions in a deuterium plasma with random thermal motion, then neutron measurements provide a method of measuring ion temperature as well as yielding information on plasma density and position.

Total number of neutrons emitted in a discharge is measured with boron trifluoride proportional counters, and activation counters in which neutrons are slowed down in paraffin to activate an indium or silver jacket surrounding a proportional or Geiger counter. Source of the neutrons and direction of emission is detected by using collimator channels.

Number of neutrons emitted as a function of time is obtained with crystal and liquid scintillation counters. Energy spectrum of the neutrons is found by scanning the tracks from the recoil protons produced in nuclear emulsions or high-pressure cloud chambers.

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Infrared Curtain System Detects

System registers appearance of moving objects as they pass through infrared light curtains. Logic circuit determines direction of travel. Direction and pass time are automatically printed on mechanical register or transmitted for remote registration

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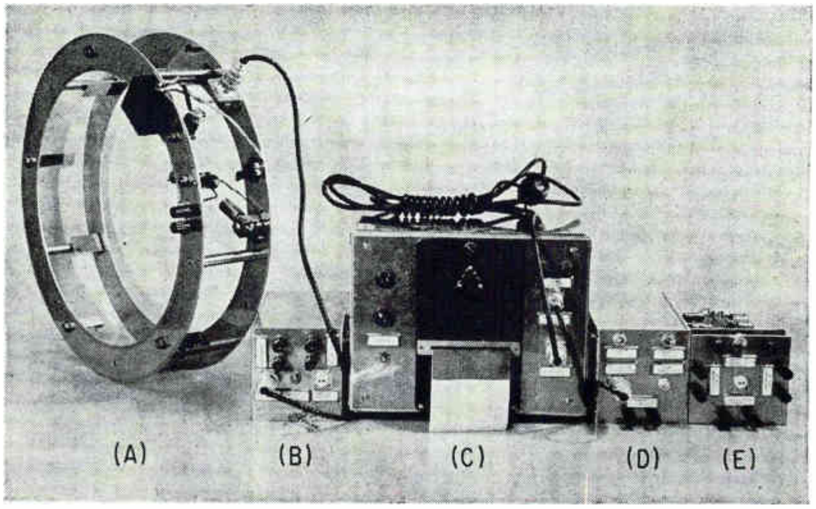

Overall system includes: infrared curtains (A), logic circuits (B), printing register and clock pulse generator (C), transmitter (D) and audio filters (E)

DETAILED KNOWLEDGE of the behavior of animals is of interest in studying their psychology. Lower organisms are often easier to study and their reactions can give information on higher organisms such as the human brain. In studying the living habits of bats, it was desirable to register the time of departure and entrance of bats living in caves. Since indication of these times had to be done in a nondisturbing way, infrared light curtains were used as detecting devices.

In the devices, signals are obtained from phototransistors when the infrared beams in two closely-spaced curtains are interrupted. Logic circuits accept these pulses for registration of events. Transistor circuits make low-power battery operation possible in the field. When reading of the registrations at the place of investigation on weekly inspections is desired, a mechanical register with a time indicator provides direct printing of the data on paper.

For remote data collection, amplitude-modulated pulse signals are created at the observation place when an event occurs. The modulation frequency, which is in the audible range, has two different values depending on which direction the animal is traveling. In the absence of events, short check signals (of a third, different modulation frequency) are emitted and used for adjustment of the receiver. The different values of the modulation frequency are recognized by the pitch of the audible signal from the loudspeaker. Band-pass filters following the audio amplifier of the receiver guide pulses of different frequency to separate registers, where they can be permanently recorded.

Mechanical printing registers are used because of good time resolution, direct information and large storage capacity. The paper advances only when an event occurs. The printed record includes the time, indicated by a continuously moving time-digit roll, and a mark distinguishing between the two kinds of event (outgoing and ingoing). Separate counters and a common time printer could be used.

The equipment, since it senses infrared, works as well in darkness as in bright sunlight without any disturbances caused by daylight illumination.

The light curtains use a number of mirrors suspended at equal interdistances along the circumference of two annular-shaped aluminum plates fastened to each other (Fig. 1). The light source is a 2.2-v, 100-ma lamp placed inside a tube together with a simple optical condensing system and an infrared filter. The beam crosses the open area a few times and is reflected by the mirrors as shown in Fig. 1B. The axial separation between the beams is 8 cm and beams are reflected 5 times. Each beam uses its own set of mirrors and the two sets are placed apart to avoid troubles from one beam being read by the other's detector.

The open areas between the rays are smaller than the smallest bats, so that every passing animal must cut off the beam, giving a signal from the detector. To determine the direction of flight, two light curtains, both contained in the pair of rings, are used. Thus, a total of two lamps and two detectors are used. The phototransistors used as detectors have a sensitive region which extends into the infrared. The signal from the collector of the phototransistor when the beam is shut off is near 1.5 mv.

Block diagram for registering the

and Counts Moving Objects

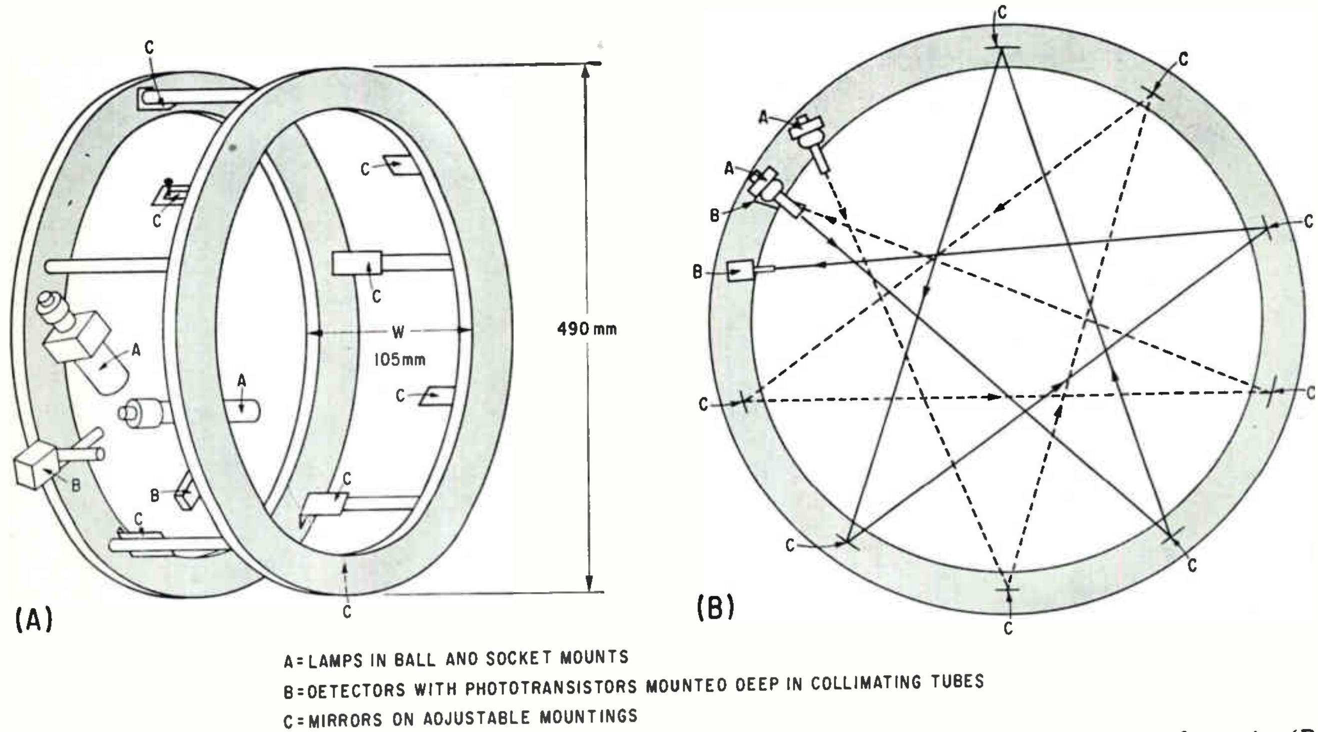

FIG. 1—Perspective sketch (A) shows arrangements for forming curtains. Light-curtain geometry is shown in (B)

events and the direction of flight is shown in Fig. 2.[1] The corresponding detailed schematic is Fig. 3. When the infrared beam in the first curtain is interrupted, a negative pulse appears at the collector of phototransistor Q_1. Temperature-compensation is provided by negative temperature-coefficient thermistor R_1.

The a-c coupled stages Q_3 and Q_5 amplify the pulse. The output negative pulse passes D_1 (inserted to discriminate against noise pulses) and triggers the univibrator consisting of Q_{10}, Q_{11} and Q_{12}. The same description applies to the other channel consisting of phototransistor Q_2 (the second curtain) and the amplifying transistors Q_4 and Q_6 and the univibrator Q_7, Q_8 and Q_9.

Thus, if there were no intercoupling between the univibrators, each one would give an output pulse when the corresponding curtains are traversed, one after the other. However, the circuit is arranged so that the univibrator which is triggered first precludes triggering of the second one because of gating transistors Q_{12} and Q_8. Thus, if for example the Q_{10}-Q_{12} univibrator is triggered first, output of Q_{11}, fed through D_3 and R_2, cuts off transistor Q_8 in the other univibrator, preventing it from being triggered during the duration of the Q_{11} pulse. Correspondingly, if the Q_7-Q_9 univibrator is triggered first, Q_{12} is cut off, preventing triggering of the Q_{10}-Q_{12} univibrator. Collector pulses of Q_9 and Q_{10} switch polarized relay K_1. In direct registration, this relay controls the printing magnets of the registers.

A relatively inexpensive register with only one time-pulse counter was used. The printing magnet was actuated for both kind of events. On the return movement of the magnet, the paper is advanced one step. Time pulses are obtained from a synchronous motor driving a comb wheel acting on a pressure-actuated switch. A second printing magnet actuated simultaneously with the first and gives a simple identification mark to distinguish between entrance and departure.

The axial separation between the light beams is 8 cm. The upper limit to the bats' speed for positive determination of the direction is determined by circuit speed. The univibrator that is triggered first should have time to close the gate of the other. In the actual circuit the limit of time separation between the pulses is of the order a couple of μsec, implying an upper speed limit of more than 10^4 meters per sec. This is well above the speeds encountered. The lower speed limit is set by the a-c coupled amplifiers, which means that a slow interruption of the beams would give no output pulse from the amplifiers. The limit for this is about 1 meter per sec with the actual circuit.

Even for the slowest moving ob-

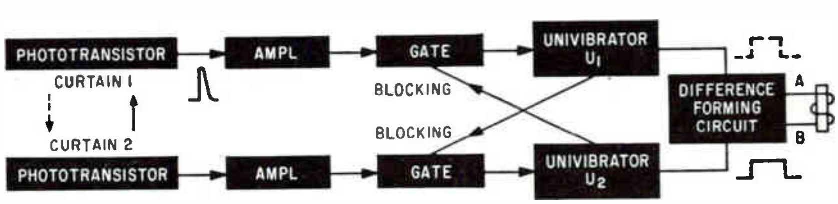

FIG. 2—Basic circuit transforms information from curtains to a form suitable for registration

jects the pulse of the first univibrator has to be sufficiently long to overlap the appearance of the detector pulse from the second light beam. For 1 meter per sec, a pulse length of 0.1 sec is safe. In this apparatus a length of 1 sec was used. This makes for convenient separation of events when using the remote registration system. For full utilization of the speed of the printing register (5 prints per sec) the pulse length should be about 0.1 sec.

For remote registration, a radio transmitter and receiver system was built. The basic detector together with the transmitter can be driven by batteries. The results can be registered at any place at a distance up to 2 kilometers with the receiver and a printing unit connected to it (with higher-power transistors in the transmitter larger distances are possible). This system allows the investigator to immediately monitor the results at any convenient site.

The principle for the remote registration equipment is outlined in Fig. 4A and the detailed drawings are given in Figs. 4B and 5. A passing bat causes the transmitter to start sending an amplitude-modulated r-f pulse of 27 Mc. The modulation frequency has different values depending on the direction of the flight (400 cps for one direction and 1,400 cps for the other). In addition, check pulses, with a modulation frequency of 800 cps, are transmitted regularly every two seconds to check the transmitter and tune the receiver. Should a flight event occur during a check pulse, the modulation frequency is changed to the proper value (400 or 1,400 cps) and the pulse is prolonged the required amount. The audio section of the receiver contains two audio filters, built for 400 and 1,400 cps respectively, the outputs of which control the printer.

In Fig. 4B, transistor Q_{21} is the crystal-controlled oscillator of the transmitter[2]. Transistor Q_{22} is the power stage which feeds the 50-ohm antenna. Oscillator Q_{19} and Q_{20} modulates the base of transistor Q_{22}. All the transistors receive battery power only during the recording of an event or during a check pulse. Check pulse generator, Q_{17} and Q_{18}, which constitutes an asymmetrical multivibrator, has battery power fed to it continuously. The multivibrator operates relay K_2 for 0.5 sec, once every two seconds. This gives power to the modulator and transmitter through the action of relay contact K_2.

Modulation frequency is determined by the voltage from the potential divider R_3 and R_4 feeding the base resistors of Q_{19} and Q_{20}. During the check pulse, in the absence of an event, transistors Q_{14} and Q_{16} are cut off and the voltage at X is such that the frequency is 800 cps. For one kind of event, Q_{14} is switched on, causing a change of the voltage at X, reducing the modulation frequency to 400 cps. For the alternate event Q_{16} is switched on, giving a higher voltage in X, which leads to a modulation frequency of 1,400 cps. Transistor Q_{14} is controlled, by a level-shifting Zener diode, from the event-registering univibrator in the basic unit (Q_7-Q_9 in Fig. 3). If the other type of event occurs the other univibrator (Q_{10}-Q_{12} in Fig. 3) is in operation causing Q_{16} to be conducting through the intermediate action of Q_{15} which inverts the voltage change. Diode D_5 avoids conduction of Q_{16} caused by the leakage current in Q_{15} in absence of signal. The same pulses which operate Q_{14} and Q_{15} also switch on Q_{13} by causing a voltage drop across R_5. In this way the transmitter and modulator receive power even if relay contact K_2 is nonoperative, that is, under the dead intervals of the check pulser.

Pushbuttons S_1 and S_2 test operation of the modulator. The buttons are interlocked so that only one can be actuated at a time, to avoid pos-

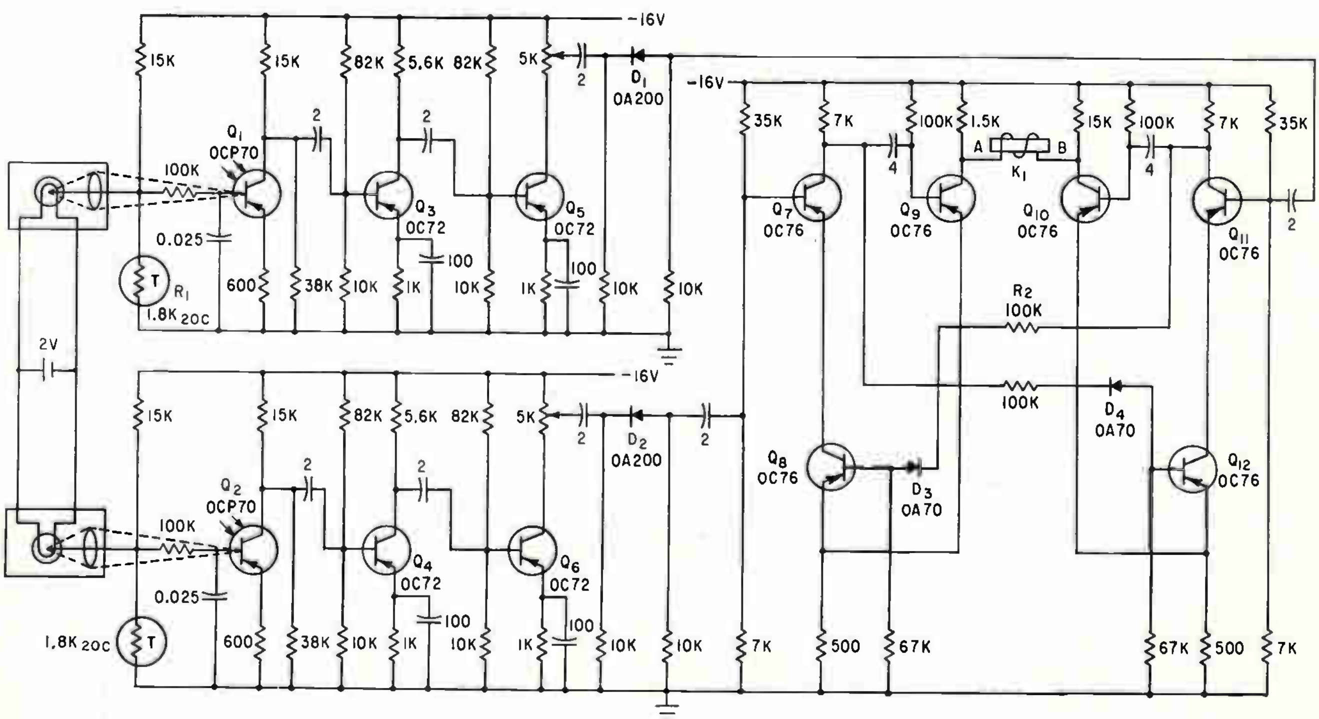

FIG. 3—*Signal across A and B is used as input to mechanical register to key transmitter*

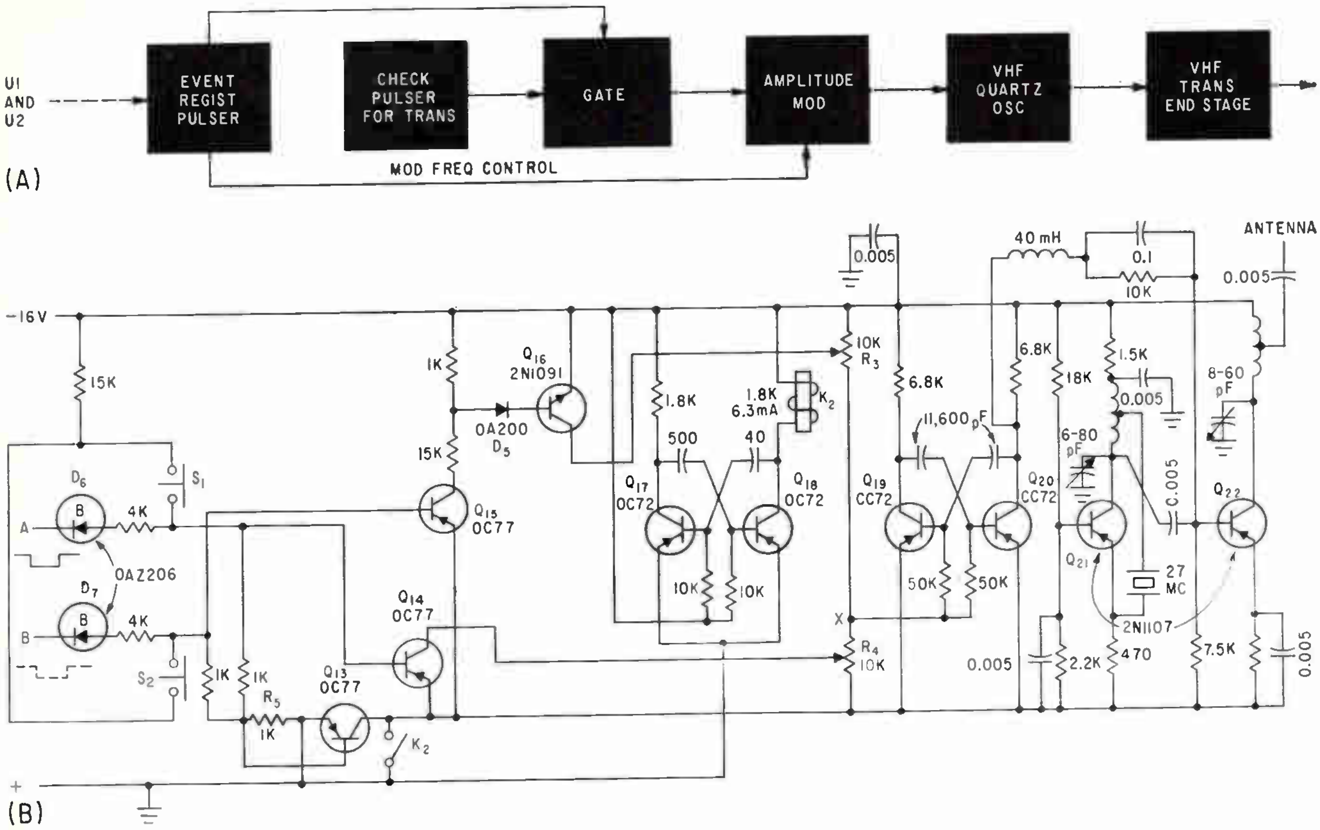

FIG. 4—Transmitting link for remote recording (A) uses Zener diodes at input (B)

sible damage to Q_{11} and Q_{16}.

The receiver is the conventional superheterodyne. A signal pip is heard in the loudspeaker when an event is registered or when the check pulser actuates the transmitter. Type of event is judged from the pitch of the note. If an event happens during the live interval of the check pulser the pitch is immediately changed to the proper value. Permanent registration is achieved by two selective amplifiers tuned to the event audio frequencies and fed from the primary winding of the loudspeaker transformer (Fig. 5). Coupling to the transformer is by capacitors. Zener diodes D_8 and D_9 protect the succeeding amplifiers. Transistors Q_{23} and Q_{24} are input-isolating emitter-follower stages feeding the parallel LC circuits through a high resistance of 20,000 ohms. The second transistor Q_{25} (Q_{26}) works as an emitter follower and half-wave rectifier at the same time. In this way the loading of the resonant circuit becomes small. The output is filtered and fed to the d-c current amplifier Q_{27} (Q_{28}) to actuate relay K_3 (K_4). Relays K_3 and K_4 could directly control the printing register, but for the convenience of using only one input to the printing register box, K_3 and K_4 are arranged so that they control an unbalanced bridge, the output of which operates a polarized relay.

The flexibility of the system allows it to be used in different field conditions. The sensing mirror ring could be placed in the opening of a cave or other residences of animals to be studied. These could be not only bats but also birds or animals whose behavior pattern may be of interest. This technique and equipment can be applied to other fields where it is desired to establish direction, passing time and number of different objects. Examples of these applications include traffic counting and industrial control systems.

This equipment has been built for L. Wallin of the Institute of Zoology of the University of Uppsala.

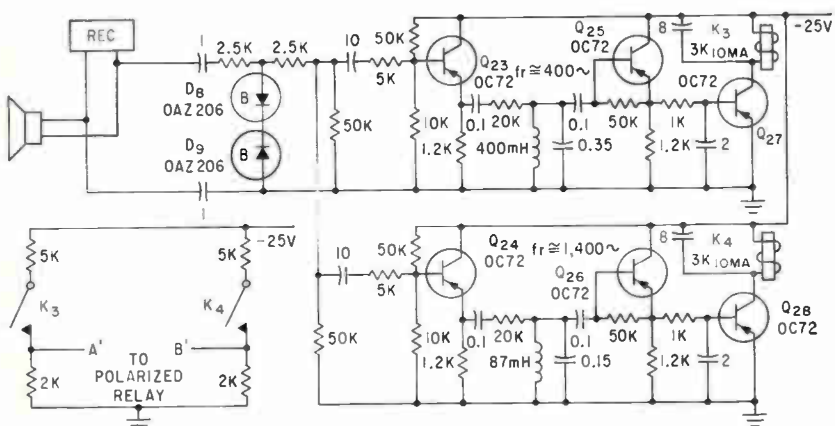

FIG. 5—Audio bandpass filters at receiver output separate recording signals

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Sonar to Survey Arctic Ocean Shelf Transmits Through Ice and Water

Sound energy is coupled efficiently into ice by oil medium. Survey of ocean shelf is carried out at low temperature with helicopter landed unit

By LEON H. DULBERGER
Assistant Editor

SONAR DESIGNED to survey the Arctic Ocean continental shelf through surface ice or directly in water is now in use by the Canadian government. The sonar's transducer is coupled to the ice by a layer of high-viscosity oil to achieve maximum sound transfer. This technique avoids drilling down to water, when ice overlays the area to be depth sounded.

The Canadian Department of Mines and Technical Surveys has used the equipment for months as part of a general northern development program. From a base on Isachsen Island, surveys are being made of the broad continental shelf. A helicopter transports the sonar to the desired location on the ice, and soundings are made minutes after setdown. Regular operation through 8 feet of ice and 1,900 yards of water is obtained. The helicopter's d-c generator supplies primary power.

In development of the sonar, the designers, Edo (Canada) Ltd., Cornwall, Ontario, tested several transducer coupling materials under field conditions. Operating on the frozen St. Lawrence River, checks were made through one foot of surface ice into 25 feet of water.

A calcium-chloride solution, and high- and low-viscosity oils were tested by preparing a smooth ice surface, on which a puddle of the material was poured, and the transducer put in firm contact with the ice.

The calcium-chloride solution produced surface reflections which distorted the transmitted pulse. This caused masking of the received signal for roughly 20 milliseconds and reduced minimum depth ability to 30 to 50 feet. Careful preparation of the ice was required for optimum results. Small voids and discontinuities in the surface reduced performance.

Use of low-viscosity oil produced marked improvement, reducing distortion to 2 to 3 msec, and allowing a minimum depth reading of 3 feet, the equipment's basic range minimum. High-viscosity oil, operated near its pour-point temperature, caused little pulse distortion or power loss.

A calibrated hydrophone was placed on the river bottom and pulse attenuation through four feet of clear ice was measured. The calcium-chloride solution resulted in a 6 to 30-db attenuation. Large variations due to ice surface preparation were noticed. Low-viscosity oil lessened this to a 3 to 6-db attenuation, high-viscosity oil reduced attenuation from zero to 3 db.

The equipment was tested using high-viscosity oil. Reliable results were obtained operating through transparent ice, porous ice with air inclusion and in open water.

The single transducer, used for both transmitting and receiving, is made up of 16 active elements of barium titanate. The ceramic elements have an efficiency of 75 percent and retain piezoelectric activity over a temperature range of minus 40 to plus 40 C. Electro Ceramics, Inc., Salt Lake City, Utah, manufactured the elements. A flotation buoy attaches to the transducer to support it one foot below the surface for operation in water.

Calibration of the sonar is in terms of time rather than distance. Speed of sound in water, or the composite media encountered is used in computing depth. For general purposes, consider 1600 yards per second accurate. A maximum time base calibration of 2.4 seconds is used, giving a maximum range of 1,900 yards.

Temperature, pressure, and to a lesser extent, salinity affect the speed of sound in water. Knowledge of these variables allows maximum accuracy to be realized.

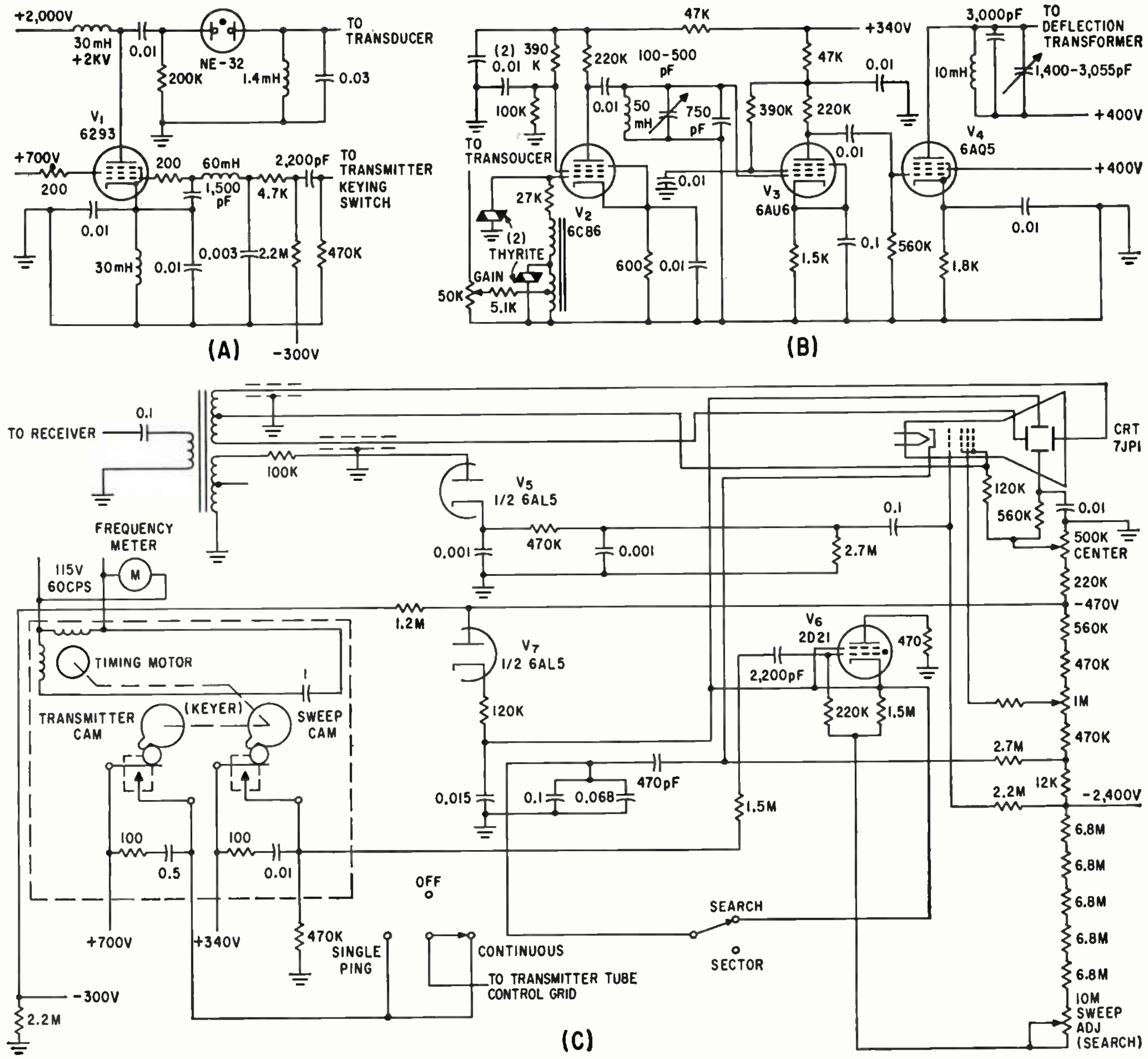
Accuracy of depth measurement is assured by precision timing of transmitting pulse and receiver display. Both functions are derived (Fig. 1) from a synchronous timing motor. The motor operates from the d-c-to 60 cps inverter which supplies a-c for the complete equipment. A reed-type meter monitors frequency.

Two cams on the motor shaft operate switches for initiating transmitting and sweep circuit action. The transmitter switch position is fixed relative to the motor camshaft. It is closed 25 times-per-second at the motor rotational speed which sets the prf. On switch closure, a positive pulse is applied through a shaping network to V_1. Duration of this key pulse allows the Clapp oscillator to operate for a period of 1 millisecond at 22 Kc.

Output energy is coupled to the transducer by an NE-32 neon tube when the voltage exceeds approximately 60 volts. This provides shaping of the output waveform.

The transmitter can be employed for single-pulse operation to provide maximum power to the transducer. A switch, allowing one minute between pulses assures full charging of power-supply capacitors.

The receiver amplifier couples to the transducer through a gain control, step-up transformer (about 8:1) which also improves impedance match, and resistor-varistor network. During transmission time the two varistors exhibit low re-



Schematic of Edo's arctic sonar. Transmitter (A) and receiver (B) both connect to single barium titanate transducer. Timing functions including display (C) are derived from cam-operated switches driven by synchronous motor

sistance and protect input tube V_2 from overload and possible blocking during echo return time.

Maximum gain at 22 Kc, is achieved with tuned circuits at the input to V_3 and the output of power amplifier V_4. Signal-to-noise ratio with the tuned amplifier is improved over a broadband design. Rejection of sea and ice noise, and noise from nearby motors or propellers is realized.

Receiver gain is 137 db measured from transducer input to primary of the deflection drive transformer. The transformer has two secondaries; one connects to the crt deflection plates, the other provides voltage to V_5. The d-c output from V_5 is applied to the crt control grid for trace brightening during echo return.

The cam switch which initiates the sweep is adjustable in position relative to the rotating cam. Its position is calibrated as a function of trace delay time, for conversion to depth. Switch closure applies a positive pulse to thyratron V_6 which discharges the sweep capacitor. Two capacitors are provided; one for the 70-millisecond SECTOR sweep mode; the other for 700-millisecond SEARCH mode. Accurate final readout is made with sector scan. Search is used for inspection of a broad depth band.

Sweep voltages are clamped by diode V_7 to prevent excessive rise across V_6 and deflection circuits.

Before time (depth) readings are made in the field, the instrument is zeroed for maximum accuracy. With the delay control set at zero, the leading edge of the transmitted pulse is aligned with a horizontally-scribed line on the crt faceplate by a centering control.

The leading edge of the received echo, as displayed in sector scan, is used for final readout. It is aligned by the delay control with the crt reference line. Delay time in milliseconds is read directly from the control's dial.

The inverter was designed by Siegler's Magnet Amplifier div., New York, N. Y., with frequency stability of $\pm\frac{1}{2}$ percent from -40 to $+40$ C.

Hybrid Bootstrap Circuits Increase Sweep Linearity

Transistor feedback circuit is used to force sweep generating capacitor to charge at constant current. High-speed sweeps can be generated and circuits need no special power supply for the transistors

By F. C. CREED, National Research Council, Ottawa, Canada

A SIMPLE sweep generator for a cathode-ray oscillograph with electrostatic deflection is the bootstrap circuit shown in Fig. 1A. Sweep voltage is generated across capacitor C_s, with sweep rate determined by the size of the capacitor and the current flowing through resistor *R*. In the quiescent condition tube V_1 is conducting heavily, the current being supplied by the B+ supply through the diode and resistor *R*. This holds the voltage across the sweep capacitor to a low value.

To start the sweep, V_1 is cut off by applying a negative pulse to its grid, thus allowing C_s to charge through *R*. As the voltage across C_s rises, the grid of V_2 rises, driving up the cathode of V_2, which is a cathode follower. Coupling capacitor C_c transfers this voltage rise to the top of *R*, so that this point rises above the B+ voltage, and thus the current through *R* is transferred from the B+ supply to the h-v supply, with the diode acting as an opening switch. Ideally, the voltage at the top of *R* rises at the same rate as the voltage across C_s, so that a constant current is maintained through *R* and a linear voltage rise across C_s. Output voltage is normally taken from the cathode of V_2, since this point rises at the same rate as the voltage across C_s and provides a low impedance source for driving the deflection system of the cathode-ray oscillograph.

The circuit of Fig. 1A is suitable only for low repetition rates because C_c loses charge during the sweep and has to be recharged during the quiescent period. Furthermore, the sweep is not absolutely linear because the voltage of the cathode of V_2 does not accurately follow that of its grid.

The first disadvantage is largely eliminated by the modification[1] shown in Fig. 1B, where C_c does not have to supply charging current for C_s but only the current required by the grid leak resistor; since this resistor can be large, the current can be kept small. Thus C_c can be small and easily recharged during the quiescent period.

However, in the circuit of Fig. 1B the sweep is not absolutely linear. Also sweep speed is limited because all of the current flowing through *R* during the quiescent period also has to flow through V_2. The magnitude of this current is therefore limited by the maximum permissible plate dissipation of V_2, whereas in the circuit of Fig. 1A this current flows through the diode and not through V_2. Quiescent current can therefore be much larger for Fig. 1A, with a corresponding increase in sweep speed.

Furthermore, much higher supply voltages are required for a given output voltage: the cathode of V_2 is approximately at B+ in Fig. 1B, whereas in Fig. 1A it is approximately at the potential of the plate of V_1. The high voltage for Fig. 1B must therefore be greater by the amount of the drop across *R*. This can be an appreciable amount, because it is necessary for the voltage drop across *R* to be many times

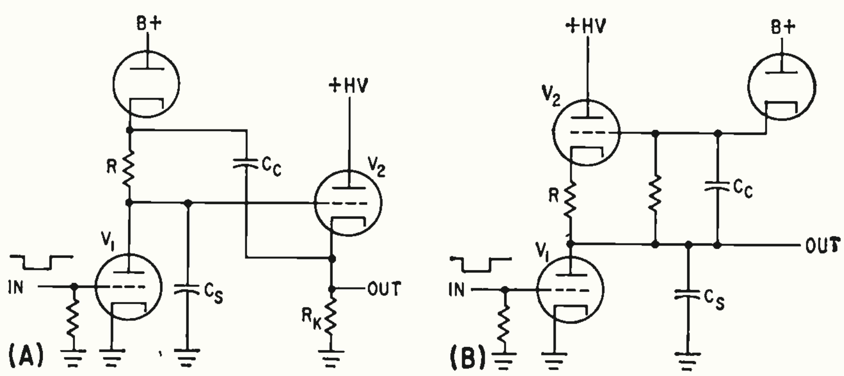


FIG. 1—Simple bootstrap circuit (A) generates sweep voltage. Circuit at (B) has higher repetition rate but sweep speed is limited

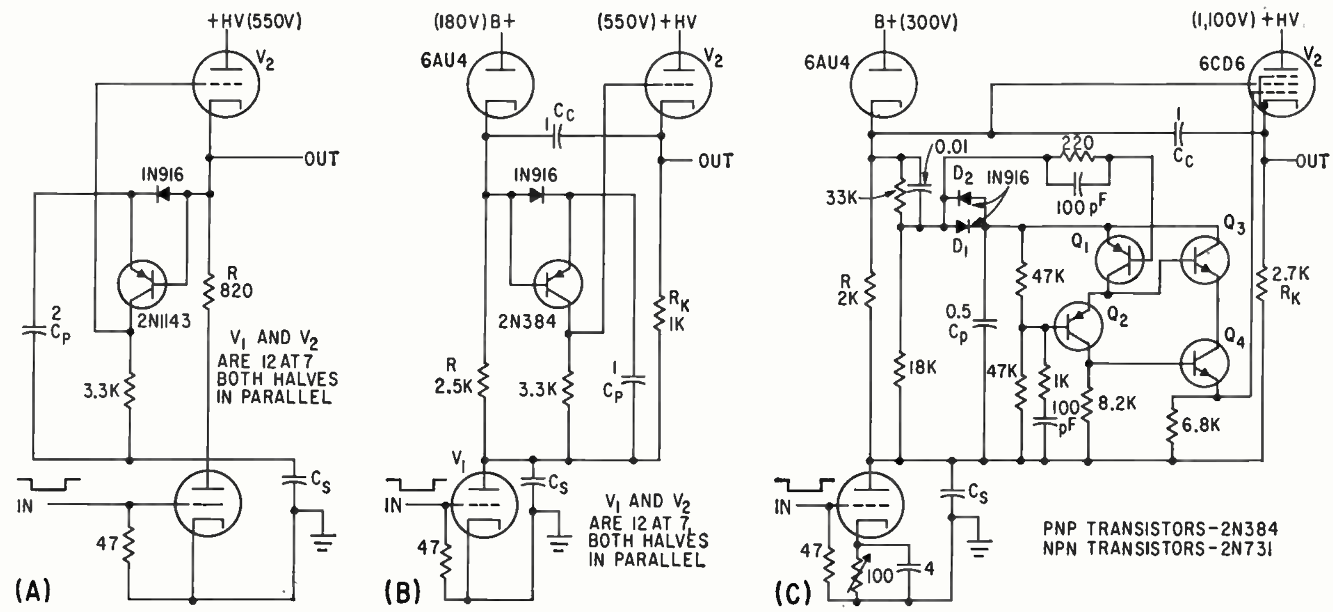


FIG. 2—Hybrid circuit (A) has high linearity and moderate sweep speed capability. Hybrid version of Fig. 1A, at (B), has high sweep speed. Circuit at (C) generates ± 800 volt sweeps of 0.15 μsec

larger than the bias on V_2; any variation in bias voltage is reflected in the voltage across R, and this voltage must be constant.

In both circuits linearity is lost because any change in voltage between grid and cathode of V_2 appears in the voltage across R—the one voltage that must be kept constant. Unfortunately, the voltage between grid and cathode of V_2 must change during the sweep because at the instant the sweep starts the current through V_2 must increase; and during the sweep the voltage across V_2 decreases, necessitating a reduction in bias to maintain a given current, a consideration especially important if V_2 is a triode.

The need for the current through V_2 to increase at the instant the sweep starts applies even more to the circuit of Fig. 1A than to Fig. 1B, especially for fast sweeps.

There are three components of the current through V_2: I_R flows through R to charge C_s; I_C charges the stray capacitances associated with the cathode of V_2 but does not flow through R; and I_{Rk} flows through the cathode resistor of V_2 in Fig. 1A.

It is apparent that the circuit of Fig. 1A requires a greater current change through V_2 than does that of Fig. 1B. In Fig. 1A, I_R does not flow through V_2 in the quiescent stage but does during the sweep. Moreover, I_{Rk} must increase during the sweep; in Fig. 1B this current is nonexistent. In addition, I_C is larger for Fig. 1A because the capacitance to ground of the diode cathode is effectively connected to the cathode of V_2; in Fig. 1B this capacitance is added to C_s. Thus Fig. 1A is inherently capable of higher sweep speeds because of the lower value of C_s; but it requires a higher I_C.

If the circuits of Fig. 1 are to generate linear sweeps the voltage across R must not change during the sweep and the changes in the voltage between grid and cathode of V_2 must be achieved without affecting the voltage drop across R. The cathode of V_2 must remain fixed with respect to the plate of V_1 but the potential of the grid must change. Previous concepts kept the grid of V_2 fixed with respect to the plate of V_1 and minimized the shift in potential of the cathode.

The required shift of the grid of V_2 with respect to the plate of V_1 during the sweep has to be such that the potential of the cathode of V_2 with respect to the plate of V_1 remains constant. Thus a feedback control amplifier must be introduced to provide a correcting signal for the grid of V_2. This amplifier must be capable of riding up with the plate of V_1 during the sweep without loading the circuit.

These requirements for the sweep generator can be met by a hybrid circuit, using a floating transistor amplifier to shift the potential of the grid of V_2. To power this amplifier it is desirable to use the voltage drop across R, since the power requirements are small and the problem of a special power supply is thus eliminated. The circuit of Fig. 1B thus converts to the hybrid circuit shown in Fig. 2A.

In Fig. 2A the transistor amplifier is powered by C_p, which is charged during the quiescent period. During this period current flow through the diode keeps the base of the transistor biased positively with respect to its emitter, so no collector current flows. The grid of V_2 is therefore held at the same potential as the plate of V_1 and C_p becomes charged to the voltage drop across R. This voltage is also the bias for V_2, since this tube is self-biasing. Capacitor C_p must be large because it must power the transistor circuit during the sweep without any appreciable drop in voltage. This is not a serious problem because C_p can be a low voltage electrolytic.

When the sweep starts, C_s charges through R, and this voltage rise is transferred to the emitter of the transistor through C_p; C_p therefore powers the transistor circuit and supplies the reference potential from the plate of V_1. The other reference potential, that of the cathode of V_2, is fed directly to the base of the transistor. If the cathode of V_2 should tend to rise

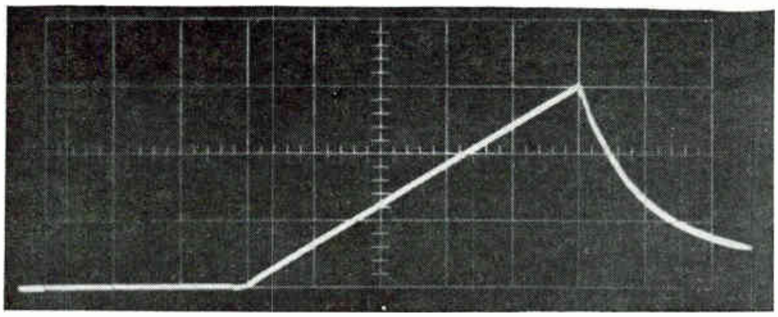


FIG. 3—Sweep voltage obtained from circuit of Fig. 2A

at a lower rate than the plate of V_1, the diode will disconnect the emitter circuit from R and the base of the transistor will then go negative with respect to its emitter. This will permit base current to flow, which will cause a much larger current to flow in the collector circuit. This collector current will raise the potential of the grid of V_2 so that more current can flow through the tube, and thus the tendency for the cathode to fall in potential with respect to the plate of V_1 will be halted. Because of the high gain of the transistor circuit, the cathode of V_2 has to fall only a fraction of a volt to obtain full correction on the grid voltage, so the voltage across R remains constant.

The sweep waveforms generated by the circuit of Fig. 2A are linear, as shown by the oscillogram, Fig. 3. Moreover, for the same output voltage, a lower supply voltage is required than for the circuit of Fig. 1B, because the voltage drop across R is only the bias for V_2, instead of the value many times this required by Fig. 1B. The same limitation on the current through R applies to this hybrid circuit, and consequently it is not suitable in this form for generating high-speed sweeps. For moderate speeds, however, it is satisfactory, especially if only modest output voltages are required.

When fast sweeps are required, the circuit of Fig. 1A is more suitable than Fig. 1B, because the current through R can be much larger. It is possible to devise a hybrid version of this circuit, and a simple form is shown in Fig. 2B. In this circuit the grid of V_2 is again held to the potential of the plate of V_1 during the quiescent period and V_2 is self-biased by the voltage drop across R_k. The voltage across R should be at least equal to the voltage across R_k, and preferably somewhat greater, so that when the transistor is fully conducting, the grid of V_2 can be driven to the cathode potential, or even into the positive grid region. It becomes possible to use the maximum current that V_2 can deliver, thus allowing the current through R to be large. The current through V_2 during the sweep will be much larger than the current through R, because a large proportion of this current is only being used to charge the stray capacitances to ground from the cathode of V_2—this current was previously referred to as I_c. Since these capacitances involve the capacitance between the cathode and filaments of both V_2 and the diode, they can be appreciably larger than the capacitance of C_s, which, for the fastest sweeps, will be only the output capacitance of V_1 and the stray capacitance from the plate of V_1 to ground. Current I_c may then become several times larger than I_R, and it is thus important to drive the grid of V_2 as hard as possible.

For fast sweeps, especially those requiring large output voltages, the circuit shown in Fig. 2B is inadequate, because the tubes required may require bias voltages greater than ordinary transistors can withstand. The oscillograph for which this work was carried out required sweep speeds to 0.15 μsec and sweep voltages of $\pm$800 v. The tubes selected required that V_2 have a bias of about 50 volts during the quiescent period, which is appreciably more than ordinary high-speed transistors can withstand. The circuit of Fig. 2C was therefore developed.

The circuit of Fig. 2C is the same as Fig. 2B, but the single transistor has been replaced by two transistors in cascade, so that the voltage across the transistor circuit can be doubled.

Transistors Q_1 and Q_2 together act as a single high-voltage transistor, and the voltage divider insures that the voltage drop is evenly divided between them.[2] Transistors Q_1 and Q_2 drive Q_3 and Q_4 as an emitter follower to provide a low-impedance source for driving the grid of V_2; direct connections between the transistors insure that the voltage drops across Q_3 and Q_4 are also balanced.

An addition to this circuit is diode D_2. This is required in the cascade connection to prevent excessive base current in Q_1 at the end of the sweep; D_2 bypasses the transistor when V_2 can no longer sustain current through R. Capacitor C_p then discharges through D_2 instead of through the emitter and base of Q_1.

The transistor circuit shown in Fig. 2 can operate with up to 70 volts across it, which is ample voltage for driving the grid of V_2. However, it is desirable to have appreciably more voltage than this across R, so that bias control of the current in V_1 can be used as a fine adjustment for sweep speed. To protect the transistor circuit, a tap across R prevents the voltage from exceeding 70 volts. Moreover, an appreciable portion of the current required by V_1 for generating the fastest sweeps is bypassed around the transistor circuit. This is made feasible by the capacitor across the upper part of the divider. The circuit of Fig. 2C then meets the requirements set forth above.

The examples illustrate the use of transistors for linearizing the output from conventional bootstrap sweep generators. Since the hybrid circuits do not require a separate power supply, they can be incorporated into conventional circuits as floating amplifiers. The technique can be applied to other circuits, especially those using cathode-followers.

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Transcribing Field Markings By OPTICAL SCANNING

Photoelectric scanner automatically transcribes into machine code a wide spectrum of field markings, including ordinary pencil markings even when smudged. Technique cuts time of punching from original source documents

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With this optical scanning punch, 40 field markings on each side of a special 90-column card can be read at the rate of 150 cards a minute

THE UNIVAC optical scanning punch automatically transcribes into machine code a wide spectrum of field markings. The punch reads photoelectrically as many as 40 characters of field markings on each side of specially printed 90-column cards, translates them into punched-card code, and block punches the information into the cards in any desired format. The unit operates at a speed of 150 cards a minute and does not require an electrographic pencil.

A variety of marks—checks, lines, crosses, numbers, letters—is compatible with the machine. Smudged and lightly marked data are also acceptable since the sensitivity of the reading mechanism can be adjusted, and multiple runs of the input may be made at various settings.

Flexibility is provided by the punch's operating speed and its programming possibilities. Built-in checking circuits isolate and identify missing and double markings. The punch can accept prepunched and preinterpreted cards; it can punch constants by lead cards or connection panel wiring; and it can verify runs of data, repunching the information slightly offset for checking.

By eliminating manual card-punching from original source documents, the scanning punch reduces the time needed for data processing. Data for automatic processing are gathered close to their source, both from central offices and from remote locations.

Many accounting and statistical jobs can be handled with the punch. Physical inventories can be speeded and simplified by using marked punch cards as warehouse reporting documents. Factory reports for payroll accounting and production control can be made directly from the shop floor, with cards at each machine station for marking of production quantities, time spent on each operation, pay and incentive rates, and other variables. Other applications include orders and requisitions, utility billing, traffic studies, census enumerations and market surveys.

The reading mechanism of the scanning punch is composed (Fig. 1A) of a row of shielded photodiodes. The exciter lamps, upper and lower, provided with lenses and reflectors are the light sources. The markings on the cards are sensed while passing under the light from the upper lamps which is reflected off the card onto the photodiodes. Decreases in the reflected light due to markings are sensed by the

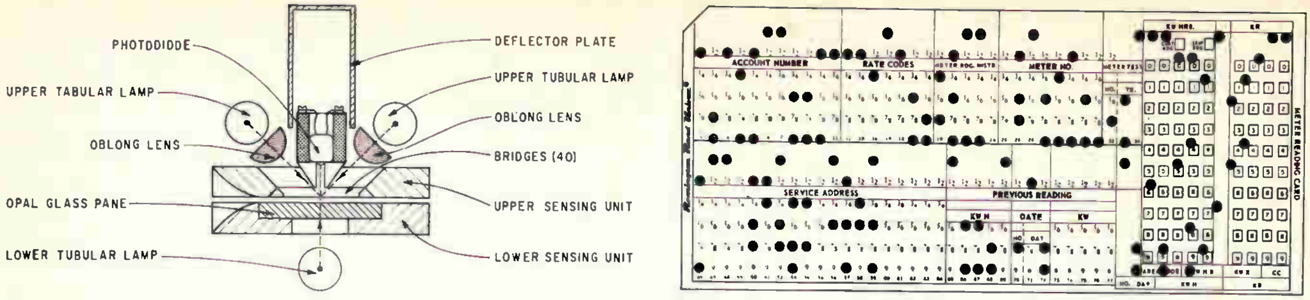

FIG. 1—Cross-section of the reading mechanism of the scanning punch (left), and typical card used with the punch (right)

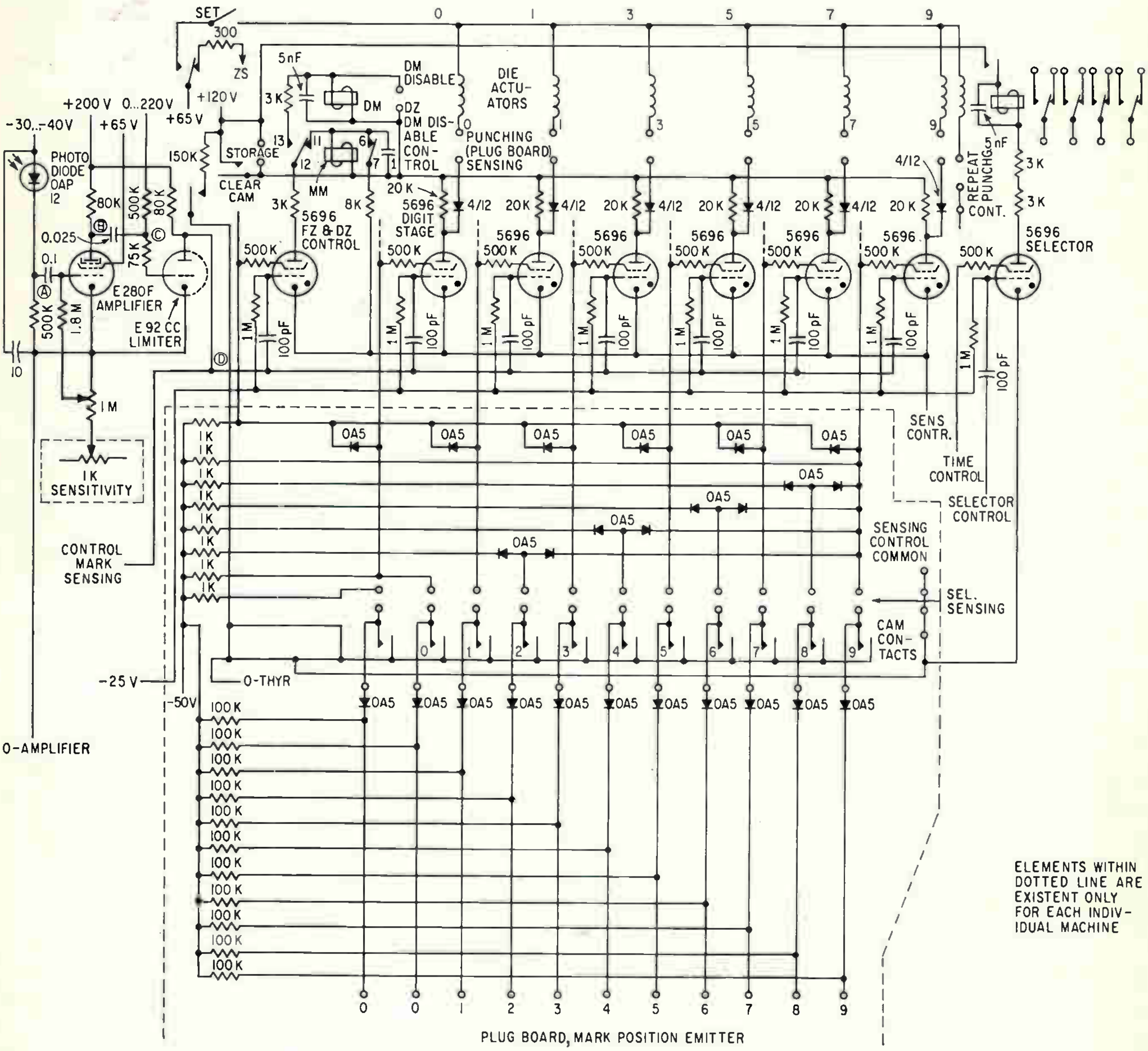

FIG. 2—Schematic for optical scanning punch. This section is for one column including one selector

diodes, and the attenuation translated into an electric pulse that is amplified, limited, controlled and translated into settings in the punching section. The holes in prepunched cards are not to be sensed and are compensated for by the lower exciter lamp, which is adjusted so that the intensity of light it transmits directly onto the photodiodes is equal to that reflected from the unmarked card.

A small stream of air from the main fan is deflected through the reading unit to keep the ambient temperature of the photodiodes from rising excessively.

The photodiodes are adjusted to function as voltage dividers—for different light intensities they correspondingly show different resistances. When light decreases, that is, when a mark is sensed, resistance increases. If, for example, a potential of -32 volts is applied to a diode, point A (see Fig. 2) will have -16 volts, assuming that with a given light the diode has a resistance of 1 megohm. Therefore, when a mark is sensed, the increased photoresistance renders the potential at point A less negative, that is, about -14 volts, a change in potential of $+2$ volts.

This positive pulse, the extent of which is in direct ratio to the width and intensity of the mark and the sensitivity setting of the diodes and which usually varies between 0.05 and 2 volts, is conducted through a 0.1-μf capacitor to the grid of a E280F tube which receives its static bias through a 2-megohm resistor. All E280F tubes have their bias jointly controlled by a 1,000-ohm sensitivity regulator. This potentiometer supplies a continually varying potential of about -3.4 to -6.4 volts. In addition to this regulator, there is for each such tube a trimming potentiometer attached to the rear of the tube panel, allowing the input sensitivity to be individually adjusted to the corresponding photodiode.

The amplification factor is approximately 230. Since the amplified voltage will never exceed the voltage applied to the plate, about 200 volts, the plate of E280F, under average conditions, will have an impulse of 150 to 200 volts. This negative impulse is conducted to the limiter stage (E92CC) by an 0.025-μf capacitor. Due to the positive voltage at point C, only greater negative voltages (the marking voltages) will affect the grid of E92CC.

The impulse, now free of interference from such factors as variations in card stock and vibration of exciter lamp filaments, reaches line D from which it can actuate seven 5696 thyratrons. The impulse always fires the thyratrons in the control stage.

All control elements (resistors and capacitors) are housed in individual cages, and each stage (amplifier, limiter, digit and control) comprises a cage and a tube. The limiter stage (dual triode) operates for two card columns.

Translation of impulses into code is controlled by a synchronizing unit composed of ten cams which operate with the feeding mechanism. Since the digits are progressively positioned on the card, the individual impulses appear at predetermined periods of time. Thus, if column 1 is marked with a 0, column 2 with a 6, and column 3 with a 9, at the moment the 0 is read, cam contact 0 is closed. The -50 volts potential at grid 2 of the digit thyratron is changed to 0 volts. Simultaneously, the reading impulse is taken from line D and, through a 100-pf capacitor, applied to grid 1 of digit thyratron 0. The latter then fires and current passes through the 20,000-ohm plate resistor causing the plate potential to drop from $+120$ volts to about $+10$ volts. None of the other digit thyratrons fires because its cam contact has not been closed, and consequently the negative potential is maintained at grid 2.

The time interval between each of the control cams of the digital positions is approximately 7 msec at the normal operating speed of 150 cards a minute. Thus, approximately 42 msec after the 0 cam, the 6 cam contact closes, applying ground potential to grid 2 of digit thyratrons 5 and 9 of column 2 (the Univac punched-card code for 6 is indicated by punches in the 5 and 9 positions of the same column). The marking impulse in line D fires these two thyratrons, and at the same time the thyratron is fired in the control stage of column 2. The same process takes place 63 msec after the initial cam closure when the 9 cam closes in column 3.

Once a marking impulse has originated in a column, the *FZ-DZ* control thyratron fires, relay *FZ* pulls up, locks up through operating contact 6/7, and extinguishes the control thyratron by transfer contact 11/12/13. Relay *FZ* in this condition means that the column in question contains a marking. Checking circuits would otherwise indicate a missing mark and its location unless disarmed by a control marking on the card or wiring on the connection panel. By means of the *DZ* relay and the *FZ* relay contact 12/13, voltage is again applied to the control thyratron immediately upon its having recorded one mark. Other marks, presumably erroneous unless alphabetical information is being recorded, will cause it to fire again, denoting the presence of a double mark, which will likewise activate checking circuits to indicate the error and its location unless disarmed.

Finally, when the entire card has been read, the clear cam contact opens, all thyratrons are extinguished, and relays *FZ* and *DZ* deenergized. If markings are to be read from one card and punched into the following, the clear cam contact is shunted by a storage-relay contact. This device can be called into play by control marking as well as by panel programming.

The electromechanical block punching mechanism of the die section has been set up. The card to be punched is clutched to a stop, the desired information punched into it, and the card fed into the receiving magazine.

The power pack supplies voltages for the following: tube filaments, punching die actuators, function lamps, exciter lamps, thyratron plate voltage, screen grids, limiters, bias for the second grid of the thyratrons, photodiodes, and the sensitivity control. All voltages are rectified, filtered and grounded to obtain the proper polarity.

The operator's control panel has, besides an OFF-ON power switch, a switch that reduces power operating voltages approximately 15 percent to test the reliability of component tolerances in areas of unreliable line voltage. A two-way program switch governs the six-pole alternate selectors on the connection panel, enabling the operator to select one of two variations of the basic program without rewiring the panel. A set of display lights indicates any errors in input that may occur, either double or missing marks, as well as the location on the card of such errors. Cards containing erroneous information can be made either to interrupt operation of the machine so they can be immediately corrected or they can be shunted into a reject receiving magazine. Either double or missing marks or both can be ignored by means of control marking or connection panel wiring. The plugboard also allows the wiring in of alphabetic or numeric constants, as well as punching data from lead or master cards. And finally the sensitivity control, with its wide range of settings, allows the transcription of a variety of markings.

Computing Noise Levels in Microwave

This article gives an evaluation of all noise entering the system, from background space noise to that generated in the microwave receiver hardware

SUBSTANTIAL IMPROVEMENTS have been made in the sensitivity of microwave receivers during the last four years. In 1956, the best receivers had an equivalent internal noise power contribution of about 1.6×10^{-11} milliwatts per megacycle of bandwidth. The corresponding noise figure of 7 db was not easily improved. No one, in recent years, had succeeded in achieving a substantial breakthrough in the reduction of internal noise of microwave receivers. In 1948 Van der Ziel[1] had pointed out the low-noise prospects of amplifiers of the type now called parametric. In 1953 Weber[2] made similar comments about the type of amplifier now called the maser.

In 1956, development of the ammonia maser brought the possibilities of drastic noise reduction to the foreground. The group[3] led by Townes presented their convictions that the ammonia maser could achieve unheard-of feats as a low-noise amplifier. It has subsequently been shown that maser devices do have remarkable low noise capabilities, with internal noise power near 4×10^{-14} milliwatts per megacycle of bandwidth.

It is now customary to compare receivers in terms of their apparent equivalent input noise temperature. The noise figure F, internal noise power N_i, and internal noise temperature T_i, are simply related by

$$N_i = (F - 1)kT_oB = kT_iB \qquad (1)$$

where k is Boltzman's constant $= 1.38 \times 10^{-23}$ joules per degree Kelvin, T_o is the reference temperature for determining F, $kT_o = 4 \times 10^{-12}$ milliwatts per megacycle of bandwidth, B is the bandwidth in megacycles, and T_i is the equivalent internal noise temperature contribution.

In internal noise temperature terms, the 7-db figure receiver has an internal noise temperature of 1,160 degrees Kelvin. The solid-state maser mentioned earlier has an internal noise temperature in the region of 3 degrees K.

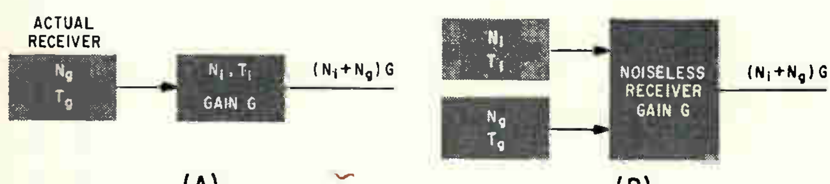

FIG. 1—Separating internal noise from total noise (A). Noise equivalent circuits (B)

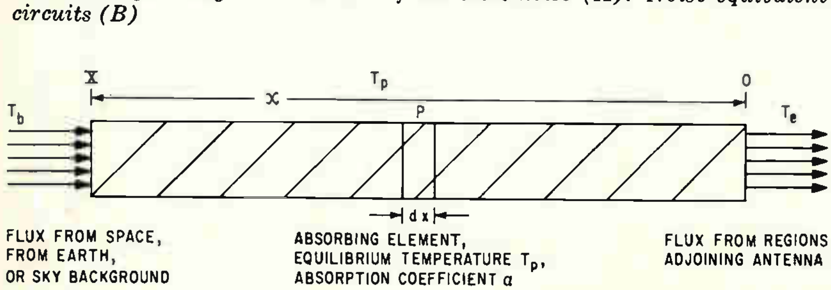

FIG. 2—Effective temperature of a ray T_e arriving at the antenna depends upon background temperature and intervening absorbing gas

In block diagram form these situations can be represented by Fig. 1 where N_g is the source noise power output, and N_i is the noise added by the actual imperfect receiver. A perfect receiver would have $T_i = 0$ and $F = 1$. The solid state maser receiver mentioned comes remarkably close to this. If $T_i = 3$ degrees Kelvin $(F - 1) = T_i/T_o = 3/290 \approx .01$, and $F \approx 1.01$.

In recent years the new classes of low noise amplifiers have given virtually complete coverage of the internal temperature range from 3 degrees Kelvin to the values of five years ago. For instance, the choice of low-noise amplifiers will probably result in the pattern shown in the table.

Results of this type can be readily achieved for voltage gain-fractional bandwidth products of 0.5; for instance, with a voltage gain of 10 and a fractional bandwidth of 0.05.

Such properties will satisfy many present-day needs. The conspicuous omission at present is in applications requiring more than 5 percent bandwidth. These properties bring about a drastic change in emphasis in microwave receiving system design. The internal noise temperatures of such amplifiers are low enough to be comparable to or smaller than the temperature of the receiving system portions preceding the first amplifiers. The noise originating in these pre-receiver components can no longer be ignored. In fact, microwave receiving system design can now be primarily limited by noise levels preceding the microwave amplifiers. The amplifying stages can be chosen to make only a small internal noise contribution to the receiver noise.

Noise contributions preceding the amplifying components arise ultimately in radiative processes, either

Receiver Systems

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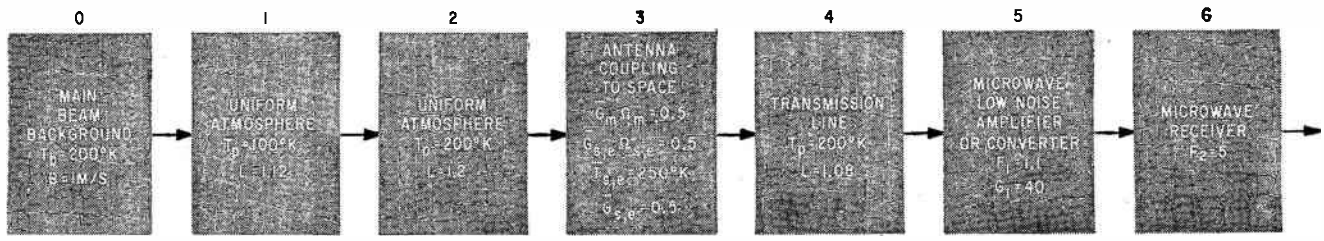

EQUIVALENT OUTPUT TEMPERATURE

200°K 189° 199° 225° 230° 10,360°K

EQUIVALENT INPUT TEMPERATURE

259°K 11,520°K

NOISE POWER LEVEL MW PER MC FLUX FROM MAIN BEAM, SIDE LOBE LEAKAGE, AND INTERNAL NOISE

2.76×10^{-12} 2.61×10^{-12} 2.75×10^{-12} 3.11×10^{-12} 3.17×10^{-12} 1.41×10^{-10}

EQUIVALENT INPUT NOISE POWER LEVEL PER MEGACYCLE FOR NOISELESS TRANSMISSION

3.57×10^{-12} 1.59×10^{-10}

SIGNAL POWER LEVEL, FOR ARBITRARY SIGNAL POWER FROM MAIN BEAM = 2.76×10^{-12} MW

2.76×10^{-12} 2.46×10^{-12} 205×10^{-12} 1.03×10^{-12} 0.95×10^{-12} 3.81×10^{-11}

$\frac{S}{N}$ 1 0.94 0.75 0.33 0.30 0.27 0.25

FIG. 3—Contributions to the overall noise that are made by each section of the receiver system

far-off in space, in the atmosphere, at the surface of the earth or sea, or in the conducting structures of the antenna and transmission line components. The methods required to compute the noise originating in each of these processes have been adequately described in the literature. A few representative references are given[4-8] and they lead to other references.

The noise flux collected by the antenna is easily evaluated, at least in principle. The antenna temperature is given by the formula in Eq. 2 and 3. The temperature-gain product must be given, or adequately approximated, throughout all space. Practical approximations are given in reference[3]. Equations 2 and 3 imply that the antenna is at or near the surface of the earth.

$$T_a = \left\{ \left(\int_m T_m G_m \, ds + \int_s T_s G_s \, ds + \int_e T_e G_e \, ds \right) \Big/ 4\pi \right\} \qquad (2)$$

$$T_a \approx \overline{T}_m \overline{G}_m \Omega_m + \overline{T}_s \overline{G}_s \Omega_s + \overline{T}_e \overline{G}_e \Omega_e \qquad (3)$$

Where the subscripts a, m, s, and e refer to antenna, main-beam, sky and earth respectively, and where temperatures are given by T, average temperatures by $\overline{T}$, gain by G, average gain by $\overline{G}$, and the fractional solid angle by Ω. The same procedure holds for any space in which the antenna is immersed. For instance, the same procedure is required for satellite-borne antennas. In these cases the angle subtended by earth will be smaller. However, in satellites the main beam in the microwave receiving antenna may be required to point toward the earth. In this case, the antenna temperature will approach the apparent earth temperature or that of its atmosphere, probably between 200 and 300 degrees K. Just beyond the earth's tangent cone the antenna temperature for a pencil beam drops abruptly.

The temperature variation with antenna background really requires polarization parameters as well as ray direction angles and temperatures. The evaluation of the antenna temperature, T_a, is therefore a tedious business requiring a large amount of input data which is seldom available. Approximations of the type indicated in Eq. 3 are often required.

The effective temperature, T_e, of a ray arriving at the antenna, Fig. 2, depends both upon the background temperature and the properties of intervening gases. In Fig. 2, the noise flux arriving at an antenna can be derived from the background and the absorptive and emissive properties of the intervening gas Eq. 5. This equation was derived using the assumption that thermal equilibrium exists. It applies for non uniform gaseous regions. For absorbing regions of constant temperature it simplifies to

$$T_e = T_b/L + T_p(1 - 1/L) \qquad (4)$$

In this, $L = \int_0^X \alpha \, dx$, the loss factor

$$T_e = T_b \exp\left[-\int_0^X \alpha \, dx \right] + \int_0^X \alpha T_p \exp\left[-\int_0^P \alpha \, dx \right] dx \qquad (5)$$

The entire calculation of the noise

COMPARISON OF NOISE FROM DIFFERENT AMPLIFIER TYPES

Internal Temperature In Degrees K	Amplifier Type
3–100	Maser
30–1,000	Parametric Amplifier (semiconductor)
30–1,000	Parametric Amplifier (electron beam)
300–1,000	Traveling Wave Tubes

levels in a system can be carried out by using these principles. Successive application of these formulas, as required, can be combined into one big involved formula. However, this is less desirable than the practice of evaluating the noise power-level or temperature block-by-block, as progress is made through the blocks in a systems calculation. By doing this, other features, such as absolute power level, saturation, and dynamic range, are also readily explored.

Consider first the equivalent temperatures and signals as seen at the outputs of the two uniform atmospheric regions, blocks 1 and 2 in Fig. 3. Using Eq. (4)

$$T_{e1} = 200/1.12 + 100(1 - 1/1.12) = 189 \text{ K}$$

The effective output temperature is somewhat reduced over the background temperature. The signal is also reduced by the factor 1/1.12 = 0.893. If the signal-to-noise ratio at emergence from the background is unity, the new signal-to-noise ratio at the output of block 1, is

$$\left(\frac{S}{N}\right)_1 = \frac{S_1}{N_1} = \frac{S_o}{N_o} \cdot \frac{S_1}{S_o} \cdot \frac{N_o}{N_1} \qquad (6)$$

$$\left(\frac{S}{N}\right)_1 = (0.893)\frac{200}{189} = 0.944\left(\frac{S}{N}\right)_o$$

The signal-to-noise ratio is reduced, as is to be expected, even though the noise level has also been reduced. This situation is unusual, but it can be encountered, both in the atmosphere and in cold transmission components.

For regions at non-uniform temperature, the more general formula, Eq. 5, must be used. To use this, both temperature, T_p, and absorption coefficient, a, must be known as a function of position.

The second block represents the more common situation. Here,

$$T_{e2} = 189/1.2 + 250(1 - 1/1.2) = 199 \text{ K}$$

The new signal to noise ratio, referred to the background signal-to-noise ratio is

$$(S/N)_2 = (0.944/1.2) \times (189/199) = 0.747\,(S/N)_o$$

In this case, the signal is reduced and the output noise is increased, both effects contributing to the reduction in signal-to-noise ratio.

The antenna block 3, is treated in a simplified manner here to illustrate some of the main features of the antenna problem. Assume that the temperature seen by the main beam is uniform over that beam and equals T_{e2} = 199 K. If half of any transmitted flux goes out on the main beam and half into the side lobes, then

$$\frac{1}{4\pi}\int_m G_m\,ds = \frac{1}{4\pi}\int_s G_s\,ds + \frac{1}{4\pi}\int_e G_e\,ds = 0.5$$

In some cases, no large error is made by assuming the antenna, gains: G_m, G_s and G_e, are constant, and have average values $\overline{G}_m$ and $\overline{G}_{s,e}$ with $\overline{G}_m >> \overline{G}_s$. The fractional solid angles are defined as,

$$\Omega_m = \frac{1}{4\pi}\int_m ds$$

and

$$\Omega_{s,e} = \frac{1}{4\pi}\int_s ds + \frac{1}{4\pi}\int_e ds$$

For high gain antennas $\Omega_m << \Omega_{s,e}$, and $\Omega_{s,e}$ is only slightly less than unity. That is,

$$1 - \Omega_m = \Omega_{s,e} \quad \text{and} \quad \Omega_{s,e} \approx 1$$

Here it has finally been assumed that

$$\overline{G}_m\Omega_m = \overline{G}_{s,e}\Omega_{s,e} = 0.5$$

The apparent antenna temperature can be calculated from Eq. 3.

$$T_{e3} = T_a = (199)(0.5) + 250 \cdot (0.5) = 225 \text{ K}$$

Ordinarily, antennas are matched to provide maximum transmission to the entire space radiation load, including both the main-lobe and side-lobe energy. An equivalent representation is given by the three-port network in Fig. 4A.

Unfortunately, a reciprocal three-port cannot be matched in all directions. On receive, the antenna produces substantial scattering both back into the main beam and into the side lobes as suggested in Fig. 4B. In the case chosen, the net transmission to the output leading to the receiver is easily calculated. The reflection coefficient back into the main beam is

$$\rho = (1/2Y - 3/2Y)/(1/2Y + 3/2Y) = -1/2$$

and

$$(1 - \rho^2) = 3/4$$

The quantity $(1 - \rho^2)$ represents the total transmission from the main beam to the output port of the receiver and to the scattering into the side lobes. This transmission is split in the ratio 2 to 1 in favor of the higher admittance. The net transmission to the receiver port is, therefore

$$(1 - \rho^2)Y/1.5Y = 2(1 - \rho^2)/3 = 1/2$$

As far as signal flux coming into the antenna aperture is concerned, only half of it arrives at the port attached to the receiver. This can be regarded as a reduction in signal-to-noise ratio. The signal-to-noise ratio out of the antenna block 3 is now

$$(S/N)_3 = (0.75)(1/2)199/225 = 0.33(S/N)_o$$

Ordinarily, the reference signal-to-noise ratio is not carried this far back toward the ultimate signal source. However, this method of treatment helps to visualize the main sources of trouble. Certainly, the antenna specifications chosen here represent a very poor antenna. This calculation does show that attention should be placed on achieving,

$$\overline{G}_m\Omega_m > \overline{G}_{s,e}\Omega_{s,e} \quad \text{or} \quad Y_m > Y_{s,e}$$

In fact, these inequalities can be strong in the case of horn antennas. From another point of view, this is true because horn antennas approach theoretical gain for a specified main beamwidth.

Very little has been said about the absolute power levels in Fig. 3. The noise power per megacycle is given by Eq. 1. This equation also indicates the linear relation between these power levels and the temperature. This noise power for the output of blocks 0, 1, and 2 includes plane parallel noise flux which will fall on the antenna aperture. The output-noise power from block 3 includes sidelobe noise leakage into the antenna. For block 4, the transmission line loss contributes some more noise power: in block 5 additional noise is added by the receiver and amplifier.

The equivalent input power level for block 5 is merely the output-noise power level divided by the gain.

An arbitrary signal power-level is assumed. For convenience in this discussion it was made equal to the background-noise power-level from block 0. All subsequent signal levels are obtained by using the gain or loss factors for each block. The signal to noise ratios were computed directly from the pertinent values given in Fig. 3. The signal-to-noise ratio always decreases, as can be expected from thermodynamic principles. In block 5, the ratio of the input and output signal-to-noise ratios is the familiar noise factor definition.

$$F_1 = (S/N)_{i5}/(S/N)_{o5} = 1.1$$

The degradation of signal to noise is fairly severe in this example. The designer would not have to tolerate the poor antenna if economics permitted antenna improvement.

Ordinarily, signal to noise ratios are only calculated from the output of the antenna, on through such components as 4 and 5. The signal to noise ratios given in Fig. 4 are easily converted to any reference desired.

Now, going back to the remainder of the temperature calculations, the equivalent temperature is raised by the transmission line loss given in block 4. Computation here is like that for block 2.

$$T'_{e4} = 225/1.08 + 290(1 - 1/1.08) = 230 \text{ K}$$

For the low-noise receiver, the temperature due to internal noise is given by Eq. (1).

$$T'_{i5} = (F_1 - 1)T'_o = (1.1 - 1)290 \text{ K} = 29 \text{ K}$$

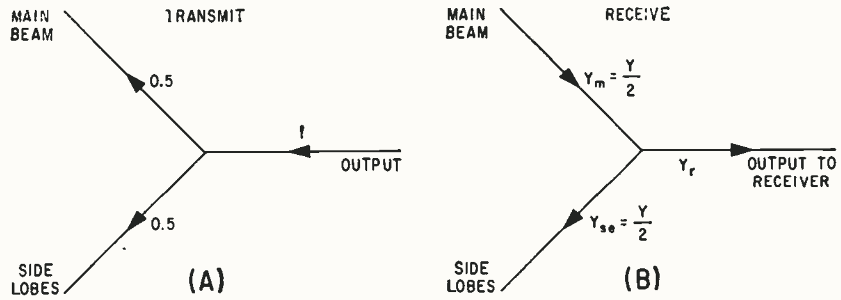

FIG. 4—Antenna equivalent circuits, with transmitter equivalent on left and receiver on right

The equivalent input temperature for a receiver contributing zero internal noise and having equal noise-power output is

$$T'_{e4} + T'_{i5} = 259 \text{ K}$$

The output noise level for a gain of 40 is as large as the noise from a source of temperature

$$T'_{e5} = (T'_o + T'_{i5})G = 10{,}360 \text{ K}$$

The remainder of the microwave receiver has a noise factor of 5 as given in block 6. The internal noise added by this receiver can be represented by

$$T'_{i6} = (F_2 - 1)T'_o = (5 - 1)290 = 1{,}160 \text{ K}$$

The effective temperature is now,

$$T'_{e6} = T'_{e5} + T'_{i6} = 11{,}520 \text{ K}$$

This is equivalent to an input noise power level of,

$$N_6 = kT_{e6}B = 1.59 \times 10^{-10} \text{ mw per megacycle}$$

The S/N ratio is now 0.25.

The combined noise figure of blocks 5 and 6 are frequently given as

$$F_{12} = F_1 + (F_2 - 1)G_1 = 1.1 + (5 - 1)/40 = 1.2$$

The internal temperature due to the two blocks combined is

$$T'_{i56} = (F_{12} - 1)\,T'_o = (0.2)(290) = 58 \text{ K}$$

and the equivalent input temperature for the 5 and 6 block combination is $T_{i56} = T_{e4} + T_{i56} = 288$ Kelvin. This equivalent input temperature is now referred back to the input to the low noise amplifier, block 5. An output temperature for block 6 is given by

$$T_{out} = T_{ei56}G = (288)(40) = 11{,}520 \text{ K}$$

This corresponds to a noise power level of 1.58 × 10^{-10} mw per Mc. It is also to be noted that the ratio of the S/N ratios from blocks 4 and 6 equals the combined noise factor for blocks 5 and 6.

$$F_{12} = 1.2 = \frac{0.30}{0.25} = 1.2$$

This set of computations illustrates most of the aspects of the problems encountered. Approximations have been freely made to avoid the tedious details of exact computations. This is a reasonable process, because adequate data concerning temperature, antenna gain, and absorption distributions are seldom available. However, microwave system designers need to make some approximate calculations concerning these matters. This is required to permit an intelligent choice of system components. All of the components, including the antenna, need to be given careful consideration in any effort to obtain an optimum design.

It is to be noted that these sample calculations can be made using principally the following formulas:

$$N_i = (F - 1)\,k\,T_o\,B = k\,T_i\,B$$

$$T_a = \bar{T}_m\bar{G}_m\Omega_m + \bar{T}_s\bar{G}_s\Omega_s + \bar{T}_e\bar{G}_e\Omega_e,$$

$$T_e = T_b/L + T_p(1 - 1/L) \quad \text{and}$$

$$\left(\frac{S}{N}\right)_{n+1} = \frac{S_{n+1}}{N_{n+1}} = \frac{S_n}{N_n}\,\frac{S_{n+1}}{S_n}\,\frac{N_n}{N_{n+1}}$$

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Inverter Control Circuit Saves Power

By D. W. R. McKINLEY,
National Research Council,
Ottawa, Canada

THE IDLING d-c current of small rotary converters or transistor power inverters may be 1 or 2 amperes, or even greater, which is an appreciable standby drain on the battery. It is often inconvenient to switch the inverter input on and off during periods of intermittent use, for example, when operating a portable electric drill. The control circuit shown uses inexpensive components and reduces the standby current to less than a milliampere (the I_{co} of transistor Q_1). Although the relay draws from 100 to 200 ma while the inverter is on, there is an over-all saving in ampere hours, even if the demand duty cycle is as high as 90 percent. This is valuable in a permanent installation, such as a summer cottage, where a-c power should be available on demand at several remote outlets, but where the actual use may amount to only a few hours a day.

The sensing element is a pair of back-to-back silicon diodes, D_1 and D_2. Over a range of a few milliamperes to several amperes, the voltage in either direction across this diode pair remains between 0.4 and 0.6 volt. The voltage loss in the 110-v, a-c load circuit is therefore insignificant, and is also relatively independent of load. This would not be the case if a purely resistive sensor were used. The current rating of each diode should equal half the maximum load current, but the piv rating need not exceed a few volts. The voltage developed across D_2 is more than sufficient to turn on the germanium *pnp* transistor Q_1 in normal ambient temperatures.

For positive operation of some types of transistors at low temperatures a second diode may be inserted in series with D_2 to double the available bias voltage; it is not necessary to add another diode in series with D_1. Transistor Q_1 may be any of a wide variety of medium-power audio transistors. It should have a current rating of about an ampere and a voltage breakdown somewhat greater than the supply voltage. No heat sink is needed since the transistor is either cut off or fully on.

With no load, the relay is open and the input to the inverter is disconnected. With load, a d-c bias is developed across D_2 that turns on Q_1 and closes the relay. The capacitance shunted across the relay coil stores enough energy to hold the relay down until the inverter output voltage builds up. This occurs quickly with a transistor inverter but more slowly with a motor-generator unit. The load current through D_2 keeps the relay closed until the load is removed. The system operates with resistive loads of several thousand ohms if sensitivity control P_1 is set at its full 50-ohm value. This load sensitivity may be adjusted to any desired minimum load by decreasing the resistance P_1. The value of R_1 is not critical, since it merely limits the actuating current to a few milliamperes.

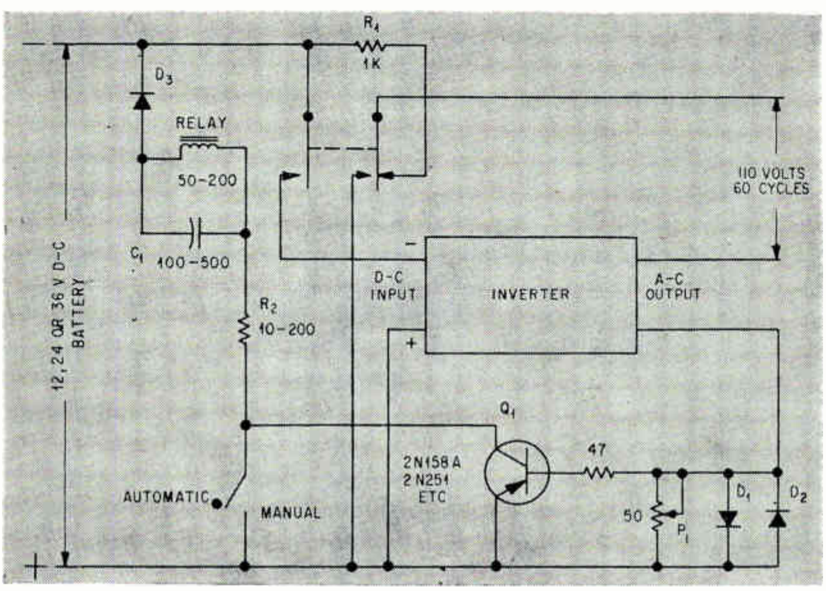
The relay contacts should be capable of carrying the maximum d-c input and a-c load currents. However, the contacts are required to break only the idling d-c current of the inverter, not the maximum current, hence a relatively inexpensive relay is satisfactory. Many varieties of small commercial 12-volt relays, which operate on 100 to 200 ma coil current, work well for any supply voltage from 12 to 36 volts, with appropriate choice of R_2. The value of C_1 is selected to suit the characteristics of the relay and the inverter. As a rough guide, 250 μf across a coil resistance of 100 ohms provides an adequate time constant for a transistor inverter.

The small 500-ma diode D_3 is simply cheap insurance to protect the inverter and Q_1 against inadvertently connecting the batteries with the wrong polarity.

Still better insurance, against a jammed relay for example, may be obtained by inserting a high-current diode in the main supply lead, but such a diode would cost considerably more, would need a heat sink, and would introduce a small voltage drop and a corresponding power loss.

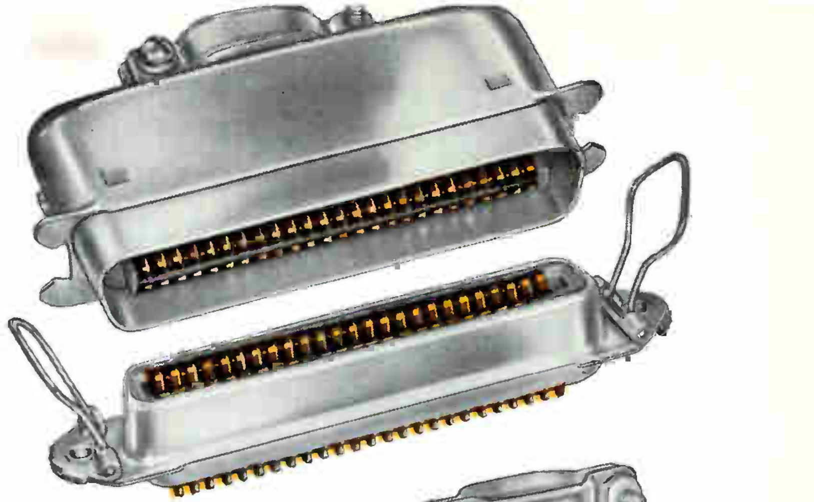
Several types of 12-volt 15-ampere transistor inverters are available. Two or three units will operate satisfactorily from a 24 or 36-volt battery with inputs in series and the outputs in parallel, to yield two or three times the single-unit output power.

The control system also works with a d-c-to-d-c converter. Here D_1 is not required.



Inverter control circuit. Sensitivity is adjusted by varying 50-ohm potentiometer P_1; current I_{co} of the transistor is the only standby drain

The smooth, easy insertion and extraction action, the self-wiping, self cleaning features and the double-sided, flexing action of both mating contact members make Micro-Ribbons the first miniature connectors to provide reduction in size with added reliability.



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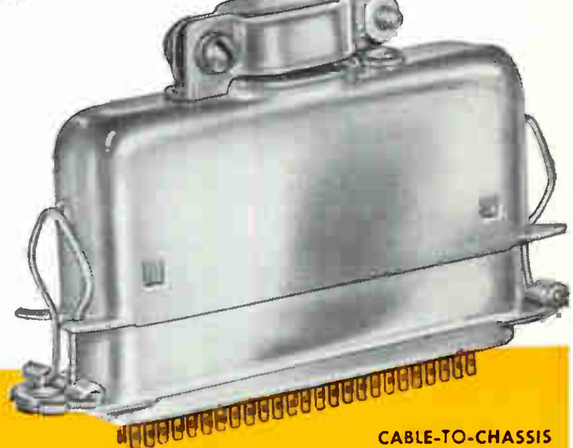

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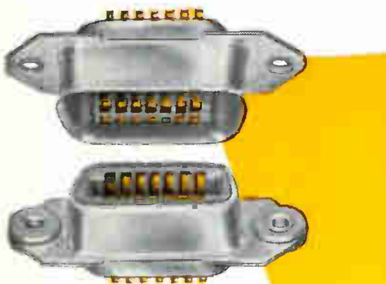
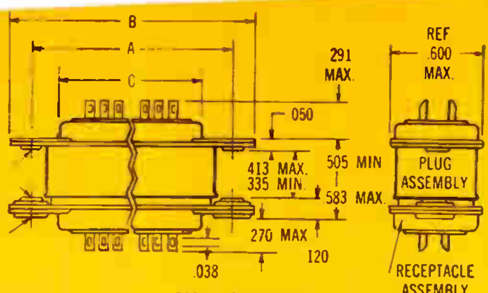


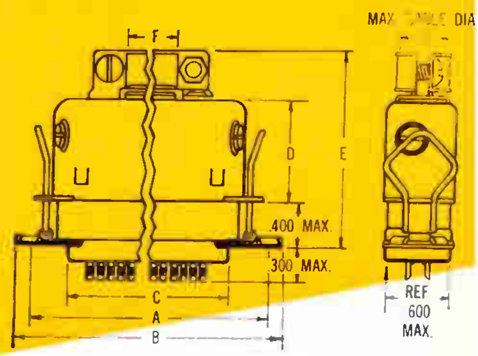
14 CONTACTS



RACK & PANEL TYPE

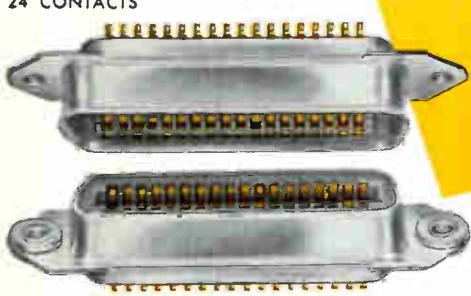
DIMENSIONS

		14 Contacts	24 Contacts	36 Contacts	50 Contacts
BOTH TYPES	A	1.417	1.842	2.352	2.947
	B	1.750 REF.	2.175 REF.	2.685 REF.	3.280 REF.
	C	910 REF.	1.335 REF.	1.845 REF.	2.440 REF
CABLE TO CHASSIS TYPE ONLY	O	.843	.843	.905	1.000
	E	1.668 MAX.	1.668 MAX.	1.730 MAX.	1.825 MAX.
	F	.306 MAX.	.473 MAX.	.640 MAX.	.766 MAX.
	G	.422 MAX.	.473 MAX.	.473 MAX.	.473 MAX.



CABLE TO CHASSIS TYPE

24 CONTACTS



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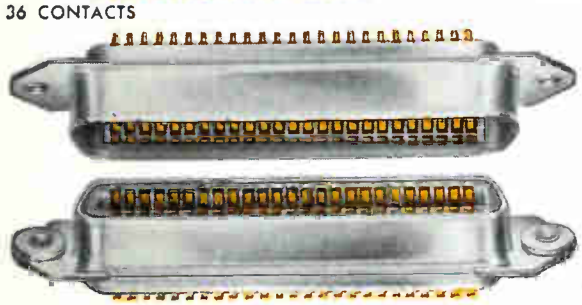
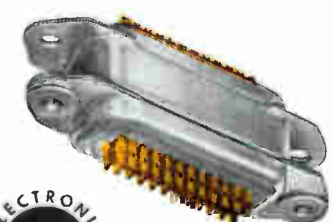


50 CONTACTS

RACK AND PANEL TYPES



ELECTRONIC DOT ASSEMBLIES

RACK AND PANEL CODE NOS.

CONTACTS	PLUG	SOCKET
14	57-10140	57-20140
24	57-10240	57-20240
36	57-10360	57-20360
50	57-10500	57-20500

CABLE-TO-CHASSIS CODE NOS.

	PLUG WITH CAP	SOCKET WITH LOCK
14	57-30140	57-40140
24	57-30240	57-40240
36	57-30360	57-40360
50	57-30500	57-40500

NOTE: Above code nos. have shells cadmium plated plus clear chromate. For cadmium plus yellow chromate Add -1 to the nos. shown.

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Receiver Reads Out Intercepted Frequencies

CONTINUOUS monitoring of transmissions over a broad band of frequencies is possible with a proposed receiving system that provides crt readout of intercepted frequencies. The technique was described at the Military Electronics Conference in a paper by John L. Grigsby, Applied Technology, Inc., Palo Alto, Calif.

Superheterodyne or trf scanning receivers for this application offer good sensitivity but low intercept probability. Channelized receivers with 100 percent intercept probability must be very complex to have good sensitivity over large bandwidths.

In the proposed system, tangential sensitivity is about −70 dbm. Frequency determination is about 5 percent accurate and is displayed as angular displacement with amplitude represented by radial displacement.

A reactive input filter for each of two channels results in standing waves with amplitudes and positions dependent on signal frequency and amplitude. Standing wave amplitudes are sampled with the detected outputs fed through vertical and horizontal deflection amplifiers.

In an idealized system, reactive elements are assumed to be open- or short-circuited lines, detectors and amplifiers are linear, and detectors do not load reactive elements. With quarter wavelength reactive elements at 2 Gc, detector amplitudes are $V_v = K \mid \cos(\pi f/4) \mid$ and $V_h = K \mid \sin(\pi f/4) \mid$, where f is frequency and K depends on signal amplitude and reactive element impedances.

If detected outputs are proportional to standing wave amplitudes and V_v and V_h are applied to the vertical and horizontal deflection plates, deflection angle is $\theta = \tan^{-1}(V_v/V_h) = (\pi f/4) - (\pi/2)$, where $0 \lesseqgtr \theta \lesseqgtr \pi/2$ and $2 \lesseqgtr f \lesseqgtr 4$. Thus deflection angle is proportional to frequency and independent of signal amplitude. Deflection amplitude, $R = (V_v^2 - V_h^2)^{\frac{1}{2}} = K$, is proportional to signal amplitude and independent of frequency.

To keep the detectors from loading the reactive elements and modifying the standing wave pattern, a power splitter is used with output impedance Z_o, matching detectors with impedance Z_o and reactive elements with impedance $Z_o/2$.

With square-law detectors, angular deflection becomes $\theta = \tan^{-1}[\cot^2(\pi f/4)]$, where $0 \lesseqgtr \theta \lesseqgtr \pi/2$. Amplitude response is now $R = (V_v^4 + V_h^4)^{\frac{1}{2}} = K^2 [\cos^4(\pi f/4) + \sin^4(\pi f/4)]^{\frac{1}{2}}$, which is constant within 1.5 db of input signal level.

Agc and r-f limiting prevents driving the square-law detectors into the large signal region where the rectification law could change and a given angular deflection could result from different frequencies existing at different amplitudes. With square-law detectors, the readout suffers from angular compression at the extremeties of the frequency range. A linear relationship could be obtained with video amplifiers having square-root response.

A useful compromise can be obtained if the power splitter, detectors and reactive elements all have impedance Z_o. Square-law detector output would be $V_v = K^2 \cot^2(\pi f/4)/[\cot^2(\pi f/4) + \frac{1}{4}]$ and $V_h = K^2/[\frac{1}{4}\cot^2(\pi f/4) + 1]$. Angular deflection with linear amplifiers is $\theta = \tan^{-1}(V_v/V_h) = \tan^{-1}[\cot^2(\pi f/4)] [\cot^2(\pi f/4) + 4]/[4 \cot^2(\pi f/4) + 1]$, where $0 \lesseqgtr \theta \lesseqgtr \pi/2$.

As input frequency varies from 2 to 4 Gc, angular deflection changes from 0 to 90 degrees. However, a bandpass filter must be used at the input to prevent repetitive deflection throughout the 90-degree sector as frequency varies from 0 to 2 Gc, 2 to 4 Gc, 4 to 6 Gc, etc.

This characteristic can be useful if transmission lines are used as the reactive elements. Coarse and fine frequency determination can be obtained with two pairs of frequency-determining elements, detectors, amplifiers and crt's. If the coarse system has quarter wavelength lines at 2 Gc and the fine at 100 Mc, angular deflection on the fine crt would sweep 90 degrees for each multiple of 100 Mc. A 2,440-Mc signal would appear at about 17.5 degrees on the coarse and 40.5 degrees on the fine crt. Frequency changes going from an even toward an odd multiple of 100 Mc would increase deflection toward 90 degrees, while going from odd toward an even multiple would decrease deflection toward 0 degrees.

Equipment used to demonstrate feasibility of the technique consisted of a power splitter, quarter wavelength lines at 100 Mc, matched square-law detectors and matched linear deflection amplifiers. A swept-frequency signal generator provided nearly constant voltage from 200 to 300 Mc, and a 100-percent amplitude modulated signal generator was used for frequency calibration.

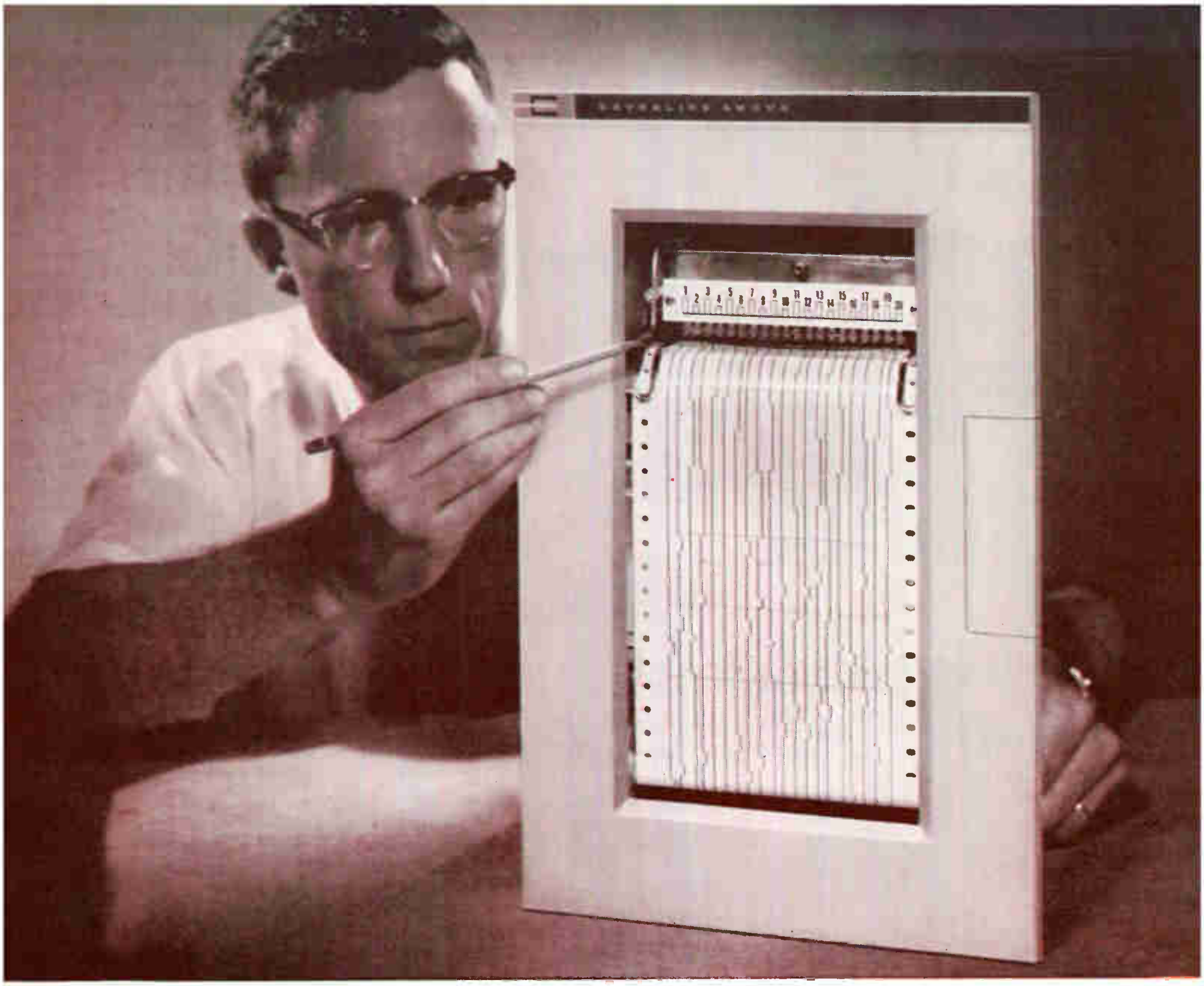
In demonstrating the technique for 2 to 4 Gc, it was found that the most accurate system requires matched detectors, matched pulse rise times and gains in video amplifiers, compression of the dynamic range of input signals and adequate reactive filter elements in the higher frequency regions.

Two-Maser Spectrometer Could Aid Cancer Study

MASER spectrometer provides a thousandfold increase in ability to observe chemical reactions involving free radicals. The new chemical tool could aid in finding cancer cures, improving rocket fuels and lowering the cost of atomic power.

Two masers are used in the instrument, which was developed by Melpar, Inc. A maser oscillator provides microwave energy that is absorbed by the sample, which results in a signal that is amplified by a second maser.

Specifically, the maser spectrometer provides a highly sensitive means for determining characteristics of electrons in the sample to be investigated. Electromagnetic and geometric characteristics of these



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electrons are responsible for the properties and reactions of the substance. The spectrometer permits direct observation of effects resulting from unbound electrons in organic materials and the electron spin effect in paramagnetic material.

While in the presence of a controlled magnetic field, the sample to be tested is subjected to microwave energy. The frequencies at which microwave energy is absorbed in the substance depend on its chemical characteristics. The maser-amplified signal resulting from the absorption is fed through electronic circuits and displayed graphically.

Interpretations are made through analysis of the graph. For example, certain reactions occur in cancer cell growth. Direct observation of the chemical changes that have taken place could be a first step in controlling them and therefore curing the disease.

Another potential application of the instrument involves rocket fuels. In both liquid and solid rocket fuels, it is known that free radicals are created as a result of chemical reactions. However, the exact nature of these reactions is not known. By permitting observation of these reactions, the maser spectrometer may permit creation of other free radicals to make fuels for rockets and space vehicles more effective.

Other possible benefits from information provided by the instrument include improved rocket motor casings, lighter and more effective space vehicle instrumentation, better and cheaper drugs, and improved synthetic fabrics and plastics.

Speech Recognition Gets Push From Synthesizer

ANALYZER-SYNTHESIZER of speech sounds could bring automatic speech recognition closer to practical applications. Speech recognition systems could enable voice programming of computers or voice dialing of telephones, and they could permit the human voice to operate typewriters and to route mail at post offices.

The analyzer-synthesizer project is aimed at proving the effectiveness of a method of analyzing speech sounds that is being developed for Rome Air Development Center. The work is being done by Sylvania Electric Products, a subsidiary of General Telephone & Electronics, at its Applied Research Laboratory.

Analyzing speech sounds is the first step in developing any automatic speech recognition system. Essentially, these systems would translate human speech into some kind of mechanistic language that could be used to control a machine or to be operated upon by a computer.

In the present project, it is assumed that this process can be reversed with the machine language translated back into speech. A computer is being used to convert a set of numbers into a tape recording that synthesizes human speech.

The purpose of the project is to determine the feasibility of a more efficient method of analyzing speech sounds. To test the technique, a tape recording is introduced into a digital computer where the sounds are analyzed mathematically. The resulting numerical data is then synthesized and recorded. At the conclusion of the project, the synthesized and the original recordings will be reproduced for comparison. Fidelity of the recording made from the computer data will indicate successfulness of the anlyzing method.

In the proposed method, the speech waveforms are analyzed in terms of about 30 orthonormal (uncorrelated) functions. These functions are chosen to resemble sound waveforms that occur naturally in speech. All sounds are represented as the sum of the same set of orthonormal functions with only the coefficients of the functions changing for different sounds.

To simulate perfectly the many variations in actual speech would require a very large number of functions. However, using about 30 functions is expected to result in sufficient fidelity for most speech recognition purposes.

Results of the speech analyzer-synthesizer project could be valuable in another area. The information may be applicable to speech compression for transmission over narrow bandwidth communications channels by improving the naturalness of voice reception.

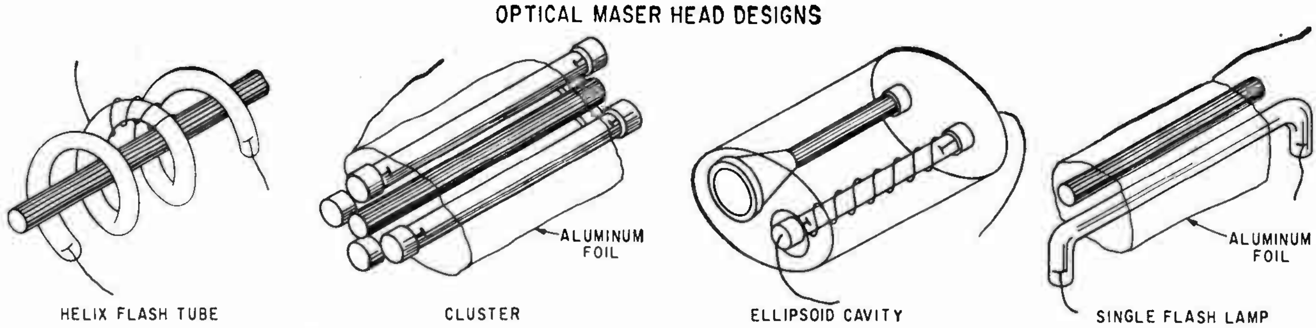

FIG. 1—Optical pumping schemes used in recent successful ruby optical masers. Idea is to concentrate light emitted from flashlamps onto ruby rod

Off-The-Shelf Components for Optical Masers

WITHIN A YEAR following the announcement of its development[1] the ruby optical maser, or laser, has reached do-it-yourself status. Manufacturers of ruby rod stock, electronic flash equipment, and precision optical apparatus, together can supply, on an off-the-shelf basis, all components necessary to assemble a research instrument.

To illustrate, this column mapped out the simple and inexpensive optical maser described below by considering catalogs and data sheets of several components and materials suppliers. Such a system might be used in new materials and advanced applications research, and to study the yet unexplained properties of stimulated radiation emission.

A typical optical maser consists of an optics head and an associated power supply as shown in Fig. 2. Mounted within the head are an optical quality ruby rod and a photoflash lamp system used as an optical pump. Most common dimensions for the ruby rod are 0.25 in. diameter and from 1.5 to 3 in. long. End faces of the rod are ground parallel to each other, polished optically flat, and coated to be almost totally reflecting. The ruby rod comprises its own optical system as far as beam generation is concerned, but additional optics may be tacked on externally to focus or direct the beam. Actual mechanics of optical maser operation and coherent light generation have been adequately covered in many references. It will suffice to mention here that the output beam is highly collimated, highly coherent, and almost monochromatic, having an approximate wavelength of 6943 A. This last value is a characteristic of ruby devices, and will differ for other materials. Output appears as a burst of red light; shape of the burst depends on the power output of the flashlamps as shown in Fig. 3[2].

The optical pump is made up of one or more electronic photoflash lamps and a suitable reflector arranged to direct as much emitted light as possible into the ruby rod. Fig. 1 illustrates the various optical pumping schemes that have been used successfully to date. A spiral flash lamp surrounding the ruby rod was used in the first reported optical maser.

Recent studies have shown that the pump threshold level, or minimum power input to the flash lamps at which maser action is observable, can be drastically reduced through careful design of the reflector. Threshold levels have been reduced by factors of ten by rearranging the reflector geometry.

Ellipsoid cavities have been used successfully by several researchers. Here, the flashlamp and ruby rod are mounted at the respective foci of the elliptical cylinder to take advantage of the basic analytic geometry property of the ellipse: all light rays leaving the lamp at one focus will be directed through the ruby at the other.

A simpler and quite effective technique[3] is to cluster straight flash tubes around the ruby rod, and to wrap the complete package with degreased aluminum foil. In this case the foil reflector also acts as the trigger electrode to fire the flash lamps. Single tubes can be

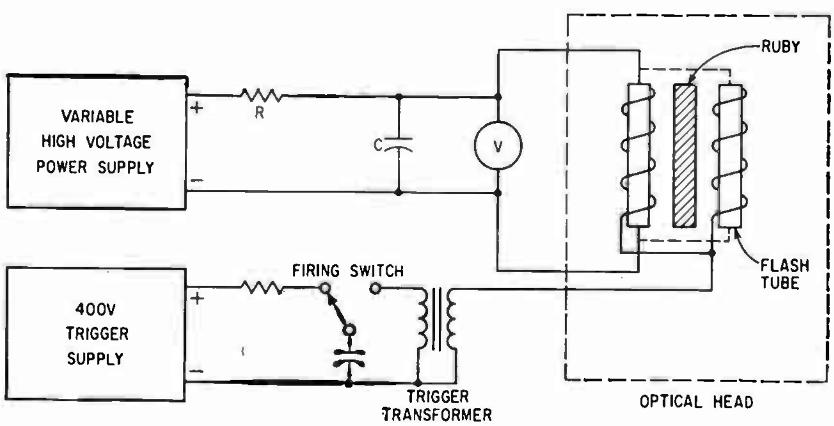

FIG. 2—Schematic of a typical optical maser system. High voltage supply can be simple transformer-rectifier that trickle charges the capacitor bank

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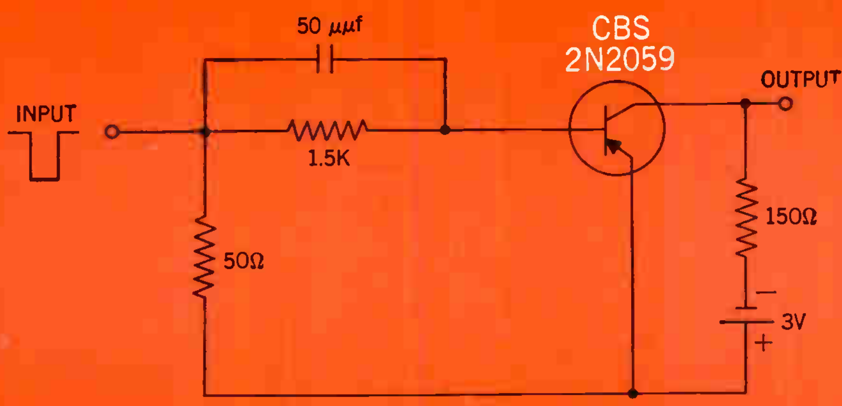

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CBS 2N2059 SPECIFICATIONS

Ratings

T_J . . . −65° to 100°C

V_{CBO} . . . 10 V.

V_{EBO} . . . 2 V.

I_C . . . 50 ma.

Typical Characteristics

h_{FE} . . . 100

V_{CE} (sat) . . . 0.1 V.

f_T . . . 70 mc.

C_{ob} . . . 2.5 pf.

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Straight flash tubes suitable for single or clustered application can be obtained in several power ratings[3,4]. U-shaped lamps are a bit easier to handle and mount than straight models as connections to the lamps are out of the way of the ruby rod.

One manufacturer[1] publishes a comprehensive manual covering several flash tube types that includes details on power supply requirements and design, and flash lamp operation. The same company also publishes a data sheet describing the construction of a simple optical maser.

More important than reflector geometry in determining the threshold level are the characteristics and dimensions of the ruby rod. An earlier report in this column (ELECTRONICS, May 5, 1961, p 88) covered the important optical properties of maser quality ruby. Present off-the-shelf ruby rods will display maser action at threshold levels of 150 joules, if reflector geometry is efficient. One company[5] reports that required pumping power is approximately linear with the rod diameter, all other factors being equal. Using a 0.1 in. diameter rod maser action was observed at a pump power level of under 100 joules. The first successful optical maser required a pump power of over 2,400 joules.

Optical quality ruby in boule form is obtainable from suppliers, but a more convenient form is an already cut, ground and polished rod with parallel end faces[6]. The end surfaces can be easily silvered using conventional techniques to produce the partially transmitting mirror surfaces. One disadvantage of silver coatings is high absorption of transmitted light. Multilayer dielectric coatings are nonabsorbing, but they require commercial application and are more expensive than silver.

One manufacturer[5] will supply a pedigreed ruby rod coated with multilayer films. This ruby has been test operated in an optical maser, and is supplied along with complete performance data and major parameters.

Optical maser pulse repetition rate is limited by the power dissipation capabilities of the flash lamps,

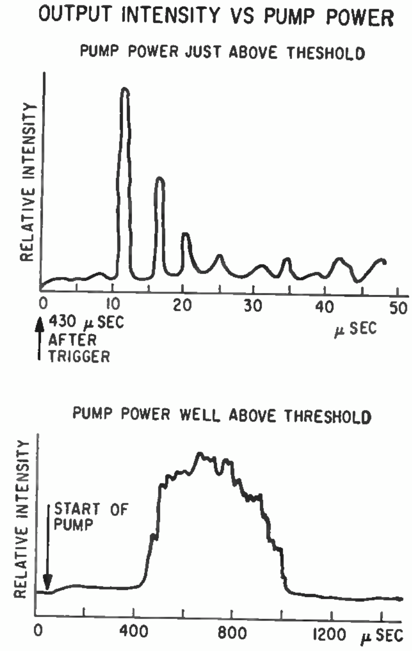


FIG. 3—Performnce curves showing measured light output of Raytheon ruby optical maser for two values of pump power

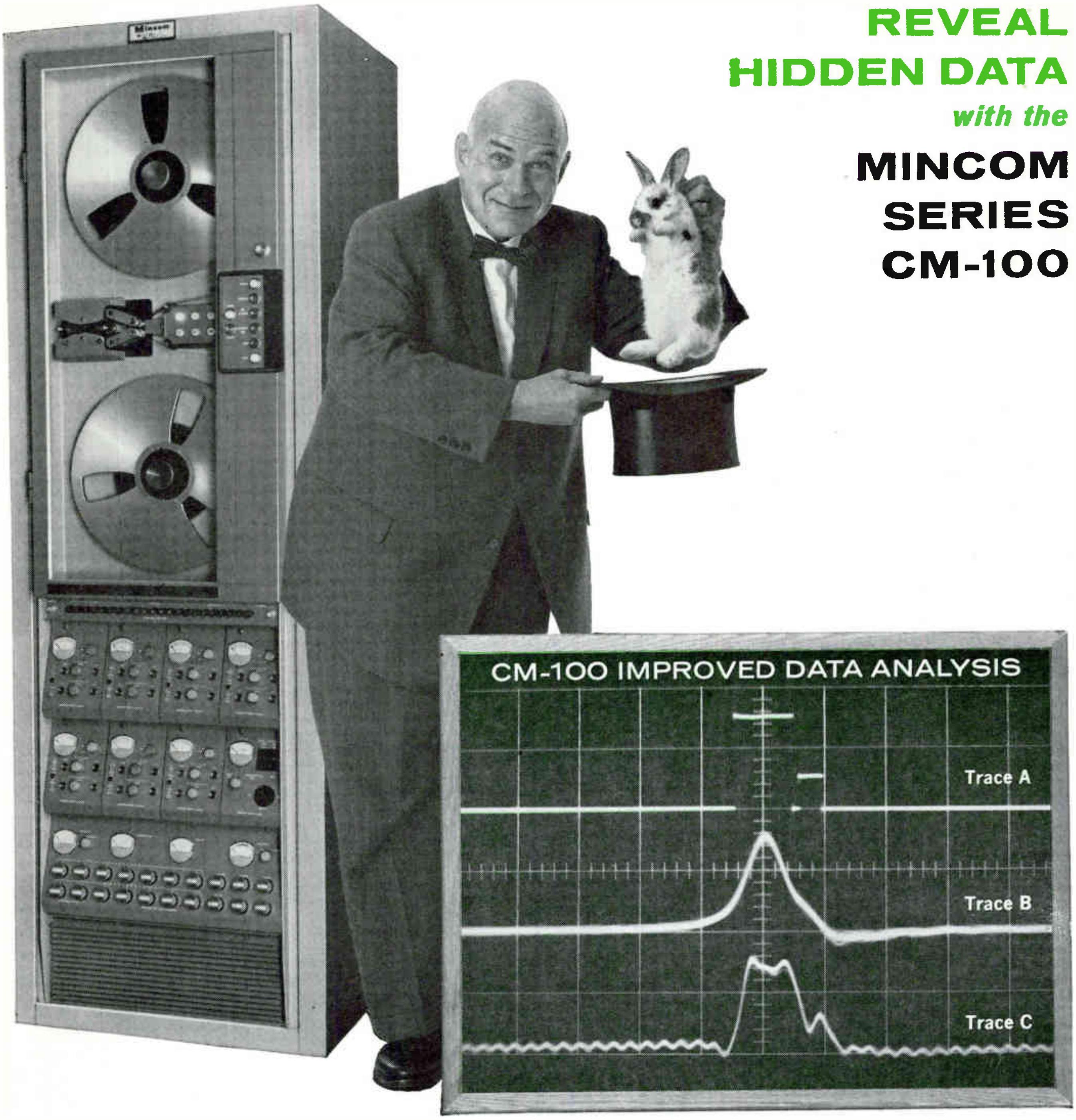
heating of the ruby rod, and the size of the power supply. With external cooling, repetition rates can be increased to several bursts per second if the power supply is adequate. As in conventional electronic flash technique, the high voltage power supply charges a capacitor bank which discharges through the flashlamp when triggered.

The simplest optical maser head would consist of a cluster of inexpensive flashlamps, or a single higher power lamp, and an aluminum foil reflector combined with a silvered face ruby rod. Trigger power can be obtained from the main supply through a simple voltage divider, or from a high voltage battery. Actual component values and operating levels depend on the type and configuration of flash lamps used, and the threshold level of the ruby rod. A safe design center is a 2,000-volt main supply coupled to a 125 μf capacitor bank, for an energy storage capability of 250 joules. R.M.B.

REFERENCES

(1) T. H. Maiman, Optical Maser Action in Ruby, British Comm. and Elect., 7, p 674, 1960.
(2) Raytheon Company, Special Microwave Device Oper., Waltham Ind. Park, Waltham 54, Mass.
(3) Edgerton, Germeshausen and Grier, Inc., 160 Brookline Ave., Boston 15, Mass.
(4) General Electric Photo Lamp Dept., Nela Park, Cleveland 12, Ohio.
(5) Perkin-Elmer Corp., Electro-Optical Div., Norwalk, Conn.
(6) Linde Company, A Division of Union Carbide Corp., 4120 Kennedy Ave., East Chicago, Ind.

REVEAL HIDDEN DATA *with the* MINCOM SERIES CM-100



10 μs pulse separated from 4 μs pulse by 1.2 μs space. Trace A: 100-kc system input. Trace B: 100-kc output. Trace C: CM-100 output. Sweep Rate: 10 μs/cm. Vertical Deflection: .5v/cm.

Pulses recorded on any standard 100-kc system reveal previously undisclosed data when played back on the Mincom Series CM-100 Video Instrumentation Recorder/Reproducer. At 60 ips, a prerecorded tape from a standard 100-kc recorder will present on the CM-100 an improved frequency response of 200-220 kc ± 4 db with a practical limit of 250 kc. CM-100's superior playback heads and phase-compensating electronics produce better rise time, correcting for phase shift and overshoot. This recovery of hidden data is only one of the advantages of the CM-100, a 7 or 14-track 1-megacycle system which is now performing predetection recording/reproducing on an operational basis—in FM, FM/FM modulation, PCM and PCM/FM. Write for specifications.

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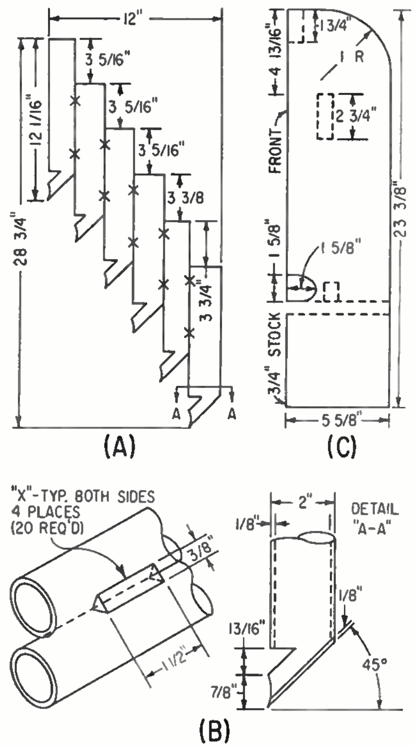
Tubular Racks Supply Large Variety of Wires

WIRE SUPPLY RACKS that look like a pipe organ, curving up and around the top of a workbench, put as many as 500 combinations of wire colors and lengths within easy reach of an assembler. They are used at the York Division, Bendix Corp., York, Pa., when a production run requires wire in a large variety of lengths and color codes.

Each individual rack in the "organ" is a series of plastic tubes cemented together like an inverted stair. Construction is shown in Figs. A and B. The tubes are cemented together with blocks cut to fit between two tubes. The top of each tube is left open for loading. The bottom is cut at a slant and closed with a flat plate. An access notch is cut in the tube above the bottom.

The slanting bottom makes the wire ends slide forward to the notch, while the uncut portion below the notch keeps the wire ends in the tube. To remove a wire, the assembler reaches into the notch with a pair of long-nose pliers.

A curved strip of metal is fastened to the lower tube of each rack, so the rack can be hung from a wooden frame bolted to the rear of the workbench. Fig. C is an end view of a frame. The dimensions in the figure are for two-inch tubing. Racks are also made with three-quarter-inch tubing, permitting a much greater variety of wires to be supplied an assembler.



Construction drawings for two-inch tube racks and bench frame

There are 400 different color-length wire combinations at this bench

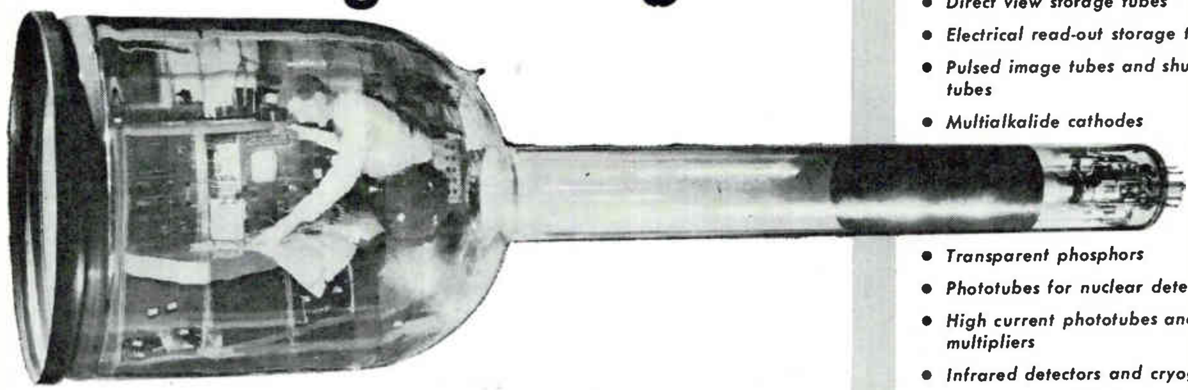
Line of 15 "pipe organs"

Usually, each rack contains a single color in graduated lengths. Tubes are made of clear plastic to facilitate color selection. If it should be necessary to use a color-blind employee for wiring, color is identified on adhesive tabs placed on the tubes. All employees are tested for color-blindness, since color coding is used extensively in the plant.

Wire lengths are indicated on adhesive tabs on all tubes. To prevent errors in reading fractional lengths, wire lengths are always identified by a "decimal" convention. Under the convention, one-eighth inch is 0.1, not 0.125. A length of 16¼ inch is given as 16.2 and 5½ is 5.4.

Racks are loaded in a room containing the wire cutting and strip-

"bottled engineering"



- *Ultraviolet photodiodes and multipliers*
- *Infrared and visible photo-multipliers*
- *Direct view storage tubes*
- *Electrical read-out storage tubes*
- *Pulsed image tubes and shutter tubes*
- *Multialkalide cathodes*
- *Transparent phosphors*
- *Phototubes for nuclear detection*
- *High current phototubes and multipliers*
- *Infrared detectors and cryogenics*
- *Infrared to visible image converter tubes*
- *Star tracking photomultipliers*
- *Image dissector tubes for spectrometry*
- *Image intensifiers and light amplifier tubes*

If you require something really special or unique in vacuum tubes, ITT can give you precisely the kind of advanced original thinking and hardware needed to satisfy your application. For 20 years our staffs have provided the level of engineering-in-a-bottle which establishes the threshold of knowledge in this field. ITT has created hundreds of tube types for radiation detection, light amplification, display and for many other purposes, including the representative types listed at right.

With this unique facility at your disposal you need not design electronic systems around tube components that only "approach" your needs. You can get exactly the kind of "bottled engineering" required, from ITT. Send your requirements directly to Mr. Dean Davis, Tube Laboratory Manager.

If you design electronic systems requiring special purpose vacuum tubes, a new ITT-developed slide chart, "Phosphors and Photocathode Characteristics", will be of interest and value. Send requests to Component Sales.

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ELECTRODYNAMIC INSTRUMENT CORPORATION
Subsidiary of Reed Roller Bit Company
1841 Old Spanish Trail Houston 25, Texas

CIRCLE 67 ON READER SERVICE CARD

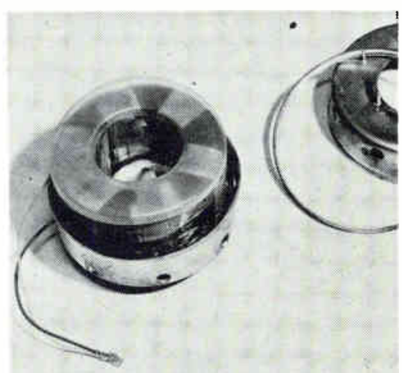
This rack is made of two-inch tubes

ping equipment. Wire preparation personnel are given lists of the sizes and colors of wires needed to prepare the units assigned to an assembly station. The lists are prepared on punched card sorting machines. Wiring requirements for each unit are coded in advance on the cards, which are kept up to date with engineering changes.

The procedures are parallel in purpose to the use of projector slides to guide printed wiring board assembly (ELECTRONICS, p. 80, July 14, 1961). They were devised to speed up production of military computer units produced intermittently with engineering changes between production runs. Each run requires wiring of 187 different plug-in units, in which boards and tube socket chassis are mounted.

The same assembler can produce one unit after another in quick

Drawn Mylar Insulators



Self-centered Mylar film forms are used by Raytheon to insulate electromagnet coils from their housings. The coils, used in microwave cooking units, require a class B insulation with minimum thickness. The forms are drawn in matched metal molds, by Silicone Insulation, Inc., New York, N. Y.

succession when all wires needed are available. The assembler is given standard wiring tools, a methods sheet and a visual aid indicating the location, length and color of each wire and its connection points.

As the printed wiring boards are prepared and the plug-in units assembled and wired, the large back panels are also wired. Panels are wired on large trunnion fixtures (Flotron, Inglewood, Calif.) which permit the position of bulky panels to be changed quickly. The fixtures are lined up next to a skate conveyor. Pipe organ racks, mounted on skids, are placed on the conveyor. Assemblers share the racks, passing them along on the conveyor.

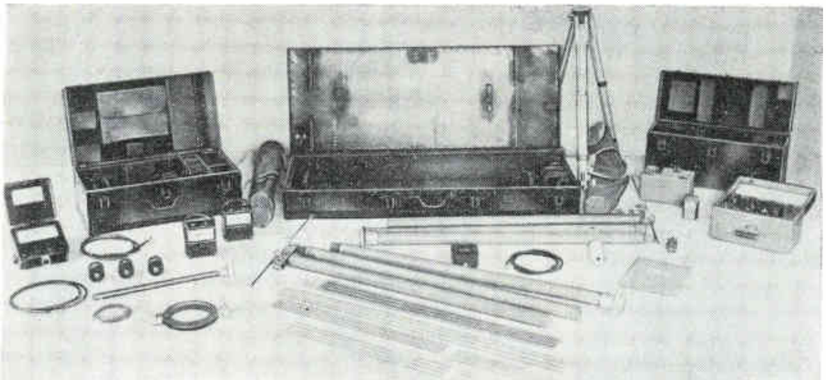
Bullet Guides Draw Sleeving Over Cable

BULLET-SHAPED guides enable one man to rapidly draw plastic sleeving over harness cables, according to Macdonald & Co., Glendale, Calif. A wire attached to the guide is fastened to one end of the cable. The sleeving is started over the beveled end of the guide and then is placed between two upright rollers, with the guide on one side of the rollers and the cable on the other. As the operator alternately stretches and relaxes the sleeving, it will work its way onto the cable. The guides and rollers are made in sets for sleeves of one-quarter inch to two inches in diameter.

Russians Etch Fine Tungsten Filaments

SUPERFINE TUNGSTEN filament wire is brought down to size in Russia by electrolytic etching. The wire is rewound through two baths. Electrolyte is 15 to 20 percent sodium hydrate solution. Variations in wire diameter are minimized by close tolerances on drawn wire and by maintaining a constant current density. Output was improved by reducing the size of the bath to 1.57 inches and using a weaker electrolyte solution. D-c etching will give approximately 10 percent more output than a-c, according to a report in *Tsvetnye Metally* No. 33.

New On The Market

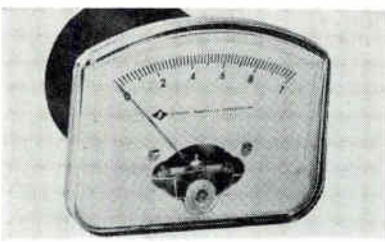


Antenna Set
LABORATORY STANDARD

STANDARD ANTENNA set model SA-301 permits laboratory standardization of field strength from 10 Kc to 300 Mc. The units generate an accurately known field from 10 Kc to 30 Mc and accurately measure fields from 30 Mc to 300 Mc. The set, complete except for r-f source, includes loop and dipole antennas, baluns, tripods, precision meters, cables and accessories.

All components correspond to a set certified by the National Bureau of Standards. Set and calibration techniques with formulas are available from Empire Devices Inc., Amsterdam, N. Y.

CIRCLE 301 ON READER SERVICE CARD



Frequency/Pulse Converter
METER READOUT

PRECISION frequency to analog transducer with integral indicating meter is available from Pioneer Magnetics Incorporated, 850 Pico Blvd., Santa Monica, Calif.

The Megacycler-Meter uses only static elements to produce d-c meter current directly proportional to input frequency or pulse rate. Accuracy with 2½-in. meter is ± 1 percent of full scale; accuracies of ± ½ percent are available.

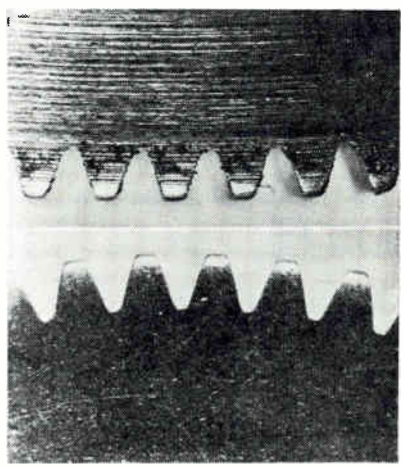
Model MM-1000-D has a range of 0 to 250 cps to 0 to 1,000 cps. Seven standard models cover the range from 15 cps to 12 Kc (to 100 Kc upon request).

Models are available for input signals of 2 watts, 100 mw and 0.1 μw.

CIRCLE 302 ON READER SERVICE CARD

Ultrasonic Deburring
ABRASIVE IN LIQUID

ULTRASONIC system provides in excess of 200 watts per gallon to remove metal microburrs without damaging parts or disturbing tolerances. Parts to be deburred are immersed in a liquid in which high-grade abrasive is suspended. Two and one-half gallon, stainless steel tank, UT 25, is driven at 55 Kc by



generator, Ug 500. Generator output averages 500 watts, 1,000 watts on peaks.

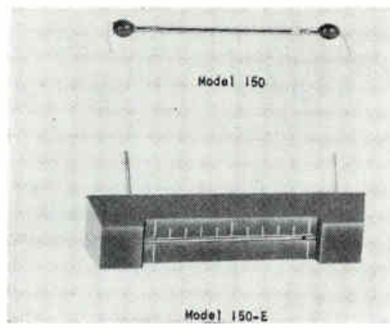
Advantages include low cost, no chemical action to damage parts, low labor requirements, high precision and close control of tolerances. Manufacturer is Ultrasonic Systems, Inc., 2255 S. Carmelina Ave., Los Angeles 64, Calif.

CIRCLE 303 ON READER SERVICE CARD

Ampere-Hour Meter
ELECTROLYTIC

MINIATURE ampere-hour meter for military and industrial uses consists of a capillary glass tube containing a mercury anode and cathode separated by an electrolyte. Current flow transfers mercury across the electrolyte, giving linear displacement of the gap.

Model 150 is 1½ inches long by 0.050 inch o-d, with a scale length of one inch. The unit meets MIL-



E-5272C for both vibration and shock, has an operating range of −30 to 110 C. It operates on d-c or pulsed d-c signals with any waveform.

Model 150E is the same unit in a plastic case. Single units are available from stock at $5 for Model 150, $8.00 for 150E. Manufacturer is Curtis Instruments Inc., 45 Kisco Ave., Mt. Kisco, N. Y.

CIRCLE 304 ON READER SERVICE CARD

Multiplex Stereo Generator
MODULATES F-M SIGNAL

MULTIPLEX STEREO generator provides a composite stereo signal for modulating an f-m generator (Measurements 210A or other make with similar modulation, frequency and phase response recommended). The composite signal conforms to the recently approved FCC multiplex system, Docket 13506. An audio oscillator with floating 500/600-ohm output and an oscilloscope are also required.

Left (L) and right (R) outputs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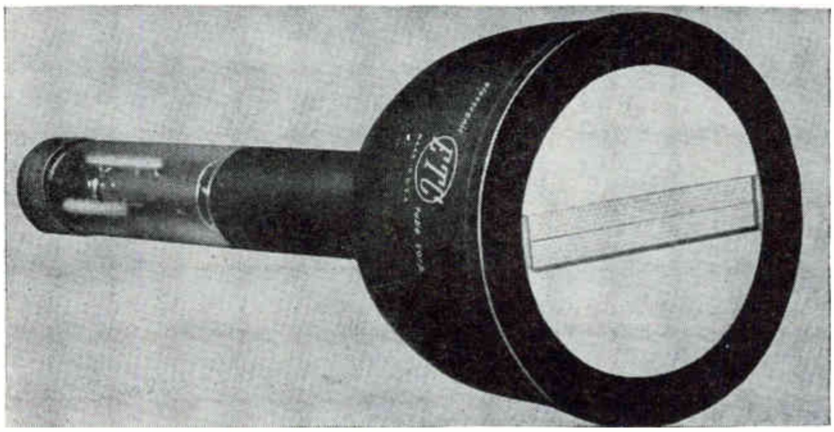
CLECO
number 3 screwdriver
weighs only 12 ounces (just a few ounces more than a manual screwdriver). It delivers the famed Clecomatic accuracy to meet the most exacting production specifications.
Let your nearby Cleco representative customize this fully automatic tool to your precise torque requirements.

from a stereo record or tape may also be used as an input for listening tests of multiplex receiving equipment. Separate R, L, L = R and L= −R modulation without pre-emphasis can be produced.

Model 830 requires 7 inches height in 19-inch rack, is priced at $1,000 by H. H. Scott Inc., 111 Powdermill Rd., Maynard, Mass.

CIRCLE 305 ON READER SERVICE CARD



Fiber Faceplate Crt

HIGH RESOLUTION GUNS

CATHODE-RAY TUBE uses a bundle of 0.001-inch fibers set into a 5-inch aluminized screen in a panel $\frac{5}{8}$ by $3\frac{1}{2}$-inch, gaining 625 vertical light dots by 3,500 horizontal light dots or lines. M-1014P16 tube uses P16 phosphor but other phosphors are available.

The fiber-optics panel of the tube transmits 70 to 75 percent of the ultraviolet spectral energy generated by the P16 material—sufficient to excite Kalvar photographic film.

The crt uses electrostatic focus and magnetic deflection with a 40-degree deflection angle. Similar tubes can be produced with fiber optic panels 6 inches or more in diameter using 0.0003-inch fibers to achieve resolutions better than 2,000 by 2,000 dots per inch. Manufacturer is Electronic Tube Corp., 1200 E. Mermaid Lane, Philadelphia 18, Pa.

CIRCLE 306 ON READER SERVICE CARD

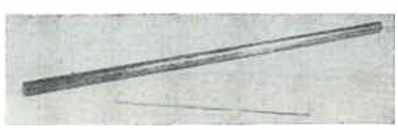
Voltage Ratiometer

COMPLEX A-C SIGNALS

COMPLEX voltage ratiometer makes precision a-c measurements in magnitude and phase angle, as well as measuring in-phase and quadrature components. Reference for in-phase measurements is provided by an inductive divider with an accuracy of one ppm. Null detector is a model VM-204 three-frequency phase-angle voltmeter. Attenuating network and dual-scale mechanism allow direct reading of phase angles of all input voltages and ratios. The unit also contains a 90-degree phase standard so that calibration and adjustment can be made at operating frequency.

CVR-551 ratiometer, by North Atlantic Industries Inc., Plainview, N. Y., tests guidance equipment, synchro and resolver components, and missile and drone controls.

CIRCLE 307 ON READER SERVICE CARD



Radio Beacon

NO BATTERIES

THE TRAILMARKER is a small rugged, inexpensive radio beacon that will be tested this summer in Greenland under operational conditions. It defines an electronic path or highway over featureless terrain, marks a safe corridor through minefields and identifies advance supply positions. Trailmarkers can be placed in position by advance ground parties or dropped from aircraft. A transmitter/receiver, mounted in a Jeep, light plane or helicopter, interrogates the Trailmarker beacon and receives guidance information.

Unit does not require batteries, since it uses energy from the interrogating transmitter as its source of power. Range is approximately $\frac{1}{2}$ mile. Life expectancy is long and it can operate in any kind of weather, even when covered by snow. Manufacturer is General Precision Lab., 63 Bedford Rd., Pleasantville, N. Y.

CIRCLE 308 ON READER SERVICE CARD

Diode Assemblies

HIGH-VOLTAGE

BURMAC ELECTRONICS CO., INC., 142 South Long Beach Road, Rockville Centre, L. I., N. Y. Line of h-v silicon diode assemblies are available with inverse voltage ratings of 1 Kv to 50 Kv and current ratings of 1 ma to 750 ma. Model CR101 is offered with stud terminals and insert mounting. It has a peak inverse rating of 4,000 v and current rating of 100 ma at 100 C.

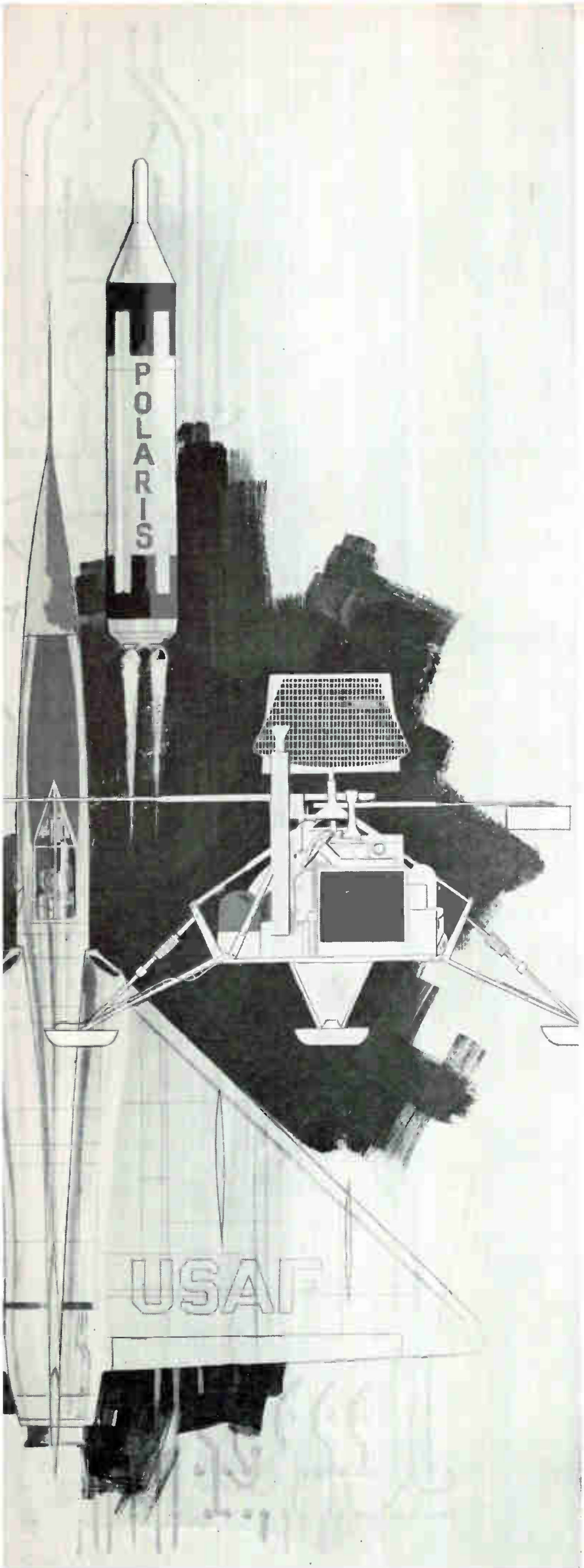
CIRCLE 309 ON READER SERVICE CARD

High-Purity Elements

FOR SOLID STATE PHYSICS

L. LIGHT & CO. LTD., Poyle Estate, Colnbrook, Bucks, England, has available ultra-pure elements, single crystals and compounds for solid state physics and metallurgical research. Notable among these are 99.999 percent pure phosphorous and boron. Single crystals of indium arsenide, with mobilities in excess of 20,000 are being grown by the Czochralski process.

CIRCLE 310 ON READER SERVICE CARD



Opportunities for

circuit designers

Requirements of new and continuing projects, such as Surveyor and supersonic interceptor fire control systems have created new openings for circuit designers. The engineers selected for these positions will be assigned to the following design tasks:

1 the development of high power airborne radar transmitters, the design of which involves use of the most advanced components,

2 the design of low noise radar receivers using parametric amplifiers, solid state masers and other advanced microwave components,

3 radar data processing circuit design, including range and speed trackers, crystal filter circuitry and a variety of display circuits,

4 high efficiency power supplies for airborne and space electronic systems,

5 telemetering and command circuits for space vehicles such as Surveyor and the Hughes Communication Satellite,

6 timing, control and display circuits for the Hughes COLIDAR* (Coherent Light Detection and Ranging).

In addition, openings exist for several experienced systems engineers capable of analysis and synthesis of systems involving the type of circuits and components described above.

If you are interested and believe that you can contribute, please airmail your resume to: **Mr. Robert A. Martin,** Supervisor, Scientific Employment, Hughes Aerospace Engineering Division, Culver City 71, California.

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PRODUCT BRIEFS

A-C MILLIVOLTMETER transistorized. Electronic Applications Co., 10916 Basye St., El Monte, Calif. (311)

PRECISE POSITION REPEATER panel-mounted unit. Theta Instrument Corp., 520 Victor St., Saddle Brook, N. J. (312)

ANTENNA MULTICOUPLER feeds six receivers. Rohde & Schwarz Sales Co., Inc., 111 Lexington Ave., Passaic, N. J. (313)

DIRECT WRITING OSCILLOGRAPH sealed inking system. Photron Instrument Co., 6516 Detroit Ave., Cleveland 2, O. (314)

LINEAR ACCELEROMETER three-axis. Humphrey, Inc., 2805 Canon St., San Diego 6, Calif. (315)

A-C SOLENOID no cycle chatter. Rocker Solenoid Co., 140 No. Marine Ave., Wilmington, Calif. (316)

ISOLATION TRANSFORMERS ultra-shielded. LJ Products, 7464 Girard Ave., LaJolla, Calif. (317)

PHASE ADAPTER variable output. Dawe Instruments Ltd., Harlequin Ave., Great West Road, Brentford, Middlesex, England. (318)

POWER AMPLIFIER for industry, research. Marantz Co., Inc., 25-14 Broadway, Long Island City 6, N. Y. (319)

DIFFERENTIAL PULSE COUNTERS for adding, subtracting. Presin Co., Inc., 2014 Broadway, Santa Monica, Calif. (320)

TWO-CHANNEL OSCILLOGRAPH compact, pen-and-ink. Keystone Development Corp., 2813 Westheimer Road, Houston 6, Texas. (321)

MOLDED CARBON POT ½ in. diameter. Clarostat Mfg. Co., Inc., Dover, N. H. (322)

FAST-SETTING EPOXY CEMENT for strain gage use. The Budd Co., Box 245, Phoenixville, Pa. (323)

HIGH-OUTPUT AMPLIFIER for channels 2-13. Jerrold Electronics Corp., 15th and Lehigh Ave., Philadelphia 32, Pa. (324)

INSTRUMENT COUNTER high-speed readings. Durant Mfg. Co., Milwaukee 1, Wisc. (325)

Literature of the Week

COMPUTING COMPONENTS Electronic Associates, Inc., Long Branch, N.J. A four-page folder tells how special purpose analog computers are easily assembled using the TR-5 mounting units and PACE solid state analog computing components. (326)

MAGNETIC AMPLIFIER Microdot Inc., 220 Pasadena Ave., S. Pasadena, Calif. Bulletin BMA-1 describes a bistable magnetic amplifier for missile ground support applications. (327)

DATA COMMUNICATOR Bendix Computer Division, 5630 Arbor Vitae St., Los Angeles 45, Calif. Brochure describes the DC-11 Data Communicator, an accessory to the G-20 computer. (328)

LOW-NOISE TWT'S General Electric Co., Schenectady 5, N.Y. A 16-page bulletin includes a basic description of low-noise twt's design and application information and specifications on seven tube types now available. (329)

SHIFT REGISTER Magnetic Research Co., 179 Westmoreland Ave., White Plains, N. Y. Bulletin describes model 743 multidirectional magnetic shift register. (330)

PRESSURE CELL Baldwin-Lima-Hamilton Corp., Waltham 54, Mass. A differential pressure cell, for the critical needs of missile and aircraft wind tunnel research is described in data sheet 4381. (331)

EPOXY MAGNET WIRE Anaconda Wire and Cable Co., 25 Broadway, New York 4, N.Y., has issued a brochure on its class B cement coated epoxy magnet wire. (332)

FREQUENCY COUNTERS Northeastern Engineering, Inc., 25 South Bedford St., Manchester, N.H. Catalog DS-201 contains technical specification data on the series 14 frequency counters, together with six plug-in accessories. (333)

STABILIZATION KIT Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. Bulletin describes a new approach in printout record stabilization. (334)

SELENIUM DUAL DIODES International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa. Bulletin describes high reliability, low cost selenium dual diodes for detector and rectifier circuits. (335)

COMPUTER SIMULATOR Rese Engineering, Inc., A and Courtland Sts., Philadelphia 20, Pa. Technical bulletin 60-F covers a computer simulator for testing complete digital memory systems. (336)

AMPLITUDE DISTRIBUTION ANALYZER Quan-Tech Laboratories, Inc., Boonton, N.J. A fully transistorized instrument for determining the amplitude probability distribution of random signals is the subject of a recent bulletin. (337)

TWO-CHANNEL RECORDER Esterline-Angus Instrument Co., Inc., Box 596, Indianapolis 6, Ind. A 4-page folder discusses the model 602, which simultaneously records two channels of plotted data vs time in the same space formerly required for one. (338)

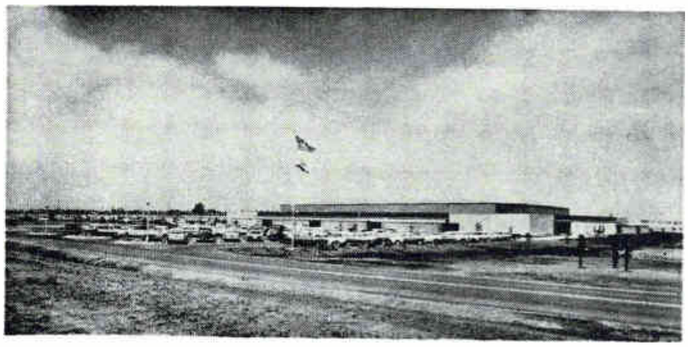
WIRE & CABLE Brand-Rex Division, American Enka Corp., 31 Sudbury Road, Concord, Mass. A 12-page brochure describes and illustrates the company's new wire and cable manufacturing facility in Gardena, Calif. (339)

EPOXY RESINS Food Machinery and Chemical Corp., 161 E. 42nd St., New York, N. Y. Data on high-temperature properties of Oxiron epoxy resins and on the potential of these materials in laminate applications are reported in a technical bulletin. (340)

GLASS-BONDED MICA Electronic Mechanics, Inc., 101 Clifton Blvd., Clifton, N. J., has published literature detailing new information on Mykroy glass-bonded mica as a high frequency insulator. (341)

SOLDERING IRONS Hexacon Electric Co., 130 W. Clay Ave., Roselle Park, N. J. Catalog No. 111 illustrates and describes 80 models in seven distinct types of industrial electric soldering irons. (342)

MINIATURIZED TRANSFORMERS Microtran Co., Inc., 145 E. Mineola Ave., Valley Stream, N.Y. Transformer handbook manual covers technical data, catalogs, pricing, and facilities and policies. Request on company letterhead.



Collins Moves to New R&D Center

COLLINS RADIO COMPANY'S western operation has completed its move into a new multi-million-dollar, 120,000-sq-ft communication and data processing research and development center at Newport Beach, Calif.

More than 1,000 employees at the new Collins Information Science Center are planning, designing and developing data communication and data processing systems and equipment and developing computer programming techniques for business, industrial, military and scientific uses. Other activities include information systems and solid-state research and prototype equipment production.

Among the center's current projects are data transmission systems for the Atlantic and Pacific missile ranges; data and teletypewriter transmission systems for Naval tactical communications; data transmission terminals for major Air Force communication systems; data equipment for the Army Fieldata program; a data system for vlf shore stations and Naval units and magnetic tape and punched card transmission systems employing wire line, oceanic cable and h-f radio as transmission links.

In addition to these specialized projects, ISC also serves as data systems consultant to the company and is currently developing an extensive line of communication and data processing equipment to be used and marketed by other Collins divisions.

Designed primarily for R&D, the center is the first building on a 100-acre site within a proposed University City and campus of the U. of California. The master site plan calls for eventual construction of several more buildings, including manufacturing facilities and additional R&D laboratories.

Heading the new center is M. L. Doelz, a Collins vice president and member of the corporate management council. Other key management positions are held by R. D. Johnson, director of operations; D. L. Martin, director, systems planning; R. L. Ericson and R. R. Mosier, directors of research and development; and S. G. Burke, director of information systems.

Terminal-Hudson Names Hecht V-P

TERMINAL-HUDSON ELECTRONICS, INC., of New York, has appointed Irwin Hecht to the newly-created post of vice president for sales. The company recently acquired Hecht Electronics, Inc., of Roslyn Heights, N. Y., of which Hecht is president.

Previously, Hecht was president of Hudson Industrial Electronics, a division of Hudson Radio & Television Corp. He was at one time a project engineer with Emerson Radio & Phonograph Corp. and Radio Engineering Laboratories.

Stackpole Carbon Advances Campbell

DUDLEY H. CAMPBELL has been named to the newly-created post of chief engineer of the Control & Switch department at Stackpole Carbon Co., St. Marys, Pa.

His new position stems from a consolidation of engineering efforts for two departments for which he has largely been responsible since joining Stackpole in 1959. As chief engineer of the department, Campbell will have charge of the engineering and development of Stackpole variable composition resistors, slide switches, and other electromechanical products.

Hallikainen Instruments Appoints Pritchett

WILSON S. PRITCHETT joins Hallikainen Instruments of Berkeley, Calif., as chief electrical engineer in charge of electronic and electrical aspects of instrument development and design. For the past four years he has been chief engineer of Knopp, Inc. of Oakland, Calif.

Redgrift Heads Up Westran Engineering

HARRY F. REDGRIFT has been appointed director of engineering for Western Transistor Corp., Gardena, Calif. He was formerly senior project engineer with the Transitron Corp., working with silicon transistors.

Redgrift's experience includes

Electroplated WIRES

Our facilities for continuous electroplating of wire are rated among the largest in the field. All our plates are exceptionally uniform and well bonded to the base wire . . . Gold, Silver, Nickel, Rhodium, Tin, Indium and many other metals, or combinations, are plated onto wires of Tungsten, Molybdenum, Nickel, Bronze, Copper, Silver, etc. . . . Copper wires, used for electrical connections, are made highly corrosion-resistant by Gold plating . . .

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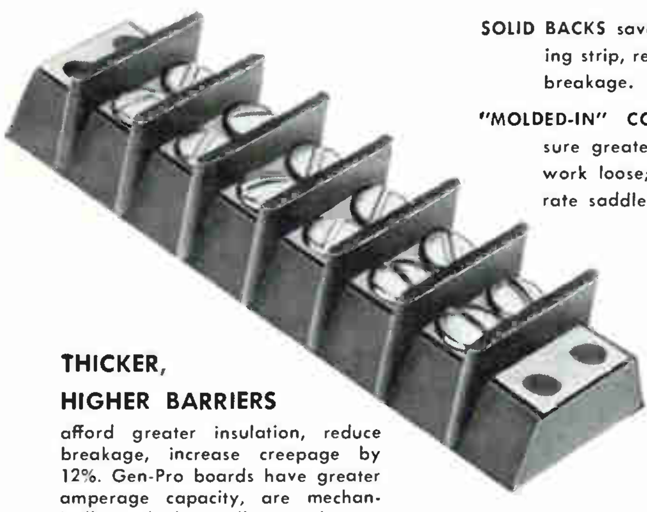

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Smallest – Reduced 25%

SPOT SWEEP
Straightest . . . .

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five years at Raytheon Corp., and three years at Hughes Products, semiconductor division, as head of product engineering for silicon transistors.

Daystrom Appoints Development Engineer

DONALD S. TAYLOR has joined Daystrom, Inc., military electronics division, Archbald, Pa., in the position of development engineer. He will be responsible for performing basic design and development on electrical and mechanical devices involved in the company's R&D work on nuclear instrumentation.

Prior to becoming associated with Daystrom, Taylor was a senior electrical engineer with Combustion Engineering Co., Windsor, Conn.

Nytronics Names Chief Engineer

APPOINTMENT of Harold C. Baumann to the position of chief engineer for the corporation's American Essex Division is announced by Nytronics, Inc., Berkeley Heights, N. J.

Baumann has been associated in engineering and executive capacities with Bell Telephone Laboratories, Warner Brothers Pictures, National Broadcasting Co., Stavid Engineering, and more recently with Ford Instrument Co., division of Sperry-Rand Corp.

Announce Formation of New Company

CONTROL LOGIC, INC., Natick, Mass., was recently formed to specialize in application services and the design and production of advanced data handling and control products.

The principals are Samuel Bass, president; Don E. Deuitch, vice president and director of engineering; and Bruce E. Peck, vice president and director of product design. All three were previously with Epsco, Inc., as division manager, components division; chief engineer, components division; and director of product design, respectively.

PEOPLE IN BRIEF

Everard Mott Williams, head of the Dept. of Electrical Engineering, Carnegie Institute of Technology, elected to the board of directors of Electronic Associates, Inc. *William E. Roberts*, formerly of Bell & Howell Co., named president and chief executive officer of Ampex Corp. *Charles S. Mertler* of Stevens Manufacturing Co. promoted to engineering vice president. *Keith Bennett* leaves IBM Corp. to join Burroughs Corp., as chief industrial engineer. *J. V. Holdam*, previously with Laboratory for Electronics, appointed vice president of Dresser Industries. *Henry J. Zimmermann* advances to director of M.I.T.'s research laboratory of electronics. *Roger E. Bremer* transfers from Ohio Injector Co. to Electronic Energy Conversion Corp. as executive vice president. *William Maier* leaves General Motors to join Micronics, Inc. as director of research and development. *Richard M. McIntyre*, ex-Douglas Aircraft, appointed systems analyst at General Precision. *Berthold Pollick* moves up at Fairchild Camera and Instrument Corp. to director of engineering, defense products division. *Alan G. Richards*, formerly of Bjorksten Research Labs, joins the Bell & Howell Research Center as assistant to the director.

electronics

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THE GARRETT CORPORATION AiResearch Manufacturing Division Los Angeles, California	90*	6
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UNITED ELECTRODYNAMICS INC. Pasadena, California	84	13
P-7077	84	14

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NAME ....

HOME ADDRESS..

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

HOME TELEPHONE...

Education

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

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

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8461

☐ Aerospace	☐ Fire Control	☐ Radar
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Please indicate number of months experience on proper lines.

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Position requires interest in development of new scientific instruments plus sound theoretical background and at least 5 years' experience in producing scientific instruments.

Excellent salary and fringe benefits program.

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5.4 to 5.9 kMc

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Varian Associates' new VA-126 pulse power amplifier traveling wave tube is particularly well-suited for advanced coherent radar systems employing frequency agility. With high gain and high efficiency over the full bandwidth, the tube offers a new standard in transmitter performance.

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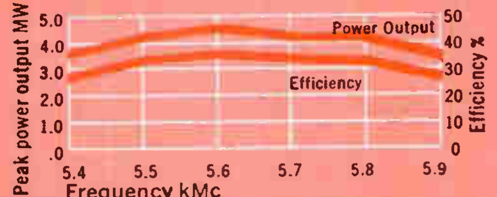

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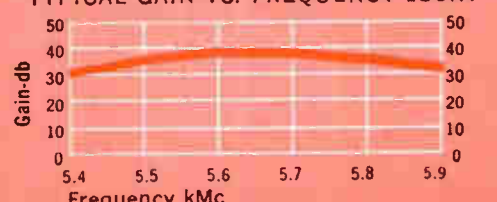

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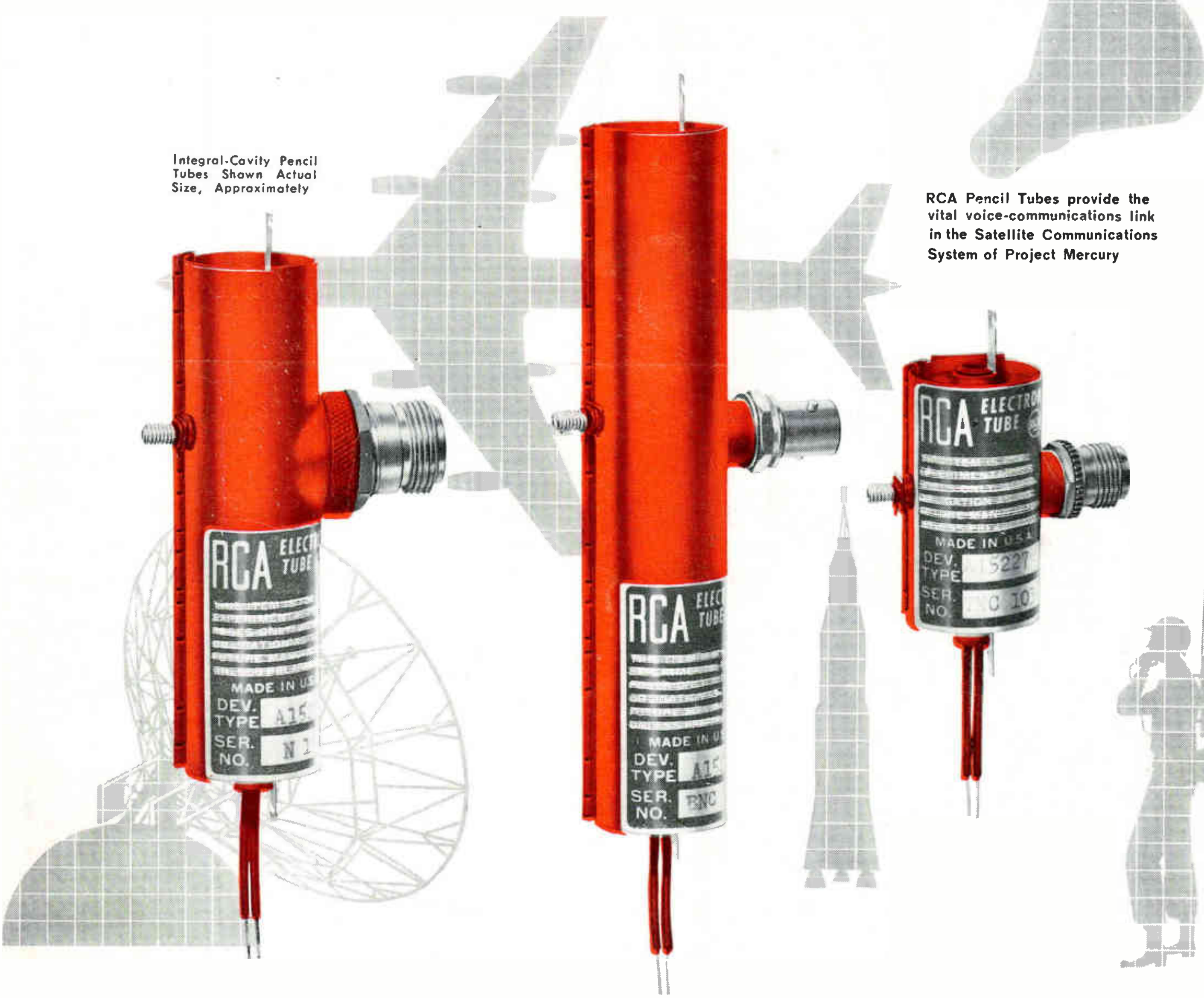

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RCA Pencil Tubes provide the vital voice-communications link in the Satellite Communications System of Project Mercury

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- From 900-3400 Mc
- Low-cost
- Includes RF Circuitry
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OVERALL RF PERFORMANCE ASSURED

Now, RCA offers the recognized performance-advantages of the famous coaxial pencil tube . . . in a design which combines the pencil tube with a mechanically-tuned cavity—to produce a single-unit, compact, low-cost microwave oscillator.

Wherever circuit compactness and gross weight are major considerations in microwave designs, RCA Integral-Cavity Pencil Tubes hold intrinsic possibilities—for CW, plate-pulse, or cathode-pulse work. There's a choice of over 20 types. And note this: RCA's Applications Engineering group is available to discuss special Integral-Cavity Pencil Tubes "tailored" to your specific requirements.

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RCA-Dev. Type	Power Output (Watts)	Duty Cycle	Freq. (Mc)	Input Pulse Voltage
A-15132	500 (Peak)	0.001	1100	50
A-15228	300 (Peak)	0.001	2000	50
A-15234	100 (Peak)	0.001	3000	50
A-15221	1	CW	1100	—
A-15227	0.3	CW	2000	—
A-15233	0.1	CW	3000	—

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