July 28, 1961

electronics

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W. W. MacDONALD, Editor

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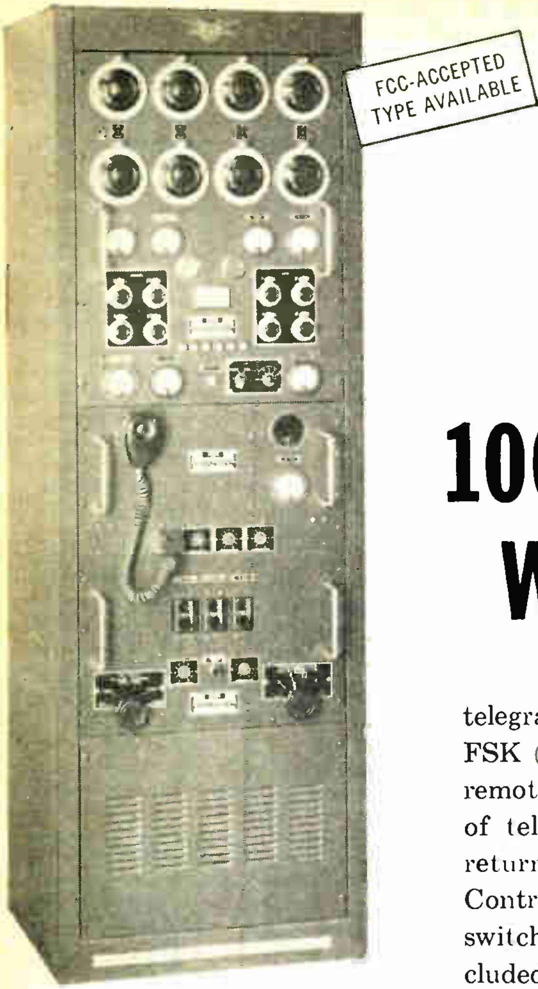

The world-famous

AEROCOM 1046 TRANSMITTER

1000 W CARRIER POWER WITH HIGH STABILITY

The Aerocom 1046 Transmitter is designed to give superior performance for all point-to-point and ground-to-air communications. It is now in use throughout the world in climates ranging from frigid to tropical (operates efficiently at —35° to +55° Centigrade).

As a general purpose High Frequency transmitter, the 1046 supplies 1000 watts of carrier power with high stability (above —10° Centigrade: ±.003% for telegraph and telephone. Temperature controlled oven for FSK). Multichannel operation is provided on telegraph A1, telephone A3 and FSK (Radio Teletype). It can be remotely controlled using one pair of telephone lines plus ground return with Aerocom Remote Control Equipment. Front panel switches and microphone are included for local control.

Four crystal-controlled frequencies (plus 2 closely-spaced frequencies) in the 2.0 - 24.0 megacycle range can be used one at a time, with channeling time only two seconds. Operates into either balanced or unbalanced loads. The power supply required is nominal 230 volts, 50 - 60 cycles, single phase.

The housing is a fully enclosed rack cabinet of welded steel, force-ventilated through electrostatic filter on rear door.

Telegraph keying (A1): Up to 100 words per minute. Model 1000 M Modulator (mounts in transmitter cabinet) is used for telephone transmission; a compression circuit permits the use of high average modulation without overmodulation. Model 400 4 Channel exciter is used for FSK.

Output connections consist of 4 insulated terminals (for Marconi antenna) and 4 coaxial fittings Type SO-239, which can be used separately or in parallel in any combination. For 600 ohm balanced load, Model TLM matching network is used, one for each transmitter channel.

As in all Aerocom products, the quality and workmanship of Model 1046 are of the highest. All components are conservatively rated. Replacement parts are always available for all Aerocom equipment.

Complete technical data on Aerocom Model 1046 available on request.

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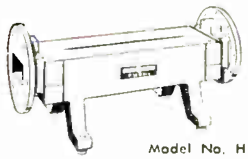
Interchangeable SLOTTED SECTIONS

convenient and positive

- conveniently interchangeable waveguide sections
- no slope adjustment required
- vernier position scale readable to 0.1 mm.
- dial gauge holder and movable stop
- tapered slots to minimize residual VSWR

INTERCHANGEABLE WAVEGUIDE SECTIONS



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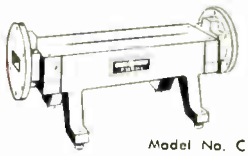

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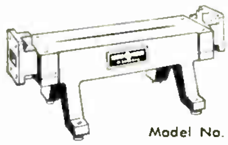

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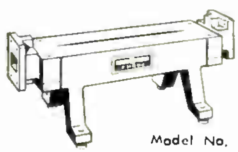

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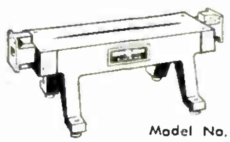

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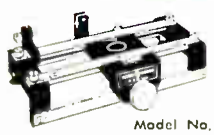

Model No. Z116A

Like the finest camera with a precisely fitted set of lenses, the FXR Universal Carriage and family of five Interchangeable Slotted Sections are matched to perfection. "Togetherness" with this unrivalled modular waveguide system gains new meaning . . . more rapid interchange of each section without tools or need for alignment, and more dependable performance over the entire frequency range from 3.95 kmc to 18.00 kmc. Another fine FXR "package" with quality and reliability built into it—from the first mark on the drawing board.

SERIES 115 PRECISION SLOTTED SECTIONS

MODEL NO.	FREQUENCY RANGE (KMC)	WAVEGUIDE DIMENSIONS (Inches)	INSERTION LENGTH	WAVEGUIDE TYPE	FLANGE TYPE
H115A	3.95- 5.85	2 x 1	10⅜ in.	RG-49/U	UG-149A/U
C115A	5.85- 8.20	1½ x ¾	10⅜ in.	RG-50/U	UG-344/U
W115A	7.05-10.00	1¼ x ⅝	10⅜ in.	RG-51/U	UG-51/U
X115A	8.20-12.40	1 x ½	10⅜ in.	RG-52/U	UG-39/U
Y115A	12.40-18.00	0.622 x 0.311 ID	10⅜ in.	RG-91/U	UG-419/U

ACCESSORY: FXR Model No. B200A Tunable Probe.
All units when mounted in Z116A Carriage:
Slope—1.01 max. Irregularity—1.005 max.

Write for Bulletin No. SS115 or contact your local FXR representative.

FXR *a division of* Amphenol-Borg Electronics Corporation
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PRECISION MICROWAVE EQUIPMENT • HIGH-POWER PULSE MODULATORS • HIGH-VOLTAGE POWER SUPPLIES • ELECTRONIC TEST EQUIPMENT

electronics
July 28, 1961 . . Volume 34 Number 30

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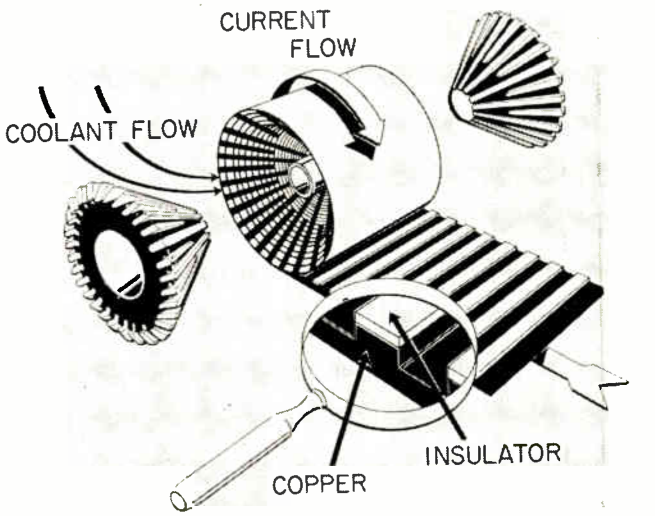


BREAKTHROUGH IN MAGNETICS. In an article on page 43 of our October 2, 1959 issue, Henry H. Kolm, of MIT, predicted that a solenoid designed like the one in the diagram would produce a continuous magnetic field of 130 kilogauss. The magnet has now been built and is operating at the new National Magnet Laboratory. It generates 126 kilogauss and should do better when more operating power is available. The achievement is expected to spur developments in fields as diverse as superconductivity, microwave tubes and magnetohydrodynamics. For a report on this new magnet in a new laboratory, see New England Editor Maguire's report on page 24.

MOBILE MISSILE RANGES. Many of the islands in the Atlantic Missile Range are not in the right position for best monitoring of long-range ICBM test shots. Ships can be put in the right place at the right time. On page 22, Associate Editor Mason details how two more ships will be readied for this important work, at a cost of $60 million.

EXPANDING FIELD of electron-beam technology is finding application in such areas of direct interest to our industry as microminiaturization and data recording. These and other applications of electron beams are discussed in this issue by Robert Bakish of Alloyd Electronics Corp. in Cambridge, Mass. His article begins on p 39.

Coming In Our August 4 Issue

PLASMA ENGINEERING. One of the major problems in plasma research is the accurate measurement of parameters such as temperature, density and velocity of the ions and electrons. This subject, referred to as plasma diagnostics, is surveyed next week by Assistant Editor Wolff in the second article in his series on plasma engineering. You'll learn about the use of electrical and magnetic probes, microwaves, high-speed photography, spectroscopy and other techniques for studying plasmas.

ADDITIONAL FEATURE MATERIAL to appear next week includes: sonar for surveying the ocean through arctic ice by Assistant Editor Dulberger; an infrared curtain system that detects and counts various moving objects by P. A. Tove and J. Czekajewski of the Institute of Physics in Uppsala, Sweden; and computing noise levels in microwave receiver systems by H. H. Grimm of General Electric Co.

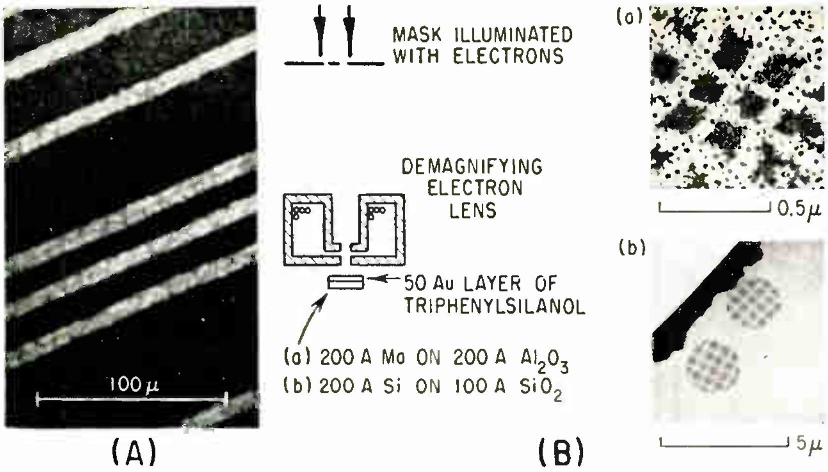


FIG. 2—Electron-beam cutting of resistor; resolution is 10 μ (A). Micrographs in (B) show resolution better than 0.1 μ for electron machining

text of the Bible could be recorded on a fraction of the area of a postage stamp.

Among the most promising applications to microelectronics is the processing of a wide range of materials at a fine resolution with a low level of stress and structural damage.[2] Resolutions as good as 1/10 μ can be obtained.

In microelectronic fabrication, the electron beam can be used as either a tool to heat materials for evaporation or as a probe for obtaining information from the workpiece.

For example, in the thermocompression bonding that attaches lead wires to transistors, electron beams can be used as a source of heat to carry out the weld, or in the manner of a scanning electron microscope, to obtain information from the workpiece so that the technique of using a mechanical tool to press a wire down into the workpiece could be carried out more accurately or made more automatic. Figure 1B, which shows images obtained with a scanning electron microscope, illustrates the possibilities for quality and process control on small operations. The lefthand photo shows the thermocompression-bonded lead attachments of an unbiased silicon mesa transistor; the right-hand photo shows these leads with the emitter junction back-biased 4.5 v.

Operation of a scanning electron microscope is shown in Fig. 1C. Resolution to 300 A has been attained. Resolution of an electron-beam microanalyzer, whose output of characteristic x-rays is monitored for the positive identification of workpiece materials, is limited to a region of 1 μ.

Electron beams are also used for welding and drilling, cutting grooves in metal films for producing resistors, and forming *p-n* junctions.

Figure 2A shows an electron beam used for cutting grooves in metal films to produce resistors. The resistive material, a nickel-chrome alloy typically 100-A thick, is deposited on a ceramic substrate, and the beam removes areas from the alloy to form nonconducting paths. Resolution is of the order of 10 μ. Resistance can be monitored while the cutting proceeds. There seems to be no reason why a conductive coating laid down by vapor deposition could not be cut by this process.

It is not unlikely that an electron beam system for dicing semiconductor materials will be developed.

For electron-beam forming of *p-n* junctions, a layer of impurity is deposited onto the semiconductor and temperature is raised locally to produce alloying. Unalloyed impurity layer is then selectively etched away. Resolution of the order of 5 μ may be obtained.

In electron-beam activated micromachining (Fig. 2B) electrons are used in nonthermal manner and limitation of resolution imposed by thermal conduction is avoided. A magnetic lens projects the electron image onto the workpiece, whose surface has been covered with a layer of a chemical such as triphenylsilanol. Electron bombardment produces a latent image which can be converted into a silica mask by heating specimen to 200 C. A gaseous etch then removes unprotected parts of workpiece.

Other nonthermal electron-beam fabrication techniques include mo-

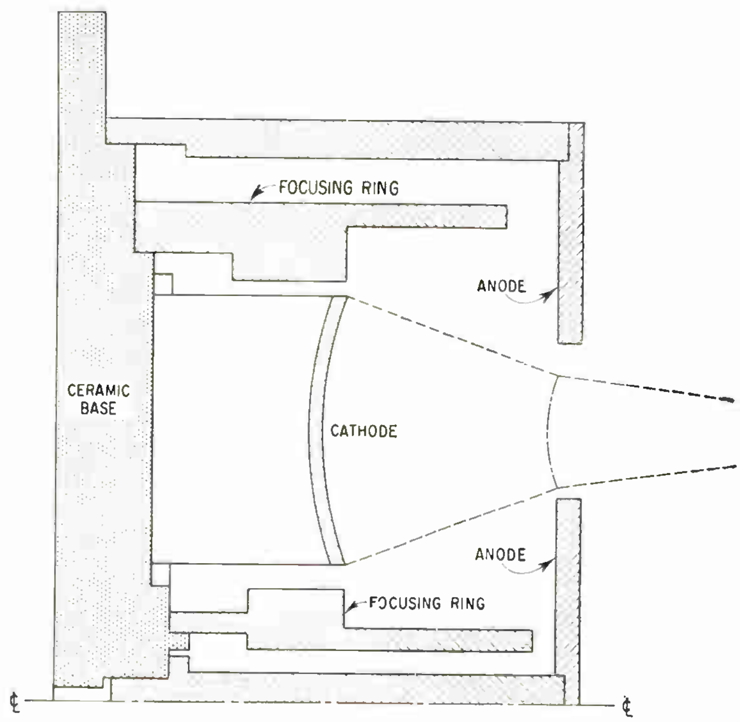


FIG. 3—Half cross-section of experimental toroidal gun for generating hollow beams

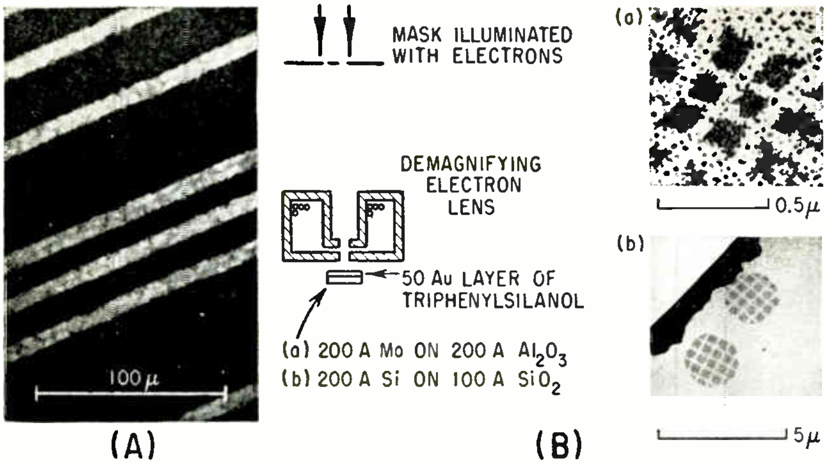
Raytheon Cathode Ray Tubes Operate at 100,000 feet without Corona

The Raytheon CK1354 and CK1355 display cathode ray tubes, used in the SAC "Hustler," are designed to operate in unpressurized areas of aircraft at altitudes up to 100,000 feet without corona. The CK1354, a three inch tube, is used for photographic purposes and the seven inch CK1355 is used in a direct visual application. Quick disconnect features eliminate potting of high voltage terminals and allow rapid replacement.

Both tubes are designed to meet exacting mechanical [illegible] the high altitude requirements of Mil-I-6181-B.

If the development of airborne radar equipment is currently of interest to you, then investigate the many advantages offered by these remarkable tubes. Also inquire about the other types of industrial and military cathode ray tubes in Raytheon's comprehensive line.

For technical information or design assistance please write to Raytheon, Industrial Components Division, 55 Chapel Street, Newton 58, Massachusetts.



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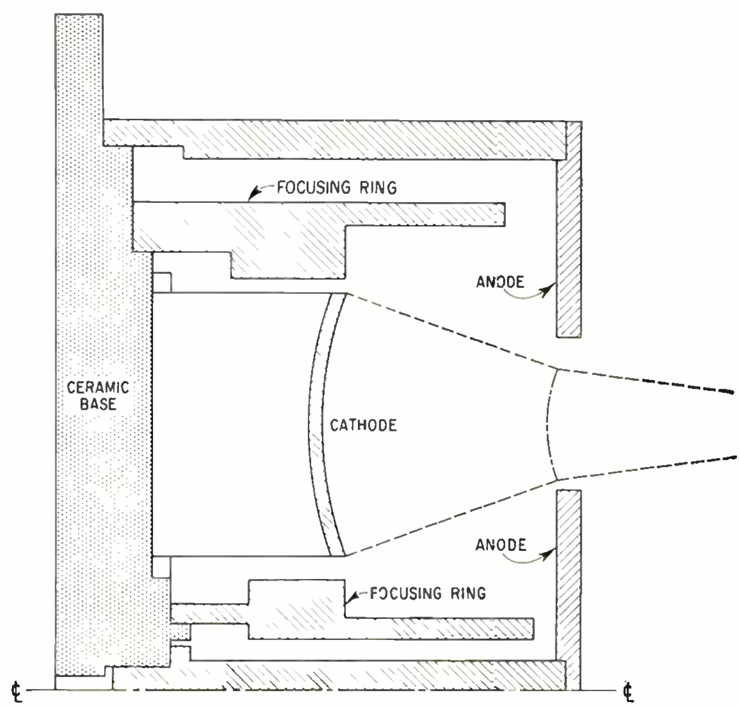


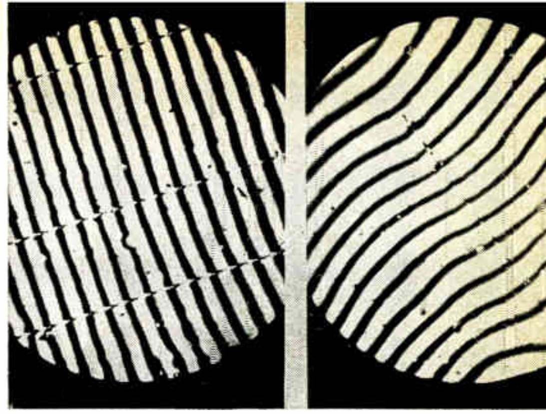
FIG. 3—Half cross-section of experimental toroidal gun for generating hollow beams

electronics
July 28, 1961

ELECTRON BEAM Versatile Tool and Mushrooming Technology

Describes the application of electron beams to electronics manufacturing, microminiaturization, recording information, and to the analysis of materials and processes

By ROBERT BAKISH   Alloyd Electronics Corp., Cambridge, Mass.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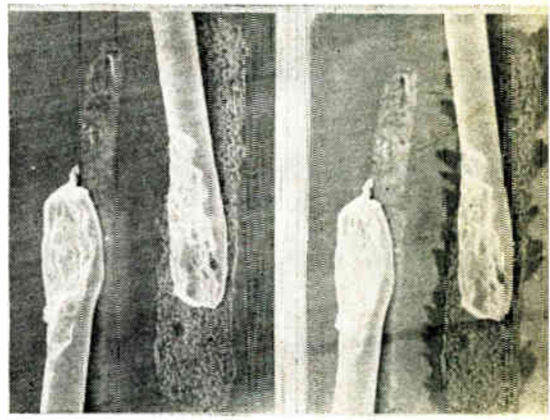
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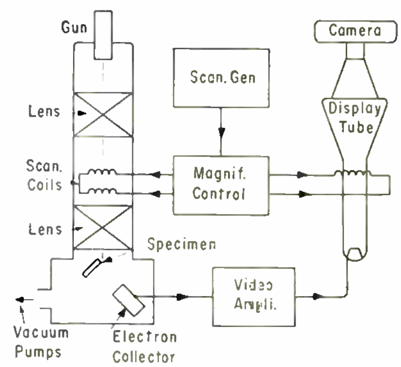


(C)

FIG. 1—Interference microscope picture of 5 and 3 μ-wide slots (A). Applying a reverse bias to emitter junction (B) renders p-n junction visible (40 μ shown) and demonstrates irregular diffusion. Scanning electron microscope (C)

INTENSIVE laboratory efforts in a half-dozen nations is steadily widening the applicability of electron-beam technology and fashioning the electron gun into one of the most versatile of engineering tools.

Already linked with research and production in microminiaturization and thin-film component technology, electron beams are opening up prospects in tangential fields. Among these fields are: microprobe analysis for quality and process control in submicron ranges; hollow beams for increased efficiency in high-power microwave and milliammeter-wave tubes; microrecording and microprinting at high density; specialized closed-system welding of metals; and formation of junctions in thermoelectric and other semiconducting materials.

Many microminiaturization applications can use the electron-beam's properties. Since absorption takes place on solid bodies in a small layer below 300 Kev, nearly 100 percent of the incident energy is converted to heat in the material; additionally, beam intensity, shape and position, lend themselves to high precision and instantaneous control[1]. A further advantage is the high energy-density that an electron-beam can accommodate.

In cutting slots on thin layers of silicon, the milling cuts stripped off material to a depth of only 0.5 μ (micron) and to a width of 3 μ. Figure 1A shows milling work of this type.

Use of positive ions instead of electrons removes the X-ray handicap in high-voltage operations, and gives promise in three-dimensional deposition processes for microcircuits and in shallow-penetration machining and cutting operations where extremely short-range energy is needed.

The future of electron beams for microstorage of information was illustrated at the third Alloyd Electronics Electron Beam Symposium. G. Mollenstedt of the University of Tubingen demonstrated abilities to resolve recorded information to 5 angstroms. At this resolution, the

Engineers Examine Nervous System

INTRODUCTION to the Function and Structure of the Nervous System, a course to be given at UCLA Medical School this Fall, is reported to be an attempt to "bridge the gap between engineering and biology". Engineers and physicists taking the course will examine the human nervous system in a search for solutions to problems in space travel, communications systems and mechanical brains. George P. Moore of the Department of Physiology is the course organizer and instructor. He says the course will benefit three classes of engineers: those concerned with information storage; those studying subjects analogous to the nervous system, such as communications; and a few who want information to build plastic models. It is conceivable, says Moore, that more will be learned about the development of the nervous system during the course, and that in the future damaged nervous systems may be repaired with engineering methods and in engineering terms.

OFFICE OF NAVAL RESEARCH has donated a 10-foot dish radio telescope to UCLA. It will tune in on 4 to 8 millimeter waves. The system's beamwidth is between 1 and 2 tenths of a degree, enabling it to be directed toward specific regions of the sun or moon. This will promote research on variations in activity at different portions of the sun, localized differences in temperature on the moon and lunar volcanic activity.

THOMAS ALVA EDISON FOUNDATION and representatives from electronics and other New Jersey industries have cooperated with educators in producing a science program that has become a part of the state educational system. Foundation Executive Director George E. Probst hopes the project will gain the attention of science-based industrialists across the country to bring about similar enterprises in other states. One example of industrial participation is that by New Jersey Bell Telephone Company. Producing and sponsoring a lecture-demonstration entitled The Science of Semiconductors, the company highlights the principles underlying development of transistors. Designed for high school physics classes, the lecture-demonstration is given to both public and private high schools by the company's traveling lecturer who uses company-supplied apparatus and materials.

CRITICAL PATH SCHEDULING is the subject of a training and workshop course to be given by Univac Division of Sperry Rand at Purdue University from July 31 through August 4. Similar to PEP and PERT, Critical Path Scheduling is a technique for tighter management control. Course includes sessions on: Fundamentals of Critical Path Scheduling, Relationship of Time and Cost, Selection of Optimum Schedules, Multiproject Scheduling, Manpower Allocation Procedures, Project Control, Utilizing an Electronic Computer.

Space-Age Transmitter

Solid-state microwave transmitter developed by General Telephone & Electronics for space communications. Firm says unit has 10 times frequency stability of conventional transmitters, operates with about two watts of output power within S-band (1,700 to 2,300 Mc)

Probing Automatic Speech Recognition

SYLVANIA'S Applied Research Laboratory is working toward an automatic speech recognition system this week. Future applications of system would include voice-operated typewriters, voice-dialing of telephones, voice-programming of computers and voice routing of mail.

A speech sound analysis method is being tested by introducing a tape recording of the human voice into a digital computer where the sounds are mathematically analyzed and resynthesized.

The method analyzes the wave forms that comprise speech in terms of a fixed set of orthonormal (uncorrelated) functions, chosen to resemble sound waveforms that occur naturally in speech.

All sounds are represented as the sum of the same 30-odd orthonormal functions, with only the coefficients of the functions changing for different sounds. An infinity of functions would be required to simulate perfectly the countless variations that occur in actual speech, but the set of approximately 30 functions should result in sufficient fidelity for most purposes, company says.

French Solar Battery Goes Into Operation

ENERGY CONVERSION devices are receiving attention from French scientists. An operational solar battery set up near Toulon is currently being observed.

The project is the result of studies carried out for the Bureau of Investment in Africa by the Physico-Chemical Research Center of the Compagnie Generale de Telegraphie sans Fil (C.S.F.), and supported by the Technical Service of Air Telecommunications.

The battery uses solar energy only as heat, first converting light waves to heat and absorbing visible radiation in black collectors. Electric energy is produced by using thermoelectric material.

A square meter of a solar battery can deliver 50 watt-hours a day. Seventeen square meters of the C.S.F. battery, for example, provide 100 w at noon on a clear day. The on-load voltage is 24 v.

Defense . . .

where the wavelength intervals are: 0.01 micron up to one micron; 0.1 micron from one to two microns; one micron at wavelengths greater than two microns.

The carbon arc and the high-pressure mercury-xenon bulb have already been ruled out as energy sources for operational reasons.

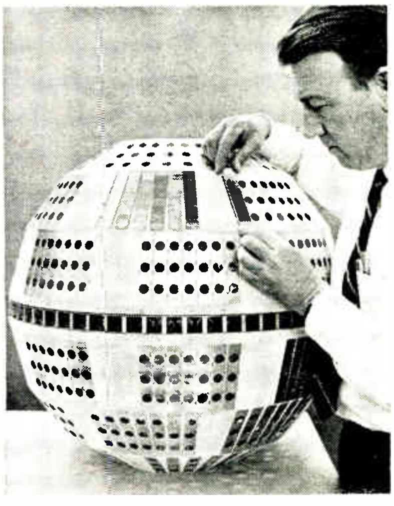
In addition to being integrally designed with the source, the optical system must have an intensity variation of less than ± 5 percent over the whole test area extending from 3 to 30 feet in diameter. Ideally, it should be collimated so that all of the high-intensity energy incident upon any point is received within a cone of half angle of 0.4 degree and so that 50 percent of the energy is received within a cone of half angle of 0.3 degree. For the lower intensity, these half angles would be 0.2 degree and 0.13 degree. During the next five years, however, half angles one order of magnitude larger are acceptable.

Surfaces of the optical system directly exposed to thermal radiation from the test object should appear as diffused black bodies at near liquid-nitrogen temperatures.

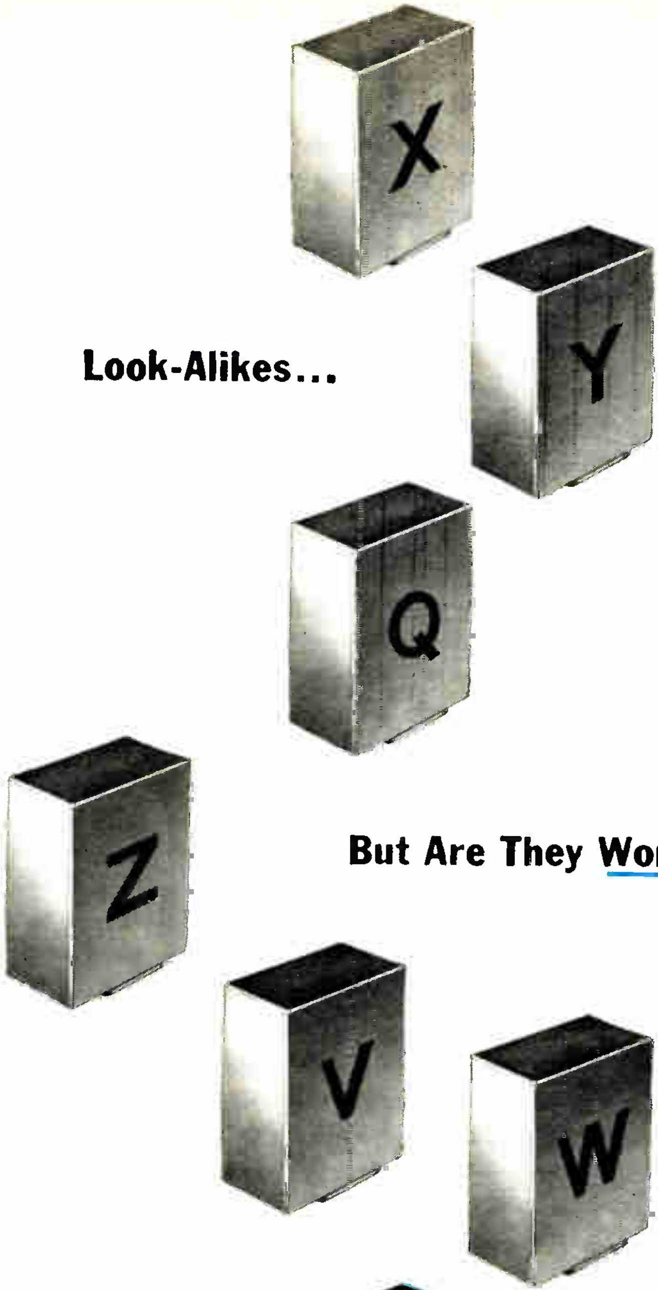
Being sought in the radar, tracking, and tv fields are:

- An expendable and inexpensive technique of having an aerial vehicle—balloon, parachute, rocket—sense and telemeter its own position (X, Y and Z) without ground tracking and preferably without a cooperative ground transmitter.
- An indicator showing closing-in rate of air or ground vehicles. Only the two closing objects must be shown in the output and, if possible, the evasive action to be taken.
- A surface navigation system for hydrographic and oceanographic survey. It must have long-range capabilities for midocean surveys, and must be accurate within 1,000 feet regardless of distance from shore. Preferably, it should be self-contained, but, if it is ground-referenced, the shore equipment should be portable and relatively inexpensive.
- An image orthicon camera tube with nonlinear transfer characteristic. Present orthicon tubes are sensitive in their control adjustments to varying light levels: highlights produce, in accordance with their linear transfer characteristic, comparatively too many transfer electrons that partly hide or drown the weaker signal and destroy sensitivity. The Council feels that a nonlinear transfer characteristic would cut down the excess production of transfer electrons at high light levels. Comparable contrast sensitivity for low and high light levels should be maintained.
- A missile-borne vehicle detector for finding small, supersonic objects in space or the atmosphere at ranges of thousands of feet. Present radar and infrared principles and equipment are not adequate for finding small, high-velocity spacecraft. A passive detector is preferred.
- A practical instrumentation system capable of tracking missiles during the early phase of launch—the first 30,000 feet. It should not suffer from the geometric dilution of precision afflicting present tracking systems. It must produce data as precise as that following the first 30,000 feet.
- An acceptable standard for the check-out of trajectory measurement systems. Presently, missile trajectory measurement system are checked by independent systems that seldom agree on the accuracy of the system being checked.
- A small, self-contained stable frequency standard occupying a cubic foot of space or less and operative in a missile-borne environment.

Gems Protect Cells



Man-made sapphires protect solar cells from space radiation on new Bell Labs communication satellite



Look-Alikes...

But Are They Work-Alikes?

Bendix-Pacific 300 Series Telemetry

The Recognized Standard

MODEL TOE-300 OSCILLATOR

Experience earns leadership.
There are fifteen years of design and application experience behind Bendix-Pacific telemetry components — a depth of experience unmatched by any other manufacturer.

This is why the 300 Series equipment is the recognized standard — complimented by look-alike copies, but standing alone in accuracy, performance and extended reliability.

Bendix-Pacific Division
NORTH HOLLYWOOD CALIFORNIA

THE Bendix CORPORATION

Defense Needs Electronics Inventions

DEFENSE PROBLEMS areas recently outlined by the National Inventors Council of the U. S. Department of Commerce stress requirements for improved electronic equipment, ranging from a low-noise radar antenna to a touch-tuning control for all airborne radio sets.

Need for the low-noise antenna points up a limitation of radar systems having low-noise parametric or maser amplifier receivers: low system sensitivity due to high antenna noise temperature.

Other antenna needs:

- Improved transmitting antennas in the 3-30-Mc band, for ground vehicles and aircraft. Physically short antennas using materials designed to reduce propagation velocity are suggested by the Council as one approach. Ferrite materials like those used in receiving antennas may provide another approach.
- Readily constructed hardened antennas that will maintain dimensional tolerances of a few tenths of an inch over temperature ranges that could exceed 100 F are needed for long-range ground applications.
- Improved radiation efficiency is being sought for 100-Kc, pulsed, high-power transmission antennas. The antenna type now in use is a 625-foot top-loaded unipole with radial ground system. While improved radiation efficiency is a consideration, designs must conform to practical considerations of height, ground space limitations and cost. Suitable antenna insulators that will not arc under adverse climatic conditions are also needed.

A simple method for coherent frequency multiplication from 10 Gc to 1,000 Gc is being looked for. Technique would have to produce an output power of not less than 1 microwatt at 100, 300 and 1,000 Gc. Spectral width due to phase jitter introduced by multiplier chain should be less than 1 part in 10^{13}.

High-frequency power sources having average powers of 10-15 Kw must be found for Z-band, K-band and millimeter regions to fully exploit high-frequency advantages of wide bandwidth, directivity, size and weight compactness and resistance to jamming.

A lightweight, simple, reliable and inexpensive process for communicating through plasma sheaths generated by reentry vehicles, one that would use phenomena already available in space, is urgently needed. It should be almost independent of vehicle-borne devices.

The Council is shopping for electrocardiogram electrodes for semipermanent (perhaps up to a year) attachment without skin penetration. They must not irritate the skin, change resistance nor create electrical noise. Presently, such ecg electrodes require an electrically conductive paste which dries and irritates the skin.

Present sawtooth generator designs that have a field linearity of not better than approximately 1 percent are not good enough for many applications. A new design is desired that would give at least 0.1-percent linearity under all conditions and that would use transistors where advisable.

Airborne communications equipment is wanted that would provide a greater use of the vhf spectrum of 108 to 136 Mc to satisfy air-control needs of the future. Closer frequency spacing must be achieved while maintaining receiver selectivity, transmitter frequency stability and operational reliability. The equipment should be small, lightweight and need low power.

Simulation of solar illumination in outer space is required for environmental testing of spacecraft and spacecraft equipment. Attention is being given to duplicating illumination in the portion of space between the orbits of Venus and Mars. The problem can be divided into simulating the source of radiant energy and developing an optical system to present the energy to the test specimen.

The energy source must be capable of producing energies variable betwen 30 and 200 Kw multiplied by the inverse of the transmission and collection efficiency of the optical system, usually less than 10 percent. The spectrum of the radiation should be as close as possible to that of the sun (Smithsonian Physical Tables, 9th Edition). Deviations of 10 percent in each wavelength interval might be tolerated

Testing Lightweight Solar Concentrator

Solar concentrator mounted on aircraft searchlight housing is tested with cryogenic calorimeter. Thompson Ramo Wooldridge Inc. developed unit for Air Force as part of thermionic power system particles and more effective use of bubble chambers. It will result in higher resolution for mass spectrometers and will advance atomic beam experiments, it is reported.

Other potential applications are thermonuclear fusion containment, magnetic shielding of space travelers without prohibitive amounts of mass shielding, inductive storage of large amounts of electrical energy in space, construction of superconducting gyroscopes with absolute accuracy for inertial navigation in space, and loss-less generation and transmission of electrical power.

Advances in magnetism are also increasing interest in biomagnetics —particularly since it has been established within the last two years that magnetic fields exert significant effects on biological entities at the organismic and cellular levels. In addition, higher resolution for electron microscopes may clarify body processes that can now be only deduced.

Computer Runs Self From Program to Program

ITS NEW OPERATING SYSTEM enables an electronic computer to virtually run itself from one program to another without human intervention, Minneapolis-Honeywell's EDP division reports.

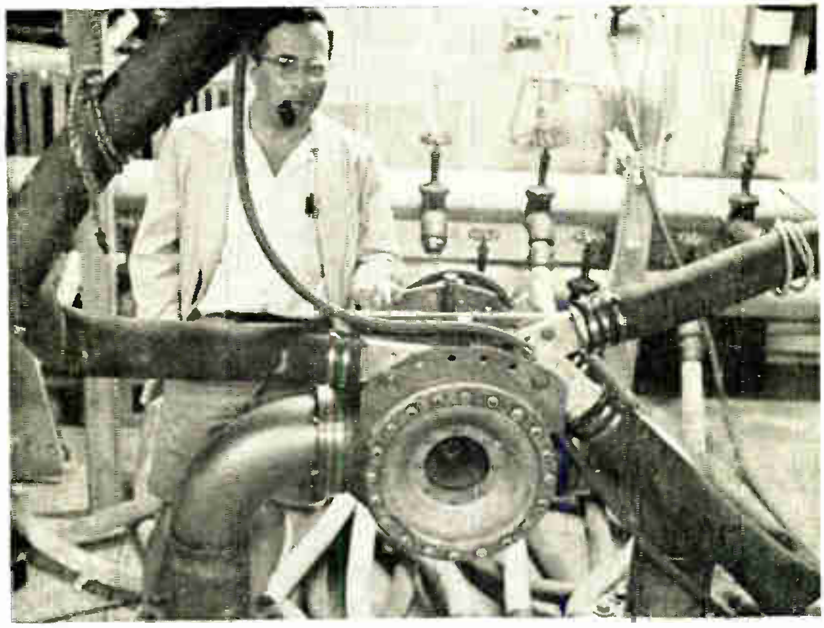
The system, known as Executive Scheduler and Monitor, is designed to achieve economy and efficiency in running a series of parallel programs on the Honeywell 800.

The system reads schedule information, locates programs on the program tape, checks that the programs can be run simultaneously, converts them to working programs with memory, tape unit and peripheral equipment addresses, and inserts label information into the programs and places them on the production-run tapes.

The system then automatically loads the programs from the production-run tape into the computer and turns them on and itself off. As each production program ends, it calls on the system to initiate loading of the next program. Any long-running program may call on the system to restart without loss at a later time.

New Magnet to Spur Solid-State R&D

By THOMAS MAGUIRE
New England Editor



Inventor Kolm and his 126-kilogauss, continuous field solenoid. Grapefruit-sized magnet is surrounded by coolant pipes and 10,000-ampere cables

GENERATION of a continuous magnetic field of 126 kilogauss in a solenoid magnet recently at MIT (ELECTRONICS, p 11, July 14, 1961) signals the advent of an exploratory tool expected to have widespread scientific implications. It can, for example, help develop electron microscopes of unprecedented resolution, broaden solid-state resonance experiments, and influence magnetohydrodynamic power generation, investigation of superconductivity, creation of higher-power microwave tubes and space travel.

Magnetic fields approaching a million gauss have been achieved with pulsed apparatus, but such fields have durations of only a microsecond or millisecond. The previous record for a continuous field has been 100 kilogauss. Fields produced in iron laboratory magnets have been limited by practical gap size and by the value at which iron saturates. Elimination of the iron requires approximately 1,000 times as much current to generate a field of equal intensity.

Design principles for the new solenoid were presented in ELECTRONICS October 2, 1959 (p 43) in an article by the inventor, Henry H. Kolm of MIT Lincoln Laboratory. Kolm is now a staff member of the National Magnet Laboratory under construction at MIT under an Air Force Office of Scientific Research contract.

The magnet consists of a tapered, 135-foot-long ribbon of copper scored with 3,000 square slots and wound with insulation into a cylinder. Cooling water is forced between the aligned slots at 320 gallons per minute. In the center of the coil is a tube, one inch in diameter by two inches long. An intense field is produced in the tube as 10,000 amperes of current pass through the coil.

The solenoid was built by High Voltage Engineering Corp., Burlington, Mass. The precision and small size—the Kolm magnet is about the size of a grapefruit without auxiliary apparatus—required special fabrication machinery. The operating version differs from the original design (see illustration on page 4 of this issue) in that insulation is carried on a second and thinner tape instead of the copper ribs.

Kolm points out that the principle limiting factor now is the amount of well-regulated d-c power available. Total test power available was 1.88 megawatts. Higher fields may be produced when a source of eight megawatts becomes available at the laboratory. Cooling also imposes limitations, since all the power must be dissipated as heat. The tests were run in the summer; the magnet may produce higher fields in the winter.

D. Bruce Montgomery, of the laboratory staff, and Professor Francis Bitter are developing a 250-kilogauss magnet. This level probably will not be achieved until the new facilities at the National Magnet Laboratory are available in 1963.

Higher fields will be of special significance to creation of new structures of crossed-field devices for operation between 4 mm and the submillimeter level.

Among solid-state experiments that can take a giant step forward with high fields are the cyclotron resonance measurements of semiconductors, a project of special interest to Benjamin Lax, director of the National Magnet Lab. To get cyclotron resonance at submillimeter or infrared wavelengths, a field of at least 200 kilogauss is needed. In the far-infrared frequencies, work with pulsed fields is difficult and inaccurate, so continuous fields are needed.

Problems in superconductivity research that the newly-attained fields can help solve include the quenching of superconductivity in new materials. At Bell Telephone laboratories recently, researchers were unable to quench the superconductivity of a composite of tin and niobium, although they used a field of 88 kilogauss.

Higher fields are expected to aid the advance of nuclear physics, specifically the analysis of high-energy has the prime responsibility under a contract with Patrick AFB, Fla. Equipment and cost breakdown is as follows:

(1) $12.6 million for modification and stabilization of the two ships. Equipment will be furnished to determine geodetic position, ship heading, and provide stable orientation information for the computers and recorders.

(2) $23.3 million to develop and furnish equipment to provide target trajectory and C, X and L-band radar reflectivity data on targets. The equipment will also determine location of impact point relative to ship and detection trail from primary target.

(3) $930,000 to provide and install all radio communications equipment on board ship.

(4) $2 million for telemetry; to furnish and install a four-channel recovery and recording system with 100-percent backup. An antenna system will be supplied with the telemetry equipment which will have both manual and automatic tracking capability.

(5) $5.9 million to furnish consoles for operation and coordination of the instrumentation system. Included in this array is data handling, recording, display and computer equipment; optical director; boresight camera, and infrared tracking systems for alignment and calibration of the instrumentation.

(6) $400,000 for furnishing and installing a shipboard meterological system to provide precise measurements of meterological parameters at surface and in the upper atmosphere.

(7) $4 million for the engineering effort to plan, design and supervise the installation and integration of all equipments and systems.

(8) $1.4 million for technical progress reports, engineering data, determining and providing initial replacement parts requirments and indoctrination training of instrumentation operating personnel.

(9) The remaining $9.47 million will go for instrument modification of C-130 aircraft, communications equipment being installed, a U. S. Coast and Geodetic Survey of the range and approximately 80 miscellaneous electronic devices for installation throughout the range.

Soviet Component Lag Seen

AMBITIOUS SOVIET PLANS for rapid growth of electronic output may be threatened by the failure of component production to maintain the required pace. The onset of this problem is suggested by scattered and fragmentary data which the Soviet regime has permitted to filter through the Iron Curtain.

These data indicate that original Soviet plans called for an annual production rate of 200 million electron tubes of all types to be reached by 1960. Actual output in 1960, however, amounted to only 125 million units. By comparison, according to EIA estimates, U. S. manufacturers' sales of receiving tubes alone have ranged between 400-480 million units per year since 1955.

While the USSR could bridge its electron tube gap by large-scale substitution of transistors and crystal diodes, there are growing indications that the Soviet semiconductor industry also is lagging substantially behind the needs of equipment manufacturers. In contrast to a high degree of public optimism shown earlier, the Soviet press has grown increasingly obscure in recent years concerning current levels of semiconductor output in the USSR. The most recent information available relates to 1957 during which year, according to official statements, Soviet industry produced approximately 20 million semiconductor elements of all types. These announcements provided no further information as to how this output was distributed between transistors and diodes. Corresponding U. S. production for 1957 totaled approximately 100 million units, including 29 million transistors and 71 million semiconductor diodes.

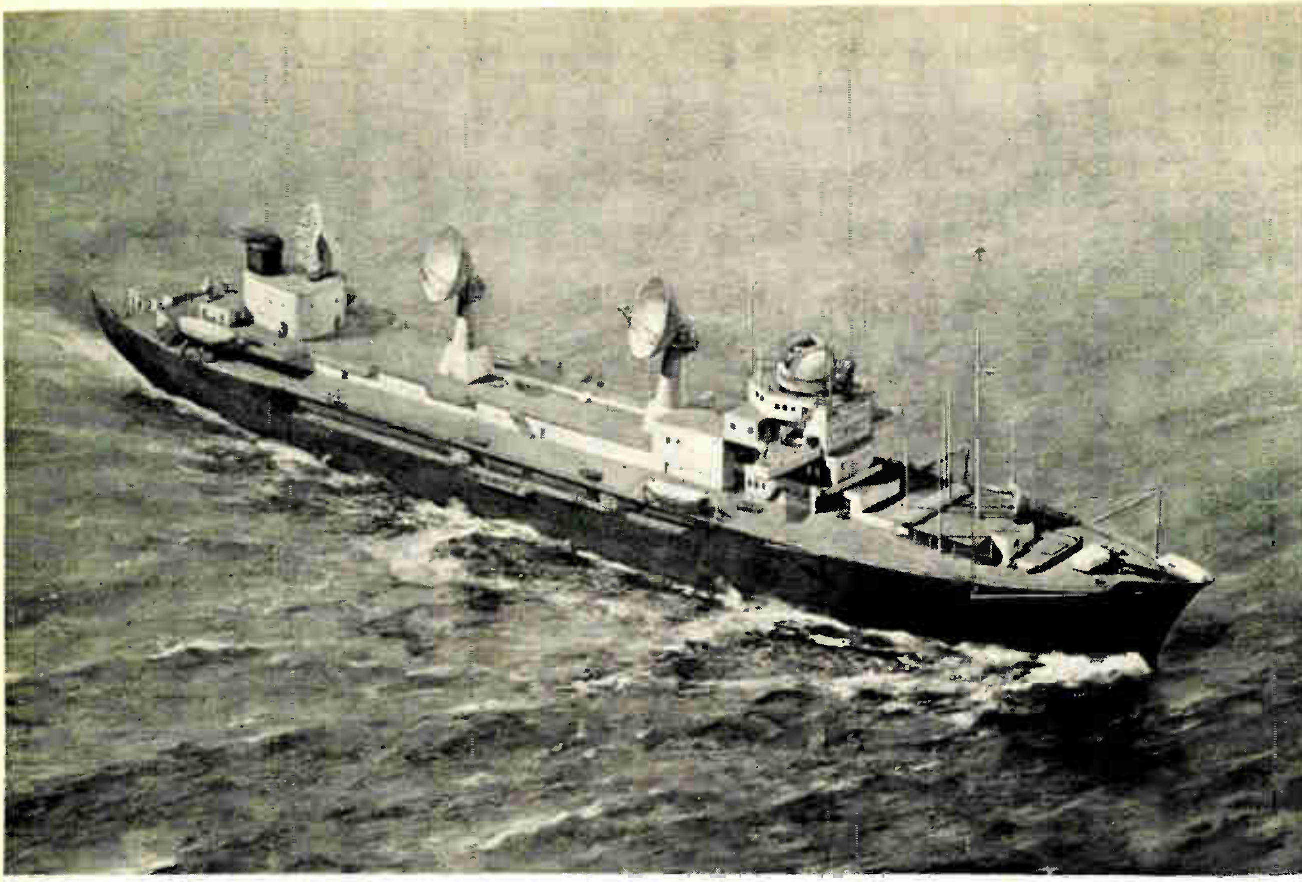
Since the 1957 announcements, the USSR has studiously avoided the publication of hard figures on achieved levels of semiconductor output. There appears to be some significance, however, in the fact that late-model Soviet electronic computers are still based on vacuum tubes rather than transistors and that transistorized radio receivers are only now beginning to trickle into Soviet retail outlets.

In the mid-fifties, when component production was forging ahead very rapidly, the Soviet electronics press appears to have been encouraged to publish indexes showing the rapid overall growth of electronics production in the USSR. With the apparent failure of tube and semiconductor manufacturing to advance in accordance with earlier expectations, however, Soviet press media have fallen silent in recent years concerning the actual record of electronics industry growth.

Given the historical devotion of Soviet leaders to the most rapid possible expansion of Russia's war potential, it seems a virtual certainty that every effort will be made to assure that the military electronics program in the USSR does not falter. The brunt of any slowdown in the growth of Soviet electronics production would most likely be reflected in those branches of the industry responsible for production of civilian equipment. In this connection, it might be noted that, in contrast to earlier Soviet plans, announcements scheduling an output of 10.2 million home radios and tv sets in 1960, actual output last year amounted to only 5.9 million units.

Infrared Binoculars

Infrared binoculars for night viewing are under development at the U. S. Army Engineer R&D Laboratories, Fort Belvoir, Va. The optical system utilizes an infrared converter tube



This touched-up photo shows how Sperry Rand will convert two troop carrier ships to floating missile ranges

Missile Ranges Expand at Sea

By JOHN F. MASON, Associate Editor

AN IMPORTANT STEP in the changing shape, size and requirements of the nation's missile ranges takes place with the demothballing of two retired C-4 type troop carrier ships.

These ships will become Mobile Atlantic Range Stations (MARS) to extend the Atlantic missile range beyond the last island outpost at Ascension Island, 4,300 nautical miles from the Cape. This will take care of tests such as the recent Atlas shot from Canaveral that went 9,000 miles to the Indian Ocean.

Mobile stations such as these can also monitor the actual flight path of long-range missiles, which is east of the island chain. Since the earth rotates 7½ degrees east during a missile's 30-minute flight, the missile lands 7½ degrees west of the point it's heading for as it is launched. For this reason, long shots are fired in an easterly direction toward Africa. By the time the missile gets there, Africa has moved on to the east; the missile misses Africa and lands in the Indian Ocean. The practical importance of these physical phenomena is that many of the islands in the AMR chain are not in the right place for long-range shots. Mobile ships can be put in the right places.

Another application for shipboard missile ranges is in space flights. A group of four ships might be instrumented with an interferometer system and placed under the point in a parking orbit from which a lunar probe would take off for the moon.

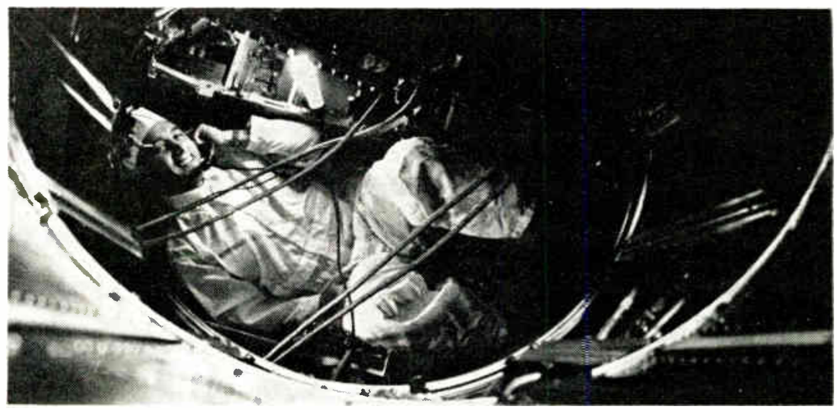
The Pacific Missile Range has six ships used for tracking, telemetry and recovery. The Atlantic Missile Range now has two tracking ships. The two new MARS ships will make four. Two more will probably be needed for the range's normal workload. If AMR is assigned the task of becoming the official range for space launches, eight to ten more ships will be needed.

Estimated cost of converting and instrumenting the two MARS ships is $60 million. Sperry Rand Corp.

The first developmental S-C 2000 console delivered to Mitre Corp.

WASHINGTON OUTLOOK

THE ADMINISTRATION'S new defense plans came out this week. As ELECTRONICS went to press here was the outlook: Procurement of tactical arms and equipment, including electronics gear, will be accelerated in an effort to bolster the nation's capacity to fight limited wars. Exact cost of the added electronics buying is still unknown, but total price tag of Kennedy's expanded defense plans is expected to run from $2-billion to $3-billion. The sum will cover many readiness measures other than major procurement items. The size of the expected boost indicates that some long-range programs will be added. It had been anticipated, earlier in the defense policy review, that the Pentagon was to be limited to additional production only of items to be delivered over the next 12 months.



CHANGES MADE in the "Liberty Bell" Mercury-Redstone 4 space capsule included a new rate stabilization and control system (RSCS). Astronaut Alan B. Shepard's Freedom 7 capsule relied on a straight manual control system to maneuver the capsule in space by opening and closing 6 gas jets at the base and neck of the capsule. MR-4 carries the new RSCS, backed up by the manual system. Using the new system last Friday, Astronaut Gus Grissom (in the capsule, above, during a checkout before the flight) could control the jets by a control-stick. The stick actuates electrical signals that open and close solenoid valves at the jets.

SOVIET AIRPOWER REVELATIONS have intensified pressures on the administration for a massive stepup in aircraft development and production. Considerable support exists for the Air Force's plea for another wing of B-52 bombers, a doubling in B-70 development effort this year (including reinstatement of electronic subsystem work), and procurement of 275 extra Republic F-105 fighter-bombers. There is also sentiment for reinstating the F-108 project—in which electronics work figured so prominently. But so far there is no sign of change in administration policy.

ELECTRONICS MAY SOON provide additional "eyes" for piloting submarines deep in the ocean depths. A system known as Contact Analog (CONALOG), under development, will display a safe course on a tv-type screen. The operator merely keeps an indicating dot properly positioned on the electronic "highway" to keep the submarine on course.

Basically, the system works like this: as the submarine dives below the ocean surface, course, speed and depth information is fed into a display generator which transforms the data into a visual display. When a course change is ordered, the indicated course curves along the desired path. Changes in depth cause the displayed course to rise or drop.

In recent tests on the nuclear attack submarine Shark (SSN-591) the CONALOG system has been highly successful.

rectifiers and Zener diodes

An average of 16 separate life, electrical, mechanical and environmental tests prove out the quality that has been built into General Electric low current rectifiers and zener diodes. The use of "getters", the finest hermetic seal available, hard soldered joints, and welded main and tube seals are only a few of the reasons they test out so well. Silicon rectifier type 1N538, for example, was put through torturous life test studies over a period of *10,000 hours* at maximum temperature, current and PRV . . . and came through with a 99% survival percentage.

For complete technical information, just call your Semiconductor Products District Sales Manager. Or write Rectifier Components Department, Section 25G26, General Electric Company, Auburn, New York. In Canada: Canadian General Electric, 189 Dufferin Street, Toronto, Ont. Export: International General Electric, 150 E. 42nd Street, N.Y. 17, N.Y.

For fast delivery of selenium, germanium, and silicon rectifiers at factory-low prices, see your authorized G-E distributor

Progress Is Our Most Important Product

GENERAL ELECTRIC

CIRCLE 13 ON READER SERVICE CARD

tronics Corp., West Germany. It projects a three by 4½-foot picture on a home wall screen, from a 2½-inch crt. Scan lines are eliminated by a plastic sheet placed under the face of the picture tube. Sony displayed an eight-inch, 13½-pound transistor tv set operating from a-c or battery power. It costs just under $250.

Westinghouse has an "instant tv" standby circuit which keeps the set warmed up while it isn't used and protects it against initial power surges. Sound can be transferred remotely to a radio or earphone while the set is muted.

Solid-State Oscilloscope Reads Out Automatically

CALIFORNIA INSTRUMENTS Corp. reports development of a lightweight (10 to 12 pounds) fully automatic oscilloscope. Automatic functions are performed digitally with solid-state circuits. The San Diego firm told ELECTRONICS that it has licked the problems of obtaining stability from low-level amplifier input and getting sufficient dynamic voltage swing from transistors to operate the scope tube. Early models will be demonstrated at Wescon, full production is expected in October.

Automatic features reported include: vertical sensitivity adjusts so waveform of a circuit under test always appears on the screen; a given number of cycles, from d-c to the megacycle range, will appear on the screen; the image is automatically centered and d-c offset can be read exactly; vertical scale, sweep speed and other parameters are shown digitally on Nixie tubes. The instrument, costing about $1,500, is expected to reduce errors in laboratory work, allow production testing by inexperienced workers and simplify training of military personnel.

High School Students To Operate Computer

COMPUTER PROGRAMMING and operating techniques are being taught 16 students at a Westport, Conn., high school. They'll work with the computer three and one-half hours daily for four weeks. Similar programs have been started at several other high schools. The program will test feasibility of computer training at precollege level. Royal McBee is providing an LGP-30 computer and and instructor.

Electronic Yelper Is New Ambulance Helper

HIGH PITCHED AUDIO signal, described as a cross between a yodel and a war whoop, is emitted by a 50-watt oscillator introduced by Federal Sign and Signal Corp., Blue Island, Ill. It is intended as an attention-commanding supplement to sirens or public address systems carried by ambulances, police, fire, defense and other emergency vehicles. Company expects yelper to provide police and public safety agencies with greater flexibility in meeting emergencies.

Electrostatic Printer May Make Circuits

HIGH-SPEED, noncontact process for printing on irregular surfaces shows promise in several electronics applications. Using an electrostatically charged stainless steel or conductive nylon screen of 200 to 400 lines per inch, the machine transfers the charge to dry ink or other material. The material travels in a straight line toward a plate of opposite charge. Particles are intercepted by the surface to be printed and are fixed by heat or vapor.

The machine uses about the same voltage at a tv set, is capable of 300 impressions an hour and has printed 3,600 linear feet a minute. It was developed by the Graphic Science Lab at Stanford Research Institute and sponsored by Electrostatic Printing Corp., San Francisco.

Applications reported by the company include depositing conductive material for printed circuits, printing irregularly shaped dials, labeling small components, and—since no pressure is exerted—it may even be used for printing on eggs and filled burlap bags. Deposits can range from a few mils in thickness to one-eighth inch.

In Brief . . .

SANDERS ASSOCIATES, in one day this month, got $40 million in military prime contracts for aircraft, antisubmarine warfare and missile defense systems. Company's backlog is now $90 million.

AVCO RECEIVES $29.6 million in new prime contracts for Titan and Atlas ICBM work. Contract, from the Air Force Ballistic Systems Division, is split 50-50 between R & D and production of reentry vehicles, backup equipment and site activation.

UNIVERSITY OF MICHIGAN's Institute of Science and Technology has a $287,000 Air Force contract to investigate ways of protecting aircraft and space vehicles from hostile missiles. Program includes study of ir-guided missiles and computer simulation of missile attacks.

FAA WILL TRACK down interference with four mobile vans, one for each FAA region. Astronautics, Inc., Melbourne, Fla., will provide the vans for $198,600.

AEC IS REPORTED ready for seismic testing with an underground telemetry system. Transmitter and receivers will be located at bottoms of three 500-foot holes in a salt mine at Winnfield, La. Signal reception will be studied; there'll be no explosion.

GE INSTALLS two solid-state supervisory, control, monitoring and alarm system linking three substations of the Western Massachusetts Electric Co. GE says it is the first solid-state installation in the utilities industry.

EIA IS SOLICITING quarterly market data from some 1,800 industrial electronics manufacturers, will feed back industry totals to contributors. New committee chairman is Robert E. Peterson, of Philco.

SUMMER LECTURE program in superconductive computer circuit design and related physics will be given Aug. 14-25 at MIT.

ELECTRONICS NEWSLETTER

Stereo Bonanza Predicted at Chicago Show

FM STEREO POLL by National Association of Broadcasters led to prediction last week by John F. Meagher, NAB vice president for radio, that stereo radio receiver sales are a "potential bonanza".

The survey of 381 representative stations showed 185 planning f-m stereo broadcasts. Of these, two were on the air, 77 more will broadcast this year, 46 more in 1962. There are 866 licensed f-m stations on the air today and another 210 are under construction.

Stereo is already being broadcast in New York, Chicago, San Francisco, Seattle, Dallas and Detroit. A San Francisco station, planning to broadcast stereo this month, expects its listeners to buy 25,000 multiplex receivers in 1961, Meagher said.

But Meagher added a big "if" to his report before the National Association of Music Merchants convention in Chicago. Although f-m stereo opens the door for promotion on the scale that greeted tv and stereo phonographs, "chicken and egg" indecision could delay full effect up to five years.

Quick success, he explained, depends on aggressive development and cooperation between set manufacturers, distributors and dealers, and broadcasters. Cost, doubts about receiver availability, quality of monophonic reception or quality of new receivers could dampen the market. Broadcasting economics depend on advertiser interest, which in turn follows public interest, he pointed out.

FCC Commissioner Robert E. Lee, speaking at the EIA-sponsored stereo symposium at the convention, said stereo would be frozen in the f-m band for several years. The a-m band isn't adequate, he said, and tv stereo sound won't be available in the foreseeable future.

Television Camera Sees in the Dark

IMAGE ORTHICON television camera for night battlefield surveillance has been developed by Admiral Corp. for the Army's Signal Research and Development Laboratory. The camera, using transistors and a low light level tube, weighs 35 pounds. A miniaturized version is planned. The camera can see a person several hundred yards away, in almost total darkness. One unit has already been delivered to White Sands Missile Range, N. M.

CRT-Fiber Optics System To Print Computer Output

INFORMATION TECHNOLOGY division of General Dynamics/Electronics told ELECTRONICS a few days ago that it has successfully welded a full-page-width fiber optics bundle to the face plate of a cathode-ray tube. The development is said to significantly increase brightness and resolution in computer readout and recording instruments. Fuzziness and halo effect are virtually eliminated for line-at-a-time printing.

The fibers, each one-half inch long and 0.0008 inch in diameter, are stacked in a bundle eight and one-half inches wide. Two of the requirements for successful image transmission are that each fiber occupy the same relative position at both ends of the bundle and that each fiber be smaller than the finest detail of the image to be reproduced.

Operating as light conductors by internal reflection, the fibers transmit light with loss of only a fraction of one percent per inch. They are made of transparent dielectric clad with glass having a lower refractive index. Reduction in light scatter and diffusion makes resolution a function of sharpness of the electron beam on the inner surface of the tube face. Brightness is limited only by saturation of screen phosphors.

... Uhf Tv Boom too?

DURING HIS TALK at the EIA symposium on stereo last week, FCC Commissioner Robert E. Lee added a strong plug for uhf tv. A changeover from vhf to uhf would, he said, create new markets for millions of uhf receivers.

"All tv must ultimately be moved to uhf," he said. "The Commission has determined we must utilize uhf if we are to have competitive service."

Lee predicted that educational and subscription tv would build public demand for uhf and "may even persuade" manufacturers to make all-channel sets. The Commission has as a "last resort" asked Congress to require all sets shipped in interstate commerce be all-channel, he said.

Multiplex Dominates Chicago Exposition

THERE WAS JUST as much action as talk on f-m stereo at the Music Merchants convention in Chicago last week. Dozens of manufacturers offered prototype multiplexers and adapters ranging in price from $30 to $50, including several Japanese and Canadian models.

Major shipments of stereo consoles are expected to start about October, to be followed later by end-table radios. The full sales surge is anticipated in 1962.

Capehart introduced a mobile system to rebroadcast stereo at any electric outlet in a home. Device installed in any stereo receiver transmits A and B channels to floating speakers, reproducing stereo or monaural records or radio. Pilot Radio used a multiplex synthesizer to demonstrate its new receiver. Broadcasting less than 100 feet, the transmitter included a crystal-controlled 19-Kc oscillator, frequency doubler, add and subtract circuits, suppressed carrier amplitude modulator and monitor for the FCC standard composite signal.

Among television introductions was Telerama, made by Saba Elec-

COMMENT

Interservice Data Exchange

I should like to express our appreciation for the article on our Interservice Data Exchange Program (IDEP) which appeared in your 2 June 1961 issue. The facts on the IDEP program were excellently presented.

This office is constantly seeking methods and techniques of presenting to the public the importance of reliability in our ballistic missile and space programs, and particularly industry which is vitally concerned in this area. Articles such as this one aid us in this effort.

VINCENT J. BRACHA,
MAJOR, USAF
BALLISTIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
LOS ANGELES, CALIF.

Small Business Administration

. . . We are . . . appreciative of the recount on the SBA Research and Development program (p 26, June 16). As pointed out, many small firms as well as the larger prime electronic systems contractors are somewhat unfamiliar with the broad service nature of this Administration. Your coverage of just one facet of our operations should prove enlightening to your subscribers.

. . . One section in your magazine has always attracted my special attention—the *Electronics Newsletter.* These factual briefs help to keep a busy executive abreast of current happenings . . . more effectively than monthly publications.

ALBERT WIEBE
SMALL BUSINESS ADMINISTRATION
NEW YORK, N. Y.

Secrecy

The remarks by Admiral Rickover directed at a toy manufacturer with the assertion that their 18-in. toy replica of the Polaris carrying atomic submarines had given to the Russians the secrets of the Polaris atomic submarines are surprising in view of Admiral Rickover's acknowledged outstanding technical knowledge, keen intelligence and talent. I believe that the Polaris atomic submarine system is one of our greatest deterrents to attack in addition to being an outstanding defensive weapon system and our country owes much to Admiral Rickover for having the courage of his convictions and fighting through the entangling red tape to see this project a reality. However, the charge in itself points up the frustration, confusion, ignorance and inadequacy under which the armed services operate in the realm of secrecy. The toy manufacturer had not purloined the secrets nor engaged spies for this purpose; but, in reality had only assembled the information that had been previously released by the Department of Defense.

It has been asserted that copious numbers of documents on all categories have been stamped Top Secret, Secret and with other restricting symbols in a wild endeavor to cover up the errors, malpractice and waste in the national services. . . . On occasion, several concerns will be doing R & D work without the benefit of knowledge gained by others doing similar work, resulting in much time consuming and expensive duplication of research activities. The fact that a document has a secret stamp upon it does not necessarily mean that this will prevent the Russians from obtaining this same information. As a matter of fact, foreign government embassy officials are permitted to search and have access to documents that the average engineer is not permitted access to or knowledge of, even though such a person might like to have this information for reference or to evaluate the information in conjunction with some project upon which he may be interested or working.

. . . I do not mean to infer that our secrecy stamps should be deleted from all technical data; but, rather it should be applied to that data that is actually in the category of information that has not been discovered by or generally used and known to a foreign government.

. . . Is the secrecy label a deterrent to our advancement in the technological field and a cover up for Washington and contractor blunders or is it mostly to keep foreign governments from knowing what they already know?

ENCINO, CALIF. T. R. SLOCUM

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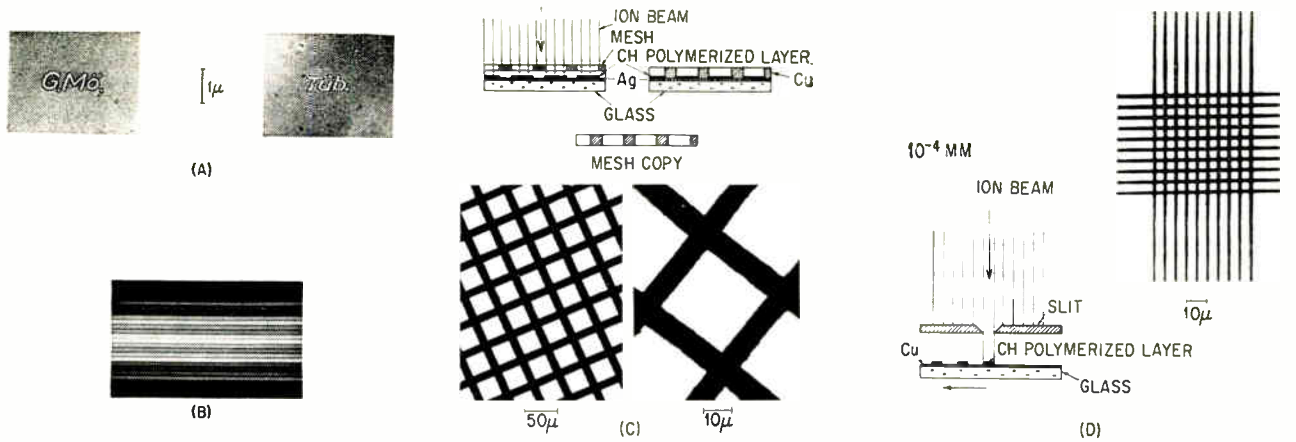

FIG. 4—Letters 0.5μ high recorded with electron-probe microrecorder (A). Electron interference pattern produced by five microslits (B). Method for producing contact copies and examples of fine nets made by copying (C). Production of nets with regulated mesh width (D)

lecular-beam etching for thin film work, direct decomposition to give either an insulating or conducting deposit depending on the type of vapor, and use of electron irradiation instead of visible light for the exposure of photoresist coatings.

Electron-beam cutting of resistive and conductive paths on a ceramic substrate is an example of a process that can now be used for production. However, improvements in instrumentation are needed so that closed-loop control can be applied. It would also be useful to have electron beams of submicron diameters; such beams could be used in a nonthermal manner for high-resolution fabrication. Submicron beams are desirable, not so much for extremely small components or for extremely high packing densities, but so that components of present-day size might be fabricated to closer dimensional tolerances.

In one approach to improving the efficiency of microwave tubes, dense hollow beams of electrons are passed through longitudinally uniform structures.[3] For high-power traveling-wave tubes and other tube types, it is desirable to increase the coupling between the electron beam and the wave sent along the helix configuration. Use of a hollow beam improves the interchange of energy by getting as much of the beam's energy as possible close to the helix. The toroidal electron gun shown in Fig. 3 is one method of generating a hollow beam. Another possible application of hollow electron beams is to weld transistor cans or other parts having circular symmetry; here, a variable-radius high-intensity beam would be used.

The electron beam microprobe analyzer competes with conventional chemical-analysis techniques which must use a sample many times larger.[4] When a specimen is irradiated with a finely focused electron beam, about 1 μ in diameter, an X-ray spectrum is produced which consists principally of characteristic radiations of the elements present. This spectrum is analyzed with an X-ray spectrometer to determine the elements and their respective concentrations. Detectability limit is about 100 parts per million for elements like Cu, Ni and Co in steel. Principal advantage of the electron microbeam probe is ability to analyze an extremely small quantity of material, so its most promising application is in diffusion. Analysis of individual particles in aerosols is another application. Smallest particle detectable is one that would weigh only 10^{-11} gram.

Electron-beam tape-recording techniques are being explored in dozens of laboratories with promising results in information density and speed.[5] Among these techniques are:

(1) Recording directly with electron beams on photographic film in a vacuum with subsequent wet development; this technique is usually confined to electron-microscope work.

(2) Using a thin-window c-r tube to let light from a phosphor directly affect (without lens imaging) a light-sensitive Electrofax tape, thus allowing a dry-image development. R. E. Olden of RCA recently made satisfactory exposure under conditions equivalent to 150,000 characters per sec with no loss of definition of 200 photographic lines per inch. The limit to printing speed is the ability to handle and process Electrofax paper.

(3) Using fine wires in the end of a c-r tube to apply beam charges to Videographic tape for subsequent dry development. Litton Industries' Printopix and A. B. Dick Co.'s Videograph printing use this approach.

(4) Thermoplastic recording, such as the method of W. E. Glenn of G.E. The electron beam writes directly, in a vacuum chamber, on a plastic consisting of a high-melting base film coated with a transparent conductor which has a thin film of thermoplastic on its surface. When the film is heated, the charge pattern laid down by the electron beam causes ripples to form in the thermoplastic and these ripples are frozen in place when the plastic is cooled. Recorded information may be projected on a screen by a modified Schlieren optical system.

(5) Writing, in a vacuum, on untreated plastic and then exposing the invisible beam trace to a slight nucleation deposit of evaporated silver followed by a heavier deposit of evaporated zinc. The metals either prefer or abhor the area acted on by the beam, so a record of the beam path is obtained. This method was briefly examined some

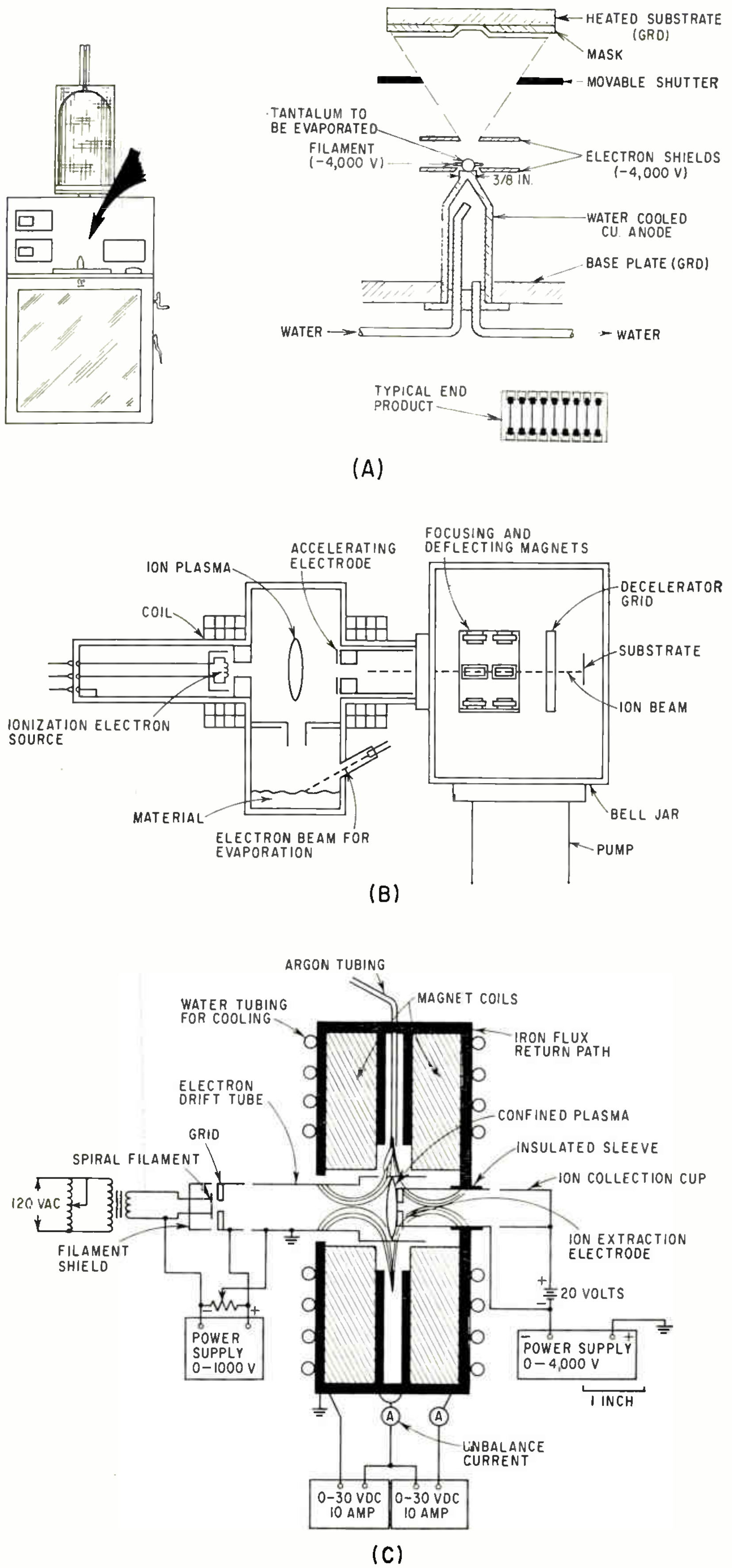

FIG. 5—Electron bombardment evaporator (A). Ion-beam gun (B). In (C), a magnetic bottle is produced by two opposing solenoidal fields, this forming a sharply defined lens-shaped ion plasma

years ago at Bell Telephone Laboratories.

For comparative evaluation of processes, a figure of merit is needed regarding ability to record fine detail. Other considerations might be: the stage reached in development: initial and operational equipment costs; simplicity and practicability; speed not only of recording but of development and read-out; storage capacity per unit area and per unit volume; ease of access to the information; erasibility and correctability of the record; usable life of the record; environmental conditions for storage; the need for special equipment to read the information.

A modified electron microscope and beam-guidance system is advancing microrecording, fabrication of fine gratings for a variety of applications, and production of mesh grids for image orthicons and of microresistors.[9] An electrical or magnetic lens can produce electron beams of about 200 A in diameter. It is difficult to guide these beams and to record them. Recording is difficult because photographic plates are not suitable. Collodion layers of about 500 to 1,000 A are suitable as recording film. Effect of the irradiated charge quantity on collodion foil results in different colors when observations are made through an interference filter, or in different shades of gray in black-and-white reproduction.

With a platinum aperture of 4-μ diameter in the specimen plane, an electron beam was guided along a stencil pattern on the fluorescent screen to write letters of 0.5 μ on collodion foil (Fig. 4A). With this size letter, it would be possible to write the text of the Bible on a fraction of the area of a postage stamp. Recording was effected by a mechanical lateral displacement of the aperture above the objective lens, but in a new instrument the gratings and letters can be produced by magnetic deviation of the beam. The collodion foil can also be used to make contact reproduction by electron, ion, ultraviolet or X-ray beams of a specimen which can be viewed neither in the light nor in the electron microscope.

A polymerized hydrocarbon layer can be deposited on surfaces that are irradiated by ion, electron, ultraviolet or X-rays in a vacuum of 10^{-4} mm Hg. With this deposition effect, it is possible to make self-supporting microslits that are fine enough to use as gratings for multiple-beam interferometry experiments (Fig. 4B).

Fine mesh grids for image orthicons and other electronic applications can be produced or copied by electron beam methods. For contact copies, the original is laid on silvered glass plate and irradiated with ions. A polymerized hydrocarbon layer is formed that has an electrical conductivity much below that of silver. Therefore, precipitation of copper in an electrolytic bath is prevented, permitting distinct contact copper copies of the original grid to be obtained (Fig. 4C).

To produce grids of any desired mesh size, a narrow linear ion beam (Fig. 4D) formed by a fine slit produces a polymerized hydrocarbon strip on an evaporated copper layer on a glass plate. A precision displacement mechanism with interferometrical control can displace and turn the slit. If the copper layer is then treated with gaseous chlorine, copper is transformed to copper chloride at all places not protected by the polymerized layer. When the copper chloride is dissolved in water, only the copper grid remains. The grid is then immersed in an electrolytic copper or nickel bath to thicken it and make possible its removal without destruction. By the same method, it is possible to produce microresistors of copper 1 μ in width, 1,000 A in thickness and 1 mm in length, and with resistance values of 300,000 ohms.

High-accuracy thickness measurement of evaporated silver films can be obtained by electron-absorption measurements in an electron microscope.[7] This method is particularly applicable to detecting the removal of surface layers of electron-transparent thin-film specimens. Removal of one monolayer can be detected. The technique is suitable for any type of thin film of equal thickness over an area of at least 3 sq mm. Capability of the method is very effectively demonstrated by measuring the spattering-yield constant of silver bombarded by argon ions inside the electron microscope.

There are electron-microscope applications to studying the growth and structure of thin films. In epitaxy, quantitative data concerning the removal or growth of additional surface layers is badly needed, as is data regarding a controlled-etching process of thin-film substrates in vacuum. For experiments, an auxiliary appartus is attached to the specimen chamber of the electron microscope, permitting the thin-film specimen to be etched by sputtering or coated by evaporation without being removed from the vacuum.

Experiments substituting evaporation for cathodic sputtering in processing tantalum thin-film components indicated no apparent difference in the capacitors and resistors produced by the two methods.[8]

Work is continuing toward higher power inputs and lower pressures to increase film-production rates at lower background pressures and thereby produce films of higher purity.

Tantalum films have a special advantage for component use due to their refractory nature, ability to form either thermal or anodic oxide films, inertness to chemical attack and unusual electrical properties. Thin-film capacitors, for example, show a high capacitance per unit area (5 microfarads per square cm per rated volt), low leakage currents (about 750 ohm-farads at 1.5 times working voltage), dissipation factors of 1 percent or less, and a dielectric breakdown strength of about 5 $\times$ 10^6 volts per cm.

Most of the work done until recently was based on tantalum deposited by cathodic sputtering—a relatively slow process which requires a moderate gas pressure and is hard to measure and predict accurately. A simple evaporator is seen in Fig. 5A. A commercial coater with 14-in. glass bell jar is used for the vacuum system. The gun is an annular type.

An experimental ion source has been built as the first step in developing a three-dimensional deposited-circuit system using a directed beam of ion (Fig. 5B and 5C).[9] Fabricating microminiaturized circuits by deposition from an ion beam would eliminate the problems encountered in vapor deposition. The high-current (100 ma) ion source is to produce a beam of ions that are focused and deflected magnetically and/or electrostatically and are deposited on a substrate in a prescribed configuration. The system, still in the research stage, would take advantage of the short-range energy, shallow penetration of ions to provide a three-dimensional deposited network. The proposed technique would eliminate most connections and assembly operations, and thereby improve reliability. Layers would be smaller in volume than an equivalent stack of substrates with two-dimensional deposits.

Results thus far indicate that the ion-beam gun deposition system can be completely automated. An ion gun system could fabricate electrical components, protective coatings, produce special alloys and high-purity materials. Possibilities for modifying properties of semiconductors are being explored.

Among the major problems yet to be overcome are efficient containment of the plasma from which the ions are extracted, deflection and focusing techniques, deposition of ions on the substrate in such a way as to prevent sputtering, and beam neutralization before particles strike the substrate.

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Varistor Network Controls

Oscillator has a range of 10 times lowest frequency, with an upper limit of several kilocycles. Output amplitude varies about 10 percent and harmonic distortion is negligible

By MASAMI UNO,
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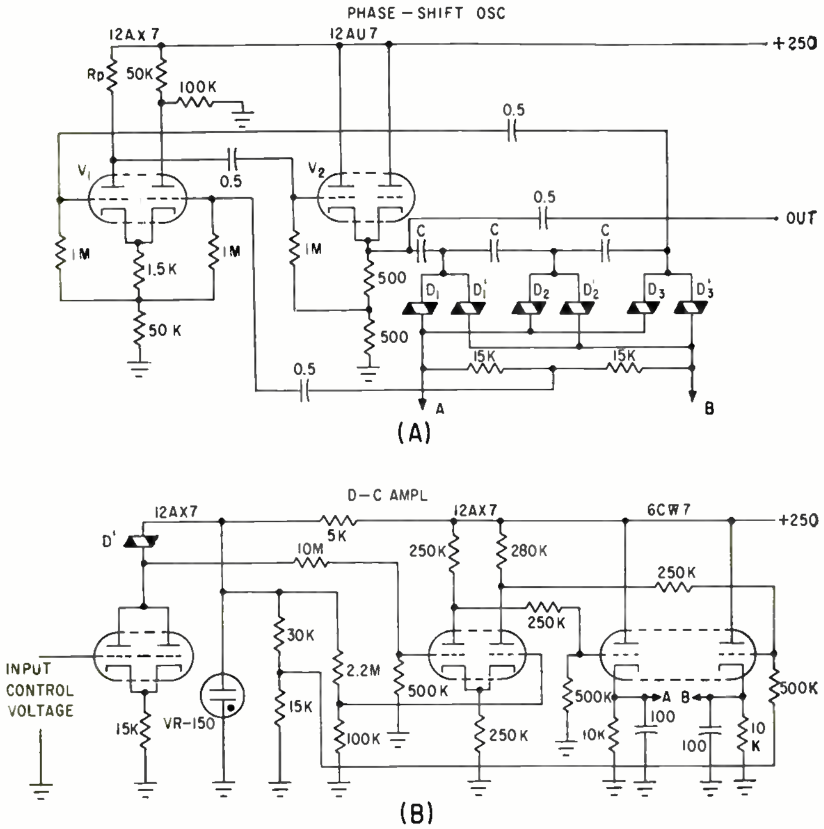


FIG. 1—Phase-shift oscillator (A) uses two varistors for each resistance element in the phase shift circuit. Control voltage amplifier (B) feeds phase-shift circuit at points A and B

THE SMALL SIGNAL resistance of a nonlinear resistor (varistor) varies with the voltage applied to it. Hence, if varistors are used for the phase-shift resistors in a phase-shift oscillator, the frequency can be controlled by the magnitude of the voltage applied to the varistors.

At least two circuits of voltage-tuned oscillators have been published, one by McGaughan[1] and another by the author[2]. The first is a simple circuit having negligible harmonic distortion and less than 5-percent amplitude variation, without using a filter or limiter. The range of linear frequency variation, however, is only three-to-one. A linear variation range of ten times can be obtained with this circuit.

The complete circuit is shown in Fig. 1. The phase-shift circuit is of the parallel resistance type; nonlinear resistors, silicon-carbide (SiC) varistors, are used because of their uniform characteristics. Each resistance component is a set of two SiC varistors of the same characteristic, connected differentially to reduce harmonic distortion.[2, 3] Voltage gain of 29 is obtained by the first-stage differential amplifier and second-stage cathode follower; the latter works as an impedance converter.

The control circuit for the SiC varistors is shown in Fig. 1B. Input control voltage is amplified, then applied to the SiC varistors in the phase-shift circuit, changing their a-c resistance and thus the oscillation frequency.

A triode differential amplifier V_1 is the first stage of the oscillator instead of the usual pentode. One input grid is for a-c amplification and is connected to the output of the phase-shift circuit; the other grid is connected to a centertap across the SiC varistors in the phase-shaft circuit.

Since both grids are at the same d-c potential with respect to ground, regardless of the voltage applied to the varistors, transients in oscillation frequency and output voltage are reduced. Transients are caused by voltage applied to input of the first stage amplifiers when a sweep

Voltage-Tuned Oscillator

voltage controls the oscillator. In the circuit in Fig. 1, the d-c transient voltages impressed on both grids of the differential amplifier are equal, hence transients are suppressed.

The voltage-current characteristic of a SiC varistor can be expressed over a limited range by

$$I = c_1 E^{\alpha} \qquad (1)$$

where E is the impressed voltage, I is the current, and c_1 and α are constants of the varistor.

If two varistors having the same characteristic are connected in series as shown in Fig. 2 and are controlled by voltage E_v, the a-c resistance r seen from terminals A and B is

$$r = \frac{1}{2 c_1 \alpha}\left(\frac{1}{2}\right)^{1-\alpha} E_v \qquad (2)$$

since r is the parallel a-c resistance of two varistors. The configuration reduces harmonic distortion and the two varistors in parallel may be considered as a linear a-c resistor varying approximately with E_v.

If the nonlinear resistor configuration is used for each resistance component in the phase-shift circuit, oscillation frequency is given (from Eq. 2) by

$$f = \frac{c_1 \alpha}{\pi C \sqrt{6}}\left(\frac{1}{2}\right)^{\alpha-1} E_v^{(\alpha-1)} \qquad (3)$$

where C is the capacitance in the phase-shift circuit. Varistors with $\alpha = 2$ are needed when a linear relationship between f and E_v is required. This condition must also be met to eliminate harmonic distortion due to the nonlinearity of the varistors. Harmonic distortion is completely eliminated theoretically, provided the characteristic of the varistors connected differentially are identical.

Since SiC varistors behave as linear resistors in a range of about ten volts, E_v must be 20 volts minimum. And, for linear variation of oscillation ten times the lowest frequency, E_v must vary from 20 to 200 volts. To obtain a wide variation of frequency with a small control voltage, a d-c amplifier is used; its output voltage is used as E_v. However, a d-c amplifier with

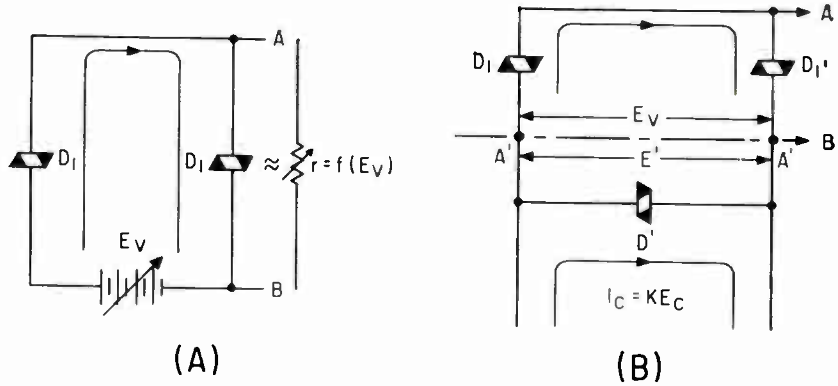


FIG. 2—Two varistors connected differentially (A) approximate a resistor that varies with E_v. Compound control circuit is shown at (B)

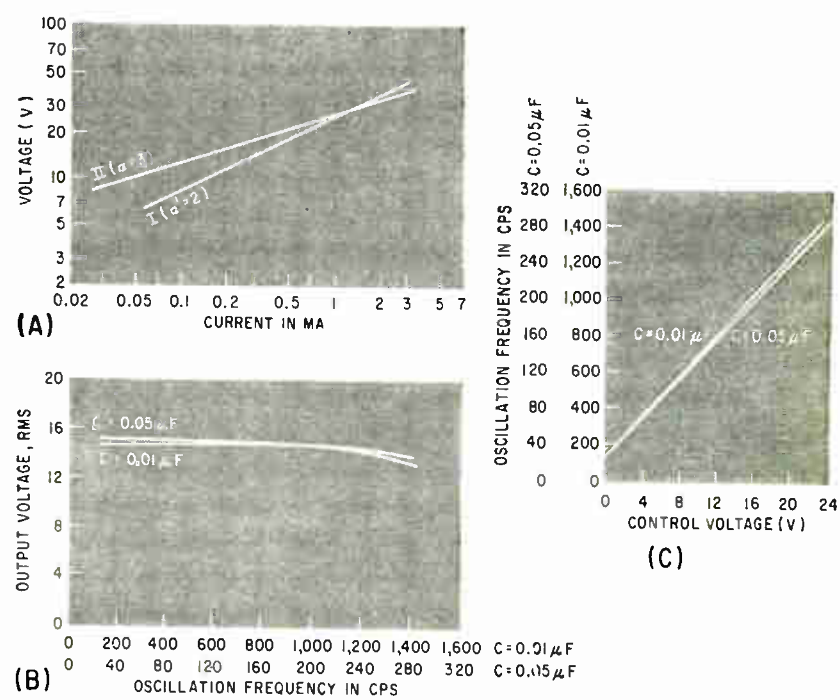


FIG. 3—Characteristics of SiC varistors used in the oscillator (A). Output has a frequency variation of about 10 to 1 (B). Output amplitude varies about 10 percent from maximum (C)

a plate supply voltage of three hundred volts or so could not develop a linear output of two hundred. Thus, for a wide frequency range of linear variation, the condition of $\alpha = 2$ will be inadequate.

A new control circuit of SiC varistors, called a compound control circuit,[3] is used in the voltage-tuned oscillator.

If SiC varistors having α of more than 2 are used, the value of E_v will be smaller but the linearity of frequency will be reduced. By using the compound circuit in Fig. 2B, linearity of frequency can be obtained with SiC varistors having α greater than 2.

In Fig. 2B, the combination of D_1 and D_1' in parallel is a resistance component in the phase-shift circuit; the two in series are controlled by the terminal voltage of another SiC varistor D'. Furthermore, D' is controlled by a current I_c which varies with control voltage E_c, such that $I_c = K\ E_c$, where K is a constant. If the voltage-current characteristic of D' is

$$E' = c_2' I_c^{\beta} \qquad (4)$$

where c_2' and β are constants, then, since E' corresponds to E_v of Eq. 3, oscillation frequency f is obtained from Eq. 3 and 4 as

$$f = \frac{c_1 \alpha}{\pi C \sqrt{6}} \left(\frac{c_2'}{2}\right)^{(\alpha-1)} K^{\beta(\alpha-1)}\, E_c^{\beta(\alpha-1)} \qquad (5)$$

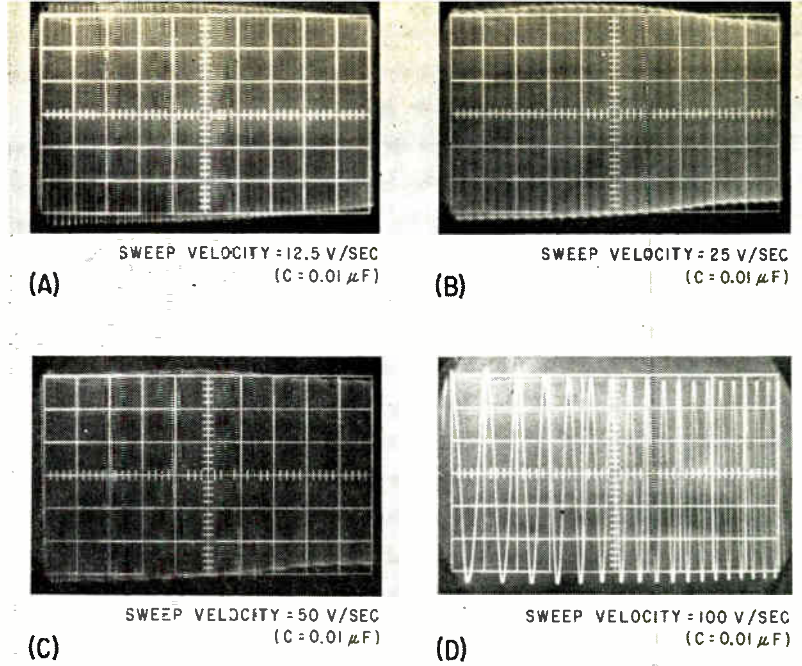


FIG. 5—Output waveforms for sawtooth control signal. Circuit follows

If

$$\beta = \alpha' = 1/(\alpha - 1) \qquad (6)$$

then Eq. 5 becomes

$$f = \frac{c_1 \alpha}{\pi C \sqrt{6}} \left(\frac{c_2'}{2}\right)^{(\alpha-1)} K E_c = k E_c \qquad (7)$$

If the condition for α and α' given by Eq. 6 is satisfied, it is possible to vary oscillation frequency linearly with control voltage, even if α is more then 2. Therefore, the range of E_c for a wide variation of frequency will be small compared to that required when $\alpha = 2$. In the circuit, a d-c amplifier is inserted between points A'-A' of Fig. 2B. An arbitrary SiC varistor can be used for D', subject only to the limitation of Eq. 6. The amplifier does not require a large linear output voltage; the amplifier circuit is shown in Fig. 1B.

The constant current flowing through D' is provided by a current feedback triode amplifier, the first stage of the control circuit in Fig. 1B. The voltage change in D', caused by the input control voltage, is applied through the midstage amplifier to the final stage differential cathode follower, to which the varistors of the phase-shift circuit are connected.

The gain of the amplifier must be selected so that the percentage of variation in voltage across D' will be the same as that applied to D_1 and D' in series. Hence, if A is the required voltage gain (considering the reduction of gain in the divider resistors at the input and output of the amplifier), and E_o' and E_{co}, the voltages across D' and that applied to D_1 and D_1' in series respectively, when the control voltage is zero, A is given by

$$A \cdot \frac{E_o'}{E_{co}} = 1 \qquad (8)$$

The control voltage E_{cn} required for the range of oscillation frequency n times the lowest is given by

$$E_{cn} = (n - 1)\, E_B'\, \mu \qquad (9)$$

where μ and E_B' are the amplifica-

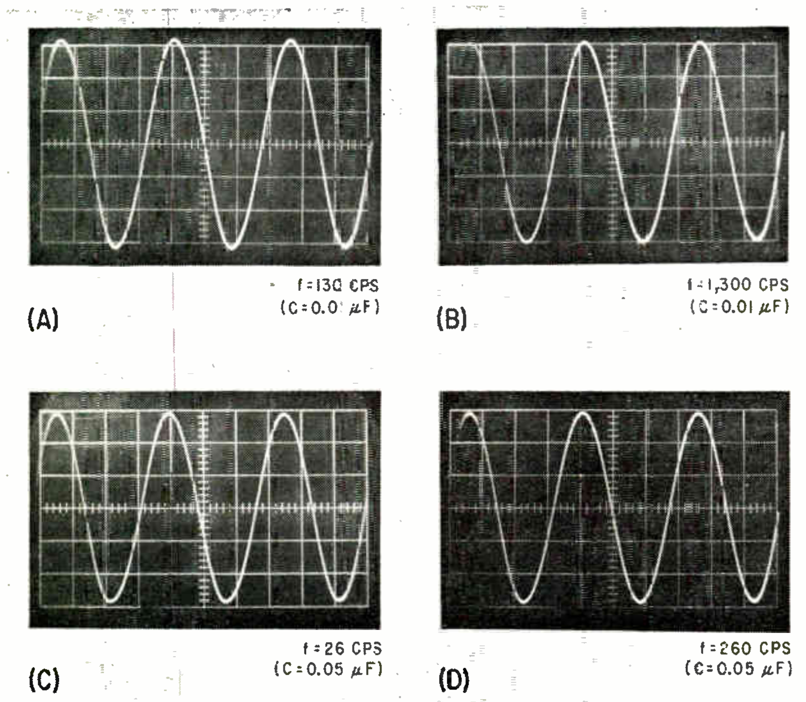
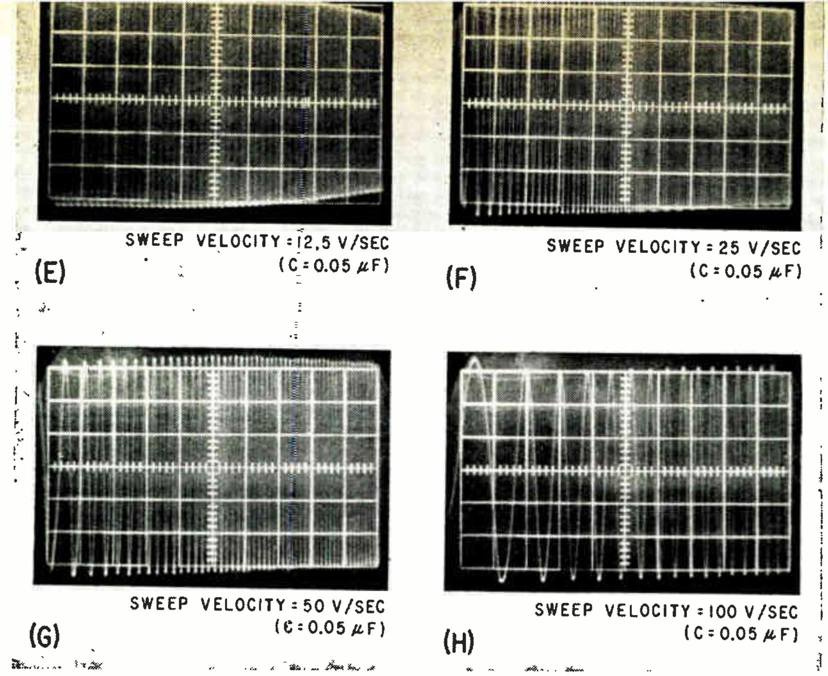


FIG. 4—Output waveforms for constant control signal



control voltage up to about 5 sweeps per sec (100v per sec)

tion factor and plate supply voltage of the constant current valve respectively.

The a-c resistance of SiC varistors varies with ambient temperature, and the oscillation frequency will vary accordingly. When the compound control circuit is used, oscillation frequency will vary with temperature because one source of variation with temperature is the change in a-c resistance of the varistors in the phase-shift circuit; the other is variation of voltage across D', which causes a variation in the output of the d-c amplifier.

The temperature coefficient of frequency, $df/dt \cdot 1/f$, is obtained by differentiating Eq. 3 with respect to temperature t.

Assuming c_1 and E_r are functions of t

$$\frac{df}{dt}\cdot\frac{1}{f} = \tau + (\alpha - 1)\,\frac{\partial E_r}{\partial t}\cdot\frac{1}{E_r} \qquad (10)$$

In Eq. 10 $\tau \equiv \partial c_1/\partial t \cdot 1/c_1$ and is the temperature coefficient of c_1. The temperature coefficient of E_r in the second term is expressed as

$$\frac{\partial E_r}{\partial t}\cdot\frac{1}{E_r} = -\beta A\,\frac{E'}{E_r}\,\tau' \qquad (11)$$

where τ' is the temperature coefficient of c_1', the conductance of D'. Considering $\beta\ (\alpha - 1) = 1$ and $A \cdot E'/E_r = 1$, which are the conditions for compound control, the temperature coefficient of frequency becomes, from Eq. 10 and 11

$$\frac{df}{dt}\cdot\frac{1}{f} = \tau - \tau' \qquad (12)$$

The a-c resistance variation with temperature of D' and the SiC varistors in the phase-shift circuit act in opposite ways to reduce the temperature coefficient of frequency. The coefficient will be reduced to zero provided that SiC varistors with equal temperature coefficients of conductance are used. This is difficult in practice but the temperature effect on oscillation frequency is smaller than both τ and τ', and is of the order of 10^{-3} or less.

In Fig. 3A the voltage-current characteristics of the varistors are shown. Curve I shows the characteristic of the varistor used for D', which has an α' of 2. Curve II shows the average characteristic of the six varistors used in the phase-shift circuit, which have α of 3.

The variation of frequency with control voltage is shown in Fig. 3B, where curve I is for C = 0.01 μf and curve II is for C = 0.05 μf. A linear variation ten times the lowest frequency is easily obtained in each band with a control voltage of about twenty volts. The variations of output voltage are shown in Fig. 3C. In each case the amplitude change from maximum is less than 10 percent over the frequency range. Figure 4 shows output waveforms, which are all very nearly sinusoidal.

The photographs in Fig. 5 show the variations in amplitude and frequency when the oscillator is swept by a control voltage that increases linearly with time from zero to a maximum of about 22 volts. For a sweep velocity less than 50 v per sec, amplitude variation is similar to that shown in Fig. 3C. At a sweep velocity of 100 v per sec, neither frequency nor amplitude follow.

The temperature coefficient of frequency variation was from -1.9×10^{-3} to -1.7×10^{-3}, at temperatures from 20 to 65 C, while that calculated from Eq. 11 is from -0.8×10^{-3} to -0.73×10^{-3}, using measured values of τ and τ' from 7.9×10^{-3} to 6.3×10^{-3} and from 8.9×10^{-3} to 7.1×10^{-3}.

The performance of the voltage tuned oscillator in summary:

(1) Linear oscillation frequency range of ten times for a control voltage change of about 20; variation of amplitude over the range is about 10 percent.

(2) Harmonic distortion is negligible over the range.

(3) Oscillation follows sweep control vontage changes of less than 50 v per second.

(4) Temperature coefficient of oscillation frequency is less than a few parts per thousand.

(5) Frequency and amplitude stabilities for changes in cathode and plate supply voltage of 5 percent are 2 and 10 percent respectively.

Although oscillation frequency is limited to from 26 cps to 1300 cps in the circuit shown, it may be extended higher or lower by changing C. However, the upper frequency is limited to several Kc because the small C required for high frequency reduces the frequency stability because of stray capacity; also, the capacitance of SiC varistors used is about 300 pf, based on a dielectric constant of 200. This capacitance can be important at 10 Kc, since the lowest a-c resistance of the varistors is about 3,500 ohms.

The author is grateful to Dr. Z. Abe and Mr. S. Chiba of Hitachi Lab. for many suggestions.

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Tunnel-Diode Fast-Step Generator

For tests of wideband systems, this tunnel-diode step generator provides steps that are fast and that are free from overshoot

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DYNAMIC RESPONSE of a wideband system is commonly and conveniently specified in terms of the output waveform (10 to 90 percent rise time, and percent overshoot and undershoot) resulting from a step input. When speed characteristics of a system are specified in terms of step response, the input step should be free of overshoot and should make its step transition at least twice as fast as the output step.

One type of reliable step generator is the mercury-wetted relay. However, this device has serious drawbacks: steps can be generated only at relatively low repetition rates of a few hundred per second; and the relay cannot be triggered with a value of jitter that would be low enough to be compatible with its rise time.

The step generator described here does not have these limitations. It was developed for testing a Hewlett-Packard 185A/187B sampling oscilloscope with a rise time of 0.5 nanosecond and bandwidth of 800 Mc. However, it is useful with systems of rise times up to 35 nanoseconds or 10 Mc bandwidth. The unit (Hewlett-Packard model 213A) can deliver positive and negative 400-mv steps of approximately 0.25 nanosecond rise time into a 50-ohm system. It can be triggered with ½ volt signals to produce steps at repetition rates of 0 to 100 Kc, or it can free run at about 100 Kc.

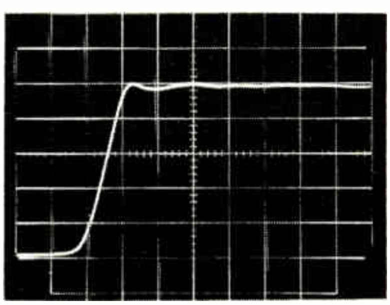
The step generator does not generate an actual step, since that may be done but once, but rather a pulse about 2 microseconds long. The pulse is flat within 1 percent for 100 nanoseconds following the ¼ nanosecond rise time. Step testing is limited to this portion of the pulse. This rise time and flat duration cover frequency domain effects from about 800 Mc to 10 Mc. The spectrum can be filled in practically down to d-c, if necessary, with a 20-nanosecond rise-time low-frequency square-wave generator.

The basic generator (Fig. 1A) consists of an RCA 1N3130 50-ma germanium tunnel diode switching into a 50-ohm load. To minimize connection inductance, the tunnel diode is mounted between conductors within the hollowed end of the output 50-ohm coaxial connector. Bias is supplied to the tunnel diode from a low impedance voltage source through an inductance. This arrangement makes the circuit d-c stable at just one point to take care of the tunnel diode reset problem. A resistor in series with the trigger signal supplies a current trigger.

Referring to Fig. 1B and 1C the voltage bias provides a trigger sensitivity control and is adjusted to a point *A*, just short of V_p. Application of the trigger increases the current to I_p at point *B* which is unstable so a rapid transition to quasistable point *C* occurs. During this time, in effect, the 10-μh inductor and trigger supply a constant current I_p to the tunnel diode and load. The load and tunnel diode conduction action will not accept all this current and the excess represented by the separation between the load line and the diode characteristic flows into the diode capacitance. This rate of charging the diode capacitance determines the rate of transition from *B* to *C*, which is the rise time of the step. This is an accelerating process due to the negative resistance characteristic up to the valley voltage V_v, then decelerating to point *C*. The 1N3130 specification states that the rise time switching with a constant current bias typically is 0.2 nanosecond and maximally 0.5 nanosecond. An approximate relation for tunnel diode 10 to 90 percent rise time reported to be in good agreement with measured results for slower diodes is $t_r = (V_f - V_p)\,C/(I_p - I_v)$ second, where *C* is the diode capacitance.

Typical values for the 1N3130 in this relation give $t_r = 0.15$ nanosecond and the most unfavorable give $t_r = 0.3$ nanosecond. Switching into a 50-ohm load approaches this constant current mode as the load line is nearly horizontal. The combined rise times of the generator and 185A/187B sampling oscilloscope observed on the oscilloscope display is typically 0.5 nanosecond. The oscilloscope's measured bandwidth is 800 Mc which corresponds to a rise time of 0.44 nanosecond. Using the relationship $T_r\,(\text{total}) = \sqrt{T_{r\,gen}^2 + T_{r\,scope}^2}$, the generator rise time works out to be about 0.24 nanosecond. Step amplitude is about 400 mv, the voltage distance between points *B* and *C*.

At point *C* the current starts to decrease slowly toward *D* at a rate determined by the 10-μh inductance. This rate of current change through the tunnel-diode incremental resistance determines the slope at the top of the step following the rise. The slope is less than 1 percent in 100 nanoseconds. The total time for the current to fall to *D* is about 2 microseconds. Point *D* is unstable and there is a rapid transition to quasi-stable point *E*. During this transition the inductor supplies a constant current I_v, which is considerably less than the load and



Oscillogram of fast step produced by tunnel diode step generator. Display is on sampling oscilloscope; vertical scale, 100 mv/cm; horizontal scale, 0.5 nsec/cm

Produces Positive or Negative Steps

tunnel-diode conduction action require. This deficiency of current, represented by the separation between the tunnel-diode characteristic and the load line, is supplied from the diode capacitance. This rate of discharge determines the time of transit from D to E (about 1 nanosecond). From point E the current increases slowly toward point A; again the rate is determined by the inductor. At point A the circuit is again at steady state and ready for another trigger. Since the whole sequence requires about 8 microseconds, the maximum repetition rate is about 100 Kc.

If the voltage bias is increased from point A to point B, or slightly beyond, the generator will free run as a relaxation oscillator at a repetition rate between 100 Kc and 200 Kc. The voltage bias supply must have an output resistance, R_o, less than a certain value to allow the circuit to free run and be triggered with maximum sensitivity. The requirement is that with the voltage bias adjusted to point B. the voltage bias load line must not intersect the diode characteristic at any other point. For the 1N3130 this resistance is about 5 ohms. Figure 1D illustrates what happens if this value is exceeded. After one triggering the operating point does not return to B but stops at X which is also a stable d-c point, and the diode cannot be triggered again. If the bias voltage is reduced to permit resetting, a large current, the vertical distance between Y and B, is required to trigger.

The basic generator produces only a positive step output. Figure 2 shows the circuit of the 213A generator, where two tunnel diodes back-to-back permit the generation of both step polarities at a single output. These diodes are mounted inside the output connector. Tunnel diode conductance is so high in the reverse direction that the characteristic of a back-to-back pair is only slightly different from the forward characteristic of a single tunnel diode. Output polarity switch S_2 provides a positive bias and trigger to tunnel diode D_3 to generate a positive step, and inverts the bias and trigger to negative for diode D_4 to generate a negative step. A 2N383 emitter follower provides the low output impedance required of the voltage bias source. The power supply is floating to permit bias reversal. Switch S_1 and transformer T_1 permit triggering on either polarity. Diodes D_1 and D_2 and the 200 ohm resistors limit trigger currents to 5 ma to prevent large triggers from influencing the step wave form.

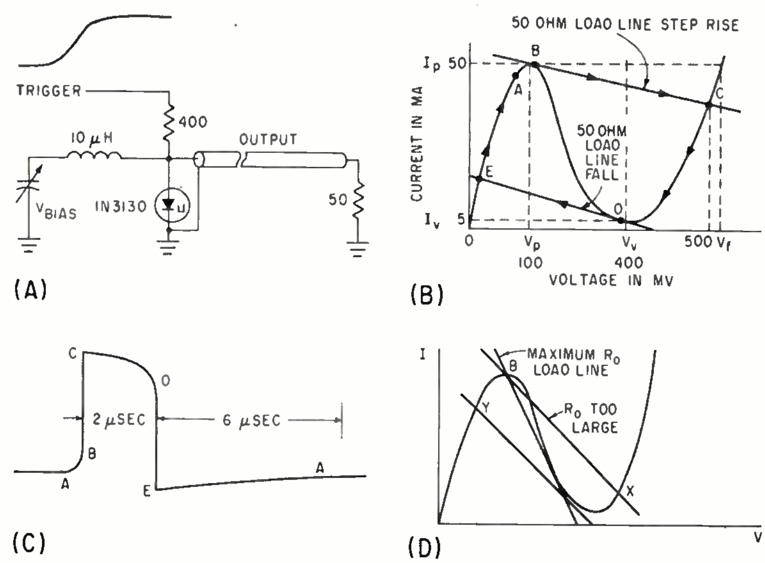


FIG. 1—Basic circuit of step generator (A); tunnel diode characteristic with operating path superimposed (B); output waveform of generator (C); and illustration of how bias supply output resistance determines triggering characteristics (D)

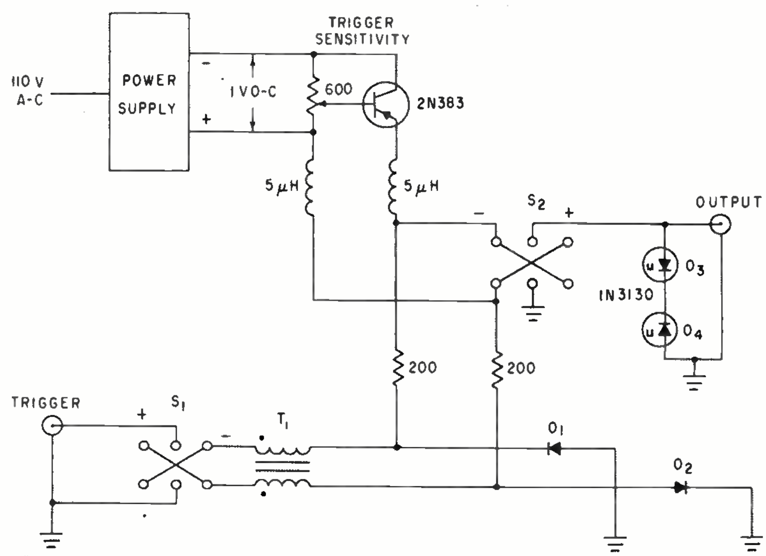


FIG. 2—Final circuit of fast step generator which produces either positive or negative steps at single output

Acknowledgment is due Victor Van Duzer who saw the application of the tunnel diode as a step generator, and demonstrated it with the basic circuit.

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Physically Short High-Power Balun

This continuously variable impedance transformation has a physical length as short as λ/30. It has operated at 5 Mw peak power over a frequency range of 10 megacycles to 30 megacycles. Complete design details are given

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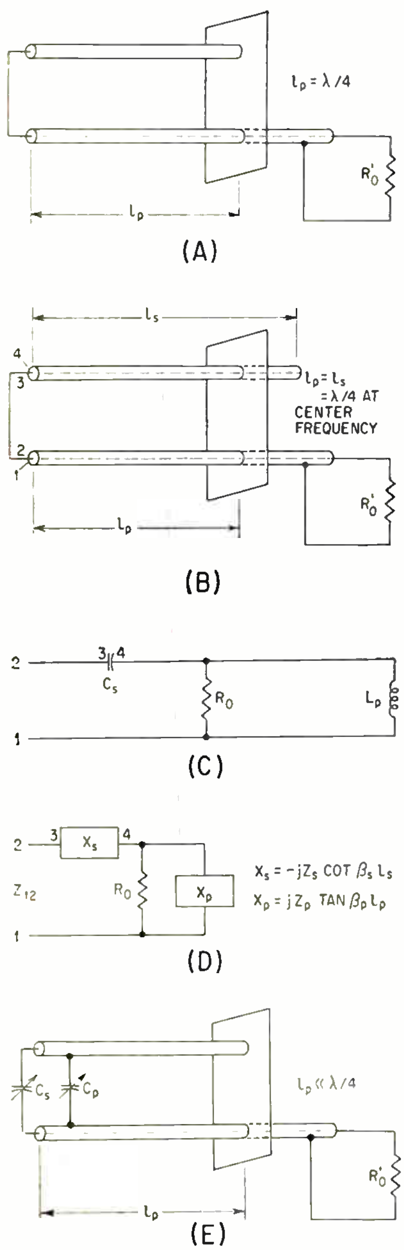


FIG. 1—Simple coaxial line balun (A) is usually λ/4 long. Broad band balun (B), lumped constant equivalent (C), alternate equivalent (D) and final design (E)

BALUN is an abbreviation of balance-to-unbalance transformer[1] and it includes any r-f device requiring a transformation from a balanced voltage to one unbalanced to ground. One example is a dipole antenna connecting to a coaxial line. Another would be a push-pull amplifier driving a coaxial transmission line. The latter example puts a more exacting demand on a balun, as vswr's of more than 1.2 to 1 may create excessive changes in the plate load impedance of the amplifier as it is tuned over its frequency range. The amplifier would then have to have some system that would both resonate the tube output capacitance and provide impedance transformation. This usually requires two sets of pi-networks with six tunable elements to maintain the desirable plate load and circuit Q. The balun described provides tuning and matching functions with two controls over a wide frequency range. It could also be used to resonate tube output capacitance, and it will also permit matching an improperly terminated coaxial line. With proper design Q can be maintained nearly constant in value.

There are many types of baluns appearing in various physical configurations. One type suitable for many applications is constructed from coaxial transmission line and is a quarter wavelength long at the design center frequency[2]. Figure 1A illustrates the device. The outer shield has been removed. This balun has limited broadband performance and has a fixed impedance transformation, being a one-to-one impedance transformer. With 50-ohm coaxial line it will transform fifty ohms unbalanced to a fifty-ohm balanced load.

The performance of this balun may be improved by adding a series compensating reactance as shown in Fig. 1B[3,4]. The broadband properties of the balun may be enhanced by using a tuned inner line section. Starting from terminals 1 and 2 of Fig. 1B the following impedance is seen

$$Z_{12} = -jZ_s \cot \beta_s l_s + j \frac{R_o Z_p \tan \beta_p l_p}{R_o + jZ_p \tan \beta_p l_p}$$

where R_o is the balanced impedance across terminals 1 and 4, Z_s is the characteristic impedance of the upper coaxial line, inner to outer conductors and Z_p is the characteristic impedance between outer coaxial line conductors.

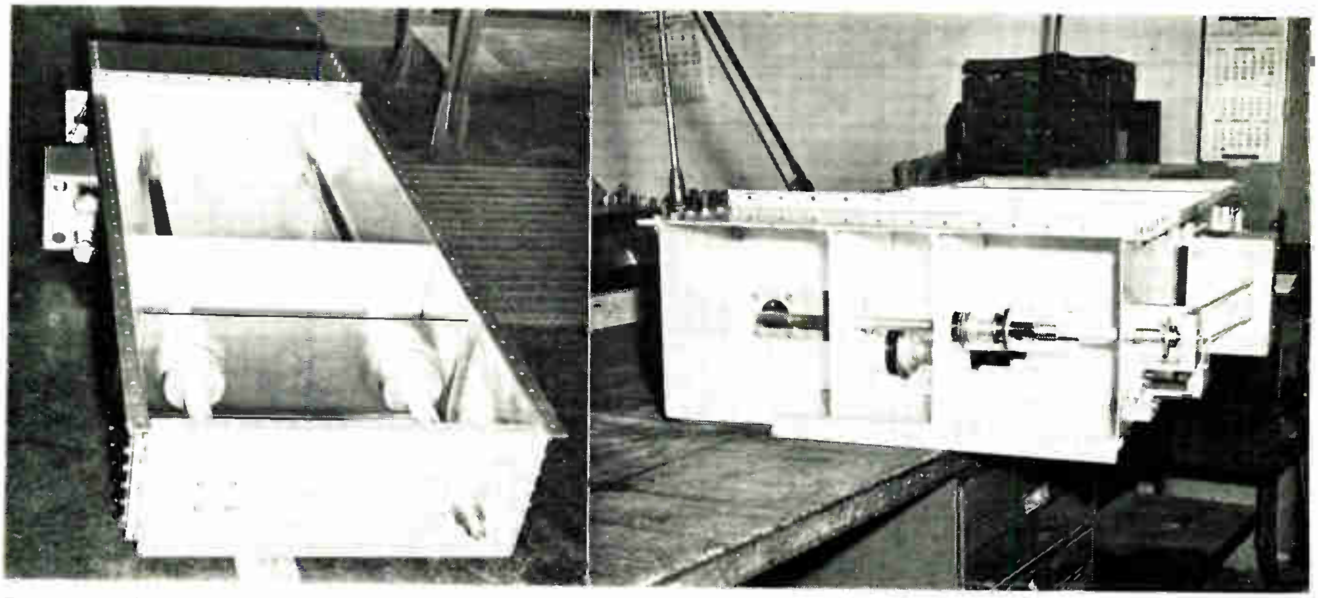
The device may be represented by the lumped-constant equivalent circuit shown in Fig. 1C.

Here C_s represents the equivalent capacitance of the open-circuited line section between terminals 3 and 4, and L_s represents the equivalent inductance of the short-circuited 2-wire section between terminals 1 and 4.

Note that C_s and L_p are variable with frequency because of the reactance properties of transmission lines at high frequencies. Alternate representation is shown in Fig. 1D, where the reactive variation with frequency is now specified.

At the design center frequency of this Roberts balun, $X_p = \infty$ and $X_s = 0$. It must be λ/4 long at this frequency. On the upper side of this frequency, X_p is some value of capacitive reactance and X_s is some value of inductive reactance. The result is an input impedance that is resistive, but will deviate from R_o in value. At frequencies below the design center, X_s is capacitive,

Is Continuously Variable



Prototype of variable-transformation balun. Input is shown at left and vacuum-capacitor output end shown on right

X_p is inductive and Z tends to be resistive. This produces broadbanding and a more nearly pure resistive transformation than given by the balun of Fig. 1A. The Robert's balun is a one-to-one impedance transformer.

The balun described uses these concepts in a different approach, resulting in a device that will give exact impedance matches by adjusting C_s and L_p to present the desired X_s and X_p for a given frequency.

The required conditions for an exact transformation with unity power factor are started by solving for the unbalanced input impedance Z_{12} in Fig. 1D.

$$Z_{12} = jX_s + [R_a (jX_p)] / [R_a + jX_p]$$
$$= jX_s + [X_p^2 R_a + jX_p (R_a)^2] / [R_a^2 + X_p^2]$$
$$= X_p^2 R_a / (R_a^2 + X_p^2) + jX_p R_a^2 / (R_a^2 + X_p^2)$$

The network transforms balanced impedance R_a to

$$R_a' = \frac{(X_p)^2 R_a}{(R_a)^2 + (X_p)^2}$$

For unity power factor

$$X_s = \frac{-X_p (R_a)^2}{(R_a)^2 + (X_p)^2}$$

For the above conditions, the value of unbalanced impedance R_a' is a function of X_p for a given R_a. The value of X_s is also determined by X_p.

Should the balun be terminated on the unbalanced side and the value of balanced impedance required, the conditions for an exact transformation are

$$R_a = \frac{(R_a')^2 + (X_s)^2}{R_a'}$$

$$X_p = \frac{(R_a')^2 + (X_s)^2}{X_s}$$

Different physical forms are taken by X_s and X_p. One approach is to construct a device similar to that of Fig. 1B but consider the line lengths l_s and l_p as variable.

A variable length of open-circuited transmission line l_s, presents a reactance of $-jZ_s \cot \beta l_s$ between terminals 3 and 4 where Z_s is the characteristic impedance of line l_s between inner and outer conductor, and $-jX_s = -jZ_s \cot \beta l_s$.

The two outer conductors of the coaxial lines have a reactance at terminals 1 and 4 of $jX_p = jZ_p \tan \beta l_p$ where Z_p is the characteristic impedance between outer conductors of the coaxial lines.

Line lengths l_s and l_p are adjusted to satisfy the expressions given above. Transformations of impedance up to 20 to 1 have been achieved.

To use this device at low vhf frequencies and simultaneously keep physical dimensions small, portions of transmission line are replaced with variable lumped capacitors as shown in Fig. 1E.

Here, $-jX_s = -j\,1/\omega C_s$ where ω = angular frequency and

$$jX_p = \frac{jZ_p \tan \beta l_p (-j\,1/\omega C_p)}{jZ_p \tan \beta l_p - j\,1/\omega C_p}$$

where $\beta = 2\pi/\lambda$

The general reactances X_s and X_p are replaced by the specific circuit reactances of Fig. 1E.

This configuration has some advantages over the previous configuration $-l_p$ can be made less than $\lambda/30$, and still give excellent matching characteristics with good balance and C_s and C_p can be vacuum-variable capacitors that are capable of wide ranges of capacitance. Along with compactness, this configuration eliminates the need for sliding contacts. The adjustments will be the settings of C_s and C_p. The main limitation on the length of the balun l_p is the matter of Q and its effects on bandwidth An operating Q will be defined as reactive volt-ampere storage/power

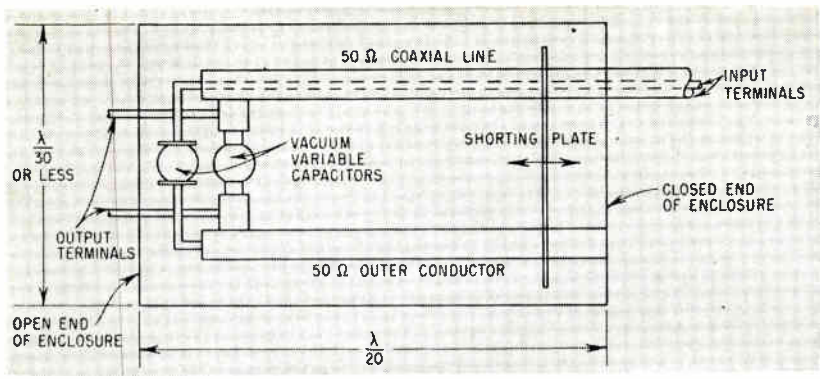


FIG. 2—Final layout of balun showing some construction details

dissipated in R_o' neglecting capacitive line storage.

For the above device this becomes

$$Q_{op} = \frac{1}{R_o'}\left[\frac{1}{\omega C_s} + \frac{(R_o')^2 + 1/\omega^2 C_s^2}{1/\omega C_p}\right]$$

$$= \frac{f}{\Delta f}$$

If C_p is small, Q will be nearly constant with frequency as $1/\omega C_s = X_s$ always has the same value when a given impedance transformation is desired. Usually Q will be low even when C_p is not small.

As an example of the degree of foreshortening of the line l_p and its effect on Q, transform fifty ohms unbalanced to one hundred ohms balanced at 20 Mc with a Q of 2. Substituting

$$100 = \frac{(R_o')^2 + (X_s)^2}{R_o'} = \frac{(50)^2 + (X_s)^2}{50} = R_o$$

$$X_s = 50 \text{ ohms}$$

$$X_p = \frac{(R_o')^2 + (X_s)^2}{X_s} = \frac{(50)^2 + (50)^2}{50}$$

$$= 100 \text{ ohms}$$

$$Q = \frac{1}{50}\left[50 + \frac{(50)^2 + (50)^2}{1/\omega C_p}\right] = 2$$

thus $1/\omega C_p = 100$ ohms. Choose Z_p arbitrarily as 200 ohms. A length of 0.58 meters for l_p will give 50 for the reactance of the two conductor line. This will be magnified by the parallel $1/\omega C_p$ to give 100 ohms for X_p.

It should now be possible to have a balun with an ideal impedance transformation of 2 to 1 less than 2 feet long and with a Q of 2 at 20 Mc. The Roberts balun would have to be nearly 4 meters long at this frequency. The balun is now reduced in length by over 6 to 1 and a fair bandwidth is still obtained. Impedance may be transformed continuously to 50 ohms balanced by adjusting C_p and C_s, without exceeding a Q of 4. The length is not too short in terms of power handling capability and voltage breakdown. A Q of 2 would dictate a bandwidth of 10 Mc. If a broadband match is desired, note that for a bandwidth of 5 Mc the vswr will not exceed 1.08/1. A balun constructed similar to the above unit has performed at peak power levels of 6.5 megawatts and average powers of 120 kilowatts. Figure 2 shows typical construction details.

A full-scale balun was constructed from nine-inch coaxial transmission line. A variable position shorting plate was included to permit variation of l_p. Lumped capacitor elements were used. With a fixed shorting plate set at a length of three feet, a balanced load of 120 ohms was transformed to an exact 53 ohms over the 10 to 30 Mc range. Figure 3A shows a comparison of calculated and experimental results for a balun with 140-ohm balanced load with vacuum-variable capacitors and a fixed 35-in length (l_p). Since C_s determines the impedance transformation, C_p is not shown. The match is exact and the performance of the balun can be predicted with reasonable accuracy. Another balun was constructed from smaller coaxial line and transformed 600-ohm load to 50-ohms unbalanced. Both were capable of handling the full power capability of the coaxial lines from which they were constructed.

Figure 3B shows high-power balun design parameters.

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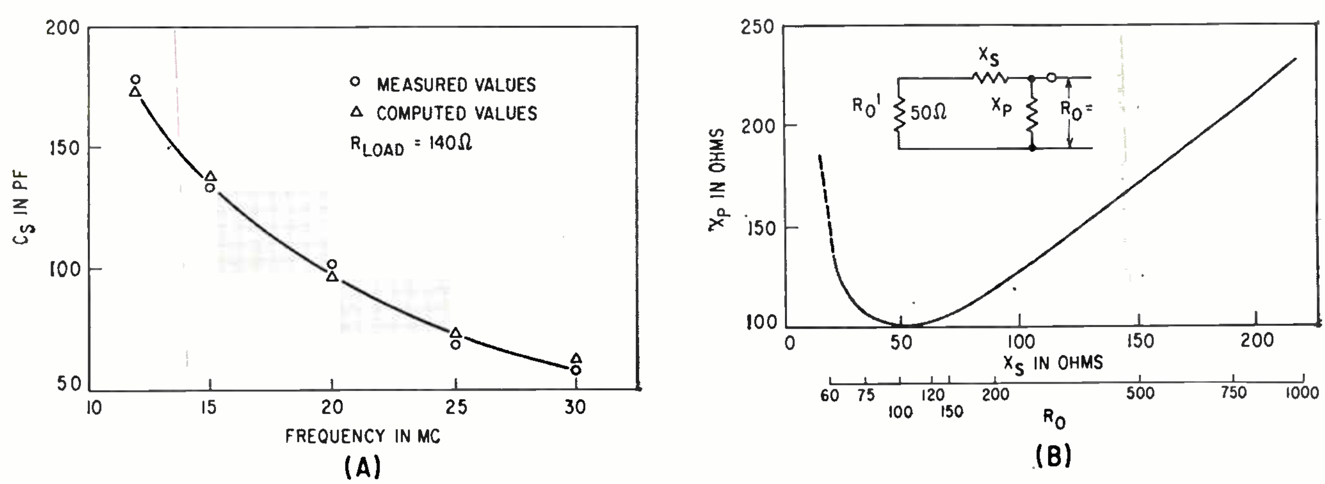

FIG. 3—Balun performance figures (A) and design parameters for high-power balun (B)

Automatic Servo-Driven Bridge Measures Analog Voltage Ratios

Uses servo system to drive balancing arrangement; maintains 0.002 percent accuracy despite quadrature components in voltage being measured

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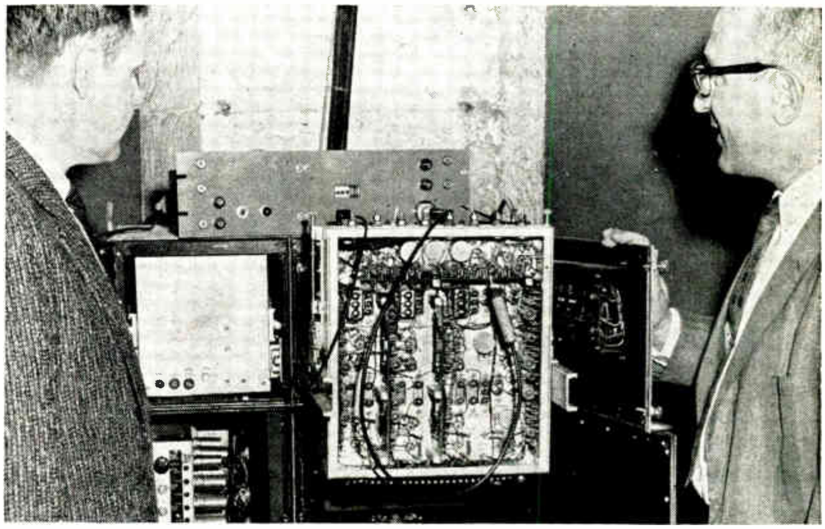

Authors demonstrate high-accuracy automatic bridge used to measure ratios of analog voltages in an analog computer

THIS AUTOMATIC ratio bridge measures the ratio of analog voltages in a 400-cycle analog computer. The bridge provides readings, accurate and repeatable to 0.002 percent, that can be made easily and rapidly by untrained operators. The maximum slewing time to cover its entire range is 30 seconds. The main difficulty in accurate performance is measuring voltages having an appreciable quadrature component.

One method of measuring voltage ratio is to use a circuit similar to that of Fig. 1A.

While the circuit is straightforward, it is difficult to increase its resolution capabilities. If the decade divider has high-resolution, and this capability is to be fully used, extraneous noise in the computer must be prevented from masking the true signal. The noises that interfere with the null balance are quadrature voltages, harmonics and other residual fluctuations in the computer. These voltages, while small in comparison with the signal voltage, can be high enough to interfere with accurate balance.

With a base computation voltage of 35 volts and a resolution capability of 0.001 percent, the null detector circuit should be capable of detecting a voltage of 350 microvolts. Noise voltages of this magnitude will tend to mask the null and obscure a precision adjustment. A phase shift of one hundred thousandth of a radian at 35 volts will give a quadrative component of this magnitude and, with an uncorrelated type of null detector, will mask the true null adjustment.

In minimizing the masking effects, the computer should have a base computation voltage with low harmonic distortion and noise, and the phase shift of all components used in the computer should be minimized. It is, however, virtually impossible to achieve zero phase shift at all settings for components such as potentiometers, resolvers and tachometers; therefore, the operator must determine a true null in the presence of noise and quadrature components.

A block diagram of the automatic ratio bridge is shown in Fig. 1B. The main components of the system are the nulling transformer, transistor preamplifier, phase-sensitive detector (chopper demodulator and modulator), high-gain, transistorized servo amplifier, servo motor, and a high-resolution rotary auto-transformer with counter. Measurements indicated that a voltage of approximately 7 volts at the control phase of the servo motor was necessary to overcome the stiction in the output shaft. For a resolution capability of 0.001 percent and a base voltage of 35 volts, it is necessary that 7 volts at the control phase of the motor be produced for an unbalance voltage of 350 microvolts. This indicates a gain requirement of 20,000 times. Since the input transformer has a step-up ratio of 1:4, gain of the servo amplifier and its output transformer should be 5,000.

The main features of the automatic ratio bridge are the phase sensitive detector, rotary auto-transformer with direct indicator, and the servo system for automatic

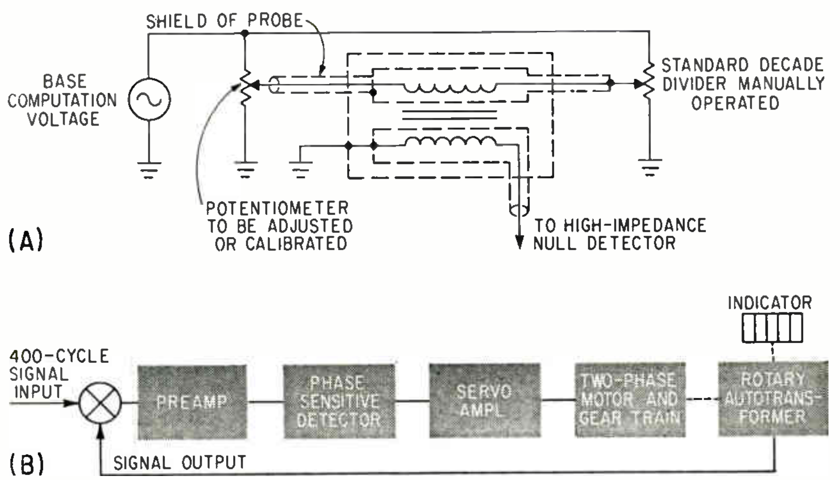

FIG. 1—*Conventional bridge circuit for measuring voltage ratio (A); block diagram of automatic bridge (B)*

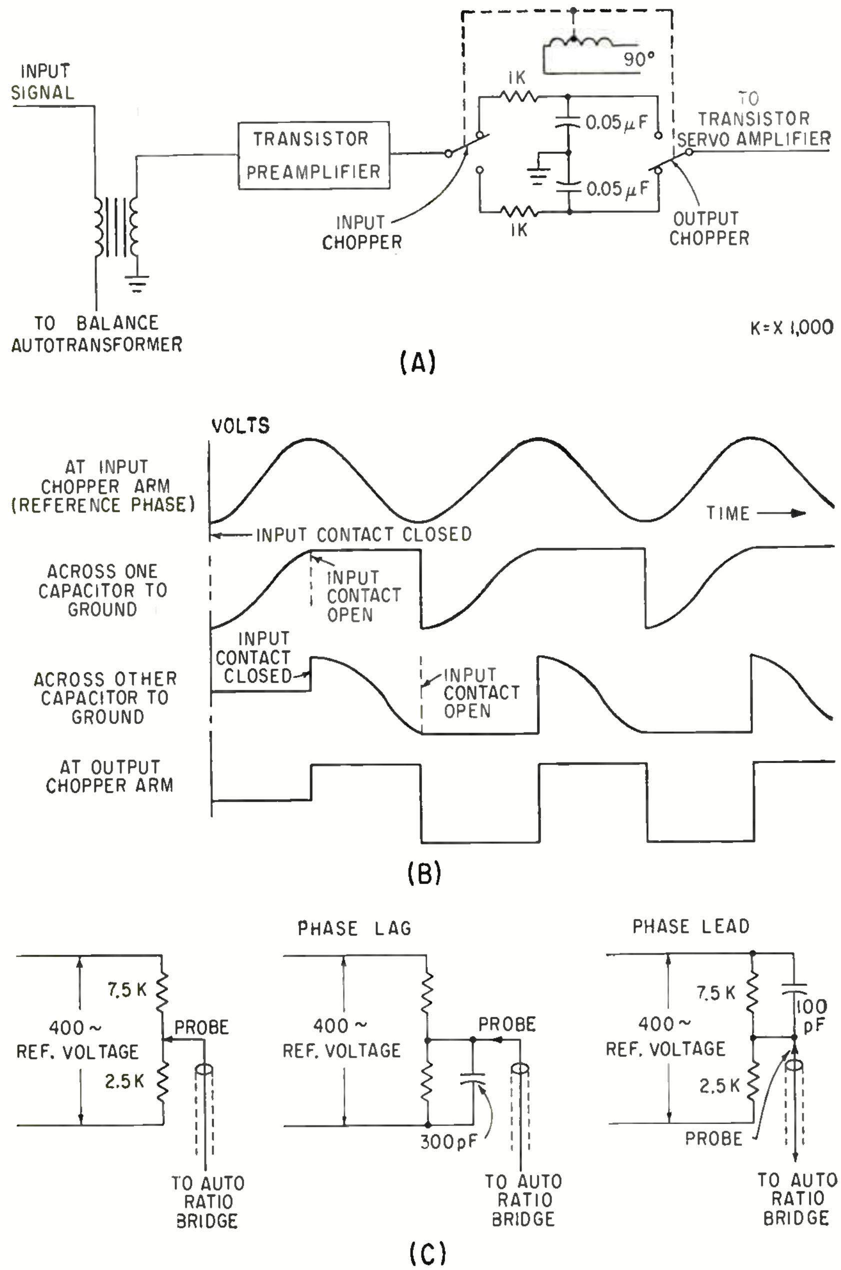

FIG. 2—*Short-time-contant demodulator and modulator circuit (A); waveforms of short-time-constant filter, showing in-phase reference signal (B); networks for checking quadrature rejection (C)*

nulling. The standard decade divider of Fig. 1A, which is manually operated, is replaced by the motor-driven rotary autotransformer having a resolution of 0.0005 percent. The high-impedance null detector in Fig. 1A is now the input preamplifier of the servo system of Fig. 1B. In Fig. 1B the 400-cycle signal input comes from the potentiometer or booster amplifier to be adjusted and the symbolic differential represents the transformer circuit of Fig. 1A. The overall system of Fig. 1B provides a highly sensitive, fast response, automatic nulling system of high accuracy which minimizes operator fatigue in checking out analog computer adjustments.

Quadrature rejection is important in the servo-system design since voltages several times higher than the 350-microvolt maximum sensitivity voltage will saturate the amplifier. If quadrature voltages exist at the null point, the high-resolution capability is lost. One method, using choppers for removing the quadrature component, is shown in Fig. 2. An investigation was made of the phasing and filter network to be inserted between the demodulator and modulator of the choppers.

One filter network investigated uses a short time-constant in the filter section and switching of the chopper at approximately 90 deg with respect to the reference phase.[1] The phasing of the choppers is adjusted to maximize the quadrature rejection of the chopper circuit. The input and output switch arms are so connected that if the first arm is connected to one filter, the second arm is connected to the other. Waveforms in the network, for a high-impedance load, are shown in Fig. 2B. This circuit has several advantages over a chopper circuit that incorporate a long-time-constant filter.[2] Among these advantages are an extremely fast response in the demodulator system, an output shifted 90 degrees with respect to the reference phase, and a square-wave output whose peak-to-peak value is close to the peak-to-peak value of the input sine wave.

The first feature is important where it is necessary to avoid long time-constants that may affect the stability of the servo system. The feature second permits the line voltage to be connected directly to the line phase, thereby avoiding phase shift networks, while the third factor permits high sensitivity in the chopper circuit.

The circuit shown in Fig. 2A samples the 400 cycle information supplied to the chopper arm and holds this value of voltage on one of the 0.05-microfarad capacitors while the arm is connected to the other filter section consisting of a similar 1000-ohm resistor and 0.05-microfarad capacitor. Phasing of the input chopper arm switching is important for maximum quadrature rejection. As shown in Fig. 2A a 90-degree excitation source is applied to the switching coil of the chopper. Due to phase shifts in the chopper, as well as the amplifiers, the applied voltage to the switching coil of the chopper is made variable in phase. To check the adjustment of the switching time of the chopper, the circuit of Fig. 2C was used. Initially two resistors, one a 7,500-ohm and the other 2,500 ohm, were connected across the reference phase. The input probe of the bridge was now connected to the junction point of the two resistors and the ratio of these two resistors was directly read to five places from the front panel dial as shown in Fig. 1A. Next either phase lead or phase lag networks were obtained as shown in the figure. With the value of capacitors shown the phase shift will be in the order of 0.1 degree. The in-phase component of the voltage at the junction point remains constant within the accuracy of this bridge; however a quadrature voltage is now present. By adjusting the excitation voltage on the switching coil of the chopper the dial reading on the automatic ratio bridge could be made to remain constant. If the phasing of the switching of the quadrature arm is not correct, connection to the three circuits will give variations in readings outside the tolerance of the bridge. The correct phase for switching the input chopper is that which will give zero output voltage from the chopper circuit when a quadrature voltage with respect to the reference phase is applied at the input of the automatic ratio bridge. This means switching the input arm when the voltage across the 0.05 microfarad

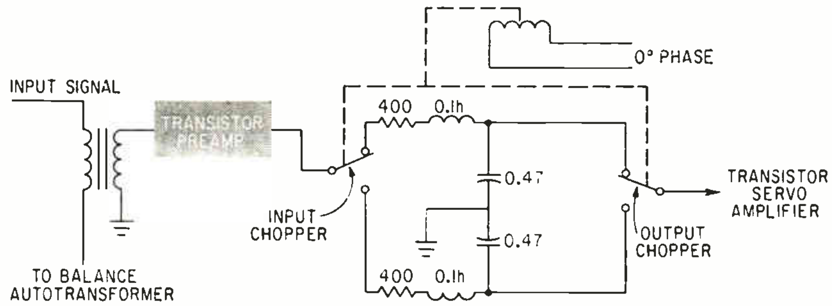

FIG. 3—Transistor chopper with low-frequency filter network

capacitor is zero for an impressed quadrature voltage at the input. The simplest check for this was the circuit of Fig. 2C. Phase shifts up to 0.5 degrees were checked by using different value of capacitors in the circuit of Fig. 1A. For phase shifts greater than 0.3 degree the phase-shift networks in Fig. 2C will change the magnitude of the in-phase voltage by a value greater than the accuracy of the bridge. In interpreting the readings of the bridge for such phase shifts, correction was made for the change in in-phase voltage.

The idealized diagram of Fig. 2B shows the conditions in the demodulator and modulator circuit of Fig. 2A. The upper sketch shows the waveform of the input signal at the chopper arm; the next lower waveform shows the voltage across one of the 0.05-microfarad capacitors when the excitation for the chopper has been adjusted. When the input contact opens, the voltage across this capacitor is held at the same value and is transferred through the output chopper contacts at 180 degrees out of phase with the input chopper (See Fig. 2A). The next lower waveform in the sketch shows the waveform on the other 0.05-microfarad capacitor. The open time in the break-before-make type of choppers used is not shown, nor is the charging time of the 0.05-microfarad capacitor.

The open time delays the application of the input waveform to the filter; once applied however the short time constant enables the capacitor to charge close to the full value of the applied voltage. If the phase balance of the chopper is not zero adjustment of the switching time will compensate for this. The output waveform applied to the subsequent servo amplifier is as shown in the last diagram.

Despite the above considerations, a filter network with a lower cutoff frequency was selected (see Fig. 3). This lower frequency filter gave superior performance in rejecting noise and distortion components existing at the null balance point. Since this feature was of the utmost importance, lower conversion-gain and lower cutoff frequency were accepted. The cutoff frequency of the filter was set as low as possible without introducing instability into the system. This low cutoff frequency was satisfactory in the filter, as noise reduction was more important than achieving a shorter settling time. Measurements made on quadrature, distortion, and noise rejection after the long time-constant filter, indicated rejection ratios greater than 60 db. Theoretically, with proper phasing, the rejection of the quadrature component should be 100 percent.

In Fig. 3, the phasing of the chopper arm is shown as zero. However, because of phase shift in the transistor preamplifier and production tolerances of the transistor choppers, it is necessary to adjust the phase of the input chopper to be in phase with the in-phase error signal at the input to the chopper. This adjustment is done by setting the input chopper so that the same reading is obtained in the presence of a small quadrature voltage. The main source of error in the automatic bridge occurs when measurements are made on voltages having phase shifts greater than ±0.5 degree. This situation produced readings outside the accuracy quoted.

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Differential Amplifier With Regulator Achieves HIGH STABILITY, LOW DRIFT

Unique circuit configuration of this direct-coupled differential amplifier makes possible low drift and high common-mode rejection ratio. Meets requirements of missile telemetry systems

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WHEN d-c signals are to be amplified, the usual approach is to use a direct-coupled circuit. The difficulty of maintaining sufficiently low drift in a direct-coupled configuration led to the development of chopper and chopper-stabilized circuits, where a mechanical chopper reduces drift to low values. Unfortunately, other shortcomings arise, and in most applications the direct-coupled d-c amplifier would be preferable if the drift could be reduced to an acceptable value. The advantages over the chopper or the chopper-stabilized types include rapid recovery from overload, freedom from hash, simplicity and small size due to absence of transformers and capacitors.

A d-c amplifier for airborne or missile telemetry use must meet many specifications. The usual requirements for differential input, single-ended output, signal levels and linearity are easy to meet. Those which are difficult to achieve, especially simultaneously, are low drift over a wide temperature range, stable though adjustable gain, wide frequency response, high input impedance, high common-mode rejection factor, insensitivity of performance to source resistance, small size, weight and low power requirements. The d-c amplifiers described here provide exceptional performance in all these respects simultaneously. There is no unique set of specifications, since the design can be tailored for particular applications.

The following figures are typical: gain stability ±0.75 percent; frequency response ±1 percent to 10 Kc, 3 db down at 50 Kc; differential input resistance greater than 1 megohm; common-mode rejection factor 120 db to 400 cps, 100 db to 2 Kc, for common-mode voltage ±5 v peak and for a gain of 1,000. The gain is adjustable over a 2-to-1 range with maximum preset to any value between 200 and 1,000. For a gain of 1,000 the maximum differential input signal is ±5 mv peak. The output capability is ±5 v into 20,000 ohms with output re-

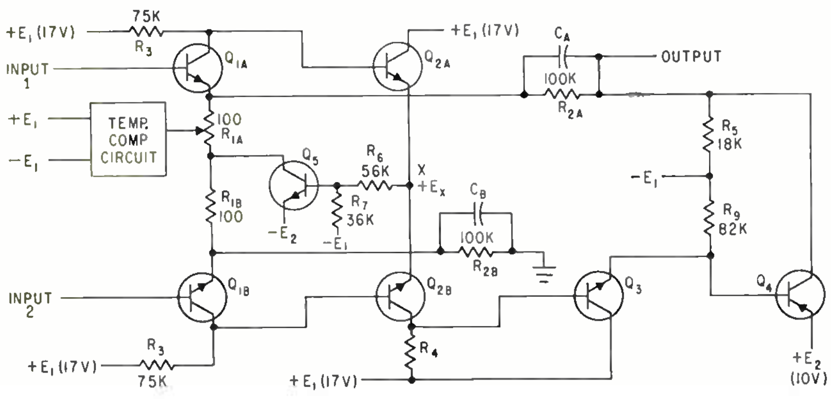
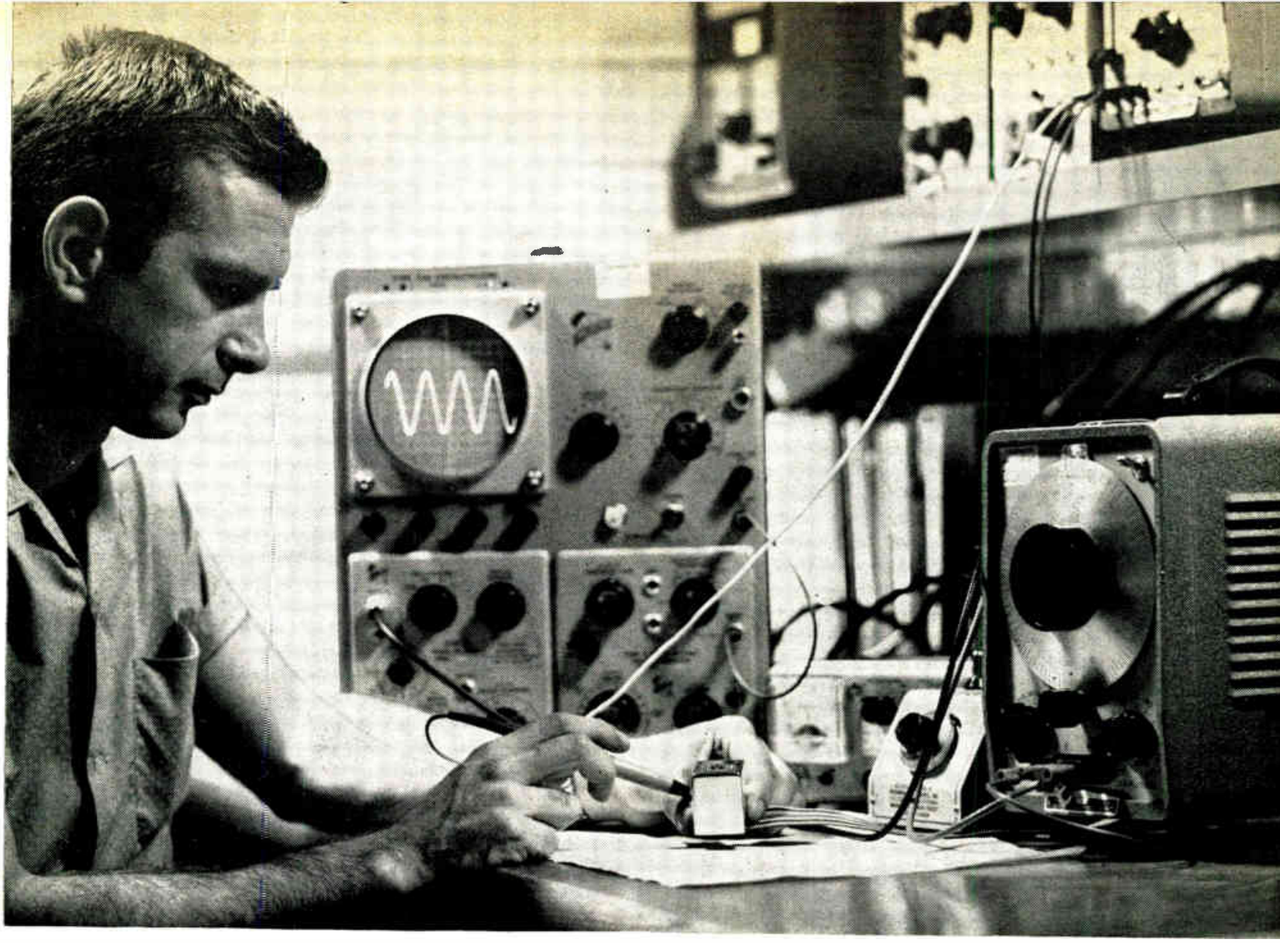


FIG. 1—Basic circuit of the amplifier. Voltages E_1 and E_2 are obtained from a reference diode string fed from the power supply. Resistor R_9 serves as a gain control



The low-drift transistor d-c amplifier under test. To alleviate temperature problems, differential amplifier uses a pair of matched transistors in one can

sistance less than 100 ohms, and with up to 100 percent offset adjustment. The drift is to some extent a function of the signal source and a typical equivalent input drift is ± 100 μv for eight hours over a temperature range of 25 C to 100 C.

For extreme temperature environments, an amplifier is available with an internal heater so that eight-hour input drifts of ± 100 μv can be maintained over ambient temperatures from -55 C to 100 C. Size and weight are tailored to meet environments, and are typically 3 cubic inches and 4 ounces for the heaterless models. Required power supplies are 20 ma at plus and minus not less than 18 v ± 1 percent. The model containing a heater is about 7.5 cubic inches, weighs 6 ounces, and requires an additional input of up to 300 ma (for -55 C ambient) at $+28$ v unregulated.

The circuit of the heaterless d-c amplifier is shown in Fir. 1. Transistors Q_{1A} and Q_{1B} form a differential first stage, Q_{2A} and Q_{2B} a differential second stage, and Q_3 and Q_4 form the single-ended third and fourth stages. Overall negative feedback is taken from load resistance R_5 and applied in series with the differential input. Resistance R_5 is an internal load; any external load is connected between output and ground. The circuit is inherently capable of converting a differential input to a single-ended output, and is superior in three respects to a circuit which is differential throughout and in which only one output of the two is used: the output resistance is considerably lower for the same loop gain, much better common-mode rejection is obtained, and fewer transistors are required.

With zero input signal, there is no voltage between the output terminal and ground. Internal load resistance R_5 is connected to negative supply voltage E_1 to permit operating current to flow in output stage Q_4 under quiescent conditions.

With a differential input signal, input 1, for example, goes positive and input 2 goes an equal amount negative. The current in Q_{1A} increases while that of Q_{1B} decreases. The current changes in resistances R_3 (both) cause the input voltage to Q_{2A} to decrease and that of Q_{2B} to increase. The increased current in Q_{2B} causes an increased voltage drop across R_4, and reduces the input voltage to emitter-follower stage Q_3. The lower emitter voltage of Q_3 causes an increase in the base-emitter voltage of Q_4, hence Q_4 conducts more current through R_5 and the output voltage goes up. A resistance from the emitter of Q_3 to negative supply voltage $-E_1$, to provide correct operating current, is not shown in the schematic. A fraction of the voltage between output and ground is injected in series with the input through negative feedback path R_{2A}, R_{1A}, R_{1B} and R_{2B}.

Transistor Q_5 does not act as a constant-current sink for the currents in R_{1A} and R_{1B}, as it would if resistance R_6 were returned to a fixed supply voltage. Instead, the connection allows Q_5 to fulfill two important requirements. Imagine that the half of the circuit containing Q_{1B} and Q_{2B} is folded over to lie on top of the half containing Q_{1A} and Q_{2A} (see Fig. 2). The path

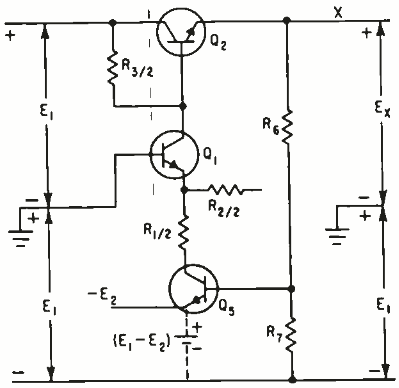


FIG. 2—Differential stages folded over and drawn to reveal a voltage regulator circuit

from point X through Q_5, $Q_{1A,B}$ and $Q_{2A,B}$ back to point X is a voltage regulator circuit in which $(E_1 - E_2)$ is the reference, and $(E_X + E_1)$ is the regulated output voltage. Transistor Q_5 is the error amplifier, and Q_2 is the series element whose current is controlled by Q_5. Transistor Q_1 does not contribute to this mode of operation of the circuit, and serves merely to transmit the collector current variations of Q_5 to the base of Q_2.

The voltage between X and the negative suply $-E_1$ is constrained to be closely equal to $(E_1 - E_2)(R_6 + R_7)/R_7$. The higher the common-mode loop gain, designated G_c, the more highly regulated will be the voltage E_X at X. Since the voltage across each R_3 is approximately $E_1 - E_X$, the collector currents of Q_{1A} and Q_{1B} are stabilized, which is the first of the two functions of Q_5. Each collector current is set to 100 μa, this low value being chosen to make the noise contributions of Q_{1A} and Q_{1B} small, and to allow a large value of R_3 which makes the common-mode loop gain G_c large.

To understand the second function of Q_5, it must be recognized that in the presence of arbitrary voltages at the two amplifier inputs, the collector current of Q_5 contains both differential and common-mode components. These result from conditions imposed by the feedback path. A high value of G_c permits the collector current of Q_5 to adjust as required to the inputs, while the collector currents of Q_{1A} and Q_{1B}, and hence their base currents, hardly change. Thus, the second function of Q_5 is to maintain high signal impedances at the inputs to Q_{1A} and Q_{1B}.

There is typically about 45 db of overall negative feedback in the complete amplifier, which implies a differential loop gain of about 200. This high value ensures low output resistance, high differential input resistance, and stable gain determined essentially by the feedback elements. Close, but not necessarily exact, equality between R_{1A} and R_{1B}, and between R_{2A} and R_{2B}, is required. Under these conditions, gain G_1 from input 1 and gain G_2 from input 2 may be written $G_1 = (R_{1A} + R_{2A})/R_{1A}$

$$G_2 = G_1\left[1 + \frac{R_1}{R_2}\left(\frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2}\right)\right]$$

where $R_{1A} \approx R_{1B} \approx R_1$, $R_{2A} \approx R_{2B} \approx R_2$, $R_{1B} - R_{1A} = \Delta R_1$, and $R_{2B} - R_{2A} = \Delta R_2$. For a gain of 100, typical values are R_1 =1 K and R_2 = 100 K, hence for small percentage unbalances $\Delta R_1/R_1$ and $\Delta R_2/R_2$ the gain G_2 is very nearly the same as G_1. Both gains are determined by R_{1A} and R_{2A}, with only weak dependence on R_{1B} and R_{2B}. The frequency response of the amplifier can be controlled by capacitance C_A, with only weak dependence on C_B.

The degree of rejection of common-mode input signals is sensitive to asymmetry in the resistance pairs R_1 and R_2. The amplifier common-mode rejection factor C, defined as the ratio of the common-mode input voltage to the differential input voltage which produces the same output voltage, is given by

$$\frac{1}{C} = \left[\frac{\Delta R_1}{R_1}\left(1 - \frac{1}{G_c}\right) - \frac{\Delta R_2}{R_2}\right]\Big/ G$$

where $G_1 \approx G_2 \approx G$, and G_c is the common-mode loop gain previously defined. The value of C is maximized by adjustment of R_{2B} and C_B, which may be designated as common-mode adjustments with negligible effect on the gain or on the frequency response. However, the converse is not true. Any attempt to alter the gain by changing R_{2A} would have a disastrous effect on the common-mode rejection factor. Means must be found to change the effective ratio of R_{1A} to R_{2A} without destroying the symmetry.

Gain variation can be accomplished by bridging a gain control resistance between symmetrical tapping points on R_{2A} and R_{2B}, as shown in Fig. 3A. In the gain equations, R_{2A} (or R_{2B}) should then be replaced by the effective value R_{2E} given by $R_{2E} = R_2 + 2(R_1 + R_8)(R_2 - R_8)/R_9$.

It is possible to achieve gains variable over a two-to-one range without interaction between the gain and common-mode adjustments.

Care must also be taken to avoid upsetting the optimum common-mode rejection when changing the quiescent output level. The most convenient way to introduce an output level control which satisfies this requirement is to remove R_{2B} from its ground connection and to return it to the slider of a potentiometer across the supply voltages. The impedance level of the potentiometer must be low enough that the effective value of R_{2B} is changed by an acceptably small percentage throughout the desired level range, to avoid undue degradation of the common-mode rejection factor. Alternatively, the common-mode adjustment can be reset for a particular output voltage level.

In the presence of a level control, the lower output terminal remains at ground, as shown in Fig. 3B.

The amplifier common-mode rejection factor is sensitive to unbalance in the signal source resistances. If the rejection factor is adjusted to be infinite with equal source resistances, the common-mode rejection factor C' in the presence of an unbalance ΔR_s in the source resistances is given by $1/C' = \Delta R_s/\beta_1 R_2 G_c$ where β_1 is the common-emitter current gain of Q_{1A} or Q_{1B}. It is the absolute and not the percentage unbalance of the source resistances which is significant. A typical value for C' is 10^6, or 120 db, for ΔR_s = 100 ohms, therefore the common-mode rejection factor is little affected by normal source resistance unbalances.

Although the above description of the amplifier indicates excellent characteristics with respect to its signal-handling capabilities, the crucial test of a d-c amplifier is its drift performance. Drift in a direct-coupled d-c amplifier originates almost exclusively in the differential input transistors, and arises primarily because of aging and temperature changes in the saturation currents, the base-emitter voltages, and the current gains. Use of silicon transistors with room temperature saturation currents in the order of 1 na (millimicroamp) effectively eliminates this source of drift with normal low-impedance signal sources such as strain gages and thermocouples. However, the other two drift sources are important.

The base-emitter voltage of a silicon transistor is stable with time but exhibits marked temperature dependence, decreasing by approximately 2 mv for every degree centigrade rise in temperature. Even though the base-emitter voltage drops of Q_{1A} and Q_{1B} are in series opposition, and even if Q_{1A} and Q_{1B} are exactly matched, an equivalent input drift of 20 μv will result for every 0.01 deg C temperature differential between these two transistors. The availability of two matched transistors in one can, the FSP-2 of Fairchild Semiconductor Corp., has alleviated the problem of temperature differentials.

In addition to this effect, there is also a drift source due to unavoidable unbalance in the temperature dependences of the base-emitter voltages in Q_{1A} and Q_{1B}. In the double unit, the values of dV_{be}/dT are typically matched to about 1 part in 100, but even this would give rise to an equivalent input drift of 20 μv for every degree change in ambient temperature. This is unacceptable, but because the base-emitter voltage at constant current is closely linear with temperature, compensation is possible. The compensation function is provided by an auxiliary circuit which supplies a current linearly dependent on temperature.[2] As shown in Fig. 1, this current is injected at a tapping point on the resistance R_{1A} or R_{1B}, thus generating a voltage in series with the inputs which is linearly dependent on temperature. Adjustment of the tapping point permits the inherent unbalance of dV_{be}/dT in Q_{1A} and Q_{1B} to be reduced by a factor of as much as 100. The equivalent input drift from this cause can be held to about 20 μv over a range of 100 deg C. This high degree of cancellation depends upon closely equal temperatures of Q_{1A}, Q_{1B} and the compensating circuit, an equality which is in turn limited by the thermal design.

The remaining source of drift is the variability in the current gains of Q_{1A} and Q_{1B}. Since the collector current of each transistor is stabilized by Q_5, each base current flows through the resistance of its signal source and thereby gives rise to a spurious input signal. It is apparent, that the drift performance of the amplifier cannot be specified independently of the signal-source characteristics. However, performance can be so specified that the expected drift can be determined for a particular source configuration. A typical value for the current gain of a double unit is 40 at 25 C, with a possible unbalance between the two units of about 10 percent. Since in the amplifier each collector current is stabilized at 100 μa, each base current is nominally 2.5 μa at 25 C. If the ambient temperature increases, each base current decreases fairly linearly at about 15 na/deg C, again with a possible unbalance between the two units of about 10 percent. These figures make possible an estimate of the temperature drift in the presence of given source resistances. For example, if the source resistance in series with each input is 0.5 K, then an equivalent input drift up to ± 0.1 $(0.5 \times 15) = \pm 0.75$ μv per deg C could be expected. The fact that this drift is approximately linear with temperature permits compensation. If the source resistance is known, drift due to current gain changes can be cancelled along with that due to base-emitter voltage changes and it is necessary to set the temperature compensation adjustment in the presence of the desired source resistances. There then remains only drift due to the varying base current flowing in any unbalanced source resistance. For example, if the 500 ohm source resistances were unbalanced by 5 ohms, an uncompensated equivalent input drift of about 0.075 μv per deg C would result.

The examples indicate the dependence of the amplifier drift performance on the signal-source configuration. If the drift thus obtainable is undesirably great, or if independence of the source configuration is desired, it is necessary to use an internal heater to eliminate temperature-dependent changes in the amplifier parameters. The heater used in these amplifier models is continuously controlled by an internal subsidiary amplifier referenced to a thermistor sensor, and the main amplifier temperature is maintained very nearly constant. As a result, low drifts can be achieved over wide ambient temperature ranges.

The assistance of C. E. Everest is gratefully acknowledged.

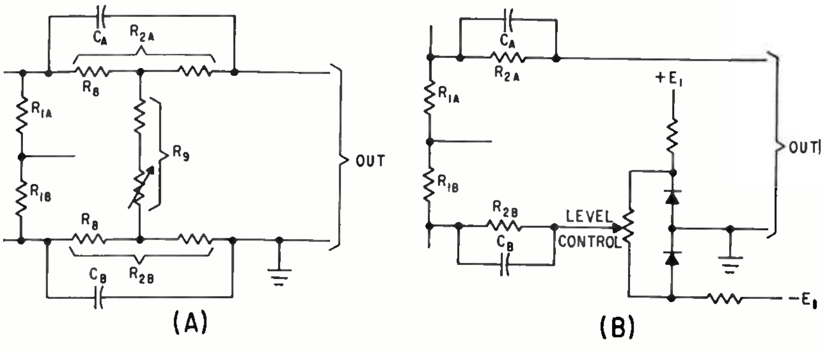


FIG. 3—Introduction of a gain control by bridging resistance across symmetrical tapping points on R_{2A} and R_{2B}, in (A); introduction of a level control by connecting R_{2B} to a low-impedance potentiometer across a bias voltage, (B)

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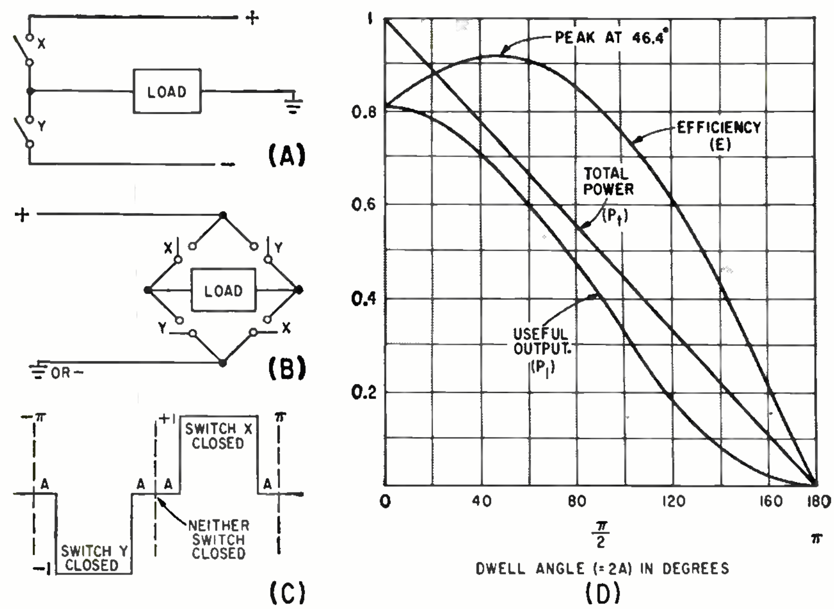
(2) W. T. Matzen and J. R. Biard, Differential Amplifier Features d-c Stability, ELECTRONICS, Jan. 16, 1959.

How Optimum Dwell-Time Reduces Converter Harmonics



Diagrams of converter (A) and bridge converter (B); timing sequence (C) shows dwell-time as equal to 2A; and graph (D) of total power, useful power and conversion efficiency plotted against dwell-time

By D. D. WILCOX, Senior Staff Engineer, Ampex Data Products Co., Redwood City, Calif.

IN USING silicon-controlled rectifiers, switching transistors and similar devices in d-c to a-c converters, it is often necessary to reduce the harmonic content of the output when a squarewave form is employed. A dead time or "dwell-time" is usually inserted into the square waveform between the time a given end of the load is connected to positive and negative volts.

The circuit is generally as shown in (A) or (B). The silicon-controlled rectifiers or transistors are symbolized by switches, X and Y, which are closed alternatively. Harmonic content is reduced by controlling the switches so that a dwell-time exists between the opening of the X switches and the closing of the Y switches, and conversely (Fig. C). The timing sequence is: X, 0 (neither closed), Y, 0, X, 0, Y, 0, etc. A dwell-time of 60 deg yields an output wave containing no third harmonic.

Dwell-time is a variable, selected by the circuit designer, and system specifications can require minimization of total harmonic content rather than a specific harmonic power. It is desirable to calculate percentages of harmonic as dwell-time is varied. By determining the Fourier series for the waveform in dwell-time, the power in each of the harmonics can be evaluated. Since total power must equal the sum of the harmonic powers, ratios can be established among total power (P_t), desirable power at fundamental frequency (P_1) and undesirable harmonic power.

With dwell-time equal to $2A$ (Fig. C), the conversion efficiency (E) will be:

$$E = \frac{P_1}{P_t} = \frac{\frac{8}{\pi^2}\cos^2 A}{(\pi-2A)\,\pi} = \frac{8}{\pi} \cdot \frac{\frac{1}{2}+\frac{1}{2}\cos 2A}{\pi-2A}$$

$$= \frac{4}{\pi} \cdot \frac{1+\cos 2A}{\pi-2A}$$

With A variable, maximum efficiency will occur when

$$\frac{dE}{dA} = 0 = \frac{4}{\pi} \cdot \frac{(\pi-2A)(-2\sin 2A)+2(1+\cos 2A)}{D^2}$$

$$4A\sin 2A - 2\pi\sin 2A + 2 + 2\cos 2A = 0$$

$$(\pi-2A)\sin 2A = 1+\cos 2A$$

By trial and error, $A = 0.405$ rad $= 23.2$ deg and optimum dwell angle $= 2A = 46.4$ deg.

Total power (P_t), useful power (P_1), and conversion efficiency (E) are plotted against dwell-time ($2A$) in Fig. D.

The best dwell-time for maximum conversion efficiency and lowest total harmonic content is about 45 deg, with dwell-time not critical at this angle. Conversion efficiency is 90 percent or better over almost a 40-deg spread, and varying the output voltage by controlling dwell-time does not result in large variations in total harmonic content.

Where minimum total harmonic power is the criteria, 46.4 deg is optimum dwell-time. This angle is not critical, and high efficiency can be maintained over a wide range of dwell angle.

To demonstrate, for a conversion efficiency of 90 percent, dwell-time can be varied from about 28 deg to about 65 deg, with output voltage controllable from 56 percent to 75 percent (from curves). Using these figures, a converter capable of converting d-c and a-c can be designed so that rms a-c voltage can be varied from 112 v to 150 v, with d-c supply voltages of 200 v, and with conversion efficiency of 90 percent or better over the entire range

$$\frac{112}{56} = \frac{150}{75} = \frac{200}{100}.$$

Similarly, 90-percent efficiency can be maintained in a converter designed to deliver 115-v a-c over an input d-c voltage range

$$\frac{115}{75} \leq E \leq \frac{115}{56},$$

$$153 \leq E \leq 206.$$

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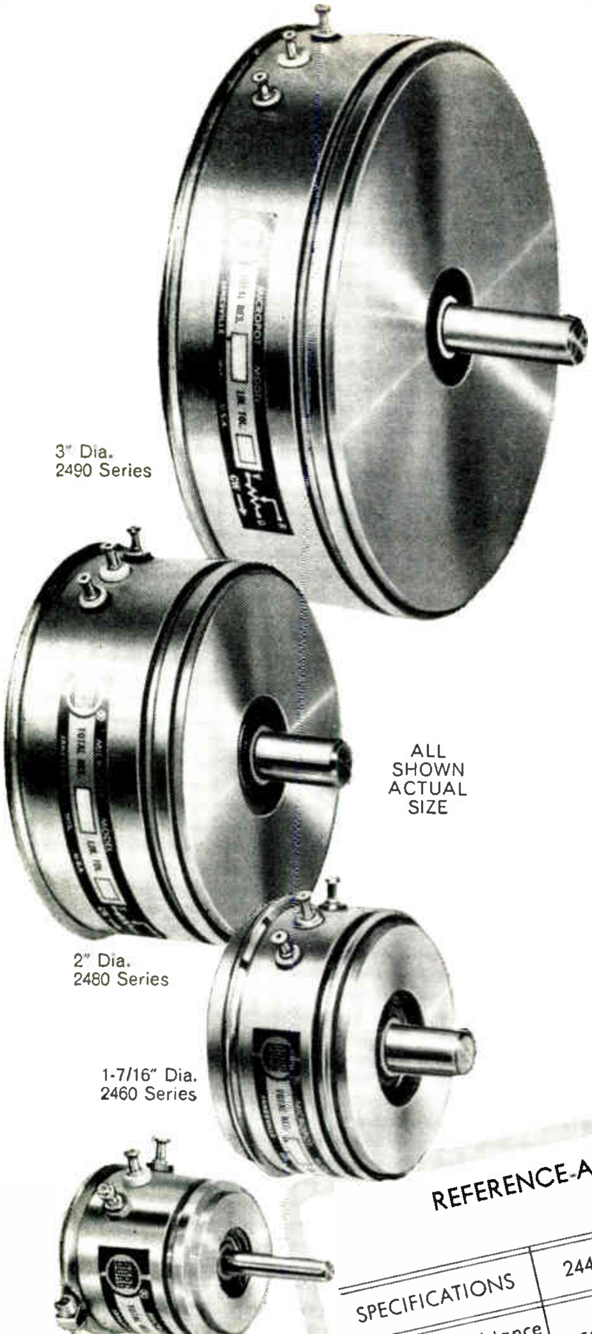

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Temperature Range (°C)	−55 to +125	−55 to +125	−55 to +125	−55 to +125
Power Rating (watts)	3	4	5	6
Standard Linearity Tolerance (%)	±.5	±.5	±.5	±.5
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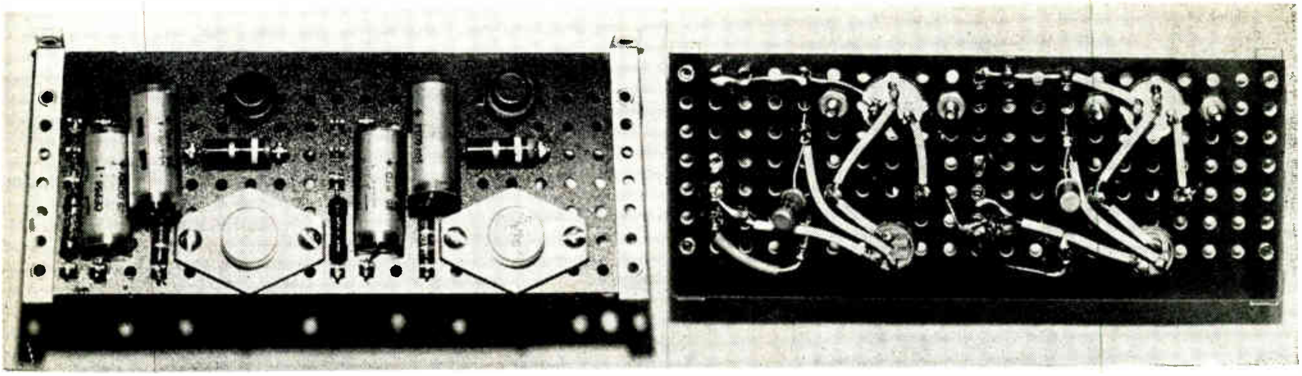


Upper and lower views of assembly card carrying the regulator sections of positive and negative supplies

Regulated Positive-Negative Supply Delivers Low-Voltage Direct Current

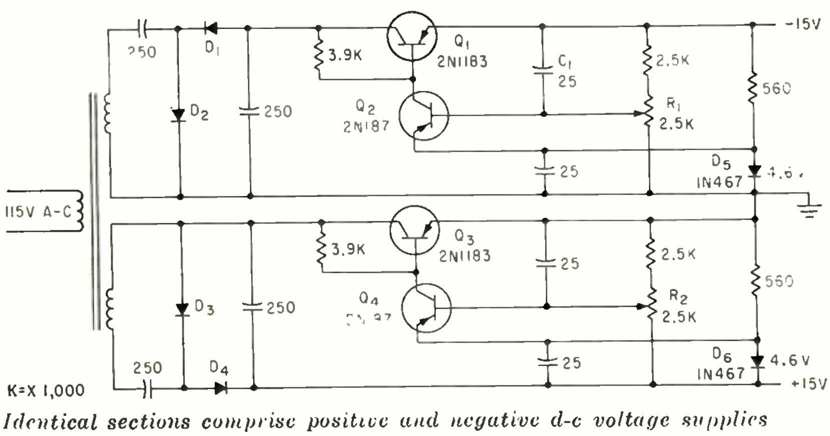
By D. T. BIRCH and K. E. CHELLIS, Tallahassee, Fla.

THIS SUPPLY has many applications where a source of constant low voltage is desired. Its output voltage is adjustable from 11 to 15 v d-c, and is nearly constant from no load to 300 ma, or from 90-v a-c to 140-v a-c line-voltage variations. Ripple at no load is 2 mv, and at full load is 5 mv.

Maximum current can be increased by substituting higher-power transistors with better heat sinks for the 2N1183's (see the schematic) and by using huskier rectifier-filter components. The ripple content can be improved considerably with LC filters.

The half-wave voltage doubler provides 35 v for the regulator. A half-wave configuration was chosen because the transformers were available. The one used here is a Merit P3085 that has two separate 13-v 3-amp windings; 12.6-v heater transformers would serve as well. No variation in performance was observed between half-wave or full-wave doublers. Rectifiers D_1 to D_4 are replacement-type 500-ma silicons. Potentiometers R_1 and R_2 are of the 2-w linear carbon type. All components are mounted on terminal cards. The rectifiers and filter capacitors are on one board, the regulator circuits on another.

Since the two regulators are identical, only the functioning of one will be discussed. Transistor Q_1 is in series with its load. The bias of Q_1, which controls its effective resistance, is determined by the parameters of d-c amplifier Q_2. Zener diode D_5 furnishes a reference voltage for the emitter of Q_2. Varying potentiometer R_1 varies the bias of Q_2 and hence, its effective resistance. This in turn varies the effective resistance of Q_1, thus varying the output voltage. Any change in output voltage due to load variations will cause a change in the bias on Q_2, thus compensating for the load variation. Fast fluctuations in the load will be transmitted to Q_2's base through capacitor C_1.



Identical sections comprise positive and negative d-c voltage supplies

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```
         AM   FPN-8,01,10        03366 11 03129 00001
         TF   *+18,KOUNT4        03378 26 03396 03952
         TFM  ,70,10             03390 16 00000 00070
         B    NEGK               03402 49 03318 00000
EQUALK   AM   KOUNT4,02,10       03414 11 03952 00002
         TF   *+18,KOUNT4        03426 26 03444 03952
         TFM  ,70,10             03438 16 00000 00070
         TF   *+30,KOUNT4        03450 26 03480 03952
         TF   *+23,KOUNT5        03462 26 03485 03957
         TD                      03474 25 00000 00000
         AM   KOUNT5,01,10       03486 11 03957 00001
         CM   KOUNT5,FPN,7       03498 14 03957 03137
         BNH  EQUALK             03510 47 03414 01100
FLAGK    BNF  *+24,FPN           03522 44 03546 03137
         TDM  DECK+21,2,10       03534 15 03876 00002
         BB                      03546 42 00000 00000
POSK     MM   FPN-8,02,10        03558 13 03129 00002
         S    KOUNT4,99          03570 22 03952 00099
         TF   *+18 KOUNT4        03582 26 03600 03952
                                 03594 16 00000 00070
              0,KOUNT4           03606 26 03636 03952
              23,KOUNT5          03618 26 03641 03957
                                 03630 25 00000 00000
              4,02,10            03642 11 03952 00002
              T5,01,10           03654 11 03957 00001
              KOUNT5,FPN,7       03666 14 03957 03137
         BNH  *+96               03678 47 03774 01100
         CM   KOUNT4,DECK,7      03690 14 03952 03855
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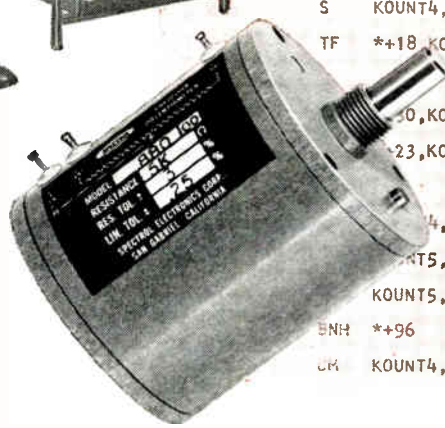

The above equation is the mathematical expression for the non-linear function required of a precision pot to relate voltage ratio $\frac{e_o}{E_i}$ to potentiometer shaft position θ.

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Basically, it works this way: Computer input data is in the form of programmed equations or tabulated X and Y coordinates. Previously programmed tapes with general equations for non-linear applications (on file at Spectrol) operate on the data, to compute output in terms of winding equipment settings, cam angles and radii. An electric typewriter prints out this information on a form such as that shown above, which is sent directly to production, eliminating delays and potential transcription errors.

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Wind Tunnel Studies Are Made on Parabolas

By J. B. TIEDEMAN,
University of Kan.,
Lawrence, Kan.

SEVEREST aerodynamic loads on parabolic antennas are produced by winds forty-five degrees from the axis of symmetry. Forces from winds at this critical angle consistently exceeded those from head-on winds in a series of experiments in the University of Kansas wind tunnel. The project was initiated and supported by the John A. Costelow Co., Topeka, to obtain data for use in designing antenna tower structures.

The tests were made to determine loads produced by winds from a wide range of directions on parabolic reflectors. Wind directed toward the edge of a parabola follows the surface closely, but head-on wind cannot change direction quickly enough at the edges and flow is separated from the surface. Transition from attached to separated flow occurs at some angle between the two conditions with an abrupt change in aerodynamic loading.

The 5-ft diameter wind tunnel permitted a standard 18-inch microwave reflector with 4.3-inch focal length to be used as the model. The unperforated sheet metal reflector had a 1½-inch deep reinforcing flange around the circumference. Two smaller models without flanges (11 and 14 inches in diameter) were also tested to reveal scale effects and determine the effects of the flange.

Forces and moments were measured with a strain-gage balance system that rotated with the model to provide force components in the model coordinate system. The balance system worked well for the large force component along the axis of symmetry, but transverse forces and moments were so small compared to tare drag on the model support that errors were as large as 50 percent.

No significant scale effects were observed, and the effective Reynolds number of 10 million is high enough to suggest that scale corrections are unnecessary in applying results to full-size antennas. The flange seemed to affect only a small range of angles near the head-on wind direction, where it increased drag about 20 percent.

Axial force coefficients of 2.3 were observed consistently at 45 degrees from the axis of symmetry, compared with head-on coefficients of 1.4 for unflanged and 1.7 for flanged models. Lateral and moment coefficients were also greater at 45 degrees but were only about 0.2. Wind at this critical angle results in force acting in a direction within 5 degrees of the axis of symmetry.

Use of the force coefficients can be demonstrated by a 6-ft reflector in a 50-mph wind at sea level. Projected reflector area A is 28.3 sq ft, standard air density is 0.002378 slugs per cut ft and converted wind velocity is 73.3 ft per sec. Dimensionless aerodynamic force coefficients C are related to corresponding forces by $F = qAC$, where q is dynamic air pressure (half the product of air density and square of wind velocity) or 6.38 lb per sq ft.

With the maximum axial force coefficient of 2.3 at the critical angle, axial force is 415 lb. With the maximum lateral force coefficient of about 0.2, a lateral force of about 42 lb would act through the vertex of the paraboloid.

The moment about an axis through the vertex normal to the plane defined by wind direction and the axis of symmetry is related to moment coefficient C_m by $M = qADC_m$, where D is antenna diameter. With the peak moment coefficient of about 0.2, the moment is 249 ft-lb in the form of a couple to be added to the effects of the lateral and axial forces acting through the antenna vertex. Both lateral force and couple reach peaks at the critical angle. Their torsion effects are cummulative in a direction tending to rotate the antenna into the wind if it is mounted as usual with the convex surface toward the tower. If it is mounted so the axis of symmetry intersects the elastic axis of the tower, the axial force will not twist the tower, but some residual torsion created by the lateral force and moment cannot be completely eliminated.

The moment arm of the lateral force can be minimized by mounting the reflector as close to the tower as possible, but the couple associated with the moment coefficient cannot be eliminated.

System Shows Retrieved Documents Immediately

INFORMATION retrieval from large collections of documents can be made more effective with a newly developed electromechanical searching device. The equipment is based on the microcite system.[1] It combines design simplicity with automatic features to make decentralized search facilities possible.

The improved microcite machine was developed by the National Bureau of Standards under sponsorship of the Department of Defense. It will aid the instrument reference service of the Bureau in making available to government and industry information about instruments and control systems.

Much current effort in the field of information retrieval is directed towards development of complex systems to search vast memories automatically and furnish documents in a desired form. High cost of such machines requires centralized operation, which inhibits direct participation of the researcher.

With the microcite equipment, the researcher always controls the search process and knows immediately the nature of the information recovered.

The new development can be more fully appreciated if the microcite concept and the peek-a-boo technique of which it is an adaptation are understood. In the peek-a-boo technique, punched cards are used with each punched card representing an index word. The positions of the holes in the card

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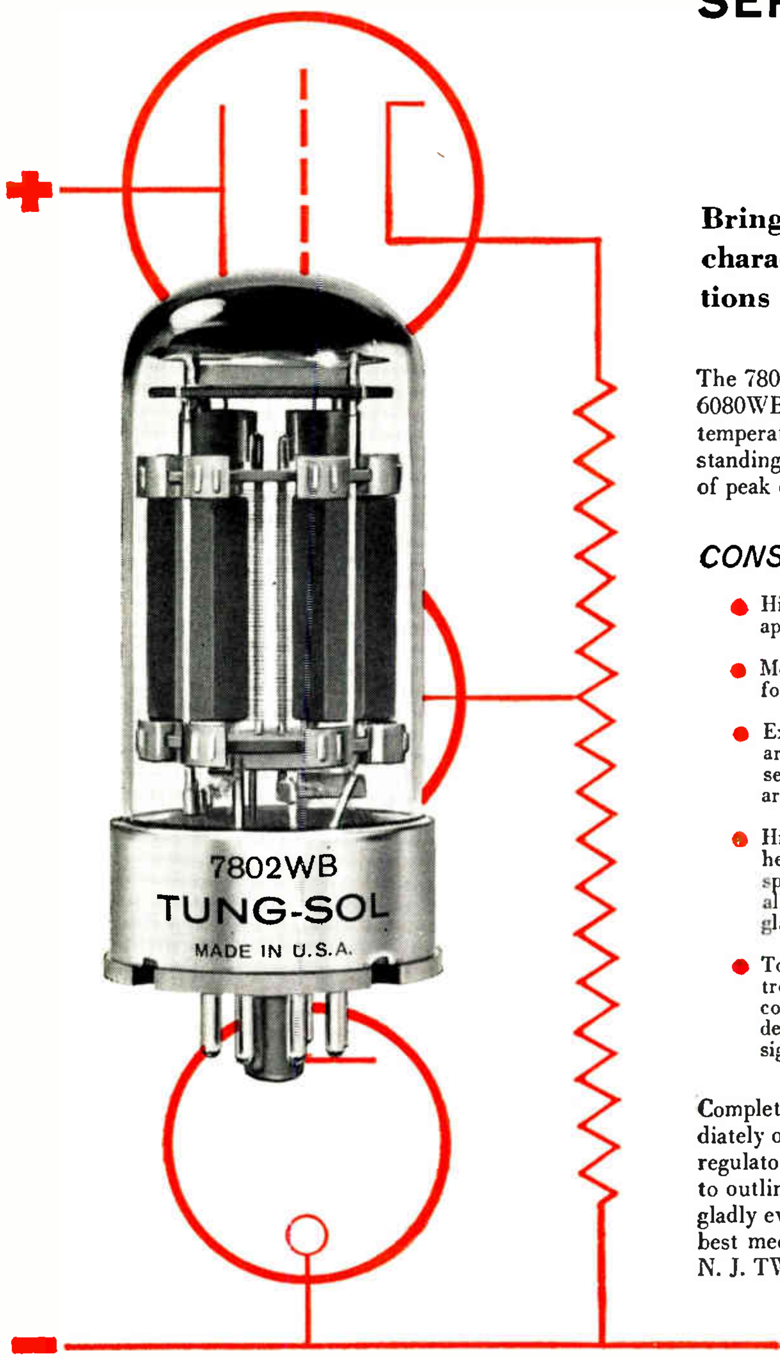

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CIRCLE 65 ON READER SERVICE CARD

identify documents pertaining to the index word. One search technique, referred to as the logical product, is performed by superimposing the appropriate peek-a-boo cards and noting the positions of the holes that are not blocked by any of the selected cards.

More complex logical operations can also be performed. In the peek-a-boo system, hole position is usually interpreted as a document serial number by a coordinate grid printed on the card or on a transparent overlay. The researcher is directed by the serial numbers to a file (serial list) of citations and abstracts of the documents sought or directly to a file of the documents.

The microcite concept eliminates the document file step by immediately providing a microfile image of the citation and abstract. Instead of reading serial numbers, a description of a document emerging from the search can be viewed directly at each hole position. In a preliminary model, microimages of the citations and abstracts were reproduced on a film overlay and read at the holes through a microscope. Although this procedure demonstrated the effectiveness of the microcite principle, it is relatively inefficient for large collections.

The new microcite equipment can search millions of documents. At the Bureau, it has been designed for sets of 18,000-document peek-a-boo cards with corresponding abstracts for each set carried on a 15-inch square sheet of photographic film called the matrix. In operation, the film matrix appropriate to the peek-a-boo set being searched is selected and mounted on a drum. The selected peek-a-boo cards are placed on an illuminated area of the machine.

Two control wheels position a set of cursors successively on each unobstructed hole. Turning the control wheels causes rotation and translation of the drum carrying the film matrix so that as the cursor is set on each hole, a full-size image of the citation and abstract corresponding to that particular hole is projected on a screen in front of the searcher.

A copy of any abstract can be obtained by moving a lever to record the desired image on a roll of photosensitive paper. Alternately, serial numbers of the document can be noted or transcribed into punched tape or printed on paper tape. The electrically coded serial number output made available for this transcription could also be fed into a document-storage machine that would provide copies of complete documents.

By making results available immediately, detection and adjustments can be made for contingencies such as misinterpretation of index terms, interference from documents of which the researcher was unaware, misconceptions about the volume of relevant information in the collection and even modification of interest with more information.

REFERENCE

(1) Microcite, An Aid to More Effective Referencing, *NBS Tech News Bull*, 41, 1957.

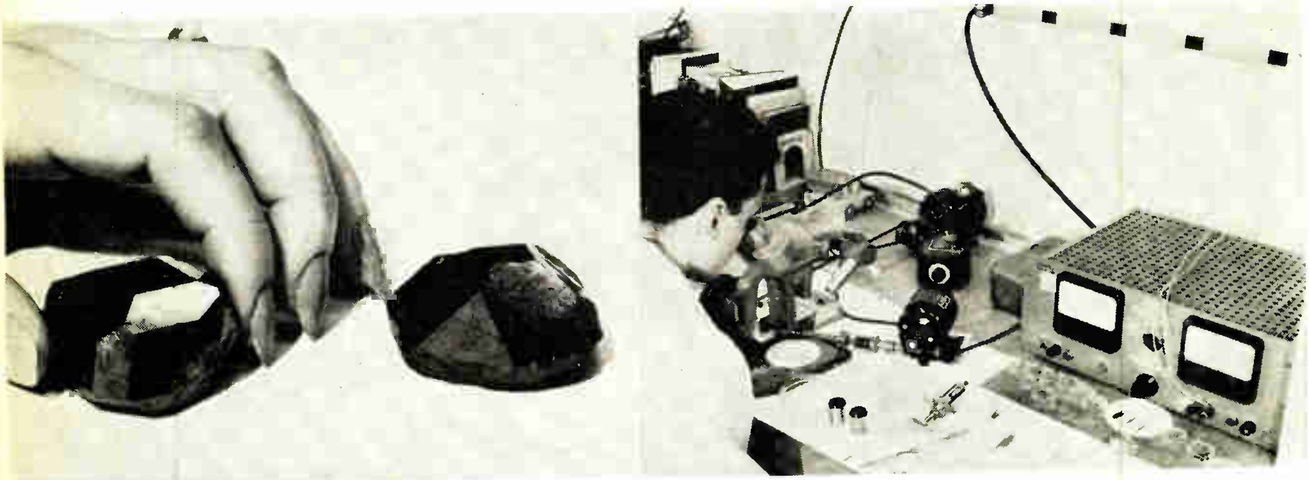
System Sorts Logs According to Size

ELECTRONIC system has been developed that measures and sorts timber at a sawmill according to the Swedish International Press Bureau. The installation is in the Skutskar Sawmill near Gavle, which is at the southern end of the Gulf of Bothania.

The system does the work of 12 to 15 men, handling 600 logs an hour. It was developed by Philips Telindustrie, Stockholm, and is also expected to result in considerable savings in raw material because of its high measurement accuracy.

Logs enter the mill on a conveyor at a speed of one meter per second. Photosensitive detectors along the conveyor feed data into counting circuits that use a total of 700 transistors. The information is later used at the sorting line where logs are pushed into different size pockets from where they are brought to the appropriate saw frames.

An added feature of the system is a metal detector to discover nails or other metal objects embedded in the timber. When metal is detected, a spray is automatically triggered that colors the spot where the object is located. The system later pushes logs with colored spots from the line automatically.



New microwave areas may be opened up for study now that Airtron has demonstrated the ability to grow single-crystal yttrium iron garnets weighing 85 and 95 grams (left). Garnets are polished by equipment (right) while crystal surface is checked through binocular microscope. Differential-speed drives on two polishing heads cause sphere held between them to turn in random fashion. Resonance line width of crystal is a function of surface finish

Large Garnets Pave Way for New Devices

IN THE NEXT FEW YEARS, significant advances will be made in the application of improved ferrites, synthetic garnets and rare earth oxides for high-powered microwave applications. And these developments will follow an improved understanding of relations between the composition and structure, and the magnetic properties of ferrites and garnets.

Primarily of interest to laboratories studying narrow-linewidth resonance phenomena, yttrium iron garnet (YIG) crystals have already found their way into devices such as tunable filters and low-power limiters. And these crystals are being investigated under a variety of experimental conditions.

Now, however, new applications are opened up for study, since Airtron[1] has grown single-crystal YIG weighing 85 and 95 grams. And there is a continued effort on techniques for the growth of single crystals of ferrimagnetic and ferroelectric materials having high degrees of purity.

At present, not much information is generally available on just where and how large YIG crystals will be used. But recent inquiries asking about the availability of large crystals indicates that there are some knowledgeable device designers around who have ideas for these crystals that may open up substantial new applications.

The purpose of growing large crystals for microwave applications is to provide the engineer with an entire new class of materials with sharply refined electromagnetic and electro-mechanical properties, compared to polycrystalline materials previously used.

Without dwelling too long on the physics involved, it is fairly easy to gain an intuitive insight into the reason for this improved behavior:

Fundamentally, there is an interest in the magnetic effects associated with orbital orientation and spin of electrons. Because the atoms in single crystals are already well ordered (organized), compared to those in polycrystalline materials, it follows that the magnetic behavior of single crystals is more sharply defined, giving us the improvement in performance.

Although the effects sought occur in nature, (magnetite and lodestone), raw materials can be tailored to suit specific device needs, so that new effects can be induced, or existing effects can be heightened by modifying the basic mix from which the crystals are grown.

Principle crystal formulations of interest in this area besides yttrium iron garnet, include: modified YIG, lithium ferrite, and yttrium gallium garnets.

Applications include a tunable filter (microwave frequency) which can be placed in a waveguide and which will permit the flow of only a narrow frequency range, rejecting the remainder; a low-level limiter; ferrite amplifiers (at present of scientific interest, but not as practical as some of the more recent microwave diode amplifiers); plus possible application in ferrite circulators and isolators at frequencies much below those now feasible. These last two are extensions of classical applications, since there have been polycrystalline ferrite isolators and circulators around for many years.

At Airtron, other crystals are also being grown, some of which are for quite different purposes. For example, they are actively studying zinc oxide crystals and have grown some large ones. Interest in zinc oxide centers around its piezoelectric behavior. This fact is a fairly recent discovery, and several significant applications are expected, the most obvious is in delay lines at frequencies over 100

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Mc. The piezoelectric coupling coefficient (a measure of the efficiency of conversion from electrical to mechanical energy or vice versa) of zinc oxide is about four times that of quartz. Jim Nielson, who is in charge of Airtron's crystal growth program, worked with zinc oxide before this piezoelectric effect was discovered, so his lab had the ability to grow medium size ZnO crystals when this need became apparent.

Airtron has a broad capability to grown single crystal ferrites and garnet materials, using both the molten salt and floating zone techniques. Equipment includes four pot-type ovens for molten salt crystal growth, three of which have a 200 ml flask capacity, while the fourth holds a 1,200 ml container.

Temperatures in these furnaces are controlled to within ±1 C or better, at 1,250 C, while normal operating range is 600 to 1,500 C.

With this equipment a broad range of crystals can be grown including: yttrium iron garnets and substituted yttrium iron garnets; single crystal ferrites such as lithium ferrites, cobalt ferrites and nickel ferrites; magnesium iron spinels; zinc oxide; iron oxide; barium and bismuth titanates; and many others.

The crystal laboratory contains high-polish sphere grinding equipment using a refinement of the Bond technique. Final polishing is done with aluminum oxide powder which has an average grain size of 0.3 microns.

A precise statement of production capacity for this equipment depends upon the kind of material produced and the size of the crystal desired. For example, 400 grams of garnets per month can be produced, which means 1,000 70-mil spheres suitable for device use.

Guaranteed-quality single-crystal materials of yttrium iron garnet and lithium ferrite are now available from stock. YIG garnet is useful for frequency around 2,000 to 4,000 Mc, with resonance linewidth of 0.4 to 0.45 oersteds. YIG can be furnished as polished spheres, rough-ground spheres, cubes, discs, or special shapes.

The larger crystals have been made possible by changing the growth process. One big crystal can be grown by controlling the temperature distribution and using a different shape of furnace. Besides making larger crystals available for new device possibilities, the larger chunks of single crystals also produce a higher yield for smaller crystals.

Lithium ferrite crystals are of interest for frequencies between 5,000 Mc to 10,000 Mc, with linewidths down to 5 oersteds.

REFERENCE

(1) J. W. Nielson, Manager, Solid State Materials Laboratory, Airtron, a division of Litton Industries, 200 East Hanover Avenue, Morris Plains, New Jersey. Telephone: JEfferson 9-5500.

More Money Spent On Materials Programs

OVER A YEAR AGO, a committee of the National Academy of Sciences, National Research Council, recommended that the Government accord high priority to the science of materials, to the training of materials scientists and engineers, and to programs for the development of new and improved materials.[1]

Since then, the call for a materials push has been hearkened to from many quarters.

In July 1960, the Advanced Research Projects Agency, Department of Defense, announced that Cornell University, University of Pennsylvania, and Northwestern University were selected to set up vastly enlarged programs for the expansion of basic research in the science of materials[2]. This program has been further expanded with the recent announcement that five more universities will now participate. Harvard, Brown, MIT, Stanford and Chicago were awarded contracts totalling $13.4 million.

What does this program hope to accomplish? Scientific objectives lie in four active fields considered likely to lead to important electronic devices, and likely to attract an increasing number of students: magnetic and low-temperature research; semiconductors and their applications to devices; electronic materials development and preparation; and solid-state structure studies by advanced techniques.

REFERENCES

(1) Urge Materials Push, ELECTRONICS, p 84, Apr 8, 1960.
(2) Program Sets Up Materials Science Center, ELECTRONICS, p 80, July 22, 1960.

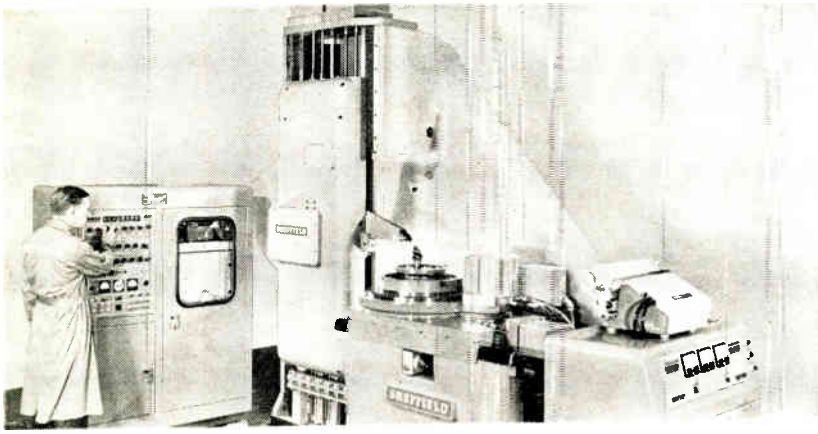
Tape Controls Precision Gaging Machine

MEASURING MACHINE, tape-controlled to automate the inspection or sizing of parts of any shape, was recently demonstrated by The Sheffield Corporation, Dayton, Ohio. The system can rapidly measure symmetrical parts such as nose cones, over a range of 20 inches in diameter and height.

The huge gage will simultaneously measure inside and outside dimensions or contours, compute wall thickness, give a visual readout of each measurement and print deviations from nominal dimensions.

It will detect dimensional variations as small as 0.00001 inch. Accuracy of wall thickness measurement, according to Sheffield, is 0.00005 inch. Electronic gaging styli can be positioned within 0.0001 inch of any point or angle in the measuring range. A typical measurement program for a nose cone, with 795 measurements plus 265 wall thickness computations, would take about two hours to complete.

There are five axes of controlled motion. The inside stylus moves vertically, the outside stylus moves horizontally and vertically, the work table moves horizontally and the work part can be rotated on the work table.



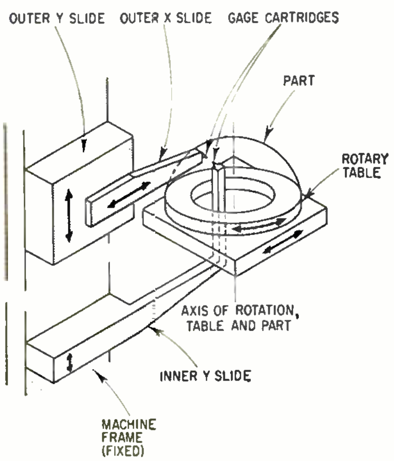
System includes control console (left), measuring machine and printer

Under numerical control, the machine will scan a plane as the part is rotated. If a deviation out of tolerance limits is detected, the machine goes into point-to-point measurements. Scanning is resumed when dimensions return within allowable limits. The machine will also measure at increments. Deviations within limits are printed in black and deviations outside limits are printed in red.

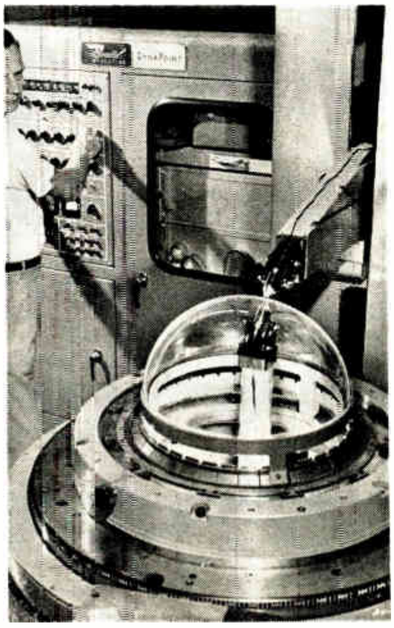
Under manual control, all the conditions can be set up manually. The operator can also explore a part of unknown dimensions. Styli slide positions are printed. The printed record can be used as the tape manuscript for reproducing the part.

Nominal dimensions of a part are used in tape-programming of workpiece and styli positions. Positioned data on the tape is translated into command signals by a Bendix Dyna Point numerical control unit. The sensing elements are slide-mounted, rotating ball Electrojet gage cartridges connected to electronic amplifiers. Positioning of machine parts is handled hydraulically by a power servo system and monitored by an independent instrument servo system.

The machine is used in a controlled-temperature cabinet or room to insure measurement accuracy and repeatability. Heat-generated support equipment is located outside the room and the hydraulic fluid is chilled to 68 F.



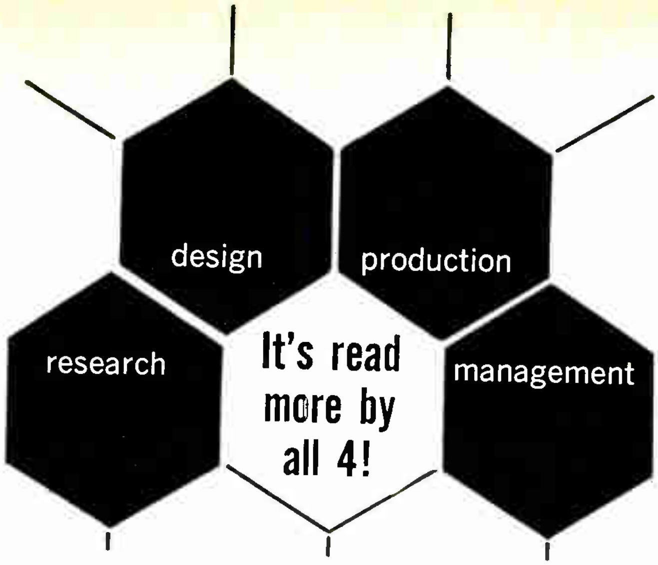
Machine parts move in five axes (arrows)



Demonstration of transparent dome measurement

Pantograph Machine Makes P-C Patterns

FREE-HAND SKETCHES are translated into one-to-one printed wiring board layout transparencies by a recently developed machine. It mechanizes the process of scribing wiring patterns on coated plastic film like Keuffel & Esser Stabilene (ELECTRONICS, p 62, Aug. 29, 1958). The



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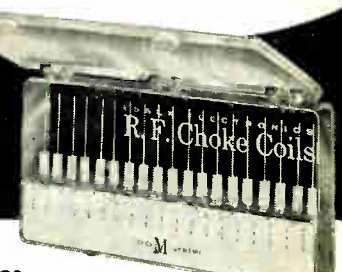

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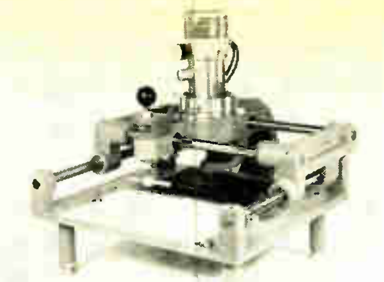


Routing tool scribes coated plastic film

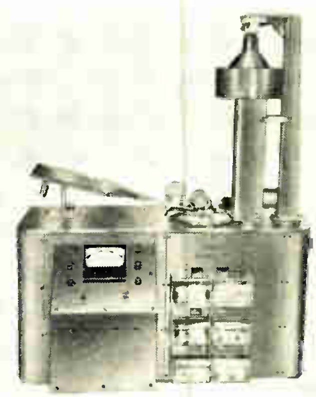
machine can also be used to drill printed wiring boards.

Operating like a pantograph drill, the machine steers a small routing tool over the film. The tool removes the film from wiring paths. Land areas are punched in the film by using another tool in the drill head.

Wiring paths are first sketched on tenth-inch-grid paper, with conductor widths, land or pad areas and other details noted. The sketch is placed on a template. The operator first guides the styles through each pad into the template, punching the holes in plastic film under the drill head. Wiring paths are then routed between holes.

The transparency can then be used as artwork for normal silk-screen or photoetch processes. The machine is made by the Special Products Division, Melpar, Inc., Falls Church, Va. The standard model handles layouts up to eight by 12 inches.

Meter Relay Sorts Photoelectric Cells



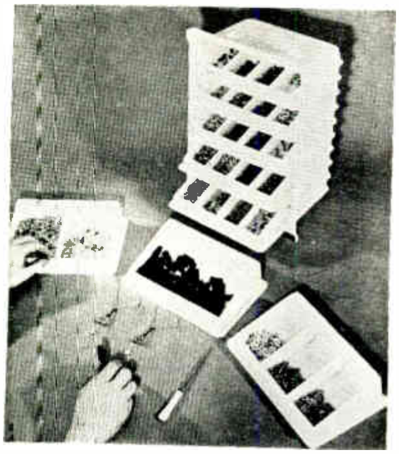
SOLAR CELLS are sorted into conversion efficiency ranges by a machine developed by the Chrysler Corp. Missile Division, Huntsville, Ala. Cells are matched within 0.5

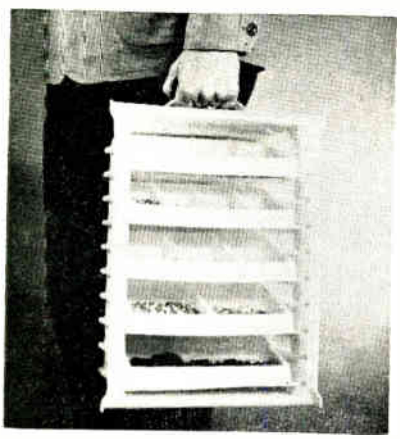
percent, in ranges of less than eight percent, 8-8.5, 8.5-9, 9-9.5, 9.5-10, and over 10 percent efficiency. Sorting rate, in the prototype model, is 12 per minute.

Cells are loaded, from a feed tray, into a test disc with four slots 90 degrees apart. At the test position, the cell is exposed to a photoflood lamp and the cell's effective output is measured by a meter relay. The meter actuates a chute-gate device and opens a receiving bin corresponding to the measured efficiency. The slots are stepped through load, test and sort positions.

Photoflood intensity is regulated and calibrated. A standard cell is used for monitoring. The meter relay is calibrated to read voltage as cell efficiency.

Plastic Bins Provide Portable Part Supply





Portable parts storage bins are handy for setting up assembly stations. The bins and carrying case illustrated are thermoformed from high density polyethylene (Grex, W. R. Grace & Co.) by Highland Products, Inc., Dover, N. J. Bins can be removed or stepped in the cabinet when parts are needed. A clear plastic front cover and handle make the cabinet a carrying case

semiconductor products news

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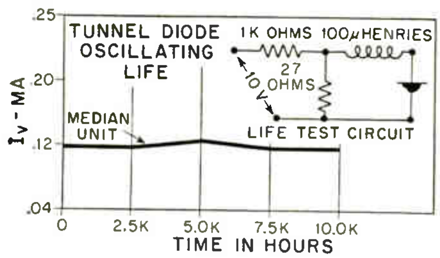
As more and more G-E germanium tunnel diodes are being designed into low level switching circuits, it becomes increasingly apparent that many design engineers prefer to determine their own electrical specifications. Your wish is our command, and a section of our manufacturing line is now exclusively utilized to "tailor make" your tunnel diodes. Example: you can choose your own specs for peak current from .25 to 250 ma. and one other important parameter, such as capacitance or peak voltage.

While you're ordering your tunnel diodes, you might be interested in another little G-E gem of reliability data, compiled on our computer-general purpose line. Twelve units were subjected to 10,000 hours of life testing . . . with virtually no degradation of characteristics. One more example from over 3 million tunnel diode hours of life testing, with truly remarkable results.



Incidentally, you can also order "A" versions of these germanium tunnel diodes, specifically designed for your fastest switching applications. You'll get speed so fast that it pushes the capability of present sampling scopes. You also get extremely tight control of the three primary requirements for switching tunnel diodes; peak point, temperature stability and switching speed.

Applications are bustin' out all over

A great deal has been written in recent months on tunnel diode usage, particularly in the UHF and microwave areas. Now that practical tunnel diode devices are available, the circuit designer has a real need for a comprehensive and authoritative survey of this information, along with a concentrated bibliography. If you'll pardon a modest bow of the head and downcast eyes, the job has been done.

Erich Gottlieb, one of G-E's top tunnel diode application engineers, has covered the field of articles and papers published over the last year on tunnel diode usage at UHF and microwave frequencies. Over 90 pages of authoritative information, this survey is divided into four main sections: Amplifiers, Oscillators, Converters and General Information. Particular attention has been paid to noise figure and gain bandwidth, and how they relate to stability.

If you have a "need to know," drop us a line to Section ***25G101*** for your free copy.

Friend Erich has also recently finished an application note of his own called "Tunnel Diode Sinewave Oscillators" that we'll be glad to send to you. And Dr. C. S. Kim has finished a "Tunnel Diode Converter Analysis." For copies of either/both, write to Section 25G101.

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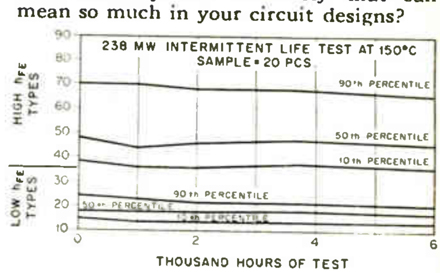
. . . that our 2N497A-498A and 2N656A-657A medium power silicon mesa transistors are indeed the industry's most thoroughly characterized and tested! You have probably seen our published 1,000 hour life tests. May we modestly bow our head again while you look over the following 6,000 hour chart, and note the long term stability and reliability that can mean so much in your circuit designs?



Footnote to the above: the "A" versions are exclusive from General Electric, have higher power with cooler operation (cool transistors are reliable transistors), low input impedance (200 ohms vs. the usual 500 means more signal gets into the transistor and more current flows out), and lower saturation resistance (10 ohms vs. the usual 25 means less power loss when you turn the unit on). How can you go wrong?

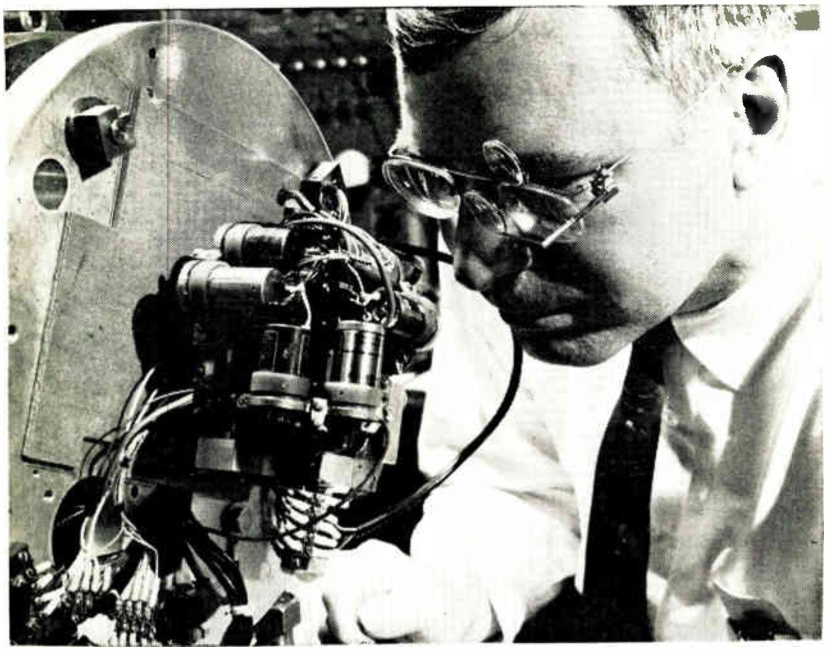
MIL types?

Can we put in a plug for USN 2N388? Phone your District Sales Manager, or buzz your G-E Semiconductor Distributor.

Semiconductor Products Department, Electronics Park, Syracuse, New York. In Canada: Canadian General Electric, 189 Dufferin St., Toronto, Ont. Export: International General Electric, 150 E. 42nd St., N.Y. 17, N.Y.

GENERAL ELECTRIC

New On The Market



Tri-Axis Accelerometer

ONE MILLIONTH TO 30 G

SPACE GUIDANCE instrument that can measure forces of one millionth to 30 times the pull of gravity in any direction has been developed by Sperry Gyroscope Co., Great Neck, N. Y.

Weighing slightly over two pounds, the accelerometer can replace a trio of single-direction accelerometers, giving a substantial weight and space saving. Equipment presently needed to integrate the information supplied by three conventional accelerometers is also eliminated.

One lightweight frame incorporates three separate accelerometer axes, thus guaranteeing alignment of the three axes.

The instrument is also suitable for surface and airborne applications where miniaturization and accurate performance are required.

CIRCLE 301 ON READER SERVICE CARD

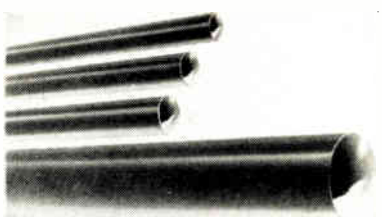
Small Trigger Tube

LOW COST; COLD CATHODE

SMALL, COLD-CATHODE trigger tube is designed for medium-speed computing and data processing applications, and in time delay, electronic relay, trigger and counter services. Tube requires no filament power or keep-alive current, stands at full sensitivity while consuming no power. Tube has radioactive material to insure operation in darkness.

Type Eii-38 tube in quantities of 1,000 is priced at $.80, at $1.50 in small quantities. Manufacturer is Electronic Industries Inc., 18 Marshall St., S. Norwalk, Conn.

CIRCLE 302 ON READER SERVICE CARD



Lapped Ruby Rods

TO 3 INCH DIAMETER

LARGE VARIETY of ruby optical masers is available for immediate delivery by Adolf Meller Co., Providence, R. I. Lapped ruby rods can be supplied in stock sizes up to 3 inches in length at 0 degrees (with C axis parallel to cylinder axis) to 2½ inches at 90 degrees orientation; and to ⅝ diameter by 7¾ inches length for standard oriented rubies. All material is slow grown, annealed for minimum strain, and guaranteed to lase. Measurements as low as 0.18 wave numbers have been registered; orientation within 1 degree; flatness ¼ wave or better; parallelism 6 seconds of arc. Doping is 0.04 percent chrome by weight, with nine other dopings available. Rubies can be supplied with polished diameters.

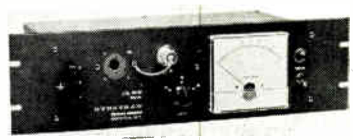
CIRCLE 303 ON READER SERVICE CARD

Transistor Test Set

MEASURES $r_b'C_c$

DIRECT READING instrument is suited for laboratory, production testing and incoming inspection of mesa, surface barrier and drift transistors.

Model 1824 provides direct readings of the $r_b'C_c$ product, with range of $r_b'C_c$=0 to 30, 0 to 100 and 0 to 300 picosec; error in measurement is 5 percent. Instrument accommodates both long and short lead transistors. Three terminals on front panel are for emitter current and collector voltage biasing; bias supplies are not included. The transistor test socket is wired for grounded base biasing. Size: 5¼ high × 19 wide × 8 inches deep. Price is $590, with delivery in 30 to 60 days, from Dynatran Electronics Corp., 178 Herricks Rd., Mineola, N. Y.



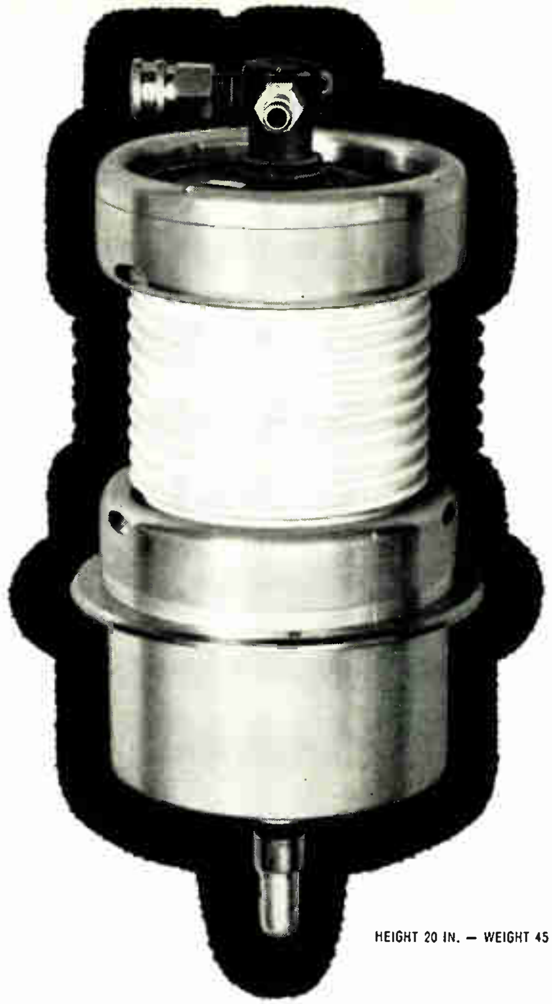
CIRCLE 304 ON READER SERVICE CARD

Minuteman Transistors

MILITARY APPLICATIONS

RELIABLE mesa switching and amplifier transistors, developed specifically for the Air Force Minuteman missile, are now available for other critical military applications. Two transistor types are available immediately in production quantities to qualified firms.

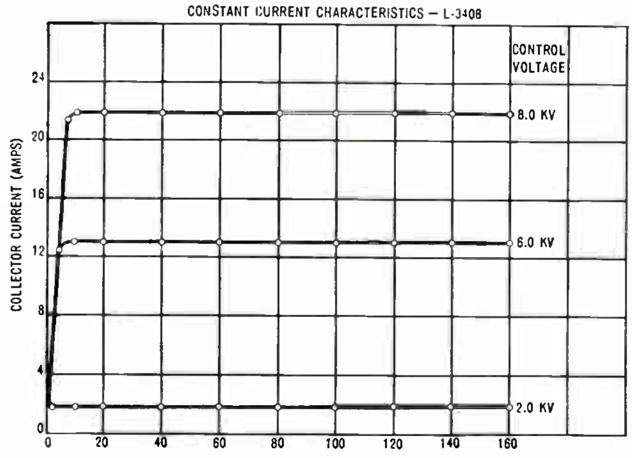
Reliability goal for transistors used in the project is a (guaranteed) failure rate of less than



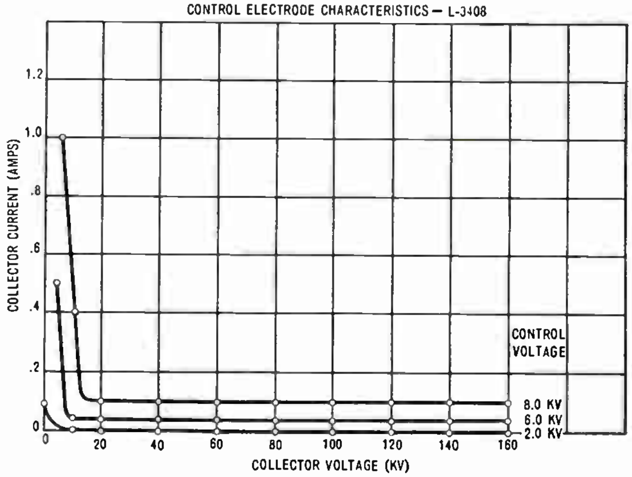
HEIGHT 20 IN. — WEIGHT 45 LBS.

NEW LITTON INJECTRON* HOLDS OFF 150 KV, SWITCHES 20 AMPS

CONSTANT CURRENT CHARACTERISTICS — L-3408



CONTROL ELECTRODE CHARACTERISTICS — L-3408



*An advanced concept by Litton for high power beam switching with high efficiency and fast rise time. Requires only low control voltages. Collector current is largely independent of collector voltage, resulting in pentode-like current characteristics. Ideal for floating deck modulators for switching modulating anode klystrons. L-3408 is in field operation now. Other models for cathode switching to 750 amps, 350 KV coming soon. *Contact us at San Carlos, California, for more information.*

LITTON INDUSTRIES

Electron Tube Division

MICROWAVE TUBES AND DISPLAY DEVICES

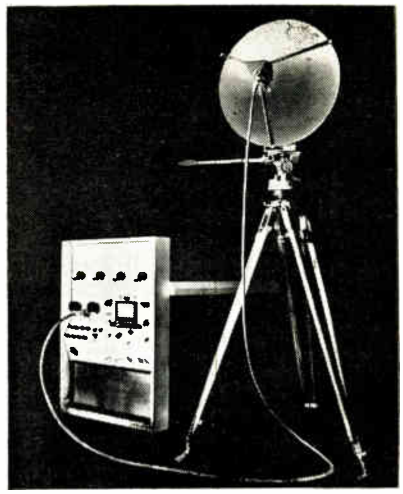
0.0007 percent per thousand hours. While analysis of data is not complete, preliminary studies indicate the objective has been attained.

The 101 is a high-speed germanium mesa computer transistor with a current-gain-bandwidth produce of 350 Mc. The 101B is furnished with all test data; the identical 101A is available without substantiating data, at reduced cost.

Type 201 is for amplifier applications, is also available with and without substantiating data.

Both transistors are available in 100-up quantities from Motorola Semiconductor Products Inc., Phoenix, Ariz.

CIRCLE 305 ON READER SERVICE CARD



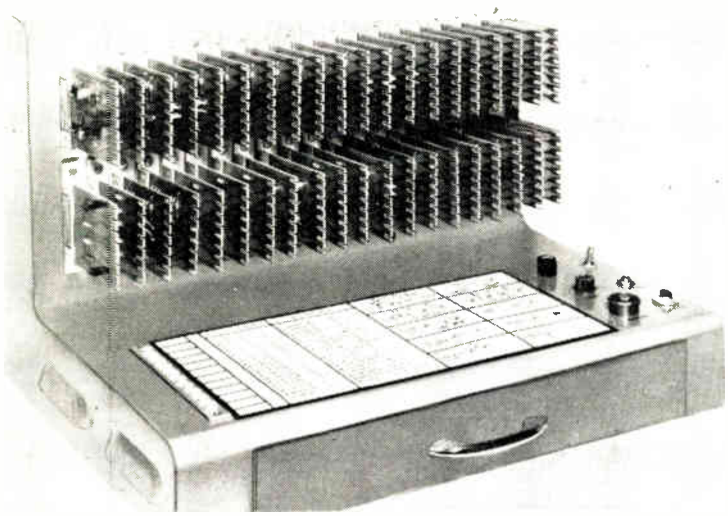
R-F Interference Set

1 TO 10 GC RANGE

INTERFERENCE-FIELD intensity measuring equipment is a sensitive, frequency selective, calibrated microvoltmeter and receiver covering 1 to 10 Gc. It analyzes and monitors all conducted and radiated r-f energy within the frequency range. Model NM-62A meets the requirements of all military services.

Features include: instant band switching and automatic tuner selection; automatic frequency scanning; X-Y plotter output; video output; 60 Mc i-f output; switch for field intensity, quasipeak, direct-reading peak or slideback peak measurements. Oscillator radiation is less than 290 picowatts (120 mv); shielding effectiveness is 70 db. Pick-up devices include four horn-antennas and one broadband discone. Price is $17,750—less antennas—with delivery in April, 1962. Manufacturer is Stoddart Aircraft Co., 6644 Santa Monica Blvd., Hollywood 38, Calif.

CIRCLE 308 ON READER SERVICE CARD

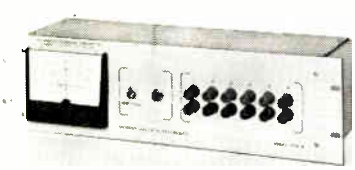


Digital Breadboarding Console

VARIETY OF NETWORKS

LOW-COST DIGITAL breadboarding and training console is self-contained, fully assembled with from 30 to 40 DigiBits—transistorized digital elements—a complete complement of controls including manual pulser, manual reset, external pulse input, clock frequency selector switch, indicator lights, power supply and slide-on interconnecting jumpers. Design features include rapid network assembly (decade counter in 5 to 10 minutes) and solderless interelement connections. Price of the 30 package DigiLab with two clock frequencies and 1-amp power supply is $755; 40 package unit with five clock frequencies is $895. Delivery after Sept. 1 is from 2 to 4 weeks, from Tech Serv Inc., 4911 College Ave., College Park, Md.

CIRCLE 306 ON READER SERVICE CARD



Primary Voltage Reference

GUARANTEED STABILITY

SOLID STATE, primary voltage reference has guaranteed stability of 2 ppm per 3 months and 3 ppm per year. Model PVR-6 uses precision Zener references; calibration accuracy is 0.0015 percent. Tests prove the stability of the reference may be equal to or better than the stability of the saturated cell (temperature controlled). Priced at $3,850, the reference is accompanied with readings showing stability for 3 months. Manufacturer is Calibration Standards Corp., 1025 Westminster Ave., Alhambra, Calif.

CIRCLE 307 ON READER SERVICE CARD

Core Tester

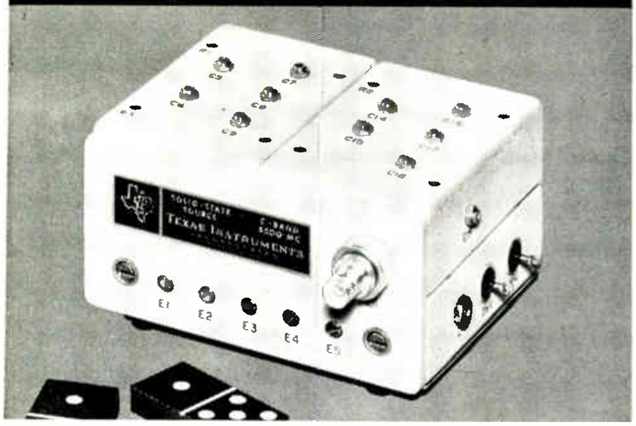
COMPACT UNIT

MAGNETICS INC., Butler, Pa. Model D constant current flux reset tester, used for production testing of tape wound cores for magnetic amplifiers, operates from 115 v a-c, 60 cps, with no other power supply needed. It is capable of testing according to procedures defined by AIEE, in frequencies of 60, 400, and 1,600 cps.

CIRCLE 309 ON READER SERVICE CARD

NEW...SOLID-STATE MICROWAVE SOURCES

from 30 mc to 10 kmc!



REPLACE KLYSTRONS IN FIXED-FREQUENCY APPLICATIONS!

Solid-state microwave sources from Texas Instruments now give you a small, light-weight, reliable means of generating crystal-controlled, low-power microwave signals. Designed with TI XD-500 gallium arsenide diodes, these devices can be used wherever reliable, fixed-frequency, r-f sources are needed; for example, local oscillators, parametric amplifier pumps, higher frequency telemetry transmitters, microwave transmitter exciters, laboratory and portable field test signal generators and frequency standards, and phase-locked oscillators. Modular construction lets you add new frequencies by "stacking," or modify frequencies by changing multiplier units. Sources for your special needs can be supplied by modifying standard TI designs.

TYPICAL SOLID-STATE SOURCE CHARACTERISTICS	
frequency accuracy	Crystal, Standard models 0.005%
frequency stability	0.005%
band pass	1% to 5% up to 3 kmc Less than 1% above 3 kmc
spurious frequencies	Down 30-40 db
output impedance	50 ohms
primary power requirements	28 v dc positive; power requirements, 1-20 watts depending on frequency and power output; 28 v regulated power supply operating from 115 v 60 cps or 400 cps can be provided.

Harmonic generators — to frequency multiply existing power outputs to frequencies as high as 20 kmc — are also available. For details on TI's Solid-state microwave sources and harmonic generators, write for Bulletin No. DLA-1218. For information on other microwave devices contact MARKETING DEPARTMENT.

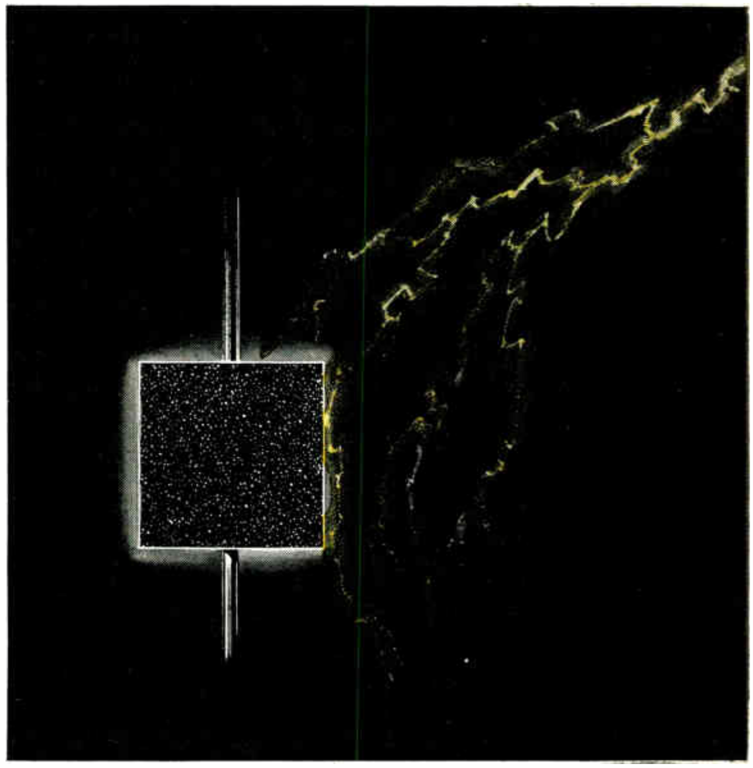
APPARATUS DIVISION

TEXAS INSTRUMENTS INCORPORATED

P. O. BOX 6015 DALLAS 22, TEXAS

CIRCLE 204 ON READER SERVICE CARD

"Black CRYSTOLON*" grain



...crystals that master lightning

Often referred to as "Black CRYSTOLON", Norton E 179 CRYSTOLON Electrical Grade silicon carbide grain is widely used in lightning arrestors — and in a steadily increasing variety of other nonlinear resistor applications in the electrical-electronics field.

These applications include protection of coils from overvoltage, protection of relay contacts, and general voltage stabilization . . . with voltage or surge control requirements ranging from thousands of amps to microamps . . . in resistors ranging in volume from thick arrestor blocks to paper-thin varistors.

To control its semiconduction properties, E 179 differs from regular CRYSTOLON silicon carbide grain by the addition of alumina. But the most important control of E 179 is constant control through each step of manufacture, from electric furnace to shipping drum. Accurate, duplicable grain impedance (resistivity) is assured by careful furnacing, grain processing, sizing, blending and surge testing.

In loose pack or ceramic bonded form, E 179 CRYSTOLON grain has the nonlinear current-voltage relation $I = AE^n$, where "A" and "n" are constants. For loose grain "n" may be as high as 10; for bonded grain it is usually between 3 and 7.

For surge tests, standard 280 ampere pulses are passed through a column of compressed E 179 CRYSTOLON grain, 1″ diameter x 1″ long. Voltage across the cell is measured in kilovolts per inch. E 179 CRYSTOLON grain is available in sizes of 60 to 240 mesh, covering a surge test range of 1.6 to 13.0 KV/inch.

For further facts, contact NORTON COMPANY, Refractories Division, 686 New Bond Street, Worcester, Mass.

*Trade Mark Reg. U. S. Pat. Off. and Foreign Countries.

NORTON REFRACTORIES

Crystallizing ideas into products

CIRCLE 81 ON READER SERVICE CARD

PRODUCT BRIEFS

STATIC INVERTER transistorized. American Electronics, Inc., 1598 E. Ross Ave., Fullerton, Calif. (310)

SERVO AMPLIFIER solid state. Electromation Co., 4254 Glencoe Ave., Venice, Calif. (311)

OSCILLOSCOPE high sensitivity. Allen B. DuMont Lab., 750 Bloomfield Ave., Clifton, N. J. (312)

PRESSURE TRANSDUCER low-range. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. (313)

MODULAR RECEIVER phase lock. Smyth Research, 3555 Aero Court, San Diego 11, Calif. (314)

UNIVERSAL MOTOR for Mil Spec uses. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio. (315)

ELECTRONIC TIMER instant reset. The Pioneer Electric & Research Corp., 743 Circle Ave., Forest Park, Ill. (316)

WAVEGUIDE ARC DETECTOR optical sensing. FXR, Inc., 25-26 50th St., Woodside 77, N. Y. (317)

TELEMETRY FILTERS epoxy encapsulated. Key Resistor Corp., Gardena, Calif. (318)

VACUUM FURNACES cold wall. Geophysics Corp. of America, Bedford, Mass. (319)

MEASURING SET junction capacitance. Summers and Mills, 1511 Levee St., Dallas 7, Texas. (320)

LINEAR ACTUATOR uniform long stroke. Skinner Precision Industries, New Britain, Conn. (321)

COMPACT OSCILLOSCOPE many applications. National Union Electric Corp., Bloomington, Ill. (322)

RELAY RECEPTACLE for plug-ins. Precision Connectors Inc., P.O. Box 96, Mineola, L. I., N. Y. (323)

EXTENSIBLE-RETRACTABLE CABLES 1 to 1,000 conductors. Spectra-Strip Wire & Cable Corp., P.O. Box 415, Garden Grove, Calif. (324)

TELEMETERING TRANSMITTER for medical research. Sage Instruments, Inc., 9 Bank St., White Plains, N. Y. (325)

Literature of the Week

A-C CAPACITORS General Electric Co., Schenectady 5, N.Y. Publication GEZ-3305, four pages, illustrated, gives information on h-v capacitors rated 0.25 through 17.0 μf, 1,000-2,600 v a-c. **(326)**

CONNECTORS Hermetic Seal Corp., 4232 Temple City Blvd., Rosemead, Calif. A three-color, four-page brochure describes representative models of the Atlas line of high reliability plastic molded rack and panel connectors. **(327)**

D-C AMPLIFIER Microdot Inc., 220 Pasadena Ave., S. Pasadena, Calif. A small, solid state direct-coupled differential input d-c amplifier for rugged environments is described in bulletin DCA-1. **(328)**

MICROWAVE WAVEGUIDE FILTERS Microwave Development Laboratories, Inc., 15 Strathmore Rd., Natick, Mass. Catalog No. FP61 provides detailed electrical data including band pass and insertion loss on a series of standard waveguide filter designs. **(329)**

DIGITAL INSTRUMENTS & SYSTEMS Erie-Pacific, Div. of Erie Resistor Corp., 12932 S. Weber Way, Hawthorne, Calif. A short form catalog illustrates and describes electronic counters, digital instruments, interval timers and digital control systems. **(330)**

SYNCHROS Vernitron Corp., 125 Old Country Road, Carle Place, L.I., N.Y., has published data sheet CS/TS-4-11-1 to aid in the rapid and correct selection of size 11 control and torque synchros for servo applications. **(331)**

INSTRUMENTS & COMPONENTS Alford Mfg. Co., 299 Atlantic Ave., Boston 10, Mass. Catalog SH-61 describes the company's r-f instrument and coaxial components. **(332)**

CRYOGENIC DATA Cryogenic Engineering Co., 200 W. 48th Ave., Denver 16, Colo., has published a cryogenic data card bringing together data from almost 100 sources into a simple reference card. **(333)**

AUTOMATION SERVICES McDonell Aircraft Corp., P.O. Box 516, St. Louis 66, Mo. A 21-page brochure outlines the scope of the company's consulting, systems design, programming and data processing functions. **(334)**

ANTENNAS & ACCESSORIES Prodelin, Inc., 307 Bergen Ave., Kearny, N.J. Catalog 598 describes a complete line of 2-way antennas and accessories. **(335)**

DYNAMIC RADAR SIMULATORS Remanco, Inc., 1805 Colorado Ave., Santa Monica, Calif. Four-page brochure tells the reasons for dynamic testing of radar, what it is and what it can do. **(336)**

VARIABLE RESISTOR CTS of Berne, Inc., Berne, Ind. An advance data sheet details technical specifications on an insulated miniature preset wirewound variable resistor. **(337)**

MICROWAVE ANTENNAS Technical Appliance Corp., Sherburne, N.Y. Complete technical data on a wide range of spun and mesh microwave antennas are found in catalog No. 100. **(338)**

MICROWAVE INSTRUMENTATION Wave Particle, 150 South Second St., Richmond, Calif. A short form catalog pictures and describes the firm's microwave signal sources, levelers, amplifiers, low-noise amplifiers, and power supplies. **(339)**

TELEMETRY ANTENNAS Andrew Corp., P. O. Box 807, Chicago 42, Ill., has published a catalog covering over 30 antennas for missile guidance, tracking and telemetry operations. **(340)**

AMPLIFIERS Lel, Inc., 75 Akron St., Copiague, N.Y. A 48-page catalog covers a line of microwave receiver mixer-preamplifiers, parametric amplifiers, and laboratory receivers. **(341)**

D-C POWER SUPPLY Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif., has issued a 2-page bulletin describing a d-c power supply designed for solid state computer and other digital system applications. **(342)**

PRESSURE POTENTIOMETERS Trans-Sonics, Inc., P.O. Box 328, Lexington 73, Mass. A complete line of miniaturized pressure potentiometers is described in technical bulletin 1045. **(343)**

Technical Research Group Adds Plant

ALAN F. KAY, vice president of Technical Research Group, Inc., Somerville, Mass., announces the purchase of a new plant in nearby East Boston. The new 25,000-sq-ft facility, in addition to the present Somerville location, will be used by the antenna and microwave department. Alan Simmons, manager of the department, reports the division doubled its sales volume in the last year.

The antenna and microwave department of TRG has been engaged in antenna research and prototype production since 1953, and in research and production of millimeter microwave components since 1957. The new plant will be used for large precision antenna and microwave projects.

Corporate headquarters of TRG are situated in Syosset, Long Island, N. Y., where other fields of activity include radio and optical frequency spectroscopy, and navigational and simulation equipment and systems.

The East Boston facility features a 60-ft by 160-ft antenna erection and test area; 10-ton bridge crane; truck and dockside shiploading facilities; 34-ft stud height; controlled heating throughout, which is important for precision fabrication.

Gerald Brown has been appointed general manager of the new facility. He was formerly chief engineer of the Diamond Antenna & Microwave Corp. and also was with the Gabriel Electronics division of the Gabriel Corp. Bruno Pawlowski has been named chief engineer. He had been chief engineer and engineering marketing manager at Gabriel.

Malech Takes Post At Dorne & Margolin

ROBERT MALECH has been appointed head of the advanced antenna development section of Dorne & Margolin, Inc., Westbury, N. Y. In this capacity he will be responsible for the development of new basic approaches for antenna systems and components.

Malech was formerly head of the microwave systems group and senior project member at Radio Corp. of America, serving as consultant to RCA facilities at Camden and Moorestown, N. J. (BMEWS).

Philco Corp. Forms Microelectronics Dept.

THE LANSDALE DIVISION of Philco Corp. has announced the formation of a new microelectronics department for the development, manufacture and marketing of highly miniaturized semiconductor circuits, and with it three personnel appointments.

William F. Long, former manager of marketing research for the division, has been named to head the new department.

John Roschen, section manager of the division's semiconductor R&D laboratories, has been designated to supervise device development.

Richard Wagner, formerly specialist on pilot production for the division's R&D laboratories, was appointed production manager.

Boggs Moves Up To R&D Director

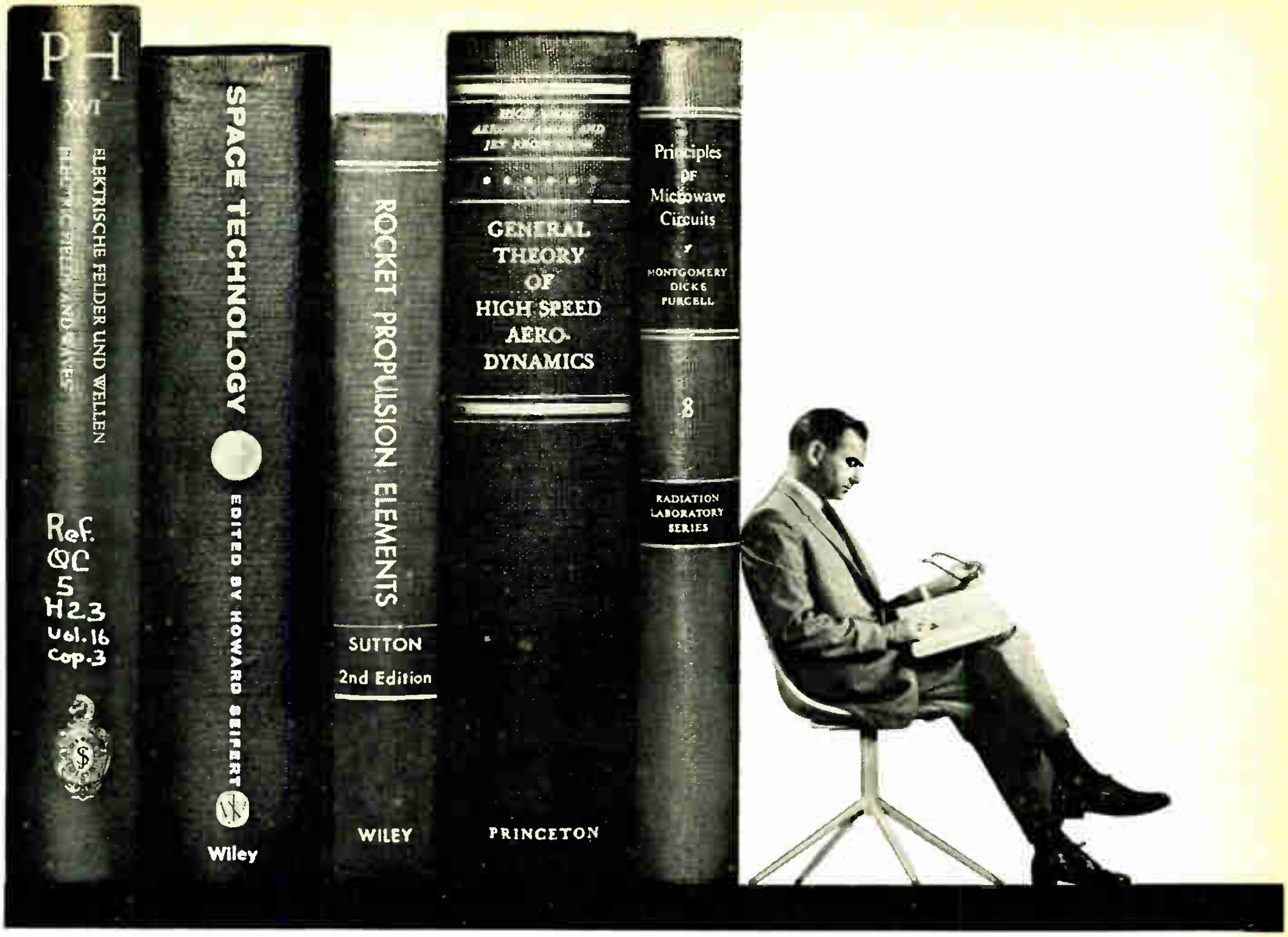
APPOINTMENT of Gail E. Boggs as director of research and development at Page Communications Engineers, Inc., Washington, D. C., is announced.

Formerly an assistant director of R&D, Boggs joined the company in 1956. Since that time, he has been engaged in system design studies on the potential use of both active and passive satellites for reliable long distance communications including consideration of satellite detection and tracking problems.

Fairchild Camera Appoints Levine

TO MEET the increasing need for technical planning and coordination at the corporate level, Samuel W. Levine has been appointed to the newly created post of technical assistant to the president's office at Fairchild Camera and Instrument Corp., Syosset, N. Y. He has been with Fairchild since 1953.

In his new position, Levine will be responsible for the review and coordination of technical develop-



scientists and engineers in a unique leadership role

The frontiers of space science and technology are being expanded at Aerospace Corporation. The scientists and engineers of this leadership organization are the critical civilian link uniting government and the scientific-industrial team developing space systems and advanced ballistic missiles. In providing broad scientific and technical leadership to every element of this team, they are engaged in a balanced program of activities spanning the spectrum from basic research and forward planning through general systems engineering. Included in the latter are technical supervision, integration and review of the engineering, development and test operations of industry to the extent necessary to assure achievement of system concept and objectives in an economical and timely manner. These people are privileged to view both the state-of-the-art and system development in their totality. Now more men of superior ability are needed: highly motivated scientists and engineers with demonstrated achievement, maturity, and judgment, beyond the norm. Such men are urged to contact Aerospace Corporation, Room 110, P. O. Box 95081, Los Angeles 45, California.

Organized in the public interest and dedicated to providing objective leadership in the advancement and application of space science and technology for the United States Government.

AEROSPACE CORPORATION

ment programs that are jointly sponsored by two or more divisions of the corporation. In addition, he will aid in the evaluation of R&D programs currently underway and planned in all Fairchild divisions. He will also be concerned with the appraisal of the technical capabilities of companies being considered for acquisition.

LaHiff Joins DCA As Divisional Head

DYNAMICS CORP. OF AMERICA announces the appointment of William J. LaHiff as general manager of its Farmingdale Division (at Farmingdale, N. J.), a development and manufacturing facility added recently to accommodate expanded DCA production in the fields of broadcasting and communications equipment, transformers, and electronic medical instruments.

He was previously sales manager in charge of research and development for Budd Electronics Co.

Transitron Promotes William E. Slusher

TRANSITRON ELECTRONIC CORP., Wakefield, Mass., has promoted William E. Slusher to the newly-created position of director of electronics for the semiconductor firm. Reporting directly to the president, he will have direct responsibility for three departments: applications, evaluations and life tests.

Slusher has been associated with Transitron for seven years.

Willenbrock Accepts Sperry Research Post

F. KARL WILLENBROCK, associate dean of engineering and applied physics at Harvard U., has been appointed senior consultant of the Sperry Rand Research Center in Sudbury, Mass. He is also acting as research director during the summer university recess and will return to Harvard in the fall.

PEOPLE IN BRIEF

Thomas E. Holland of Beckman & Whitley, Inc., accepts the post of corporate vice president for research and engineering. *Dean C. Smith*, formerly with Thor Power Tool Co., joins Oak Manufacturing Co. as vice president of manufacturing. *J. F. Clayton* moves up to staff engineer, weapon systems, at the Bendix Corp. *Gus J. Smyrnos*, ex-General Electric, joins the engineering staff of Lynch Communication Systems. *Harold E. Felix* transfers from Douglas Aircraft to Midwestern Instruments as vice president and director of engineering. *Ira Kamen*, previously with Portland Industries Corp., chosen executive vice president of Teleglobe Pay-TV System, Inc. *Homer J. Stewart*, aeronautics professor at California Institute of Technology, elected to the board of directors of Bogue Electric Manufacturing Co. *Edgar G. Grant* promoted to director of new product planning by the military electronics division of Daystrom, Inc. *John Strella* leaves Republic Aviation Corp. to become a senior member of Auerbach Electronics' technical staff. *James L. Palmer*, formerly with Litton Industries, joins the research and development dept., Huggins Laboratories, as director of research. *Howard Hamer*, ex-Electronic Measurements Co., appointed president and chief engineer of Howard Instrument Co.

EMPLOYMENT OPPORTUNITIES

electronics

WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

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

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

STRICTLY CONFIDENTIAL

Your Qualification form will be handled as "Strictly Confidential" by ELECTRONICS. Our processing system is such that your form will be forwarded within 24 hours to the proper executives in the companies you select. You will be contacted at your home by the interested companies.

WHAT TO DO

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

COMPANY	SEE PAGE	KEY #
ARMOUR RESEARCH FOUNDATION Illinois Institute of Technology Chicago, Illinois	42*	1
THE BOEING COMPANY Seattle, Washington	17-18	2
CENTRAL RESISTOR CORP. Addison, Illinois	90	3
CORNELL ASSOCIATES, INC. Chicago, Illinois	90	4
ESQUIRE PERSONNEL Chicago, Illinois	90	5
THE GARRETT CORPORATION AiResearch Manufacturing Division Los Angeles, California	90	6
LOCKHEED California Div. Burbank, California	111*	7
MONARCH PERSONNEL Chicago, Illinois	90	8
REPUBLIC AVIATION Farmingdale, L. I., New York	89	9
WLAC-TV INC. Nashville, Tenn.	115*	10

* These advertisements appeared in the 7/21/61 issue.

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electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME ....

HOME ADDRESS..

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

HOME TELEPHONE..

Education

PROFESSIONAL DEGREE(S)..

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check)

7281

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

CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines.

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

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

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