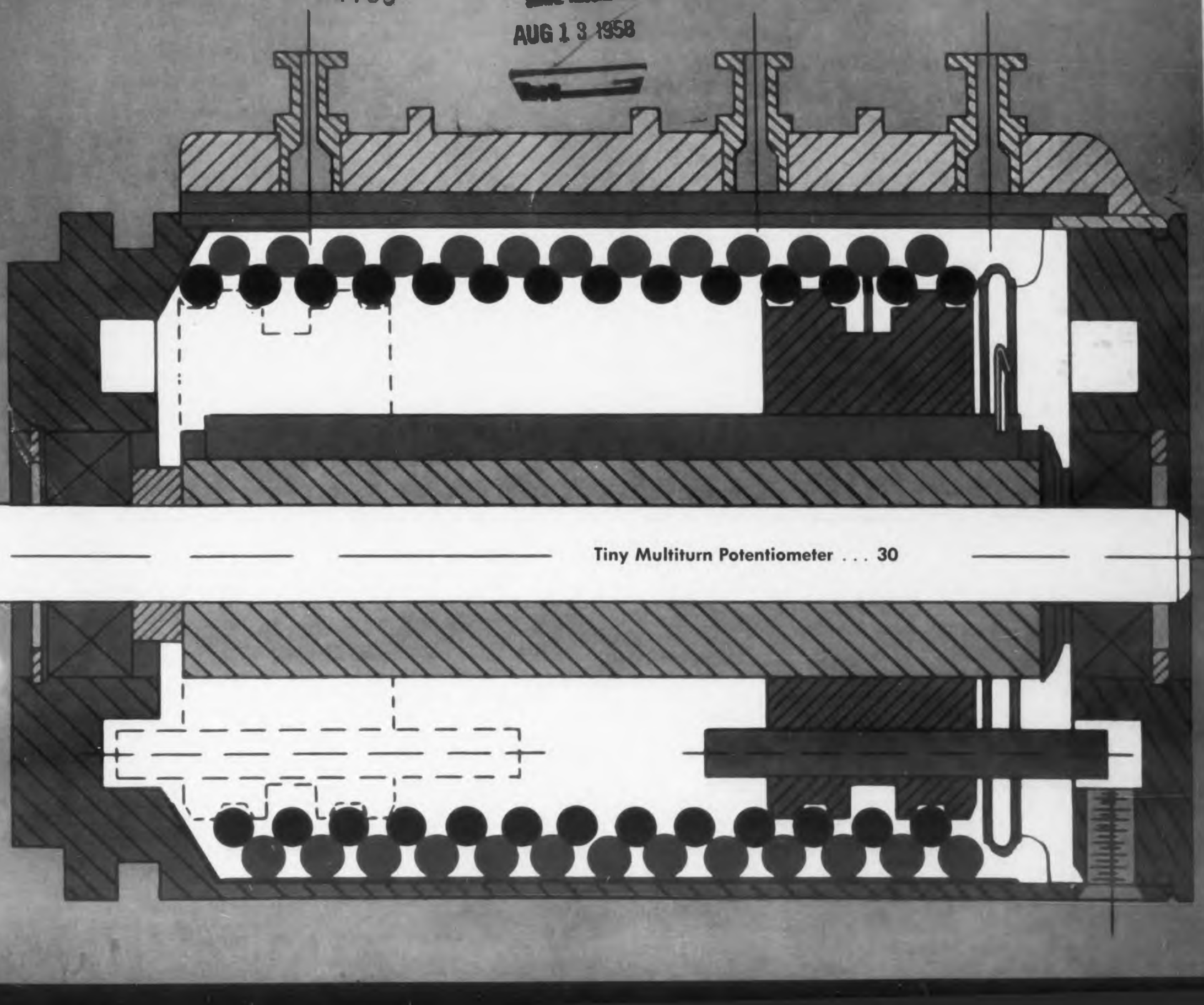
July 23, 1958

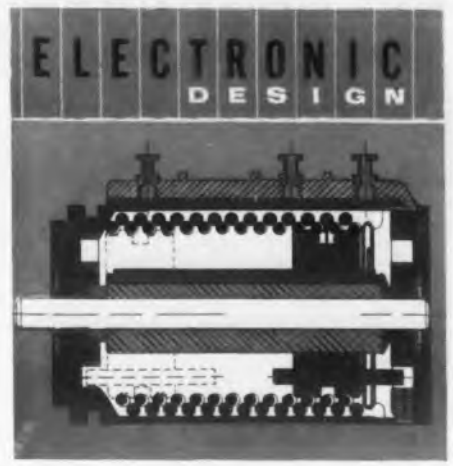
ELECTRONIC DESIGN

AUGUST 6, 1958



Tiny Multiturn Potentiometer . . . 30

HIGHLIGHTS OF ISSUE



August 6, 1958 Vol. 6
Number
16

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Hayden Publishing Co., Inc., 830 Third Avenue, New York 22, N.Y.

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ELECTRONIC DESIGN is published bi-weekly by Hayden Publishing Company, Inc., 830 Third Avenue, New York 22, N. Y., T. Richard Gascoigne, President; James S. Mulholland Jr., Vice-President & Treasurer; and David B. Landis, Secretary. Printed at Hildreth Press, Bristol, Conn. Accepted under section 34.64, P. L. & R. authorized. Additional entry, New York, N. Y. 30,000 copies this issue.

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ENGINEERING REVIEW

For more information on developments, described in "Engineering Review," write to the address given in the individual item.

Jupiter IRBM Re-entry

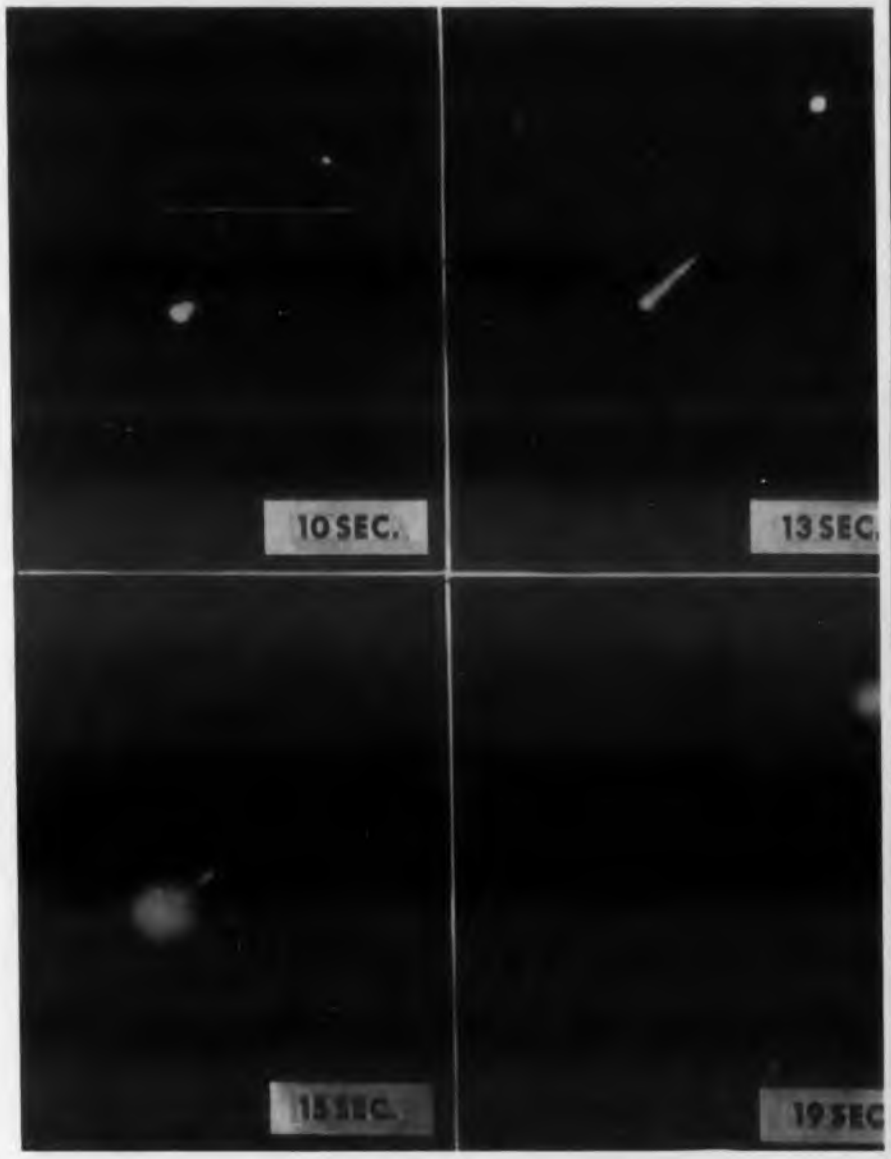
Photographs of the spectacular re-entry into the Earth's atmosphere of the Jupiter IRBM were recently released.

This missile firing marked the first successful recovery of a full-scale Jupiter nose cone.

These pictures were taken as part of "Operation Gaslight," the armed forces project for investigating the physics associated with the re-entry of the Jupiter missile.

Photographs showed that, within seconds after the first re-entry light was observed, the phenomena had blossomed into three distinct objects. The brightest object, which resembled a huge magnesium flare, was assumed to be the booster (rocket body). The light emitted by this object definitely pulsated. At one time, the object's trajectory was nearly in line with the planet Jupiter, and was estimated to be at least 1000 times brighter.

(Continued on following page)



First photographs ever released of the re-entry of the Jupiter IRBM into the earth's atmosphere. At 19 seconds, the instrument package (out of picture) has completely burned out, and the distance between the nose cone and rocket body increases rapidly.

Spectral Meteor Camera was one of the major instruments used in "Operation Gaslight." It is made up of a cluster of six-F-8 Aerial Cameras equipped with spectral gratings and arranged so as to afford a panoramic view of a large portion of the sky. This meteor camera is shown mounted on the 5 in. guns of the USS Stickell.

Radiometer is one of the instruments used to measure the radiation from the Jupiter IRBM as it re-entered the atmosphere.

ENGINEERING REVIEW

The second brightest visual object was assumed to be the instrument compartment. The trajectory of the instrument compartment during its burning stage was much shorter than the booster and nose cone. During the last few seconds of the visible flight, the booster and nose cone moved behind a large cumulus cloud to the south of the USS Stickell. The radiation was so intense that the whole cloud was illuminated.

Barnes Engineering Co., Stamford, Conn. performed spectral and radiometric measurements on the re-entering bodies of the missile.

Colleges To Get Nuclear Reactor Simulators

Four Universities will be supplied with nuclear reactor simulators by Minneapolis-Honeywell Regulator Co. The schools—University of West Virginia, University of Minnesota, University of Oklahoma, and Wayne State University in Detroit—will use the simulators to train prospective nuclear engineers in all phases of reactor operation. Incorporating a working full-scale model of an automatic control system for power and research reactors, the simulator also features an electronic computer circuit which recreates reactor operational characteristics.

With the simulator, electrical signals can be generated similar to those obtained from sensing elements in a nuclear reactor. Interchangeable plug-in circuitry permits simulations of either U-235, U-233, or plutonium fuel. The simulated signals are amplified, recorded, and automatically controlled with the same instruments used on real reactors. The control system has a control permit circuit that prevents switching to automatic control unless the power level is within 10 per cent of the control setting. Range of the simulator is 0 to 150 per cent of reactor design power.

◄ CIRCLE 4 ON READER-SERVICE CARD

Tilted Underwear—Origin of Telemetering?

Demonstration of imaginative historical research into the origination of telemetering caught our attention at the National Telemetering Conference held recently. Gen. Earle F. Cook, US Army Signal Corps R & D Chief, explained: "It winds back to a Carthaginian officer in 200 BC, who fell upon the science when his orderly laundered his fighting undergarments one night and hung them out to dry. Next morning at dawn, the officer peered from his tent and observed a blustery wind blowing them mightily on the line. Taking a look at the vectors at work, he promptly decided his course of action. 'To hell with it,' he said, 'I'm not going out to fight today.' And don't think it was in the least empirical—the force and angle of wind components lifted the before-mentioned underpants in a true sin-and-cos relation, with relative humidity disclosed by extrapolation-in-reverse from the time of laundering. Ergo: in early warfare man deduced the parameters of weather from a comfortable distance—increase of said comfortable distance being something the science has been after ever since."

Inchworm

Installation at Torrington Needle Bearing plant controls centerless grinding operations to consistent accuracy within a tolerance of 50 millionth of an inch. The motor, manufactured by Airborne Instruments Laboratory, Mineola, N.Y., is a linear actuator which replaces the lead-screw in mechanisms requiring micro-inch dimensional controls. "Inchworm" operations are push-button controlled.

ENGINEERING REVIEW

The new IBM 88 Collator, a high-speed card filing machine, arranges punched cards in any desired sequence at rates of up to 1300 cards per min.

New Filing Machine Arranges Punched Card Sequence Rapidly

Punched cards may be arranged in any desired sequence at speeds better than two and one-half times faster than its predecessors by a new card filing machine.

Principal function of the new IBM 88 Collator is to compare two files of punched cards simultaneously in order that the cards can be matched, merged, selected, and sequence-checked for subsequent accounting operations. With the device, cards are entered into the machine from card feeding devices at each end. The primary or main feed consists of a file feed device that can hold up to 3600 cards, and the secondary feed is a conventional card hopper. Cards enter from each feed device at the rate of 650 per min., so that with both feeds in use, up to 1300 cards per min can be processed.

One major feature of the Collator is its non-stop stackers which enable the operator to remove cards from any of the five card pockets without the need for stopping the machine and with no danger of card jams. Other features are the error detection circuits which guard against double punches and blank columns on the card record, and the sequence-checking units built into the card feeding devices, enabling the IBM 88 to perform identical or completely different operations in each feed at the same time.

CIRCLE 523 ON READER-SERVICE CARD

ANATHERM can be used at any hottest-spot temperature over the range of 105°C to 155°C. It can save you money . . . *and* save you space.

More horsepower per pound—it's yours with 155°C Anatherm

First polyester high temperature enamel magnet wire available in complete range of sizes—round, square, rectangular.

Of course you don't fry eggs on them, but motors are being run hotter today. These higher operating temperatures can put you on a *hot spot* with your customers—if motors fail.

Solution: Anaconda Anatherm Magnet Wire. Anatherm is a new polyester film-coated wire—fully tested for use at "hottest spot" temperatures up to 155°C. With this new higher level of thermal stability, Anaconda Anatherm is the first film-coated wire to meet the newly adopted 155°C (AIEE Class F) rating!

Greater thermal stability—plus excellent abrasion-resistance, chemical stability and dielectric strength—make Anatherm ideally suited for a variety of applications. It's especially practical where maximum performance and reliability are required from smaller equipment operating at higher temperatures.

As a polyester magnet wire, Anatherm can be used equally successfully at any hottest-spot temperature from 105°C to 155°C.

Available in standard film-thickness of round wires, sizes 8 to 46, inclusive, and in a full range of sizes of square and rectangular wires. For more information, see the Man from Anaconda. See "Anaconda" in your phone book—in most principal cities—or write: Anaconda Wire & Cable Co., 25 Broadway, N. Y. 4, N. Y.

58661

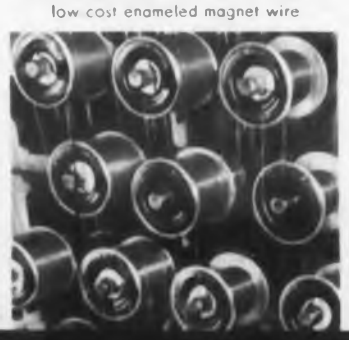
ASK THE MAN FROM ANACONDA® *ABOUT* **ANATHERM MAGNET WIRE**

For you, Anatherm can mean smaller electrical equipment . . . higher operating temperatures. See details on reverse side—

ANALAC 105°C (AIEE Class A) solderable magnet wire

VITROTEX 130°C (AIEE Class B) glass-insulated, high heat resistance

PLAIN ENAMEL 105°C (AIEE Class A) low cost enameled magnet wire



NYFORM 105°C (AIEE Class A) superior windability

EPOXY 130°C (AIEE Class B) general compatibility

MAGNET WIRE DATA SHEET

from

Anaconda Wire & Cable Co.

IMPORTANT FACTS FOR YOUR WORK...

...about Anatherm 155°C (AIEE Class F) Magnet Wire

When proper advantage is taken of Anaconda Anatherm's higher 155°C characteristics, electrical equipment can be improved in these ways:

RAISES LIMITING OPERATING TEMPERATURES. Anatherm raises limiting operating temperatures to 155°C. This high heat resistance means extra protection . . . longer equipment life . . . wider range of applications.

REDUCES FRAME SIZE. Anatherm gives more horsepower from the same space or the same horsepower from a smaller motor. Costs are cut for you, and your customers benefit from smaller over-all components.

INCREASES HORSEPOWER RATINGS. Anatherm is the best of the polyesters. Its high heat resistance means higher permissible operating temperatures, greater horsepower rating.

UPGRADING. Anatherm helps upgrade standard equipment. Gives added heat insurance through thermal stability. Particularly suited for overloads.

COMPATIBILITY. With polyesters, importance must be placed upon a completely compatible system. Varnish manufacturers have recently developed polyester varnishes which allow a compatible polyester magnet wire system. A number of varnishes other than polyester are compatible with Anatherm, but consultation with varnish suppliers before use is recommended.

TECHNICAL PROPERTIES

MECHANICAL PROPERTIES

Anatherm has unusually high abrasion-resistance. This characteristic allows it to be wound on both conventional and automatic winding equipment. Anatherm offers excellent flexibility and adherence properties. It meets NEMA snap test requirements and exhibits excellent adherence to the conductor.

ELECTRICAL PROPERTIES

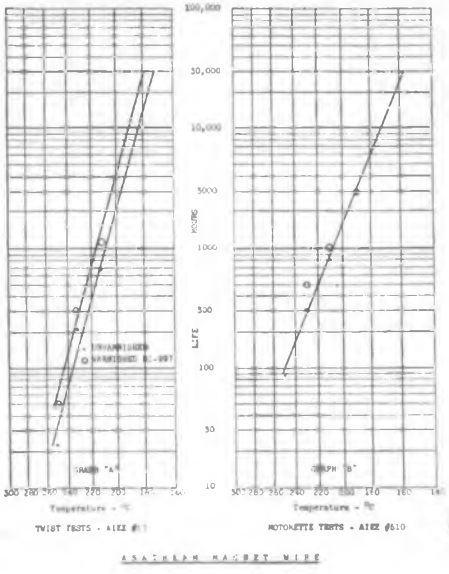
Anatherm maintains its dielectric strength under prolonged heating at high temperatures. It consistently exceeds dielectric strength requirements for NEMA dielectric twist test.

CHEMICAL PROPERTIES

Anatherm will resist toluol, VM & P Naphtha, Ethyl Alcohol and 5% Sulphuric Acid. Anatherm is a polyester and exhibits the best characteristics of this class of chemical compound. However, all polyesters must be used with certain precautions where moisture and/or enclosed systems are concerned. Similar precautions must be taken where chlorine-base supporting insulations, such as neoprene and polyvinyl chloride, are present. Polyesters should not be used in applications subject to exposure to concentrated alkalies.

THERMAL PROPERTIES

Anatherm is offered as a 155°C (AIEE Class F) magnet wire based on AIEE #57 and #510 test methods. These tests, performed by Anaconda engineers, show Anatherm as being capable of a 30,000-hour life at 157°C in an unvarnished state and the same life at 175°C when treated with a silicone or polyester type varnish. Thus Anatherm, when suitably varnished, has reserve stability even above the 155°C rating at which it is being offered. The thermoplastic flow temperature for Anatherm, based on MIL-W-583A, is very high (250°C). Anatherm also shows outstanding retention of flexibility after aging. Wire can be heated 168 hours at 175°C and then wound on three times its own diameter without cracking. Its heat-shock characteristics are exceptionally good for a polyester wire: Anatherm will withstand a 1x mandrel wrap at 155°C for one hour.



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Latest information . . . full technical data.

The Solaris is the first hearing aid to be placed on the market that uses the sun's rays for power. Arrow indicates silicon cells on temple bar.

New Hearing Aid Operates On Solar Energy

A revolutionary new eyeglass hearing aid, the Solaris, that operates on power from ordinary sunlight is now available.

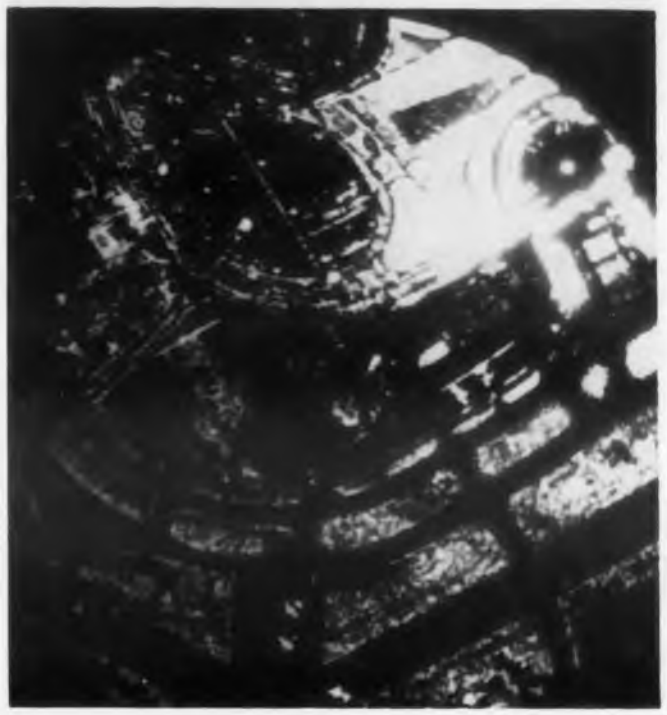
Using silicon cells of the same type used to power the radio transmitter in the Vanguard satellite, the Solaris automatically cuts into a battery supply when light is insufficient. The storage battery is made of nickel-cadmium and weighs only a fraction of an oz according to Zenith Radio Corp., Chicago, Ill.

Bright sunlight will recharge the battery. The instrument is equipped with four silicon cells which are mounted in tandem under a plastic covering on top of one of the eyeglass bars.

. . . 3999, 4000 . . . All There

More than 4000 bits of information can be stored on thi five-in.-sq "memory frame" being produced by RCA for a new high-speed electronic computer used by the AEC. The frame is composed of thin strands of insulated copper wire and tiny ferrite cores, 83,000 of which weigh only a pound. The cores are subjected to temperatures of 1100 to 1350 C. They are then strung on fine insulated copper wires to form a frame-like assembly. The frames are being made at the RCA Materials Development Lab, Needham Heights, Mass.

CIRCLE 523 ON READER-SERVICE CARD



Idlewild Airport as seen on the Airborne Instruments ASDE radar scope.

Idlewild Airport Installs Surface Detection Equipment

Airport Surface Detection Equipment (ASDE) has been made a part of the traffic control system at Idlewild Airport. Mounted atop the cab at the summit of the 187-ft control tower, ASDE's antenna sweeps the 5000-acre expanse to give air traffic control crews a complete picture of the changing conditions on the surface of the field. An experimental model was successfully tested there in the fall of 1952, and the present equipment incorporates many refinements suggested by that trial performance.

ASDE has a maximum range of four miles, though its 16-in. (diam) scope usually displays an area of only two miles about the control tower. With a resolution of more than 1000 lines per diam, the display tube can distinguish objects separated by as little as ten ft. Two men standing at arms length from each other, 1500 ft away from the tower, will also be clearly defined. To achieve the necessary bandwidth for such resolution, ASDE operates at frequencies in the 24,000 mc range. These frequencies, though highly susceptible to absorption by weather conditions, are not seriously impaired at ASDE's short operating range.

The antenna reflector is 12 ft wide and obtains a radar beam 0.25 deg wide, reportedly the narrowest beamwidth used in any present radar system. The antenna scans the field at a rate of 60 rpm and is designed to operate in

winds up to 50 mph, and will be able to operate in 120 mph gales because of the enclosure of a radome made of dacron coated with polyethylene.

ASDE was designed and built by Airborne Instruments Lab, 160 Old Country Rd., Mineola, N.Y.

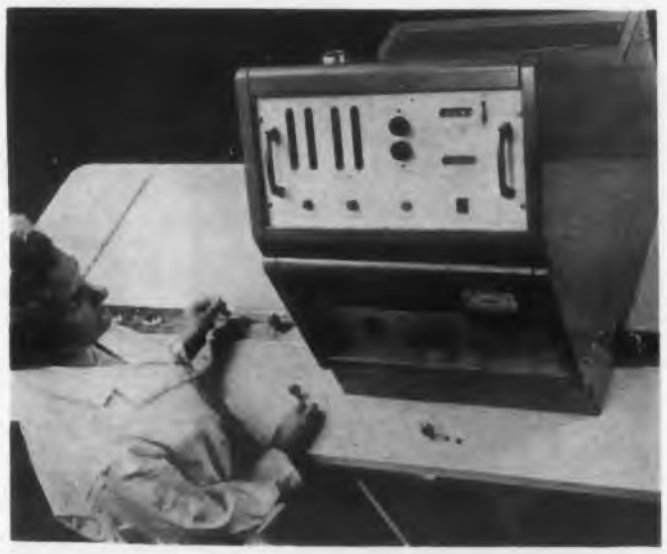
Radioactivity Used To Inspect Assemblies for Hidden Parts

Radioactivity is being used for the first time to inspect production line assemblies for the presence of hidden vital parts.

The U. S. Army Ordnance Corps has purchased the first model for checking artillery-shell fuse heads to make sure they contain a complete firing-pin assembly. Developed by Nuclear Corp. of America, 400 Park Ave., New York, the Atomonitor as it is called, searches for parts which are plated with 1/100th of a microcurie of radioactive silver. This material presents no health hazard even in great quantities. Its radioactive longevity, however, is such that Atomonitor inspection is possible up to a year after plating.

Assemblies to be inspected are transported on a conveyor at the rate of up to 3000 per hour. A scintillator in the device checks each unit for the presence of radioactivity. If it finds none, it automatically ejects the assembly into a bin below. Counters on the machine's control panel indicate how many units have been inspected and how many rejected. If desired, the machine also will keep track of the rejection rate and ring an alarm if it exceeds a predetermined maximum.

The unit built for the Ordnance Corps has an accuracy of 9,999,999 out of 10-million as far as detecting incomplete fuse heads is concerned. The probability of its mistakenly rejecting a good assembly is 1 in 100,000.



Atomonitor inspects production-line assemblies for the presence of hidden vital parts.

Transparent, colorless slide produces a full-color picture on the screen by means of a new projection technique. A special projector translates "color information," which has been recorded in tiny ripples on a clear gelatin film, into primary colors which are projected simultaneously onto the screen.

Transparent Screen Records Color Information

A colorless, transparent slide which produces a full-color photograph when projected on a screen may have eventual importance in color TV.

Color information is recorded in tiny ripples on a clear gelatin film, according to Dr. William Glenn, a physicist at the General Electric Research Lab., Schenectady, N.Y., who developed the system. The ripples in the film serve as a diffraction-grating system, and a special projector is used to "translate" the diffraction patterns—overlapping series of light waves—so that brilliant primary colors are projected on the screen at the same time. In a recent demonstration, Dr. Glenn used slides in the standard 2 x 2 size, and because the diffraction ripples were only a thousandth of an inch apart, the projected picture had a resolution comparable to a good TV picture.

Color information may also be recorded on black-and-white film by placing a special mask in front of the film in an ordinary camera. The diffraction-grating system produces a "positive" color picture if the monochrome slide is either positive or negative. Dr. Glenn explained that the technique has not yet been developed for wide use in photographs.

An unusual aspect of the system is that it makes possible a full-color picture produced by two primary colors, one fixed and one variable, instead of the usual system of three fixed pri-

maries. For the clear and transparent "color slides," diffraction-grating ripples are printed on chromated gelatin. Black-and-white "color slides" utilize fine-grain photographic film. Dr. Glenn suggested that the Swiss Eidophor System for black-and-white TV projection, in which diffraction gratings are written onto an oil film by an electron beam, might be modified for simultaneous color projection using the new technique. Possible advantages of the new system in color television would include high brightness, perfect color register, and greater simplicity than color-TV systems now in use.

Commercial Solar Energy Converter Developed

Practical conversion of sunlight into electrical power for communication and signal devices is now possible. Basic component of the new commercial solar system, developed by the Hoffman Electronics Corporation's Semiconductor Div., Evanston, Illinois, is a 12 by 20 in. aluminum panel containing 144 wafer-thin, circular silicon solar cells. This energy is either fed into storage batteries or used directly. The modular units may be connected together to produce multiples of 5 w either as a direct power supply, or for charging continuously over an indefinite time 6, 12, or 24 volt storage batteries.

Solar converter, shown connected to a voltmeter, is reportedly the world's first practical solar energy unit designed to convert sunlight directly into commercially usable quantities of electric power.

ENGINEERING REVIEW

Navigation Simulator Trains Students

Dead reckoning, celestial, and pressure pattern navigation are being taught by a new navigation simulator. The 1A19 Celestial Navigation Trainer is designed for flights at all latitudes including polar, 100,000 ft altitude, 1500-knot air speed, 300-knot winds, and vertical speeds up to 10,000 fpm. Large face operating instruments are mounted on the classroom wall in front of the student body. All students can therefore read continuously their barometric altitude, radio altitude, compass, free air temperature, air speed, and time. The system is so designed that the compass may represent correctly either a magnetic compass or a slaved gyro or free gyro compass. The air speed indication may be in terms of either indicated air speed or true air speed. One observation booth is provided in which the students may observe selected stars. The training device can present any heavenly body as seen from any point on earth from any type of aircraft at any time. Reflectone Corp., Stamford, Conn., developed the device in conjunction with U. S. Naval Training Devices Center, Port Washington, N.Y.

Microwave Equipment Airlifted

Atop a 9,800 ft peak in northwestern New Mexico there sits a pipeline microwave system, the result of an unprecedented airlift by jet helicopter. Installed by General Electric's Communication Products Department of Syracuse, N.Y., the system will help control the surge of crude oil through pipe extending from Utah to California, a route of more than 850 miles. Especially designed for high altitudes, the Republic Aviation aircraft lifted nearly three tons of equipment. Decision to fly the material to the mountain peak was made by engi-

◀ CIRCLE 11 ON READER-SERVICE CARD

neers when weather conditions made it virtually impossible to reach the top over rough, snow-clogged roads which extended only part way up the rocky mountain.

The communications system includes 100 per cent rf and multiplex standby equipment. Vhf repeaters facilitate voice communication from the pipeline's office at Los Angeles to its facilities at Farmington, New Mexico, not far from the mountain location. Included in the communication plans are a dial-selective party-line telephone-type channel form and a private channel.

Auto Radar Undergoing Tests

Auto radar may soon warn the driver of traffic hazards. Tests are now being conducted under actual road conditions and a production version of the device is under development. A radar antenna about the size of a hollowed-out steak platter is mounted in the front radiator grill of the car. Signals are sent out which are converted into an automatically regulated "beep-beep" sound. The driver is thereby told whether he is closing the gap too rapidly between his car and the one in front, if he is approaching an object on a possible collision path, or if cross traffic threatens collision.

If a motorist is overtaking another car at moderate speed, or if the other car is still some distance away, the "beep-beep" warning is very light, the engineers said. But as the other car gets nearer, the radar warning signal becomes progressively louder and more insistent.

Developed by Bendix Aviation Corp., Detroit, Mich., the new device limits the signals to objects within the car's safe stopping distance, ignores situations in which the car in front is within dangerous distance but is pulling away, permits adjustment for open-country or congested-traffic driving and reduces background noises that would confuse the signal.

CIRCLE 12 ON READER-SERVICE CARD ➤

Talos missile being fired from Talos Defense Unit during test at White Sands Missile Range, N. Mex. on Dec. 13, 1957. The target was a drone flying far down range at medium altitude. A direct hit was scored.

Most Accurate Radar In Talos Defense Unit

Details of the Talos Defense Unit, the first fully automatic base for firing and guiding missiles to their target, were revealed recently by RCA.

The system uses what is reportedly the most accurate instrumentation radar—the AN/FPS 16—which can distinguish a 5 in. object at a distance of 1 nautical mile with an error margin of 1 in.

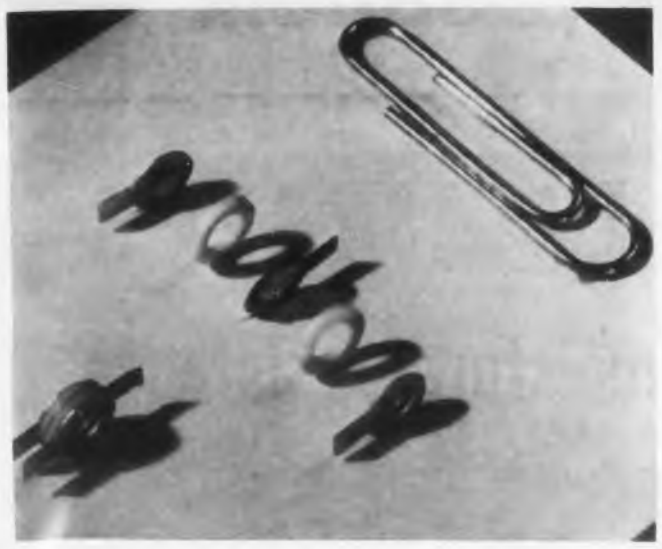
At present, the radar can track aircraft or missiles to approximately 290 statute miles. Extension of the range to beyond 500 miles will be possible by addition of a modification now being developed, RCA reports.

The AN/FPS 16 uses a monopulse tracking system and operates at C— band. The operating console is designed so that a single operator can control every operation of the radar. A three-color video display is used in the main fire control console to permit simultaneous engagement of several targets.

Standardization of the AN/FPS 16 at the various test ranges has been effected.

The Talos Defense Unit is capable of automatically handling, loading and launching the missile. Elimination of the necessity of personnel in the missile launching area is thereby assured.

Disclosure of the Unit was attended by ceremonies in which RCA was awarded the Navy's Certificate of Merit for its development of this automatic base.



Inside view of GE's new no-filament high-temperature tube.

Miniature Vacuum Tubes Operate in 600 C Range

Transistor-sized ceramic vacuum tubes have been developed by the General Electric Research Laboratory, Schenectady, N.Y. Not much larger than a shirt button, the new tube operates only at ambient temperatures in the 600 C range. It contains no filament. Cathode heating is supplied by high ambient temperatures outside the tube.

This is the latest in a series of developments that have been aimed towards two goals:

- Reduce the bulk of present vacuum tubes and eliminate the glass envelope;
- Construct tubes to withstand the same high temperatures as GE's newly-developed high-temperature components.

Disadvantage of the tubes, of course, is their inability to work at temperatures below about 500 C. Their use will be limited to applications where high ambient temperatures are prevalent, such as high-temperature industrial processes and in missile electronics. The design is still in the laboratory stage and no tubes are commercially available at this time. The table lists some characteristics of two experimental models.

Characteristics of New Miniature Ceramic Tube

	Tube A	Tube B
Entire Tube Temperature	600 C	600 C
Mutual Conductance	250 micromhos	250 micromhos
Plate Current	0.5 ma	5 ma
Grid Voltage	0	0
Plate Voltage	50 volts over	50 volts over
Grid Current	0.1 microamp	0.1 microamp
Amplification Factor	15	100

WASHINGTON REPORT

Herbert H. Rosen

AMB Rises to the Challenge

Contracts, impending legislation, and a new test center mark the progress made so far by the Air Modernization Board. Established during the last session of Congress, AMB has already awarded over $10 million in contracts and has others under negotiation. In addition, more than $30 million will be appropriated the new agency for more R & D in air traffic control during fiscal year 1959.

General Precision Laboratory, Inc. appears to have the inside track on the development of control equipment. Last February, a $4.3 million contract was awarded to them for an enroute portion of an air traffic control data processing central. Early in June, a $3.97 million supplemental contract went to GPL for the transition and terminal portion of the data processing central. Moreover, GPL is expected to help RCA in the development of AGACS—an automatic ground-air-ground communication system. Initial contract cost is more than $1 million. The program, ultimately should run around $5 million.

Keystone to AMB's equipment development program is to be GPL's data processing and display equipment. The transition and terminal equipment contract calls for computers, controller consoles, flight-strip printers and display equipment "that will permit programmed landing sequences and take-offs of aircraft so that minimum landing delays and holding at terminals are experienced."

The AMB-GPL contract also calls for installation of the equipment for "interchange of SAGE data and to permit trials of Air Defense Command operations . . ." While initial tests will be limited to the New York area, AMB is setting up its own test center. Late in June, the Navy Air Station at Atlantic City became the National Aviation Facilities Experimental Center—the "Cape Canaveral" of civil aviation.

A housekeeping contract has been awarded to Ole Hansen & Sons, Inc. of Pleasantville, N.J. It is estimated that the first year's operations will cost about $1.5 million.

All of this shows progress is being made—at least engineering talent is being bought to develop vitally needed equipment. Meanwhile, in response to more recent tragic air crashes, Con-

Dow Corning Silicone Dielectrics

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CIRCLE 541 ON READER-SERVICE CARD

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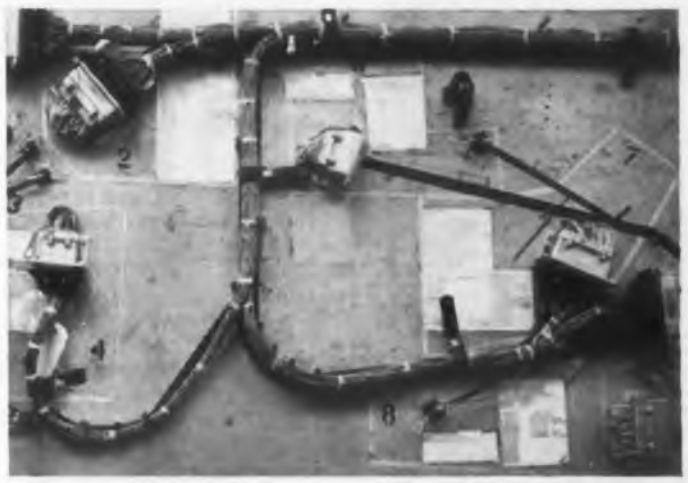

Wiring panel for Convair B-58 Hustler.

For further information on these products write Dept. 168

gress is quickly considering passage of a Federal Airway Act. Senator Warren G. Magnuson (D-Wash) dusted off a bill he had been saving—S-3880—and hearings by Senate Finance Committee were begun. It appears that the bill is virtually guaranteed passage during this session.

In the words of the President: "All functions now carried out by the Civil Aeronautics Administration . . . Airways Modernization Board . . . safety divisions of the Civil Aeronautics Board . . . (and) parts of the Department of Defense . . . should be transferred to the new Agency." A congressionally-approved Administrator and Deputy shall be in full control of the Federal airways—in about every manner conceivable. Further, provisions are to be made to have both civilians and military personnel on the staff

With all of this activity as background, General Precision Equipment Corp. came to Washington to demonstrate its new HIDAN—High Density Air Navigation method. It has two major components: an airborne, automatic navigator called RADAN; and a small computing device which "instantly indicates the position of the aircraft and, when programmed for a flight, continuously calculates the divergence of the actual position of the aircraft from its planned position. This divergence is shown instantaneously on an indicator in the cockpit." The RADAN portion—a Doppler instrument giving ground speed and drift angle—has been produced by GPL for the Air Force since 1948.

Adoption of a HIDAN-type system would seriously reduce the need for large numbers of the proposed VOTAC systems now being installed along the Federal skyways. It could also cut into the TACAN units.

BuAer Issues Circuit Standards

A new military standard—MIL-STD-439 (AER)—calling for the use of preferred circuits, will soon be a standard requirement in Navy Bureau of Aeronautics contracts. Thirty of the preferred circuits for miniature tubes developed by the National Bureau of Standards make up the specification. All are single function circuits —multivibrators, i-f strips, block oscillators, video, pulse and audio amplifiers and similar circuits.

Navy engineers waited more than three years before incorporating the circuits into a specification. In that time, tests and experiments were conducted to check them out. In the process, two NBS circuits were eliminated. Officials estimate that a preferred circuits specification for subminiature tubes is about a year away. Recently the Navy started a program that will ultimately lead to preferred transistor circuits. NBS is coordinating the program and making final tests and selection of standardized circuits.

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	STA-172	1.2	30	36
	STA-177	1.0	35	42
400 SERIES	STA-457	7	10	12
	STA-462	4	15	18
	STA-467	3	20	24
	STA-472	2.4	30	36
	STA-477	2	35	42
200 SERIES	STA-257	17	10	12
	STA-262	11	15	18
	STA-267	8	20	24
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CIRCLE 18 ON READER-SERVICE CARD

Aug. 19-22: WESCON

Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, Calif. Sponsored by Seventh Region of the IRE and WCEMA. More than 200 technical papers will be presented in 42 sessions at the Ambassador Hotel. The concurrent exhibit of electronic equipment and services will occupy more than 900 booths in the Pan-Pacific Auditorium plus four special pavilions. Included in the technical program will be two "invited" and two "special" sessions. Topics of the invited sessions are "Parametric Amplifiers and Masers" and "Industry Looks at Fusion Power." An evening session on "Biological Measurement in Space Travel" is scheduled with a second evening session topic yet to be announced. There will also be panel sessions on "Contract Implications of Military Electronics Reliability Requirements" and "Modern Management Problems in an Increasingly Complex Technology." A complete breakdown of technical sessions will be found below. For more information write Western Electronic Show and Convention, 1435 S. La Cienega Blvd., Los Angeles 35, Calif. For complete convention coverage, read ELECTRONIC DAILY, published every day during the show.

WESCON Program

All A.M. sessions begin at 9:30, P.M. sessions at 2:00, Eve. sessions at 8:00 P.M.

Abbreviation Key: Ballroom (Ba), Boulevard Room (Bo), Embassy Room (E), Sunset Room (S), Venetian Room (V).

Session and Number	Time and Location
Aeronautical Electronics	
Airborne Electronic Devices (8)	Tues pm-Bo
Antenna Arrays (27)	Thurs am-V
Antennas and Propogation (35)	Fri am-Bo
Antennas (40)	Fri pm-Bo
Audio (15)	Wed am-V
Radio and TV (32)	Thurs pm-V
Advanced TV Techniques (37)	Fri am-V
Circuit Theory	
Circuit Analysis and Design (9)	Tues pm-Ba
Circuit Design (14)	Wed am-Ba
Transistor Circuits (17)	Wed pm-S
Communications	
Communication Systems and Vehicular Communication (42)	Fri pm-V
Components	
Component Materials (26)	Thurs am-Ba
Component Parts (31)	Thurs pm-Ba
Computers	
Computer Applications (1)	Tues am-E
Computer Devices (6)	Tues pm-E
Analog Computers (23)	Thurs am-E
Control Systems	
Automatic Control (18)	Wed pm-Bo
Industrial Electronics (36)	Fri am-Ba
Human Engineering	
Human Factors in Engineering (29)	Thurs pm-S
Information Theory	
Information Theory (4)	Tues am-Ba
Instrumentation	
Instrument Tools (13)	Wed am-Bo
Instrument Systems (19)	Wed pm-Ba
Management	
Modern Management Problems (12)	Wed am-S

Session and Number	Time and Location
Microwaves	
Microwave Theory and Technique Session I (5)	Tues am-V
Session II (10)	Tues pm-V
Parametric Amplifiers and Masers (11)	Wed am-E
Microwave Propogation (20)	Wed pm-E
Microwave and High Power Tubes (24)	Wed pm-V
Microwave Ferrites (30)	Thurs am-S
	Thurs pm-Bo
Medical Electronics	
Biological Measurements in Space Travel (21)	Wed Eve-E
Medical Electronics (39)	Fri pm-S
Military Electronics	
Military Electronics (25)	Thurs am-Bo
Nuclear Science	
Industry Looks at Fusion Power—Panel (16)	Wed pm-E
Production	
Production Techniques (34)	Fri am-S
Reliability	
Reliability Session I (2)	Tues am-S
Session II—Panel (7)	Tues pm-S
Solid State Session I (33)	Fri am-E
Session II (38)	Fri pm-E
Special Devices	
Special Electronic Devices (28)	Thurs pm-E
Telemetering	
Telemetry (3)	Tues am-Bo
Biological Measurement in Space Travel (21)	Wed Eve-E
Writing and Speech	
Engineering Writing and Speech (41)	Fri pm-Ba

EDITORIAL

Drawing The Line In Computer Design

In our editorial of June 25 we asked if we must always start from scratch every time we faced a design problem. Could not some aspect of digital circuit design be considered "standard?" After surveying the views of digital computer designers, we concluded that the majority of designers of military systems felt it was too premature to standardize on any specific designs but that some sort of flexible standardization was desirable. In this editorial we will look at some of the areas suggested as starting points.

- Standardize on modular units. The most reasonable view seems to be to emphasize the modularization concept but to put no restrictions on dimensions or construction techniques.
- Consider logical circuits. The odds are against agreement on picking the optimum ranges for some dozen characteristics of circuits and physical modules, but a tabulation has never been made. If a reasonable number of requirements fall within one or two groups, standardization is feasible and not difficult. Since each logical step is small, modularization should be applied to a function rather than a basic step.
- Standardize machine language for data processing machines. There is little or no likelihood of standardizing input and output devices. Such equipment which "communicates" with other devices will be almost impossible to pin down.

Experienced military designers feel that each circuit is a compromise between simplicity, low cost, and performance. These factors complicate attempts to determine appropriate standards.

Forceful arguments against standardization of even subassemblies is the large number of such "standardized" units offered by each manufacturer of commercial building blocks. Attempts to get a small number of building blocks does not appear to be successful. Although useful for breadboarding, they are not ideal for production runs.

Before arguments for or against standardization can be weighed objectively, a study of exactly what is involved is necessary. Until this is done, the retort to pleas for standardization will continue.

Time spent on determining standards and getting manufacturers to agree on them would be better spent improving the product.

If there are to be standards for military computers, the military will have to take the lead. This subject will be discussed in a future editorial.

Over 200 papers will be given this month at the West Coast's annual big electronics meeting. Running from Aug. 19th through 22nd, WESCON also boasts over 700 exhibitors this year. Might be a good place to discuss your standards problems.

Concentrated Filter Passbands

Part 1

Mechanical Filters

Frederick A. Schaner
The Daven Co.
Livingston, N. J.

For many years, engineers have tried to find better ways to form straight-sided, flat-topped passbands without cumbersome, cascade transformers and tubes used in i-f amplifiers, and without RC and iron-core/capacitor combinations used in low frequency work.

Three distinct filter types have evolved. Each is effective for certain applications; none is effective for all. They all are passive, and provide all the required selectivity. To reduce noise, they are normally applied before any amplification.

The three types are: ▪ Mechanical; ▪ Crystal; ▪ Electrical or LC

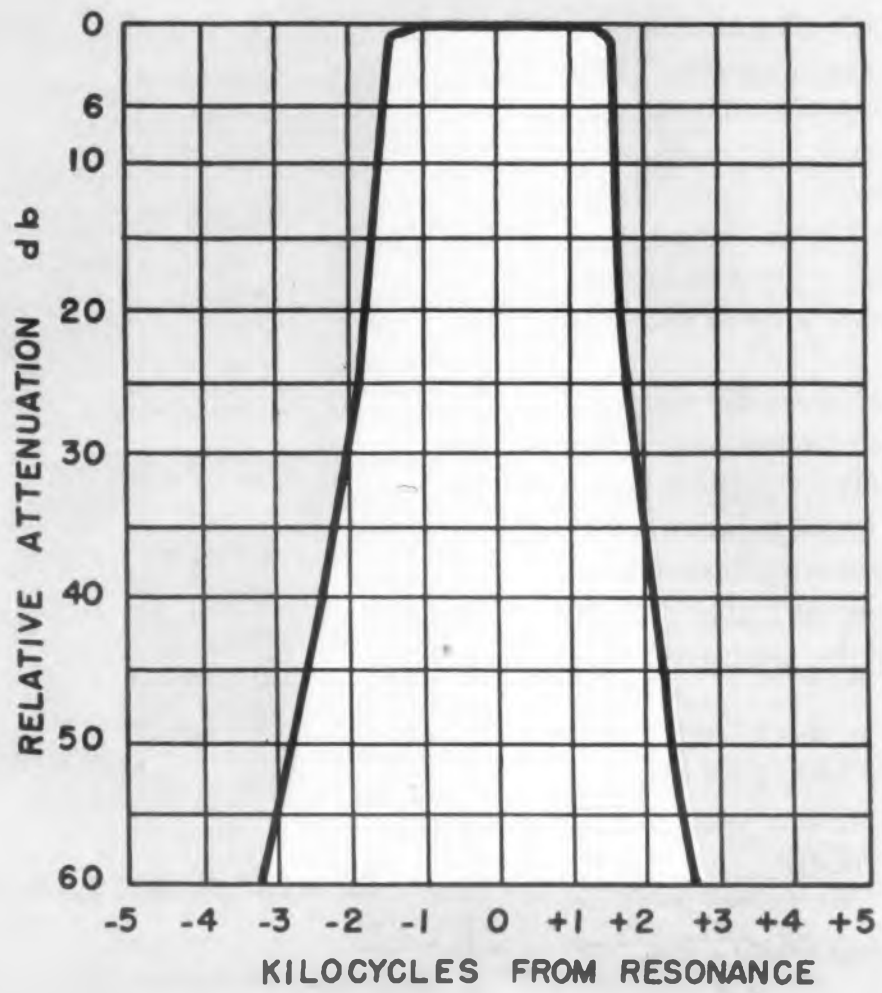


Fig. 1. Selectivity of a typical six disk mechanical filter.

MECHANICAL filters can provide characteristics unobtainable with electrical circuits. While electrical elements have relatively high losses, mechanical elements can have Q's of 5000 and more. This permits treating mechanical filters as lossless elements.

Their frequency characteristics are permanent, so no adjustment can be made after final alignment.

All mechanical filters consist of input and output transducers, and a resonant mechanical section in between. Many structures have been used as mechanical resonators. Of these, three types are the most common.

Filter Types

1. One type has a number of rectangular resonant plates, interconnected by fine wires.
2. Another type has a cylindrical rod, machined to form alternate necks and slugs. In this case, either the necks or the slugs can be used as resonators.
3. The third type is a cylindrical arrangement of disk resonators, interconnected by coupling wires.

Four methods of electromechanical transduction have been commonly used during the last ten years; electromagnetic, electrostatic, magnetostrictive, and piezoelectric.

■ Electromagnetic and electrostatic transducers were used in early filters. Since they are lumped constant devices, their use has been restricted to the lower frequency range because parasitic resonances limit their high frequency performance.

■ Magnetostrictive and piezoelectric transducers are basically distributed constant systems, so they can be used at radio frequencies when proper dimensions are chosen. Magnetostrictive transducers are most frequently used in mechanical filters today for their efficiency, economy and stability.

Frequency Characteristics

The excellent frequency characteristics of a resonant mechanical section provide an almost rectangular selectivity curve. The input and output transducers serve only as electrical-to-mechanical and mechanical-to-electrical coupling devices and do not affect the selectivity characteristics. These are determined only by the resonant elements.

An electrical signal at the input transducer is converted to a mechanical vibration by magnetostriction. This mechanical vibration travels through the resonant mechanical section to the output transducer where it is converted back to an electrical signal by magnetostriction.

A small permanent magnet in each transducer helps provide optimum electrical-mechanical coupling. It supplies magnetic bias to the transducer core. The impulses then add to or subtract from this magnetic bias, causing vibration of the filter elements corresponding to the input signal. The vibration, of course, is almost imperceptible.

For a restricted frequency range, magnetostrictively driven filters have several advantages over electrical equivalents. From 60 to 600 kc, the mechanical elements are extremely small, so a mechanical filter with better selectivity than the best conventional i-f systems can be pack-

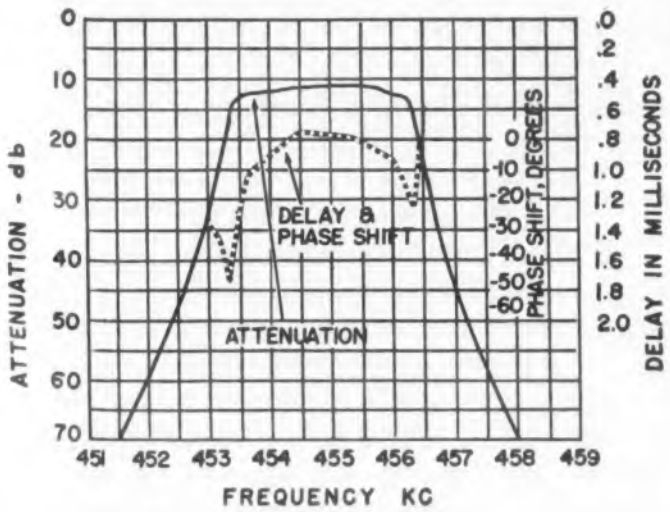


Fig. 2. Time delay and attenuation of a typical six disk filter.

aged smaller than a single broadcast receiver i-f transformer.

It is almost impossible to distinguish the relative advantages and disadvantages of the three common types of resonant elements. All three perform equally well, the principal difference between them being that they are the result of separate investigations. For convenience, one can consider the resonant disk type only.

Performance Characteristics

Table I shows the performance of a typical 6 disk mechanical filter. This filter has a center frequency of 455 kc and a 3.1 kc bandwidth between the 6 db points. The shape factor of this filter (ratio of bandwidth 60 db down from the highest peak to bandwidth 6 db down) is less than 2.1.

This low value of shape factor permits unusually high rejection of unwanted signals. The broad nose of the curve passes portions of the signal which would be attenuated in a standard rounded i-f selectivity curve.

To realize full benefit from a mechanical filter's selectivity characteristics, shielding is necessary between the external input and output circuits. This shielding should be able to reduce the energy transfer between these circuits at least 100 db. If the input circuit couples energy to the output around the filter, the selectivity will deteriorate and the passband will be distorted.

As with almost any mechanical resonant circuit, elements of the filter have multiple resonances. These produce spurious transmission paths through the filter and produce minor passbands at frequencies on either side of the primary passband. Careful filter design reduces these sub-bands to a low level and removes them from the immediate area of the major passband.

However, where increased attenuation is needed at the spurious frequencies, additional selectivity can be added with tuned circuits before or after the mechanical filter. Two conventional i-f transformers usually suffice. Their passbands should have nearly constant attenuation in the band of the mechanical filter to obtain full benefits from the flat passband characteristics.

Mechanical filters with different bandwidths can be switched into a circuit. This can provide variable selectivity. One receiver, for example, has plug in provision for 800, 1500, 3100, or 6000 cps filters. A front panel switch selects the desired filter. The 3100 cps filter is ideal for phone signals, including single side band.

OPERATING CHARACTERISTICS OF TYPICAL MECHANICAL FILTER

OPERATING FREQUENCY	455 ± .25KC
NOMINAL BANDWIDTH AT -6 DB	3.1 KC
MAXIMUM BANDWIDTH AT -60 DB	6.5KC
SHAPE FACTOR 60DB TO 6DB LESS THAN	2.1/1
MAXIMUM RESPONSE VARIATION WITHIN PASSBAND	3 DB
OVERLOAD SIGNAL INPUT VOLTAGE	2 VOLTS RMS
INSERTION (TRANSMISSION) LOSS	10DB NOM.
OPERATING TEMPERATURE RANGE	-40° C TO +85°C
INPUT & OUTPUT IMPEDANCE	14K OHMS RESISTIVE AT RESONANCE
CASE SIZE	3/4 DIA. X 2 5/8 LONG

TABLE 1

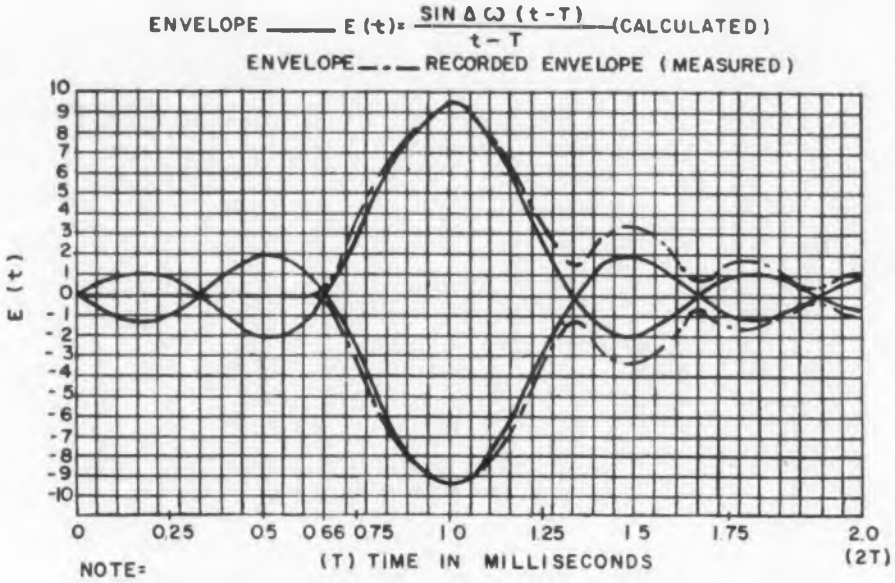


Fig. 3. Impulse response. Solid line represents calculated value. Dashed line is measured value.

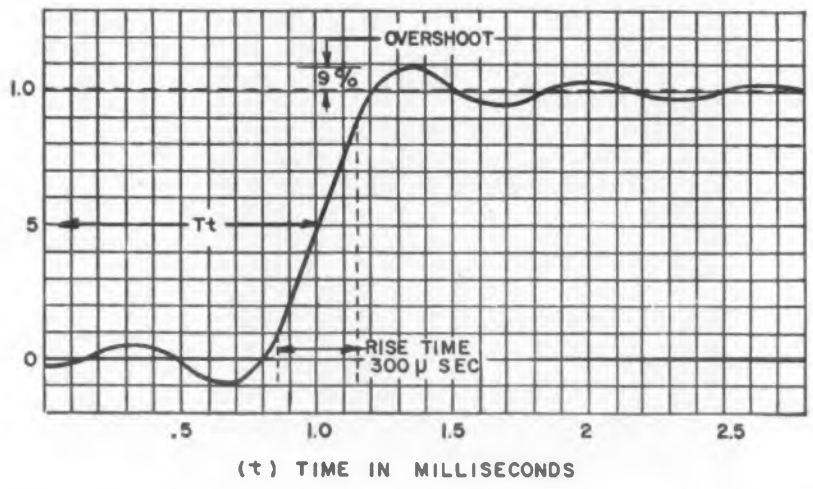


Fig. 4. Step function response of a six disk filter with a pulse modulated carrier input.

Signal Requirements

The maximum signal input for a particular filter is one which provides an output voltage 0.5 db below what it would be if the filter's input-output voltage relationship were perfectly linear. (In a specified range, the filter's output is essentially proportional to its input.) Momentary surges of several times the maximum signal input will not damage the filter.

The filter's transducer coils are usually designed to carry up to 20 madc. The effect of dc in the coils is analogous to increasing the fixed grid bias on a tube. Assuming optimum performance with zero current, the maximum signal swing without distortion becomes more limited when the dc current is increased.

Operating Requirements

The input and output transducer coils must be resonated. The value of resonating capacity should be specified for any filter. This value includes the total external capacity of tubes, stray and wiring. The specified value is nominal, and the filter itself should be resonated at its nominal center frequency.

Since the filter has a high impedance, source and load impedances should be about ten times the resonant input and output impedances.

Time Delay

Fig. 2 shows the plot of time delay in a mechanical filter. It is obtained by passing a modulated signal through the filter and measuring the resultant modulated envelope phase shift through the filter. The delay is then computed from

$$t_d = \frac{\theta}{360\, f_m}$$

where t_d is the time delay in seconds, θ is the phase shift of the modulation envelope in degrees, and f_m is the modulating frequency in cps.

The time delay shows rapid variations near the edges of the passband as shown in Fig. 2. But the delay across the passband is of primary interest. A typical commercial filter has a phase shift variation of 5 deg over 75 per cent of the passband. This is equivalent to a time delay variation of about 0.2 milliseconds.

As an approximation, time delay varies inversely with bandwidth for a given center frequency, that is, $t_d \propto 1/B$, with f_c, the center frequency, constant, and B, the filter bandwidth.

Impulse and Step Response

The response to both impulse and step functions is shown in Figs. 3 and 4. The filter whose response is shown has a 3.1 kc bandwidth and has six disks. As with all practical filters, mechanical filters have a finite rise time. It depends only on the bandwidth, and is given by $t_r = 0.90/B$, t_r is the rise time in msec and B is the filter bandwidth in kc.

A step function, applied to any mechanical filter, results in a theoretically constant overshoot. In the case of one manufacturer's filters, this overshoot is 9 per cent.

The anticipatory transient duration from time zero of the applied step function to a point half way up the rising slope of the filter output, depends on the filter bandwidth and the number of disks. The transient time is $t_t = N/2B$ where N is the number of disks.

The impulse response shown includes the calculated and measured response. The transient time from time zero of the applied impulse to the peak of the filter output pulse is the same as the calculated transient time for the step function response.

Environmental Effects

Mechanical filters are as rugged as ordinary receiving tubes. They operate satisfactorily when subjected to continuous vibration with a total excursion of 0.060 in. over a vibration frequency range from 10 to 55 cps. They can take 15 g shock lasting 11 msec.

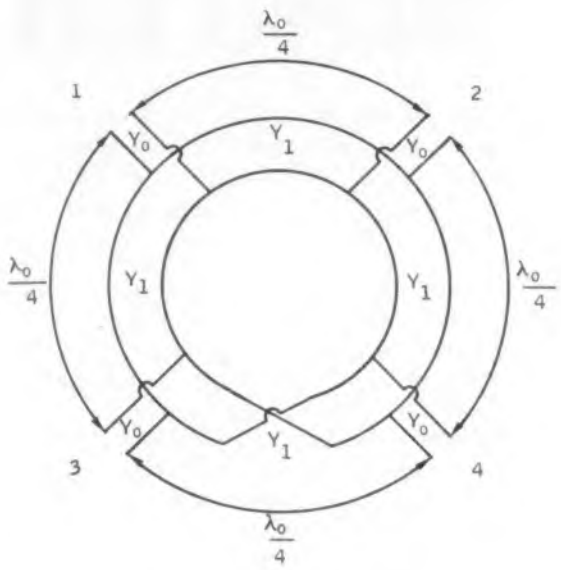
Their shift with temperature can be held to within 10 ppm per deg C. Since they are hermetically sealed, humidity has no effect.

Application Of Coaxial Bar Hybirds

Since Bogart Mfg. Co. announced their new coaxial bar hybrids (ELECTRONIC DESIGN, March 1, 1957, p. 38) many new applications have been disclosed. This article discusses a number of applications evolved by engineers in the field.

A hybrid is, basically, a four-terminal device which has the following properties:

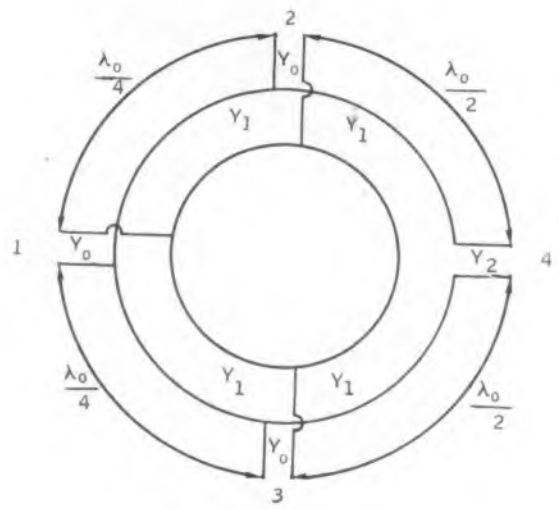
- Opposite arms are isolated from each other.
- If power is fed into any of the arms, it will divide evenly between the two remaining unisolated arms.
- The division of power is independent of the phase of the impedances on the output arms if the degree of mismatch is identical.
- Power from one input arm arrives in phase at the two output terminals. The power fed from the second input arm arrives at the outputs with a 180 deg phase difference.
- The conventional coaxial hybrid (a) has the form of a ring with spacings of a quarter-wavelength between three arms with a spacing of three-fourths wavelength between the second and fourth arms. Each arm is shunt connected to the main ring and the properties outlined above are achieved by the spacings between arms. In the series-shunt hybrid of the Bogart type (b) three of the arms are shunt connected, but the fourth arm is fastened in series to the main line. Arm 4 can be matched to Y_0 if the admittance of a portion of the ring is altered. The essential hybrid properties are, therefore, practically independent of frequency since phase reversal from the fourth arm does not rely on sections of transmission line.



$Y_0 = \sqrt{2}$ (50 OHMS)

$Y_1 = 1$ (70.7 OHMS)

(a)



$Y_1 = 1$ (70.7 OHMS)

$Y_0 = \sqrt{2}$ (50 OHMS)

$Y_2 = \frac{Y^2}{Y_0} = \frac{1}{2}$ (100 OHMS)

(b)

Miniature, Broadband Balanced Mixer

Apply the received signal to arm 1 and the local oscillator to arm 4. If crystal holders, (nominally matched to 50 ohms) are attached to arms 2 and 3, the device becomes a mixer. The received and local oscillator signals may be interchanged at arms 1 and 4. Most local oscillators, especially in the lower frequency bands, have coaxial outputs. Also, broadband coaxial crystal mixer arms have been designed by Bogart to work with these units, and are now available. For a receiving system, therefore, a coaxial hybrid is much smaller and more convenient than a comparable waveguide unit. (Table 1)

Power Divider

Apply a signal (such as a transmitter) to arm 1. (Fig. 1) The power will then divide equally between arms 2 and 3 provided that these two arms are matched to 50 ohms, or otherwise have the same degree of mismatch. If, for example, the output arms both have VSWR values of 2/1, they would then receive equal power regardless of the phase of the mismatch, since one of the properties of the hybrid is that isolation exists between opposite arms.

This situation would have practical significance in the case of two identical antennas fed from the same transmitter with unequal lengths of cables between antennas and inputs. Arm 4 is terminated in a matched load. The input signal could also be applied to arm 4 with arm 1 terminated, although the construction of the hybrids is such that arm 4 cannot handle the same level of power as arm 1. The standard hybrid utilizes a smaller coaxial cable on arm 4. Arms 1, 2, and 3 employ a larger cable about 3/8 in. diam.

Signal Addition in a Single Load

If two signals of different frequencies are applied to arms 1 and 4, and the output loads on arms 2 and 3 are matched to 50 ohms, or, closely matched to each other, then the power will divide equally between them with good isolation (greater than 30 db) maintained between arms 1 and 4. If it is desired to feed two transmitters into a single antenna (Fig. 2), the antenna may be placed at either arm 2 or 3 with a dummy load (matched to the antenna) on the remaining arm. It should be noted that there will be a 3 db loss in output since half of the power is dissipated in the dummy load.

Variable Power Divider, Attenuator, or Phase Comparator

If two outputs may be taken from a single generator and fed into arms 1 and 4 with zero phase shift between them, and if arms 2 and 3 are matched, the two signals will add in one of the arms and subtract in the other. If the two signals were equal to begin with, one of the output arms will, therefore, receive no power and the other arm will receive the total sum of the two powers. If a variable, lossless, phase shifter is placed in one of the lines, as shown, then the proportion of power delivered to arms 2 and 3 may be varied so that any power ratio may be obtained. If two outputs cannot be obtained directly from the generator, two hybrids may be used in tandem, as shown in Fig. 3.

The hybrid may also be used as a phase comparator where the magnitudes of output signals at arms 2 and 3 can be related to the relative phase betwen two equal input signals and the phase relationship between the signals accurately measured.

General Monopulse Applicatiom

The coaxial hybrid may be used in any application where an in-phase, out-of-phase relationship, is desired between two inputs. One such ap-

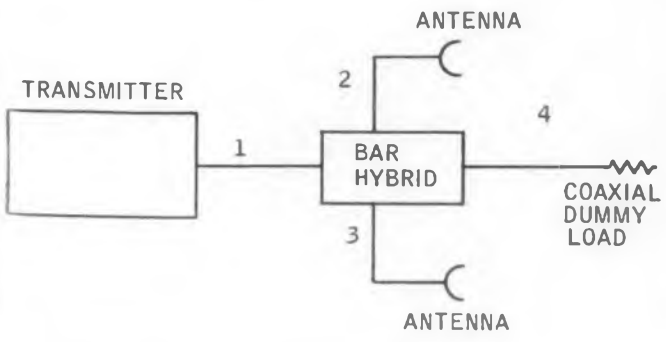


Fig. 1. Using a coaxial bar hybrid as a power divider.

Application of Coaxial Bar Hybrids

continued

plication exists in a monopulse system where it is necessary to add and subtract two rf signals. A transmitter signal fed into arm 1 (Fig. 4) will divide equally, and in phase, to arms 2 and 3. Received signals may be fed back into arms 2 and 3 of the hybrid. Arm 4 will then yield a difference signal, and arm 1 a sum signal.

Hybrid Duplexer

Many of the applications mentioned have long been used in conventional waveguide hybrids commonly termed "Rat Races." Coaxial hybrids, however, have the advantage, in many applications, of a much broader bandwidth. One such application is in a duplexer design for TR-ATR application. Referring to Fig. 5:

- A transmitter is sending power into arm 1 (hybrid 1) which splits up evenly at arms 2 and 3 and fires the TR tubes.
- All power is reflected back into the main line and out of phase because of the differential $\lambda/4$ arm in arm 3.
- The power then enters arm 4 and the antenna with little or no power re-

Fig. 2. Adding signals in a single load.

Fig. 3. Bar hybrids in tandem.

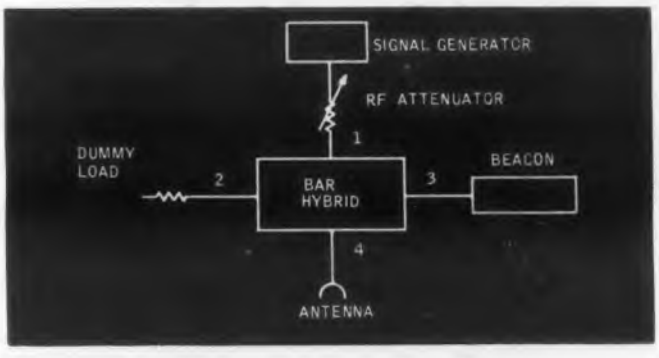


Fig. 4. Applying bar hybrids in a monopulse system.

flected back to arm 1.

- During receive time, echoes picked up by the antennas enter arm 4 and since the TR tubes are no longer firing, split up evenly at arms 2 and 3.
- These two signals are now fed through two lengths of line, different in length by $\lambda/4$ to equalize phase, to arms 2 and 3 of hybrid 2.
- All energy is summed in arm 1 with a termination placed on arm 4 to absorb any small residual signals.
- The output of arm 2 is now fed to arm 1 of hybrid 3 which is simply used as a balanced mixer.

Beacon Switching Device

A signal generator applies to a low-level signal to arm 3 of the hybrid through a variable attenuator (Fig. 6). This signal splits evenly between arms 1 and 4 with half the power being dissipated in the dummy load terminating arm 4. The portion of the signal entering arm 1 triggers a beacon transmitter which sends a high-level signal back into the hybrid. The beacon signal splits evenly between arms 2 and 3. The attenuator at arm 3 absorbs the signal and arm 2 is attached to an antenna for transmission to the aircraft or missile.

Table 1. Typical Characteristics of S-Band Hybrids

S-Band	Bar Hybrid	Magic Tee	Short Slot Hybrid
Approx. bandwidth (%)	50	12	12
Max vswr	2.00	2.00	1.12
Max balance (db)	0.2	0.25	0.25
Max isolation (db)	30	35	30
Approx. wt (oz)	12	48	33
Dimensions (in.)	4 x 3½ x 1	11 x 10 x 8	15 x 8 x 4

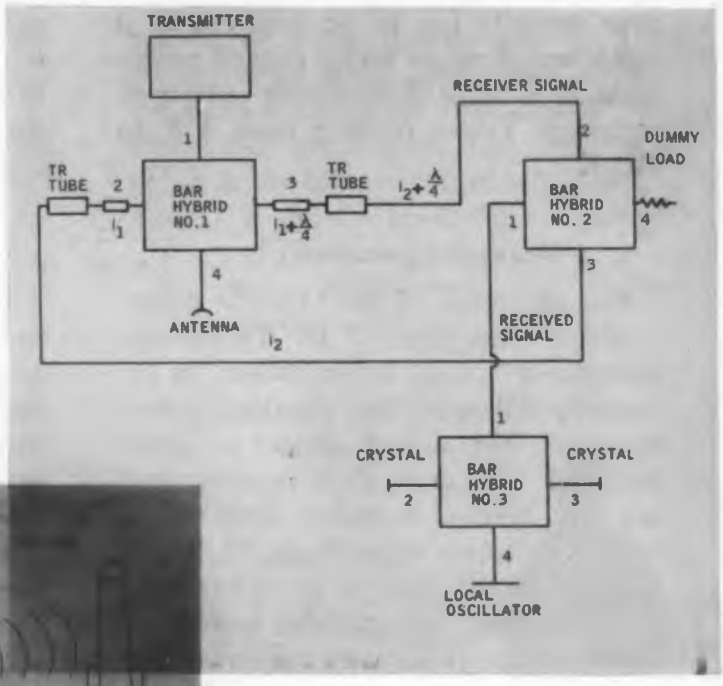


Fig. 5. Puplexer design for TR-ATR applications.

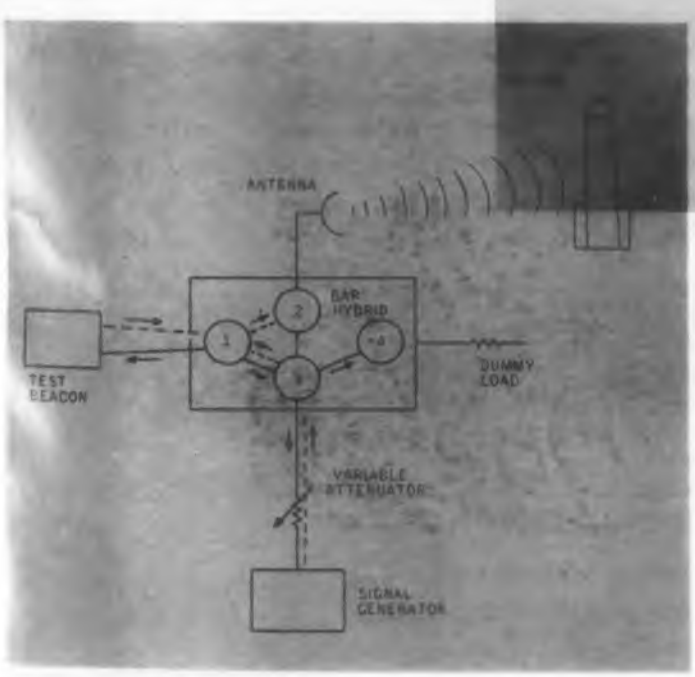


Fig. 6. Beacon switching device using a bar hybrid.

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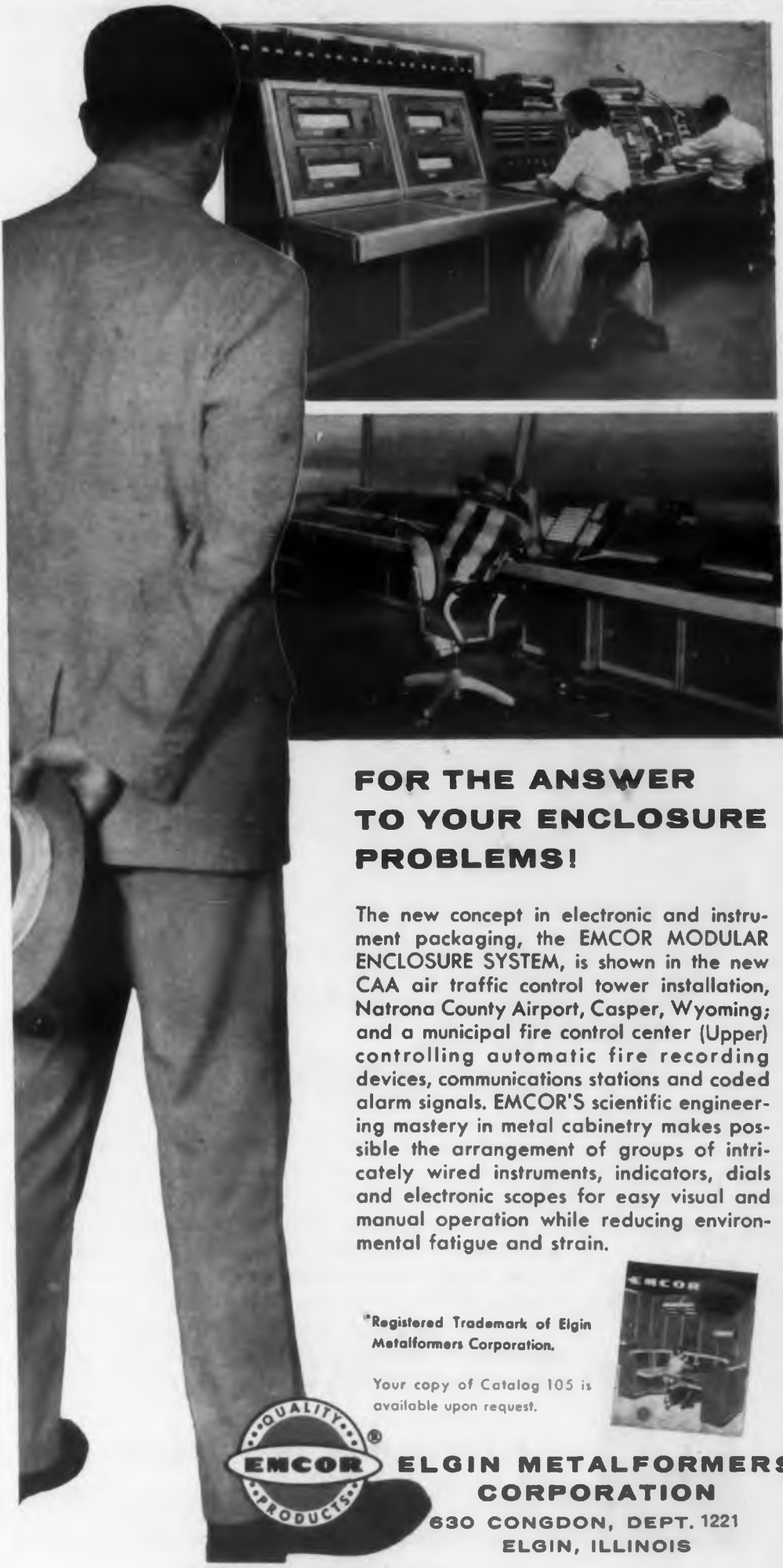

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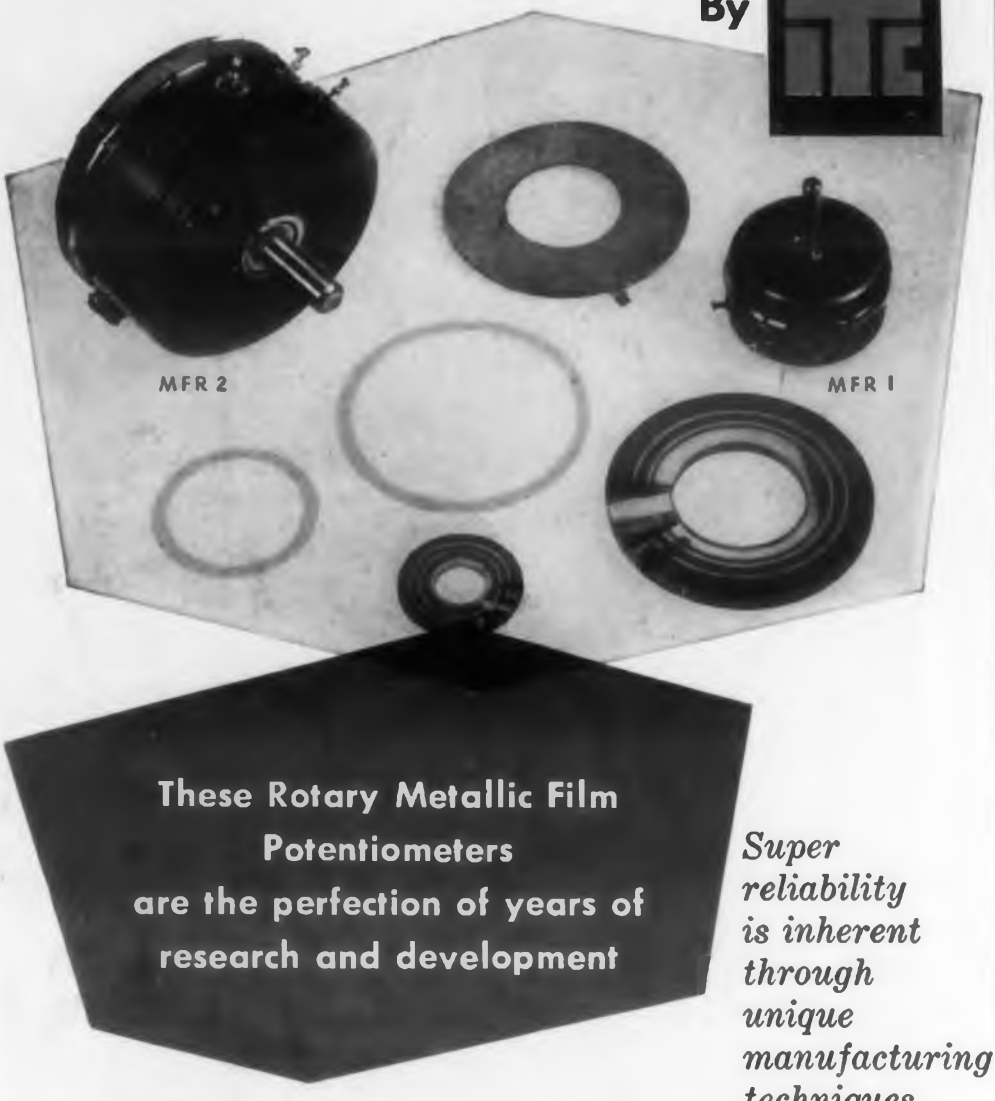

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Unusual Operation . . .

The operation of the M10T09 potentiometer manufactured by Technology Instrument Corp., Acton, Mass., is essentially different from standard potentiometers. The sliding contact is shown in Fig. 1. The shaft, shaft insulator and key are bonded together with epoxy cement to form a rugged unit. The slider is keyed to the shaft to permit translational motion, yet prohibit rotational motion of the slider with respect to the shaft.

The thread on the OD of the slider is identical with the thread on a wire guide. This forces the wiper contact to follow the helical pattern of the resistance winding. See Fig. 2. The electrical path from winding contact to external terminal is completed through the key to the slip ring contact, from the slip ring contact to the slip ring and from the slip ring to the external terminal.

. . . and Unusual Construction

Engineers at TIC decided upon a new technique to lay the windings into the base of the potentiometer. They felt that the usual method of buffing insulated wires with some abrasive compound to permit contact between the wiper and winding inevitably scratched the surface of the windings and disturbed the uniform spacing of the individual turns. This resulted in lower linearity and more noise.

Accordingly, bare wire is used as the

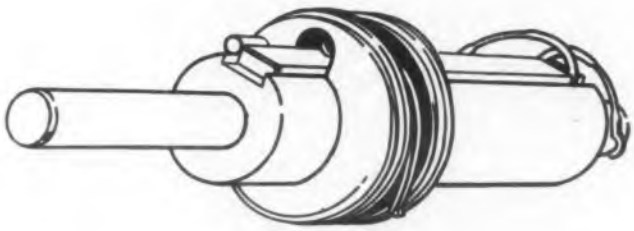


Fig. 1. Rotating subassembly showing sliding contact, shaft, shaft insulator, and key.

resistance element to completely eliminate the need for buffing. By spacing the bare wires slightly farther apart than for the case of insulated wire, shorting between turns is avoided.

The method of laying in the windings is both ingenious and simple:

- A 30 in. piece of insulated magnet wire is laid under tension along the groove portion of the plug shown in Fig. 3. This wire is actually the guide for the wiper assembly.
- The bare resistance wire is then wound around a copper rod. The copper rod is removed and the bare winding is now laid down under tension, in the grooves formed by the guide wire.
- A coating of epoxy cement is applied to the subassembly and then properly cured to hold the winding and wire guide securely in place. Teflon washers prevent the cement from adhering to another surface.
- Insulation between the winding and the base is provided by a piece of Mylar, 0.005 in. thick. With the winding plug in place in the base, additional epoxy cement is applied between the winding and the Mylar insulation. When cured, this cement locks the winding firmly in place in the base. The plug now screws out simply and easily without disturbing either the winding or the wire guide.

The result is that at no time through the entire process has the portion of the winding that is contacted by the wiper, been exposed to contamination by adhesives or other foreign matter. The cleaner wiper action due to this process results in a low noise resistance of 100 ohms max at 4 rpm. The resolution sacrificed by this technique is negligible. For a 1 K unit the resolution is 0.000255 (reciprocal of number of turns).

For more information, turn to the Reader-Service card and circle 26.

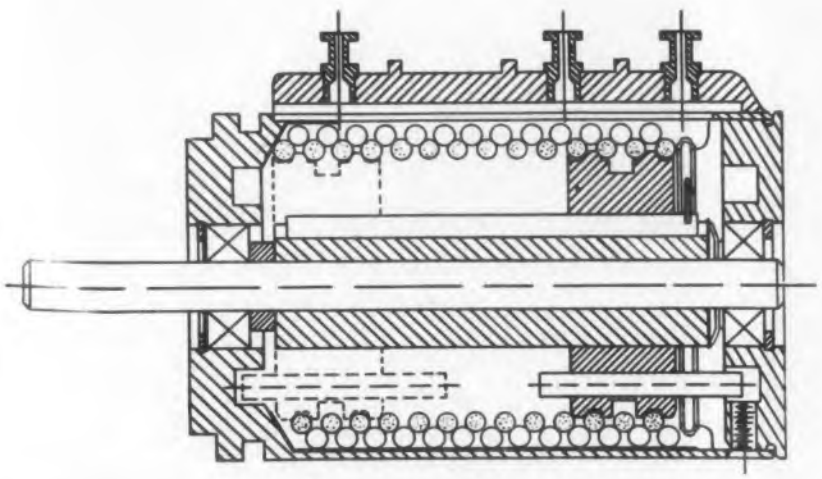


Fig. 2. (above) Cutaway view of the M10T09 potentiometer.

Fig. 3. (right) The winding plug on which the bare resistance wire and the wire guide are wound.

Design Considerations for . . .

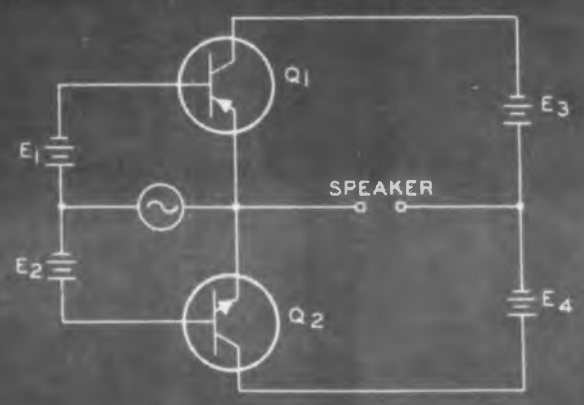
Class B Complementry-Symmetry Audio Amplifiers

C. F. Wheatley

Rodio Corporation of America
Semiconductor and Materials Division
Somerville, New Jersey

In this basic complementary-symmetry circuit, the pnp transistor Q_1 receives base bias voltage from E_1 and collector voltage from E_3. The npn transistor Q_2 receives a base bias voltage from E_2 and collector voltage from E_4. A positive voltage from the generator increases the collector current in Q_2 and decreases the collector current in Q_1, thereby producing an output signal across the load. The quiescent collector currents caused by voltages E_1 and E_2 determine the class of operation—class A, Class AB, or Class B.[1]

This article applies the basic complementary-symmetry principle to the practical design of a Class B system having optimum performance. Optimum performance is considered to be achieved when a maximum clipping-level power output is obtained for a given load and supply voltage with a maximum power gain from the driver input to the load. Distortion is not considered of prime importance because it can be modified considerably in a given circuit by the degree of matching of transistors, the quiescent idling current, and the presence of negative feedback (at some sacrifice of power gain). It is assumed in the design that a single voltage supply is desired.



TWO BASIC circuits that approach optimum performance, together with their mid-frequency equivalent circuits, are shown in Figs. 1 and 2.

In Fig. 1, the collector supply, E_{cc}, is at ac and dc ground with respect to the input, and, therefore, full supply voltage is available for earlier stages. However, the over-all efficiency of the circuit shown in Fig. 2 is higher because the circuit is not driver limited and the full power-output capabilities of transistors Q_1 and Q_2 may be realized. In addition, the dissipation rating of transistor Q_3 may be much lower in the circuit of Fig. 2 because a voltage rating of only a few volts is required for Q_2, rather than the full supply voltage required in the circuit of Fig. 1. Much higher values of collector-to-base intrinsic capacitance and conductance may also be tolerated in the circuit of Fig. 2. Both circuits are equally satisfactory with regard to over-all power gain, distortion, and input impedance.

Circuit Parameters

In the design of conventional Class B circuits, the supply voltage, power-output rating, and load impedance are usually all given for a fixed application. For a push-pull design in which the output transformer is omitted, however, only two of these three parameters may be given be-

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C. Frank Wheatley entered the University of Maryland and received the B.S. degree in Electrical Engineering in 1951. The same year, he joined the Tube Division of RCA in Harrison, N.J. as a design and development engineer working on transistors. He was a production engineer on transistors from 1953 to 1954, and has since been working as an application engineer in the Semiconductor and Materials Division.

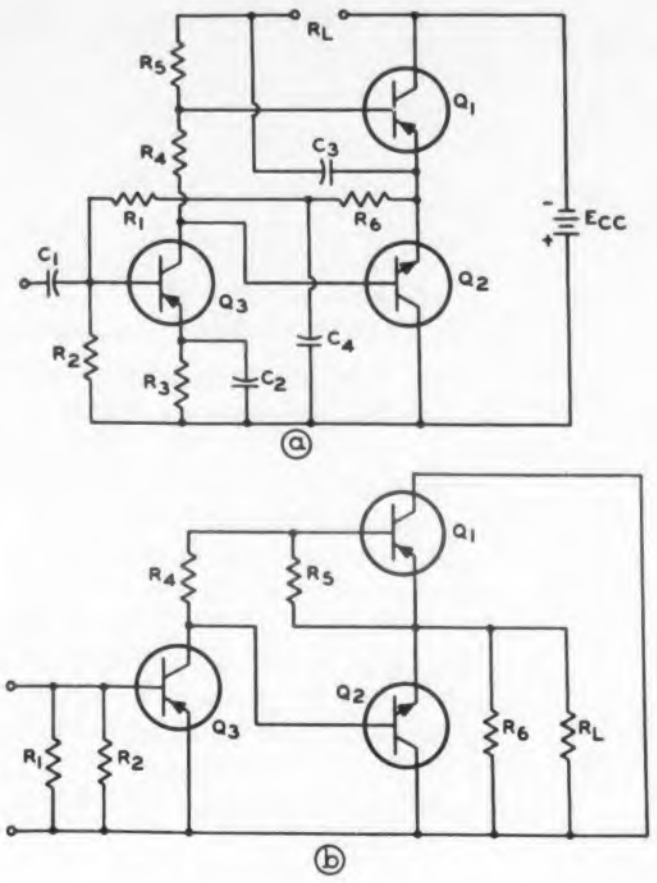

Fig. 1. A practical complementary symmetry 10 w circuit (a) and its ac equivalent (b).

cause they are related by a simple equation. For Fig. 2:

$$Po = \frac{(V_{cc} - V_1 - V_2)^2}{8\,R_L} \qquad (1)$$

For Fig. 1:

$$Po = \frac{(V_{cc} - V_1 - V_3 - V_4 - V_5)^2}{8\,R_L} \qquad (2)$$

where Po is the power-output at the point of clipping; V_{cc} is the collector supply voltage; V_1, V_2, and V_3 are the collector-to-emitter saturation voltages (often referred to as the "knee") of Q_1, Q_2, and Q_3, respectively; V_4 is the base-to-emitter saturation voltage of Q_2; V_5 is the dc voltage drop across R_3; and R_L is the load impedance.

If rated power output is defined at the 10 per cent distortion level rather than clipping level, equations (1) and (2) should be multiplied by a factor of 1.2. This factor is derived on the basis of other considerations not pertinent to this article.

When germanium-alloy transistors are used, V_1, V_2, and V_3 are essentially independent of collector current and have a value of about 0.3 v. For silicon-alloy transistors, their value is about 0.6 v.

If grown-junction transistors are used, the

TABLE I

Circuit of Fig. 2 Power output = 175 milliwatts	Circuit of Fig. 1 Power output = 10 watts
R_1 = 4700 ohms	R_1 = 680 ohms
R_2 = 3900 ohms	R_2 = 220 ohms
R_3 = 330 ohms	R_3 = 24 ohms
R_4 = 82 ohms	R_4 = 8.2 ohms
R_5 = 1200 ohms	R_5 = 390 ohms
R_6 = 270 ohms	R_6 = 2200 ohms
R_L = 50 ohms	R_L = 16 ohms
Peak I_c = 100 milliamperes	Peak I_c = 1.1 amperes
$P_{2Q_1} = P_{2Q_2}$ = 60 milliwatts	P_{1Q_1} = 3 watts
β min = 45	P_{1Q_2} = 3.5 watts
V_{cc} = 9 volts	P_{1Q_3} = 0.81 watt
7.2 volts at 2 milliamperes supplied to earlier stages	V_{cc} = 38 volts
	β min = 40

emitter and collector bulk resistances add from 0.1 to 1 v to V_1, V_2, and V_3, depending upon the transistors and their peak currents. The value of V_4 varies from about 0.25 to 0.5 volt for germanium-alloy transistors. The effect of emitter bulk resistance adds about 0.05 to 0.5 volt if grown-junction transistors are used. V_4 is about 0.4 volt higher for silicon transistors than for germanium transistors. Specific values of V_1, V_2,

NOMENCLATURE

P_o = output power at the clipping level

V_1, V_2, V_3 = collector-to-emitter saturation voltages of Q_1, Q_2, Q_3

V_4 = base-to-emitter saturation voltage of Q_2

V_5 = dc voltage drop across R_3

V_{eff} = an idealized supply voltage equal to the peak-to-peak output voltage at the clipping level

Peak I_c = peak collector current of Q_1 or Q_2

P_{1Q_1} = maximum dissipation of Q_1 in the circuit of Fig. 1

P_{1Q_2} = maximum dissipation of Q_2 in the circuit of Fig. 1

P_{2Q_1} = maximum dissipation of Q_1 in the circuit of Fig. 2

P_{2Q_2} = maximum dissipation of Q_2 in the circuit of Fig. 2

I_{o_1}, I_{o_2} = quiescent collector current of Q_1, Q_2

I_{co_3} = the collector-to-base leakage current of Q_3

β_1, β_2, β_3 = base-to-collector current amplification factor (beta) of Q_1, Q_2, Q_3

Peak I_b = peak base current of Q_1 or Q_2

I_{c_3} = operating collector current of Q_3

$r_{bb'_1}$, $r_{bb'_2}$, $r_{bb'_3}$ = base-lead resistance of Q_1, Q_2, Q_3

V_{be_1}, V_{be_2}, V_{be_3} = base-to-emitter voltage of Q_1, Q_2, Q_3 under quiescent conditions

I_{b_3} = operating base current of Q_3

R_e = emitter bulk resistance (plus any unbypassed emitter resistance)

Peak V_{b_2} = peak base voltage required to drive Q_2 to peak I_c

I_4 = dc current supplied to earlier stages

I_5 = dc current through R_2

V_6 = dc voltage supplied to earlier stages

τ_1, τ_2, τ_{12} — low frequency time constant caused by C_1, C_2, C_1 and C_2

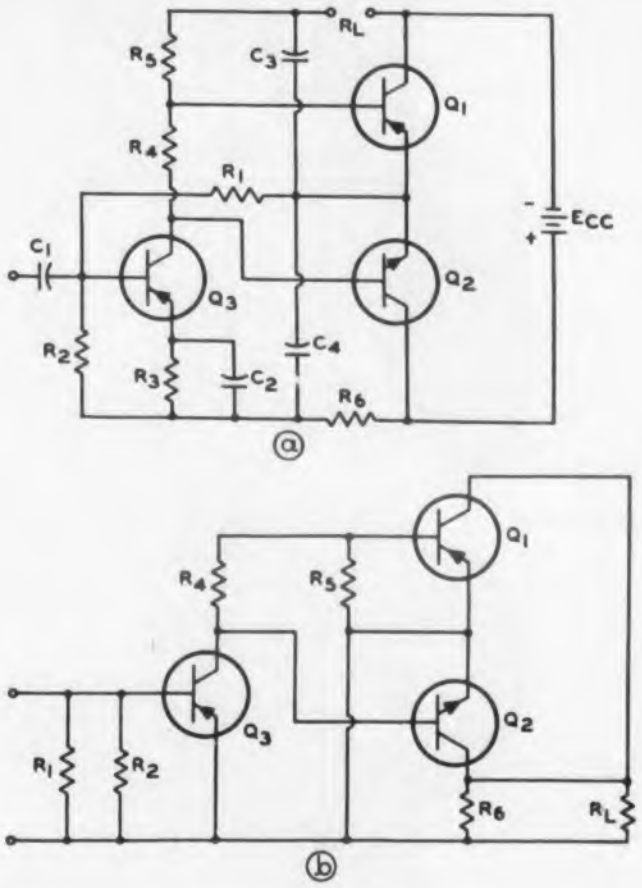

Fig. 2. A practical complementary symmetry 175 mw circuit (a) and its ac equivalent (b).

V_3, and V_4 can be obtained from the characteristic curves of the particular transistors selected.

V_5 is a self-bias voltage for transistor Q_3. The larger the value of V_5, the greater the thermal stability and interchangeability of Q_3 (assumed that R_2 is fixed). V_5 should not usually be less than 0.1 v. A typical value is about 0.5 v. Large values of V_5 (Fig. 2) do not adversely affect performance, and values approaching $V_{cc/2}$ may be used.

Load impedance, R_L, (Fig. 3) is shown as a function of effective collector supply voltage, V_{eff}, for values of maximum undistorted sinusoidal power output ranging from 10 milliwatts to 100 watts (assumed that "linear" transistors are used). Actual supply voltage (V_{cc}) for Fig. 2 is given by:

$$V_{cc} = V_{eff} + V_1 + V_2 \qquad (3)$$

For Fig. 1:

$$V_{cc} = V_{eff} + V_1 + V_3 + V_4 + V_5 \qquad (4)$$

Transistor Parameters

Due to avalanche multiplication effects,[6,7] transistors Q_1 and Q_2 may have two collector-to-emitter voltage ratings—one rating under forward-bias conditions, and the other under reverse-bias conditions. For a resistive load under Class B operation, the forward-bias rating must equal or exceed $V_{eff/2}$ while the reverse-bias

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rating must equal or exceed V_{eff}. For most applications however, reactive loading is occasionally present (near speaker resonance, turn-on transients, and turn-off transients). With a reactive load the voltage and current are out of phase, causing the transistor to be forward-biased at voltages well in excess of $V_{eff/2}$. Where high excitation under reactive loading may be encountered, the forward-bias voltage rating must approach V_{eff} to prevent transistor destruction under transients.

The peak collector current (I_c) rating for Q_1 and Q_2 must be equal to or greater than:

$$\text{Peak } I_c = \frac{V_{eff}}{2}\left(\frac{1}{R_L} + \frac{1}{R_6}\right) \qquad (5)$$

It should be noted that R_6 is not the same for the circuits shown in Figs. 1 and 2. Normally, the value of R_6 in the circuit of Fig. 1 will not appreciably affect the peak collector current. In the circuit of Fig. 2, however, R_6 may contribute 15 to 20 per cent of the value of peak I_c. The actual value of R_6 will be determined later. For the purpose of defining Q_1 and Q_2 peak current ratings, the following equations are sufficiently accurate. For Fig. 1:

$$\text{Peak } I_c \cong \frac{V_{eff}}{2R_L} \qquad (6)$$

For Fig. 2:

$$\text{Peak } I_c \cong \frac{1.15\ V_{eff}}{2R_L} \qquad (7)$$

Maximum power dissipation of Q_1 and Q_2 under sine-wave excitation is, in many cases, almost the same as the average power dissipation when speech or music is programmed. Consequently, Q_1 and Q_2 must be able to withstand the full dissipation given by the following equations on a continuous basis. (A complete analysis of transistor dissipation under Class B operation will appear in a forthcoming issue of ELECTRIC DESIGN.)

In the circuit shown in Fig. 1, the maximum dissipation of Q_1 is given by:

$$P_{1\,Q_1} \cong \frac{(V_{eff} + 2\ V_1)^2}{40}\left(\frac{1}{R_L} + \frac{1}{R_6}\right) + \frac{(V_{eff} + 2\ V_1)}{2}(I_{o_1}) \qquad (8)$$

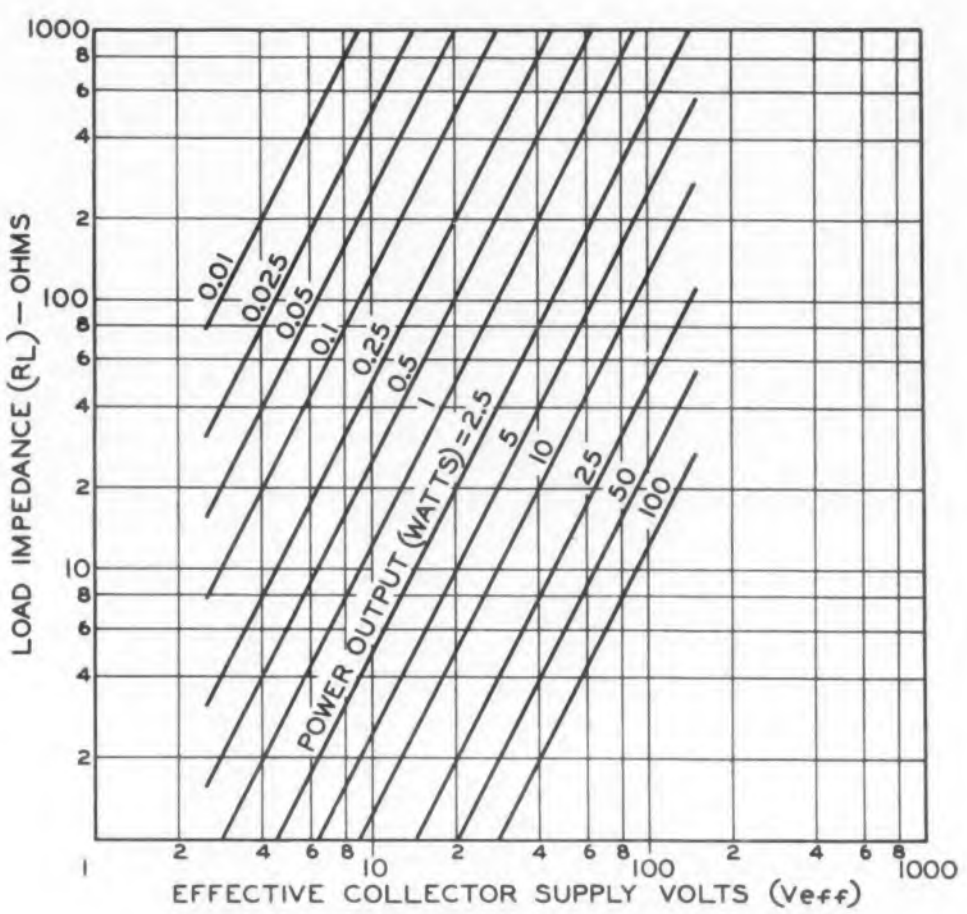

Fig. 3. Load impedance versus effective collector supply voltage for various output power levels.

and the maximum dissipation of Q_2 by:

$$P_{1\,Q_1} \cong \frac{(V_{eff}+2\,V_3+2\,V_4+2\,V_5)^2}{40}\left(\frac{1}{R_L}+\frac{1}{R_6}\right) + \frac{(V_{eff}+2\,V_3+2\,V_4+2\,V_5)}{2}\,(I_{o_2}) \quad (9)$$

In Fig. 2, the maximum dissipation of Q_1 is given by:

$$P_{2\,Q_2} \cong \frac{(V_{eff}+2\,V_1)^2}{40}\left(\frac{1}{R_L}+\frac{1}{R_6}\right) + \frac{(V_{eff}+2\,V_1)}{2}\,(I_{o_1}) \quad (10)$$

and the maximum dissipation of Q_2 by:

$$P_{2\,Q_2} \cong \frac{(V_{eff}+2\,V_2)^2}{40}\left(\frac{1}{R_L}+\frac{1}{R_6}\right) + \frac{(V_{eff}+2\,V_2)}{2}\,(I_{o_2}) \quad (11)$$

Here, I_{o1} and I_{o2} are the quiescent collector currents (idling currents) of Q_1 and Q_2 respectively. These currents will vary appreciably with temperature unless special provisions are made, as will be discussed later.

Because R_6 is normally much greater in the circuit of Fig. 1 than in the circuit of Fig. 2, the dissipation of Q_1 is normally less in the circuit of Fig. 1, all other conditions being equal. A direct comparison cannot be made between the circuits for Q_2 dissipation because of the effects of V_2, V_3, V_4, and V_5.

The mid-frequency equivalent circuits in Figs. 1 and 2 show that Q_1 is driven from a source having an impedance equal to R_5 and Q_2 from a source having an impedance equal to $(R_4 + R_5)$ (both transistors are operated in the common-emitter configuration). This statement assumes that the output impedance of Q_3 is practically infinite, which is a reasonable assumption. Normally, R_4 is quite small compared to R_5; therefore, the source impedance may be considered to equal R_5 for both Q_1 and Q_2. Because R_5 shunts some of the signal current from the bases of Q_1 and Q_2, it is desirable to make R_5 large relative to the input impedance. Q_1 and Q_2 may then be considered to be driven from a current source. Consequently, it is desirable to match the base-to-collector current amplification factors, or "betas," of Q_1 and Q_2. The distortion introduced by beta-mismatch is even-order distortion which, except for intermodulation effects, can be accepted in rather large amounts. The per cent second-harmonic distortion (% 2nd) is given by[8]:

$$\%\ 2\text{nd} = 42\,\frac{\beta_1-\beta_2}{\beta_1+\beta_2} \quad (12)$$

where β_1 is the beta of Q_1 and β_2 is the beta of Q_2.

The driver transistor, Q_3, must supply signal current to the bases of Q_1 and Q_2 and also to R_5. The peak base current (I_b) of the output stage, Q_1, is given by

$$\text{Peak } I_b = \text{Peak}\,\frac{I_c}{\beta_1} \quad (13)$$

In order to determine the maximum drive needed, it is necessary to determine peak I_b for the minimum value of β_1 anticipated. The value of β_1 should be evaluated for a dc collector current at, or near the peak I_c given previously.

Because the driver distortion is a function of the ratio of the ac current to the dc current (among other things), it is desirable that the driver dc current be large compared to peak I_b. However, the value of R_5 will vary inversely with the driver dc current, and it is desirable to keep R_5 as large as possible to maintain maximum over-all gain. For a satisfactory balance between distortion and sensitivity, the driver current (I_{c3}) should be equal to:

$$I_{c3} = 1.5\ \text{Peak}\ I_b \quad (14)$$

Determination Of Resistances

When the value of I_{c3} is known (or assumed), the value of resistor R_5 may be determined as follows:

$$R_5 = \frac{1}{I_{c3}}\left[\frac{V_{eff}}{2}+V_1-V_{be_1}-I_4\,R_6\right]-R_6 \quad (15)$$

where V_{be1} is the base-to-emitter bias voltage required to establish the quiescent collector current I_{o1} in transistor Q_1, and I_4 is the dc current necessary for earlier stages (Fig. 2). When alloy-junction transistors are used, V_1 is about equal to V_{be1}. In addition, the product $I_4\,R_6$ is usually small, and R_5 is normally much larger than R_6. On the basis of these approximations, therefore, equation (15) can be simplified as follows:

$$R_5 \cong \frac{V_{eff}}{2\,I_{c3}} \quad (16)$$

The value of R_4 is given by

$$R_4 = \frac{(V_{be_1}+V_{be_2})}{I_{c3}} \quad (17)$$

where V_{be2} is the emitter-to-base bias voltage required to establish the quiescent collector current I_{o2} in transistor Q_2. The values of V_{be1} and V_{be2} need not be identical to obtain the quiescent collector current required to reduce cross-over distortion (i.e., the transfer characteristics of Q_1 and Q_2 at low collector currents need not be matched). This method of biasing permits greater variation of V_{be} for individual transistors than conventional Class B operation.

Because V_{be} must be reduced by approximately two millivolts per C temperature rise to maintain a constant I_c, the resistance R_4 should be temperature sensitive. Best performance is obtained when R_4 consists of two properly designed semiconductor diodes operated in the forward mode. Satisfactory results may also be achieved by the use of a thermistor-resistor network, and, in some cases, with merely a fixed resistor.

Cross-over distortion at high frequencies is not caused by quiescent current level, but may be traced to two contributing factors[8] (if it is assumed that transformers are not used). If the distortion is essentially independent of amplitude, a beta-frequency-response mismatch is responsible. If the distortion is a perturbation in the cross-over region, the minority carrier storage is responsible.

The value of resistors R_1, R_2, R_3, and R_6 must be determined separately for the circuits shown in Figs. 1 and 2. For the circuit of Fig. 1:

$$R_3 \cong \frac{V_b}{I_{c3}} \quad (18)$$

where it is assumed that $I_{c3} \cong I_{e3}$.

For good thermal stability, R_2 should not be much greater than ten times R_3 (and should be smaller, if practical). If R_2 becomes too small, however, it shunts the input impedance of Q_3. The input impedance of a transistor (R_{in}) is given by

$$R_{in} = r_{bb'} + \frac{\beta}{I_e}\left(\frac{KT}{q}\right) + \beta\,R_e \quad (19)$$

where $r_{bb'}$ is the equivalent base-lead resistance, K is Boltzmann's constant, T is the temperature in degrees Kelvin, q is the charge of an electron, and R_e is the emitter bulk resistance (plus unbypassed emitter resistance, if present).

Intrinsic collector-to-base conductance is neglected in this expression. The value of KT/q is 25.9 millivolts at 300 K. The value of R_2 must be selected to provide a good balance of sensitivity and thermal stability. If good thermal stability is not obtained, the dc potential at the emitters of Q_1 and Q_2 will change rapidly with temperature, thereby causing unsymmetrical clipping and a considerable reduction in the output power. If difficulty is encountered in determin-

ing a suitable value for R_2, it may be advantageous to choose a larger value of V_5.

Resistors R_1 and R_6 establish bias on Q_3 and provide dc feedback to maintain the emitter potential of Q_1 and Q_2 at the desired level.

The current flowing through $(R_1 + R_6)$ is the sum of the base current of Q_3 and the current through R_2. The base current of Q_3 is given by:

$$I_{b_3} \cong \frac{I_{c_3}}{\beta_3} - I_{co_3} \tag{20}$$

where I_{co3} is the collector leakage current of Q_3. The current through R_2 is given by:

$$I_{R_2} = \frac{V_5 + V_{be_3}}{R_2} \tag{21}$$

where V_{be3} is the base-to-emitter voltage of Q_3 when I_{c3} flows. The voltage across $(R_1 + R_6)$ is $\left[\frac{V_{eff}}{2} + V_3 + V_4 - V_{be_3}\right]$. The total resistance $(R_1 + R_6)$, therefore, is given by:

$$(R_1 + R_6) = \frac{(0.5\ V_{eff} + V_3 + V_4 - V_{be_3})}{I_{b_3} + I_{R_2}} \tag{22}$$

Ideally, R_1 should be large compared to the input impedance of Q_3, and R_6 should be large compared to R_L, both consistent with equation (22). As R_6 is increased in value, C_4 is reduced in value because the pertinent decoupling time constant is essentially proportional to $R_6\ C_4$.

The dissipation of transistor Q_3 in the circuit of Fig. 1 is given by:

$$P_{1_{Q_3}} = I_{c_3}\ (0.5\ V_{eff} + V_3 + V_4 - V_{be_2}) \tag{23}$$

In the circuit shown in Fig. 2, it is desirable to choose R_6 first. The larger the value of R_6, the less shunting effect it has upon R_L, and the smaller C_4 may be. As R_6 is made larger, however, the voltage available for Q_3 and earlier stages is reduced. A value of R_6 between five and ten times R_L is usually satisfactory, although the actual value is determined by the specific application. It may, for example, be desirable to let R_6 equal R_L in the form of another speaker.

The voltage available to earlier stages drawing a total current of I_4 (as previously defined) is given by:

$$V_6 = V_{eff} + V_1 + V_2 - (I_{c_3} + I_4)(R_L + R_6) - I_5\ R_6 \tag{24}$$

where I_5 is the current through R_2 (normally, $I_5 < 0.2\ I_{c3}$). This voltage, V_6, must be considered, therefore, in determining R_6. As shown below, V_5 must also be considered.

The collector-to-emitter voltage supplied to Q_3

Fig. 4. Phase shift is responsible for diagonal clipping.

must be sufficient to avoid driver limiting. For most applications, this voltage is equal to:

$$\text{Peak } V_{b_2} \cong \text{Peak } I_{c_1}\left(R_{e_2} + \frac{r_{bb'_2}}{\beta_2}\right) \tag{25}$$

Variations from one transistor to another should be considered when determining peak V_{b2}. Fortunately, when β_2 is small, $r_{bb'2}$ is usually small also. Therefore, the variation in peak V_{b2} should be relatively small.

In order to drive Q_2 to the clipping point:

$$V_5 \leq 0.5\ V_{eff} + V_2 - V_3 - \text{peak } V_{b_2} - V_{be_2} - (I_{c_3} + I_4 + I_5)R_6 \tag{26}$$

The larger the value of V_5, the lower the dissipation of Q_3. The dissipation of Q_3 is given by:

$$P_{2_{Q_3}} = I_{c_3}\ [0.5\ V_{eff} + V_2 - V_{be_2} - V_5 - (I_{c_3} + I_4 + I_5)\ R_6] \tag{27}$$

Thermal stability and transistor interchangeability may also be improved more readily when a relatively large value of V_5 is used. The value of R_3 is given by:

$$R_3 \cong \frac{V_5}{I_{c_3}} \tag{28}$$

where it is assumed that $I_{c3} \cong I_{e3}$.

The parallel combination of R_1 and R_2 (relative to R_3) determines the thermal stability and interchangeability. For good thermal stability, the parallel combination of R_1 and R_2 should not be much greater than ten times R_3 (and should be smaller, if practical). However, because the input impedance of Q_3 is shunted by R_1 in parallel with R_2, R_1 and R_2 should be chosen large compared to the input impedance equation (19).

If the parallel combination of R_1 and R_2 is defined as R_x, the value of R_2 is given by:

$$R_2 = \frac{R_x}{1 - \dfrac{(V_5 + V_{be_3} + I_{b_3}R_x)}{[0.5 V_{eff} + V_2 - (I_{c_3} + I_4 + I_5)\ R_6]}} \tag{29}$$

and the value of R_1 is given by:

$$R_1 = \frac{R_2 R_x}{R_2 - R_x} \tag{30}$$

An assumption was previously made regarding the approximate value of I_5, the dc current through R_2. The value of I_5 may now be determined as follows:

$$I_5 = \frac{V_5 + V_{be_3}}{R_2} \tag{31}$$

If the value of I_5 determined from equation (31) causes an appreciable change in the assumed total of $(I_{c3} + I_4 + I_5)$, a re-evaluation will be in order.

Capacitance Values

Although it may be desirable to choose C_1, C_2, C_3, and C_4 empirically, some effects of the capacitors must be considered. In addition, an empirical derivation of the capacitors should allow for the rather wide tolerances normally encountered with electrolytic capacitors.

If all capacitors except C_1 are assumed to equal infinity, and if R_1 and R_2 are assumed large as compared to R_{in}, the low-frequency time constant is given by:

$$\tau_1 \cong C_1\ (R_g + R_{in}) \tag{32}$$

where R_g is the resistance of the generator driving the amplifier, and R_{in} is given by equation (19). Although a large value of R_g permits a small value of C_1 for a given low-frequency response, the terminal voltage at the generator is subject to the low-frequency time constant, $R_{in}\ C_1$. Consequently, an appreciably greater dynamic range may be required for the generator in order to employ the capacitor predicted by equation (32).

If all capacitors except C_2 are assumed to equal infinity, and if R_1 and R_2 are assumed large compared to R_{in}, the low-frequency time constant is given by:

$$\tau_2 \cong \frac{C_2}{\left[\dfrac{1}{R_3} + \dfrac{\beta_3}{R_g + R_{in}}\right]} \tag{33}$$

Normally:

$$R_3 >> \frac{R_g + R_{in}}{\beta_3} \tag{34}$$

Therefore, equation (33) may be rewritten: . . . .

$$\tau_2 \cong \frac{C_2}{\beta_3}\ (R_g + R_{in}) \tag{35}$$

As in the case of C_1, a large value of R_g may permit a small value of C_2, but create a problem of low-frequency dynamic range. The voltage on

Q_3 must be sufficient to accommodate C_2.

In most applications, R_1 and R_2 are large compared to R_{in}, and inequality (*34*) is realized. In such cases, the low-frequency time constant can be expressed simply:

$$\tau_{12} \cong \frac{C_1 C_2 (R_g + R_{in})}{(\beta_3 C_1 + C_2)} \qquad (36)$$

If $C_1 = C_2/\beta_3 = C$

equation (*36*) can be simplified:

$$\tau_{12} \cong \frac{C (R_g + R_{in})}{2} \qquad (37)$$

When the reactance of C_3 becomes significant compared to R_L, the load on the output stage becomes complex. Because an elliptical load line is then produced, diagonal clipping of the output results at high power levels. This type of distortion is shown in Fig. 4. The dynamic range of Q_3 is also reduced. The C_3 R_L time constant should be large compared to the lowest frequency at which full power output is desired.

C_4 affects the frequency response and the dynamic range of the amplifier in a complex manner. Although C_4 may be calculated, an empirical solution is recommended. C_4 will normally be larger for the circuit of Fig. 2 than for the circuit of Fig. 1.

Typical Values

Typical component values (Table I) are given for two circuits designed by this method. The 175-milliwatt circuit employs the circuit of Fig. 2, while the 10-watt circuit employs the circuit of Fig. 1. These examples do not show any preference of circuit as a function of power level, but merely present two of the infinite possibilities. Capacitor values are not given because they depend upon the particular application.

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Minimize Local Oscillator Drift*

Part 2

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Part 1 of this article introduced an analysis of local oscillator drift.

In this, the concluding part, the analysis is applied to practice in a "step-by-step" stabilization of a typical uhf and vhf local oscillator.

HERE is a procedure to stabilize a local oscillator commonly used in commercial vhf television receivers. The same approach should hold for local oscillators in receivers operating up to and including the uhf band.

The Original Oscillator

Circuitry. The original, uncompensated vhf television oscillator circuit is shown in Fig. 1. Its frequency varies from 101 mc at channel 2 to 257 mc at channel 13. The inductances L_2 and L_3, at channel 13, are short-circuited. Under these conditions the inductance L_1 and the circuit capacitances constitute the frequency-determining elements. At channel 7 however, only L_3 is short-circuited. Consequently, L_2 tunes from channels 7 to 13 inclusive, whereas L_3 tunes from channels 2 to 6 inclusive. All capacitances external to the oscillator tube are not temperature-sensitive.

Frequency Characteristics. When installed in a commercial vhf color tv revceiver, the frequency characteristics of the original local oscillator at channel 6 are illustrated by the Δf (overall) curve in Fig. 2 which exhibits two distinct changes in slope. Accordingly, there are at least two major components of frequency deviations.

1. The fast-acting component is

$$\Delta f_1 = \alpha_1 (1 - \epsilon^{-\beta_1 t})$$

where α = maximum oscillator frequency deviation, and β = the rate of change of oscillator frequency. The fast-acting component is caused by the changes of tube capacitances during the early minutes of operation. To evaluate this component, all associated circuit elements of the original oscillator are replaced by a single inductance L_o made of Milvar wire, having an extremely low coefficient of thermal expansion. L_o and the tube capacitances then constitute the frequency determining elements. The corresponding frequency deviations are

$$\Delta f_1 = -0.00475 f (1 - \epsilon^{-0.55 t}) \qquad (1)$$

It is evident that the frequency deviation, Δf_1 is directly proportional to the oscillator frequency. At channel 6, the oscillator frequency is 126 mc; so $\alpha_1 = -0.610$ mc and $\beta_1 = 0.55$ which is independent of the oscillator frequency.

2. The slow-acting component is

$$\Delta f_2 = \alpha_2 (1 - \epsilon^{-\beta_2 t})$$

The difference between the instantaneous overall frequency deviation Δf and the fast-acting component Δf_1 gives the slow-acting component Δf_2. At channel 6,

$$\Delta f_2 = -0.500 (1 - \epsilon^{-0.04 t}) \qquad (2)$$

Requirements for Frequency Stabilization. To obtain good frequency stabilization of the original local oscillator, the following requirements must be met.

- At least two compensating elements, A and B, are needed – A to compensate for the fast-acting component Δf_1, and B to compensate for the

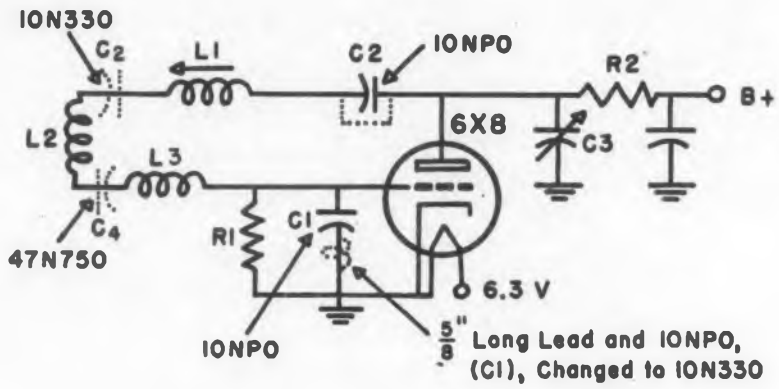

Fig. 1. Local oscillator circuit of vhf tv receivers. The dotted components are for stabilization.

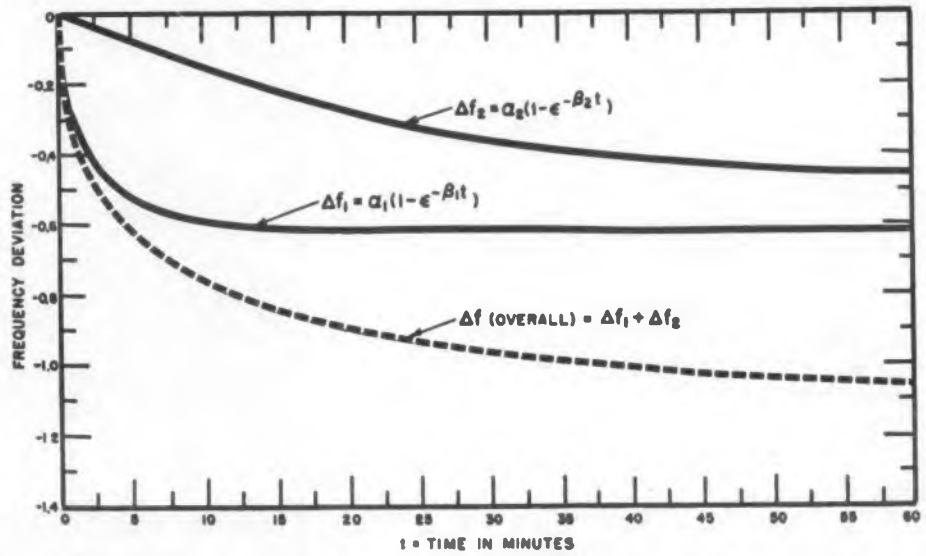

Fig. 2. The original frequency characteristics of the vhf local oscillator, with the fast-acting (Δf_1) and slow-acting (Δf_2) deviation components.

* By courtesy of Product Engineering, Radio Corporation of America

slow-acting component Δf_2. The expressions for A and B are, respectively

$$\Delta f'_1 = \alpha'_1 (1 - \epsilon^{-\beta'_1 t}) \text{ and}$$
$$\Delta f'_2 = \alpha'_2 (1 - \epsilon^{-\beta'_2 t})$$

- These two compensating elements must be so situated in the oscillator circuit that β'_1 of A approaches the value of β_1 of Δf_1, and β'_2 of B approaches the value of β_2 of Δf_2.
- The compensating elements must exhibit negative temperature sensitivities, in this case, to raise the oscillator frequency with temperature rise.
- The magnitudes of α'_1 of A and α'_2 of B must approach those of α_1 of Δf_1 and α_2 of Δf_2.

Stabilization Procedures. The stabilized oscillator circuit is again shown in Fig. 1, with the modifications indicated by the dotted components.

1. The capacitance C_1 (replaced with 10N330 and a lead of 5/8 in.) compensates for Δf_1, the fast-acting component of the oscillator-frequency deviation. For perfect compensation

$$\Delta f'_1 = \Delta f_1$$

$$or \qquad \Delta f'_1 = -\alpha_1 (1 - \epsilon^{-\beta_1 t}) \qquad (3)$$

To make $\beta'_1 = \beta_1$, the capacitance C_1 must be as close as possible to the source of the heat flow. It is therefore placed at the grid pin of the oscillator tube. The resultant β'_1 value is 0.29 as compared to β_1 of 0.55 for the fast-acting component. The discrepancy between β'_1 and β_1 unavoidably introduces a compensation error, ξ where

$$\xi = \Delta f_1 + \Delta f'_1 \qquad (4)$$

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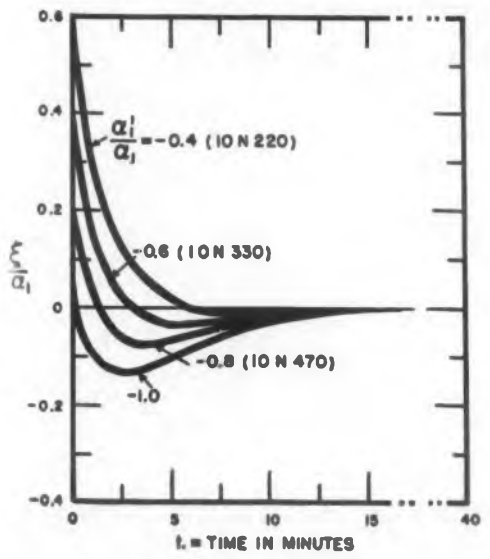

Fig. 3. The compensation error with

$$\epsilon = \alpha_1 (1 - \epsilon^{-.29t}) + \alpha_1 (1 - \epsilon^{-.55t})$$

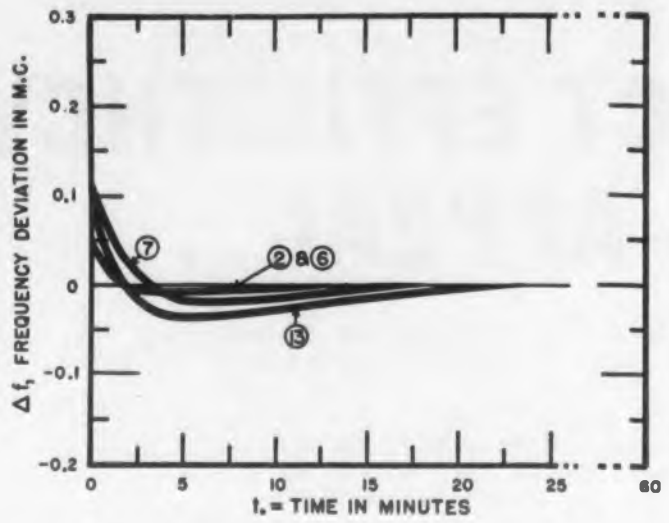

Fig. 4. Frequency characteristics of a stabilized vhf tv local oscillator.

The compensation error expressed in eq. (4) is evaluated in Fig. 3 with values for α'_1 to be —0.4, —0.6, —0.8 and —1.0 of the α_1 value. The error is minimum when $\alpha'_1 = -0.6\ \alpha_1$. At channel 6, $\alpha_1 = -0.610$ mc according to eq. (1). The corresponding compensating error, after two minutes of operation is $-0.04\ \alpha_1$ or —0.025 mc, and $\alpha'_1 = -0.6\ \alpha_1$ or 0.360 mc. A compensating capacitance of 10N330 produces these results approximately.

The added inductance, consisting of a 5/8 in. lead of C_1 makes α'_1 proportional to the oscillator frequency, as α_1 does, at all channels.

2. The capacitance C_2 (replaced with 10N330) compensates for the slow-acting component for channels 7 to 13. At these upper vhf channels, the inductance L_3 and capacitance C_4 are short-circuited. Again for perfect compensation,

$$\Delta f'_2 = \Delta f_2$$

$$or \qquad \Delta f'_2 = -\alpha_2 (1 - \epsilon^{-\beta_2 t}) \qquad (5)$$

C_2 is situated among the associated circuit elements of the local oscillator where the rate of temperature rise is relatively low. Hence the value of β'_2 is approximately equal to β_2. The capacitance and temperature sensitivity of C_2 are determined in a manner alagous to that for C_1 and the corresponding $\alpha'_2 = \alpha_2$ at all upper vhf television channels.

3. The added capacitance C_4 (47N750), together with C_2 are effective in frequency stabilization at the lower vhf channels. Owing to the difference in L/C ratios at the lower oscillator frequencies, C_2 is not sufficient to compensate for the frequency deviation. The addition of C_4 makes α'_2 (at lower channels) $= \alpha_2$. The β'_2 value of C_4 is about equal to the β'_2 value of C_2 because the locations of these two elements are equally distant from the heat source.

Residual Frequency Deviations. A typical production vhf television receiver incorporating these compensating elements behaves as shown in Fig. 4 at channels 2, 6, 7, and 13. The maximum residual frequency deviation is less than ±50 kc after a period of two minutes, and all channels become almost completely stabilized within 30 minutes. This residual frequency deviation during the early minutes of operation is principally caused by the discrepancy between the β'_1 value of the compensating element and the β_1 value of the fast-acting component.

To further minimize local oscillator drift, oscillator tubes other than the miniature type must be used or the compensating element C_1 must be built inside the oscillator tube to produce a β'_1 value about the same as β_1. Due to constructional differences, the β_1 of the RCA pencil triode tube, for instance, is 0.32 which is so close to the β'_1 value of 0.29 that any local oscillator using a pencil triode tube can be compensated more exactly than shown by Fig. 4.

Considerations For UHF Local Oscillators

The same approach used to stabilize a vhf television local oscillator applies equally well to uhf local oscillators. Appropriate compensating elements can again be secured by analyzing the original frequency characteristics of the oscillator with the aid of the analytical representation expressed in

$$Q = \alpha\ (1 - \varepsilon^{-\beta t})$$

where Q is the instantaneous cathode-to-grid radiation; α is the total radiated power; and β is a time constant, determining the rate of heat flow from cathode to grid.

Dimensional Resonances. The stabilization procedures at uhf, however, are further complicated by the fact that some of the associated circuit elements of the local oscillator may have electrical lengths comparable to a quarter wavelength of the local oscillator frequency. To illustrate this complication, a typical uhf commercial tv local oscillator is shown in Fig. 5a. It covers a continuous frequency range from 517 mc at channel 14 to 931 mc at channel 83 by means of a variable ganged capacitor. This is coupled to the 6AF4A oscillator tube by a transmission line having a characteristic impedance of approximately 150 ohms.

At the socket pins of the 6AF4A, the oscillator voltage between the grid and plate falls to a minimum value at approximately 1000 mc. Any temperature sensitive element placed across these two points would affect the oscillator frequencies either above or below that frequency. At 1000 mc the effect is theoretically zero. Since the oscillator line is 1-9/16 in. long, the voltage minimum or null point at the other end of the line corresponds to 500 mc.

If the distance at the junction between the oscillator line and the stator assembly of the ganged capacitor is assumed to be zero, then the null points along the line are illustrated in Fig. 5b. For instance, the 725 mc null point occurs at 7/8 in.

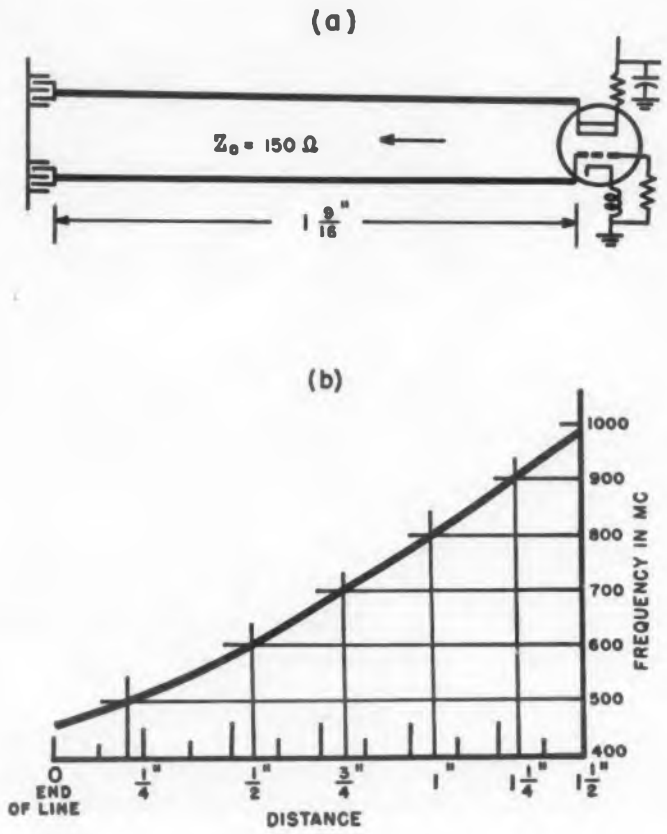

Fig. 5. A typical uhf tv local oscillator (a), with the associated null points along the transmission line (b).

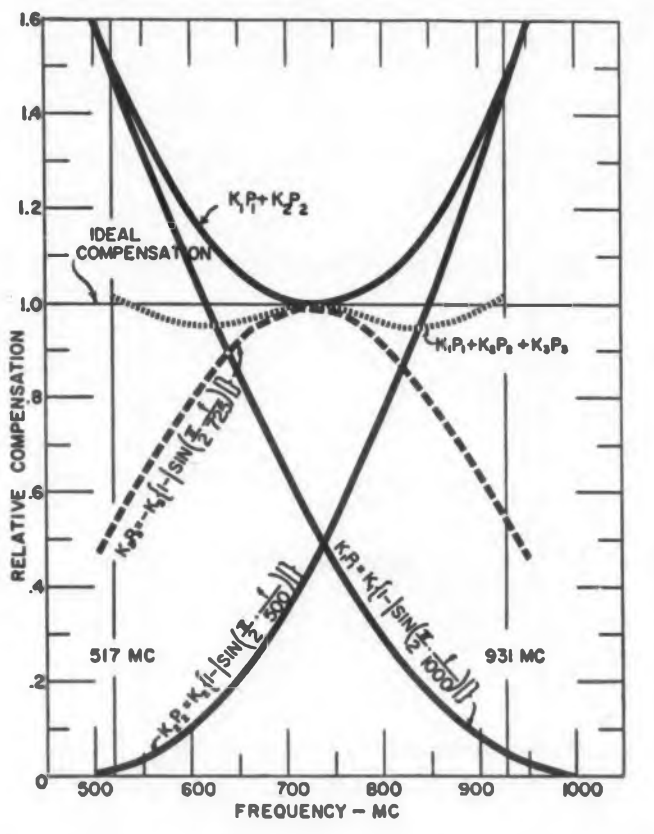

Fig. 6. Three point compensation curves for the uhf local oscillator.

Relative Effectiveness of Compensating Elements. By placing an appropriate temperature-sensitive capacitor at any point x along the oscillator line, the relative effectiveness of frequency compensation (P_x) at an oscillator frequency (f) is determined by

$$P_x = 1 - |\sin\theta|$$

where $\theta = 1/2\,\pi\, f/f_x$

and f_x = null frequency corresponding to point x.

Three-Point Compensation. One compensating element, when properly placed in the uhf oscillator circuit, is sufficient only in receivers designed for a single-frequency or very narrow frequency range operation. To cover an extended band of frequencies, three compensating elements are required for good stabilization. Let compensating capacitances C_1, C_2, and C_3 be connected at points along the oscillator line corresponding to null frequencies of 1000, 500, and 725 mc respectively. The relative compensations of C_1 ($f_{x1} = 1000$ mc) and C_2 ($f_{x2} = 500$ mc) on the oscillator frequency are given by the K_1P_1 and K_2P_2 curves respectively in Fig. 6. The $K_1P_1 + K_2P_2$ curve shows the combined effect of C_1 and C_2.

It must be stressed that the temperature sensitivities and capacitances of these compensating elements depend on the α values needed at these frequencies. The constants K_1, K_2, and K_3 take into account the differences in temperature sensitivities and capacitances of these three compensating elements. Furthermore, since the oscillator line is a good heat conductor, the β values at these three locations do not differ too much.

The contribution of C_3 ($f_{x3} = 725$ mc having a positive temperature sensitivity) is represented by the dashed curve K_3P_3 which leads to an overall compensation marked $K_1P_1 + K_2P_2 + K_3P_3$. Several commercial uhf television receivers have been stabilized with three-point compensation. The residual frequency deviations are less than ± 100 kc at any uhf television channels.

Automatic Recorders Can Help

With the aid of the automatic recording equipment, the analytical expression for frequency deviations greatly simplifies local oscillator stabilization.

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Ambient temperatures, dielectric breakdown, characteristics and weight requirements have also been optimized by this in-line arrangement. The manufacturer reports operation in ambients of 150 C. Dielectric breakdown occurs as high as 1500 vrms due to self-sealing connectors and wider spacing of contacts. Weight of the relay is 3.5 oz and it measures 1.12 in. in diam and 2.88 in. long.

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Manufactured by Patwin Co., Waterbury, Conn., the Magneline indicator has a total weight of 3.3 oz, and can be compactly stacked for multiple digit display. Digits measure 5/8 x 3/8 in., can be read up to 25 ft away and at angles of 60 deg.

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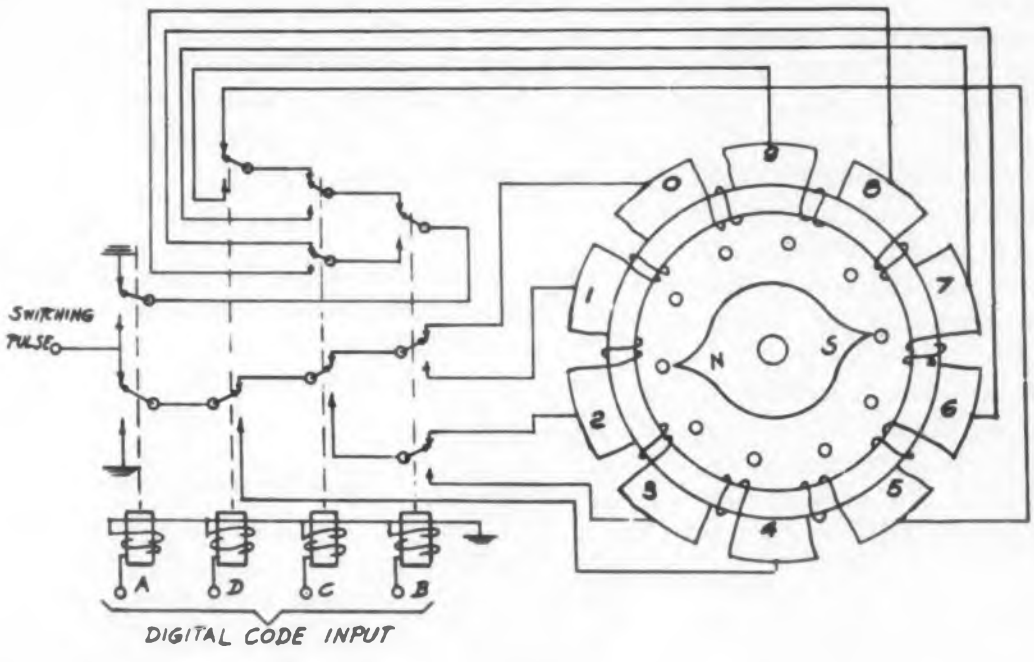

Input code allows the coil of the indicator to be energized at one point and grounded at the opposite point.

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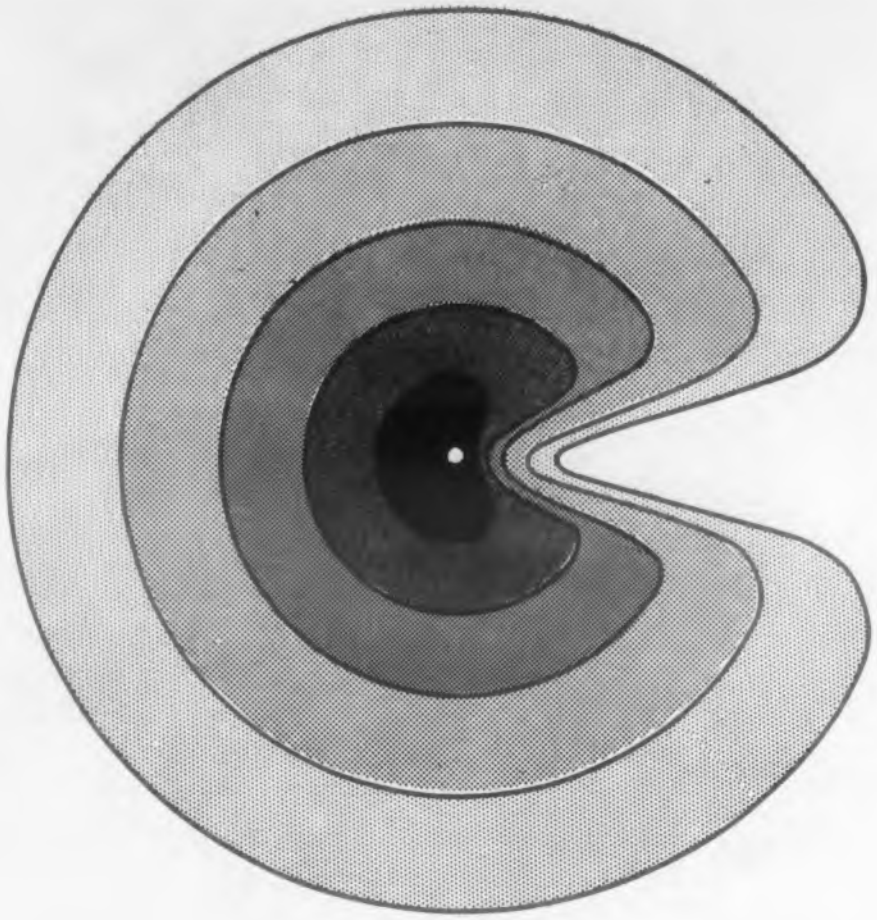

How to eliminate unwanted signals in

Omni UHF and VHF Antennas

A. G. Holtum, Jr.
Chief Engineer
Andrew Corp.
Claremont, Calif.

Unwanted signals in vertically polarized omnidirectional uhf and vhf antennas can be eliminated. A null in the desired direction can be created by synthesizing an array with "off the shelf" antennas. Techniques employed to adjust the parameters of such an array are discussed in this article.

ELIMINATION of a uhf or vhf signal in one direction from an omnidirectional antenna is possible by forming an array using the omnidirectional radiator and one unidirectional radiator properly phased and graded. It is possible to synthesize a pattern which is essentially omnidirectional except for an incremental null in one direction. If the radiation pattern of the unidirectional antenna is known, we can, with certain simplifying assumptions, compute the synthesized pattern.

Consider, for example, a corner reflector with a gain of 6 db over that of a unipole and ground plane. If these antennas are positioned as shown in Fig. 1, the expression for the resulting free space field strength for any direction in azimuth is:

$$E \cong \frac{k}{r}\left[\,1 + A \mid f(\phi) \mid \epsilon^{j(\rho - \delta\beta)}\,\right] \qquad (1)$$

This assumes there is no interaction or mutual effect between the antennas and is an approximation of the free space pattern in the horizontal plane.

If the parameters are adjusted so that there is a null in the $\phi = 0$ position, A will have the value -1, and $f(\phi)_{max} = \mid f(0) \mid = 1$. Note that the antennas are mounted in a plane perpendicular to the direction of the desired null. This aspect effects maximum phase change per unit angle resulting in a smaller increment between minimum and maximum field strength.

Then, if $A = -1$, $|f(0)| = 1$, and $f(\phi)$ is defined for all values of ϕ, we have all the information necessary to compute the pattern. Assuming that the corner reflector is mounted such that its phase does not vary appreciably with ϕ, i.e. $\rho \cong 0$ we have from (1)

$$E \sim 1 - \mid f(\phi) \mid \epsilon^{-j\beta s \sin\phi} \qquad (2)$$

which gives the relative value of E (field strength) at a constant distance r, ($r >> \lambda$) from the antenna. Fig. 2 (a) is a plot of the pattern for $s = \lambda$; Fig. 2(b) shows the relative pattern for $s = 5\ \lambda$.

Feed Systems

To properly grade and phase the antennas forming the array, it is necessary to employ some sort of attenuator or power dividing network and a phase shifter (Fig. 4). The attenuator is needed to adjust the magnitude of the field strength produced by the corner reflectors to equal that of the omnidirectional antenna; the

Originally an Easterner, Al Holtum, Jr. moved West in two steps. After World War II, he worked in the Signal Corps Engineering Labs at Fort Monmouth, N.J. He specialized in antennas.

In 1954 he became chief of the Radio Communications Division at the Signal Corps Electronic Proving Ground, Ft. Huachuca, Ariz. There, he was concerned with testing and evaluating communication systems and concepts.

Recently Al left the sunny Arizona desert and moved over the mountains to often sunny Claremont, Calif. Here he is chief engineer of Andrew California Corp., an affiliate of Andrew Corp. They design and manufacture antennas and antenna systems.

phase shifter is required to adjust the phase of the corner reflector to 180 deg with respect to the omnidirectional antenna.

Best Spacing

Spacing of the antennas determines the width of the incremental null in the composite pattern. As spacing approaches zero, the width of the null approaches the order of the beam width of the corner reflector. As spacing increases, the width of the null becomes smaller, and additional nulls are introduced (Fig. 2).

Assuming that secondary nulls which are formed will not perturb the pattern beyond given limitations, an optimum value for spacing can be found.

Assume that the pattern perturbation is to be limited so that secondary nulls will not reduce the field strength by more than 3 db below that of the omnidirectional antenna alone. From equation (2):

$$E_{min} \sim 1 - | f(\phi)_1 | \qquad (3)$$

And from a graph of the normalized function, the value of ϕ, for which $|f(\phi) = 0.3$, (*making* $E \cong 0.3$). Using Equation (2) secondary nulls can be determined from

$$\beta s \sin \phi = 2\pi n, \text{ where } n = 1, 2, 3 \ldots$$

and the first secondary null will occur for

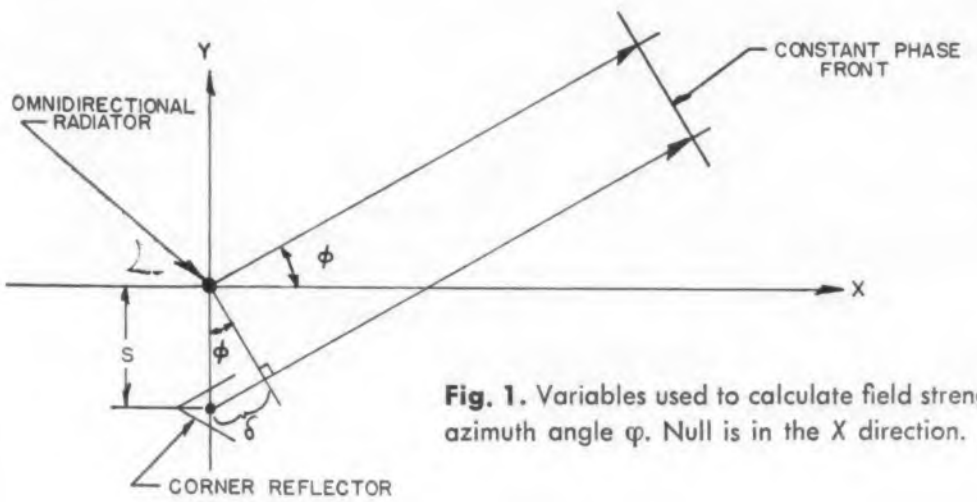

Fig. 1. Variables used to calculate field strength at any azimuth angle φ. Null is in the X direction.

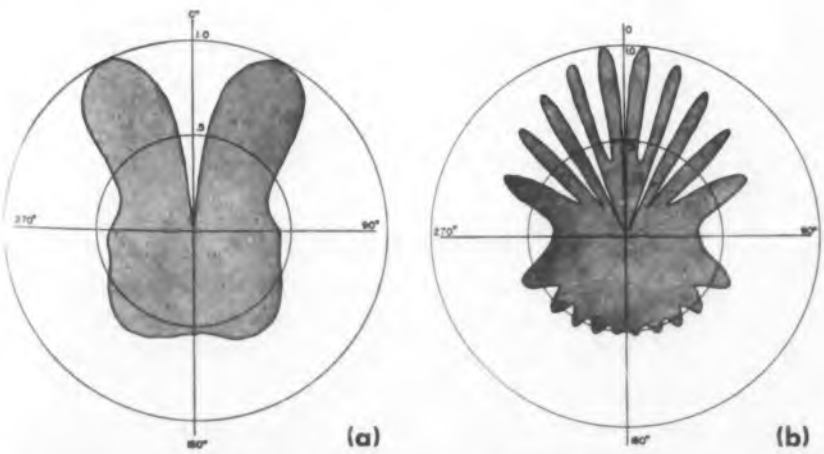

Fig. 2. Field strength pattern using a unipole and corner antenna at a spacing of one wavelength (a) and 5 wavelengths (b).

on the fence about signal generators?

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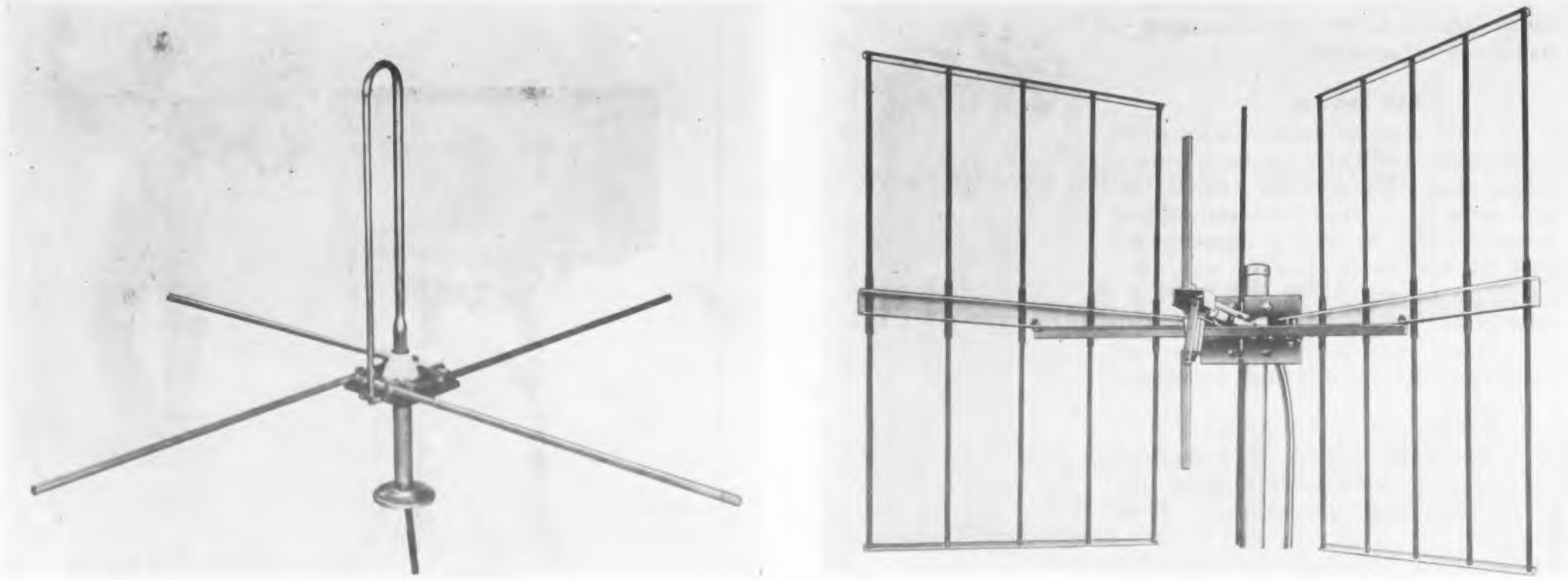

(a) (b)

Fig. 3. Typical "off the shelf" Andrew Corp. antennas used in the array. Omnidirectional type 925-4, (a), is used with corner type 3605, (b).

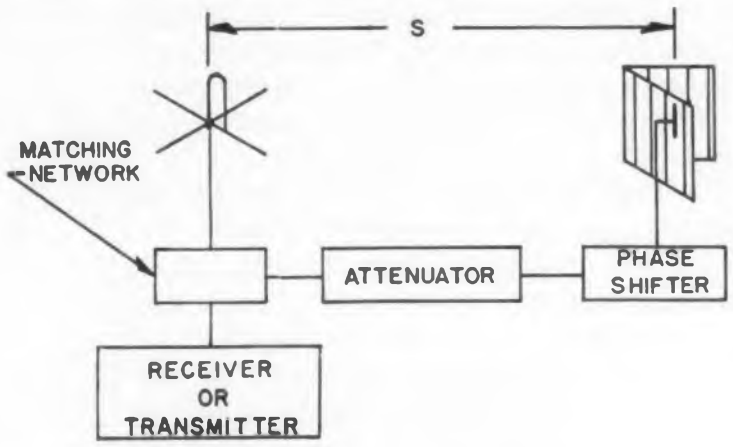

Fig. 4. Functional circuit used to grade and phase antennas forming the array.

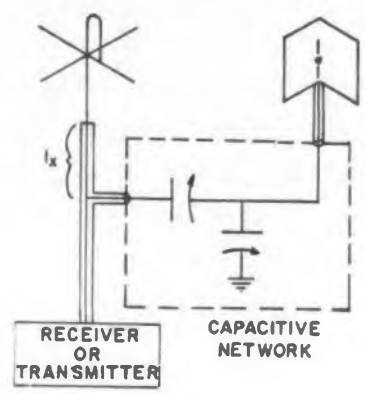

Fig. 5. Block diagram of both antennas and their phasing network.

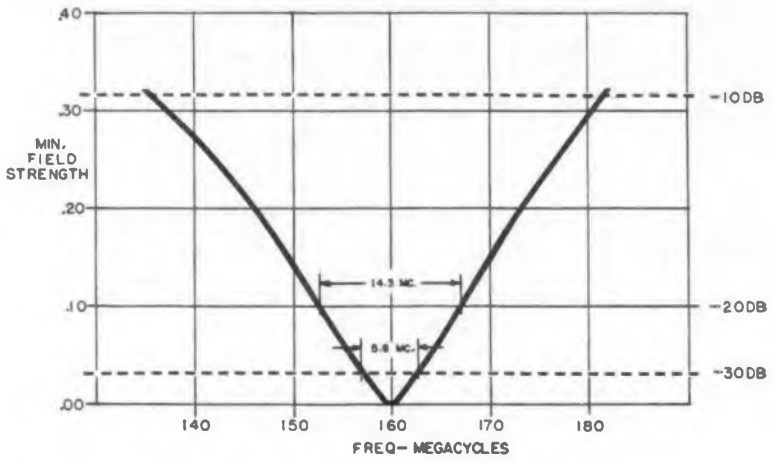

Fig. 6. Null or field strength vs frequency based on a perfect null at a center frequency of 160 mc.

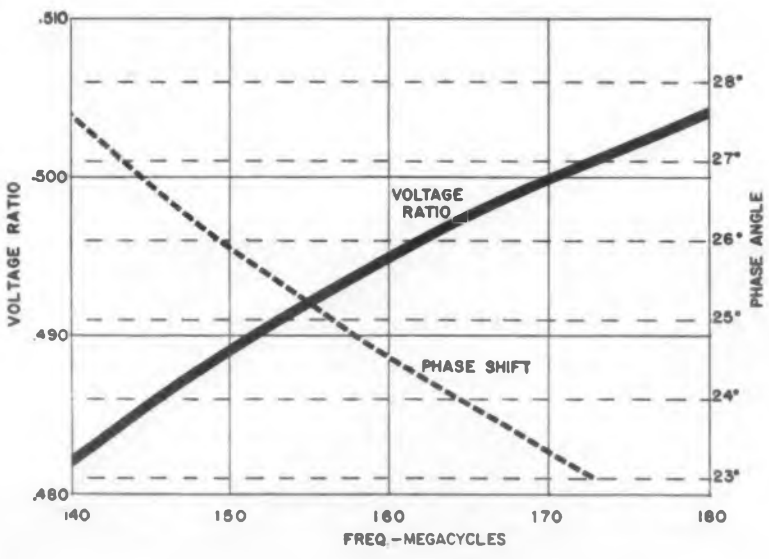

Fig. 7. Attenuation of the capacitive L—network vs frequency.

$s = \frac{\lambda}{\sin \phi_1}$ where ϕ_1, is the angle chosen. Suppose:

$$| f(\phi) | = 0.3 \text{ at } \phi_1 = 80°$$

Then:

$$s = \frac{\lambda}{0.98} \cong \lambda$$

Perturbation Due to Reflections

Our simplified expression, Equation (2), is for the relative field strength in free space. In practice, when the array is mounted, reflections from objects and the ground plane will perturb this pattern somewhat. The perturbation will be

most significant at the null itself, but this can be "tuned" out by readjusting the feed line parameters slightly and "minimizing" the unwanted signal.

Practical Installation

Using standard antenna components (Fig. 3), an array was erected try this method. An L-network of two variable capacitors in combination with a differential in transmission line length (Fig. 5) can be adjusted to give the appropriate attenuation and phasing to the signal impinging on the array.

In analyzing this circuit the approximate bandwidth was computed assuming matched conditions for both antennas. Plot of the null or field strength in the direction of the null versus frequency (Fig. 6) is based on a perfect null at a center frequency of 160 mc. Fig. 7 shows the voltage ratio or attenuation and phase shift of the capacitive network versus frequency.

In this circuit, the differential in transmission line lengths is added in such a way so that incremental changes in frequency will cause compensating changes in phase in the line differential, l_x, with respect to the L-network of capacities. This technique broadens the effective bandwidth.

Using the technique described, it may be possible to synthesize to good approximation many special radiation patterns using a combination of standard antennas. To predict the possibilities more accurately, accurate phase, amplitude, and gain measurements must be made of standard antenna types.

Acknowledgement

The author is indebted to Dr. Victor J. Andrew who conceived the basic idea.

Nomenclature

A = proportionality constant

$\beta = \frac{2\pi}{\lambda}$

$\delta = S \sin \varphi$

$f(\varphi)$ = radiation function of directional antenna

k = constant, dependent upon radiated power

λ = wavelength in free space

r = distance from antenna

ϱ = phase angle, associated with $f(\varphi) = / f(\varphi) / \varepsilon^{j\rho}$

s = spacing between antennas

φ = azimuth angle

High Input Transistor

G. Franklin Montgomery Nationa

INPUT impedance in transistor circuits from 50 to 100 meg can be obtained by using cascaded emitter-follower stages. A cascade of two common-collector stages is shown in Fig. 1. It has an input resistance of approximately $\beta_1 \beta_2 R$, where β_1 and β_2 are the current amplifications of the first and second transistors, and R is the load resistance at the emitter of the second transistor. In parallel with this input resistance is the collector resistance of the first transistor and the effective resistance of its biasing network. If $\beta_1 \beta_2 R$ is large, the parallel resistances establish an upper limit on the total input resistance.

Stampfl and Hanel[1] have shown how feedback may be applied from the second emitter to the first collector to reduce the shunting effect of the collector resistance. The same technique can be used to reduce the effect of the bias network as well. Additional coupling components are needed to supply the feedback.

If the power supply is permitted to float, the feedback can be obtained with only two additional components. Fig. 2 is a typical arrangement. CK722 transistors demonstrate the performance obtainable with inexpensive units. With the output open-circuited, the voltage amplification in the audio-frequency range is nearly unity, and the input resistance is about one meg. With an output load of 1000 ohm, the

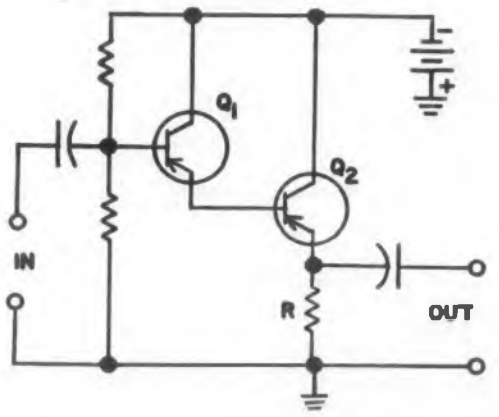

Fig. 1. A cascade of two common-collector stages.

Impedance Amplifier

Bureau of Standards Washington 25, D. C.

voltage amplification is 0.8, and the input resistance is about 150,000 ohm. With high-gain transistors having low leakage current, the bias resistances can be increased, and input resistances of 50 to 100 meg can be obtained.

An experimental amplifier is in use with the following parameters:

- Transistors: type 2N105
- Bias resistors: 4.7 meg collector to base; 2.2 meg base to battery. Collector and emitter resistors in second stage: 15K each.
- Power gain into 12K load: 34 db
- Input impedance: with 12K load resistance, 33 meg; with infinite load resistance, greater than 50 meg.
- Battery voltage: 22 v.

In applications where noise figure is important, it is sometimes erroneously supposed that this type of amplifier requires a large source of impedance. For a low noise figure, the source impedance should be that which is optimum for the same amplifier operated without feedback, usually about 1000 ohm.

References

1. Transistor Amplifier with Extremely High Input Impedance, R. A. Stampfl and R. A. Hanel, Proceedings of the National Electronics Conference, Vo. XI, pp 1-7, Oct. 1955.

2. A High Input Impedance Transistor Circuit, Philip J. Anzalone, ELECTRONIC DESIGN, pp 38-41, June 1, 1957.

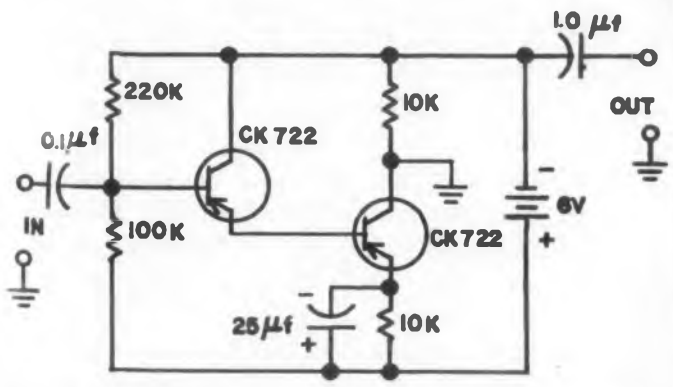

Fig. 2. A typical feedback arrangement where an input impedance of 1 meg is obtained with the output open-circuited.

Ferrites Can be Replaced With Yttrium-Iron Garnet

YTTRIUM-IRON garnet, YIG, a rare earth expected to replace ferrites in microwave applications, is commercially available for the first time.

Produced by Microwave Chemicals Laboratory Inc., 282 7th Ave., New York, YIG has extremely low loss, much lower than conventional microwave ferrites in the microwave region. This polycrystaline material also manifests a much narrower ferrimagnetic resonance line width. Compared to ferrites which have line widths of more than 200 oersteds at 9000 mc, YIG shows a line-width of 55 oersteds at this frequency.

Saturation magnetization of YIG is 1750 gauss. It is noted, however, that some parameters may be varied by introducing other rare earths into the formulation. For example, the saturation magnetization can be held approximately constant, and the line width varied by the introduction of samarium. Similarly, line-width may be held constant and saturation magnetization reduced with the addition of gadolinium. Saturation magnetization values between 450 and 2000 gauss have been obtained by changing the chemical construction.

YIG, which weighs only slightly more than ferrites, has 97 per cent of the

Off-the-shelf samples of yttrium-iron garnet, a rare earth expected to replace ferrites in microwave applications.

theoretical X-ray density. No special machining problems are encountered, though YIG is harder than ferrites.

Available in either rectangular or cylindrical shape, the standard bar size is 1 in. x 1 in. x 3 to 6 in. long.

Among the typical applications cited for this ferrimagnetic material which take advantage of its non-reciprocal properties are: switches, isolators, circulators, paramagnetic amplifiers, radar, ferrite-tuned resonance cavities, modulators and ferri-directional couplers. Though costing more than ferrites, YIG promises to reap many more benefits.

For more information, turn to the Reader Service card and circle 39.

Data on YIG

Density	5.05±0.05
Hardness	8.5
$4\pi M_s$	1750 gauss/cc
Typical resonance line width	9 kmc 55 oersteds 3 kmc 30 oersteds
Dielectric loss tan (20mc)	0.003
Curie temperature	300 C
g factor	2.00 (10 kmc)

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Transistorized High Frequency Chopper Design

Rob Roy
Control Instrument Co., Inc.
Brooklyn, N. Y.

Here is a high frequency chopping technique which balances out unsymmetrical transistor switch impedances and undesirable carrier leakage.

BY SEPARATELY chopping positive and negative halves of modulating signals, transistorized choppers can operate well beyond the usual 60 or 400 cps. Here is how to design one to chop at 275 kc with minimum carrier leakage.

The Grounded Emitter Chopper

The transistor, with its low saturation impedance, and high cutoff impedance, is ideal for a chopper. The grounded emitter configuration requires least carrier drive for effective switching. Fortunately, this matches the requirement for low carrier leakage with zero signal.

To analyze the operation of a transistorized chopper, the large signal equivalent circuit of a grounded emitter pnp transistor is shown in Fig. 1. The pertinent loop equations are

$$V_b = (r_e + r_b)\, I_b + r_e\, I_c \qquad (1)$$

$$V_{ce} = (r_e - \alpha_e\, r_c)\, I_b + [r_e + (1-\alpha_e)\, r_c]\, I_c \qquad (2)$$

Fig. 2 shows the linearized characteristics which correspond to eq (2).

The limits of chopper operation are defined by the switching of either the emitter or collector diode. The emitter diode switches (corresponding to transistor cutoff) when

$$I_e = -(I_b + I_c) = 0 \qquad (3)$$

or

$$I_b = -I_c$$

Then eq (2) reduces to

$$V_{ce} = r_c\, I_c \qquad (4)$$

or

$$I_c = -\alpha_e\, I_e$$

Rob Roy has been particularly active in character recognition work. His latest work is on a machine which will read typewritten characters, even on a mutilated page, and convert them to teletype code.

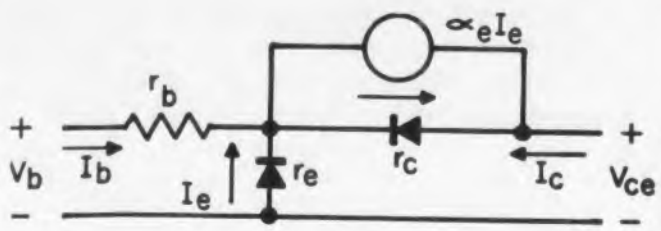


Fig. 1. Large signal equivalent circuit of grounded emitter pnp transistor. Here $\alpha_e = \alpha + (r_b/r_c)(1 - \alpha)$, with α defined as $-(\delta I_c/\delta I_e)$ with collector voltage constant.

Fig. 2 shows this as line *OC*.

The collector diode switches when

$$I_b = \left(\frac{1 - \alpha_e}{\alpha_e}\right) I_c \tag{5}$$

For this condition eq (2) reduces to

$$V_{ce} = r_e I_c/\alpha_e \tag{6}$$

which is plotted as line *OB* in Fig. 2.

These two lines, *OB* and *OC*, define saturation and cutoff respectively. The active region for the transistor lies between them.

If a loadline is drawn on these characteristics, its intersection with *OB* and *OC* define transistor chopper operation. If a load R is assumed in series with a source $(-V_{cc} + V_s)$, with V_{cc} the collector supply voltage, and V_s the modulating signal, then

$$V_{ce} = -I_c R_L - V_{cc} + V_s \tag{7}$$

One sees from eq (6) that at point *A* of Fig. 2

$$I_c = \frac{(-V_{cc} + V_s)\,\alpha_e}{\alpha_e R_L + r_e} \tag{8}$$

$$I_b > \frac{(1 - \alpha_e)(-V_{cc} + V_s)}{\alpha_e R_L + r_e}$$

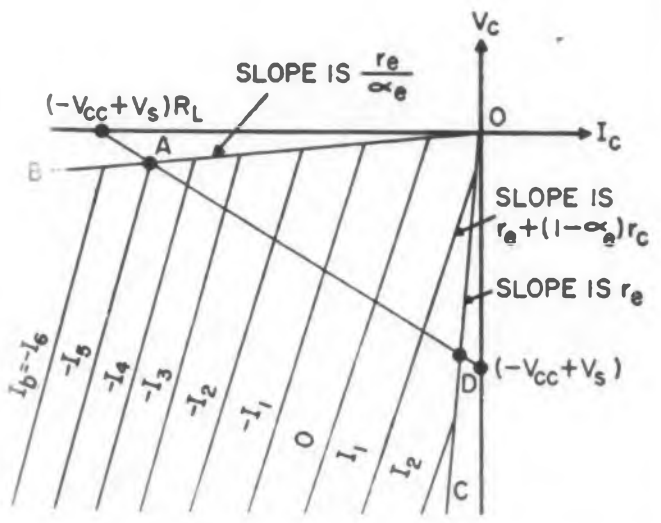


Fig. 2. Line *AD* is the load line in the switching region of the linearized collector-emitter characteristics.

Equations (7) and (8) define the chopper's saturation state, while eq (3) holds for cutoff. The slopes of lines *OB* and *OC* define the switch impedances.

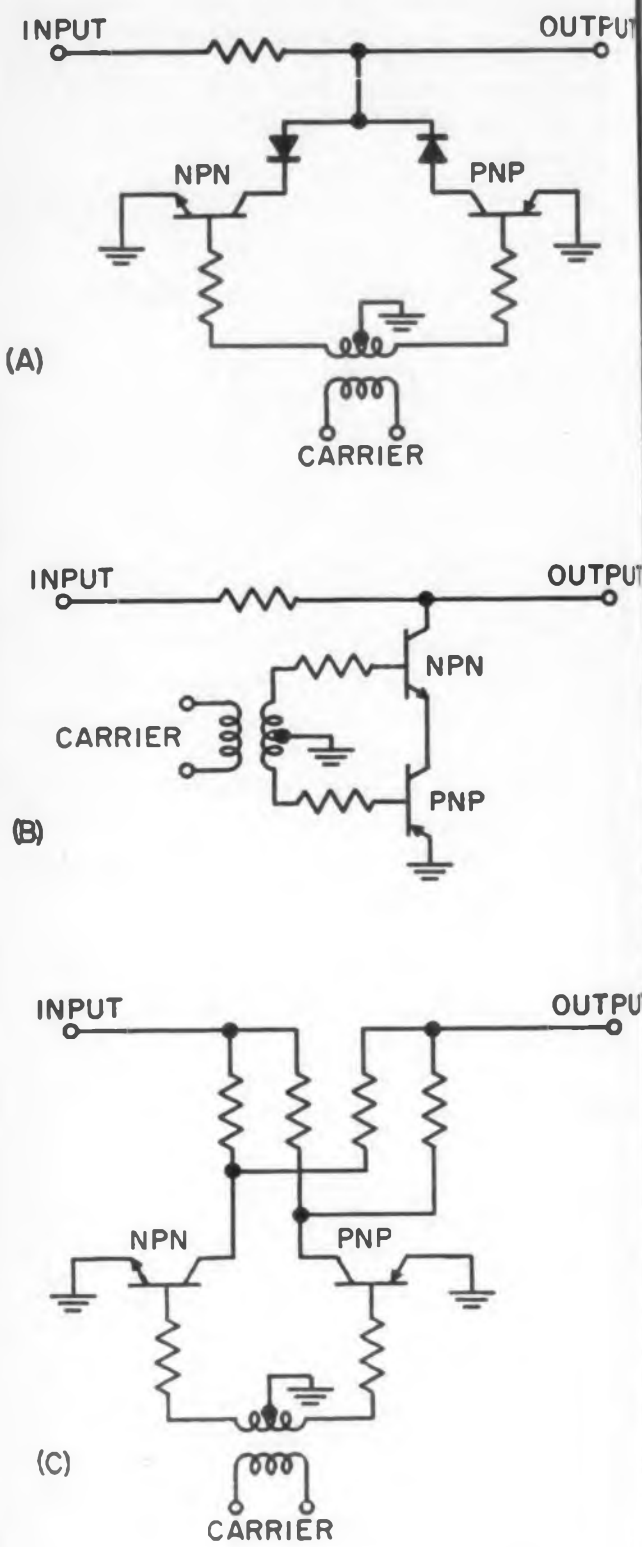


Fig. 3. Three basic chopper configurations.
A. The diodes separate the incoming audio into positive and negative halves and the complementary transistors chop the individual halves of the signal.
B. A tandem transistor combination. Each transistor alternates chopping with its dual.
C. Here the positive and negative signals are chopped individually, and summed in the output.

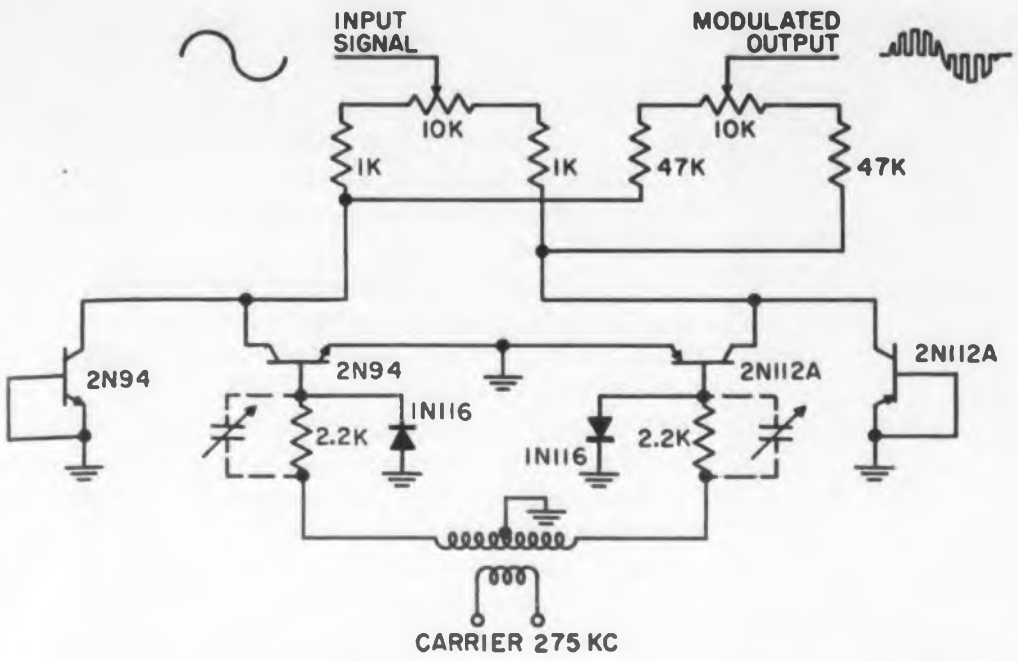


Fig. 4. This high frequency chopper minimizes carrier leakage.

Three Chopper Configurations

Fig. 1 shows that for a positive collector to emitter voltage, the collector diode switches, leaving the base without switching control. But for bilateral operation, one must separate the incoming signal into its positive and negative halves, and separately modulate each polarity. Fig. 3 shows three possible chopper configurations.

- Method *A* uses separation diodes to separate the incoming audio signal into its positive and negative parts. Complementary transistors then chop the signal. The npn transistor chops the positive half, while the pnp chops the negative half.
- Method *B* uses a unique tandem combination of pnp's and npn's. Each transistor alternates the chopping operation with its dual. The npn shorts the negative audio signals and chops the positive audio signals. The pnp works exactly in reverse, shorting the positive signals and chopping the negative.
- Method *C* chops the positive and negative signals individually, then sums the two outputs. Since the "off" impedance of an npn transistor differs from the "off" impedance of a pnp, the method requires balancing the output signal. This is shown in Fig. 4.

Carrier Leakage

Due to resistive and capacitive leakage between collector and base, there is a small carrier level at the output when there is a zero input signal. This carrier signal, if it is as large as the weakest modulating signal, can seriously distort it. For a system which depends on correlation techniques, the signal waveshape must be preserved.

Method *A* causes a small distortion at the low signal end, due to the finite voltage differential required for diode switching.

Method *B*, though novel, has little provision for eliminating carrier leakage.

Thus, method *C* is the only remaining choice. Fig. 4 shows that the carrier leakage on each collector is approximately 180 deg out of phase. By summing and balancing, one can practically eliminate any carrier at the output. A small capacitor of about 5 to 15 μμf, across one base resistor, is used to phase shift one carrier slightly. This can improve the zero signal carrier suppression even further.

The rather unusual use of transistors on the collectors of each half of the chopper provide an extremely low impedance clamp for very small reverse polarity modulating signals. Crystal diodes require too large a voltage differential for effective clamping. The transistor configuration clamps to within tenths of a volt.

Circuit Performance

The chopper in Fig. 4 is designed for a 275 kc carrier frequency, but the carrier can be changed from 100 kc to 350 kc with no more than a two per cent change in leakage. At lower frequencies, even down to 400 cps, this chopper is more than adequate.

The chopper takes modulating signals from 1/2 to 20 v, a 40 to 1 range. The maximum carrier leakage is 40 db below the output of the weakest modulating signal, and the deviation from an ideal linearity curve is no more than two per cent. With a 400 cps carrier, the deviation doesn't exceed one per cent, with input signals from 1 mv to 20 v.

Acknowledgment

The author is indebted to Carl Mengani for his many valuable suggestions.

MEETING REPORT

Telemetering Industry Prepares For Frequency Band Shift

Ben Patrusky
Assistant Editor

RECOMMENDATIONS made recently to the Dept. of Defense in a classified report may hurl telemtering equipment manufacturers into hectic R & D activity. The report, prepared by Aeronutronics Systems, Inc., Glendale, Calif., as part of an over-all probe into military telemetering needs, will be released shortly. According to informed sources attending the National Telemetering Conference, it suggests that all telemetering activity on the 215 to 260 mc band cease by 1970, with phase-out from 215 to 225 mc by Jan. 1, 1960.

The new frequency band recommended for telemetering is in the 1300 mc band. Certain telemetering applications requiring long-range and very narrow bandwidths will be permitted on the old band on a non-interference basis.

No enforcement agency is involved in this evaluation. The report is supposedly a primer for industry. Publication of the report probably will be considered tantamount to establishing a government equipment purchasing policy.

Manufacturers attending the Telemetering Conference indicated what they felt the implications of these recommendations were to them:

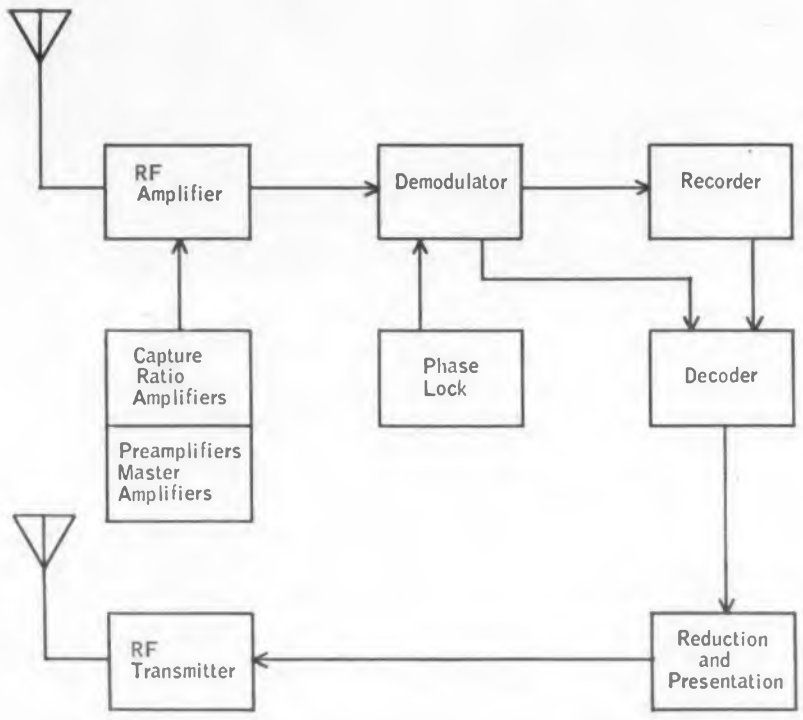
- Accelerate development of microminiature components and equipment.
- Necessitate design of new transmitters and receivers, since there is at present no such equipment available within this new range.
- Increase use and development of pcm telemetry.

Several manufacturers did indicate that programs are at present underway to develop equipment to meet these new recommendations. Particular emphasis, they report, is being placed on antenna design.

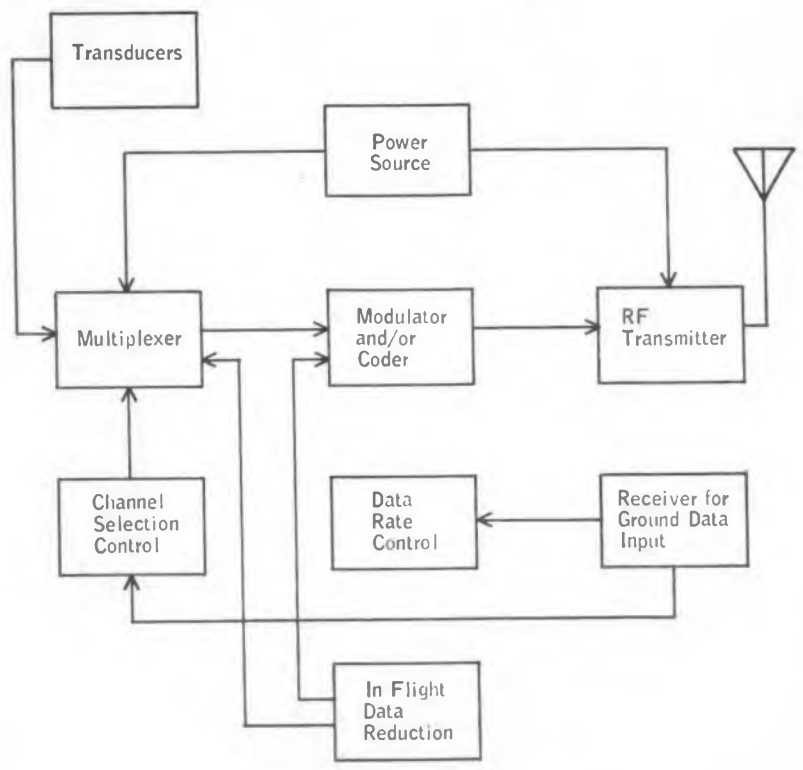
Design for the new frequency was not the only recent R & D stimulant administered to the industry. Gen. Earl F. Cook, Army Signal Corps R & D Chief, gave conferees a look at the long-range military tactical telemetering needs. This is what the military wants, he said:

- A "telesensory soldier" reporting strategic data from the battlefield.
- Ground-based automatic weather stations to give sypnotic weather data.
- Constant-level balloons which move across wide areas at predetermined heights to record weather information horizontally.
- Drone aircraft with sufficient power to telemeter data back from behind enemy lines while remaining secure from enemy counter-measures.
- New concept of conveying mass data and pictures across space.

These needs, the General contended, are "musts" in the event of modern warfare. He explained that battles will be fought "in layers" by foot soldiers, aircraft, missiles, and space vehicles. Ground forces will be spread thin and instead of massed front lines, "you will see a porous battlefield, perhaps fifty miles in depth." Information from the sparsely inhabited battlefield—everything from radioactive fallout to cloud cover data—will have to be telemetered back, he said. He pictured the telesensory soldier as a



Block diagram (left) of complete ground station telemetering system incorporating features yet to be achieved.



Block diagram (right) of Mr. Gardenhire's proposed airborne telemetering system.

"grounded satellite talking only when queried . . . with a built in IFF so he won't talk to strangers . . . something we could use for soldiers on 6-hr pass in Paris or Algiers."

Also needed will be advanced telemetering equipment for remote automatic weather stations. Wide-ranging balloons at the same time could "shoot" the weather horizontally and replace such devices as vertical sounding balloons carrying radiosondes. The General added that "signals from present telemetering gear simply are not strong enough to cover the wide sweeps our equipment would make into enemy territory."

Getting telemetered data back from drone aircraft without alerting the enemy is another problem to be solved. "We need relative immunity to countermeasures," said Cook, "some shield against enemy deception, jamming or modulation of our sensor elements. Otherwise we have a bandit by the bank teller's cage."

Delegates were also urged "to get ready to send an electronic picture back from the moon . . . a photograph of environment and operations." The General estimated that power requirements for sending an 8 x 10 glossy photograph or TV picture back would be about 208,000 w.

Meanwhile, the telemetering industry attempted to crystallize their own equipment problems. At a panel discussion, I. Gardenhire of Radiation Labs, Inc., Orlando, Fla., outlined, en toto, the needs of telemetering facilities in both the ground and airborne installations.

As far as data collection is concerned, he cited the following:

- High-gain small antenna.
- Airborne receivers.
- Beyond the horizon reception.
- Wide-band phase lock.
- Video recorder demodulator.
- In-flight data reduction.

As for information acquisition:

- Microminiaturization.
- Integrated construction.
- Planned redundancy of information.
- Solid-state design.
- High-power efficiency.
- Stabilized directional antenna.

Acquisition at very low elevation is another major requirement. With regard to the airborne vehicle itself, Mr. Gardenhire cited needs such as:

- Equipment to transmit back to the vehicle to tell it what to do.
- Channel selection control.
- Data rate control.

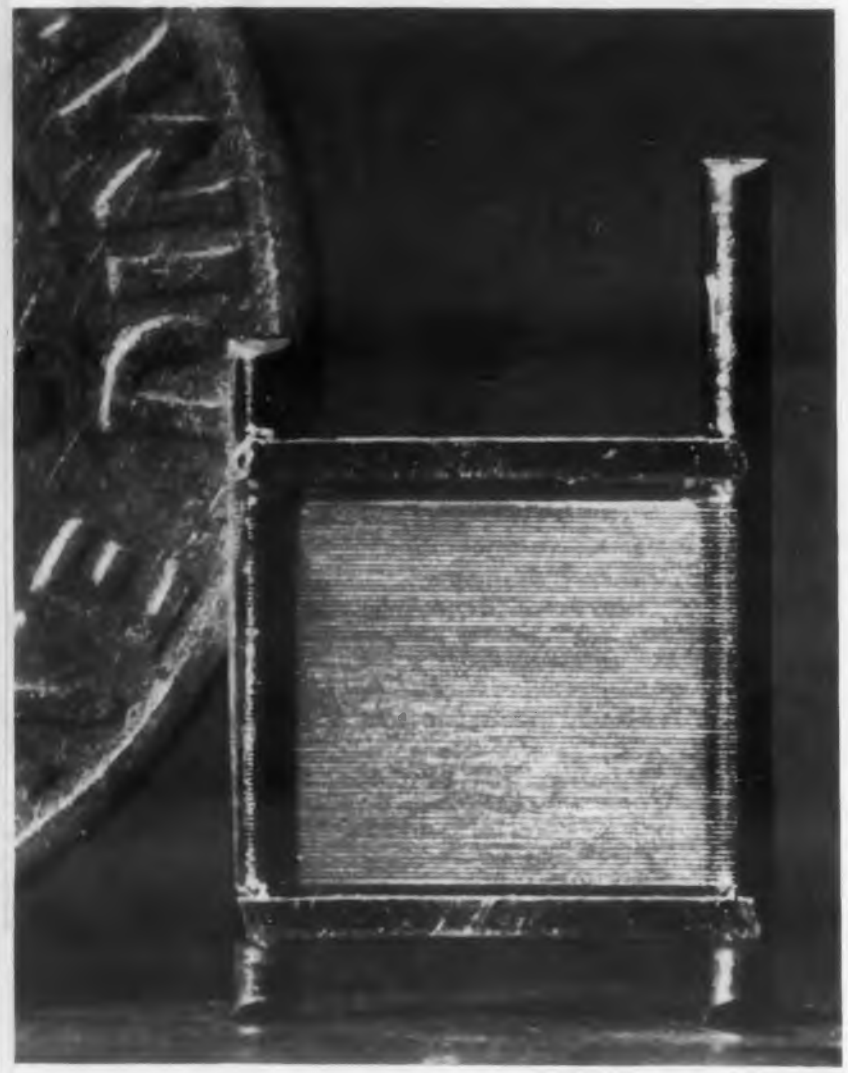
Real time data reduction is necessary in the ground installation.

Accompanying block diagrams describe the complete receiving and transmitting systems as spelled out by Mr. Gardenhire.

WESCON

NEW PRODUCTS

Preview of the 1958 WESCON at Los Angeles. Booth numbers of products being announced at the show are at the bottom of each item.



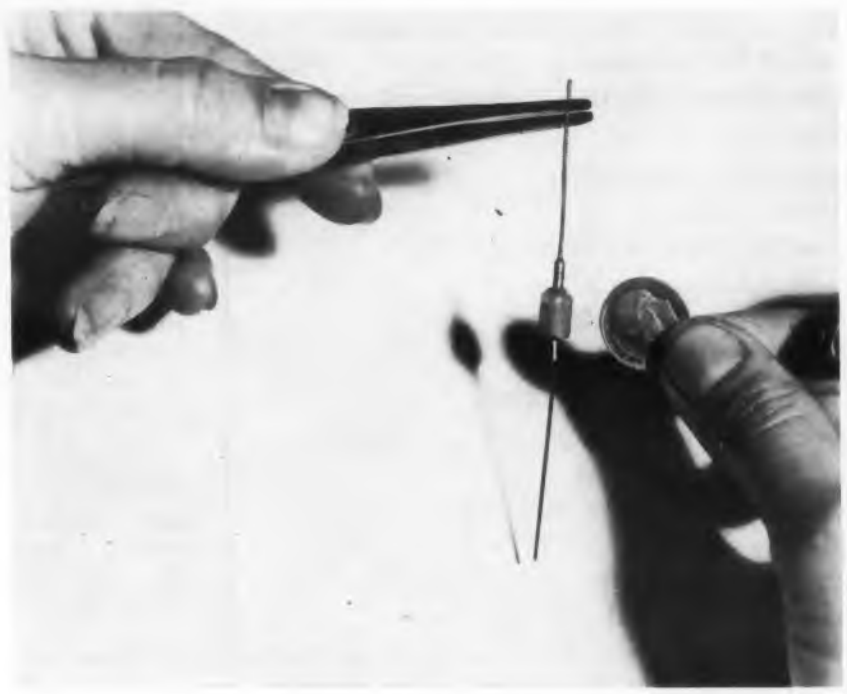
FRAME GRID TUBES

Available in production quantities, two tubes, the 6DJ8 and the 6ES8, are being built with frame grid construction. Both are double triodes with high transconductance figures of 12,500 μmhos. The 6DJ8 is a sharp cut-off general purpose type; the 6ES8 has remote cut-off and is designed primarily for use as a cascode amplifier in TV tuners up to 220 mc. Noise figure in a tuner is 6.5 db or less at 200 mc. Both tubes have extremely close grid-to-cathode spacing made possible by the frame grid, resulting in a high gain bandwidth product. With minor equipment modification, the tubes can be used in place of such types as the 6BQ7A, 6BZ7, or 6BS8.

Amperex Electronic Corp., Dept. ED, 230 Duffy Ave., Hicksville, N. Y.

Wescon Booth 1731-32

CIRCLE 46 ON READER-SERVICE CARD



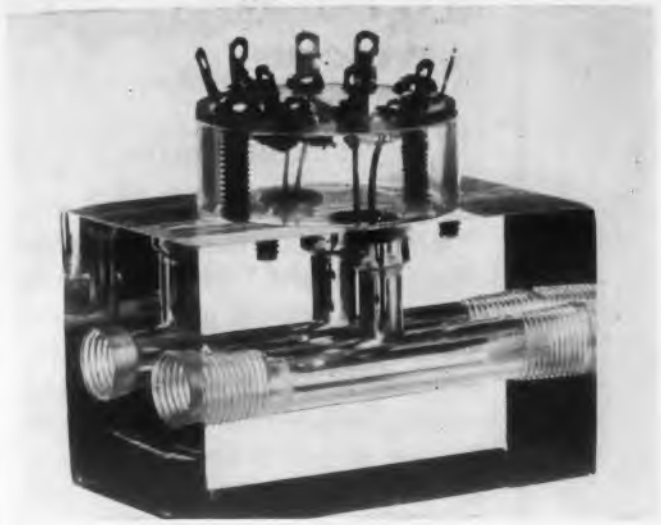
SILICON RECTIFIERS

Plastic molded, the PA series silicon rectifiers measure 1/8 in. in diam and are rated at 300 ma dc output current. Peak inverse voltages range from 50 to 1000 v. The units are relatively low priced for high volume use.

General Instrument Corp., Automatic Mfg. Div., Dept. ED, 65 Gouverneur St., Newark 4, N.J.

Wescon Booth 1803-04

CIRCLE 47 ON READER-SERVICE CARD



GAS ANALYSIS CELLS

Thermistors in a bridge network, located almost directly in the gas flow path, provide accurate, sensitive and fast thermal conductivity analysis. The M 182 and M 214 gas analysis cells are designed primarily for chromatographic equipment. Cell blocks are constructed of stainless steel.

Victory Engineering Corp., Dept. ED, P.O. Box 573, Union, N. J.
Wescon Booth 1734

CIRCLE 48 ON READER-SERVICE CARD

TRANSISTORS

Power gain of 10 db at 200 mc can be obtained from this line of high frequency transistors. Oscillation is evident at levels above 500 mc.

Motorola Inc., Semiconductor Products Div., Dept. ED, 5005 E. McDowell Rd., Phoenix, Ariz.
Wescon Booth 628-29

CIRCLE 49 ON READER-SERVICE CARD

ONLY KIN TEL DIGITAL VOLTMETERS GIVE YOU ALL THESE ADVANTAGES...

1. SINGLE-PLANE READOUT: KIN TEL digital voltmeters employ a simple projection system to present numbers on a readable single plane...no superimposed outlines of "off" digits...reduced possibility of error. Standard lamps give 7000 to 8000 hours of life, compared with 100 to 200 hours for ordinary readouts.

2. COMPLETE LINE OF ACCESSORIES—SPECIAL SYSTEMS: Versatile "digital building blocks" permit measurement of AC, ohms, ratios of AC and DC, automatic scanning of multiple inputs. Preamplifiers increase digital voltmeter sensitivity to 1 microvolt DC, 10 microvolts AC. Buffers permit driving typewriters, tape punches and printers. KIN TEL's Special Products Department can design and manufacture digital instruments to meet your special requirements . . . complete digital systems for data logging, missile checkout and automatic production line testing.

3. ADVANCED CIRCUIT DESIGN: Transistors employed where they contribute to performance and reliability...relay drive coils energized with DC as in telephone type service to provide long, trouble-free operation...automatic, continuous standard cell calibration. No electronic circuitry in readout allows easy remote mounting. Sensitivity control permits stable reading of noisy signals.

4. MANUFACTURING EXPERIENCE: KIN TEL has manufactured over 10,000 "standard cell accuracy" DC instruments on a true production line basis. Only by this method, by years of repeated manufacturing experience, by an over-all awareness of the accuracies and tolerances involved, is it possible to guarantee consistent accuracy and reliability...to assure real value for every dollar you invest.

5. NATIONWIDE APPLICATION ENGINEERING FACILITIES: KIN TEL has engineering representatives in every major city. An experienced staff of over 200 field engineers is always immediately available to help solve your application problems, provide technical data, or prepare a detailed proposal. Factory level service is available in all areas.

6. DESIDERATE SPECIFICATIONS (MODEL 401 DC DIGITAL VOLTMETER):

Display...Four (4) digit with automatic polarity indication and decimal placement. Total display area 2" high x 7½" long, internally illuminated. Individual digits 1⅛" high.

Automatic Ranges...0.0001 to 999.9 volts covered in four ranges. Sensitivity control provides least digit sensitivities of .1, 1, and 10 mv.

Accuracy...0.01% ±1 digit.

Counting Rate...30 counts per second, providing average balance (reading) time of 1 second, maximum balance time of 3 seconds.

Reference Voltage...Chopper-stabilized supply, referenced to an unsaturated mercury-cadmium standard cell.

Input Impedance...10 megohms, all ranges.

Output...Visual display, plus print control. Automatic print impulse when the meter assumes balance. No accessories required to drive parallel input printers.

Input...115 volt, 60 cycle, single phase, approximately 75VA.

Dimensions...Control unit, 5¼" high x 19" wide x 16" deep. Readout display, 3½" high x 19" wide x 9" deep.

Weight...Approximately 40 lb.

Price...$2,100

Write today for descriptive literature or demonstration. 5725 Kearney Villa Road San Diego 11, California

WESCON SHOW—Booths 1413, 1414, 1458, 1459

KIN TEL
A Division of Cohu Electronics Inc.

CIRCLE 50 ON READER-SERVICE CARD

NEW PRODUCTS
at WESCON

Accelerometer
Full scale output to 60 v

A differential transformer accelerometer, model 7-34 has full scale output up to 60 v in ranges from ±1 g to ±50 g. Temp compensated damping is within 0.1 per cent of critical, without the use of heaters. Output at full deflection is up to 0.5 per v excitation, and at zero acceleration the deflection is less than 0.5 per cent of full scale.

Edcliff Instruments, Dept. ED, P.O. Box 307, Monrovia, Calif.
Wescon Booth 943

CIRCLE 52 ON READER-SERVICE CARD

Switches and Relays
With spark suppression

Rotary stepping switches and relays equipped with semiconductor spark suppressors, will be shown. Silicon carbide varistors replace capacitor-resistor combinations used for spark suppression on all 24, 48 or 110 v dc types 44 and 45 rotary stepping switches and series OCS relays. Besides weight and space reduction advantages, the varistors do a better job of arc suppression, and reduce radio interference appreciably.

Automatic Electric Co Dept. ED, Northlake, Ill.
Wescon Booth 1518-19

CIRCLE 53 ON READER-SERVICE CARD

Ceramics
Wafers and seals

These AlSiMag ceramic wafers measure 0.310 x 0.310 x 0.010 in. They are intended to supplement the thin ceramics produced for printed circuitry, internal insulators and spacers for vacuum tubes. Also being shown are 7-pin tube stems with metal-ceramic high temp seals.

American Lava Corp., Dept. ED, Cherokee Blvd. & Mfrs. Rd., Chattanooga 5, Tenn.
Wescon Booth 606-07

CIRCLE 54 ON READER-SERVICE CARD

◀ CIRCLE 51 ON READER-SERVICE CARD

Multiplier Phototubes

For low level light sources

The 6655-A Multiplier Phototube is a head-on 10-stage multiplier phototube intended for use in scintillation counters. Spectral response covers the range from about 3000 to 6500 angstroms.

The 7200 Multiplier Phototube is a 9-stage type with S-19 response. Range is 1800 to 6000 angstroms.

Also being introduced is the 7212 Beam Power Tube for use under severe shock and vibration. The tube has a max plate dissipation of 25 w under ICAS conditions in modulator service and in cw service. In the latter service, it can be operated with full input to 60 mc and with reduced input to 175 mc.

Radio Corp. of America, Electron Tube Div., Dept. ED, Harrison, N.J.

Wescon Booth 1635-36

CIRCLE 470 ON READER-SERVICE CARD

Ultrasonic Power Supply

1500 w continuous output

The D-1320 ultrasonic motor-generator power supply is rated for 1500 w continuous output at 15,000 to 25,000 cps. Instant operation, no sliding contacts, long bearing life, and class H insulation are features.

D & R Ltd., Dept. ED, 402 E. Gutierrez St., Santa Barbara, Calif.

Wescon Booth 635

CIRCLE 56 ON READER-SERVICE CARD

Insulating Boards

Pre-punched in different patterns

An addition to a line of pre-punched insulating board, the G pattern has 0.062 in. diam holes on a 0.1 in. grid with alternate holes missing. This pattern is designed for mounting transistor circuits since the holes match the JETEC transistor lead spacing.

Vector Electronic Co., Dept. ED, 1100 Flower St., Glendale 1, Calif.

Wescon Booth 1244

CIRCLE 57 ON READER-SERVICE CARD

CIRCLE 58 ON READER-SERVICE CARD ➤

NEW PRODUCTS
at WESCON

Magnet Wires

Two new types

Two types of magnet wire, S-Y Bondeze and Nyleze, will be displayed. The first type is a tough, self bonding solderable wire which winds a self-supporting, bobbinless coil without special adhesives. Nyleze is an all purpose wire used on high speed automatic winding equipment, or where varnish and compound treating conditions are extreme. Dimensions and price are same as Formvar.

Phelps Dodge Copper Prod. Corp., Inca Mfg. Div., Dept. ED, Fort Wayne, Ind.
Wescon Booth 213-14

CIRCLE 60 ON READER-SERVICE CARD

Rotary Switch

12 positions, up to 5 sections

Type MA-12 miniature rotary switch provides 30 deg indexing, 12 contact-positions, up to 5 sections, with current-carrying capacity of 3 amp. Interrupting rating is 1/2 amp 115 v ac. Designed to meet MIL-S-3786. The switch can be furnished with up to six poles per section; rotation may be unlimited, or limited from 2 to 12 positions. It measures 3/4 in sq; with 5 sections, the back-of-panel depth is 2-3/4 in.

R-F Electronics, Inc., Div. of Electro Switch Corp., Dept. ED, King Ave., Weymouth 88, Mass.
Wescon Booth 741

CIRCLE 61 ON READER-SERVICE CARD

Energy Storage Capacitor

Low inductance of 0.01 μh

The energy storage and discharge capacitor line now includes a new design of high voltage, low inductance types for thermonuclear equipment and similar fast discharge and energy storage applications. Self-inductance of less than

0.01 μh is the lowest now available and provides optimum efficiency of operation. Voltage ratings are available from 10 to 50 kv with capacitance values from 1 to 25 μf. The capacitors have a standard case weighing less than 75 lb.

General Electric Co., Dept. ED, 1 River Rd., Schenectady 5, N.Y.
Wescon Booth 529-30

CIRCLE 62 ON READER-SERVICE CARD

Transistors

Diffused base silicon types

NPN diffused base silicon transistors, manufactured by a combined alloy and gaseous diffused process for good mechanical stability and electrical characteristics.

Units possess an alpha cutoff frequency of 50 mc, voltage breakdown of 60 v, low frequency current gain of 50 and power gain of approximately 18 db at 12.5 mc. Also featured are low saturation resistance which makes them ideal for large as well as small signal applications at temp to 165 C.

Raytheon Mfg. Co., Dept. ED, 55 Chapel St., Newton 58, Mass.
Wescon Booth 639-40

CIRCLE 63 ON READER-SERVICE CARD

Impedance Bridges

40 cps to 250 mc range

Impedance bridges, precision oscillators, microwave equipment and resonant cavity wave meters will be exhibited by this newly-established subsidiary of Wayne Kerr Co., Ltd., of England.

The impedance bridges run from 40 cps to 250 mc and feature vhf bridges used for admittance measurements for cables, transmission lines, feeders, antennas and with special application in transistor parameter measurements.

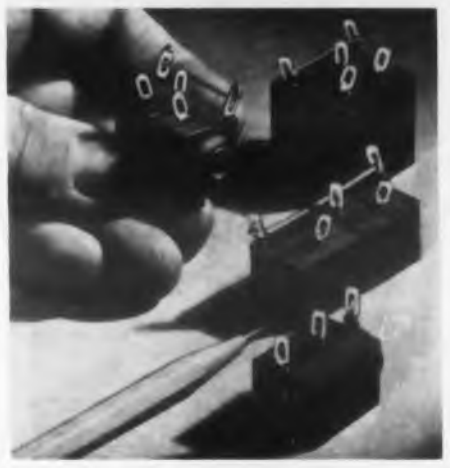
Wayne Kerr Corp., Dept. ED, 2920 N. Fourth St., Philadelphia 33, Pa.
Wescon Booth 840

CIRCLE 64 ON READER-SERVICE CARD

CIRCLE 65 ON READER-SERVICE CARD ➤

NEW PRODUCTS
at WESCON

Bridge Rectifiers
Miniature selenium types



An expanded line of selenium bridge rectifiers includes two new types for use in magnetic amplifier, light industrial and radio-tv applications. Type 61-4037 is a single phase bridge rectifier rated to provide 100 ma output into a resistive load, with a max input voltage of 260 v rms. Designed for use directly from a 117 v ac system, type D-3575M is a single-phase full-wave bridge rated to deliver an output of 9 w, continuous duty.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.
Wescon Booth 1447-48

CIRCLE 67 ON READER-SERVICE CARD

Space Room
For uhf-vhf testing

A prefabricated free space room for all types of uhf-vhf microwave antenna or radome testing. The room consists of wooden frames supplied predrilled and with bolts for assembly, including a flush door with necessary hardware. The absorbing material is supplied in sections

bonded to aluminum foil. Absorbing material can be supplied for frequencies from 50 to 50,000 mc.

McMillan Lab, Inc., Dept. ED, Brownville Ave., Ipswich, Mass.

Wescon Booth 903-04

CIRCLE 68 ON READER-SERVICE CARD

Test Equipment

Eight models introduced

Eight electronic measuring instruments will be introduced at the show. The equipment includes a signal generator, two voltmeters, a clip-on milliammeter, two electronic counters, a digital delay generator and a dual trace oscilloscope.

Model 524D electronic counter provides for measurements from 0 cps to 10 mc automatically and directly in one self-contained unit, without calculation or interpolation. Crystal oscillator stability is 5 parts in 10^8 per week. The 524C electronic counter (shown), is similar to the 524D, except that it is equipped with a nixie readout.

Model 122A oscilloscope is a low frequency scope giving a dual trace presentation by use of an alternate sweep or chopped sweep arrangement. It has a max sensitivity of 10 mv/cm. Bandwidth is 200 kc.

Model 606A signal generator covers a range 50 kc to 65 mc. Output is 3 v full range, and may be continuously attenuated to 0.1 μv.

Model 405A digital voltmeter indicates voltages to three places, shows sign and automatically places decimal point.

The 428A clip-on milliammeter measures dc currents as low as 3 ma full scale without the need to break leads.

Model 218A digital delay generator produces two exact time intervals or pulse delays independently adjustable from 1 to 10,000 μsec in 1 μsec steps. Continuous interpolation between steps is calibrated in tenths of microseconds.

Hewlett-Packard Co., Dept. ED, 275 Page Mill Rd., Palo Alto, Calif.

Wescon Booth 1450-51

CIRCLE 69 ON READER-SERVICE CARD

BEYOND ACCEPTED STANDARDS OF TUBE RELIABILITY. 50,000 high-reliability tubes at a time—a half million a month—receive a special burn-in at General Electric's 5-Star factory. Tube performance is stabilized. Early-life inoperatives are weeded out. Every G-E 5-Star Tube also has passed rigid mechanical and electrical tests before shipment.

OPERATION up turn — Buy now for extra values — GENERAL ELECTRIC

BE SURE YOU GET STABILIZED TUBES WHEN YOU PAY FOR HIGH RELIABILITY!

Only General Electric stabilizes all high-reliability tubes by factory burn-in. What does this 5-Star process mean to you, a manufacturer of electronic equipment with critical sockets?

It's extra protection against production-line shutdowns in your plant, because stabilizing helps weed out any early-life tube inoperatives. Likewise, it's a special safeguard that your radar, communication, or other equipment will prove dependable from the start, when placed in service.

Stabilizing also promotes more uniform tube performance . . . your designers can count on 5-Star Tubes meeting rated requirements at all times. This helps assure that your equipment will continue to perform reliably—building a solid reputation that will lead to repeat orders for new equipment.

When you specify high-reliability tubes, be sure you get the superior quality that only General Electric *stabilized* 5-Star tubes offer! Any G-E Receiving Tube Department office listed below will be glad to supply further information. Phone today!

EASTERN REGION
200 Main Ave., Clifton, N.J.
Phones:
(Clifton) GRegory 3-6387
(N.Y.C.) WI. 7-4065, 6, 7, 8

CENTRAL REGION
3800 N. Milwaukee Ave.
Chicago 41, Illinois
Phone: SPring 7-1600

WESTERN REGION
11840 W. Olympic Blvd.
Los Angeles 64, Cal.
Phones: GRanite 9-7765
BRadshaw 2-8566

Progress Is Our Most Important Product

GENERAL ELECTRIC

12-11-204

NEW PRODUCTS at WESCON

Cable Jacket

For temperatures to 3000 F

An addition to the Zippertubing line, Thermazip will withstand 2000 F continuously and 3000 F for brief periods.

Manufactured of an aluminized reflective asbestos fiber, Thermazip cable jacket is closed by a plastic or metal zipper track stitched to the fiber with high temp Teflon thread.

The Zippertubing Co., Dept. ED, 752 S. San Pedro St., Los Angeles 14, Calif.
Wescon Booth 320

CIRCLE 72 ON READER-SERVICE CARD

Terminals

Printed circuit types

Two printed circuit terminals have been added to the existing line. Types 2228 and 2420 are precision-machined in brass and finished with copper flash and a 0.003 in. tin-lead solder plating. Also announced are printed circuit coil forms, types 2525, 2530, 2540, 2550, available with four terminals and made completely of class H materials.

Cambridge Thermionic Corp., Dept. ED, 445 Concord Ave., Cambridge 38, Mass.
Wescon Booth 1139

CIRCLE 73 ON READER-SERVICE CARD

Laminated Plastics

Paper-base

Type EP-22 is an industrial laminated plastic possessing excellent electrical characteristics over a wide range of humidities and temperatures. The material is an Alpha paper filler impregnated with epoxy resin. It is available in sheets and strips from 1/32 to 1/4 in. thick, and in sheet sizes 36 x 36 in. and 36 x 72 in.

Synthane Corp., Dept. ED, 12 River Rd., Oaks, Pa.
Wescon Booth 302

CIRCLE 74 ON READER-SERVICE CARD

◀ CIRCLE 71 ON READER-SERVICE CARD

Epoxy Resin Systems

Easily used

PRH 308, a single component thixotropic system, is a filled system composed of Resin 21. Because the curing agent is incorporated into the resin, neither mixing nor weighing are required.

PRH 400, a flexible epoxy protective coating, is a solvent based epoxy system which is recommended as a protective coating for printed circuits and other electrical and electronic components.

Permacel-LePage's Inc., Dept. ED, New Brunswick, N.J.
Wescon Booth 126

CIRCLE 75 ON READER-SERVICE CARD

Potentiometers

Three liquid-filled types

Three liquid-filled potentiometers include the 10-turn, 1-1/16 in. model 4203; 10-turn, 2 in. model 4613 and the 3-turn, 2 in. model 4713. These pots offer a life span of at least 10-million shaft revolutions, increased dielectric strength, greater heat dissipation, extremely low noise throughout life, and operation under water.

Beckman Instruments, Inc., Helipot Div., Dept. ED, Newport Beach, Calif.
Wescon Booth 1351-52

CIRCLE 76 ON READER-SERVICE CARD

Analog-Digital Converter

Converts ten low-level inputs

The Panec system sequentially converts up to 10 low level inputs to digital form at a rate of up to 20 conversions per sec. The output of any one or all ten channels in sequence can be recorded on an analog strip chart recorder, or presented visually in numerical form on an in-line digital readout, or recorded on a digital printer, tape punch or card punch. Resolution of the system is 10 μv.

Cohu Electronics, Inc., Cohu Research Div., Dept. ED, 14743 Hall St., Van Nuys, Calif.
Wescon Booth 1458-59

CIRCLE 77 ON READER-SERVICE CARD

CIRCLE 78 ON READER-SERVICE CARD ➤

NEW PRODUCTS
at WESCON

Resistance Bridge Indicator

Self-balancing

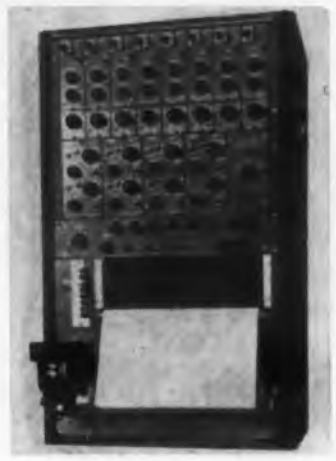
Model A resistance bridge indicator is a self-balancing, accurate, and compact instrument for measuring outputs of resistance bridge transducers in the range of 50 to 1000 ohms. Outputs from either full or half bridges with 1, 2, or 4 active arms are read from a digital display without necessity for external accessory equipment or manual null-balance operation.

Calibrated to read directly in micro-inches per in. strain with strain gage inputs.

Datran Electronics, Div. of Mid-Continent, Dept. ED, 1836 Rosecrans Ave., Manhattan Beach, Calif.

Wescon Booth 1615-16

CIRCLE 97 ON READER-SERVICE CARD



Recording System

Very high sensitivity

Type R Dynograph all-transistor direct-writing recording assembly, features a high sensitivity of one microvolt per division for dc or ac signals, a frequency response from dc to 160 cps flat within 10 per cent and available with one, or more, of the following recording systems: ink curvilinear, electric curvilinear, heat rectilinear or electric rectilinear recording. The assembly can be supplied with a wide variety of input couplers to enable transducers to be coupled directly. No external excitation, bridge balance or calibration controls are required external to the assembly.

Offner Electronics Inc., Dept. ED, 5320 N. Kedzie Ave., Chicago 25, Ill.

Wescon Booth 632-33

CIRCLE 98 ON READER-SERVICE CARD

Power Transistor

Dissipates 12 w

The 2N553 is a germanium power transistor with a thermal resistance between junction and mounting base of 1 C/watt typical, 2 C/watt max. It is capable of dissipating 12 w at a mounting base temperature of 70 C.

Delco Radio Div., General Motors Corp., Dept. ED, Kokomo, Ind.

Wescon Booth 826

CIRCLE 121 ON READER-SERVICE CARD

Servo Gearhead

For size 10 or 11 servos

A precision gearhead primarily for size 10 servo motors, but also available with size 11 mounting dimensions. Output shaft is displaced off center. Ratios from 6.1 to 274:1 are available.

Clifton Precision Products Co., Inc., Dept. ED, Marple at Broadway, Clifton Heights, Pa.

Wescon Booth 749-50

CIRCLE 122 ON READER-SERVICE CARD

DC Amplifiers

Chopper stabilized or non-stabilized

Model 3120 system contains five model 3101 dual amplifiers, providing ten chopper-stabilized dc amplifiers. The system is also available with model 3102 dual non-stabilized amplifiers.

Donner Scientific Co., Dept. ED, Concord, Calif.

Wescon Booth 1211-12

CIRCLE 123 ON READER-SERVICE CARD

Synchros...another Kearfott capability

accuracy...reliability

SIZE 8

SYNCHROS FOR EVERY APPLICATION

Kearfott offers the widest range of synchros in the industry. Ruggedly constructed of corrosion-resistant materials, they give unequalled performance under every environmental condition. For best characteristics and reliability, specify Kearfott for all your synchro requirements. Here are a few typical models:

Size 8: .750" x 1.240". 1.75 oz. −54C to +125C. Available as transmitter, control transformer, resolver, and differential. Max. error from EZ: 10, 7 and 5 minutes.

Size 11 Standard: 1.062"x1.766". 4 oz. −54C to +125C. Available as transmitter, control transformer, repeater, resolver and differential for 26v and 115v applications. Max. error from EZ: 10,7 and 5 minutes standard, 3 minutes in 4-wire configurations.

Size 11 MIL Type: Dimensions and applications same as above. Meets Bu. Ord. configurations: max. error from EZ: 7 minutes.

Size 15 Precision Resolver (R587): With compensating network and transistorized booster amplifier, provides 1:1 transformation ratio, 0° phase shift. Max. error from EZ: 5 minutes.

Size 25 Ultra-Precise: 2.478" x 3.187". 45 oz. Available as transmitter, differential, and control transformer. Max. error from EZ: 20 seconds arc.

***Engineers:** Kearfott offers challenging opportunities in advanced component and system developments.*

Kearfott

GENERAL PRECISION EQUIPMENT CORPORATION GPE

KEARFOTT COMPANY, INC., Little Falls, N. J.

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

SALES AND ENGINEERING OFFICES: 1378 MAIN AVE., CLIFTON, N.J.
MIDWEST OFFICE: 23 W. CALENDAR AVE., LA GRANGE, ILL.
SOUTH CENTRAL OFFICE: 6211 DENTON DRIVE, DALLAS, TEXAS
WEST COAST OFFICE: 253 N. VINEDO AVENUE, PASADENA, CALIF.

CIRCLE 86 ON READER-SERVICE CARD

NEW PRODUCTS
at WESCON

Force-Balance Unit

Used in air data computers

This force-balance transducer operates on the principle that two coplanar forces acting at right angles to each other determine a resultant force which acts at some angle whose tangent is their ratio. The unit implements this principle by mechanically balancing two pressures or forces through a linkage system, to provide a shaft rotation functional to their ratio. This shaft rotation is used to drive such output devices as potentiometers, synchros, or coded discs. After each step of input, the sensing elements of the system return to their null position.

The accuracy and range of the instrument make it suitable for such uses as air speed computation, altimeters, and mach indication.

G. M. Giannini & Co., Inc., Dept. ED, Pasadena, Calif.

Wescon Booth 1665-66

CIRCLE 87 ON READER-SERVICE CARD

Recording Systems

Modular amplifiers and discriminators

Amplifiers and discriminators are the features of these precision magnetic tape recording systems. All units are modular. One to seven of any assortment of models plug into a common, rack-mounted power supply. One recording amplifier gives either direct or PWM modulation at turn of a switch.

Minneapolis-Honeywell Regulator Co., Davies Labs Div., Dept. ED, 10721 Hanna St., Beltsville, Md.

Wescon Booth 501-02, 505, 543-44

CIRCLE 88 ON READER-SERVICE CARD

NEW wire-wound RESISTORS*

Crafted with Precision for Reliability

For critical military and industrial applications.

Hermetically sealed by bonding glass-kovar headers to high thermal, shock resistant glass housings. 100% humidity-proof.

NETWORKS' new, truly accurate, precision Resistors are available in ¼, ½, 1 and 2 watt ratings at 105°C ±0.1 to 1%. Units for 125°C available on special order. Lug types or flexible leads. Test results prove substantial improvement over MIL specs. They combine remarkable stability, under load and on the shelf, with exceptionally low temperature coefficient.

*Patented

Reliability
Conservative Ratings
Stable Characteristics

Engineering Bulletin with complete specifications available upon request.

NETWORKS ELECTRONIC CORPORATION

14806 OXNARD ST., VAN NUYS, CALIFORNIA

Booth 1710—Wescon
CIRCLE 91 ON READER-SERVICE CARD

Reliability NEC

IS THE COMMON DENOMINATOR OF ALL NETWORKS MAGNETIC COMPONENTS

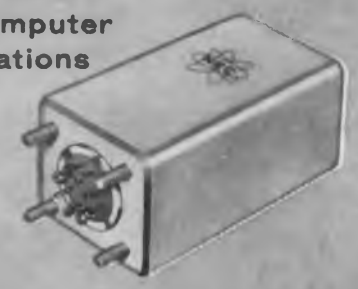
NEC CURRENT TRANSDUCTORS

For plating and other high current applications

Function as DC current transformers for metering large DC currents without conventional shunts and to isolate DC bus from metering circuit. Units rated for bus currents from 100 to 2000 amps with 2500 to 1 current ratio. Accuracy from ± ½ to 2% depending on current rating.

NEC OVER AND UNDER CURRENT SWITCHES

For computer applications



Combination magnetic amplifier and transistor switching device with extreme sensitivity and reliability. 3 to 5 milliohm insertion resistance. Switch is NC (conducting) and opens with incremental current change of 40 ma or more from preset values. Current ranges 100 ma to 10 amps available. Temperature range −55°C to +85°C.

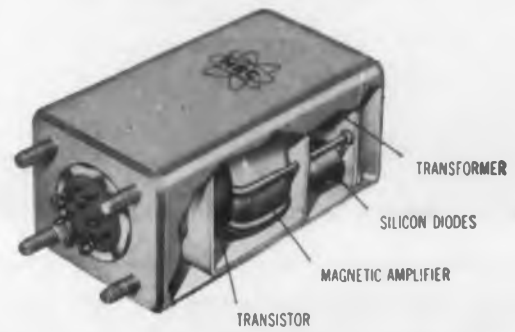
NEC FREQUENCY SENSITIVE RELAYS

For guided missile applications

DPDT contacts actuated when frequency of supply varies ± 1% from 400 cps; will tolerate line voltage variation of ± 20%. Other center frequency values available. Temperature range −55°C to +85°C. Nominal voltage input 115V ± 20%. Other voltage ranges available. Withstand vibration up to 20g from 20 to 2000 cps. Shock of 400g for 1 millisecond in all planes.

NEC SENSITIVE ELECTRONIC SWITCHES

For general applications



Both current and voltage sensitive versions available. Sensitivities of control circuit as low as 750 microwatts. Control resistance from 3 milliohms to 2500 ohms. No moving parts. Switch circuit handles up to 40 V DC at 2 amps. Temperature range −55°C to +85°C. Meet or exceed all applicable military specifications.

— Patents Pending —

COMPLETE SPECIFICATIONS AVAILABLE UPON REQUEST

Concepts of proven reliability — yesterday . . . today . . . tomorrow.
Standard or custom designs for airborne and ground applications.
Engineers, Designers and Manufacturers of All-Magnetic Components.

NETWORKS ELECTRONIC CORPORATION

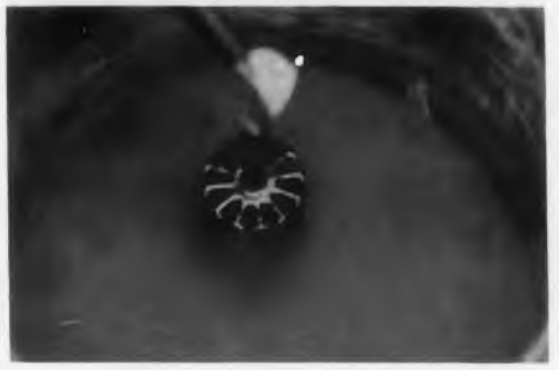
14806 OXNARD STREET • VAN NUYS, CALIFORNIA • STate 5-8805

BOOTH 1710—WESCON
CIRCLE 90 ON READER-SERVICE CARD

NEW PRODUCTS
at WESCON

Powdered Epoxy Resin

500 v per mil dielectric strength



For applications using an aerated bed, spray coating equipment or preformed resin slugs, XR-5005 epoxy resin is a rigid, ovencuring resin with a dielectric strength of over 500 v per mil. No molds are needed in application; and no mixing is required.

Units to be coated are heated from 300 to 400 F, and dipped into the suspended powder, which is bubbled by compressed air. The heat of the unit melts the resin surrounding it, causing a layer of resin to cling to it.

Minnesota Mining and Mfg. Co., Dept. ED, 900 Bush Ave., St. Paul 6, Minn.

Wescon Booth 606-07

CIRCLE 84 ON READER-SERVICE CARD

Power Supply

28 v dc, 0 to 5 amp

This transistorized regulated power supply provides 28 v dc, 0 to 5 amp, and operates from a 115-v, single-phase, 60-cps power source. Regulation is 0.1 per cent from no load to full load with 10 per cent change in input. Ripple is 0.1 per cent peak-to-peak. Voltage drift per deg centigrade rise is approximately 0.01 per cent.

General Electric Co., Dept. ED, Schenectady 5, N.Y.

Wescon Booth 515-16

CIRCLE 85 ON READER-SERVICE CARD

Transistors

Bilateral and drift types

Germanium alloyed junction transistors, for medium and high speed switching applications, and a diffused base drift transistor will be exhibited. The germanium alloyed types include two pnp types 2N592 and 2N593, and three npn types 2N594, 2N595 and 2N596. Collector to base voltage range is 20 to 40 v, and alpha cutoff frequency range is 1.5 to 5 mc.

General Transistor Corp., Dept. ED, 91-27 138th Place, Jamaica 35, N.Y.

Wescon Booth 1756-57

CIRCLE 79 ON READER-SERVICE CARD

Laminated Plastic

Phenolic glass base grade

GH-871, a phenolic glass base grade designed for short time, very high temperature applications, retains more than 95 per cent of its strength after half hour exposure at 500 F. It will withstand higher temperatures for shorter time periods. Another material, phenolite grade G-11, is a glass base epoxy.

National Vulcanized Fibre Co., Dept. ED, Box 311, Wilmington, Del.

Wescon Booth 304-05

CIRCLE 80 ON READER-SERVICE CARD

Water Loads

SL, S and X bands

Three waveguide water loads provide a convenient and accurate means of measuring microwave power when used with the model 190A calorimeter and model 189A thermopile. The loads can also be used independently as high power, low vswr terminations at the applicable waveguide frequencies.

Sierra Electronic Corp., Sub. of Philco Corp., Dept. ED, 3885 Bohannon Dr., Menlo Park, Calif.

Wescon Booth 1355-56

CIRCLE 81 ON READER-SERVICE CARD

CIRCLE 82 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Millivolt Source

For calibration of instruments

This portable millivolt source has two ranges: 0 to 10 mv and 0 to 100 mv. It remains within 0.25 per cent accurate over a reasonable period of time.

Westronics, Inc., Dept. ED, 3605 McCart St., Ft. Worth, Tex.

CIRCLE 100 ON READER-SERVICE CARD

Cathode Ray Tubes

Provide resolution of over 800 lines

Five flying spot scanners for black and white or color applications are added to a line of cathode ray tubes. Types 5AKP24, 5AUP24, 5BNP16, 5WP15, and 5ZP16 all have precision aligned guns which provide resolutions of over 800 lines at maximum anode ratings.

Raytheon Mfg. Co., Dept. ED, 55 Chapel St., Newton 58, Mass.

CIRCLE 101 ON READER-SERVICE CARD

Electric Printer

Accepts parallel or serial input

Electric printer that accepts parallel or serial input and prints from 6 to 9 columns of digits in one or two copies. Output rate from

◀ CIRCLE 99 ON READER-SERVICE CARD

parallel input is 3 lines per sec; from serial input, 4 digits per sec. Unit accepts over 100 ft of paper 3 in. wide.

Taller & Cooper, Inc., Business Automation Equipment Div., Dept. ED, 75 Front St., Brooklyn 1, N.Y.

CIRCLE 102 ON READER-SERVICE CARD

Resistor

For printed circuit use

A low operating temperature, 5 w resistor, the type PC-5 is recommended for a printed circuit board mounting in circuits requiring a wirewound resistor with an actual wattage dissipation of 5 w or less, and for any circuit requiring a wirewound resistor capable of 7 w continuous operation.

International Resistance Co., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

CIRCLE 103 ON READER-SERVICE CARD

Quadrature Rejection Unit

Rejection ratios to 1000

This quadrature rejection unit has rejection ratios of 1000 for 0-9 v input and 800 for 9-15 v input. Input impedance is 20 k; input voltage 115 v, 400 cps. Weight is 1-1/4 lb.

Thompson Prod. Inc., Dept. ED, 2196 Clarkwood Rd., Cleveland 3, Ohio.

CIRCLE 104 ON READER-SERVICE CARD

CIRCLE 105 ON READER-SERVICE CARD ➤

NEW PRODUCTS
at WESCON

VHF Sweep Generator

Provides several functions

Model SV-6 VHF sweep generator features high reliability etched circuits and quick access cabinet styling. Available with many variations of functions, such as front panel sweep width and centering controls, single or multiple attenuator positions, sine wave or sawtooth horizontal sweep output voltage, etc. An r-f output voltage of 1 v rms across 75 ohms is provided, with crystal controlled audio and video on the 12 vhf channels and i-f.

Telonic Industries, Inc., Dept. ED, 73 N. 2nd Ave., Beech Grove, Ind.
Wescon Booth 1643

CIRCLE 106 ON READER-SERVICE CARD

Servomotors

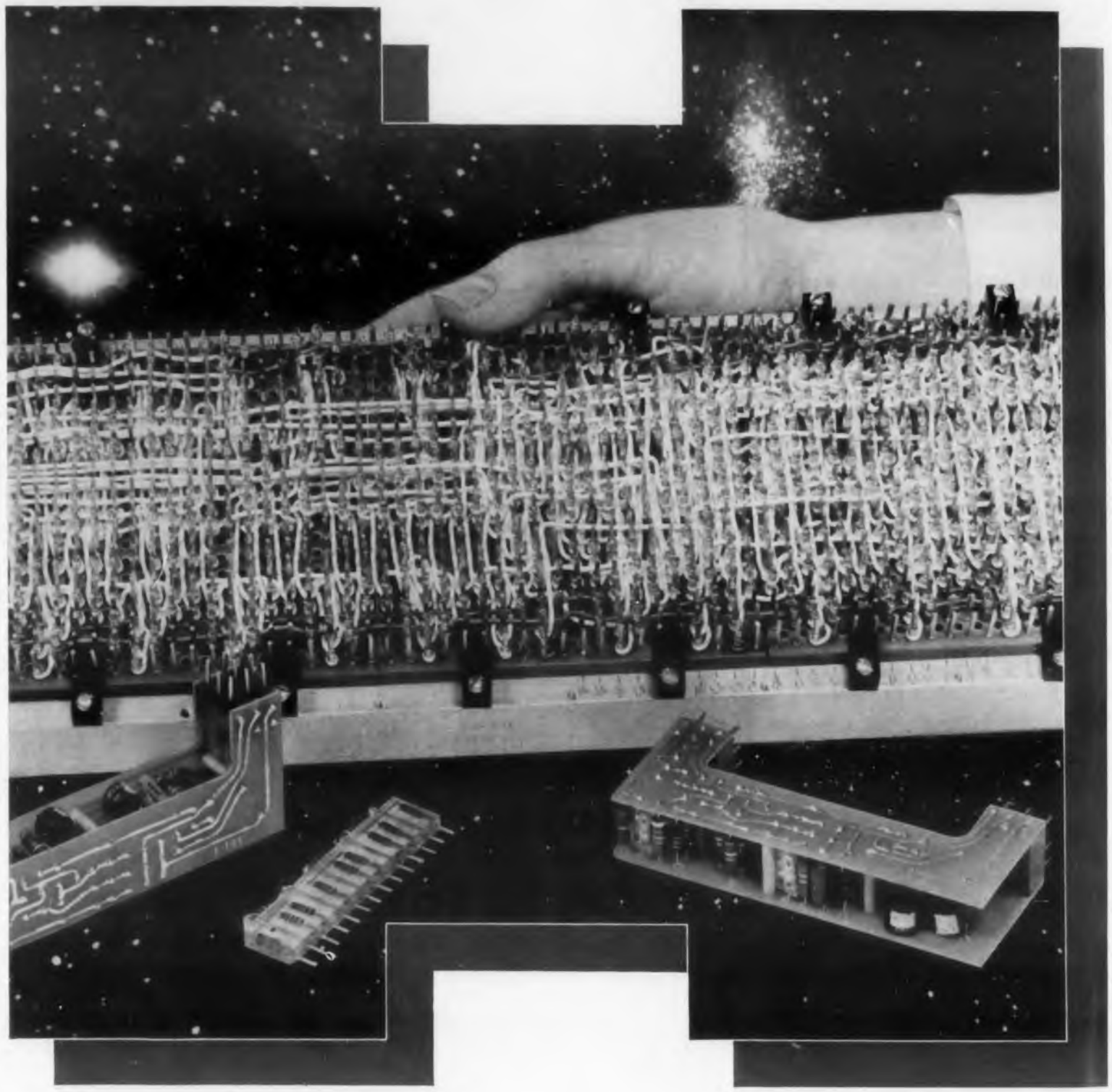
High performance size 8 units

A line of size 8 servos include two motors, two inertia-damps, two velocity-damps and a motor-generator; available in 26-v models and (except for the motor generator) in 115-v models as well. A typical unit, the 8 mg 420/410 is a 26-v, 400-cps, servomotor rate generator. Torque at stall is 0.25 oz in.; power input, 2.3 w; rotor inertia, 0.16 gm-cm^2; acceleration at stall, 110,000 rad/sec^2.

Helipot Corporation, Div. of Beckman Instruments, Inc., Dept. ED, Newport Beach, Calif.
Wescon Booth 1351-52

CIRCLE 107 ON READER-SERVICE CARD

LIFELINE FOR T



Wire Markers

Provide permanent marking

Called Mini-Markers, this wire marker gives positive and permanent identification to wires, coated wires, and components under 5/32 in. OD.

Westline Products, Div. of Western Lithograph Co., Dept. ED, 600 E. 2nd St., Los Angeles, Calif.
Wescon Booth 231

CIRCLE 108 ON READER-SERVICE CARD

Welder

Resistance type

The VTW-17 is a resistance type welder capable of welding molybdenum and tungsten rod up to 0.08 in. diam.

Vacuum Tube Products Co., Inc., Dept. ED, P.O. Box 810, Oceanside, Calif.
Wescon Booth 1303-04

CIRCLE 109 ON READER-SERVICE CARD

Magnetic Amplifier

Proportional control

The PA5E proportional amplifier is a sensitive magnetic amplifier capable of proportional control of up to 90 w output power with input power of a few millimicrowatts. This amplifier was designed specifically to provide a reliable miniaturized temperature control system for devices such as hermetic integrating gyroscopes.

Magnetic Controls Co., Dept. ED, 6405 Cambridge St., Minneapolis 16, Minn.
Wescon Booth 1108

CIRCLE 110 ON READER-SERVICE CARD

NEW PRODUCTS

Rotary Switch

Locks in position

When the key which operates the type JR switch is taken out, the switch locks in position and affords tamper-proof protection of complex electrical circuits. The switch provides control of up to three sections and eight positions.

Electro Switch Corp., Dept. ED, 167 King Ave., Weymouth 88, Mass.

CIRCLE 112 ON READER-SERVICE CARD

Flying Spot Scanner

Has bi-potential lens

Type 5ZP16 flying spot scanner features bi-potential focusing which minimizes spherical aberrations and results in a fine spot capable of high resolution. The 40-deg magnetic deflection crt has anode ratings of 30 kv.

Sylvania Electric Products Inc., Dept. ED, Seneca Falls, N.Y.

CIRCLE 113 ON READER-SERVICE CARD

Servo Elements

Miniature

Two light miniature servo elements: Model 08M10A1 26 v 400 cps size 08 servomotor has a no load speed of 6500 rpm. The 11M16A1 115 or 26 v 400 cps size 11 Linvar has an output proportional to rotor angle rising to 42.5 v.

Muirhead Instruments Inc., Dept. ED, 677 Fifth Ave., New York 22, N.Y.

CIRCLE 114 ON READER-SERVICE CARD

NEW PRODUCTS
at **WESCON**

Traveling Wave Oscilloscope

Can detect frequencies to 2000 mc

Type 2236A traveling wave oscilloscope is designed to display transient and repetitive phenomena in the millimicrosecond region. Frequencies as high as 2000 mc and voltage levels of 40 to 50 mv can be detected.

This type of oscilloscope utilizes a traveling wave type of deflection system. Helix pitch is adjusted to make the signal propagation speed down the tube match the beam velocity, thus achieving a high frequency response.

Edgerton, Germeshausen & Grier, Inc., Dept. ED, 160 Brokline Ave., Boston, Mass.

Wescon Booth 1627

CIRCLE 115 ON READER-SERVICE CARD

PC Connector

Built-in spacer

An insulating spacer molding has been designed into this 15-contact printed circuit connector to prevent the possibility of bending, twisting or shorting the contacts during assembly. The spacer is an integral part of the connector and assures uniform spacing of contacts. Connectors are supplied with the standard Bellows Action contacts.

DeJur-Amsco Corp., Electronic Sales Div., Dept. ED, 45-01 Northern Blvd., Long Island City 1, N.Y.

Wescon Booth 1521

CIRCLE 116 ON READER-SERVICE CARD

NEW PRODUCTS at WESCON

Microwave Reflector

Omnidirectional

This three dimensional microwave radar reflector device when illuminated from any azimuth or any angle in space, returns the total energy as reflected power. Based upon the Eaton Lens, the unit is effective up to X-band frequencies.

Also displayed is a do-it-yourself microwave absorber material, available as a light weight pack-in-place lossy dielectric. When formed into the proper shape and cured, it becomes a very effective microwave absorber for any pre-selected frequency.

Emerson & Cuming, Inc., Dept. ED, 869 Washington St., Canton, Mass.

Wescon Booth 326

CIRCLE 119 ON READER-SERVICE CARD

Servo Motor

Inertial damped

A new version of an inertial damped servo motor will be shown. The permanent magnet and cup are both free to rotate and no damping develops when the magnet and cup are traveling at the same speed. When there is a relative change between the cup and the permanent magnet, torque is developed in the cup and this provides the damping. The corner frequency normally specifies the inertial damping and the product of this frequency in radians per sec and the motor time constant equals unity.

Daystrom, Inc., Transicoil Div., Dept. ED, Montgomery County, Worcester, Pa.

Wescon Booth 729

CIRCLE 120 ON READER-SERVICE CARD

NEW PRODUCTS

Storage Batteries

Nickel Cadmium

Illustrated are individual storage cells with capacities of 64, 5, 2, and 1 amp hr. A nominal discharge of 1.2 low internal resistance (0.001 ohm for 10 AH type cell) permits high discharge currents.

Nicad Div., Gould-National Batteries, Inc., Dept. ED, Easthampton, Mass.

CIRCLE 93 ON READER-SERVICE CARD

Rectilinear Recorders

Choice of ranges, chart drives

Rectilinear recorders in double, standard, and small sizes provide inkless and ink recording in one unit, 3-speed transmission plus 60 to 1 speed change, and 1 per cent accuracy for moving coil movement. They come in a wide choice of ranges and chart drives.

Curtiss-Wright Corp., Electronics Div., Dept. ED, 631 Central Ave., Carlstadt, N.J.

CIRCLE 94 ON READER-SERVICE CARD

Digital Indicator

5 digit visual readout

Model 347 null-balance digital indicator is designed for input range of 0.5 to 4 mv dc. Output is 5 digit, illuminated visual and electrical digital. The unit has an accuracy of 0.05 per cent of full scale, resolution of 1/14,000 counts, and response rate of 12,000 counts per minute.

Dynametrics Corp., Dept. ED, Northwest Industrial Park, Burlington, Mass.

CIRCLE 95 ON READER-SERVICE CARD

CIRCLE 92 ON READER-SERVICE CARD ➤

NEW PRODUCTS
at WESCON

Cable Tester

Tests branching circuits

Complex, branching circuits are simultaneously high potted, tested for continuity, and measured for leakage resistance between each circuit and all others by this cable tester. Calibrated front panel controls allow independent settings of all test parameters. Checking at a rate of 5 wires per second in automatic operation, the tester stops when a faulty circuit is found.

California Technical Ind., Div. of Textron Inc., Dept. ED, 1444 Old County Road, Belmont, Calif.

Wescon Booth 1213-14

CIRCLE 126 ON READER-SERVICE CARD

Power Supply

0.05 per cent regulation

A fully transistorized power supply, model 62-121 has a regulation of 0.05 per cent for a line change of 105 to 125 v. Circuitry provides a high degree of freedom from spikes and transients.

Output range is 0.5-36 v dc at 15 amp, with full current available down to 0.5 v.

Dressen-Barnes Corp., Dept. ED, 250 N. Vinedo Ave., Pasadena, Calif.

Wescon Booth 1435

CIRCLE 127 ON READER-SERVICE CARD

Relay

Mercury-wetted contacts

Type HGS relay is similar to type HG and type HGP relays in that it comprises a sealed

pressurized switch capsule, with mercury-wetted contacts. It retains the long life and reliability features of those relays, with the added advantages of higher speed (up to 200 operations per sec) and more sensitive operation.

C. P. Clare & Co., Dept. ED, 6047 Hollywood Blvd., Los Angeles 28, Calif.

Wescon Booth 1603

CIRCLE 128 ON READER-SERVICE CARD

Rectifiers

High voltage packaged units

Rated to provide voltages as high as 100,000 v, these units have ratings from 1 ma to 1 amp. The rectifiers are assembled with either silicon or selenium types, packaged in hermetically sealed housings, and operable in temperatures to 150 C.

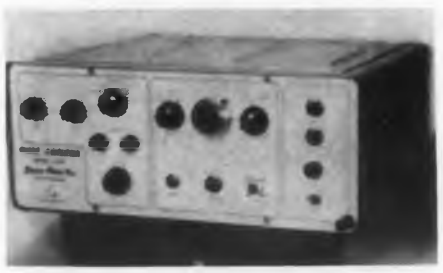
International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

Wescon Booth 1447-48

CIRCLE 129 ON READER-SERVICE CARD

Pulse Amplifier

Supplies up to 5 amp



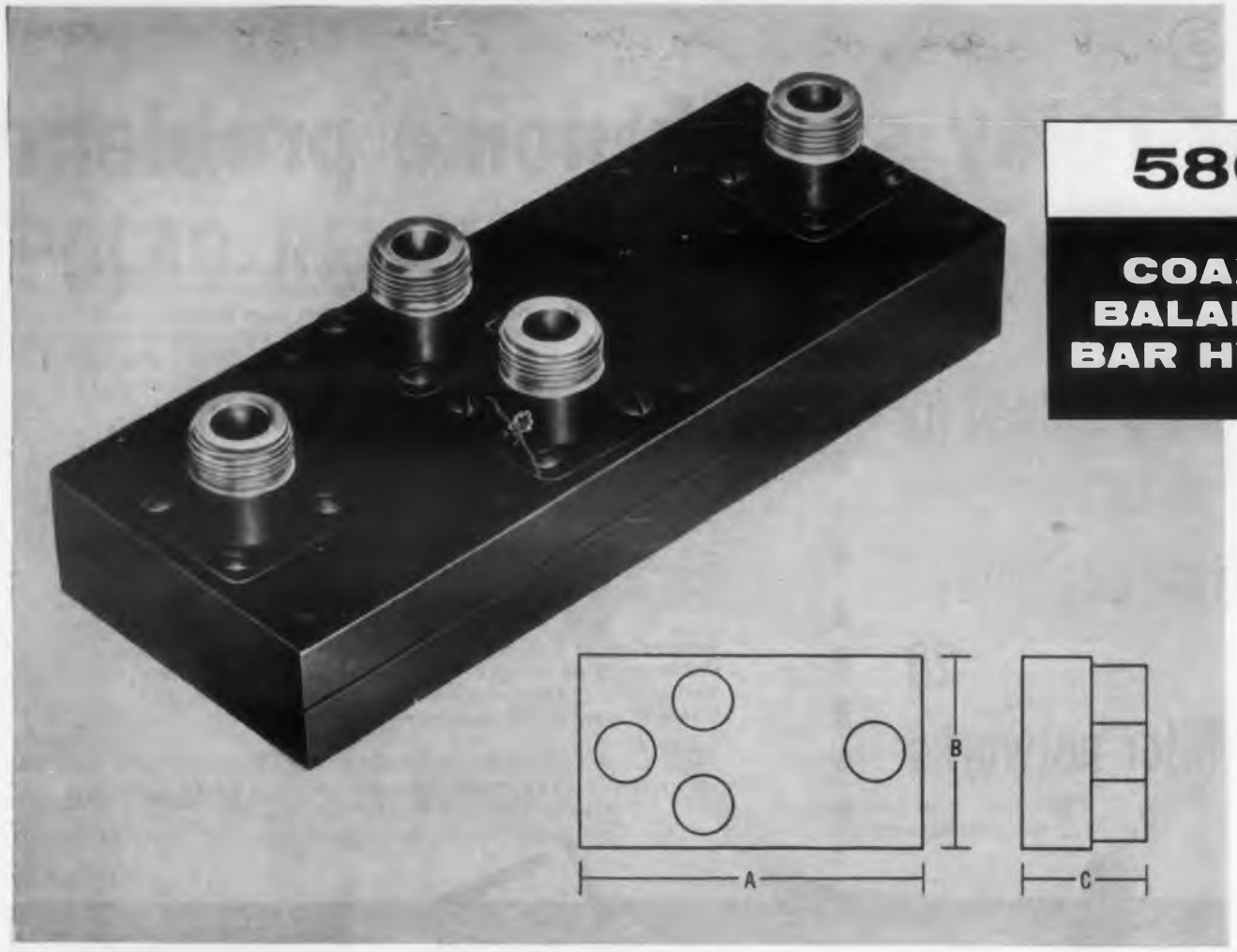
Designed for a wide range of magnetic, crystal, and capacitance element testing, model 325A pulse amplifier is a wide band unit with output versatility. The instrument is compatible with the 5000 and 5100 series pulse code generating equipment, for tape core, memory, and matrix testing applications.

The instrument provides ±50 ma to ±5 amp around ground.

Electro-Pulse, Inc., Dept. ED, 11861 Teale St., Culver City, Calif.

Wescon Booth 1645-46

CIRCLE 130 ON READER-SERVICE CARD



MODEL NL5805

The growth of the guided missiles field has provoked increased engineering activity directed towards the miniaturization of microwave components. Special techniques and materials have been developed to conform with severe space limitations and extreme temperatures. The Bogart series of bar hybrids has found wide use in military and commercial applications as **balanced mixers** (coaxial crystal mounts are available as accessory equipment), **power splitters, phase comparators, variable power dividers, fixed and variable attennators, phase shifters** for monopulse work, **duplexers** to permit design of complete coaxial R-F heads composed entirely of hybrids, and **beacon switching devices.**

A brochure entitled "Applications Employing Coaxial Bar Hybrids", in which the Bogart hybrids are presently used to perform the previously described functions, is available upon request. Special applications of Bogart Bar Hybrids can be designed to meet your specific requirements. Our applications engineers will be pleased to discuss your particular problems with you.

For characteristics of coaxial crystal mounts, refer to Bogart Series 1032.

*PATENT PENDING

Model No.	Frequency Range (Kmc/s)	Maximum VSWR (Arm 1)	Maximum VSWR (Arm 4)	Average Power Rating (Arm 1) (Watts)	Average Power Rating (Arm 4) (Watts)	Minimum Isolation (Arms 1 & 4) (db)	Power Division (Arms 2 & 3) (db)	Weight (lbs)	(A)	(B)	(C)
NX5805	7.00-10.50	1.75	2.50	200	20	30	±0.2	¾	2½	2	3
NC5805	4.70- 7.30	1.75	2.00	200	30	30	±0.2	1	3	2½	3½
NH5805*	3.50- 5.00	1.75	2.00	200	30	30	±0.2	1½	3½	3	4
NS5805	2.30- 3.70	2.00	2.00	200	30	30	±0.2	1	4	3¼	1
NR5805*	1.50- 2.30	2.00	2.00	200	30	30	±0.2	1	5	2¼	1
NL5805	.900- 1.50	1.75	1.75	200	30	30	±0.2	1¼	6	2¼	1½
NU5805*	.450- .900	1.50	1.75	200	30	30	±0.2	2½	12	2¼	1½
NV5805*	.225- .450	1.50	1.50	200	30	35	±0.2	4	12	2¼	3

Above data subject to change without notice. *Available shortly

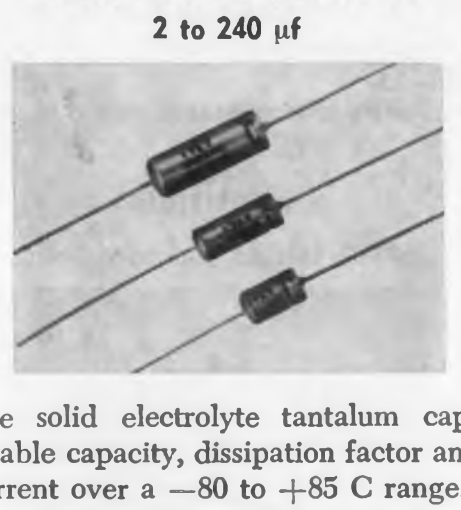
BOGART

BOGART MANUFACTURING CORPORATION
315 Seigel Street **Brooklyn 6, New York**
serving the electronics industry since 1942 design • development • production

CIRCLE 132 ON READER-SERVICE CARD

NEW PRODUCTS
at WESCON

Tantalum Capacitors
2 to 240 μf



These solid electrolyte tantalum capacito have stable capacity, dissipation factor and lea age current over a —80 to +85 C range. Thr case sizes cover ratings of 2 μf at 35 worki volts to 240 μf at 4 working volts.

International Telephone & Telegraph Cor Components Div., Dept. ED, P.O. Box 412, Cl ton, N.J.

Wescon Booth 1404

CIRCLE 133 ON READER-SERVICE CARD

Recording Heads
Two track, four channels

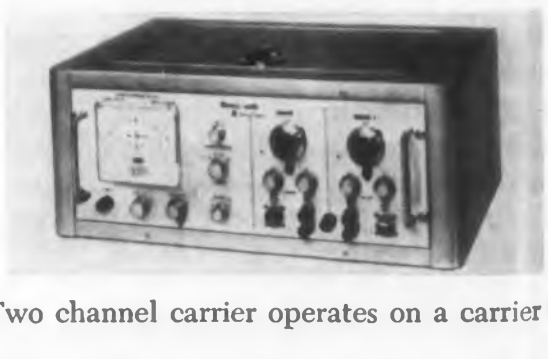
Model TR48A Isodex can record and play bac four channels on a standard 1/4-in. tape. Th unit has two tracks with gaps in-line. The trac are positioned to permit interlaced operation.

Shure Brothers Inc., Dept. ED, 222 Hartr Ave., Evanston, Ill.

Wescon Booth 1306

CIRCLE 134 ON READER-SERVICE CARD

Carrier Amplifier
Two channel



Two channel carrier operates on a carrier fr

quency of 5000 cps, with a range of 0 to 1000 cps. Also displayed are two new models of the 906 direct-recording Visicorder oscillograph. Similar in appearance to the 906, model 906A is available in two versions, the 906A-1 and 906A-2.

Minneapolis-Honeywell Regulator Co., Heiland Div., Dept. ED, 5200 E. Evans Ave., Denver 22, Colo.

Wescon Booth 544

CIRCLE 135 ON READER-SERVICE CARD

Synchros

Size 8 series

A line of size 8 synchros includes control transformers, transmitters, repeaters, resolvers and differentials. The units will feature corrosion resistant construction throughout, conforming to MIL-E-5272 specifications. Standard units will be displayed with 11.8 v, 26 v or 90 v excitation, operating over a −54 to +125 C range.

Daystrom, Inc., Transicoil Div., Dept. ED, Montgomery County, Worcester, Pa.

Wescon Booth 729

CIRCLE 136 ON READER-SERVICE CARD

Impulse Latching Relay

With manual reset

Type S11ODPB relay is available with two double throw contacts, if required. The unit operates on a 15 msec pulse and is available for 60 to 400 cps operation internally rectified. Relay consumes no power after first pulse.

Electro-Mechanical Spec. Co., Inc., Dept. ED, 1016 N. Highland Ave., Los Angeles 38, Calif.

Wescon Booth 638

CIRCLE 137 ON READER-SERVICE CARD

NEW PRODUCTS
at WESCON

High Resolution Potentiometer

Over one foot wide

A 15-in. wide single-turn potentiometer, this unit was originally designed for precision testing of aircraft actuators. Model MST-150 is available with linearities to 0.015 per cent and resolution compatible with linearity. Housing is a heat treated aluminum casting. The unit dissipates 8 w at 60 C.

Analogue Controls, Inc., Dept. ED, 39 Roselle St., Mineola, N.Y.

Wescon Booth 812

CIRCLE 140 ON READER-SERVICE CARD

Digital Voltmeter

ac-dc model

Model 402 ac-dc digital voltmeter has a new single-plane, projection type readout; 0.01 per cent dc and 0.1 per cent ac accuracy; dc measurement range from 100 μv to 999.9 v in four automatic ranges; ac measurement range from 1 mv to 999.9 v in four manual ranges; automatic ac over-range indication; ac frequency response 30 to 10,000 cps, and 10 meg input impedance on all ranges.

Cohu Electronics, Inc., Kin Tel Div., Dept. ED, 5725 Kearny Villa Road, San Diego 12, Calif.

Wescon Booth 1413-14

CIRCLE 141 ON READER-SERVICE CARD

Relays

10 amp rating

Type HR solenoid relays are rated at 10 amp, 600 v ac max, and have unitized poles, interchangeable wiping-action contacts, complete parts accessibility, and identical mounting dimensions for all ac and dc styles.

Ward Leonard Electric Co., Dept. ED, 83 South St., Mount Vernon, N.Y.

Wescon Booth 1327

CIRCLE 142 ON READER-SERVICE CARD

Power Supplies

First of transistorized series

The first two models in this series of transistorized power supplies, LT 2095 and LT 2095M, have ranges of 0 to 32 v dc. 0 to 2 amp. All models are designed to operate at max rating of 50 C ambient temperature without internal blowers or other moving parts.

Lambda Electronics Corp., Dept. ED, 11-11 131st St., College Point, L.I., N.Y.

Wescon Booth 842-43

CIRCLE 143 ON READER-SERVICE CARD

Hydrogen Thyratron

30 megawatts peak power

Model 1802 hydrogen thyratron produces 30 megawatts peak power in a small, air-cooled ceramic envelope. Salient ratings are: peak voltage, 30 kv; peak current, 1000 amp; life, 1000 hr.

Edgerton, Germeshausen & Grier, Inc., Dept. ED, 160 Brookline Ave., Boston, Mass.

Wescon Booth 1627

CIRCLE 144 ON READER-SERVICE CARD

NEW PRODUCTS
at WESCON

Strain Gage Amplifiers

Signal level suitable for telemetry

Strain gage signal amplification to voltage levels suitable for direct use in telemetry are provided by models CA3 and CA5 carrier amplifiers. They operate from a 28 v dc supply and provide an output of 0-5 v dc exactly proportional to the quantity being measured.

Statham Instructions, Inc., Dept. ED, 12401 West Olympic Boulevard, Los Angeles 64, Calif.
Wescon Booth 621

CIRCLE 147 ON READER-SERVICE CARD

Potentiometers

Rated up to 250 C

Series 314 miniature potentiometers operate in temperatures from —55 to +250 C, and withstand shock to 20 g in three axes, and vibration of 20 g to 2000 cps. They measure 1/2 in. in diam and 3/8 in. in length.

Daystrom, Inc., Pacific Div., Dept. ED, 3030 Nebraska Ave., Santa Monica, Calif.
Wescon Booth 704

CIRCLE 148 ON READER-SERVICE CARD

Mercury Pulse Generator

Can be used to test amplifiers

Output pulse height: variable from 100 μv to 100 v; shape: exponential rise to exponential decay; rise time: better than 0.05 μsec variable over a range of 1000 to 1. Decay time constant: 1, 3, 10, or 100 μsec.

Radiation Instrument Development Lab, Inc., Dept. ED, 5737 S. Halsted St., Chicago 21, Ill.

CIRCLE 149 ON READER-SERVICE CARD

Digital Voltmeter

AC voltages read to 5 digits

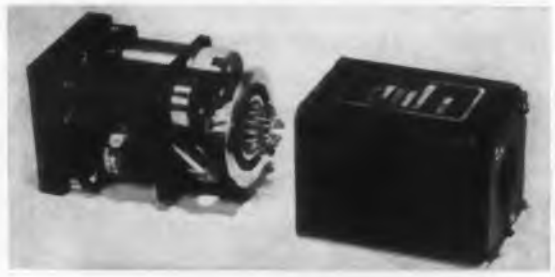
A 5-digit voltmeter system for the reading of ac voltages. A dc pre-amplifier increases the input impedance and sensitivity of the meter unit to 10 μv per digit. Accuracy of the system is greater than 0.01 per cent. Polarity and voltage ranges are automatic.

Cubic Corp., Dept. ED, 5575 Kearny Villa Rd., San Diego 11, Calif.
Wescon Booth 1554-55

CIRCLE 150 ON READER-SERVICE CARD

Resolver-Servo

For missile guidance systems



This miniaturized computer and integrator consists of a dual anti-backlash gear train, a slip clutch, a size 11 temperature compensated resolver, a size 8 motor generator and precision potentiometer, all in a pressure-sealed container measuring 2 x 2 x 3 in.

Thomas A. Edison Industries, Instrument Div., Dept. ED, 61 Lakeside Ave., W. Orange, N.J.
Wescon Booth 1748

CIRCLE 151 ON READER-SERVICE CARD

Subcarrier Oscillator

Inductance controlled

Inductance controlled subcarrier oscillator Model 0300 can be tuned to any of the 18 RDB telemetering bands in the 400 cps to 70 kc range. Output frequency is varied from its tuned center point by any inductance type transducer with two output leads. The plug-in assembly is compatible with the Bendix TJS-2 adapter.

Datran Electronics, Dept. ED, 1836 Rosecrans Ave., Manhattan Beach, Calif.

CIRCLE 152 ON READER-SERVICE CARD

NEW PRODUCTS
at WESCON

Wattmeter

Offers ±2 per cent accuracy

This panel wattmeter has accuracies of ±2 per cent at room temperature and ±5 per cent over a temperature range of —55 to +71 C. Available in a wide range of meter sizes. Ranges available extend from 25 w or vars to 1 kw or kilovar with common input frequencies.

Luscombe Engineering Co., Dept. ED, 1129 S. Fair Oaks Ave., Pasadena, Calif.
Wescon Booth 427

CIRCLE 156 ON READER-SERVICE CARD

Power Supply

For multiplier phototubes

A multiplier phototube power supply, model 30208 has an output of 800 to 2000 v dc at 0-25 ma. Output current enables the unit to operate at least 5 phototubes simultaneously, with adequate bleeder current.

Voltage is continuously adjustable. Unit provides a precise regulation of 0.015 per cent for both line and load, no load to full load.

Dressen-Barnes Corp., Dept. ED, 250 N. Vinedo Ave., Pasadena, Calif.
Wescon Booth 1435

CIRCLE 155 ON READER-SERVICE CARD

Voltage Regulator

Provides 12 kva output

Model 605 automatic voltage regulator can absorb high overload surges while delivering un-

distorted 0.25 per cent true rms voltage regulation. The unit is designed for 115 v operation, and is capable of stabilizing line voltage variations over a ±10 or ±20 per cent range. When operating within a ±10 per cent correction range, it provides a 12 kva output.

Tel-Instrument Electronics Corp., Dept. ED, 728 Garden St., Carlstadt, N.J.

CIRCLE 157 ON READER-SERVICE CARD

Oscilloscope

Low frequency

Type 401-A oscilloscope has panel controls for X and Y amplifier, sweep calibration settings, or switching from automatic to driven sweeps. The sweep circuits, designed for positive sync lockout, permit diddle free waveform stability. Sweeps of 2.5 sec full scale are offered.

Allen B. Du Mont Labs, Inc., Dept. ED, 760 Bloomfield Ave., Clifton, N.J.

Wescon Booth 1433-34

CIRCLE 158 ON READER-SERVICE CARD

Booster Amplifier

For receiver systems

This booster amplifier consists of two fully transistorized amplifiers contained in a relay-type housing measuring 1-1/2 in. diam by 2-1/2 in. high.

The amplifier has an input impedance in excess of five megohms; and feedback gain of 60 db min.

Reeves Instrument Corp., Dept. ED, Roosevelt Field, Garden City, N.Y.

Wescon Booth 1301-02

CIRCLE 159 ON READER-SERVICE CARD

NEW PRODUCTS
at WESCON

Polarized DC VTVM

250 μv full scale sensitivity

The MV-27D polarized dc microoltmeter has 250 μv full scale sensitivity. Its highest range is 0 to kv. On its three lowest ranges, 50 μv, 1 mv, and 2.5 mv, the unit ses mid-zero scales. All other anges are left-zero.

Millivac Instruments, Dept. ED, .O. Box 997, Schenectady, N.Y.

CIRCLE 162 ON READER-SERVICE CARD

Capacitors

High voltage

High voltage series of Varicap oltage-variable capacitors includes ypes with high Q factor and 20 to 00 μμf capacitance for modulaion and afc use; also types for tunng applications in values from 7 hrough 56 μμf.

Pacific Semiconductors, Inc., Dept. ED, 10451 W. Jefferson Blvd., Culver City, Calif.

CIRCLE 163 ON READER-SERVICE CARD

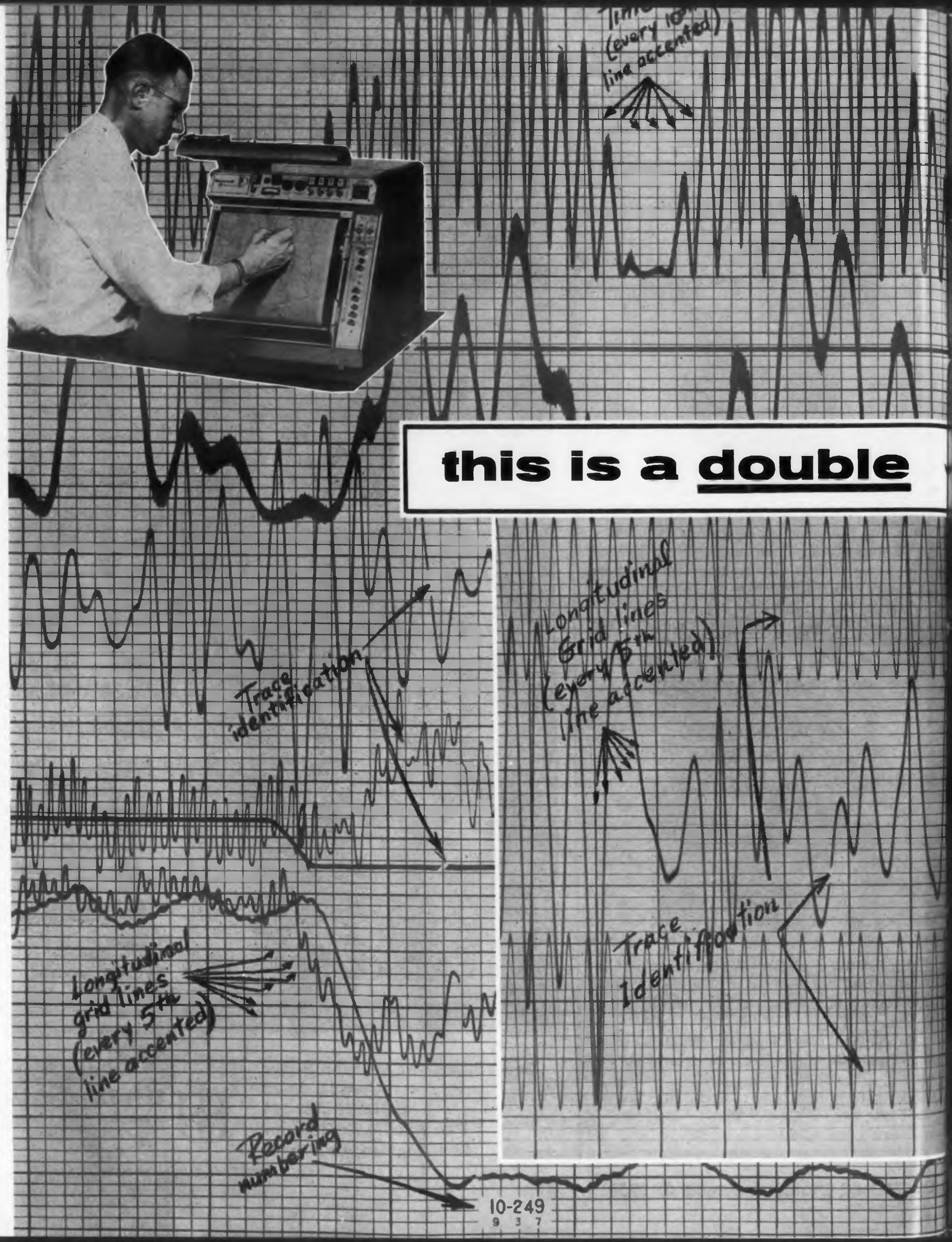
AF Subcarrier Equipment

Transistorized

This transistorized af subcarrier quipment (the KY-612 tone keyer nd TD-635 tone demodulator) ransmits binary data over commuications circuits. Designed around requencies starting at 1500 cps, paced every 3000 cps.

Rixon Electronics, Inc., Dept. ED, 2414 Reedie Dr., Silver Spring, Md.

CIRCLE 164 ON READER-SERVICE CARD



NEW PRODUCTS
at WESCON

Potentiometers

0.3 per cent linearity

Series 570 potentiometers are 1-in. diam 1 turn instruments with ± 0.3 per cent lineari and up to 265,000 ohm ratings.

As many as 45 extra terminals can be add in addition to the 3 standard terminals. Al being shown is series 230, with both linear ar non-linear functions in a compact single-tu size.

Carrier Corp., Spectrol Electronics Div., Dep ED, 1704 S. Del Mar Ave., San Gabriel, Cal *Wescon Booth 1724-25*

CIRCLE 166 ON READER-SERVICE CARD

Wattmeter

With meter-relay control

Direct monitoring and control of electrica power is provided by this locking contact watt meter. With the locking feature, high and/c low limits of wattage may be preset, with con trol action being initiated when a limit i reached. The instrument was designed by add ing a core magnet movement, as used in VH meter-relays, to the movement of a standar dynamometer type wattmeter.

Assembly Products, Inc., Dept. ED, 75 Wilso Mills Rd., Chesterland, Ohio
Wescon Booth 438-39

CIRCLE 167 ON READER-SERVICE CARD

NEW PRODUCTS
at WESCON

Relay
Heavy duty telephone type

A full yoke type armature hinge with over size bearing surfaces provides long life in 2 class 66 telephone relays.

Available with standard contact combinations to 10pdt, and with bifurcated contacts for reliable switching of low voltage.

Magnecraft Electric Co., Dept. ED, 3352 W. Grand Ave., Chicago 51, Ill.
Wescon Booth 2222

CIRCLE 169 ON READER-SERVICE CARD

Components
Miniaturized line

A line of miniature components include i-f transformers, dials, knobs, dial locks, shaft locks, flexible couplings (in 7 types), ceramic terminal strips, binding posts, gear drives, insulated potentiometer mountings, and other components.

James Millen Mfg. Co. Inc., Dept. ED, 150 Exchange St., Malden, Mass.
Wescon Booth 1324

CIRCLE 170 ON READER-SERVICE CARD

Temperature Systems
Transistorized

Transistorized temperature measurement subsystems for use with fast-response, 100-ohm-resistance temperature transducers to produce a full 5 v output for a span of 75 F. TME-1SD is single-channel; TME-2SD, a dual-channel unit.

Arnoux Corp., Dept. ED, Box 34628, Los Angeles, Calif.

CIRCLE 171 ON READER-SERVICE CARD

FLIGHT DATA and CONTROL ENGINEERS

Cross new frontiers in system electronics at The Garrett Corporation.

High-level assignments in the design and development of system electronics are available for engineers in the following specialties:

1. ELECTRONIC AND FLIGHT DATA SYSTEMS AND CONTROLS A wide choice of opportunities exists for creative R & D engineers having specialized experience with control devices such as: transducers, flight data computers, Mach sensors, servo-mechanisms, circuit and analog computer designs utilizing transistors, magamps and vacuum tubes.

2. SERVO-MECHANISMS AND ELECTRO-MAGNETICS Requires engineers with experience or academic training in the advanced design, development and application of magamp inductors and transformers.

3. FLIGHT INSTRUMENTS AND TRANSDUCERS

1) DESIGN ANALYSIS Requires engineers capable of performance analysis throughout preliminary design with ability to prepare and coordinate related proposals.

2) DEVELOPMENT Requires engineers skilled with the analysis and synthesis of dynamic systems including design of miniature mechanisms in which low friction freedom from vibration effects and compensation of thermo expansion are important.

4. PROPOSAL AND QUALTEST ENGINEER For specification review, proposal and qualtest analysis and report writing assignments. Three years electronic, electrical or mechanical experience required.

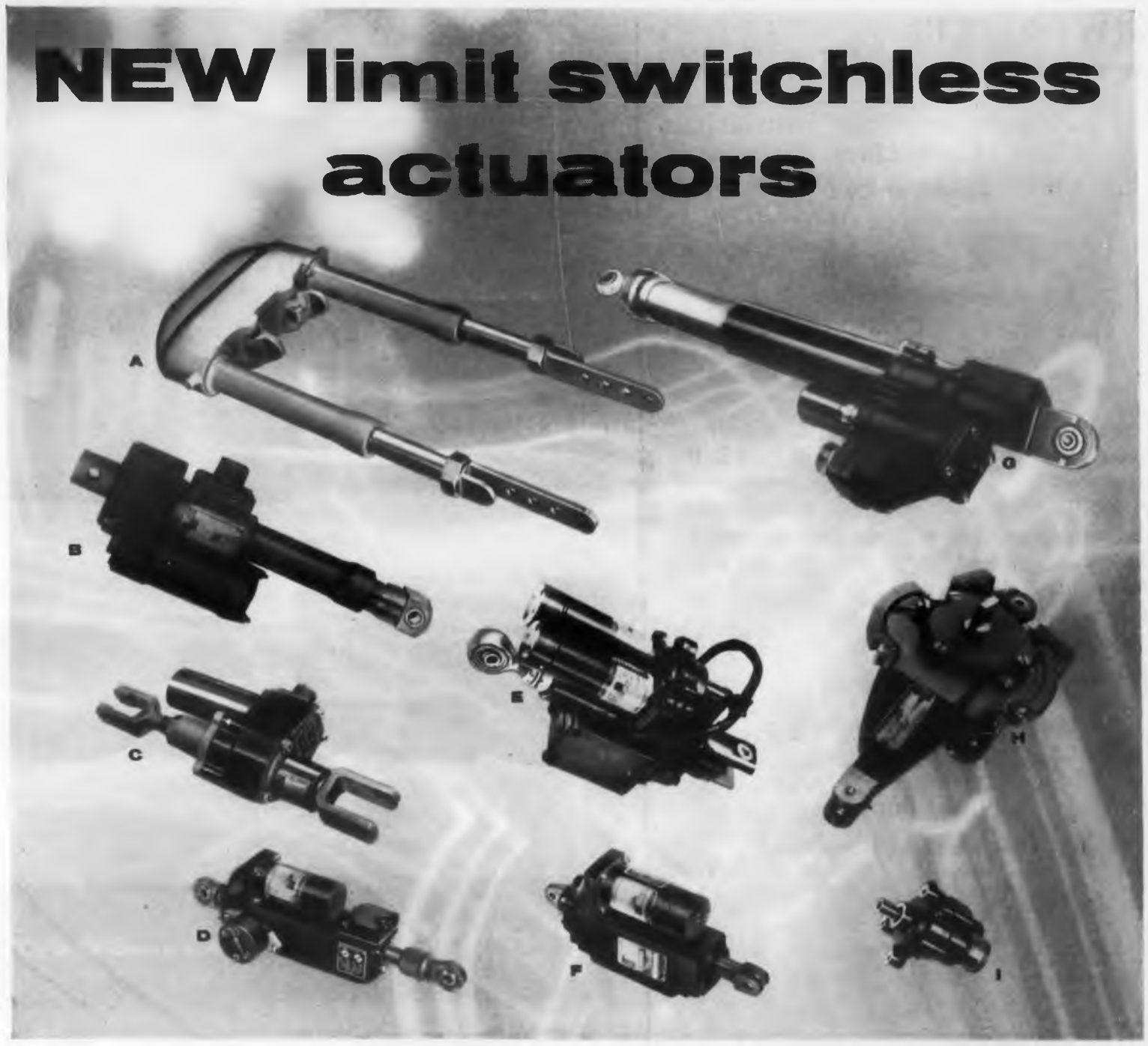
Forward resume to:
Mr. G. D. Bradley

THE GARRETT CORPORATION
9851 S. Sepulveda Blvd.
Los Angeles 45, Calif.

DIVISIONS:
AiResearch Manufacturing—Los Angeles
AiResearch Manufacturing—Phoenix
AiResearch Industrial
Rex • Aero Engineering
Airsupply • Air Cruisers
AiResearch Aviation Service

CIRCLE 557 ON READER-SERVICE CARD

NEW limit switchless actuators



Reduce weight and cost 25% below conventional design

A reduction in actuator cost and weight up to 25 per cent, with similar maintenance savings, has been achieved through the advance design of AiResearch electromechanical Limit Switchless Actuators for aircraft and missiles.

Elimination of limit switches in power actuators is a result of AiResearch development of superior high temperature motors and resilient non-jamming positive stops.

Limit switches are eliminated by two methods: 1) use of continuous stall high temperature motors, 2) use of high temperature motors with thermal protectors which permit maximum on time in the duty cycle.

Additional advantages of AiResearch Limit Switchless Actuators: they are smaller, less complex and the possibility of limit switch failure is eliminated.

Development of Limit Switchless Actuators reflects AiResearch experience in producing more than a million rotary and linear units. Current production includes several hundred actuator types, many with high temperature applications.

Your inquiries are invited.

- **A** *Seat Actuator, CONVAIR B-58*
- **B** *Seat Actuator, LOCKHEED F-104*
- **C** *Rotor Blade Trim Actuator*
- **D** *Elevator Actuator, TEMCO XKDT-1 Target*
- **E** *2-Motor Trim Actuator, REPUBLIC F-105*
- **F** *General Purpose Linear Actuator*
- **G** *Dual Purpose Feel Trim Actuator, AVRO CF-105*
- **H** *Rudder Trim, AVRO CF-105*
- **I** *Duct Shutter Actuator, LOCKHEED ELECTRA*

ENGINEERING REPRESENTATIVES: AIRSUPPLY AND AERO ENGINEERING, OFFICES IN MAJOR CITIES

THE GARRETT CORPORATION
AiResearch Manufacturing Divisions
Los Angeles 45, California • Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

CIRCLE 160 ON READER-SERVICE CARD

NEW PRODUCTS
at WESCON

Connectors

Operate at 400 F

A line of up-graded environmentally resistant connectors will be displayed. Named Real E, the connectors are designed to operate continuously at 400 F with limited operation at 500 F while maintaining moisture-resistant performance. Although smaller and lighter than AN/MS types, the connectors utilize AN/MS insert configurations and mate with other E types.

Amphenol Electronics Corp., Dept. ED, Chicago 50, Ill.
Wescon Booth 1150-51

CIRCLE 172 ON READER-SERVICE CARD

Power Supply

Transistorized, mag-amp type

Model MTRO60-5 is a transistor-magnetic amplifier regulated 0 to 60 v at 5 amp dc power supply. Line regulation is 5 mv static regulation, less than 10 mv dynamic regulation. Load regulation is less than 25 mv static regulation for changes from no load to full load, and dynamic load regulation is approximately 250 mv for no load to full load changes.

Perkin Engineering Corp., Dept. ED, 345 Kansas St., El Segundo, Calif.
Wescon Booth 1161-62

CIRCLE 173 ON READER-SERVICE CARD

Ferrite Circulator

Covers 8.5 to 9.6 kmc frequency band

Model X442A 4-terminal ferrite circulator covers the 8.5 to 9.6 kmc frequency band. Isola-

tion is at least 20 db; insertion loss is 0.5 db; vswr is 1.20. Unit is capable of 250 kw peak, 250 w average, transmitted power.

Cascade Research, Div. of Monogram Precision Industries, Inc., Dept. ED, 53 Victory Lane, Los Gatos, Calif.

CIRCLE 174 ON READER-SERVICE CARD

Emergency Switches

Used in escape gear

A rotary arm-actuated switch and a plunger-actuated switch engineered for emergency use in aircraft escape gear. High unit pressure and self-cleaning action enable the switches to function dependably under unfavorable conditions. After two years of dormancy, including 30 days at 95 per cent humidity and 100 hr of salt spray, both demonstrate a max contact resistance of 5 ohm.

Airtron, Inc., Aircraft Accessories Div., Dept. ED, 1096 W. Elizabeth Ave., Lindzen, N.J.
Wescon Booth 1564

CIRCLE 176 ON READER-SERVICE CARD

Synchronous Motor

For timing applications

For use in missile timers and similar precision timing applications, this motor has the same general construction as the standard Synchron line of magnatorc motors approved under AN-M-40.

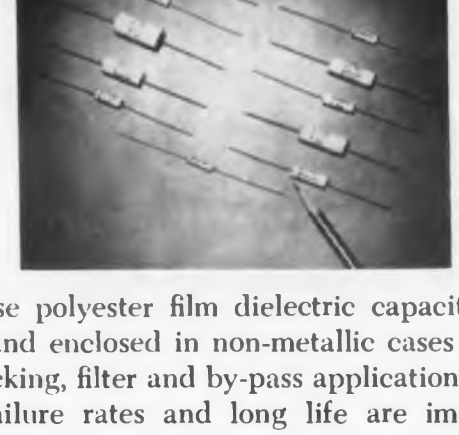
The governor-controlled motor has accuracy of ±1-3/4 per cent max error over 24 to 30 v range, −35 to +140 F.

Hansen Manufacturing Co., Inc., Dept. ED, Princeton, Ind.
Wescon Booth 941

CIRCLE 177 ON READER-SERVICE CARD

NEW PRODUCTS
at WESCON

Film Capacitors
High reliability types

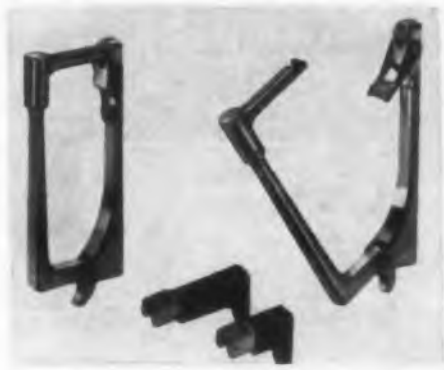


These polyester film dielectric capacitors are fixed and enclosed in non-metallic cases for use in blocking, filter and by-pass applications where low failure rates and long life are important. Lectrofilm-B capacitors are compactly wound with high purity aluminum foil and closely controlled capacitor-grade Mylar film.

General Electric Co., Dept. ED, 1 River Rd., Schenectady 5, N.Y.
Wescon Booth 529-30

CIRCLE 179 ON READER-SERVICE CARD

Chassis Latch
For heavy equipment



Aluminum alloy electronic chassis latch and adjustable fork, identified as 27L. Designed for heavy duty purposes, the latch is larger and lighter in weight than earlier designs and permits easier handling of heavy equipment.

Camloc Fastener Corporation, Dept. ED, 22 Spring Valley Road, Paramus, N.J.
Wescon Booth 101-02

CIRCLE 180 ON READER-SERVICE CARD

Audio Oscillator
Covers 18 cps to 1.1 mc range

The 510B-P audio oscillator is assembled on an oversize panel which serves as both mounting

plate and escutcheon. Total panel area is 7 x 4-3/4 in. Unit covers 18 cps to 1.1 mc range, delivers 10 v output. Frequency accuracy is 2 per cent; response is ±0.5 db.

Waveforms, Inc., Dept. ED, 331 Sixth Ave., New York 14, N.Y.

CIRCLE 181 ON READER-SERVICE CARD

Relays

Current and voltage sensitive types

Series R700 and R780 are, respectively, current and voltage sensitive relays with high resistance to shock, 2 amp resistive contact ratings, and with a temperature range from −65 to +125 C.

Relays are available in four different terminal header styles; straight pin for printed circuit applications, two sizes of solder loops and 3 leads. Switching is either spdt or dpdt.

Iron Fireman Manufacturing Co., Electronics Div., Dept. ED, 2838 S.E. Ninth Ave., Portland 2, Ore.

Wescon Booth 1261-62

CIRCLE 182 ON READER-SERVICE CARD

Wire Marker

Uses hot stamping

A wire marker will be demonstrated in conjunction with the high speed model CS-6 machine which measures, cuts and strips wire, cord and cable at speeds up to 3000 pieces per hour.

The wire marker has been designed to mark the wire continuously at set intervals. Marking is done by means of the hot stamping method which meets military specifications.

Artos Eng. Co., Dept ED, 2757 S. 28th St., Milwaukee 46, Wisc.

Wescon Booth 324

CIRCLE 184 ON READER-SERVICE CARD

NEW PRODUCTS

Automatic Gain Control

Plug-in

Mounted on a 3-1/2 x 6 in. plug-in printed circuit chassis, the model DLA-30 automatic gain control unit maintains constant servo loop gain for reference voltage variations from 2 to 100 v. It functions as a variable plate load when used with the DLA-10 servo preamplifier.

Electro Precision Corp., Dept. ED, Arkdelphia, Ark.

CIRCLE 186 ON READER-SERVICE CARD

Plotter

Traces transistor characteristics

The model 341 power transistor characteristic plotter is for use with both point-contact and junction transistors. It furnishes collector currents up to 6 amp in continuous service and produces the r_{22}, r_{12}, and h_{12} families of curves on the face of an auxiliary oscilloscope.

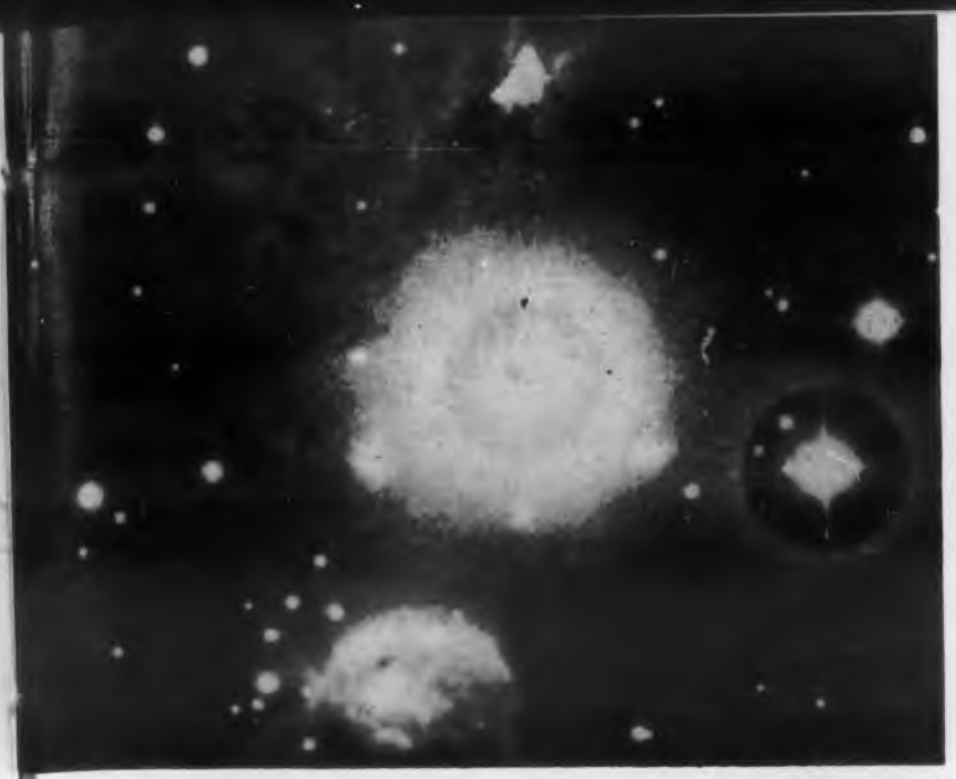
Dunn Engineering Associates, Inc., Dept. ED, 225 O'Brien Highway, Cambridge 41, Mass.

CIRCLE 187 ON READER-SERVICE CARD

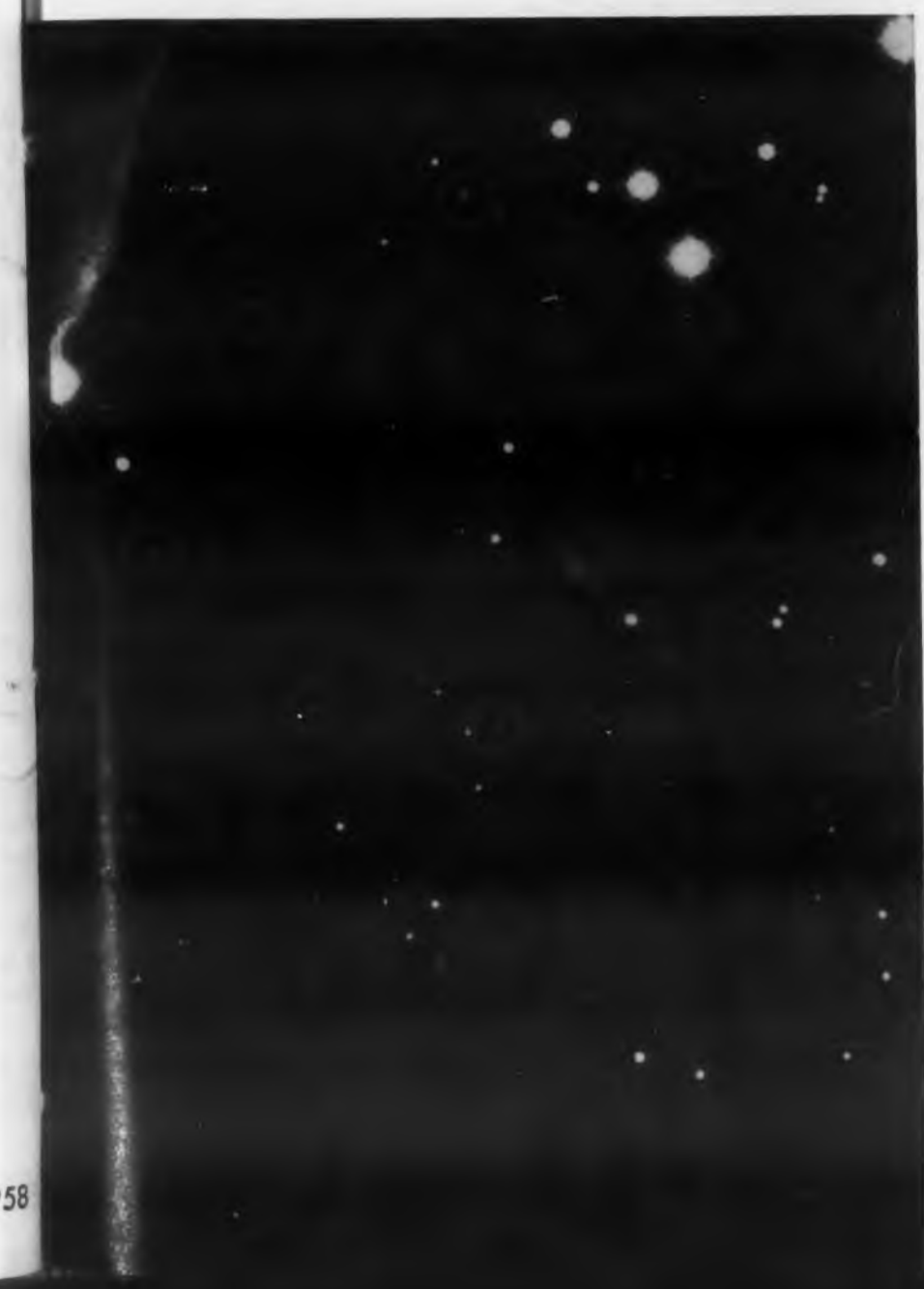
Pilot Light

Has built-in resistor

Using the high-brightness neon glow lamp NE-51H, these pilot lights require power of less than



E TECHNOLOGY



1958

FLIGHT IN THREE MEDIUMS

Several things set the Polaris apart from other outer space weapons in the ballistic missile category, for the Polaris program involves a wholly new concept of weaponry.

1. It will be dispatched from beneath the surface of the sea.
2. It will be radically smaller than currently developed land-launched missiles, yet its payload will be as effective and its range the same as other IRBMs.
3. It will be the first operational outer space missile to employ solid fuel as a propellant.
4. It will travel through three mediums in a single flight—water, air and outer space.
5. Its launching base—a submarine—is not fixed but a mobile vehicle.

OUTER SPACE PROGRAM

Very little can be said about the Earth Satellite program at this time except that its success will necessitate advancing the state of the art in all sciences.

The Earth Satellite Project is perhaps the most sophisticated outer space program to reach the "hardware" stage in the U.S. today.

ENEMY SIMULATOR

The Lockheed Kingfisher Q-5 is the nation's fastest target missile, developed for the Air Force to test the accuracy of our newest supersonic weapons.

It is a ramjet target vehicle with Mach 2-plus capabilities. The Q-5 not only has speed to match the defensive missiles, but can also simulate a vast array of supersonic enemy missiles and airplanes attacking from great height. It is instrumented to score near misses and even theoretical hits without itself being destroyed.

It is recoverable from flight by parachute to be flown again, permitting weapon system evaluation to be conducted at greatly reduced cost.

1 w on 205 v circuit. They may also be used on dc circuits over 160 v. The required resistor is built in.

Dialight Corp., Dept. ED, 60 Stewart Ave., Brooklyn 37, N.Y.

CIRCLE 190 ON READER-SERVICE CARD

Switches

Lighted pushbutton type

Two lighted pushbutton switches are available with 2, 3, or 4 spdt contact structures and 5 amp 125 or 250 v ac ratings. The 53PB8-T2 is a magnetically-held switch which employs a small dc holding coil. The 54PB67-T2 is a two position alternate-action switch.

Micro Switch, Div. of Minneapolis-Honeywell Regulator Co., Dept. ED, Freeport, Ill.

CIRCLE 188 ON READER-SERVICE CARD

Tunable Noise Generator

500 kc to 55 mc tunable frequency range

For measurements of the effects of high level noise, this tunable noise generator offers a tunable frequency range of 500 kc to 55 mc. Also useful in noise figure measurement, the unit features attenuation up to 80 db.

General Electronic Labs., Inc., Dept. ED, 195 Massachusetts Ave., Cambridge, Mass.

CIRCLE 189 ON READER-SERVICE CARD

NEW PRODUCTS
at WESCON

Potentiometer

Features low noise

Model HD-11 1-turn potentiometer features striped back coils, tapwelded terminals and Paliney No. 7 contacts throughout. During assembly the entire unit is ultra-sonically cleaned. Design has been pointed towards low noise. Standard linearity is ±0.5 per cent and the unit will dissipate 1 w at 40 C.

Hub-Pot, Inc., Dept. ED, 1242 E. Transit St., Pomona, Calif.

Wescon Booth 1513

CIRCLE 192 ON READER-SERVICE CARD

Angular Position Transducer

Sensitivity of 0.5 min arc

Model 2200 is comprised of a rotary differential transformer and integral demodulator circuit. This instrument provides infinite resolution throughout its entire range and has a sensitivity of 0.5 min of rotation at null. The differential transformer is internally connected to the demodulator to provide a dc output which is isolated from both input and ground.

Bourns Labs, Inc., Dept. ED, P.O. Box 2112, Riverside, Calif.

Wescon Booth 1104

CIRCLE 193 ON READER-SERVICE CARD

Magnetic Amplifier

7.5 v dc bi-directional output

In 0 series magnetic amplifiers, input is bi-di-

rectional, dc, for both control windings. Output is bi-directional 7.5 v dc. Gain for each control winding is 2.5 v for a 100 μa input. Gain stability is ±10 per cent.

Torotel, Inc., Dept. ED, 5512 E. 110th St., Kansas City 34, Mo.

CIRCLE 194 ON READER-SERVICE CARD

Ferrite Circulator

Compact lightweight unit

Model CKeL1 ferrite circulator is made of aluminum, weighs 6.2 oz and measures 2-3/16 in. long. Typical performance characteristics over a freq range of 13 to 14 kmc and a temp range of 55 to 130 C are: min transmit-receive isolation, 20 db; max insertion loss, 0.5 db; max vswr in any port, 1.2. Model CKeL1 is designed for 5 w average power; a medium power unit is also available.

Raytheon Mfg. Co., Special Microwave Device Group, Dept. ED, Seyon St., Waltham 54, Mass.
Wescon Booth 610-11

CIRCLE 195 ON READER-SERVICE CARD

Gearhead Motor

Withstands 7500 g of shock

Miniaturized gear head motor, model P5B827-P75, for missile application. The motor is designed to withstand 7500 g of shock. It operates on 28.5 to 31.5 v dc, developing 1000 oz in. of torque at —65 C. The gear box is a six-stage, planetary design with a reduction ratio of 13,840:1, giving the output shaft a rotation speed of 1.3 rpm. The motor meets all MIL-E-5272 specification.

Western Gear Corp., Electro Prod. Div., Dept. ED, Box 182, Lynwood, Calif.
Wescon Booth 1722-23

CIRCLE 196 ON READER-SERVICE CARD

NEW PRODUCTS
at WESCON

VU Meter

Immune to stray fields

Model 1332 VU meter uses Cormag mechanisms and can be mounted on magnetic or nonmagnetic panels without need for special adjustment. The units are immune to the effect of stray fields, and are not affected by close proximity mounting. The accuracy of these instruments is ±3 per cent of full scale.

Daystrom, Inc., Weston Instruments Div., Dept. ED, Newark, N.J.
Wescon Booth 706-07

CIRCLE 199 ON READER-SERVICE CARD

Telemetering Antenna

Helical drive

Type G-1007 antenna is a beam mode helical type for use in telemetering. Radiating element is attached to aluminum shaft with fibreglas insulator. Frequency range is 215 to 235 mc. Impedance is 50 ohm. Vswr is under 1.5 to 1. Gain is 10.5 db over isotropic source. Beamwidth is 58 deg.

Technical Appliance Corp., Special Products Div., Dept. ED, 1 Taco St., Sherburne, N.Y.

CIRCLE 200 ON READER-SERVICE CARD

Beacons

For missile and drone recovery

For missile and drone recovery, these beacons are used in the recovery of missile nose cones.

Stock beacons in various sizes and shapes, embracing both cw and pulsed techniques. Can be furnished with internal batteries or an internally mounted transistorized power supply.

Simmonds Aerocessories, Inc., Dept. ED, 105 White Plains Rd., Tarrytown, N.Y.

CIRCLE 201 ON READER-SERVICE CARD

Frequency Multiplier

Features ease of tuning

By flipping a switch on model 504C exciter unit of this multi-band frequency multiplier, the operator can transmit on the 80, 40, 20, 15, 11 or 10 meter bands. Operation requires 6 to 10 v driving power from an external crystal oscillator or vfo between frequency range of 3350 to 4000 kc, and a power supply providing filament and dc plate power. The output of model 504C is a nominal 25 w.

Barker & Williamson, Inc., Dept. ED, Canal St. & Beaver Dam Rd., Bristol, Pa.

CIRCLE 202 ON READER-SERVICE CARD

RDB Counter

Simplifies telemetering measurements

With model 2503, RDB channels and pushbutton selected and the visually displayed count is normalized to read deviation from midband directly in per cent of the midband period. The unit has five decimal places and uses an internal crystal-controlled, 100-kc time base or external time base. It also measures frequency and ratio either directly or normalized.

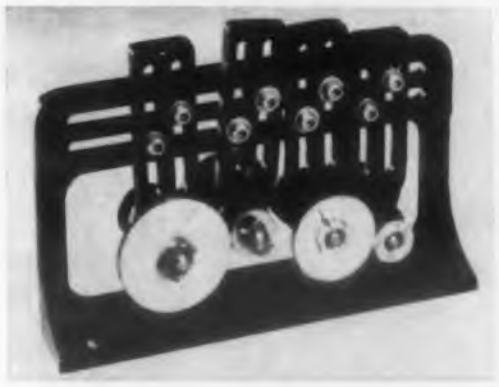
G. F. Climo, Dynac, Inc., Dept. ED, 395 Page Mill Rd., Palo Alto, Calif.

CIRCLE 203 ON READER-SERVICE CARD

NEW PRODUCTS

Gear Train

Permits quick breadboarding



The mounting centers of this hanger assembly are spaced for use with most existing breadboard plates. It permits the assembly of a complete gear train as an integral unit, which means large reductions can be independently set up prior to mounting on the breadboard plate.

Sterling Precision Corp., Instrument Div., 17 Matinecock Ave., Port Washington, N.Y.

CIRCLE 206 ON READER-SERVICE CARD

Explosive Actuator

Dimple-motor type

Screw-in type dimple motor Model 1072 comes in a wide range of 100 per cent fire and no-fire actuating currents. The end of the unit is closed with a copper diaphragm which extends 1/16 in. upon actuation.

Holex, incorporated, Dept. ED, Hollister, Calif.

CIRCLE 207 ON READER-SERVICE CARD

Lever Actuated Switch

Waterproof

This waterproof switch has been designed for

short cycle operations. It can be made with either normally open or normally closed contacts. Electrical rating is 15 amp resistive at 115 v ac.

Control Products, Inc., Dept. ED, 306 Sussex St., Harrison, N.J.

CIRCLE 208 ON READER-SERVICE CARD

Recording Head

Has precision lapped heads

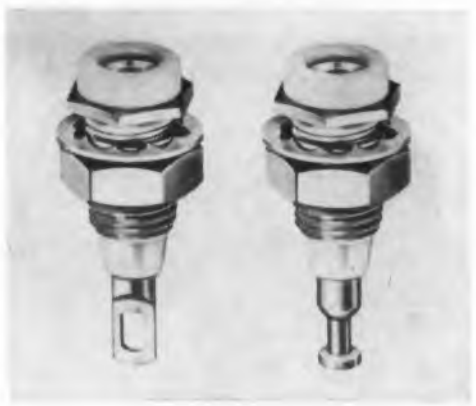
Model 303 (3 channel) twin record and playback magnetic head system has precision lapped heads with a 0.002 in. gap for the recording half and a 0.0005 in. gap for the playback half. Mu metal construction utilizing 0.0006 in. lamination provides a balanced magnetic performance for each channel with noise levels from 50 to 60 db. Each of the heads has an impedance characteristic of between 12 to 14 mh at 1 kc.

Lipps Engineering, Dept. ED, 1511 Colorado Ave., Santa Monica, Calif.

CIRCLE 209 ON READER-SERVICE CARD

Jack

Temperature range from —100 to 500 F



This test jack utilizing Teflon insulation is designed for use at temperatures ranging from —100 to 500 F. It is available with either spade or turret type solder terminals. The jack features beryllium copper spring-pin contact which is inverted to provide extra smooth insertion and firm seating of a standard 0.080 test prod.

Raytheon Manufacturing Co., Commercial Equipment Div., Dept. ED, 100 River St., Waltham, Mass.

CIRCLE 210 ON READER-SERVICE CARD

NEW PRODUCTS

Acceleration Switch

Actuated by 15 g

Model S 200-0-15G acceleration switch, for use in the ASP systems, is actuated by 15 g acceleration over a delay period of 250 msec. Shock safety limit on the sensitive axis (±10 deg) is more than 1000 g.

Cooper Development Corp., Dept. ED, 2626 S. Peck Rd., Monrovia, Calif.

CIRCLE 213 ON READER-SERVICE CARD

Accelerometer

Accurate at 50 g

Model 605 features an air-damped spring-mass system which virtually eliminates transverse acceleration error. Acceleration sensitivity perpendicular to the sensitive axis is less than resolution at 50 g. A damping ratio of 0.65 critical is standard and ratios of 0.1 to 1.0 normally can be provided.

Bourns Laboratories, Inc., Dept. ED, P.O. Box 2112, Riverside, Calif.

CIRCLE 214 ON READER-SERVICE CARD

Wirewound Control

For ambient temperatures to 250 C

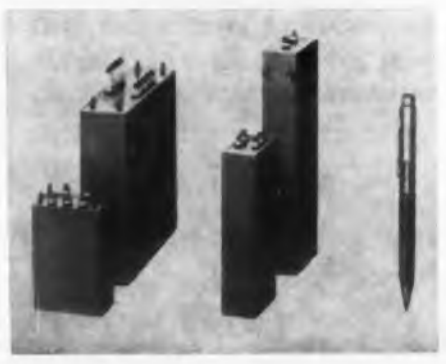
This small, wirewound control meets MIL-E-5272 specs. Hermetically sealed, it is designed for ambient temperatures to 250 C. At 200 C ambient, it is rated at 2.5 w.

P. R. Mallory & Co., Inc., Dept. ED, Indianapolis 6, Ind.

CIRCLE 215 ON READER-SERVICE CARD

Transformers

Space saving



Construction of L-shaped laminations reduces the volume of Slim-Tran transformers. Units have up to 500 va ratings. In open or in potted, encapsulated, and hermetically sealed types.

Era Electric Corp., Dept. ED, 67 E. Centre St., Nutley, N.J.

CIRCLE 216 ON READER-SERVICE CARD

Connector

Taper-contact

Miniature environmental taper-contact connectors meet or exceed MIL-C-5015 specs. In 3, 7, 12, 19, 27, 37, and 61 contact arrangements. All plugs in series available with company push-pull locking mechanism.

The Deutsch Co., Dept. ED, 7000 Avalon Blvd., Los Angeles 3, Calif.

CIRCLE 217 ON READER-SERVICE CARD

TYPICAL TEST VALUES ON COPPER CLAD PHENOLITE

GRADE	PROPERTIES OF BASE MATERIAL					COPPER CLAD PROPERTIES				RELATIVE COST
	Dielectric Constant	Dissipation Factor	Moisture Absorption	Flexural Strength	Maximum Operating Temperature	Copper Bond Strength		Hot Solder Resistance	Surface Resistance	Based on XXXP as Arbitrary Scale of 1
						Pounds to Pull 1" Strip				
	10^6 Cycles	10^6 Cycles	1/16", % 24 Hrs	Psi	Degree F	1 Oz	2 Oz	Secs to Blister 1" Square > Greater Than	Megohms, Etched Retma Comb Pattern, 96 Hrs/35°C/90% RH	1/16" Thk. 1 Oz. Copper 1 Side
P-214-B-1	5.3	.040	2.20	18,000	250	8	11	>10@ 475°F	100,000	.81
XXP-209-G-1	4.6	.037	1.30	17,000	250	8	11	>10@ 475°F	200,000	.92
XXP-239-1 PHENOCLAD	4.2	.035	0.67	15,500	250	8	11	>10@ 475°F	200,000	.92
XXXP-219-C-1	4.5	.030	0.70	15,500	250	8	11	>10@ 475°F	500,000-1,000,000	1.00
XXXP-455-1	4.0	.026	0.55	23,500	250	8	11	>10@ 475°F	1,000,000-1,500,000	1.00
XXXP-470-1	3.7	.027	0.48	14,000	250	8	11	>10@ 475°F	300,000-500,000	1.00
N-1-852-1	3.3	.030	0.20	16,000	165	8	11	>10@ 450°F	2,000,000	2.69
G-5-813-1	6.8	.018	1.00	55,000	300	8	11	—	—	2.98
G-10-865-1	5.2	.012	0.13	60,000	250	10	15	>30@ 500°F	1,500,000-2,000,000	3.49
G-11-861-1	4.9	.015	0.17	60,000	300	10	15	>30@ 500°F	2,000,000	3.55

CIRCLE 219 ON READER-SERVICE CARD

NEW PRODUCTS

Linear Counting-Rate Meter

Has seven counting ranges

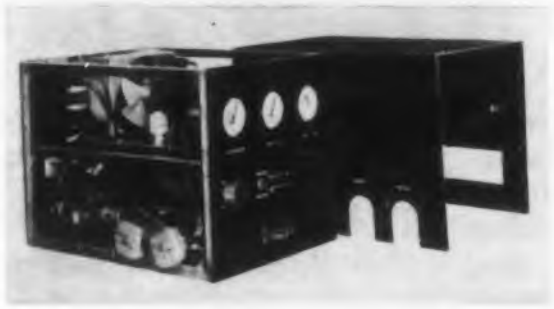
Model DM4 linear-counting rate meter features seven counting ranges, three time constants and a 60-cycle calibrating circuit. A range selection switch on the front panel permits the choice of full scale ranges from 200 through 200,000 counts per min.

BJ Electronics, Borg-Warner Corp., Dept. ED, 3300 Newport Blvd., Santa Ana, Calif.

CIRCLE 220 ON READER-SERVICE CARD

Cooling System

Achieves cell temperatures to —70 C



Model RS-25, type 100 cooling system for the detecting cell of infrared search systems. Unit achieves cell temperatures down to —70 C and operates up to 85 F and to 5000 ft altitude.

Eastern Industries, Inc., Dept. ED, 100 Skiff St., Hamden, Conn.

CIRCLE 221 ON READER-SERVICE CARD

Inertia Switches

Reset type

These reset type miniature inertia switches have a single moving part. They can be used as

one-shot closing devices without the use of a relay, or as memories to show a specific acceleration or shock level has been exceeded. The 24 standard models provide acceleration levels from 0.15 to 20 g.

Inertia Switch, Div. of Safe Lighting, Inc., Dept. ED, 527 Lexington Ave., New York, N.Y.

CIRCLE 222 ON READER-SERVICE CARD

Resistance Calibrator

Measures resistance up to 100 meg

This resistance calibrator permits resistance calibrations up to 100 meg with an accuracy of ±0.01 per cent. It enables the transfer of the accuracy of low range standards to the higher ranges with an additional error of transfer of less than ±0.0001 per cent per 2 decades up to 10 meg and ±0.01 per cent to 100 meg.

International Resistance Co., Hycor Div., Dept. ED, 12970 Bradley Ave., Sylmar, Calif.

CIRCLE 223 ON READER-SERVICE CARD

Interval Timer

Features low contact bounce

This 5 channel interval timer has a contact bounce of less than 300 μsec on make, and less than 50 μsec on break. Contacts are designed for a load current of at least 0.5 amp. Because of the synchronous drive motors, the tolerance of the timing pulses is held to ±0.2 per cent or ±10 msec whichever is greater. These tolerances are relative to a 60 cycle or 400 cycle time base accuracy.

Western Design & Manufacturing Corp., Div. U.S. Industries, Inc., Dept. ED, Santa Barbara Airport, Goleta, Calif.

CIRCLE 224 ON READER-SERVICE CARD

NEW PRODUCTS

Displacement Transducers

Designed for linear motion measurement

Models 101, 102, and 103 displacement transducers provide output voltage proportional to plunger displacement. Extreme sensitivity and stepless resolution provide accurate measurement of motions as small as 0.000001 in. or over ranges as large as 0.4 in.

Daytronic Corp., Dept. ED, 216 S. Main St., Dayton 2, Ohio.

CIRCLE 227 ON READER-SERVICE CARD

DC Amplifier

Has low drift characteristics

Characteristics of REL-120 dc amplifier are: low heat generation due to an average required input power of only 10 w; and self-contained power supply, which works directly from either 60 or 400 cps.

Rheem Manufacturing Co., Electronics Div., Dept. ED, 7777 Industry Ave., Rivera, Calif.

CIRCLE 228 ON READER-SERVICE CARD

Silicon Diode

50 to 75 kmc frequency range

Broadband high sensitivity microwave silicon diode Type MA-428 has high tangential sensitivity over the entire 50 to 75 kmc frequency range. It is estimated that system noise figures

between 15 and 18 db can be achieved, using a matched pair of these diodes as mixers in a rat race power divider balanced mixer assembly, in conjunction with a low noise i-f strip.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.

CIRCLE 229 ON READER-SERVICE CARD

Diode Handler

Sorts 3000 diodes per hour

This automatic bulk diode handler is capable of sorting up to 3000 diodes per hour into as many as 16 classifications. Diodes are transported automatically from hopper to bins, and bin contents are displayed on counters.

Stromberg-Carlson, Div. of General Dynamics Corp., Electronic Control Systems Div., Dept. ED, 2231 S. Barrington Ave., Los Angeles 64, Calif.

CIRCLE 230 ON READER-SERVICE CARD

Power Supply

0-36 v dc

Model HP361 is a transistorized instrument supplying voltage from 0-36 v dc at currents from 0 to 1.5 amp at any voltage setting. Recovery time is less than 50 μsec for a maximum line or load transient. Peak transient for a load step from zero to maximum load is less than 50 μsec. Regulation is less than 20 mv output voltage variation for line changes from 105-125 v ac.

Deltron, Inc., Dept. ED, 2905 N. Leithgow St., Philadelphia 33, Pa.

CIRCLE 231 ON READER-SERVICE CARD

NEW PRODUCTS

Vibration Tester

Has 6 ranges of displacement

Model LM-1A vibration tester provides 6 ranges of full-scale displacement from 0-.001 to 0-100 in., double amplitude. Full scale velocity ranges from 0-.01 to 0-1000 in. per sec. Full scale acceleration ranges from 0-.1 to 0-1000 g. The frequency range is from 5 to 5000 cps. The meter operates from a velocity pickup.

Ling Electronics, Inc., Dept. ED, 9937 Jefferson Blvd., Los Angeles, Calif.

CIRCLE 234 ON READER-SERVICE CARD

RF Connector

Simplified breakaway connections

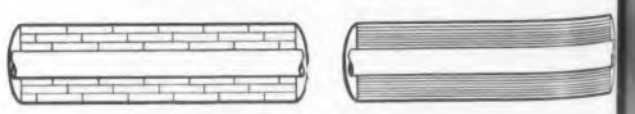
This miniature rf connector may be assembled or disassembled with the fingers and withstands a pull-out strain in excess of 20 lb. Captivated contacts insure proper engagement with mating parts. The clamping parts, insulators, and contacts are readily assembled on the cable before insertion.

Sealectro Corp., Dept. ED, 610 Fayette Ave., Mamaroneck, N.Y.

CIRCLE 235 ON READER-SERVICE CARD

Hook-Up Wire

Eight layers of wrapped Teflon



SPIRAL WRAP (⅓ LAP—no overlap)

FLEXOLON WIRE (approximately 8 layers)

The method by which Teflon tape is applied to Flexolon hook-up wire makes possible, besides its known flexibility, an average productio

length of 750 feet. This is due to the eight layers of tape, which lessen the chance of a single flow in the tape affecting insulation characteristics. Compared to the 100-ft average lengths of extruded Teflon wire, the longer lengths both reduce scrap and minimize set-up time of automatic machinery.

Flexolon wire is available in awg sizes 32 through 20. Nominal wall thickness is 0.010 in. Dielectric strength exceeds 600 v and 1000 v ratings for type E and type EE wires. All types are available in 14 solid colors or 819 stripe combinations.

Tensolite Insulated Wire Company, Inc., Dept. ED, Tarrytown, N. Y.

CIRCLE 236 ON READER-SERVICE CARD

Ohmmeter

Safe for transistor circuitry

Model 321 ohmmeter is a direct-reading instrument usable safely in all transistor circuitry. It features an absolute minimum of loading (under 30 mv to 300 ohm); wide range of 10 milliohm to 10 megohm in 8 ranges, and 2 per cent accuracy.

Electronic Applications, Dept. ED, 194 Richmond Hill Ave., Stamford, Conn.

CIRCLE 237 ON READER-SERVICE CARD

Digital Readout

Displays 4 digits plus symbol

The model 471 digital readout displays four digits and a symbol 1-1/8 in. high. Power requirements are 0.25 amp at 6.3 v ac for each symbol that is lit.

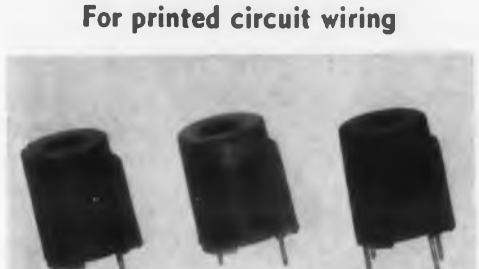
Kin Tel, Dept. ED, 5725 Kearney Villa Rd., San Diego 12, Calif.

CIRCLE 238 ON READER-SERVICE CARD

NEW PRODUCTS

Coil

For printed circuit wiring



The unit consists of an rf coil with adjustable tuning, and either one or two windings enclosed in a plastic container with leads emerging from the bottom, suitable for mounting in printed circuit boards. An advantage of this coil construction is its low temperature coefficient for inductive drift, usually running in the order of plus 50 parts per million per degree centigrade.

Essex Electronics, Dept. ED, 550 Springfield Ave., Berkeley Heights, N.J.

CIRCLE 241 ON READER-SERVICE CARD

Decode Unit

Binary to decimal

The Bina-Dec Decoder is for use in circuits requiring a binary-to-decimal conversion. Using a relay tree to perform the translation, the unit will handle four bit codes, two-out of five, and the excess 3 code. Module type construction permits assembly of as many decades as required.

Industrial Electronic Engineers, Dept. ED, 3973 Lankershim Blvd., North Hollywood, Calif.

CIRCLE 242 ON READER-SERVICE CARD

Sweeping Oscillator

15 to 470 mc range

Vari-Sweep Model 400 has a frequency range, cw or sweeping operation, of 15 to 470 mc continuously variable in 10 switched, overlapping

bands. Sweep width is 60 per cent of center frequency to 50 mc, 30 mc maximum from 50 to 400 mc, 20 mc maximum above 400 mc. Rf output is 1 v rms to 220 mc, 0.5 v rms to 470 mc.

Kay Electric Co., Dept. ED, Maple Ave., Pine Brook, N.J.

CIRCLE 243 ON READER-SERVICE CARD

Power Supplies

±0.5 per cent regulation

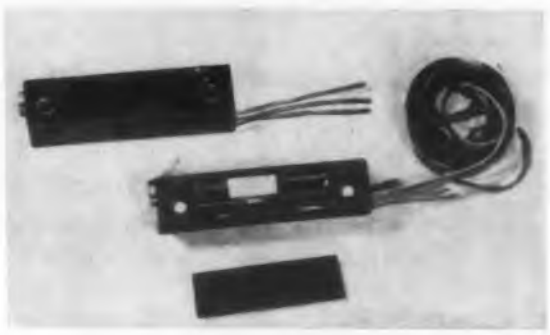
Available in a wide range of output voltages, a series of transistorized voltage regulated power supplies have channels regulated to ±0.5 per cent. The regulatory circuits are referenced to temperature compensated Zener diodes, and vernier adjustments of output voltages are provided. One unit, the Model 7PVR14, operates from a 115 v, 60 cps ac power source and provides three channel outputs: ±2 v dc at 2.5 amp, ±3 v dc at 2.5 amp, and ±20 v dc at 2.5 amp.

Western Gear Corp., Dept. ED, P.O. Box 182, Lynwood, Calif.

CIRCLE 244 ON READER-SERVICE CARD

Trimmer

1 w derated at 225 C



Type RTW is a wire-wound trimmer with 25 turn lead-screw adjustment. Resistance range is 50 to 100 K. Power rating is 1 w at 75 C derated to zero at 225 C. Dual stainless steel contacts on winding and slip ring and precious metal take-off and end tabs are included. Other trimmers, type TPC, having similar characteristics are available for printed circuit use.

Technology Instrument Corp., Dept. ED, 531 Main St., Acton, Mass.

CIRCLE 245 ON READER-SERVICE CARD

NEW PRODUCTS

Coaxial Hybrids

Features in-line design

These coaxial hybrids feature an in-line design with output arms parallel and adjacent. Two models have been developed, one for the 3500 to 4200 mc band in 7/8 coax, and a second for the 5000 to 6000 mc band in type N coax. Isolation is in excess of 25 db over most of the band. Output balance is within ±0.25 db.

Sage Laboratories, Inc., Dept. ED, 159 Linden St., Wellesley 81, Mass.

CIRCLE 248 ON READER-SERVICE CARD

Power Supply

Provides 10-14.5 v dc

The TPS-1 power supply delivers 10 to 14.5 v dc at up to 15 amp, regulated within 0.2 per cent over the full input voltage and output current ranges. Ripple is 2 mv (rms) maximum at full load, and recovery time is better than 1 msec. Internal impedance is less than 3 milliohms.

Southwestern Industrial Electronics, Dept. ED, 2831 S. Post Oak Rd, Houston, Texas

CIRCLE 249 ON READER-SERVICE CARD

DC Voltmeter-Amplifier

10 μv to 1000 v

Differential dc voltmeter-amplifier Model 98-A facilitates testing and measuring dc voltages which are off ground or superimposed on larger dc voltages. Direct reading in the 10 μv to 1000 v

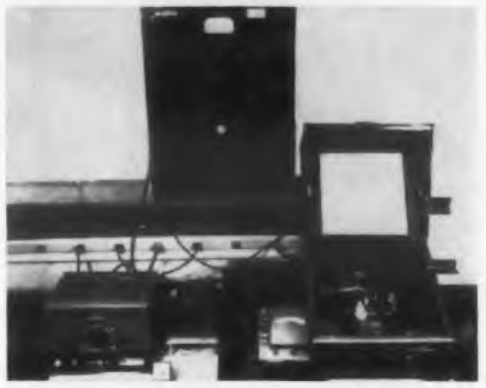
range, it has a maximum gain of 70 db. Output is ±0.5 ma into a 1500 ohm load.

Boonton Electronics Corp., Dept. ED, 738 Speedwell Ave., Morris Plains, N.J.

CIRCLE 250 ON READER-SERVICE CARD

Infrared Cell Test Equipment

Measures photodetector impedance



This line of infrared photodetector measurement equipment includes: chopper continuously variable between 20 and 8500 cps; electronic instrumentation to measure photodetectors ranging in impedance from 5 ohm to 100 meg; black body sources; and special photodetector test enclosures fitted for various methods of low temperature cooling.

Santa Barbara Research Center, Santa Barbara Airport, Dept. ED, P.O. Goleta, Calif.

CIRCLE 531 ON READER-SERVICE CARD

Filament Voltage Regulator

Extends tube life

Type EMT25136U automatic voltage regulator provides a gradual power run-up and constant regulated voltage for complex tubes. The unit is for use on nominal 120 or 240 v, 50/60 cps single phase lines. Input voltage range is 108-132 v on 120 v service and 216-256 v on 240 v service. Output voltage is adjustable from 9-24 v with sensitivity within a 1 v band at any setting. Maximum rated output load is 25 amp. Maximum voltage run-up time is 45 sec.

Superior Electric Co., Dept. ED, Bristol, Conn.

CIRCLE 251 ON READER-SERVICE CARD

NEW PRODUCTS

Synchronous Motor

60 and 400 cps reversible

This size 11 instrument type synchronous reversible motor can be used for either 60 or 400 cps operation. Pullout torque at 60 cps and 1800 rpm is 0.15 oz-in. At 400 cps and 12,000 rpm, it is 0.085 oz-in. This is achieved by using a 1 μfd capacitor for 60 cps operation or a 0.1 μfd capacitor for 400 cps. Input voltage is 115 for both 60 and 400 cps.

John Oster Manufacturing Co., Avionic Div., Dept. ED, 1 Main St., Racine, Wis.

CIRCLE 253 ON READER-SERVICE CARD

Digital Voltmeter

Measures ac or dc

Model DVA-510 modular digital voltmeter for measuring ac or dc voltages consists of a transistorized power module, dc switch module and ac converter module. The unit has a range of 0.0001 to 999.99 v and displays a five digit reading, with automatic ranging, and polarity. It is accurate to ±0.01 per cent, ± one digit, with 0.01 per cent stability.

Electro Instruments, Inc., Dept. ED, 3540 Aero Ct., San Diego 11, Calif.

CIRCLE 254 ON READER-SERVICE CARD

Capacitors

For use in filter networks

For use in filter networks, these low cost capacitors feature stability and close tolerance. In

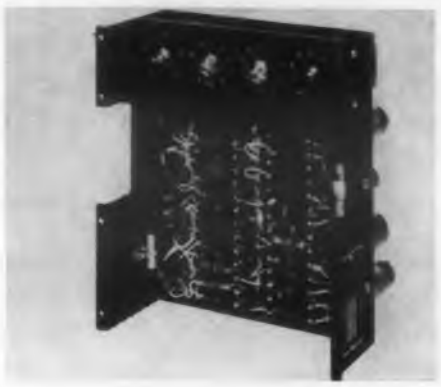
polystyrene, Mylar, or silicon-paper dielectric, units achieve a tolerance of 1 per cent and a temperature coefficient of 100 ppm.

Film Capacitors, Inc., Dept. ED, 3400 Park Ave., New York 56, N.Y.

CIRCLE 255 ON READER-SERVICE CARD

Precision Timer

Resolution of 1 msec



Model 2400 is a miniature four-decade digital timer having a time resolution of 1 msec and a maximum indicated time interval of 9.999 sec. Glow transfer tubes are used as decade counters and indicators. Pulses derived from a 1000 cps tuning fork are fed to a gated amplifier, which is controlled by miniature start and stop thyratrons.

Erie Resistor Corp., Dept. ED, 644 W. 12th St., Erie, Pa.

CIRCLE 256 ON READER-SERVICE CARD

Vibration Pickup

Magnetically damped

Using the basic design of the company's velocity type pickup, the magnetically damped type 128-1 is suitable for use in measuring vibratory motions with up to ±5 g unidirectional steady acceleration superimposed, with little change in sensitivity over a —65 to +250 C temperature range. Because of its damping and high natural frequency, it is useful both in measuring higher frequency vibratory accelerations and also in measuring low frequency jerk.

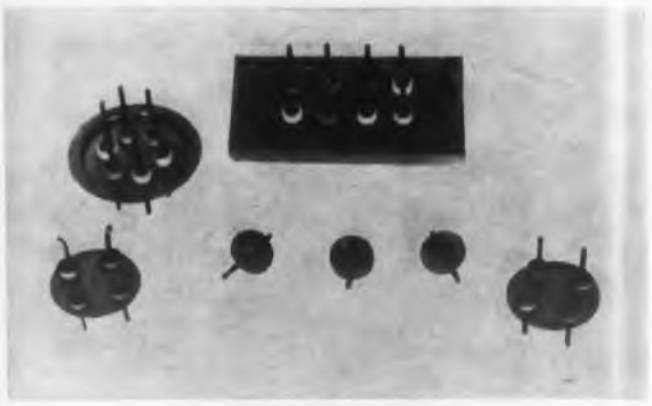
MB Manufacturing Co. Div., Textron, Inc., Dept. ED, P.O. Box 1825, New Haven, Conn.

CIRCLE 257 ON READER-SERVICE CARD

NEW PRODUCTS

Terminal Headers

Operate at 1000 C



Standard single and multiple metal-ceramic terminal headers are available for devices requiring vacuum tight, high temperature, ruggedized seals. These copper-brazed alumina to matched alloy assemblies are suitable for operation up to 1000 C, and are all helium leak checked and thermal shock tested.

Radian Engineering Associates, Dept. ED, P.O. Box 454, Mineola, L.I., N.Y.

CIRCLE 260 ON READER-SERVICE CARD

Servomotor

Size 8 takes 115 v input

For operation on 115 v, model 8 SM 460 servomotor has a low rotor inertia of 0.2 gm-cm^2 and comparatively high stall torque of 0.33 oz-in. The result is an acceleration at stall of 115,000 rad/sec^2. Power input per phase is 2.9 w. Capable of continuous duty at 200 C total unit operating temperature.

Helipot Corp. Div., Beckman Instruments, Inc., Dept. ED, Newport Beach, Calif.

CIRCLE 261 ON READER-SERVICE CARD

Linear Potentiometer

±1 per cent independent linearity

Miniature Model 141 Linipot linear potentiometer gives a precise indication of travel position and operates with a high level ac or dc out-

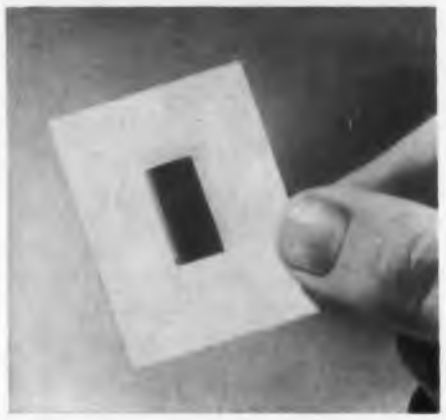
put, needing no amplification. The wirewound unit has an independent linearity of ±1 per cent and standard resistance values of 500, 1000, 2000, 5000, and 10,000 ohms.

Bourns Labs., Inc., Dept. ED, Riverside, Calif.

CIRCLE 262 ON READER-SERVICE CARD

Silicon Solar Cells

Withstand environmental extremes



Type SS solar cells are of the silicon p-n type with average conversion efficiencies of 8 per cent, based on a solar constant of 1400 w per square meter of collecting area under standard testing conditions. They will withstandup to 100 g shock for 0.003 seconds in any direction, and constant 25 g acceleration in any direction. Temperature range is —190 to +500 C.

Hoffman Electronics Corp., Semiconductor Div., Dept. ED, 930 Pitner Ave., Evanston, Ill.

CIRCLE 263 ON READER-SERVICE CARD

Power Supply

Provides 80 w output

The REL-203 transistorized power supply has an rf filter included in the 28 v input to prevent interference being conducted to radio equipment. The typical rf voltage level is down 50 db at 14 kc. An 80 w output with no heat sink is provided over a —75 to +158 F range. Input voltage is 24 to 30 v dc. Three models provide outputs of 150, 250 and 300 v respectively.

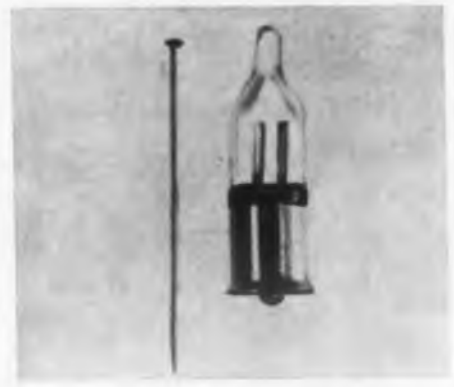
Rheem Manufacturing Co., Electronics Div., Dept. ED, 7777 Industry Ave., Rivera, Calif.

CIRCLE 264 ON READER-SERVICE CARD

NEW PRODUCTS

Neon Lamp

Built-in resistor



Measuring 1/4 in. in diameter by less than 1 in. in length, the NE2R neon lamp eliminates the need for an external resistor by having one of its own built in. The glass tip of the lamp envelope is hot formed to symmetrical appearance, and electrodes are longer than in previous types, thus increasing the area of gas excitation and resulting light.

Circon Component Corp., Dept. ED, Santa Barbara Municipal Airport, Goleta, Calif.

CIRCLE 267 ON READER-SERVICE CARD

Electrometer

High stability

Having a current range from 10^{-12} to 10^{-3} amp full scale, model E-100 features stability of 2 per cent per week on 10^{-11} and higher ranges. Accuracy is 3 per cent on 10^{-3} to 10^{-11} amp ranges and 5 per cent on 10^{-12} amp range. A 10 mv recorder output is provided. Available either rack or cabinet mounted.

Gyra Electronics Corp., Dept. ED, 518 N. Spring Ave., La Grange Park, Ill.

CIRCLE 268 ON READER-SERVICE CARD

Printed Circuit Connectors

Have wear resistant contacts

The contacts of these printed card receptacles are curved and plated, when necessary, to resist wear. The fatigue problem is solved by use of

heat-treated beryllium-copper to achieve controlled terminal hardness and strength in crucial areas. For range of board thicknesses from 0.062 to 0.103 in.

U. S. Components, Inc., Dept. ED, 454 E. 148th St., New York 55, N.Y.

CIRCLE 269 ON READER-SERVICE CARD

Pressure Transducers

Withstand 25 g vibration up to 20,000 cps

The oil-filled series 46155 Bourdon tube pressure transducers withstand vibration of 25 g up to 20,000 cps, providing stability of output signal under extreme environmental conditions. They are designed for noncorrosive gas or liquid pressure measurement within the ranges of 0 to 100 psi to 0 to 6000 psi differential or gage.

G. M. Giannini & Co., Inc., Dept. ED, 918 E. Green St., Pasadena E, Calif.

CIRCLE 270 ON READER-SERVICE CARD

Microwave Tube Power Supply

For voltage tuned oscillators

The model 602 sweeping oscillator power supply provides all power for operating voltage tuned microwave oscillator tubes covering frequencies from 1 to 26 kmc. The unit provides exponentially increasing helix voltage varying from 100 to 2500 v at 0 to 60 ma. Sweep rates are adjustable from 10 to 0.01 cps.

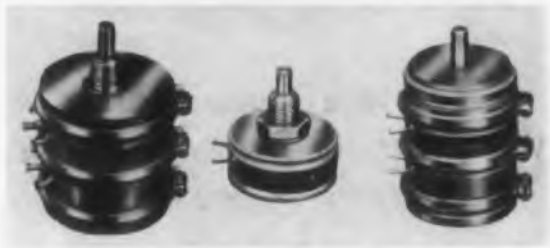
Alfred Electronics, Dept. ED, 897 Commercial St., Palo Alto, Calif.

CIRCLE 271 ON READER-SERVICE CARD

NEW PRODUCTS

Potentiometers

High resolution



In diameters from 7/8 to 3 in., these gold anodyzed single turn potentiometers feature one piece external clamp rings. They have low temperature coefficient wires, high resolution, low noise level (100 ohm max.), good linearity, 1000 v rms 60 cps dielectric strength, and a −55 to +125 C ambient temperature range.

General Scientific Corp., Dept. ED, 1509 First St., San Fernando, Calif.

CIRCLE 274 ON READER-SERVICE CARD

Strip Chart Recorder

2-5/16 in. scale length

This compact strip chart recorder has a large storage capacity. It has a scale length of 2-5/16 in. and a rated accuracy of 2 per cent of full scale.

Rust Industrial Co., Dept. ED, 130 Silver St., Manchester, N.H.

CIRCLE 275 ON READER-SERVICE CARD

Variable Voltage Source

For high-speed testing

The A-C Varivolter is an automatic and manual ac variable voltage power source consisting

of a motor-driven reversible Variac and an adjustable double-contact meter relay with interlocked motor-drive control relays. It can be operated from any power line ranging in voltage from 90 to 130 v, and the output voltage sweep can be made continuously and maximally adjustable from 0 to 135 v or limited to any narrower range.

Amplifier Corp. of America, Dept. ED, 398 Broadway, New York 13, N.Y.

CIRCLE 276 ON READER-SERVICE CARD

Control Systems

Electro-mechanical

Available for applications requiring 1/4 to 100 hp, these electro-mechanical control systems have improved dynamic response and high accuracy. Building block type components permit a variety of control arrangements, and output may be either uni- or bi-directional.

Seneca Falls Machine Co., Electronics Div., Dept. ED, Seneca Falls, N.Y.

CIRCLE 277 ON READER-SERVICE CARD

Regulated Power Supplies

Low output impedance

These regulated transistorized power supplies have low output impedance and good stability. The supplies are available with and without voltmeters and as either single or dual supplies. Two degrees of regulation are available. Input is 105 to 125 v at 60 cps; output is 6 to 30 v dc at 0.5 amp.

Vidor Instruments, Inc., Dept. ED, 13214 Crenshaw Blvd., Gardena, Calif.

CIRCLE 278 ON READER-SERVICE CARD

NEW PRODUCTS

Counter

Frequency range of 10 cps to 10 mc

This electronic counter provides eight-place Nixie read out over a frequency range of 10 cps to 10 mc. It utilizes magnetic beam switching tubes as decade dividers and scalers.

Lavoie Labs., Inc., Dept. ED, Matawan-Freehold Rd., Morganville, N.J.

CIRCLE 281 ON READER-SERVICE CARD

Latch Relay

4 w maximum power

This latch relay has dc ratings of 6 through 110 v, ac ratings of 6 through 230 v, 4 w maximum power, and 16,000 ohms maximum resistance. Contact ratings are 5 and 10 amp at 115 v ac noninductive or 26.5 v dc. Arrangements are up to 6 pdt.

Line Electric Co., Dept. ED, 271 S. 6th St., Newark 3, N.J.

CIRCLE 282 ON READER-SERVICE CARD

Subminiature Tubes

Fast warm-up

In 10 seconds after initial application of rated voltages to the cold tubes, the plate current will have reached 90 per cent of its final value. Type CK7079 is a twin triode (prototype is CK6111) with an amplification factor of 20 and mutual conductance of 5000 μmho at plate voltage of 100 and plate current of 8.5 ma for each section.

Type CK7083 is a pentode (prototype is CK5702WA) with mutual conductance of 5000 at plate voltage of 120 and plate current of 7.5 ma.

Raytheon Mfg. Co., Dept. ED, 55 Chapel St., Newton 58, Mass.

CIRCLE 283 ON READER-SERVICE CARD

AC-DC Power Supplies

5 to 28 and 100 to 300 v dc

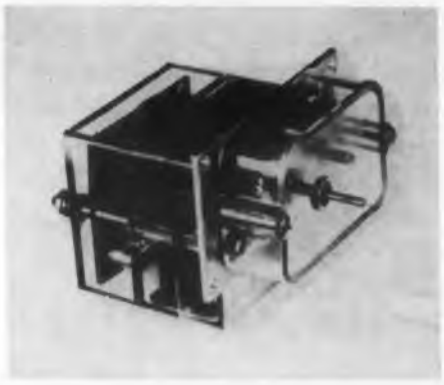
A line of transistorized ac-dc power supplies is available for supplying transistor, plate and filament voltages, either with or without regulation. The units operate from 105 to 125 v 60/cps or 400 cps single phase, or 400 cps three phase. Outputs range from 5 to 28 v dc in power ratings up to 5 amp, and from 100 to 300 v dc in ratings to 400 ma.

Universal Transistor Prod. Corp., Dept. ED, 17 Brooklyn Ave., Westbury, N.Y.

CIRCLE 284 ON READER-SERVICE CARD

Instrument Motor

Battery operated



This subfractional watt instrument motor, the model TR, occupies about 3 cu in. Stationary field coils furnish the rotative flux and are commutated by transistors. The 6 v model draws 6 ma at rated voltage and operates on power inputs as low as 20 mw. Output torques are of 10 the order of oz in. at 1 rpm.

Brailsford & Co., Inc., Dept. ED, 670 Milton Rd., Rye, N.Y.

CIRCLE 285 ON READER-SERVICE CARD

. . . see you at WESCON

If you are going to attend this year's WESCON, one stop will put you in contact with 28,000 fellow electronic design, development, and research engineers. Be sure to come to Hayden Booth No. A-445, *Electronic Design's* WESCON headquarters. Our editors will be on hand to discuss your design ideas, answer your questions, and urge you to publish material of interest to our readers.

Electronic Design is the magazine that communicates most directly to the working design engineer. The progress you report will be put to use at once by an eager, discriminating, and appreciative audience—equal in number to the entire attendance at last year's WESCON.

WE WILL LOOK FORWARD TO SEEING YOU AT THE SHOW.

NEW PRODUCTS

Terminal Bushing

Snaps in

This snap in junction terminal bushing has a quick-connect means for access through housings without pig-tail wire leads or screw terminals. Solder, crimp, and double disconnect brass terminals are available. The wire is fastened to the permanent end of the terminal, which is snap-fastened into the nylon bushing.

Heyman Mfg. Co., Dept. ED, Kenilworth, N.J.

CIRCLE 287 ON READER-SERVICE CARD

Coaxial Line Stretchers

For 250 to 5000 mc region

Designed to be used in the 250 to 5000 mc region, this line of constant impedance line stretchers employs type N connectors. The line stretchers are part of a group of coaxial tuners including double slug tuners, double stub tuners, and trombone stretchers.

Microlab, Dept. ED, 71 Okner Pkwy., Livingston, N.J.

CIRCLE 288 ON READER-SERVICE CARD

Switching Transistors

Cutoff frequencies from 5 to 20 mc

Types 2N658, 2N659, 2N660, and 2N661 range in average cutoff frequencies from 5 to 20 mc and their HFE at base current of 10 ma averages as high as 75. These are pnp germanium types in the JETEC-30 package.

Raytheon Mfg. Co., Dept. ED, 55 Chapel St., Newton 58, Mass.

CIRCLE 289 ON READER-SERVICE CARD

Diode Package

Has own mounting

This four diode package has its own means for mounting and offers protection against environmental extremes. Various inverse voltage and forward current ratings are achieved by the selected diodes. Diodes are replaceable without removing the unit from its mounting place or unsoldering the leads. Qualified per MIL-E-5272A, the units have solder type terminals.

Master Specialties Co., Dept. ED, 956 E. 108th St., Los Angeles 59, Calif.

CIRCLE 292 ON READER-SERVICE CARD

Isolation Amplifier

±0.5 db, 30 cps to 100 kc

For use with an oscilloscope or voltmeter in measuring floating ac voltages, the model 202 isolation amplifier has a frequency response of ±0.5 db, 30 cps to 100 kc, and 3 db down at 5 cps and 1 mc, approximate. Phase shift at 60 cps is under 5 deg. Isolation of input to output effective capacity is less than 4 μμf.

Quan-Tech Labs., Dept. ED, Morristown, N.J.

CIRCLE 293 ON READER-SERVICE CARD

VHF Preamplifier

45 db gain from 50 mc to 300 mc

Broadband vhf preamplifier for crystal-video detectors has a gain of about 45 db from 50 mc to 300 mc. Average noise figure is about 7 db. Power input of 70 w is required. Packaged weight is under 4 lb without power supply.

Haller, Raymond, and Brown, Inc., Dept. ED, State College, Pa.

CIRCLE 294 ON READER-SERVICE CARD

NEW PRODUCTS

Teflon Terminals

Permit strong connections

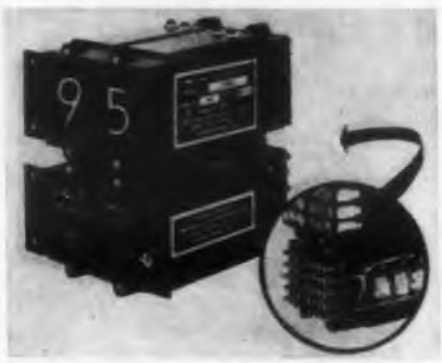
The type FT-SM-93 ML miniature feed-through Teflon terminal provides a mechanical as well as soldering bond, and is especially for use with finer wires. For security, the connecting wire first passes through a hole and then wraps around the lug. Each end lug is flatted on both sides for tighter wrapping of the wire.

Sealectro Corp., Dept. ED, 610 Fayette Ave., Mamaroneck, N.Y.

CIRCLE 297 ON READER-SERVICE CARD

Decode Unit

Binary-to-decimal



Decimal coded binary codes that may be translated with the Bina-Dec decoder include four-bit codes, two-out of five, and the excess 3 code. Module type construction permits assembly of as many decades as required.

Industrial Electronic Engineers, Dept. ED, 3973 Lankershim Blvd., North Hollywood, Calif.

CIRCLE 298 ON READER-SERVICE CARD

Pulse Height Analyzer

Linearity of 0.5 per cent

Model PHA-100/20 pulse height analyzer consists of a 100-channel analog-to-digital converter and 20 channels of glow transfer tube storage capacity. The unit has all components needed for a scintillation spectrometer except phototube

and crystal. Linearity is 0.5 per cent; deadtime is 500 μsec.

Tullamore Electronics Lab, Dept. ED, 6055 S. Ashland Ave., Chicago 36, Ill.

CIRCLE 299 ON READER-SERVICE CARD

Spectrum Analyzer

Covers frequencies from 0 to 15 mc

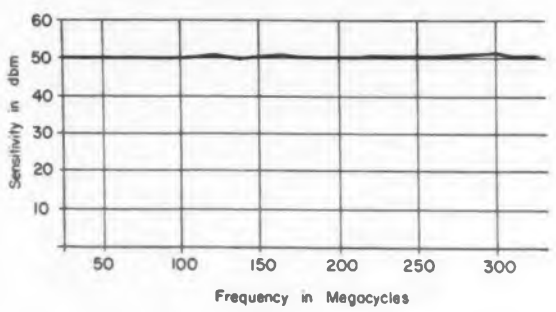
Displaying spectrum segments up to 3 mc wide, centered anywhere between 0 and 13.5 mc, the SPA-3 spectrum analyzer covers an overall frequency range from 200 cps to 15 mc. The unit provides continuously variable resolution from 200 cps to 30 kc and a variable scan rate from 1 to 60 cps. It has three amplitude scales, 100 db calibrated attenuators, 20 μv full scale sensitivity, and response flatness of ±1 db. Nominal input impedance is 72 ohms.

Panoramic Radio Products, Inc., Dept. ED, 514 S. Fulton Ave., Mt. Vernon, N.Y.

CIRCLE 300 ON READER-SERVICE CARD

Broadband VHF Preamplifier

45 db gain from 50 mc to 300 mc



This broadband vhf preamplifier for crystal-video detectors has a gain of about 45 db from 50 mc to 300 mc. Average noise figure is about 7 db. The measured tangential sensitivity of a typical vhf crystal-video detector is about —50 dbm for a video bandwidth of 1 mc. The average tangential sensitivity of this same detector using the vhf preamplifier is about —88 dbm. Packaged weight, excluding power supply, is less than 4 lb. Power input of 70 w is required.

Haller, Raymond, and Brown, Inc., Dept. ED, Circleville Rd., State College, Pa.

CIRCLE 301 ON READER-SERVICE CARD

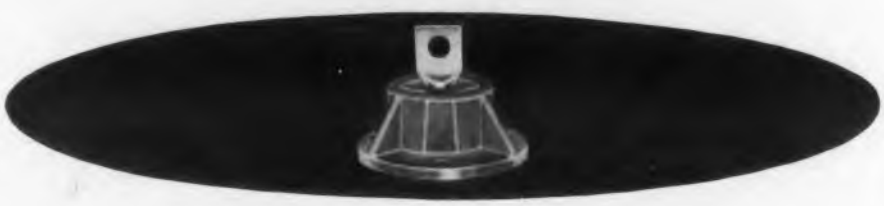
Whether you need

SILICON RECTIFIERS

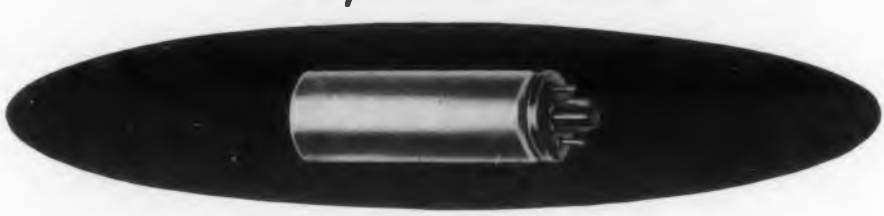
rated at 500 mils

. . . or 10 amps

. . . or 200 amps



. . . or tube replacements



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Silicon Rectifiers cover the complete range. Write for complete information or send an outline of your requirements.

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RECTIFIER DIVISION

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In Canada: 700 Weston Road, Toronto 9, Telephone Rogers 2-7535 Export: Ad Auriema, Inc., New York City

CIRCLE 303 ON READER-SERVICE CARD

NEW PRODUCTS

Transistor Tester

Direct reading measurement of small beta

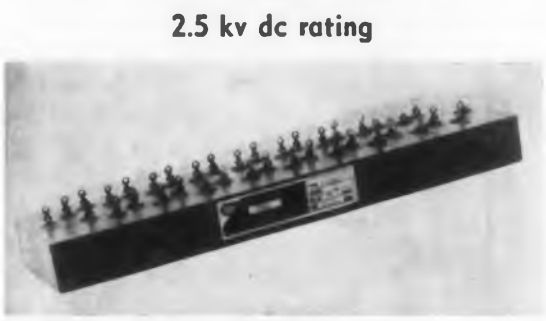
The model 201 transistor tester gives a direct reading measurement of small beta of npn and pnp low power junction transistors in three ranges: 0 to 50, 0 to 250, and 0 to 500.

Hoover Electric Co., Dept. ED, 2100 S. Stoner Ave., Los Angeles 25, Calif.

CIRCLE 304 ON READER-SERVICE CARD

Multi-Tap Delay Line

2.5 kv dc rating



Featuring a 2.5 kv dc rating, the model F384 lumped constant, multi-tap delay line has a 66 μsec total delay with taps every 2.0 μsec. Rise time is about 10 per cent of the delay selected at any one of the 33 tap points, and impedance is 9100 ohms. Other models have impedances ranging from 50 to 10,000 ohms.

Control Electronics Co., Inc., Dept. ED, 1925 New York Ave., Huntington Station, N.Y.

CIRCLE 528 ON READER-SERVICE CARD

Power Supplies

Unusual form

Two power supplies of space-saving design. A multiple output dc to dc supply, semicircular, fits into half of a 6 in. diam, 2-3/8 in. high cylinder. The other half of the cylinder holds the 25.5 to 30.5 v dc source. The unit withstands up to 100 g and operates from −55 to +70 C. It produces 150 v dc at 60 ma ±1 per cent, and 180 v dc at 85 ma ±1 per cent regulated line and load.

A second supply is 1-1/8 in. in diameter and

takes up less than 4 cu in. It produces 12,000 v dc at 1 x 10^{-7} amp from a single 1.5 v dc C size battery.

Universal Transistor Products Corp., Dept. ED, 17 Brooklyn Ave., Westbury, N.Y.

CIRCLE 305 ON READER-SERVICE CARD

Cooling Assemblies

Compact

Shown is one of a line of small packaged cooling assemblies. Capable of 600 w absorption, the unit operates on 115 v ac, single phase, 400 cps current. Liquid temperature range for this model is —40 to +250 F; liquid system pressure is 200 psi maximum; fluid flow rate is 1 gpm at 90 F; and rated delivery is 70 cfm at 2 in. wg static pressure. Other units are available in a variety of sizes and arrangements.

Borg-Warner Corp., Pesco Products Div., Dept. ED, Bedford, Ohio.

CIRCLE 306 ON READER-SERVICE CARD

Oscillographic Recording System

In one cabinet

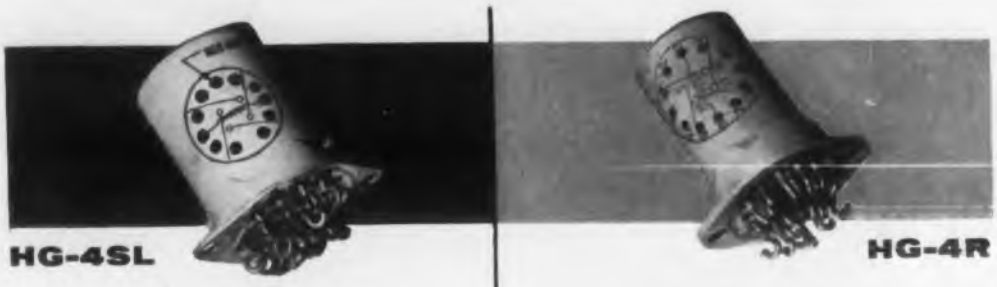
This 6-channel direct-writing oscillographic recording system, the model 156-5466, comes in a vertical cabinet 78 x 22 x 25 in. The 150 series system provides 1 per cent overall linearity, current feedback driver amplifiers and regulated power supplies for each channel, and 9 chart speeds from 0.25 to 100 mm/sec.

Sanborn Co., Dept. ED, 175 Wyman St., Waltham 54, Mass.

CIRCLE 307 ON READER-SERVICE CARD

RELIABLE AND RUGGED

shock and vibration resistant



HG-4SL

CONTACTS
1, 2, 3 or 4 pole, Form A, B or C
CONTACT CURRENT
Dry circuit to 10A resistive or 6A inductive
CONTACT VOLTAGE
Up to 1000 V, depending on current
COIL VOLTAGE
3 to 250 V DC
COIL RESISTANCE
Up to 12,000 ohm
SENSITIVITY (MAX)
350 mw
TEMPERATURE RANGE
—65°C to +125°C, Std.
to +150°C or +200°C, Special
SHOCK-OPERATING 100 G
NON-OPERATING 1000 G
VIBRATION
5 — 2000 cps @ 20 G
WILL EXCEED REQUIREMENTS OF:
MIL-R-5757C — MIL-R-25018
MIL-R-6106 — MIL-R-19523

HG-4R

CONTACTS
1, 2, 3 or 4 pole, Form A, B or C
CONTACT CURRENT
Dry circuit to 10A resistive or 6A inductive
CONTACT VOLTAGE
Up to 1000 V, depending on current
COIL VOLTAGE
6 to 350 V, 60 cps or 400 cps
COIL RESISTANCE
Up to 25,000 ohm
SENSITIVITY (MAX)
350 mw
TEMPERATURE RANGE
—65°C to +125°C, Std.
to +150°C, Special
SHOCK-OPERATING 100 G
NON-OPERATING 1000 G
VIBRATION
5 — 2000 cps @ 20 G
WILL EXCEED REQUIREMENTS OF:
MIL-R-6106 — MIL-R-19523
MIL-R-5757C — MIL-R-25018

for information on COMPLETE line, write: **H-G Inc.** BRADLEY FIELD WINDSOR LOCKS, CONN.

CIRCLE 530 ON READER-SERVICE CARD

NEW! RVG-8T 1/2" TRIMMER POT ...from Gamewell

Linearity ±3% and Power Rating 2w @ 85°C derated to 0 at 150° standard — 200°C intermittent operation available

RVG-8T Specifications
½" Trimmer Pot

Rating (watts)	2
Torque (oz.-in.) Max. special high torque available	1.
Weight (ounces)	⅓
Resistance Range ±5% 20Ω to 50K*	
Electrical Function Angle	320°
Voltage, Max. (insulation)	1000 DC
Linearity, Standard (%)	±3

*100K available
Notes: Shaft lock nut is supplied.

High Performance and Low Cost

Improve performance of your electrical and electronic circuitry with this new RVG-8T ½" Trimmer Potentiometer.

Excellent performance characteristics for its type and size. Windings are on cards or mandrels, usually with wire temperature coefficient of 20 ppm. Body is one-piece phosphor bronze, nickel plated; terminals are gold plated; stop pins and shaft are of stainless steel; precious metal contacts are used throughout. Insulation is designed to withstand 1000 volts DC.

Available now! RVG-8T is stocked in standard resistance ranges. 100 ohms to 50K ohms — up to 100K ohms available. Can be supplied with precision potentiometer tolerances, servo-mount, or for 200°C intermittent operation. Write for prices and catalog sheet today.

THE GAMEWELL COMPANY
Newton Upper Falls 64, Mass.

PRECISION POTENTIOMETER DIVISION

GAMEWELL

GA8-5

CIRCLE 309 ON READER-SERVICE CARD

NEW PRODUCTS

Gyro Test Turntable

For testing low-drift gyros

The T-806 precision tyro test turntable was designed for testing low-drift gyros in either open or closed loop. Accurate tilting permits polar axis drift tests as well as vertical, inverse vertical and horizontal axis drift tests, all without changing the position of the gyro on the turntable.

Sterling Precision Corp., Dept. ED, 17 Matinecock Ave., Port Washington, N.Y.

CIRCLE 310 ON READER-SERVICE CARD

Transistor Testers

Test forward and back currents

Two instruments, model FT 1 forward current tester and model BT 1 back current tester, have been designed for quantity testing by unskilled operators. Model FT 1, shown, has an output voltage of 0-3 v dc. Line regulation and load regulation are each better than 10 mv. Ripple and noise less than 2 mv peak to peak.

Trans Electronics Inc., Dept. ED, 7349 Canoga Ave., Canoga Park, Calif.

CIRCLE 311 ON READER-SERVICE CARD

Sine-Cosine Potentiometer

Nonlinear type

Type WPSC 1-1/8 nonlinear sine-cosine precision potentiometer provides two 360 deg sinusoidal voltage outputs. The output signals are displaced 90 deg in phase and represent the sine and cosine of the shaft rotation angle.

Waters Mfg., Inc. Dept. ED, Wayland, Mass.

CIRCLE 313 ON READER-SERVICE CARD

Power Line Carrier

Completely transistorized

This frequency shift power line carrier equipment, all transistorized, can be operated from a 48 v battery source or conventional ac power. Transmitter power input requirements are 22 w at 117 v, or 11 w at 48 v dc.

Motorola Inc., Dept. ED, 4501 W. Augusta Blvd., Chicago 51, Ill.

CIRCLE 315 ON READER-SERVICE CARD

Modular Test Equipment

Wide variety of applications

Modules for easy assembly into automatic synchro testers, inertial guidance system testers, universal radar test sets, universal resolver and synchro test consoles, resistance limit bridge consoles, and other test devices.

Kearfott Co., Inc., Dept. ED, 1378 Main Ave., Clifton, N.J.

CIRCLE 314 ON READER-SERVICE CARD

Low-Pass RF Filter

Weighs under 5 oz

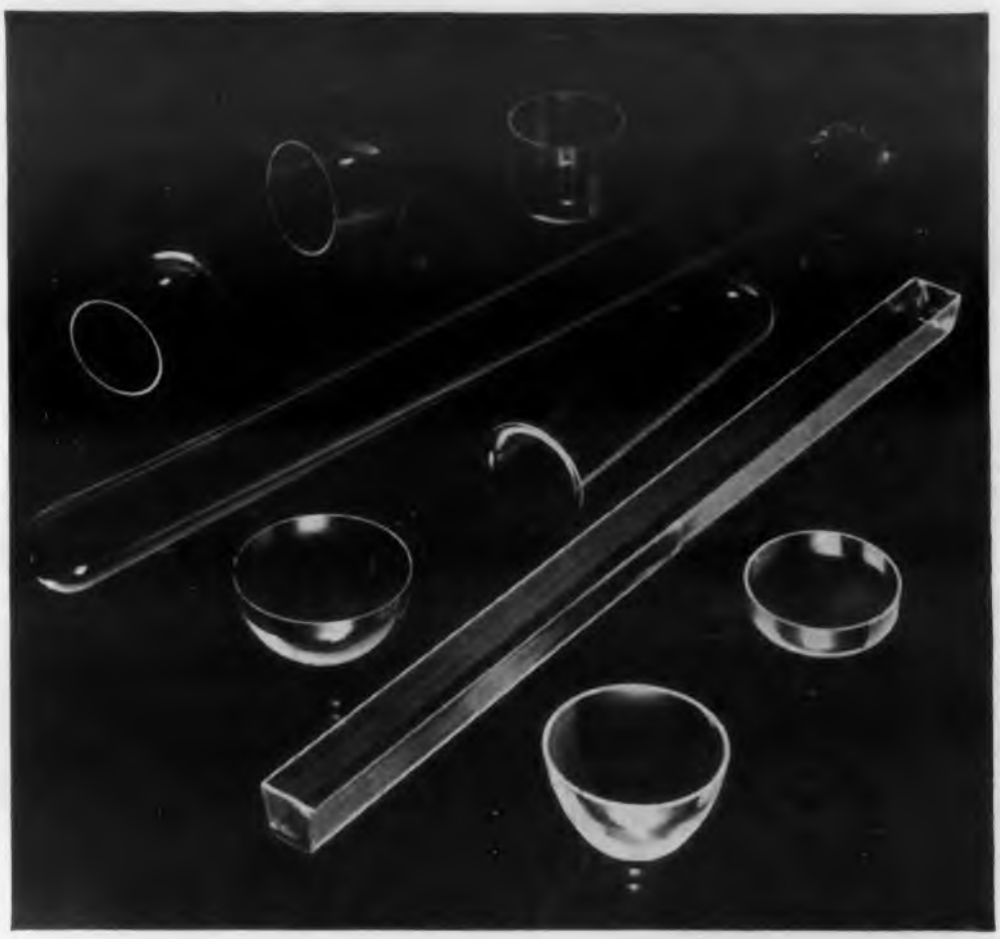
Compact low-pass rf filter designed for low insertion loss in the communication band of 225 to 400 mc with attenuation in the 950 to 1200 mc band of 80 db. Weighs under 5 oz.

Bird Electronic Corp., Dept. ED, 1800 E. 38th St., Cleveland 14, Ohio.

CIRCLE 316 ON READER-SERVICE CARD

Need High Purity fused quartz components?

General Electric offers most complete line... plus prompt delivery!



HERE'S GOOD NEWS for anyone in the semi-conductor field making silicon and germanium and using ordinary crucibles or thin wall tubing for zone refining. General Electric offers the industry's most complete line of semi-conductor components of extremely High Purity fused quartz. This enables you to fill all your quartz requirements from a single source—simplifying ordering, stocking and bookkeeping.

STOCK ITEMS AVAILABLE. General Electric now has plant facilities devoted exclusively to the making of fused quartz products—and offers a wide range of stock items for immediate—*yes, immediate*—delivery.

FREE ENGINEERING ASSISTANCE General Electric invites your requests for engineering assistance and it's free, without any obligation on your part. By using the know-how and experience of G-E engineers you not only are assured of immediate and expert help, but you also release your own staff for other assignments. Write today, to: General Electric Co., Lamp Glass Department ED-88, Willoughby Quartz Plant, Willoughby, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

CIRCLE 319 ON READER-SERVICE CARD

NEW PRODUCTS

Color Tolerance Computer

Has range from 0 to 20 NBS units

Designed for use with the IDL color-eye colorimeter, the model No. 100 delta E electronic color tolerance computer has a range from 0 to 20 NBS units. Accuracy is ±0.1 NBS unit or 3 per cent.

Instrument Development Labs., Inc., Dept. ED, 67 Mechanic St., Attleboro, Mass.

CIRCLE 321 ON READER-SERVICE CARD

DC VTVM

Accuracy 1/4 per cent absolute

Accuracy of 1/4 per cent absolute (not full scale) is obtained with the MV-57A dc vtvm. Measuring range is 100 μv to 1 kv, and input impedance is 6 meg on low ranges, and 60 meg from 1 v up.

Millivac Instruments, Dept. ED, P.O. Box 997, Schenectady, N.Y.

CIRCLE 322 ON READER-SERVICE CARD

Digital Data Logger

Takes up to 30 go-no-go signals

The DIGIDAC/Logger takes up to 30 go-no-go (on-off) signals and converts them to a one-channel digital pulse output. It can be used with tactical telemetry systems, subcarrier oscillators, checkout systems, DIGIDAC/Converter, and DIGIDAC/Comparator.

Aeronca Mfg. Corp., Dept. ED, Middletown, Ohio.

CIRCLE 323 ON READER-SERVICE CARD

Filament Transformer

For Eimac 4CX1000A

Designated as Stancor P-6463, this unit provides center-tapped secondaries of 6, 6.5, or 7 v, at 13 amp. Primary is 117 v, 60 cps. The P-6463 is designed to withstand 2000 v rms and measures 2-13/16 x 3-3/8 x 3-3/8 in.

Chicago Standard Transformer Corp., Dept. ED, 3501 Addison St., Chicago 18, Ill.

CIRCLE 326 ON READER-SERVICE CARD

AC Power Supply

Available in 19 models

The Series 7000 high-voltage ac power supplies are available in 19 models, operating on 220 or 440 v, 60 cps, single-phase inputs, with output voltages ranging from 0 to 25 to 0 to 150 kv, at 5 to 100 kva.

Beta Electric, Div. of Sorensen & Co., Inc., Dept. ED, Richards Ave., South Norwalk, Conn.

CIRCLE 327 ON READER-SERVICE CARD

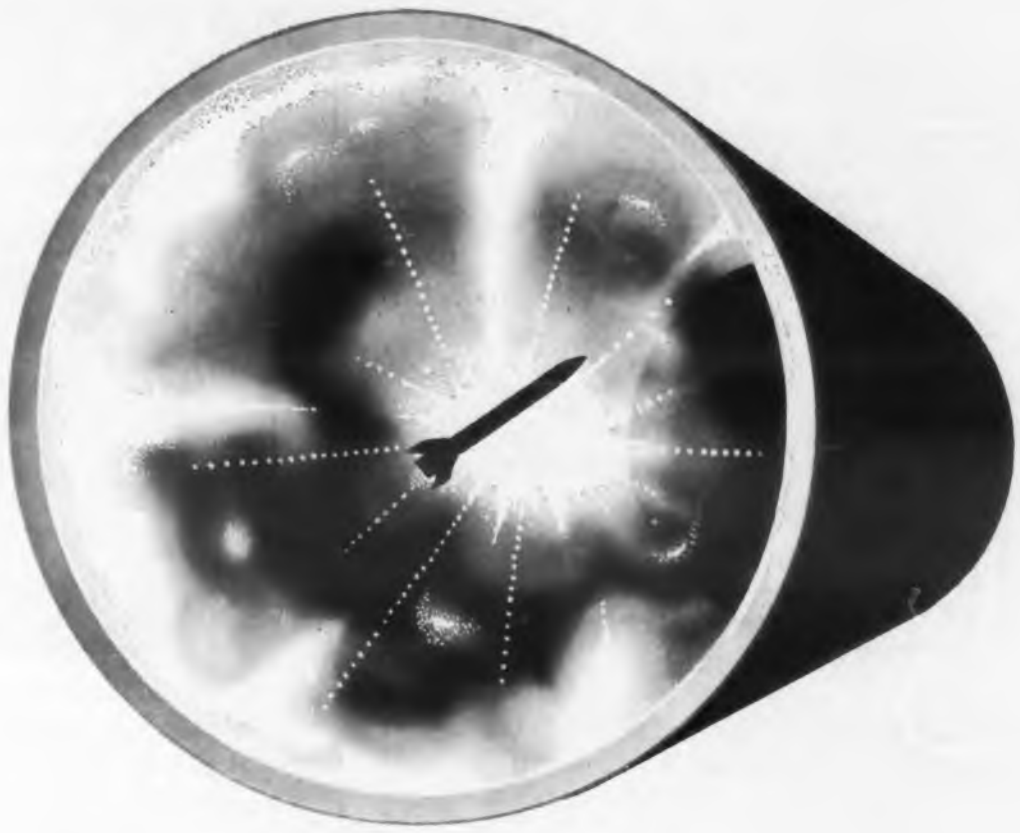
Electroformed Components

At reduced cost

Electroform process techniques specifically designed for the manufacturer of precise, complex electronic components have reduced costs by eliminating machining operations. Shown are electroformed microwave components.

General Electronic Labs., Inc., Dept. ED, 195 Massachusetts Ave., Cambridge, Mass.

CIRCLE 328 ON READER-SERVICE CARD



You name the environment ...TENNEY will simulate it!

Altitude, heat, cold, explosion, vacuum ... whatever environment you need, there is an extensively-tested Tenney prototype already built that is very near your specifications. By adjusting the prototype to fit your particular requirements, we can make delivery in a surprisingly short time. In operation, your Tenney chamber will reach ideal environmental conditions quickly, maintain them efficiently throughout the test run, and provide accurate data for quick, simple evaluation.

Tenney, pioneer in the science of environmental testing, is today the world's largest, most experienced creator of environmental testing equipment. Write today for literature describing Tenney's complete line of prototype chambers, or for information on Tenney's research and development, engineering consultation, and design services.

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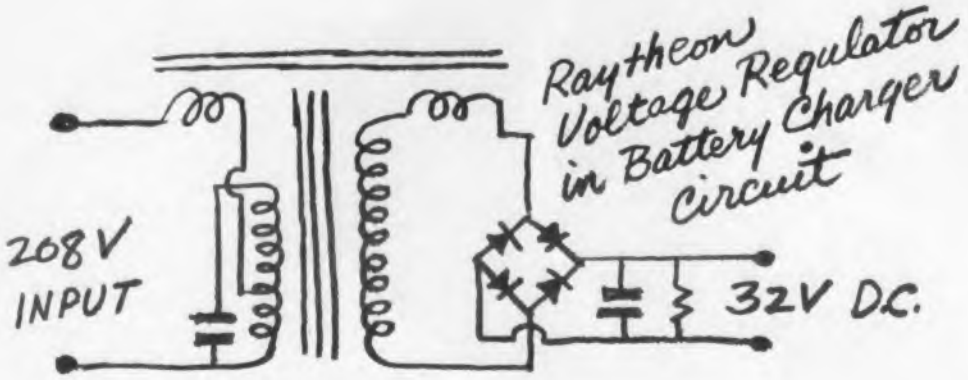
Tenney
ENGINEERING, INC.
1090 SPRINGFIELD ROAD, UNION, N. J.

PLANTS: UNION, N. J. AND BALTIMORE, MD. • THERE IS A TENNEY CHAMBER TO SIMULATE ALTITUDE, HEAT, COLD, HUMIDITY, VACUUM, EXPLOSION, SAND, DUST, FOG, AND MOST OTHER ENVIRONMENTAL CONDITIONS.

CIRCLE 329 ON READER-SERVICE CARD

IS CONSTANT VOLTAGE POSSIBLE IN THESE CHANGING TIMES?



...Basically, the problem is a classical one of semantics. Higher minds than ours have pondered this question for centuries.

As a practical exercise, let us examine the case of voltage regulation reference source in the power supply circuit shown above. This passive network corrects input voltage changes of more than ±15% of rated outputs and controls them to within ±½%...a feature that is highly important in keeping storage batteries alive longer.

The point is that constancy is a relative term understood only against a background of change. The answer then to the initial question is "yes"...constant voltage is possible.

You can get the Complete Story about voltage regulators from the higher minds at Raytheon by writing to:

VOLTAGE REGULATOR MAN
Raytheon Manufacturing Company
Magnetic Components Department
Section 6120
Waltham 54, Massachusetts

RAYTHEON

Excellence in Electronics

CIRCLE 330 ON READER-SERVICE CARD

NEW PRODUCTS

Pulse Transformers

May be impedance matched

Types PT-82 and PT-91 are miniature encapsulated units designed to plug into standard noval sockets. These transformers may be used for isolation, coupling, or blocking oscillator circuits. The windings may be connected in various ways for impedance matching. A typical blocking oscillator performance is a pulse width of 1.1 μsec and a pulse height of 70 v. (One winding.)

Berkshire Labs, Dept. ED, 578 Bank Village, Greenville, N.H.

CIRCLE 331 ON READER-SERVICE CARD

Magnetic Switching Amplifier

Designed for range of —67 to +200 F

The SA6A-1 unit, which operates from 115 v, 60 cps commercial power sources, is specifically designed for such applications as controlling temperatures in hermetic integrating gyroscopes to an accuracy of less than 0.5 F; for use with various types of fuels and liquids in circulating systems and for accurate and reliable oven temperature control. The device is designed for a temperature operating range of —67 to +200 F continuous operation. It meets all requirements of MIL-E-5272C.

Magnetic Controls Co., Dept. ED, 6405 Cambridge St., Minneapolis 16, Minn.

CIRCLE 332 ON READER-SERVICE CARD

Miniature Electrical Connectors

25 modifications available

Over 25 modifications of the basic 19-contact miniature electrical connector are now available. All connectors are environmental and meet or exceed the requirements of the latest revision of MIL-C-5015.

The Deutsch Co., Dept. ED, 7000 Avalon Blvd., Los Angeles 3, Calif.

CIRCLE 335 ON READER-SERVICE CARD

Digital Instrument

Displays numbers on cathode tubes

Model DR-4C is an electronic digital display unit providing digital readout for instrumentation and computers, features printed circuit modular construction. It operates on 115 v, 60 cps, 50 va.

Hoffman Electronics Corp., Semiconductor Div., Dept. ED, 930 Pitner Ave., Evanston, Ill.

CIRCLE 336 ON READER-SERVICE CARD

Servo Motor

125 C ambient operating temperature

This compact damped 400 cps servo motor in BuORD size 11 provides low cost servo loop damping. Ambient operating temperature is 125 C. Stall torque is 0.60 oz-in. minimum.

Servomechanisms, Inc., Mechatrol Div., 1200 Prospect Ave., Westbury, N.Y.

CIRCLE 337 ON READER-SERVICE CARD

CONQUEST OF SPACE

There are some who find fulfillment in boundless outer space. And more power to them!

But those of us who still have our feet on the ground also find real challenges in less expansive surroundings.

With the aid of a medium-power microscope and several years' experience with fluoro-chemical designs, we successfully pack 4 filter reactors and a 350 VA power transformer into 60 cubic inches of hermetically sealed inner space. Result is 6 pounds of streamlined reliable power for small space platforms...proved in performance in '58-model missiles and (pardon the expression) aircraft.

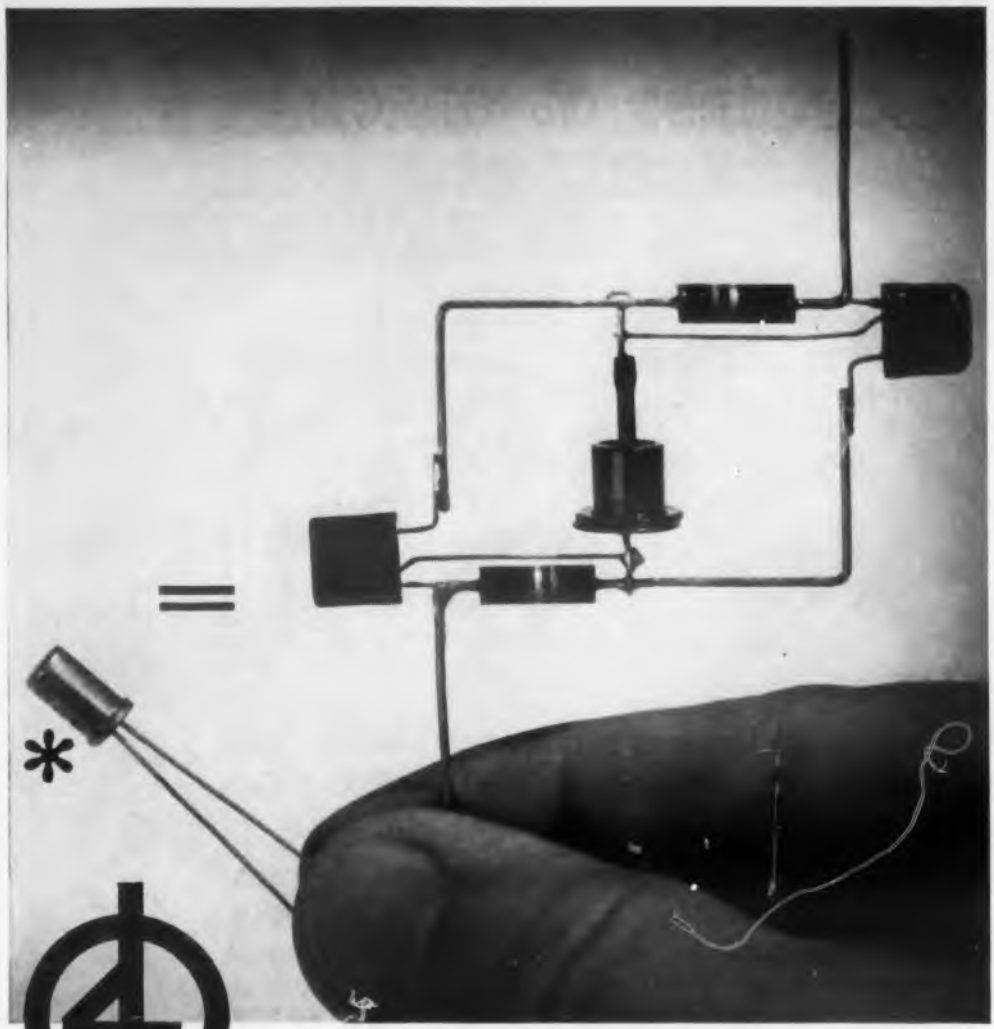
Have slide rule... will travel. You can reach us at:

Raytheon Manufacturing Company
Magnetic Components Department
Section 6120
Waltham 54, Massachusetts

RAYTHEON

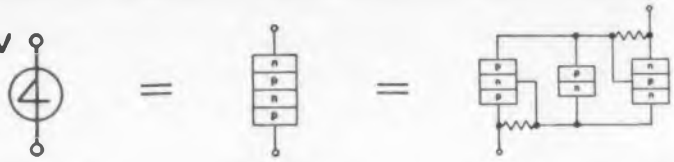
Excellence in Electronics

CIRCLE 338 ON READER-SERVICE CARD



SHOCKLEY 4-LAYER TRANSISTOR DIODE* SIMPLIFIES SWITCHING CIRCUITRY FOR COMPUTERS, TELEPHONY, CONTROL

HERE'S HOW



2-terminal switching diode ... with 4 layers, alternate n and p type ... can replace conjugate structure of 5 components

RANGE OF CHARACTERISTICS

V_b (breakdown voltage)	20-100v	R_h ("on" resistance)	< 20 ohms (from 1—3 amps., voltage < 1 volt plus 0.2 to 1.5 ohms times current)
I_b (breakdown current)	< 500 μa	Dissipation	≈100 mw
V_h (holding voltage)	< 2V	Time to close	< 0.1 μsec
I_h (holding current)	< 50 ma	Time to open	< 0.2 μsec

STANDARD TYPES AVAILABLE FOR DELIVERY NOW

No.	V_b Volts	I_b μa	V_h Volts	I_h ma	R_h ohms
4N20D	20±5	< 500	< 2	< 50	< 20
4N30D	30±5	< 500	< 2	< 50	< 20
4N40D	40±5	< 500	< 2	< 50	< 20
4N50D	50±5	< 500	< 2	< 50	< 20

ENGINEERING DATA AND ASSISTANCE

Our engineering staff, under the direction of Dr. William Shockley, will undertake circuit problems in typical applications such as: sawtooth oscillators, pulse generators, bistable circuits, ring counters and various switching functions. Special types of transistor diodes are being developed to individual specifications. Technical information on request. Write to Dept. 1-2H8.

*Invented at Bell Telephone Laboratories.

See the Shockley exhibit at WESCON.

Shockley Transistor Corporation

1117 California Avenue, Palo Alto, Calif.

A SUBSIDIARY OF BECKMAN INSTRUMENTS, INC.

CIRCLE 339 ON READER-SERVICE CARD

NEW PRODUCTS

Torque Motor

Has output stroke of ±0.007 in.

The model 102 torque motor has a ±5 lb mid-position output force; ±0.007 in. output stroke; and 800 cps resonant frequency. Hysteresis is 2 per cent maximum. Maximum power required is 2.75 w, and normal temperature range is —65 to +350 F.

American Measurement and Control, Inc., Dept. ED, 240 Calvary St., Waltham, Mass.

CIRCLE 340 ON READER-SERVICE CARD

Digital Load Indicator

Basic accuracy is ±0.15 per cent

Using a precision null balance servo system, the model DLI-2 digital load indicator gives continuous digital presentation directly in desired units. Basic instrument accuracy is ±0.15 per cent.

Performance Measurements Co., Dept. ED, 15301 W. McNichols, Detroit 35, Mich.

CIRCLE 341 ON READER-SERVICE CARD

Recorder

Accuracy is 2 per cent of full scale

Rectilinear recorder with standard chart speed of 1 in. per hr, standard scale of 0 to 1 ma, and rated accuracy 2 per cent of full scale. Response time is 1 sec maximum and galvanometer sensitivity is 1 ma dc full scale. Dry marking process utilizes pressure sensitive paper. Unit contains 63 ft chart roll.

Rust Industrial Co., Inc., Dept. ED, 130 Silver St., Manchester, N.H.

CIRCLE 342 ON READER-SERVICE CARD

Slip Rings

Custom molded

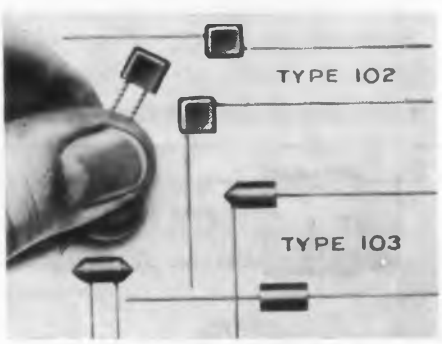
Precision molded from a combination of precious metal alloys and Plaskon Alkyd, these miniature slip rings are spotwelded to the leads to assure permanent, noise free connections. Concentricity is held to 0.002 in. T.I.R. or better.

Electro Development Co., Dept. ED, 14701 Keswick St., Van Nuys, Calif.

CIRCLE 345 ON READER-SERVICE CARD

Wirewound Resistors

Miniature



Wirewound resistors in this miniature line can be obtained in values from 1 ohm to 1 megohm to tolerances of ±0.05 per cent. Standard temperature coefficient is ±15 ppm, and power dissipation is 0.15 w.

Ultronix, Inc., Dept. ED, 116 S. Bayshore Blvd., San Mateo, Calif.

CIRCLE 346 ON READER-SERVICE CARD

Relay

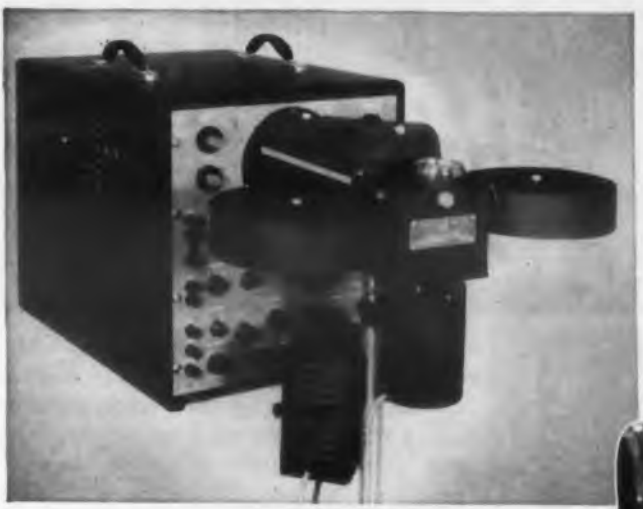
Operates from −65 to +125 C

Model R-9800 sensitive 5 amp dc relay operates from −65 to +125 C. Switch contact: 5 amp resistive load, 3 amp inductive load. Coil sensitivity is from 1 w to 40 mw with coil resistance up to 25,000 ohms. The unit withstands 30 g up to 3000 cps at the pick-up voltage. Life is 100,000 operations (minimum), 50,000 operations at +125 C with 60 mw coil sensitivity.

Hi-Spec Electronics Corp., Dept. ED, 7328 Ethel Ave., North Hollywood, Calif.

CIRCLE 347 ON READER-SERVICE CARD

for versatile 'scope recording...
SINGLE FRAME OR MOVING FILM
...½" TO 12,000" PER MINUTE



- **f:1.5 camera, to 1/100 sec.**
- **adequate film magazine**
- **universal mounting tripod**
- **continuously variable motor speed control**

ONLY **$985**

f.o.b. Phila.

SM-100 Camera mounted on 5" ETC oscilloscope. Inset shows tripod mounting and speed control.

only one of its kind...
ETC MODEL SM-100

Accurate records are yours with this sensational, new ETC recording camera. Look at the range. Where else can you find such versatility? Or use the binocular viewer which allows continuous viewing in subdued light during the recording progress.

The ETC Model SM-100 recording camera is designed primarily for use with 5" oscilloscopes, can be mounted either in horizontal or vertical position, with provision also for use with larger, sloping-face console-type 'scopes.

This camera is typical of the pioneering development of ETC in its broad line of industrial and military electronic devices, as well as single- and multi-gun cathode ray tubes.

No matter how complicated your research or testing problem, if it involves electronics, bring it to ETC.

FEATURES:

- Wollensack f:1.5, 50 mm. coated lens.
- Shutter speeds 1 to 1/100 sec.
- Diaphragm f:1.5 to f:8.
- Object to image ratio 4.5:1.
- Miniature glow lamp provides timing marks on edge of film.
- Lamp excited at line frequency using pulse shaping circuit.
- Connections available for external marker timing pulses.
- Film magazines individually removable.
- Built-in light traps.
- Solenoid actuated drive with magnetic break in supply magazine; reduces film waste.
- 1/15 hp. motor with variac speed control; no warmup time needed.
- Direct reading tachometer in in./min.
- 115V., 50-60 cycles.
- 35 mm. film or paper (perforated or unperforated).
- 400 ft. film capacity (1,000 ft. supply slightly extra).
- Weighs 35 lbs.

Headquarters for Multi-Channel Scopes and Multi-Gun CR Tubes

ETC produces a complete line of standard and special 2- to 8-channel oscilloscopes; power amplifiers; and multi-gun cathode ray tubes with from 2 to 10 guns operating on a single tube face.

Write for complete ETC catalog

ETC

electronic tube corporation

1200 E. MERMAID LANE — PHILADELPHIA 18, PENNA.

CIRCLE 348 ON READER-SERVICE CARD

AN UNPRECEDENTED EXPERIMENTAL OFFER!

A standard DC 100-microampere **METER-RELAY**

at virtually **HALF PRICE!**

Limit is 2
We pay the freight!
Immediate air delivery

$27.50 each
Standard Price $53.50

• Every engineer who needs or wants our versatile, most-used, No. 461-C locking-contact Meter-Relay for use or experiment ...but never ordered because of price or wait...can now order at *half-price* and get *immediate delivery* by return air mail!

D'Arsonval might say:

"Formidable! Incroyable! Épatant!"

Translation:

"It is a matter of great amazement to me that Assembly Products can manufacture such a superb version of my sensitive electric meter

...then add the ingenious adjustable contact within the meter

...then insure the concise, reliable contact action for 10 to 20 million cycles by means of the unusual locking-unlocking coil

...then develop the refinements which make this magnificent device capable of indicating and controlling an infinite variety of electrical, physical and mechanical actions

...then build a substantial business by direct sales to the user at most reasonable prices

...enjoy unqualified success

...AND THEN MAKE THIS UNUSUAL OFFER!"

"Could I write, I would."

AT THE WESCON SHOW AND AT THE PHILADELPHIA ISA SHOW:

Sold over our counter at the same $27.50!

OFFER ENDS OCTOBER 1, 1958 (Order postmark date)

ALSO REQUEST **FREE CATALOG** OF COMPLETE METER-RELAY LINE

api **Assembly Products**

Phone: HAmilton 3-4436
HAmilton 3-4446

75 Wilson Mills Road, Chesterland, Ohio

CIRCLE 349 ON READER-SERVICE CARD

NEW PRODUCTS

Magnetic Servo Amplifer

Reversible output

The type III magnetic servo amplifier features rugged construction and encapsulated windings. The half-wave, reversible output amplifier will drive a variety of standard low-impedance, 2-phase servo motors delivering up to 10 w mechanical output.

Reflectone Corp., Dept. ED, Stamford, Conn.

CIRCLE 350 ON READER-SERVICE CARD

Wafer Bearings

Variety of shaft and housing diameters

Microwafer bearings, narrower than standard, come in bore diameters from 0.0937 to 0.1875 in. housing diameters from 0.2500 to 0.4375 in. Of 440 C stainless steel, they have tolerances of ABEC 7 or better.

New Hampshire Ball Bearings, Inc., Dept. ED, Peterborough, N.H.

CIRCLE 351 ON READER-SERVICE CARD

Relay

Provides 3pdt switching

Model KM miniature armature type relay occupies about 0.5 cu in. and can operate on 750 mw. With arrangements up to 3pdt, the dc operated unit switches up to 2 amp at 115 v 60 cps resistive loads.

Potter & Brumfield, Inc., Dept. ED, Princeton, Ind.

CIRCLE 352 ON READER-SERVICE CARD

Frequency Converter

Input adjustable from 300 to 900 cps

Transistorized converter for ac and dc power supplies. Full scale input is adjustable from 300 to 900 cps with a minimum frequency of 10 cps. Output is 0 to 5 v dc into a 500 K load; 0 to 100 mv dc into a 10 K load; or 0 to 50 mv dc into a 5 K load.

Fischer & Porter Co., Dept. ED, 752 Jacksonville Rd., Hatboro, Pa.

CIRCLE 354 ON READER-SERVICE CARD

Photoelectric Transducer

Pin-point sized

Pin-point sized photo-electric transducer with up to 50 individual outputs per linear inch. For use in reading control signals from tape, digital computation, and evaluating optically measurable quantities.

Waldorf Instrument Co., Dept. ED, Huntington Station, N.Y.

CIRCLE 355 ON READER-SERVICE CARD

Strip Chart Recorder

Provides 1 per cent limit of error

The G-11A strip chart recorder is a small, null-balance potentiometer type. It provides 1 per cent limit of error and 1 sec full-scale balancing time with span adjustable from 9 to 100 mv.

Varian Associates, Dept. ED, 611 Hansen Way, Palo Alto, Calif.

CIRCLE 356 ON READER-SERVICE CARD

Toroidal Signal Transformers

For low-level applications

Series 791 miniature toroidal signal transformers are for low-level applications where high impedance, low phase shift, and minimum pickup are required. They can be used with input voltages of 0.5 mv.

Arnold Magnetics Corp., Dept. ED, 4613 W. Jefferson Blvd., Los Angeles 16, Calif.

CIRCLE 357 ON READER-SERVICE CARD

engineers and physicists:

learn how "TALENT GROWS at EMERSON ELECTRIC"

COME ALONG on this illustrated tour of Emerson Electric's engineering facilities. Meet our engineering staff as they meet the challenges of complex problems related to advanced electronics and missiles projects. Find out about our operating philosophy, diversified projects, size, benefits, educational opportunities, our future and *yours!*

We believe we offer the wide-open challenges and career opportunities you've been looking for. This new brochure is our way of introducing ourselves and our operations.

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CIRCLE 555 ON READER-SERVICE CARD

TOBE
CREATIVE
ENGINEERING

THE NRG-200 SERIES OF LOW-INDUCTANCE THERMONUCLEAR ENERGY-STORAGE CAPACITORS

NRG-200 SERIES SPECIFICATIONS				
Type No.	Watt Seconds	Rating		Self Inductance (Microhenries)
		Mfd.	DC Peak	
NRG-201	1000	5.0	20 KV	.04
NRG-202	1500	7.5	20 KV	.045
NRG-203	2000	10.0	20 KV	.055
NRG-204	3000	15.0	20 KV	.06

Tobe now announces the availability of a series of reliable, low-cost energy-storage capacitors for thermonuclear equipment and similar applications. The NRG-200 series capacitors have a minimum life expectancy of 1000 operations, and may be operated at ambient temperatures up to 40°C. Maximum permissible reversal voltage is 90%. They can be discharged into a very low-impedance load with complete safety.

For further technical information or engineering aid, write Tobe Deutschmann Corporation, Norwood, Mass.

Specify

TOBE®

TOBE DEUTSCHMANN • CAPACITOR PIONEERS SINCE 1929

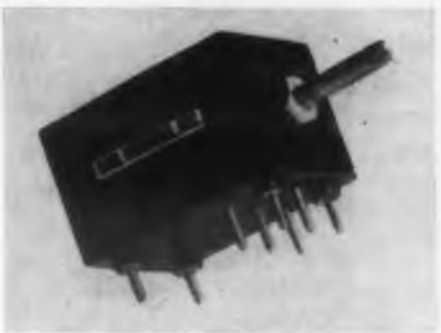
Visit us at WESCON Show Booth 1604-5.

CIRCLE 359 ON READER-SERVICE CARD

NEW PRODUCTS

Tuneable Transformers

Encapsulated units for printed circuits



This series of sealed miniature tuneable transformers and reactors for printed circuit use meets MIL-T-27A, Class R, Grade 2 or 3, and may be provided with electrostatic shielding. Construction is available with 2 to 8 functional terminals.

Coil Winders, Inc., Dept. ED, New York Ave., Westbury, N.Y.

CIRCLE 360 ON READER-SERVICE CARD

Tape Transport System

Fully transistorized

Model 424 transistorized tape transport system has start-stop times under 2 msec, permits tape speeds from 7.5 to 160 ips in both directions. Tape widths from 1/4 to 2 in.; storage bins for 3000 in. of tape.

D. G. C. Hare Co., Dept. ED, 30 Burtis Ave., New Canaan, Conn.

CIRCLE 361 ON READER-SERVICE CARD

Transistorized Power Supply

Provides 28 v dc, 0 to 5 amp

This transistorized, precision-regulated power supply provides 28 v dc, 0 to 5 amp. Voltage regulation is 0.1 per cent from no load to full load with ±10 per cent change in input. Ripple is 0.1 per cent to peak.

General Electric Co., Dept. ED, Schenectady 5, N.Y.

CIRCLE 362 ON READER-SERVICE CARD

Stretch Cable

Silicone

Silicone stretch cable extends 200 per cent and retracts to its original size. The wire has a temperature range of —150 to +375 F, dielectric strength of 550 v per mil, and tensile strength of 1500 psi.

Stretch Wire Corp., Dept. ED, P.O. Box 893, New Rochelle, N.Y.

CIRCLE 364 ON READER-SERVICE CARD

Printed Circuit Holder

Adjustable

These adjustable combination chassis and work positioners are for holding printed circuits during assembly of component parts. Boards can be positioned in any plane of a half sphere and instantly locked there.

Wilton Tool Mfg. Co., Inc., Dept. ED, Schiller Park, Ill.

CIRCLE 365 ON READER-SERVICE CARD

Ferrite Memory Core

Offers square B-H hysteresis loop

Type IR880 ferrite memory core offers a square B-H hysteresis loop, making it useful for fast switching memory matrices in digital computers. Core magnetic properties are designed for use with driving currents of about 820 ma. Output for a single turn is above 120 mv. OD is 0.08 in. ±0.003 in., ID is 0.05 in. ±0.003 in., and thickness is 0.025 in. ±0.003 in.

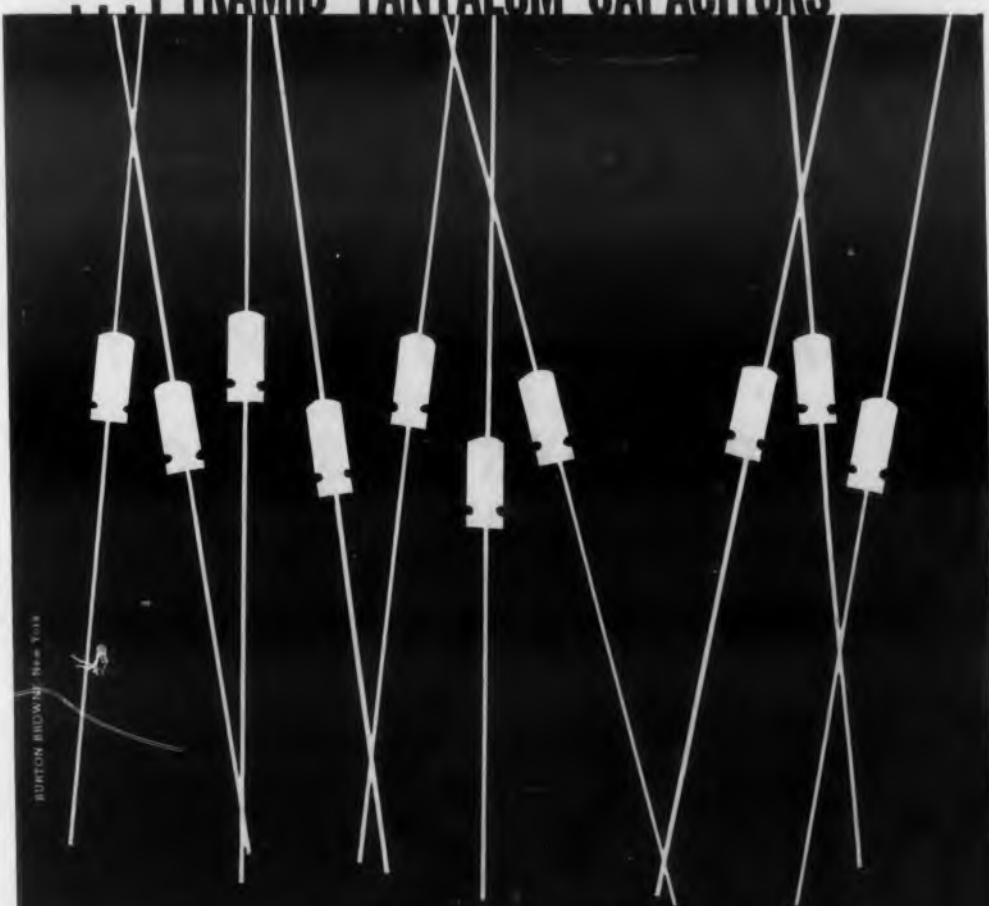
International Resistance Co., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

CIRCLE 366 ON READER-SERVICE CARD

BOOTH 1362 AT WESCON SHOW

UP TO 1000 MFD-VOLTS IN LESS THAN 2/100 OF A CUBIC INCH

...PYRAMID TANTALUM CAPACITORS



Pyramid Tantalum slug capacitors are miniaturized to provide maximum space economy.

New Pyramid Tantalum slug capacitors have cylindrical cases and contain a non-corrosive electrolyte. Due to the special construction of materials used in the manufacture of Pyramid Tantalum slug capacitors, these units are both seep and vibration proof. In addition, this type of capacitor assures long service life and corrosion resistance — made to meet MIL-C-3965 Specifications.

Commercially available immediately, these new Pyramid Tantalum capacitor units have an operating range between —55 C to 100 C for most units without any de-rating at the higher temperature.

To obtain complete engineering data and prices for Pyramid Tantalum slug capacitors, write to: Pyramid Research and Development Dept., Pyramid Electric Company, 1445 Hudson Boulevard, North Bergen, New Jersey.

CAPACITORS — RECTIFIERS
FOR ORIGINAL EQUIPMENT —
FOR REPLACEMENT

PYRAMID
ELECTRIC COMPANY
NORTH BERGEN N J

CIRCLE 368 ON READER-SERVICE CARD

Progress in the Science of Chronometry

IN 1714, the British government offered a prize of £20,000 for any means of determining a ship's longitude within 30 nautical miles at the end of a six week's voyage. John Harrison, a self-educated Yorkshire carpenter, won the prize in 1760 with an accurate clock.

IN 1958, ICBM s and earth satellites created the need for new concepts in accurate timing. To fill this need, Hycon Eastern has developed an electronic Timing System with heretofore unattainable timing precision capable of operating anywhere in the world.

AN INTEGRATED TIMING SYSTEM FOR TODAY'S GLOBAL CONCEPTS

WESCON SHOW
BOOTH NOS. 1565, 1566

Solar or sidereal time is displayed visually and is available for input to automatic computers and indexing data with many types of recorders . . . magnetic tape, oscillograms, photographs and strip charts. Furnishing a time scale with resolutions available to one microsecond, this system is ideally suited for tracking and control of missiles, astronomical measurements, and navigation systems. Write for Bulletin TS-00.

HYCON EASTERN, INC.

75 Cambridge Parkway Dept. F Cambridge 42, Massachusetts

CIRCLE 369 ON READER-SERVICE CARD

NEW PRODUCTS

Shut-Off Valves

Operate in ambient temperatures of 450 F

Fabrilite series of in-line shut-off valves to control the flow of hot, cold, or mixed air through jet plane ducts. Lighter and smaller than similar types, they operate at duct temperatures from —65 to +850 F against pressures from 5 to 225 psi, and in ambient temperatures of 450 F.

Vapor Heating Corp., Vap-Air Div., Dept. ED, 6444 W. Howard St., Chicago 31, Ill.

CIRCLE 370 ON READER-SERVICE CARD

Precision Attenuator

Frequency range of dc to 3000 mc

A 10-position turret precision attenuator which features pull-turn-push detent action. Frequency range of dc to 3000 mc on all values to 50 db, and dc to 1000 mc on values 51 db to 60 db. Any combination of values to 60 db, including fractional values, is available.

Stoddart Aircraft Radio Co., Inc., Dept. ED, 6644 Santa Monica Blvd., Hollywood 38, Calif.

CIRCLE 371 ON READER-SERVICE CARD

Tantalum Capacitors

6 to 75 v range

Small sintered-anode tantalum electrolytic capacitors with low leakage currents and power factors. Temperature range is —55 to +85 C. Voltage range is from 6 to 75 v. Capacities are from 3.5 to 325 μf.

International Telephone and Telegraph Corp., Dept. ED, 100 Kingsland Rd., Clifton, N.J.

CIRCLE 372 ON READER-SERVICE CARD

Miniature Relay

For printed circuit use

The dpdt Type GS dc relay is an improved version of the G-200. For printed circuit and other use, the

unit has a coil resistance of 600 ohms for 26.5 v dc circuits. Ambient temperature range is —65 to +125 C. Contact rating is 3 amp resistive load at 28 v dc or 115 v ac for 100,000 operations; 2 amp resistive load at the same voltages for 500,000 operations.

General Electric Co., Dept. ED, Schenectady 5, N.Y.

CIRCLE 374 ON READER-SERVICE CARD

Shaft Angle Indicator

For telemetering

In the Optisyn shaft angle indicator, the shaft rotation input yields two output wave forms which contain all information needed to measure total shaft angle. Two photo diodes are used in a current push-pull mode for each electrical wave form. With the Optisyn, a shaft position can be telemetered by transmitting two binary wave forms.

Dynamics Research Corp., Dept. ED, 44 Winn St., Woburn, Mass.

CIRCLE 375 ON READER-SERVICE CARD

Oscilloscope

Has identical X and Y amplifiers

The K-11-R rack-mounted general purpose oscilloscope has identical horizontal and vertical amplifiers and a rectangular crt. The two amplifiers cover a bandwidth from dc to 300 kc with sensitivity from 1 mv per cm to 150 v per cm.

Electronic Tube Corp., Dept. ED, 1200 E. Mermaid Lane, Philadelphia 18, Pa.

CIRCLE 376 ON READER-SERVICE CARD

Tape Wound Cores

High saturation flux density

Tape-wound cores of Supermendur, a rectangular-loop material in the range of induction from 16 to 22 kilogausses which permits weight and size reduction. An oriented cobalt-iron-vanadium alloy, Supermendur combines high saturation flux density with hysteresis loop rectangularity.

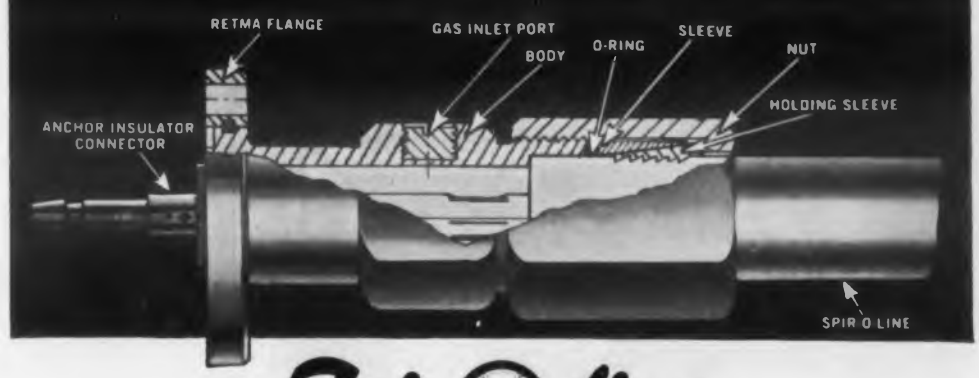
Arnold Engineering Co., Dept. ED, Marengo, Ill.

CIRCLE 465 ON READER-SERVICE CARD

Prodelin Pioneers an *All-American!*

Spir-O-lok®

CONNECTORS



AND **Spir-O-line®** FOR

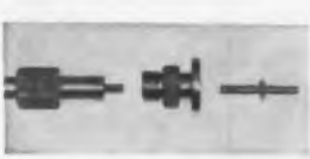
Transmission Line Assembly with 90% Less Work • Consistent, Low VSWR

Here's Prodelin's revolutionary design approach to coaxial transmission line connectors . . . *Spir-O-lok!* Its unique construction makes assembly with the Prodelin combination many times faster than with any other line and connector assembly in the industry . . . while providing consistently reliable VSWR.

See how easy a *Spir-O-lok* installation is:

CUT — With a common tubing cutter, cut the outer conductor of the Spir-O-line. Remove. The soft aluminum tubing cuts cleanly and easily.

TRIM — With an ordinary jack knife, trim the six dielectric tubes flush to the outer conductor. This is Prodelin's unique construction that simplifies connector assembly while affording best broadband performance, highest power handling, lowest attenuation and VSWR. The 6 tubes keep the Spir-O-line inner conductor perfectly centered on bends.



ASSEMBLE — So simple, one man can do it in a few minutes. Slide the nut assembly on cable, hold body while tightening nut with wrench. This forms a pressure-tight joint that cannot distort outer aluminum sheath. The connection can be re-made repeatedly without redressing cable or affecting VSWR. Insert inner conductor connector.
MATE WITH ANY EIA (RETMA) OR MILITARY SPEC CONNECTORS

ELIMINATE TERMINAL CONNECTOR; SIMPLIFY CONNECTION PROCEDURE

Incorporate Spir-O-lok in original design of equipment panel or bulkhead to save time, trouble and expense later.

PATS. PENDING

ANTENNAS and TRANSMISSION LINES
Prodelin Inc
KEARNY, NEW JERSEY, U.S.A.

***Spir-O-line* and *Spir-O-lok* . . .**
ALL-AMERICAN FROM DESIGN TO MANUFACTURE

WRITE TODAY FOR TECHNICAL BULLETIN
Dept. ED-8, 307 Bergen Avenue Kearny, N. J.

CIRCLE 378 ON READER-SERVICE CARD

NEW PRODUCTS

Cooling Unit

Capacity to 30 tons

The model 1204 air conditioning unit has a capacity of 30 tons for cooling large electronic computers. To insure continuous operation, six separate identical refrigeration systems are used.

Ellis and Watts Products, Inc., Dept. ED, Cincinnati 36, Ohio.

CIRCLE 380 ON READER-SERVICE CARD

Strain Gauge Amplifiers

Provide 0 to 5 v dc output

Models CA3 and CA5 strain gauge carrier amplifiers operate from a 28-v dc supply and provide an output of 0 to 5 v dc exactly proportional to the quantity being measured. Frequency response is virtually linear up to 2000 cps, and the unit provides infinite resolution. Transistorized throughout, the amplifiers sustain vibration up to 35 g in any axis as high as 2000 cps without change in response or accuracy. Operating temperature range is −65 to +165 F.

Statham Instruments, Inc., Dept. ED, 12401 W. Olympic Blvd., Los Angeles 64, Calif.

CIRCLE 381 ON READER-SERVICE CARD

Precision Resistors

Use alloy grid resistance element

These hermetically sealed, precision resistors use a specially designed metal alloy grid resistance element. Available in three types: CAH, 0.25 w; EAH, 0.5 w; and GAH, 1 w, with full ratings at 100 C ambient temperatures. Standard resistance tolerances are 0.1, 0.25, 0.5, and 1 per cent. Units exceed Mil specs for wire wound and metal film type precision resistors in all tests.

Allen-Bradley Co., Dept. ED, 136 W. Greenfield Ave., Milwaukee 4, Wisc.

CIRCLE 386 ON READER-SERVICE CARD

Radar Simulator

Maintains signal-to-noise ratio within 1 db

This simulator supplies radar video simulating that of a search type radar. The unit simulates the effects of antenna radiation pattern, target scintillation, and receiver thermal noise with mathematical validity. The signal-to-noise ratio of the simulated target can be adjusted and maintained within 1 db. Output amplitude covers 0 to 5 v range into a 100 ohm load.

Federal Scientific Corp., Dept. ED, 615 W. 131st St., New York 27, N.Y.

CIRCLE 387 ON READER-SERVICE CARD

NEW PRODUCTS

Power Supply

Two ranges

The magnetic and tubeless Model KM-251 delivers an output in the ranges 2 to 8 v, 0 to 30 amp, and 8 to 14 v, 0 to 15 amp. Regulation for line or load is less than ±1 per cent. Ripple is less than 0.5 per cent. An additional feature is high conversion efficiency, 75 per cent at full load.

Kepco Labs, Inc., Dept. ED, 131-38 Sanford Ave., Flushing 55, N.Y.

CIRCLE 391 ON READER-SERVICE CARD

PDM Coder

Service-free life of 1000 hours

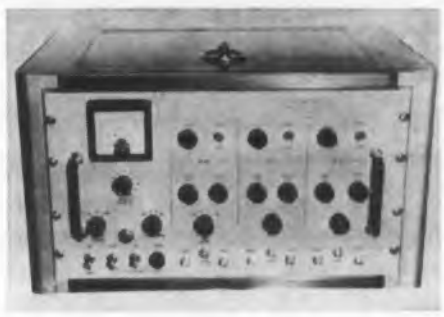
Using two Type 7-501 galvanometers with flat frequency response from 0 to 88 cps, the Type 40-101 Plexicoder has a service-free life of 1000 hr, a commutator life of 2500 hr. The unit provides four operating modes in which the commutation rate equals 112.5 samples per sec.

Consolidated Electrodynamics Corp., Dept. ED, 300 N. Sierra Madre Villa, Pasadena, Calif.

CIRCLE 392 ON READER-SERVICE CARD

Multiple Radar Target Simulator

Range positioning accuracy of 0.5 per cent



The RP 375 provides a single target, at the true radar range, for two or three nonsynchronous radars. The unit may also be used as a pulse code generator or as a general purpose precision multi-pulse generator. It has a range positioning accuracy of 0.5 per cent of the full scale range, and a range rate accuracy of 0.25 per cent of the selected value.

Remanco, Inc., Dept. ED, 128 Broadway, Santa Monica, Calif.

CIRCLE 393 ON READER-SERVICE CARD

NEW Telonic SSX-2 Sweep & Signal Generator

Offers a Complete Marker System and Provisions for Obtaining Audio and Pulse Modulated CW.

Telonic's SSX-2 covers the entire low RF and common IF frequencies and simplifies testing of IF and RF amplifiers by combining functions of sweep generator, signal generator, pulsed CW, and marker generator into one extremely accurate, compact and versatile instrument.

SPECIFICATIONS:

Sweep Generator: Tuning: 25 to 75 mc.

Sweeping: 0-40%. Leveling: 1-5%.

Signal Generator: Tuning: 25 to 75 mc. Accuracy: ±.25%.

Attenuation: (Sweep and CW) Step to 131 db. Vernier: 0-10 db. Output: .1 μv to 1.0 v.

Variable Marker: Accuracy ±.25%. Calibrations: every 250 kc to 40 mc. Every 500 kc to 75 mc.

Up to 6 additional plug-in crystal-controlled markers are available. A birdy-by-pass marker system is provided for exceptional accuracy and stability.

For complete information write for Technical Bulletin T-206.

See the SSX-2 in operation at Booth 1649 WESCON.

Telonic INDUSTRIES, Inc.
BEECH GROVE, INDIANA

CIRCLE 395 ON READER-SERVICE CARD

Line Terminals

Enables solderless connections

These terminals can be used on both stranded and solid wire and are available in sizes 22 through 16, 16 through 14, and 12 through 10. The design enables solderless connections. They feature small over-all size, wide bell-mouths, and open-end construction.

Buchanan Electrical Products Corp., Dept. ED, Hillside, N.J.

CIRCLE 396 ON READER-SERVICE CARD

NPN Transistors

For low frequencies

The 2N619, 2N620, 2N621, and 2N622 are npn silicon types. All four types are for low frequency service—the highest has an alpha frequency cutoff rating of about 400 kc. The 2N622 is a low noise type.

Raytheon Mfg. Co., Dept. ED, 55 Chapel St., Newton 58, Mass.

CIRCLE 397 ON READER-SERVICE CARD

Voltage and Frequency Sensor

Magnetic or transistor amplifier types

The sensors are available in either the magnetic amplifier or transistor amplifier types for monitoring undervoltage, overvoltage, or voltage band, and sensing underfrequency, overfrequency, or frequency band. Nominal voltages range upwards from 18 v ac or dc with accuracy of ±1 per cent. Frequencies nominally are 300 cps ac or higher with accuracy of ±2 per cent.

Jordan Electronics, Div. of The Victoreen Instrument Co., Dept. ED, 3025 W. Mission Rd., Alhambra, Calif.

CIRCLE 398 ON READER-SERVICE CARD

High Accuracy Mach Information in the DC 8

GIANNINI MODEL 451212 PRESSURE TRANSDUCER

Fast, accurate Mach information is supplied from two Giannini Model 451212 Pressure Transducers for control purposes in the new Douglas DC-8 jet-liner. This is critically important information for a passenger transport that will operate in the transonic range at 40,000 feet.

The high resistive output of the transducers, which are accurate to within 1% of reading, eliminates the need for a computing servo... *greatly simplifying the instrumentation.*

SPECIFICATIONS

RESOLUTION: to 2000 wires (0.05%)

ACCURACY: Within 1% of reading

RANGE: 0-10 to 0-50 psi (absolute, differential, or gage)

ENVIRONMENTAL: Meets appropriate MIL-SPECS.

See Us at WESCON Booth No. 1665 & 1666

Giannini measures & controls:

ω	β	θ	ψ	τ	γ	ϕ
δ	Ω_r	ω	h	P	ΔP	T
T_S	P_S	Qc	M	T_o	P_T	TAS

PRECISION INSTRUMENTS AND CONTROLS

Giannini

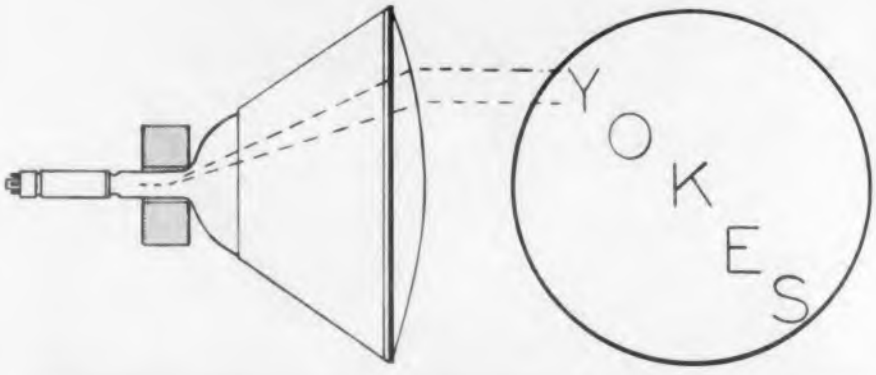
G. M. GIANNINI & CO., INC., 918 EAST GREEN STREET, PASADENA, CALIF.

CIRCLE 399 ON READER-SERVICE CARD

CELCO *Specialized*

YOKES

FOR CHARACTER DISPLAYS



YEARS AHEAD IN DESIGN PERFORMANCE

For critical applications, many of our customers have saved years of trial and error in YOKE selection by specifying **Celco** YOKES.

The construction of our yokes makes it possible to achieve **sensitivities, linearities, responses and distortion-free deflecting fields** not possible with the usual types of yoke.

For precision military and commercial displays, Celco also offers standard yokes in **7/8", 1", 1 ⅛", 2", & 2½"** CRT neck diameters.

Write for CELCO DEFLECTION YOKE Catalogue & Design Sheets or for immediate engineering assistance Call your nearest CELCO Plant:

Celco

Constantine Engineering Laboratories Co.

Mahwah, N. J.	Miami, Fla.	Cucamonga, Calif.
Davis 7-1123	Plaza 1-9083	Yukon 2-2688

CIRCLE 400 ON READER-SERVICE CARD

NEW PRODUCTS

MERCURY SWITCH.—Handles 100 amp current at 115 v, 70 amp at 230 v. Suitable for direct control of motors and generators.

American Designed Components, Inc., Dept. ED, Jericho, N.Y.

CIRCLE 401 ON READER-SERVICE CARD

SNAP-ACTION SWITCH.—Minature 5300 series with operating forces from 2 to 20 oz.

Haydon Switch, Inc., Dept. ED, Waterbury 20, Conn.

CIRCLE 402 ON READER-SERVICE CARD

FERRITE LOAD ISOLATORS.—X-band. Models with 25, 15, 30, 17, and 12 db isolation.

Rantec Corp., Dept. ED, P.O. Box 18, Calabasas, Calif.

CIRCLE 403 ON READER-SERVICE CARD

LINE REGULATOR. — Monitor Model 4.010 detects variations in conditions of voltage, frequency, and phase in power sources.

Electric Regulator Corp., Dept. ED, Pearl St., Norwalk, Conn.

CIRCLE 404 ON READER-SERVICE CARD

PRESSURE SWITCH.—Weighs 1 oz, operates from 25 to 1000 psi. Piston type spdt unit rated at 5 amp, 240 v

Alloy Bellows, Inc., Dept. ED, 18125 Roseland Rd., Cleveland 12, Ohio.

CIRCLE 405 ON READER-SERVICE CARD

CARBON FILM RESISTORS.—Types 400E and 401E, respectively rated at 1/8 and 1/4 w, are added to deposited-carbon Filmistor line.

Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

CIRCLE 406 ON READER-SERVICE CARD

SOCKET CAP SCREWS. — Cold-forged, with chip-free, perfectly formed socket for full gripping area on the hex keys. In sizes 5/8 in. diam.

Set Screw and Mfg. Co., Dept. ED, Bartlett, Ill.

CIRCLE 407 ON READER-SERVICE CARD

DRAFTING MEDIUM. — Ageproof Film stands repeated erasures and folding. Impervious to water. Tensile strength is 20,000 psi.

Eugene Dietzgen Co., Dept. ED, 2425 N. Sheffield Ave., Chicago 14, Ill.

CIRCLE 408 ON READER-SERVICE CARD

IN-LINE FUSES.—Vari-Size Fuse-In-Lines allow fuse sizes to be interchanged without tools. They may be spliced into the line close to the source of current or wherever desired.

Signal-Stat Corp., Dept. ED, 523-539 Kent Ave., Brooklyn 11, N. Y.

CIRCLE 410 ON READER-SERVICE CARD

PHONO JACK.—No. 8575 may be mounted with single nut and washer.

Richards Electrocraft, Inc., Dept. ED, 4432 N. Kedzie Ave., Chicago, Ill.

CIRCLE 411 ON READER-SERVICE CARD

RELAY.—Hi-So dry circuit unit has 10 amp contact rating.

Relay Sales, Dept. ED, P.O. Box 186, West Chicago, Ill.

CIRCLE 412 ON READER-SERVICE CARD

PACKAGED MERCURY VACUUM SYSTEM.—Model SEL-3M, capable of ultimate vacuum in the order of 8×10^{-6} mm Hg. Valves can be set to close automatically in case of vacuum spoilage.

Scientific Engineering Lab, Dept. ED, 1510 Sixth St., Berkeley 10, Calif.

CIRCLE 413 ON READER-SERVICE CARD

MEDICAL SPECTROGAMMEOMETER.—Single-channel pulse height analyzer with linear or logarithmic count rate meter.

Radiation Counter Labs, Inc., Dept. ED, 5121 W. Grove St., Skokie, Ill.

CIRCLE 414 ON READER-SERVICE CARD

PANEL MOUNT VOLTMETER.—Model 520A-P ac amplifier/voltmeter mounts interchangeably with the 510B-P audio oscillator.

Waveforms, Inc., Dept. ED, 331 Sixth Ave., New York 14, N.Y.

CIRCLE 415 ON READER-SERVICE CARD

TRIMMER POTENTIOMETER.—Model 224 miniature Trimpot operates in the −65 to +175 C range. Standard resistances from 100 ohms to 50 K.

Bourns Labs, Inc., Dept. ED, P.O. Box 2112, Riverside, Calif.

CIRCLE 416 ON READER-SERVICE CARD

OSCILLOGRAPH.—Model 606 D/R features flash timing up to 1000 cps, 5 magazine types, extremely fast or slow recording speeds.

Midwestern Instruments, Dept. ED, 41st and Sheridan, Tulsa, Okla.

CIRCLE 417 ON READER-SERVICE CARD

FOUR BRIDGES IN ONE

MODEL 291 universal IMPEDANCE BRIDGE

Measure:

1. **RESISTANCE TO 0.1%**
   0-1200 kilohms in seven ranges.
2. **CONDUCTANCE TO 0.1%**
   0-1200 millimhos in seven ranges.
3. **CAPACITANCE TO 0.2%**
   0-1200 microfarads in seven ranges.
4. **INDUCTANCE TO 0.3%**
   0-1200 henrys in seven ranges.

PRICE: $775.00

For complete information on the Model 291 Universal Impedance Bridge, see your ESI sales representative or send for ESI catalog sheet C-13.

esi

ELECTRO-MEASUREMENTS, INC.

7524 S. W. MACADAM AVENUE • PORTLAND 19, OREGON

CIRCLE 419 ON READER-SERVICE CARD

NEW PRODUCTS

TRANSFORMERS.—For transistor applications, TA-15, TA-16, and TA-17 have been added to the Stancor line.

Chicago Standard Transformer Corp., Dept. ED, 3501 Addison St., Chicago 18, Ill.

CIRCLE 421 ON READER-SERVICE CARD

CONNECTORS.—Similar in size to the BNC series, TNC connectors have a positive-locking threaded type of coupling.

Kings Electronics Co., Inc., Dept. ED, 40 Marbledale Rd., Tuckahoe, N.Y.

CIRCLE 422 ON READER-SERVICE CARD

TRIMMER POTENTIOMETERS.—Trim-Tite and Trim-Tite Jr. are respectively 1/2 and 3/8 in. in diam. High temperature units rated to 150 C, standard units to 85 C.

Fairchild Controls Corp., Dept. ED, 225 Park Ave., Hicksville, N.Y.

CIRCLE 423 ON READER-SERVICE CARD

HIGH VACUUM RECTIFIER.—Ruggedized version of the half-wave 705A unit. For use in airborne radar, electrostatic precipitators, and high voltage power supplies.

Vacuum Tube Products Co., Inc., Dept. ED, 2020 Short St., Oceanside, Calif.

CIRCLE 424 ON READER-SERVICE CARD

SILICON RECTIFIERS.—Types 1N-1730 through 1N1733, rated at 1000, 1500, and 2000 v at 200 ma and 3000 v at 150 ma.

Pacific Semiconductors, Inc., Dept. ED, 10451 W. Jefferson Blvd., Culver City, Calif.

CIRCLE 432 ON READER-SERVICE CARD

PARTS CONTAINER.—Vac-Tite box seals out moisture, opens easily. Used to protect electronic components or small ball bearings.

Clover Industries, Inc., Dept. ED, 578 Young St., Tonawanda, N.Y.

CIRCLE 433 ON READER-SERVICE CARD

ROTARY SELECTOR SWITCH.—Model C-80335-001, hermetically sealed, rated at 1650 v dc and 20 ma.

G. H. Leland, Inc., Dept. ED, 123 Webster St., Dayton 2, Ohio.

CIRCLE 434 ON READER-SERVICE CARD

BETA-GAMMA SCINTILLATION ANALYZER.—System for analytical measurement of isotopes emitting gamma or hard beta rays or both in solid or liquid samples.

Baird-Atomic, Inc., Dept. ED, 33 University Rd., Cambridge 38, Mass.

CIRCLE 435 ON READER-SERVICE CARD

PHOTO-RECORDING PAPER. — Tru-Graf 1 high speed projection paper for oscillograph testing equipment. Picks up faint lines without overexposure and blurring of the impulse trace.

Peerless Photo Products, Inc., Dept. ED, Shoreham, N.Y.

CIRCLE 436 ON READER-SERVICE CARD

PRESSURE TERMINALS. — Stack-Lugs can be nested together in pairs and the pairs stacked vertically, doubling number of terminations on each board.

Panduit Corp., Dept. ED, 14461 Waverly Ave., Midlothian, Ill.

CIRCLE 437 ON READER-SERVICE CARD

MULTI-CIRCUIT CYCLE TIMER. —In Model WD all adjustments and settings are easily made on panel face.

Zenith Electric Co., Dept. ED, 152 W. Walton St., Chicago 10, Ill.

CIRCLE 438 ON READER-SERVICE CARD

OVERPOTENTIAL TESTER. — For measuring leakage currents in insulation at voltages up to 120 kv dc. May also be used for breakdown tests.

Peschel Electronics, Inc., Dept. ED, R.F.D. 1, Paterson, N.Y.

CIRCLE 439 ON READER-SERVICE CARD

sub-miniature relays with high performance characteristics

A
MV
crystal can size

Vibration: 10 to 34 cycles per second at maximum excursions of .4". 34 to 2000 CPS 20G's acceleration.
Weight: 0.45 ounce (max.)
Size: .875" high x .797" wide x .359" thick max.
Pull-in Power: 250 milliwatts at 25°C.
Contact Rating: 2 Amps resistive at 32 VDC or 115 VAC.

B
NM
the famous NEOMITE

Vibration: 10 G to 500 cps.
Weight: .09 oz.
Size: H: .530" ±.015; W: .392" ±.010"; D: .196" ±.010"; Lead length: 1.5" ±.0625".
Pull-in Power: 100 Milliwatts.
Contact Rating: .25 Amp at 28 VDC resistive load.

C
. . . and announcing the brand-new
VG

Vibration: Low Frequency—10 G's, 10-55 CPS (total max. excursion, .06").
High Frequency—15 G's, 55-2,000 CPS.
Weight: 1.5 ozs., approximately.
Size: 7/8" ±1/64" sq. x 1 1/8" ±1/64".
Pull-in Power: 340 Milliwatts at 25°C.
Contact Rating: 5 Amps at 26.5 VDC or 115 VAC, 60 Cycles resistive load.
Shock: 100 G's, per MIL-R-5757C, Shock Test II.

Advance Sub-miniature Relays are ideal for critical aircraft and missile applications. They feature small size, low weight, and high-precision performance. All have low power requirements.

Write today for complete data sheets.

AVAILABLE FROM LEADING DISTRIBUTORS

ADVANCE RELAYS

ADVANCE RELAYS
A PRODUCT OF ELECTRONICS DIVISION
ELGIN NATIONAL WATCH COMPANY
Dept. G, 2435 N. Naomi St., Burbank, California

CIRCLE 441 ON READER-SERVICE CARD

NEW PRODUCTS

INERTIA-DAMPED SERVOMOTOR.—Size 15 offers acceleration and deceleration damping for high speed and/or high gain servo systems.

Helipot Corp., Div. of Beckman Instruments, Inc., Dept. ED, Newport Beach, Calif.

CIRCLE 443 ON READER-SERVICE CARD

TELETYPE SEND-RECEIVE SET.—Automatic model 28 operates at 100 wpm, provides facilities for sending and receiving tape and page copy.

Teletype Corp., Dept. ED, 4100 Fullerton Ave., Chicago 39, Ill.

CIRCLE 444 ON READER-SERVICE CARD

TEST-POINT JACK.—Type SKT-27 accepts probe 0.450 in. long by 0.093 in. in diam. Operates over —55 to +200 C range.

Sealectro Corp., Dept. ED, 610 Fayette Ave., Mamaroneck, N.Y.

CIRCLE 445 ON READER-SERVICE CARD

BUTT WELD AND OVERLAP SPLICER.—Combination model 300.1 handles any type magnetic material in tape widths up to 2-3/4 in.

Prestoseal Mfg. Corp., Dept. ED, 37-27 33rd St., Long Island City 1, N.Y.

CIRCLE 446 ON READER-SERVICE CARD

MOISTURE PROOF WINDOW CONNECTOR.—Certi-Seal splice provides permanent seal against vapors and fluids.

Amp Inc., Dept. ED, 2100 Paxton St., Harrisburg, Pa.

CIRCLE 474 ON READER-SERVICE CARD

LIGHT FLASHER FOR AIRCRAFT.—Smaller than previous models, the AFS-125 and AFS-126 have long life, are free from radio interference.

P. R. Mallory & Co. Inc., Dept. ED, Indianapolis 6, Ind.

CIRCLE 475 ON READER-SERVICE CARD

NIOBIUM TOLL-ROLLING.—Strip rolled as thin as 0.0005 in. to tolerances as close as 0.0001 in.

American Silver Co., Inc., Dept. ED, 36-07 Prince St., Flushing 54, N.Y.

CIRCLE 476 ON READER-SERVICE CARD

TRANSISTOR CLOSURES.—Closures for transistors, diodes, and other miniature components to specification.

Hudson Tool and Die Co., Inc., Dept. ED, 18 Malvern St., Newark 5, N.J.

CIRCLE 477 ON READER-SERVICE CARD

INSTRUMENT KNOBS.—Added to standard line, No. 1068 aluminum knobs have nylon locking bushing. Size is 1 or 1-3/8 in. diam for 1/8 or 1/4 in. shaft.

Vemaline Products Co., Dept. ED, Hawthorne, N.J.

CIRCLE 478 ON READER-SERVICE CARD

MOBILE RADIO TUBES.—Industrial tubes for 2-way mobile radio systems operating from 12 v storage batteries: RCA-7054, -7055, -7056, -7057, -7058, -7059, -7060, -7061.

Radio Corporation of America, Electron Tube Div., Dept. ED, Harrison, N.J.

CIRCLE 472 ON READER-SERVICE CARD

NEON LAMPS.—NE2K and NE2T high intensity miniature lamps consume 0.25 w at current of 2 ma.

Circon Component Corp., Dept. ED, Santa Barbara Municipal Airport, Goleta, Calif.

CIRCLE 457 ON READER-SERVICE CARD

TRIMMER.—Replacing models 120, 130, and 205, the model 200 Trimpot potentiometer has an increased power rating of 0.25 w at 70 C and an increased resistance range of 10 ohms to 50 K.

Bourns Labs., Inc., Dept. ED, P.O. Box 2112, Riverside, Calif.

CIRCLE 458 ON READER-SERVICE CARD

QUICK CONNECT SWITCH.—Type V3 spdt has ratings of: 10 amp, 125 or 250 v ac; 0.5 amp, 125 v dc; 0.25 amp, 250 v dc.

Micro Switch, Div. of Minneapolis-Honeywell Regulator Co., Dept. ED, Freeport, Ill.

CIRCLE 459 ON READER-SERVICE CARD

TUBEAXIAL FANS.—Compact units for equipment cooling in variety of shapes, sizes, and mounting arrangements. Low cost; not recommended for extreme environments.

American Standard, American Blower Div., Dept. ED, Detroit 32, Mich.

CIRCLE 460 ON READER-SERVICE CARD

SOLENOIDS.—Series O1 and O2 miniaturized industrial quality solenoids with multi-million cycle life. In push or pull models, vertical or horizontal mounting.

Detroit Coil Co., Dept. ED, Ferndale, Mich.

CIRCLE 461 ON READER-SERVICE CARD

MULTIPLIER PHOTOTUBE.—Type 7200, a 9-stage unit for detection and measurement of ultraviolet radiation. Also useful for low-level light applications.

Radio Corporation of America, Electron Tube Div., Dept. ED, Harrison, N.J.

CIRCLE 473 ON READER-SERVICE CARD

DC POWER SUPPLIES.—Model Q28-.5 is added to Q-Nobatron line of transistorized low-voltage high-current dc supplies. Output range is 18 to 36 v dc at 0 to 0.05 amp.

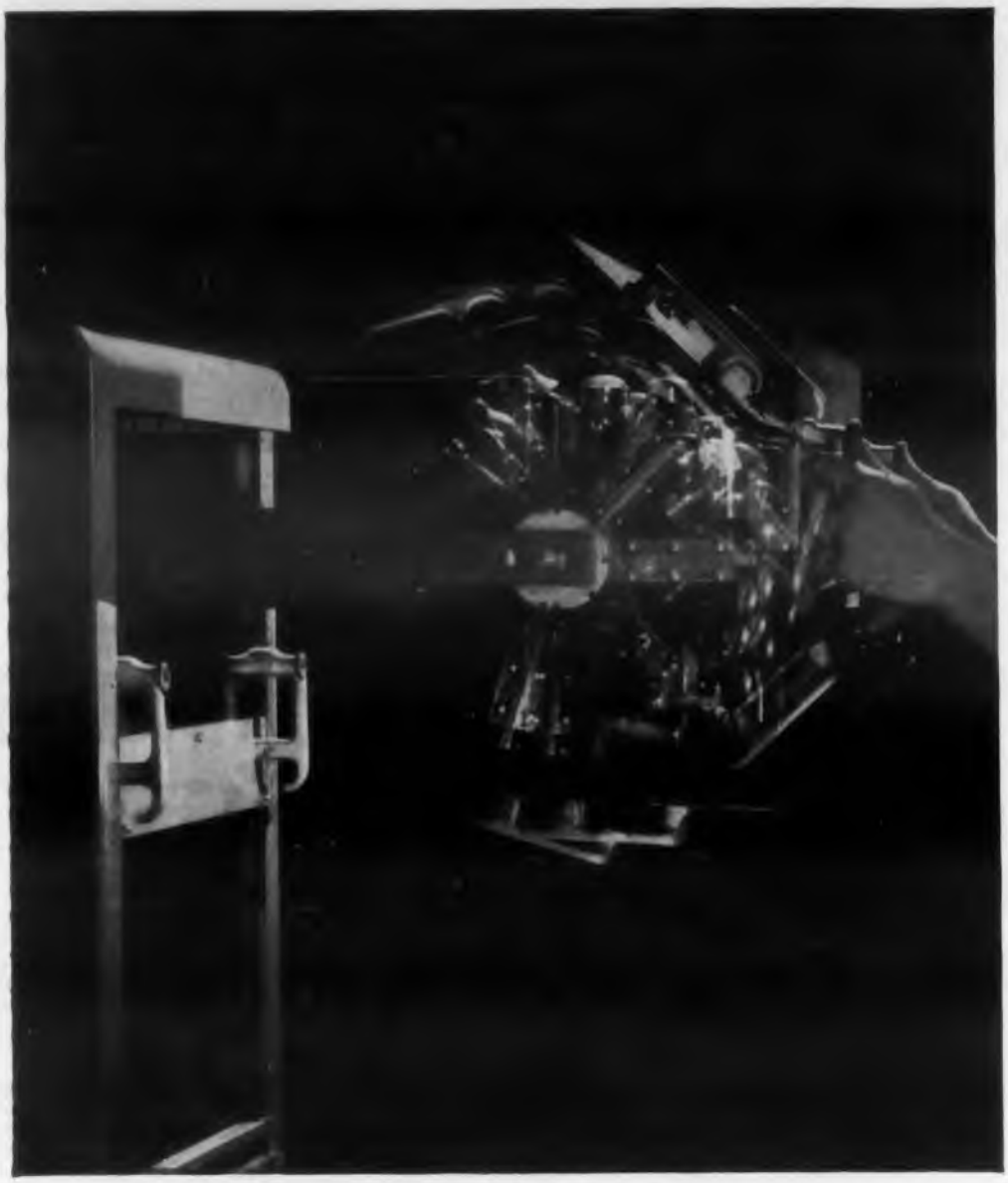
Sorensen & Co., Inc., Dept. ED, Richards Ave., South Norwalk, Conn.

CIRCLE 462 ON READER-SERVICE CARD

POWER INVERTERS.—Transistorized sine wave power inverters with 100 va, 150 va, and 500 va outputs.

Jordan Electronics, Div. of Victoreen Instrument Co., Dept. ED, 3025 W. Mission Rd., Alhambra, Calif.

CIRCLE 463 ON READER-SERVICE CARD



with Chassis-Trak slides chassis locks in seven positions

With the touch of a finger on the handles of the chassis, it can be tilted up or down (45°, 90°, or 105°), and locked in any one of seven different positions.

This means you can remove tubes or check circuitry on the chassis quickly and easily, even though the chassis is at the top *or* the bottom of the rack . . . and the chassis will not swing or move during servicing. It is firmly locked in position! A spring mechanism allows instant removal of the chassis for complete maintenance.

Chassis-Trak slides are produced from cold rolled steel, and give smooth slide action because of a permanent-dry, dust-repellant phenol epoxy formulation . . . the more you use the slides, the smoother they operate.

With the pencil-thin Chassis-Trak design, you can cut engineering costs, by mounting 17" chassis in standard 19" racks. The slides (9 lengths, 10" to 24" supporting up to 275 lbs.), are available from stock, in either the "detent" model shown above, and the "basic" model, which tilts freely upwards but has no lock assembly. Chassis-Trak engineers will also custom-build slides for any of your special installations.

"Detent" model, locked in one of seven different positions.

chassis Trak inc.

For further information, contact:

525 South Webster, Indianapolis 19, Indiana

CIRCLE 430 ON READER-SERVICE CARD

INDEX OF ARTICLES

January 8th through June 25th, 1958

Reference Keys

ABS Abstract
BD Background for Designers
DF Design Forum
GA German Abstract
ID Ideas for Design
PF Product Feature
RT Russian Translation

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G

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CONICAL SCANNERS by CANOGA

A STANDARD LINE OF RADAR TRACKING ANTENNAS IS NOW AVAILABLE FOR MISSILES AND AIRCRAFT OR GROUND BASED AND SHIPBOARD APPLICATIONS.

S, C, X, and K_u-BAND

FEATURING:

- Circular or Linear Polarization
- High Power Handling
- Broad Bandwidth
- Equal E- and H-Plane Beamwidths
- Light Weight
- Simple & Inexpensive
- Reflector Sizes From 7½ inches to 10 feet are available

Canoga Corporation has a series of tracking scanners available employing a circular feed which provides a circularly polarized or nutating linearly polarized tracking beam. A hollow shaft drive motor and spin reference generator are mounted around the waveguide spindle near the high-speed rotating joint. This direct drive eliminates gears and other drive members and provides minimum weight, maximum reliability, and optimum dynamic balance for high-speed operation. The use of only one moving part, the rotating feed-motor rotor provides the maximum in reliability and long life.

SPECIFICATIONS

Any reflector size from 8 inches to 10 feet in diameter is available.
Any frequency range within the 2700 to 14,000 megacycles range is available.

Bandwidth	10 percent
Standing waves	Less than 1.2
Gain and side lobes	Determined by reflector size
Circularity	Better than 3.0 db
Crossover	50%, 80% or as required

FOR ADDITIONAL INFORMATION COMPLETE THE COUPON BELOW AND RETURN TO CANOGA

CANOGA
CORPORATION OF CALIFORNIA
5955 SEPULVEDA BLVD
VAN NUYS, CALIFORNIA

- ☐ *ANTENNAS*
- ☐ *RECEIVERS*
- ☐ *RADAR SYSTEMS*
- ☐ *TEST EQUIPMENT*
- ☐ *MICROWAVE COMPONENTS*

NAME AND TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ STATE _____

DESIGN, DEVELOPMENT AND MANUFACTURE TO YOUR SPECIFICATIONS
CIRCLE 431 ON READER-SERVICE CARD

NEW DIEHL*

PACKAGE POWER AMPLIFIERS END POWER WASTE IN HIGH OUTPUT SERVOS

These new DIEHL small size, light weight Package Power Amplifiers achieve ideal motor conditions by providing constant 90° phase angle, infinitely smooth proportional reversing control and symmetrical control of motor voltage.

Important design and operating characteristics

- **Power gain per cycle**—can be unlimited.
- **Smooth 60-cycle AC (not pulsating DC)**—fed to motor by inverse-parallel connected thyratrons.
- **Low-impedance transistor-controlled grid circuits**—prevent accidental firing of thyratrons by external signals.
- **No special power source needed**—operates directly from 60-cycle, 3-phase power supply.
- **Tachometer feedback provided**—for AC or DC operation.
- **Exact 90° phase relation**—between control and reference phases.
- **85-90% efficiency.**
- **Response**—.008 seconds (½ cycle).
- **Driver stages**—Transistorized.
- **Rugged industrial thyratron output stage**—with 10,000 hour life expectancy.

ONE-SOURCE CONVENIENCE

DIEHL alone makes AC servomotors up to 3 HP range and now offers a complete package of Power Amplifier and matching AC Servomotors in these ratings.

Diehl*

—SEE THE **DIEHL** DISPLAY:—
BOOTH 428 AT THE WESCON SHOW,
LOS ANGELES, AUG. 19 to 22, 1958

DIEHL MANUFACTURING COMPANY

Electrical Division of THE SINGER MANUFACTURING COMPANY
Finderne Plant, SOMERVILLE, N. J.

Other available components:

A. C. SERVOMOTORS • A. C. SERVOMOTORS WITH A. C. TACHOMETERS
A. C. SERVOMOTORS WITH D. C. TACHOMETERS • A. C. AND D. C. TACHOMETERS
D. C. SERVO SETS • RESOLVERS

*A Trademark of DIEHL MANUFACTURING COMPANY

CIRCLE 533 ON READER-SERVICE CARD

INDEX OF ARTICLES cont.

I

L

M

N

NOW AVAILABLE IN FOUR VERSATILE MODELS

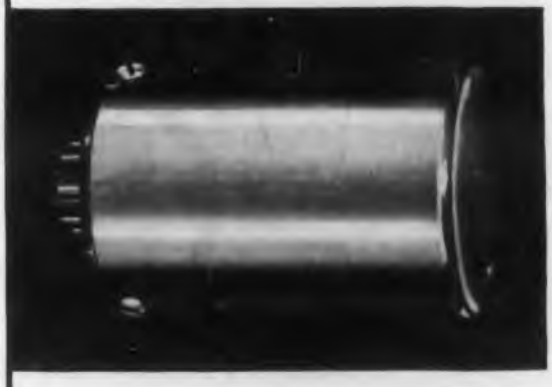
SNAP-ACTION CONTACT speed gives positive actuation . . . up to double-pole, double-throw switching in standard models.

SIMPLE TIME ELEMENT, hermetically sealed, is not subject to aging or fatigue. Core design permits fast reset: 25% of relay operating time, even with longest delay periods!

MAGNETIC COIL is accurately calibrated, uses no heaters or thermal elements. Results: relay may be energized continuously. It's a load carrier in itself; does not require auxiliary lock-in circuits.

the proven *Silic-O-Netic* time-delay relay

ECONOMICAL Type A Relay is non-enclosed, offers time delay from ¼ to 120 seconds. A low-cost relay with superior performance specifications.



PLUG-IN Type H Relay adds convenience of pin-type mounting, fits standard eight-hole sockets. Removable aluminum cover. Also made with solder-lug terminals.

HERMETICALLY-SEALED Type F Relay gives complete protection against dirt, dust and moisture. Hermetic seal is permanent . . . relay never requires adjustment. Choice of pin-type or solder-lug mounting.

PHENOLIC-ENCLOSED Type C is a low-cost, fully encased relay with D.P.D.T. switching capacity. Compact design allows easy mounting, is available with "quick-on" type contact and coil terminals.

HEINEMANN

ELECTRIC COMPANY

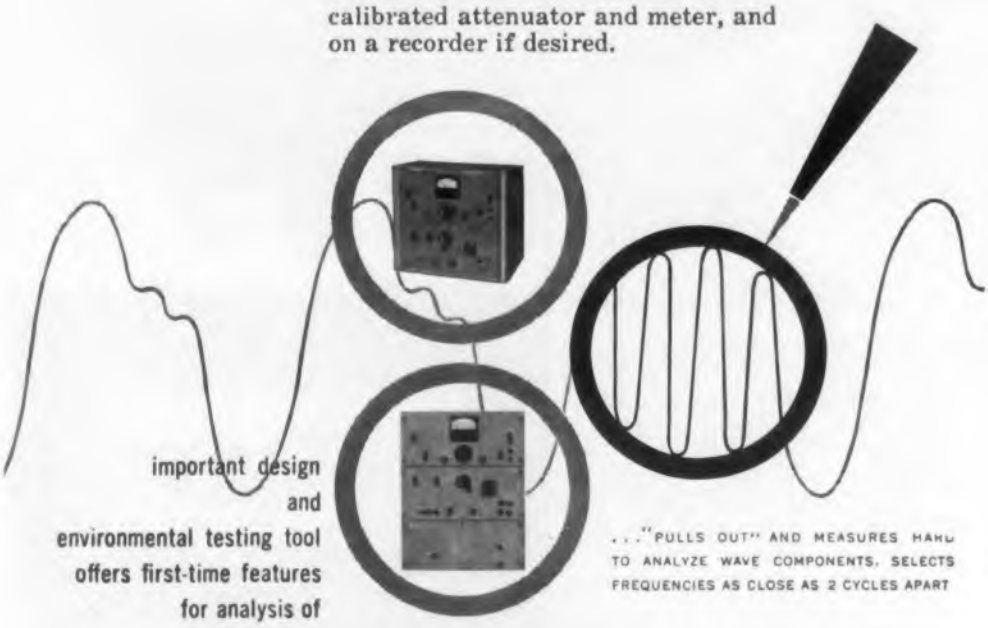
156 Plum St., Trenton 2, N. J.

New Bulletin No. 5003 includes full details and specifications for Silic-O-Netic Relays. Write for a copy.

S.A. 1098

CIRCLE 536 ON READER-SERVICE CARD

Increasingly important to environmental testing, the TP-625 Wave Analyzer System offers performance features never before available. Determines frequency and amplitude of vibration... strain... pressure – any mechanical, chemical, optical or other variable which can be converted to an electrical signal ranging from 2 to 25,000 cycles. Individual wave components are measured in decibels, in percent of total signal, or both. Results are indicated on a calibrated attenuator and meter, and on a recorder if desired.



important design and environmental testing tool offers first-time features for analysis of

...."PULLS OUT" AND MEASURES HARD TO ANALYZE WAVE COMPONENTS. SELECTS FREQUENCIES AS CLOSE AS 2 CYCLES APART

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Auxiliary equipment – TP-628 Servo Drive – allows automatic tracking to frequency set by speed of equipment being analyzed... follows RPM, multiples of RPM, or shake-table drive... throughout an operating range. Uses and applications are limitless. Other auxiliary equipment includes a TP-633 Power Integrator, which provides a power spectral density analysis of random waves. Get full details on this important design and environmental testing tool. Write for new bulletin on the TP-625 Wave Analyzer System.

Developed, improved and manufactured by

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WESCON—BOOTH 636

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INDEX OF ARTICLES cont.

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Additional New Features!

Moderately Priced!

ERA's TRANSISTORIZED HIGH CURRENT REGULATED POWER SUPPLIES

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- *Battery Substitution*
- *Computers*
- *Transistor Bias*
- *Motor and Relay Control*
- *Television*
- *All High Current Laboratory and Industrial Applications*

SPECIFICATIONS

Models listed are designed for 105-125 VAC input, 60-400 cps. Continuously adjustable output. Line regulation is within ±0.5%. Load regulation is within ±0.5%. Front panel regulation control. Frequency response of regulator extends into high audio frequencies. Ripple less than 0.05% or 5 mv. Current limiter control on front panel for full overload and circuit protection. Units are for bench or standard 19" rack mounting.

- *Continuously Variable Output*
- *Vernier Voltage Control*
- *Fast Transient Response*
- *Low Output Ripple*
- *Positive, Negative, Zero % Regulation Control*
- *Line Frequency Insensitive*
- *Remote Sensing*
- *Constant Current Overload Limit Control*
- *Positive or Negative Outputs, Ungrounded*
- *Terminals On Front and Rear*
- *Hinged Panel For Full Accessibility*
- *High Efficiency*
- *Low Heat Dissipation*
- *Compact, Light Weight*
- *Instant Warm-up Time*

TYPICAL STOCK MODELS

Model Number	Voltage VDC	Current Amps.	Output DC R (ohms)	Price FOB Factory
TR32-4	4-32	0-4	0.01	$455.00
TR32-8	4-32	0-8	0.005	$495.00
TR32-12	4-32	0-12	0.002	$575.00
TR150-1	20-150	0-1	0.5	$455.00

Additional stock models also available.

Special designs also made to customers specifications. Write for quotation.

Pioneers in Semi-Conductor and Transistorized Products.

First Miniaturized Power Packs.
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First Packaged Transistor Circuits.
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CIRCLE 540 ON READER-SERVICE CARD

TORNADO IN A TEAPOT

The new 1802 Hydrogen Thyratron—available now in commercial quantities—offers unprecedented performance and ruggedness in a miniature ceramic envelope.

This new EG&G tube delivers 30 megawatts peak power in a smaller package than any comparable unit. It supersedes many older types and surpasses the performance of the Type 5948/1754 on all counts, in less than 1/7th the size. The new 1802 is air-cooled by convection and will tolerate ambient temperatures up to 100° C. Yet its warm-up time is only 5 minutes. Other comparisons with the 5948/1754:

	1802	**5948/1754**
Input Trigger Power	250 V at 400 ohms max.	650 V at 250 ohms max.
Delay time	0.5 μs rated (average is 0.25 μs)	1 μs
Jitter	.002 to .005 μs	.02 μs
Reservoir range	±10%	±5%
Filament power	90 watts	200 watts
Ambient temp. max.	100° C.	75° C.

Ever since the hydrogen thyratron was invented by K. J. Germeshausen, president of EG&G, this company has kept in the forefront of hydrogen thyratron development. For specific data on the 1802 and for most authoritative information on gas-discharge tube types and MILLI-MIKE* CRT's, TW oscilloscopes and systems, write to us on your company letterhead.

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CIRCLE 154 ON READER-SERVICE CARD

INDEX OF ARTICLES cont.

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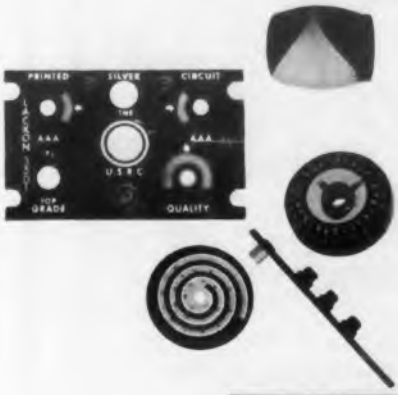
U.S. RADIUM FOR NEW IDEAS IN...

EDGE-LIGHTED DIALS AND PANELS



All USR dials and panels manufactured by the LACKON® process satisfy MIL-P-7788. Skilled personnel and advanced production techniques provide dials, panels, knobs and knob skirts with pinpoint reproduction and accuracy, as well as resistance to solvents and weathering. USR's integral edge-lighted panels represent the most significant development in the instrument and control panel field since introduction of printed circuits. These new panels simplify lighting circuit assembly and provide greater flexibility for the design engineer.

REQUEST BULLETIN 10.30 D

CATHODE-RAY TUBE PHOSPHORS

Phosphors for all cathode-ray tube applications are unsurpassed in adhesion and brightness. Closely controlled through every step of processing, USR phosphors feature high batch-to-batch uniformity. Colors are prepared to customer requirements.

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Metal and plastic dials and panels are available for instrument and control panel application. USR offers the widest selection of marking techniques and an extensive array of materials from which to choose.

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Radioisotopes and radioisotope-excited phosphors packaged in a wide variety of custom-engineered, permanently sealed containers are designed to provide optimum radiation or illumination for research, process control, data display and signalling applications.

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US RADIUM

UNITED STATES RADIUM CORPORATION

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BUYERS are delighted...
DESIGNERS are inspired...

TUFF-TUBE®

Fiberglass-Epoxy Laminated Tubing

Picture of an economy-minded P.A. in his moment of glory! Just placed a production order for Lamtex TUFF-TUBE and is counting the money he's saved. He used to buy NEMA grade G5 glass-melamine tubing—then he heard about TUFF-TUBE's new low price that's the talk of the industry.

PURCHASE PRICE COMPARISON
(3/16 ID x 1/32 Wall)

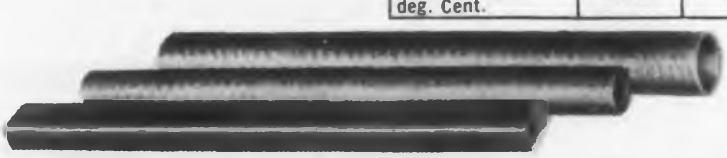
Glass-melamine G5 **$87.50** per 100 ft.

TUFF-TUBE **$66.30** per 100 ft.

Picture of a real smart designer who has just checked the specs on Lamtex TUFF-TUBE, He used to think that NEMA grade G5 glass-melamine tubing was good enough. Now he's convinced that TUFF-TUBE is more than just "good enough"—it's ideal. Below are a few reasons why.

SPECIFICATIONS COMPARISON

	Lamtex TUFF-TUBE	Typical Glass-Melamine
INSULATION RESISTANCE megohms	100.000	75
DIELECTRIC STRENGTH volts per mil, short time	500	225
WATER ABSORPTION %, 24 hr. immersion	.20	3.9
AXIAL COMPRESSIVE STRENGTH psi	20,000	13,000
CONTINUOUS HIGH TEMP. deg. Cent.	.180	150



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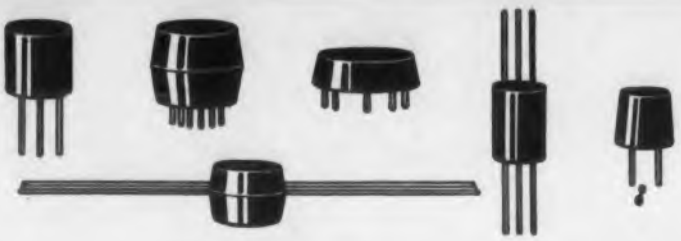
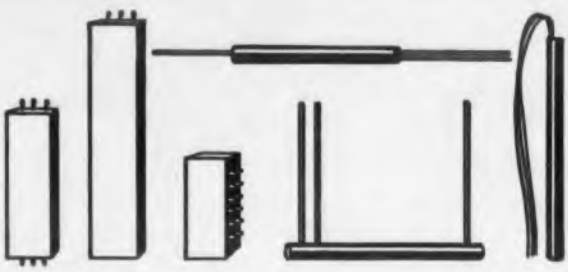
TECHNITROL
ENGINEERING COMPANY



PULSE TRANSFORMERS

Whatever your requirements may be for miniature pulse transformers, Technitrol has a design that will meet your circuit specifications. Commercial or Mil-T-27A low-power transformers with pulse widths ranging from 0.05 to 20 μsec. are available as standard stock components. *Send for Catalog 166*



DELAY LINES

Technitrol manufactures and maintains a complete stock of distributed parameter delay lines in standard package form for plug-in or pigtail mounting. Specially-designed delay lines to meet specific performance characteristics are available on order. *Send for Bulletin 174.*

TEST INSTRUMENTS

Diode Tester: for rapid, accurate checking of semiconductor diodes using dynamic curve. *Send for Bulletin 1001*
Cathode Ray Indicator: a visual indicating device for observing the output of diode testers and transistor curve tracers. *Send for Bulletin 1002*
Variable Pulser: converts any type of signal source up to 5 mc. into standardized pulses of controlled amplitude and duration. *Bulletin 1010*
Variable Frequency Oscillator: supplies a source of frequencies from 100 cps. to 5.6 mc. in 7 bands with continuous tuning over each band. *Send for Bulletin 1011*

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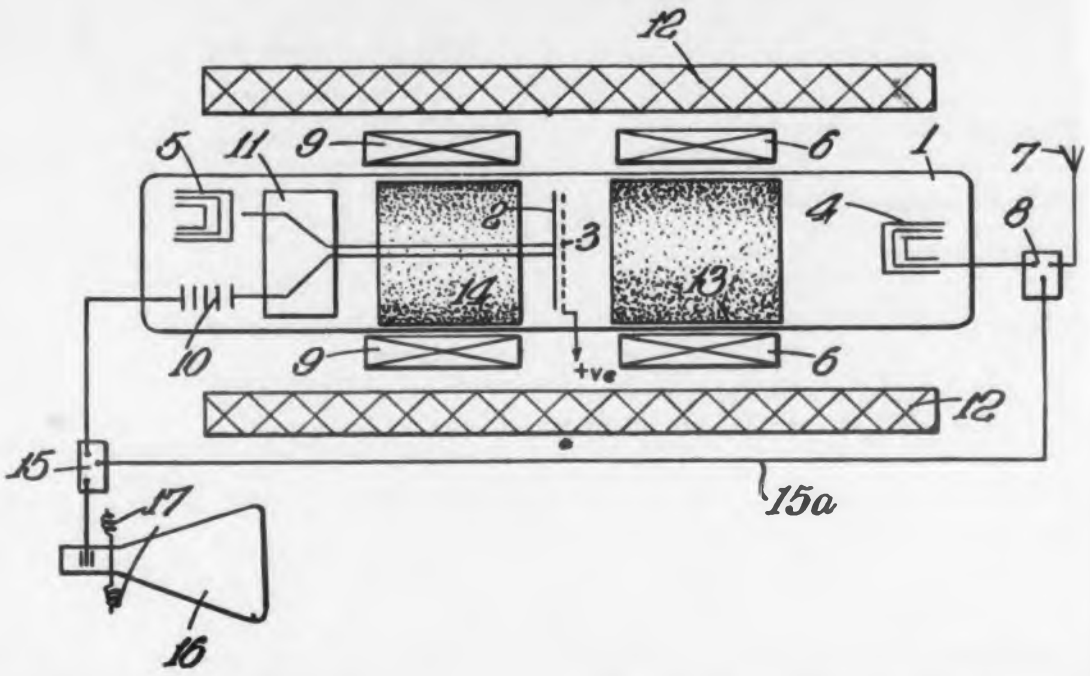
PATENTS



Cathode Ray Tube Apparatus
Patent No. 2,820,921. James D. McGee. (Assigned to Electric & Musical Industries Ltd., England)

The persistance of a display on a cathode ray tube is increased by monitoring the repeated writing and erasure of the signal on a storage mosaic.

An adaptation of the invention is illustrated. Signal input 7 connects to the intensity control of electron gun 4 through switch 8 and the scanning electron beam writes the signal on mosaic 2. A low velocity beam originates at elec-

tron gun 5 and scans the back side of mosaic 2 to restore the mosaic to the potential of the cathode of gun 5. The return beam from mosaic 2 is applied to electron multiplier 10 which connects to amplifier 15. The amplified signal is monitored by the display tube 16. Switch 8 connects the output of amplifier 15 to the writing gun 4 and the cycle is repeated to renew the charge image as it is discharged.

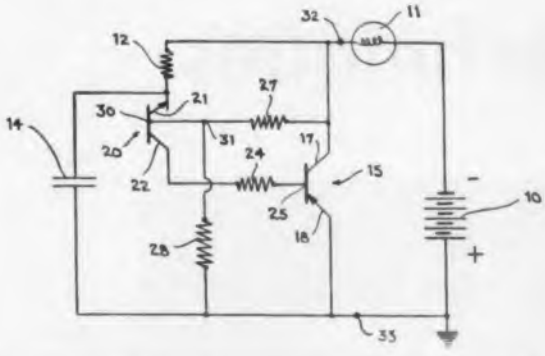
Transistor Oscillator Circuit

Patent No. 2,829,257. Elihu Root III. (Assigned to R. E. Dietz Co.)

A simple transistor switch provides a stable means which is particularly adaptable for use in a flasher warning lamp ordinarily used by motorists making repairs on the road.

The circuit operates as follows: The lamp 11 is connected to the battery 10 through the pnp junction transistor 15 which is controlled by the npn junction transistor 20. Initially, the voltage division of resistors 27 and 28 in series establishes cut-off of transistor 20 so that transistor 15 is cut-off. A small current flows through lamp 11 to charge condenser 14 until the emitter 21 becomes slightly more negative than the base 30. Transistor 20 begins to conduct through resistor 24, and the base 25 of transistor 15. As a result, transistor 15 begins to conduct a heavy current through lamp 11, collector 17 becomes more positive, and additional current flows through transistor 20. This provides more load current for transistor 15 which lights the lamp.

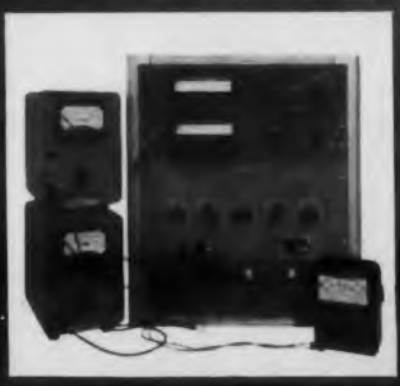
Condenser 14 now discharges through transistor 20 until the condenser voltage becomes so low that it cannot maintain conduction of transistor 20. Both transistors are therefore completely shut off, the lamp becomes extinguished and a new cycle begins.



7 *benefits for you with trio labs'* BUILD-IN *concept*

By *designing-in* trio miniature panel-mounting instruments into operating and testing equipment, you . . .

- **customize both your test set-up and instruments**
- **save space (average trio model is 4" x 4" x 4")**
- **save time: at-a-glance sequential or continuous monitoring**
- **save money: exclude unnecessary instrument functions, ranges**
- **make monitoring foolproof: read "go/no-go" by switching**
- **improve testing efficiency and system reliability**
- **increase overall design freedom**



BEFORE . . . 3 external instruments were used to measure AC and DC voltages . . . cluttered, tedious, wasteful, subject to error.

AFTER . . . 3 **trio** VTVMs integrally built-in now are always on hand to measure just the parameters you designate.

3 ways you can use Trio Labs' pioneer know-how . . .

1. choose from **trio's** complete line of "standard" models.
2. select a "special" already produced — and you save the engineering time and money that went into it.
3. consult us for design specific to your own needs.

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PLAINVIEW, LONG ISLAND, NEW YORK

trio

WESCON BOOTH 1909

CIRCLE 452 ON READER-SERVICE CARD

Get $10.00 plus a by-line for the time it takes you to jot down your clever design idea. Payment is made when the idea is accepted for publication.

Difference Voltmeter Uses Digital Techniques

HERE'S an example of how digital and logical techniques can solve analog problems. We had to make a rock solid voltmeter to measure the potential difference between two dc inputs. These two inputs could be different by only three or four millivolts, or as much as a hundred mv. Our meter was to be very stable and was to stop drifting after a minute of warm up. We also had to indicate which of the two input signals was more positive.

Here's how it was done. We fed both inputs into a "perfect chopper".* The output was a square wave whose phase indicated the polarity of the difference between the input signals. Then we amplified the square wave in an ac amplifier, and detected the output to run a high level vtvm.

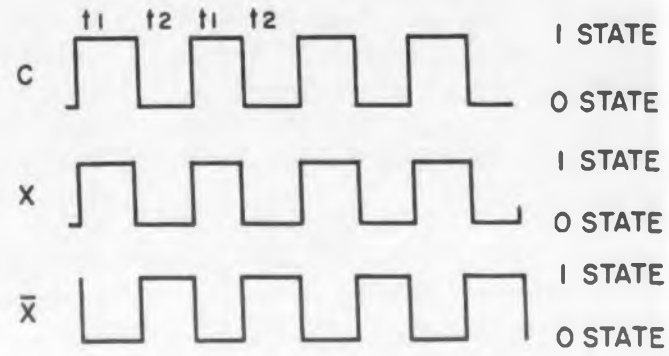


Fig. 1. Timing diagram with X, the clipped amplifier output when in phase with the chopper drive, and X the out of phase output.

Since the vtvm does not distinguish polarity, a separate circuit operates two lights to indicate the polarity of the difference signal. This circuit logically compares the amplified and clipped output of the amplifier to the squared up signal that drives the chopper. If these signals are in phase, we get a true output, if not, we get false. These true and false signals are strong enough to saturate or cut off a vacuum tube which drives a relay to control the individual lights.

Logical Polarity Comparator

The desired performance of the logic box to detect polarity is summarized by the Truth Table in Fig. 2, which refers to the timing dia-

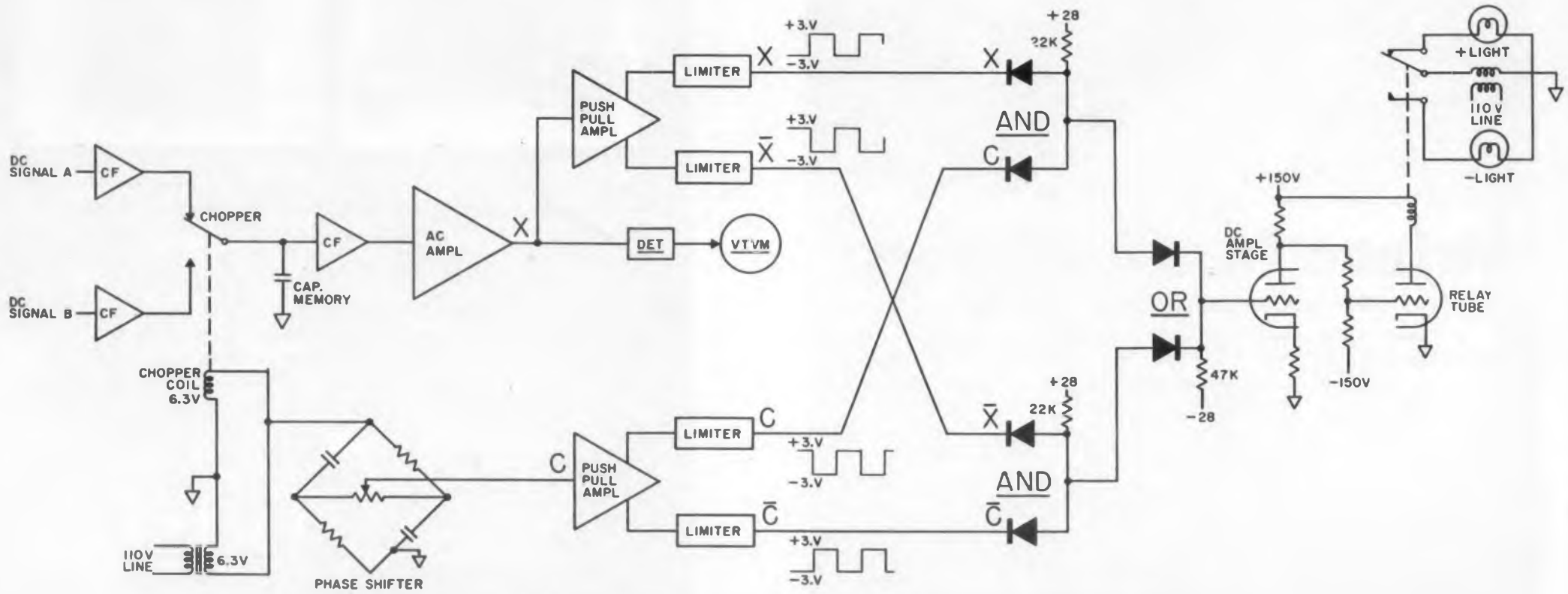


Fig. 4. Logical and digital techniques are used to make a phase sensitive difference voltmeter.

gram in Fig. 1. The table shows that:

With *X* true AND *C* true, output is true.
With *X* false AND *C* false, output is true.
With *X* false AND *C* true, output is false.
With *X* true AND *C* false, output is false.

(*X* is a chopped dc input signal. *C* is the squared up chopper drive signal.

In logical symbols, the truth table is expressed by Fig. 3. Diode logic and voltage gating are used as in Fig. 4. Here +3 v represents the True or *1* state, and —3v represents the false or *0* state.

David H. Bryan, Senior Electronic Eng., Hughes Aircraft Co., Culver City, Calif.

***Since a "perfect chopper" wasn't handy, we used a regular chopper with a capacitor memory. This prevented the chopper output from dipping to zero during the transition time of the vibrating reed. Input followers reduced the capacitive coupling between contacts and the reed, since this coupling lowers the contact impedance to ground. An input cathode follower extended the memory time without the need for a huge capacitor.**

TRUTH TABLE

TIME	X	C	DESIRED OUTPUT STATE
t_1	1	1	1
t_2	0	0	1
t_1	0	1	0
t_2	1	0	0

Fig. 2. Truth table represents the timing diagram conveniently.

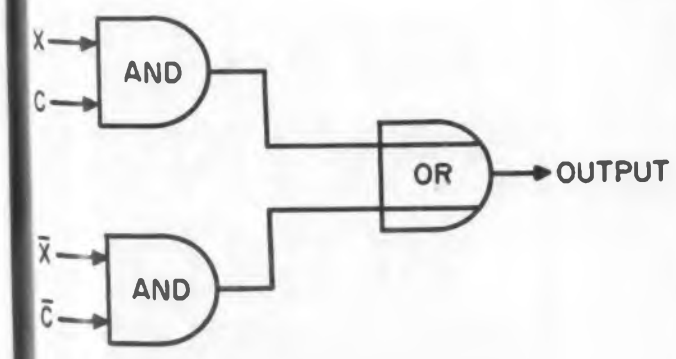


Fig. 3. Logical expression of truth table.

IDEAS FOR DESIGN

Direct Reading "Shock"

Shock levels for different block arrangements on the Barry 150/400 VD sand drop shock machine are not presented directly on the machine. Setting up shock tests necessitates converting manual data to an ordinary scale on the machine. This process is extremely time consuming.

A multiple scale was developed which presents the acceleration levels for each drop height and block arrangement. This scale replaced the ordinary inch scale supplied with the machine. Acceleration levels are presented in increments of 5 g's and drop height in increments of 1 in. The block arrangements and pulse time are presented on a reinforced transparent indicator which is attached to the movable platform. The platform is raised to the desired drop height and the acceleration and pulse time can be determined directly for a particular block arrangement without time consuming data conversion.

David D. Blair, Jr., Senior Systems Design Eng., Chance Vought Aircraft Inc., Dallas, Texas.

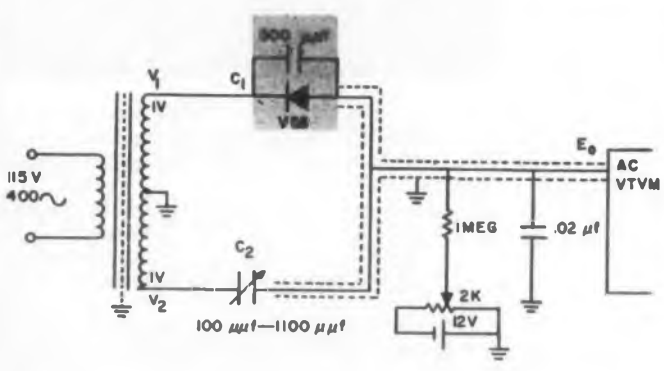
Bridge To Measure Voltage Variable Capacitors

We needed to measure the range of capacitance variation of the V56 Varicap (Pacific Semiconductor Industries) at 400 cps. This is a silicon pn junction device designed to work as a voltage variable capacitor. We wanted a bridge whose accuracy would not be affected by the impedance of the dc bias control.

The three terminal bridge, shown in the figure, did the trick. Its ac output voltage is

$$E_o = \frac{j\omega(V_1C_1 - V_2C_2)}{j\omega(C_1 + C_2 + C_3)} + 1/R_{dc}$$

At null ($E_o = 0$), $V_1C_1 = V_2C_2$, so the bridge accuracy is not affected by the dc supply impedance. C_2 is a calibrated voltage variable capaci-



Three terminal bridge measures voltage variable capacitors.

tor to rebalance the bridge when the dc control function is varied.

The 500 μμf capacitor across the voltage variable capacitor brings C_1 to a capacity level in the range of C_2.

Jerome Lyman, Electrical Engineer, Liquidometer Corp., Long Island City, N.Y.

Selecting Tapping Screws

Analyzing design factors instead of using rules of thumb in selecting tapping screws provides easier assembly and greater assurance of sound joints. Fastener specialists point out some of the important factors to consider.

Of the five common types of tapping screws, two are thread forming and three are thread cutting. The thread forming screws, types *A* and *B*, should be used with material, ductile enough to permit the deforming action of the screw. Type *A* is pointed and should be used in pierced rather than drilled holes, and where the exposed point doesn't matter.

Where the material is very hard or thick, types *A* and *B* may require too much driving effort. Then one of the thread cutting screws should be used. For hard, ductile materials, type 1 is best; while type 23 is best for soft, friable materials.

Type *F*, with four equally-spaced longitudinal slots, drives straighter than the other types.

Where load is not a factor, the metal thickness determines the screw diameter. Use a screw whose thread pitch gives at least one full thread engagement in the metal. For example, with metal 1/16 in. thick, any screw with at least 16 threads per inch can be used.

Where the load must be considered, use a screw strong enough to take the load, and one that provides the greatest thread engagement—four or five threads fully engaged, if possible. If a screw large enough to develop enough holding power doesn't have enough thread engagement, use a greater number of smaller screws.

The size of the hole in the metals to be joined is very important. If the hole is too large, the screw cannot develop enough thread depth; if too small, the screw will be hard to drive. The required hole size varies with the material thickness, type of material and style of screw.

Russell, Burdsall & Ward Bolt and Nut Co., Port Chester, N.Y.

HIGH PRECISION

Less than 0.01°C cavity temperature drift per degree ambient change is possible with the newest Robertshaw-Fulton Crystal Oven. Accomplished by employment of a unique chemical thermostat with an integral sensing and heating element in the closed loop thermal feedback circuit. By replacing conventional electrical circuitry with proportional control, the detrimental effects of contact noise and thermal oscillation are eliminated.

CHANGE OF STATE CRYSTAL OVEN

AMBIENT VS. CAVITY TEMPERATURE CHANGE

SPECIFICATIONS

THERMAL

TEMPERATURE CONTROL: Less than 0.01°C cavity temperature drift per degree ambient change.

STABILIZATION TIME: Approximately 30 minutes

ELECTRICAL

PHYSICAL

APPLICATIONS

Various devices requiring precise temperature control may be mounted within the oven cavity. Applications include: *Crystal Oscillator Circuits* — ensuring frequency stability employed in telecommunications, computers, frequency standards and marker circuits for radar and precision test equipment. Temperature sensitive components, such as zener diodes, thermocouple reference junctions and transistorized oscillator circuits.

Complete information upon request. Ask for Technical Bulletin EF-584

AERONAUTICAL AND INSTRUMENT DIVISION

Robertshaw-Fulton CONTROLS COMPANY

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REPORT BRIEFS

Electromagnetic Research

This paper presents current electromagnetic research efforts and research completed during the past few years at New York University. In the research itself emphasis has been placed on basic problems involving appreciable mathematical methodology. However, this account describes the results from the standpoint of their contribution to microwave problems, ionospheric and tropospheric progagation, diffraction, the inverse propagation and synthesis problems, antenna and waveguide theory, and other physical problems. *Electromagnetic Research at The Institute of Mathematical Sciences of New York University by Morris Kline, New York University, Institute of Mathematical Sciences, Div. of Electromagnetic Research, New York, N.Y., July 1956, 20 pp, microfilm $2.40, photocopy $3.30. Order PB 126370 from Library of Congress, Washington 25, D. C.*

Influence of Magnetic Saturation

In order to investigate the effect of saturation on transients and on voltage regulating properties, transients in a linear machine are compared with those in a machine with saturation. The usual methods for treating a linear machine are developed so that the additional complications arising from losses in the stator circuit and from the damper-winding on the rotor are taken into account. The stability conditions in connection with an actual high-speed regulator are also considered. The effect of saturation on transients is shown by a number of examples and experimental recordings. The stability limit with capacitive impedance load is calculated and checked by tests. Where relevant to working with a long line, practical aspects are discussed. *Influence of Magnetic Saturation on Transients and Voltage Regulating Properties of Synchronous Alternators, with Special Reference to Large Capacitive Loads by Erkki Voipio, Sweden, Kungl. Tekniska Hogskolan, Stockholm. 1955, 126 pp, photos, diagrams, graphs, tables, microfilm $6.30, photocopy $19.80. Order PB 124923 from Library of Congress, Washington 25, D.C.*

Two-Channel Receiver

The principles of a matched channel receiver for RDF applications are described where in the incoming signal selection is made by local oscillator tuning only. Several of the design problems are discussed, especially those dealing with the

input circuit and phase and gain matching. The design data and circuits for various parts of the receiver are given. *Phase and Gain Matched Two-Channel Receiver with Signal Selection by Local Oscillator Tuning Only, by Harold D. Webb, Illinois, Engineering Experiment Station, Electrical Engineering Research Lab., Urbana, Ill. May 1956, 41 pp, diagrams, graphs, tables, microfilm $3.30, photocopy $7.80. Order PB 126677 from Library of Congress, Washington 25, D.C.*

Measuring Contact Potential Differences

A widely used modification of the Kelvin method measures the contact difference of potential between two metals by making them the plates of a vibrating condenser and measuring resulting ac flowing in an interconnecting resistor. Such an apparatus is described in which the time changes of the potential difference are to be observed in various controlled gaseous atmospheres. This report describes the factors which influence the improvement of the sensitivity and the stability of the apparatus. A routine reset accuracy of better than ± 1 mv has been obtained in the determination of the contact potential difference. With stabilized, aged condenser electrodes in a constant atmosphere, an overall stability of ± 5 mv was measured over 96 hours. *Improvements in The Vibrating Condenser Method of Measuring Contact Potential Differences, by K. Bewig, U. S. Naval Research Laboratory. Feb. 1958, 10 pp, diagrams, graphs, table, 50 cents. Order PB 131530 from OTS, U. S. Dept. of Commerce, Washington 25, D.C.*

Phase-Frequency Characteristics

Contents: the Taylor approximation in the low interval; an outline of Darlington's approximation method by Chebyshev polynomial series; the "Chebyshev" approximation of an arbitrary low-interval phase; the Taylor approximation of an arbitrary band-interval phase; the Taylor approximation for band-interval attenuation phase; transformations using elliptic functions; Examples of band-interval "Chebyshev" approximation; some mathematical notes; Conclusions. Appendix A: notes on some Chebyshev approximations. Appendix B: the "delay" functions. *On The Approximation of Arbitrary Phase-Frequency Characteristics, by Victor H. Grinich, Stanford University, Electronics Research Laboratory, Stanford, Calif. May 1953, 151 pp, diagrams, graphs, tables, microfilm $7.50, photocopy $24.30. Order PB 126342 from Library of Congress, Washington 25, D.C.*

REPORT BRIEFS

Hypersonic Shock Tube

Theoretical and experimental studies were made of the feasibility of using a shock tube for quantitative investigations of hypersonic flow phenomena at temperatures simulating free-flight conditions. Discussions are given of high Mach number production, limitations on the test section Mach number, methods of generating strong shock waves, flows with variable specific heats and dissociation, and types of problems amenable to study with the hypersonic shock tube. The experimental investigations to date have dealt with pressure studies using piezoelectric gages and Schlieren studies of the flow. *Hypersonic Shock Tube, by Y. A. Yoler, California Institute of Technology, Guggenheim Aeronautical Laboratory, Hypersonic Wind Tunnel, Pasadena, Calif. July 1954, 183 pp, photos, graphs, microfilm $8.40, photocopy $28.80. Order PB 126833 from Library of Congress, Washington 25, D.C.*

Dielectric Condensers

The article describes the technical and technological elements which served as a basis for the evolution of two series of metal foil/paper condensers encased in metal housings (parallelipiped shape in one case, and tubular in the other). These items are comparable to better foreign products of the same type. Translated from *L'Onde Electrique*, Vol. 36, No. 348, Mar. 1956, pp 194-213. *Development of "Standardized Series of Impregnated Paper Dielectric Condensers (Capacitors), by C. M. Laurent, translated and edited by F. A. Raven, Sept. 1956, 54 pp, photos, drawings, diagrams, graphs, tables, microfilm $3.60, photocopy $9.30. Order PB 124802 from Library of Congress, Washington 25, D.C.*

Antennas

This report states the results of a study of various antenna types having characteristics suitable for use in VHF ionospheric scatter applications for point-to-point communications over distances of approximately 1900 to 2200 km. *Antennas for the Extreme Distance Range of VHF Ionospheric-Scatter Propagation, Page Communications Engineers, Inc., Washington, D.C. Nov. 1955, 92 pp, diagrams, graphs, tables, microfilm $5.40, photocopy $15.30. Order PB 126147, Library of Congress, Washington 25, D.C.*

Extraction of Noise

Message reliability is formulated in terms of risk, or average cost, associated with the process of extraction of random signals from a white-noise background. The optimum extraction process is obtained for cost criteria of different forms, and expressions for the corresponding risk are presented, together with curves which show their dependence on the signal-to-noise ratio. Extension of the theory to more general cases is briefly considered. *On The Extraction of Noise Like Signals from A Noisy Background, from The Risk Point of View, by Neil Ashby, U. S. Air Force, Air Research and Development Command, Cambridge Research Center, Electronics Research Directorate, Components and Techniques Laboratory, Bedford, Mass. Dec. 1956, 35 pp, graphs, microfilm $3.00, photocopy $6.30. Order PB 126376 from Library of Congress, Washington 25, D.C.*

Reflection of Electromagnetic Waves

By solving the integral equation of Hallen it is possible to compute the current which is caused in a straight thin metal strip by an outside incidental electromagnetic field. The present work deals with various methods for approximately solving the integral equation, and the current is represented both in the form of standing waves and in the form of waves continuously reflected. The radiation caused by the current arising has been computed. *Reflection of Electromagnetic Waves from Thin Metal Strips (Passive Antennae), by Kristen Lindroth, Kungl, Tekniska Hogskolan, Stockholm, Sweden. 1955. 64 pages, diagrams, graphs. Order PB 124920 from Library of Congress, Washington 25, D. C.*

Fibrous Microwave Absorber

Microwave absorbers made in the form of mats using fibrous materials impregnated with pigmented rubber solutions have been found to give efficient broadband absorption from 2,500 to 30,000 mc with less than 5 per cent of the reflection obtained from a smooth metal plate. Modifications of these absorbers can be made to fill such requirements as fire resistance, mechanical strength, and indifference to water and weathering. These absorbers are adaptable to mass production techniques and have been used successfully in radar dark rooms for antenna research. *Darkflex, A Fibrous Microwave Absorber, H. A. Tanner, A. G. Sands, and M. V. McDowell, U.S. Naval Research Laboatory. April 1953, 11 pp, microfilm $2.40. Order PB 130312 from Library of Congress, Washington 25, D.C.*

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INFORMATION THEORY

Conditions for Obtaining High Carrying Capacity in Communication Channels with Random Variations of Parameters by V. I. Siforov. EC 1/58, pp 3-8.

Communication channels with a random parameter variation are classified into two kinds, in accordance with their carrying capacity at low level of additive noise. The author introduces the concept of the intrinsic carrying capacity of channels of one of these types. If the total bandwidth of the frequency spectra of all the random-varying parameters of a multiple channel is less than its frequency bandwidth, then its carrying capacity increases without bound as the level of additive noise is reduced without limit. Refers to work by Shannon (The Zero Error Capacity of a Noisy Channel *IRE Transactions*, IT-2, No. 3, 1956) Elias (Predictive Coding, *IRE Transactions* on Information Theory IT-1, No. 1, 1955) and Feinstein (A New Basic Theorem of Information Theory *IRE Transactions*, IGIT-4, 1954).

Distribution of the Envelope at the Output of a Selective System Under Accidental Frequency Deviations by A. V. Prosin. EC 1/58, pp 9-14, 3 figs.

A method is given for determining the distribution curves for the envelope of the amplitudes at the output of selective systems owing to accidental swings of the voltage frequency. The distribution curves are obtained for the output of resonant systems consisting of n identical networks and n pairs of coupled networks. The condition is that the modulating voltage has a normal distribution and that the so-called quasi-stationary solution is used for the output oscillations. Simple formulas are obtained for the distribution function of a quantity that is the reciprocal of the voltage amplitude. On the basis of these formulas it is possible to calculate the probability that the envelope will exceed a previously specified value. The probabilities are plotted for various values of both the parameters of the selective systems and of the parameters of the messages. This makes possible an estimate of the requirements that must be satisfied by the amplitude limiters.

Principle of Quantization of Stochastic Signals with Unlimited Spectrum and Certain Results in the Theory of Pulse Transmission of Communication by N. A. Zheleznov. REE 1/58, pp 3-18, 2 figs.

The principle of quantization, which establishes the possibility of representing continuous signals with the aid of a

discrete aggregate of quantities, shifted relative to each other with time, is extended to include the case of stochastic signals with unlimited spectrum. A theorem is proved for the optimum expansion of the signals into orthogonal components, yielding a minimum rms error. For the transmission of pulse-modulated signals there exists a maximum possible fidelity, which cannot be exceeded for any modulation method. A method for selecting the characteristics of a transmission line to insure high fidelity is described.

Interference Immunity of Hamming's Code by G. A. Shastova. REE 1/58, pp 19-26, 8 figs.

The interference immunity of transmission of discrete communications by the Hamming code, by simple binary codes, and by a code with repetition and protection are compared subject to two initial conditions. The first condition is that the probability of distortion of one symbol be constant, the second is that the energy of the signal, which can be used for the transmission of a single communication, be constant. Conditions are obtained under which the Hamming code insures a higher interference immunity. Refers to work by Hamming (*Bell System Technical Journal*, 1950, 29, 147–160) and Elias (*Transactions IRE PGIT-4*, 1954).

MEASUREMENTS

New Method for Measuring Very Small Alternating Electric Quantities by V. S. Voyutskiy. REE 2/58, pp 244-248, 3 figs.

Description is given of a null-type compensation method for measuring very small (noise) electric voltages (or currents), whose level is considerably below the level of the intrinsic noise of the apparatus. This method is equivalent to the modulation method with respect to the freedom of the results from the fluctuations in the apparatus parameters and of the level of the apparatus noise, but does not require computing devices. An analysis of the method is given, circuits are shown, and results of the experiments are reported. See Figs. 1 and 2.

Sensitivity of a Radio Meter with Automatic Gain Control by N. V. Karlov and P. N. Lebedev. REE 1/58, pp 74-79.

Expressions are obtained for the sensitivity of a modulation radio meter, in which the sensitivity threshold is reduced by the use of automatic gain control. In practice, this changes the natural sensitivity threshold. The advisability of using automatic gain control

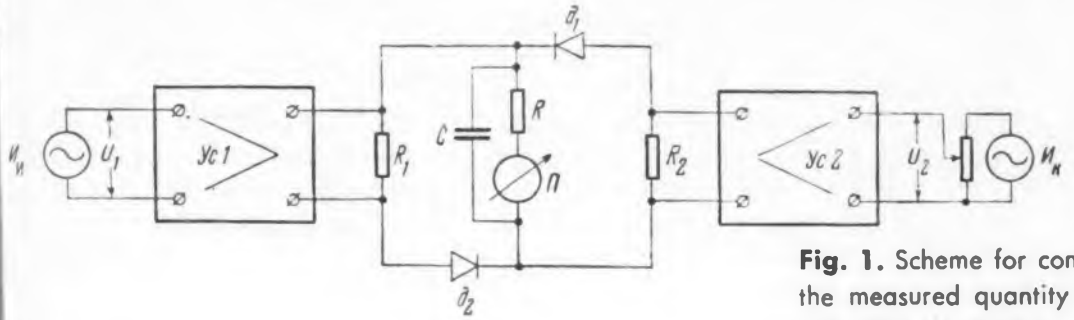

Fig. 1. Scheme for comparing the measured quantity on the left with a standard quantity on the right.

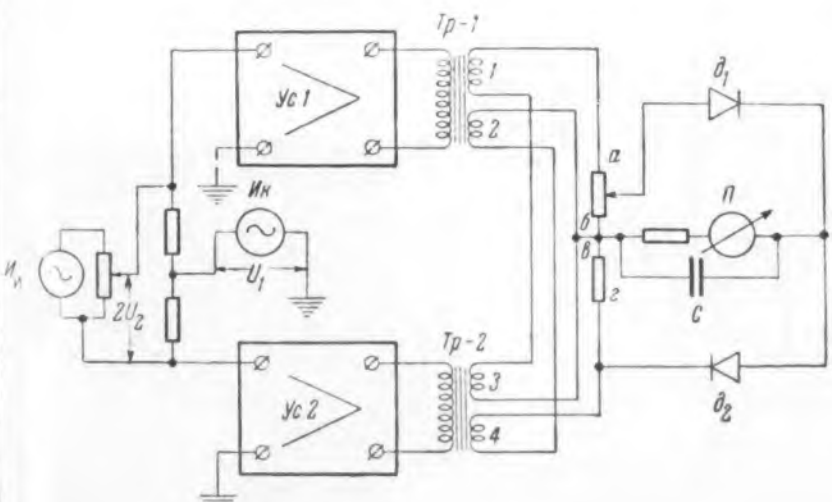

Fig. 2. The newly proposed comparison circuit.

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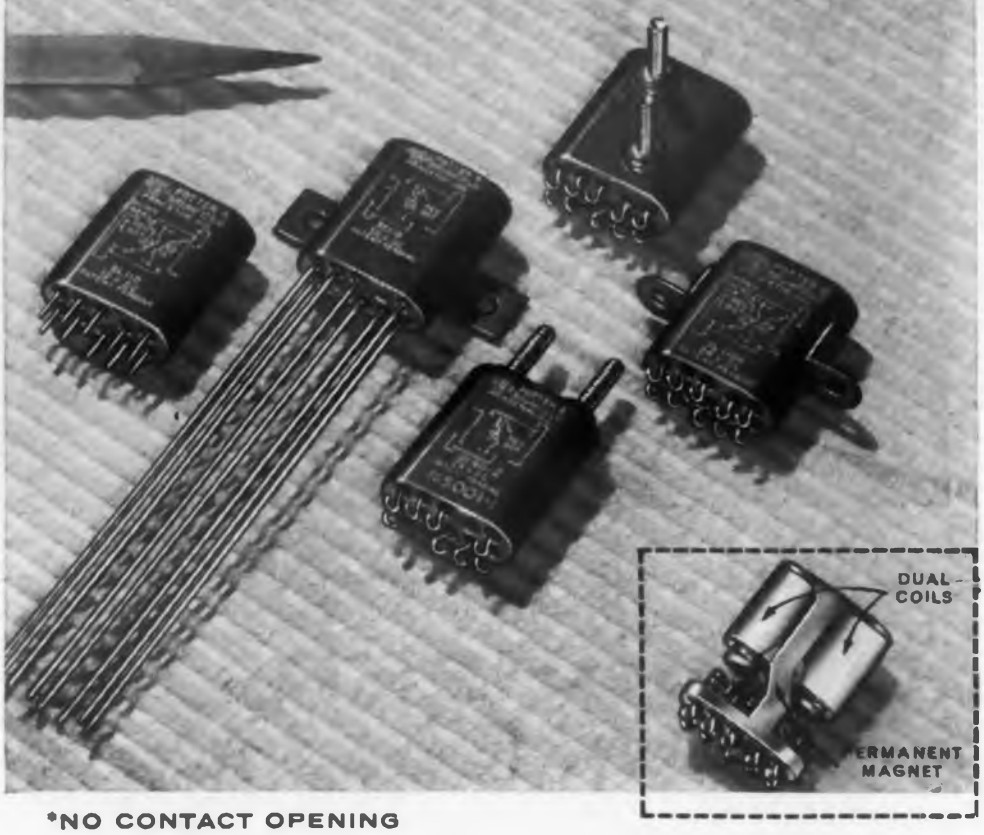

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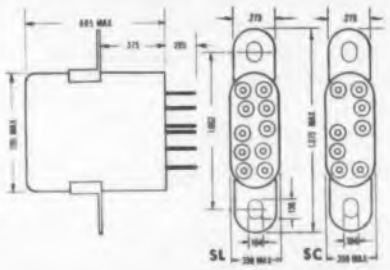

SL—dual coil latching relay. Operates on a 1 watt, 3 ms pulse at nominal voltage. Permanent magnet latch locks the armature in either position.

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RUSSIAN TRANSLATIONS

in the presence of fluctuations in the gain and in the case when the receiver has a noise factor is discussed. Reference is made to work by Selove (*Review of Scientific Instruments*, 1954, Vol. 25, page 120), Machin, Ryle, and Vonberg (*Proceedings IRE*, 1952, Part III, Vol. 99, page 177), and Ryle (*Proceedings Royal Society*, 1952, 211 A, 359).

Measurement of the Bandwidth of the Signal Radiated by a Radio-Telegraph Transmitter by M. S. Gurevich. Measurement Engineering, *(Izmeritel'naya Tekhnika)*, 1-2/58, pp 62-67, 10 figs.

The bandwidth occupied by the radiation of a transmitter is defined as the frequency band that contains 99 percent of the radiated power. It includes any discrete harmonic, whose power amounts to not less than 0.25 per cent of the total radiated power. The author considers methods for measuring this bandwidth, and gives several experimental results. He also lists various methods used for this measurement.

Electrodynamic Ammeter for the Measurement of High Frequency Currents by V. R. Lopan'. Measurement Engineering *(Izmeritel'naya Tekhnika)*, 1-2/58, pp 71-74, 2 figs, 1 table.

Electrodynamic ammeter developed at the Scientific Research Institute for Physical-Technical and Radio Technical Measurements, is described for measuring currents from 5-100 amp in the frequency range from 1 to 100 mc. The various errors in current in such measurements are discussed and tabulated. See Fig. 3.

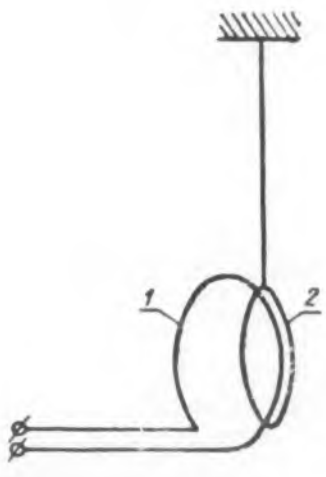

Fig. 3. The meter movement for high current measurements at high frequencies.

Phase Sensitivity of Frequency Multipliers by M. Z. Klyumel'. Measurement Engineering (*Izmeritel'naya Tekhnika*), 1-2/58, pp 58-62, 2 figs.

The phase-sensitivity of a frequency multiplier is important in designing molecular microwave generators. The article describes briefly the final results of an experimental investigation of the phase sensitivity of multipliers in this range.

CIRCUITS

Investigation of the Stationary Mode of Operation of a Regenerative Frequency Divider with a Two to One Ratio by V. S. Andreyev. REE 2/58, pp 214-226, 7 figs.

Although regenerative frequency divider circuits have been in use since 1939 (see R. L. Miller, Fractional-Frequency Generator Utilizing Regenerative Modulation, *Proceedings IRE*, 1939, 27, 7, 446), they have not yet been theoretically investigated, even in the stationary mode. The author uses the "abbreviated" system of equations to derive relations which would permit an analytical calculation of the circuit. The theoretical equations and the characteristics are different for circuits in which the tuned circuit employs an iron-core transformer and for those where an air-core transformer is used. Higher selectivity is obtained with air-core transformers, and higher phase-stability is obtained with iron-core transformers.

Operation of a Ring Converter at Small Input Signals by V. S. Andreyev. RE 12/57, pp 10-18, 7 figs.

The nonlinear elements of the ring converter are approximated by an exponential function. Relations are derived for the dependence of the output signal and the input impedances on the input signals and on circuit parameters. Numerical methods are used to solve the transcendental equation. It is shown that the purest multiplication of the input signal is reached for certain definite relationships between the circuit parameters.

Synthesis of Mixed Relay Circuits of The Series-Parallel Type by V. N. Roginskiy. AT 12/57, pp 1120-1131, 6 figs.

A Boolean treatment of analytical methods for equivalent transformations of switching circuits. It includes means for obtaining mixed relay systems by introducing elements of finite conductivity. The application of these methods in the synthesis of multi-relay circuits may reduce the number of contacts in the circuits. Reference is made to work by Shekel, "Sketch for an Algebra of Switchable Networks" (*Proceedings IRE*, Vol. 41, July 1953).

(Continued on page 184)

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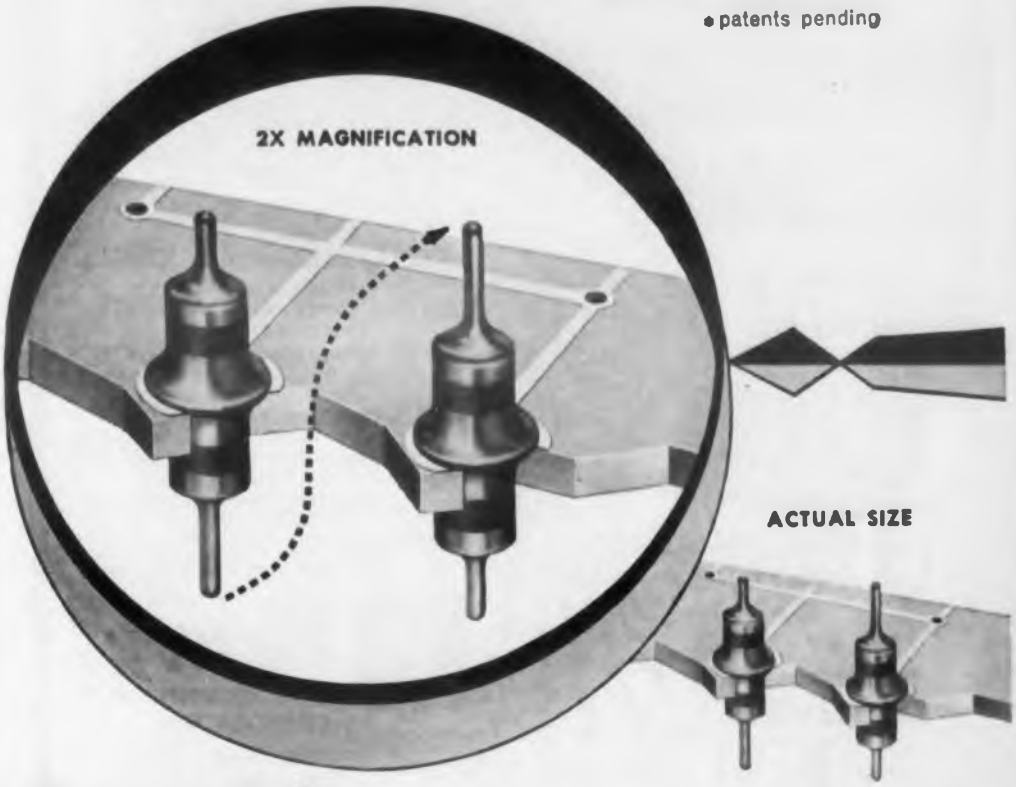

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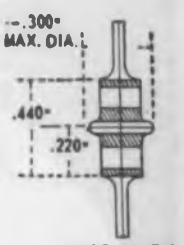

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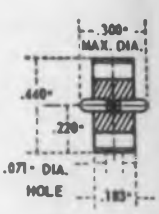

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RUSSIAN TRANSLATIONS

Null Type Telemetering System with Static Transmitter by V. S. Popov. Measurement Engineering *(Izmeritel'naya Tekhnika)*, 1-2/58, pp 43-47, 4 figs.

A telemetering system patented in Russia is described, in which the compensating element is not dynamic, but static (a thermistor). The circuit, shown in Fig. 4, is described in detail, along with the construction of the indirectly-heated thermistor.

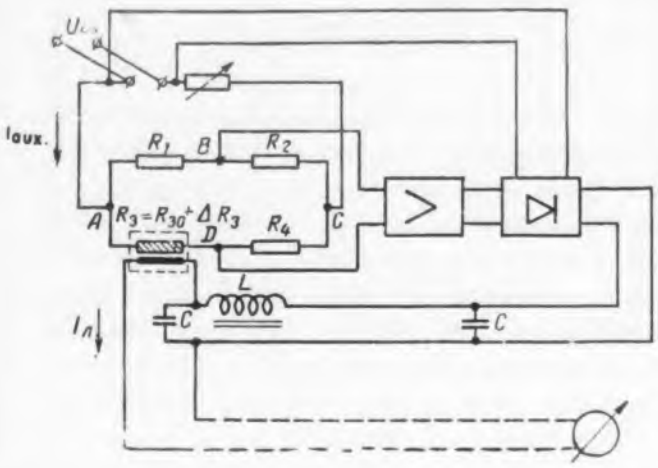

Fig. 4. The telemetering system with a thermistor as the compensating element.

The telemetering system consists of a bridge, fed from a commercial-frequency source. The line is connected to the output of the bridge through an amplifier, phase-sensitive rectifier, and a LC filter to smooth the pulsating current. A negative feedback loop, insuring automatic balancing of the bridge, is formed by connecting the filament of the thermistor in the line. When the measured quantity changes, the changed resistance of one or several of its arms unbalances the bridge. The resistance arms are so chosen that the bridge balances automatically by change of the filament current over the entire range of measurement.

Nomogram for the h-Parameters of Transistors by E. M. Manukian. RE 12/57, pp 29-35, 3 figs, 1 table.

Equvialent two-terminal pair network parameters expressed as *h*-parameters are most suitable for low frequency calculations. The article gives the most widely used formulas and a nomogram with which one can calculate the *h*-parameters and also convert *h*-parameters into equivalent *T* circuits. An example illustrates the use of the nomogram. The *h*-parameters are treated in detail by Lo and others in "Transistor Electronics," 1955.

Certain Problems in the Design of Broadband Discharge Gaps by L. R. Yavich. REE 1/58, pp 94-104, 11 figs.

A method is proposed for the design of the optimum loaded Q-factor of tuned discharge-gap elements for the protection of receivers and of certain types of four-terminal networks, which have a broadband characteristic. Generalized frequency characteristics that are obtained by this procedure are given. Formulas are derived for the analysis of the equivalent circuits that contain segments of transmission lines. Refers to work by Mumford (*Bell System Technical Journal*, 1948, 4, 684-714), Chen (*RCA Review*, 1954, Vol. 15, pages 204-229), Fano (*Journal of the Franklin Institute*, 1950, pages 57-83 and 139-154).

Relaxation Oscillators Employing Point-Contact Transistors by V. N. Yakovlev. REE 1/58, pp 61-73, 16 figs.

Phase plots are drawn for oscillators with emitter-collector and collector capacitances, and their possible operating modes are investigated. Expressions are obtained for the temporal parameters of the pulses. An investigation is also made of the dependence of the duration of the wave front on the parameters of the circuit and of the transistor. Conditions are derived for the occurrence of jumps in the self-oscillation mode. A procedure is indicated for the design of the oscillator. Reference is made to work by Lo (*Proceedings IRE*, 1952, Vol. 40, No. 4, page 1531) and Anderson (*Proceedings IRE*, 1952, Vol. 40, No. 4, page 1541).

Distortion in the Dynamics of Transmission in a System Consisting of a Compressor, an Intermediate Channel, and an Expander by V. I. Tsapalina. EC 1/58, pp 58-67, 6 figs, 3 tables.

The effect of increasing the interference rejection of long-distance telephone and broadcast channels, by compressing the dynamic range of the transmission on the transmitting end and subsequently restoring of the level at the receiver is discussed. This involves the appearance of inherent distortion, whose values are approximately determined in this article.

WAVE PROPAGATION

Possibility of Amplifying the Power of a Weak Modulating Signal by Means of a Gyromagnetic Medium by V. A. Fabrikov. REE 2/58, pp 190-197, 1 fig.

The oscillations of a gyromagnetic medium under the circular polarization are discussed, when arbitrary frequency is applied in the di-

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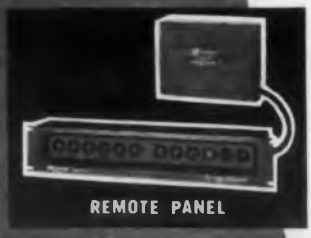

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rection of the permanent magnetization of the material. The equations of motion of the gyromagnetic moment are solved in the first approximation in terms of the amplitude of the weak modulating field. Conditions are obtained under which the imaginary part of the complex magnetic permability of the medium becomes positive with respect to this field. This corresponds to power amplification of the modulating signal on the part of the medium. The resonance relationship between the frequencies causing maximum amplification is determined. Reference is made to work by Codrington, Olds and Torrey (*Physical Review*, 1954, 95, 607), Wangsness (*Physical Review*, 1955, 98, 927), Rabi, Ramsey and Schwinger (*Reviews of Modern Physics*, 1954, 26, 167), Kaplan (*American Journal of Physics*, 1955, 23, 585) and Pippin (*Proceedings IRE*, 1956, 44, 1054).

Effect of Dielectric Film on the Attenuation of H_{01} Wave in a Straight Nearly-Circular Waveguide by B. Z. Katsenelenbaum. REE 1/58, pp 38-45.

A thin semiconducting film, placed on the internal surface of a waveguide, causes attenuation of the wave propagating in the guide. An article by Malin (Effect of Semiconducting Film on Attenuation of Waves in a Round Waveguide, *Radiotekhnika i Elektronika*, Vol. 1, 1956, No. 1, page 34) showed that in a round waveguide this attenuation has a different order of magnitude for waves of type H_{0m} on one hand, and for all other types of waves on the other. In this article the author calculates the additional attenuation for the H_{0m} mode, due to small deformation of a round waveguide, not accompanied by curvature of the axis. Reference is made to work by Morgan (*Journal of Applied Physics*, 1950, 21, 329), Miller (*Proceedings IRE*, 1952, Vol. 40, No. 9, page 1104), and Sims (*Proceedings IEE*, 1953, 100, Part IV, No. 5, page 25).

Optimum Linear In-Phase Antenna with Continuous Current Distribution by I. F. Sokolov and D. Ya. Vakman. REE 1/58, pp 46-55, 8 figs.

Dolph (*Proceedings IRE*, 1946, Vol. 34, No. 6, page 335) developed a method for calculating the optimum linear in-phase antennas, consisting of individual dipoles. This method is extended by the authors to include antennas with continuous distribution of current along the dipole. They derive and analyze formulas for the directivity patterns, for the distribution of the current amplitude, and for the efficiency.

Diffraction of Surface Electromagnetic Waves by a Semi-Infinite Impedance Plane by N. G. Trenev. REE 2/58, pp 163-171, 4 figs.

Diffraction of surface waves by the edge of an impedance half-plane results in surface waves that are both reflected and transmitted downward, as well as in a radiation field. The transmission of the surface waves takes place only if both sides of the half-plane have equal impedances. Equations are derived for the reflection and transmission coefficients.

Reference is made to an article by T. B. A. Senior, Deflection by Semi-Metallic Sheath, *Proceedings Royal Society*, 1952, 22, 1115, 213).

Diffraction of Electromagnetic Surface Waves by An Impedance Step by N. G. Trenev. REE 1/58, pp 27-37, 5 figs.

The diffraction of surface E and H waves by an impedance step is analyzed. Expressions are derived for the reflection and transmission coefficients. The diffraction field is determined, and the radiation characteristics are established. In connection with the great recent interest in waveguides that employ surface waves, it becomes advisable to study such systems, comprising several segments of surfaces, and to analyze the impedance discontinuities that takes place at the edges of these surfaces.

Power Absorbed by an Antenna from an Incident Non-Plane Wave by E. L. Burshteyn. REE 2/58, pp 186-189, 1 fig.

An expression is derived for the power absorbed by an antenna from an incident non-plane wave. Certain approximations (equivalent to the Kirchhoff approximation used in the ordinary calculation of the directivity pattern) are used to transform the resultant expression to a simple form, suitable for engineering calculations and estimates.

Symmetrical Diaphragm of Arbitrary Thickness in Round Waveguide by M. V. Butrov. REE 1/58, pp 56-60, 2 figs.

The Schwinger variational method is used to analyze the problem of the effect of a round aperture in a diaphragm of arbitrary thickness in a round waveguide, for a H_{01} mode. Unlike a planar partition, the behavior of a thick partition with an aperture is describable by means of a system of two integral equations for the electric fields specified at the input and output of the diaphragm. The symmetry of the problem makes it possible to transform the system of integral equations into two independent integral equations in terms of a certain combination of

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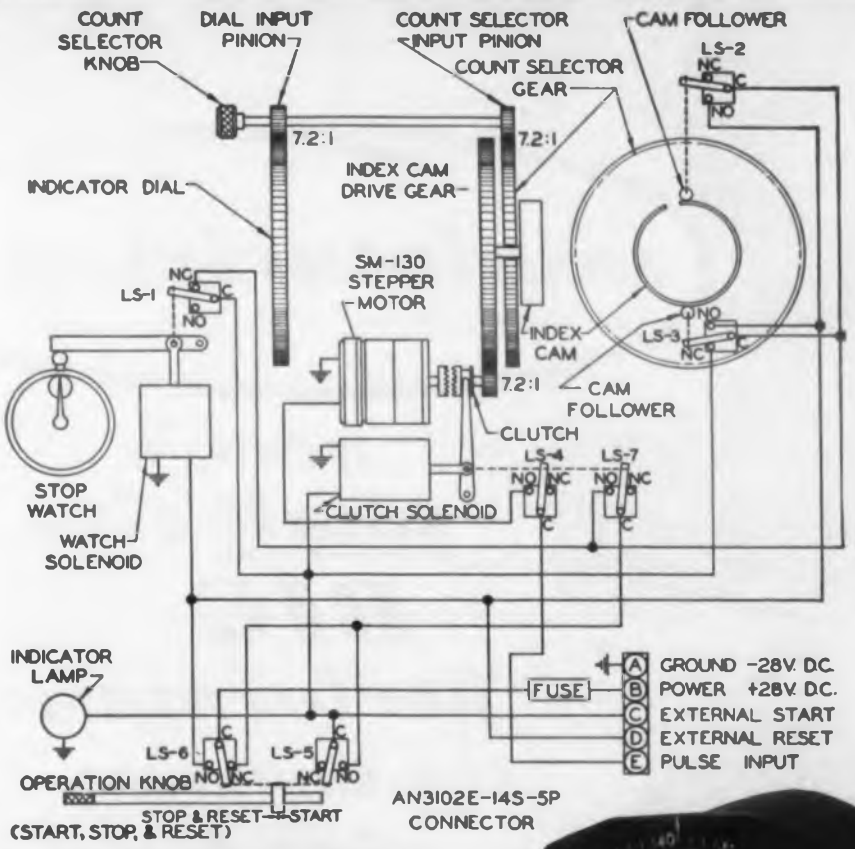

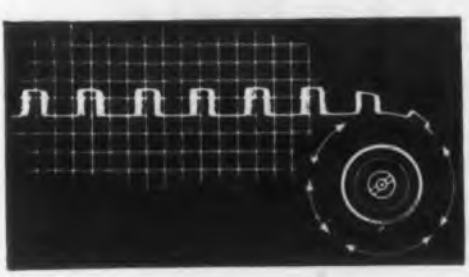

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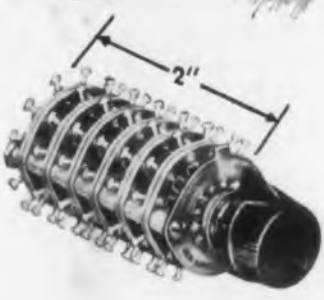

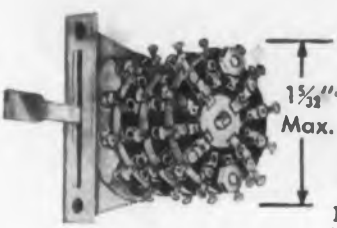

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the fields at the input and the output of the diaphragm. The resultant integral equations are then transformed to a stationary form, with the quasi-static solution being used as a comparison function. Formulas are given for the elements of the equivalent four-terminal network for one particular case. The quasi-static solution was originally obtained by Sheingold (*Journal of Applied Physics*, 1953, Vol. 24, page 4).

Contribution to the Theory of Scattering of Electromagnetic Waves by a Statistically Uneven Surface by F. G. Bass and V. G. Bocharov. REE 2/58, pp 180-185.

Scattering of electromagnetic waves by a statistically uneven surface is considered either by methods of geometrical optics (see paper by Rice, *Communication of Pure and Applied Mathematics*, 1951, Part IV, 351), or by perturbation theory (Davies, *Proceedings IEE*, 1954, Part IV, 101, 7, 209). However, neither have carried out the theory to completion, particularly when it comes to small irregularities in the surface, in which the irregularities are on the order of the wavelength or smaller. The authors formulate the boundary conditions, and determines the first-approximation field, the dispersion tensor, the second-approximation field, and the Poynting vector. Reference is also made to an article by Staras, (*Journal of Applied Physics*, 1952, 23, 10, 1152).

MICROWAVES

Radio Spectroscope for the Investigation of Rotational Spectra of Molecules by T. M. Murina. REE 10/57, pp 1271-1278, 6 figs.

A high sensitivity radio spectroscope, operating in the range from 10,000 to 43,000 mc is described. A stabilized klystron is used in the circuit, and the spectrum is automatically recorded.

Investigation of the Superregenerative Mode in a Magnetron with Slotted Anode by M. K. Belkin. REE 10/57, pp 1307-1310, 4 figs.

The superregenerative mode can be considered as a regenerative mode in which the damping varies periodically in magnitude and in sign with the superregenerative frequency. This can take place in any circuit consisting of a resonant portion and device with a drooping characteristic, whose slope is controlled by an auxiliary voltage. Normally, such a device in a superre-

generative circuit is a triode, on whose anode or grid is applied the superregenerator voltage. A magnetron with slotted anode can also be used.

TELEVISION

Development of a Transmitting Television Network in the USSR by M. Krivosheyev, and V. Vinogradov. R 1/58, pp 35-36.

Traces the development of the number of television centers in Russia, from two in 1951 to 37 in 1957, listing their location and characteristics. It is proposed to increase the number of television stations to 60 by the end of 1958.

Descriptions are given also of the various communication lines used to interconnect the television centers, the principal television cameras used, and various other improvements proposed for the Russian television system.

Amplitude Selector for Television Sets by A. Korniyenko. R 1/58, pp 37-40, 9 figs.

Description of the circuit used for separating the synchronizing pulses from the total television signal. The circuit in general is discussed, and some simplifications are described in detail.

Instrument for Television Alignment by F. Kuz'miuskiy and S. Sher. R 1/58, pp 41-43, 4 figs.

The apparatus described in this article can display the frequency characteristic of the amplifier circuits of the television directly on the screen of the kinescope of the television being aligned. The instrument consists of an fm oscillator, a modulator, a marker device, and a mixing stage intended for visual observation of the frequency characteristic. The diagram of the equipment is given as is an external view and operating instructions.

KEY

The sources of the Russian articles and their dates of issue follow the authors' names. Here is the key to the names of the journals in which the articles originally appeared.

AT	Automation and Telemechanics *(Avtomatika i Telemekhanika)*
CJ	Communications Journal *(Vestnik Svyazi)*
EC	Electrical Communications *(Elektrasvyaz')*
IET	Instruments and Experimental Techniques *(Probori i Tekhnika Eksperimenta)*
R	Radio
RE	Radio Engineering *(Radiotekhnika)*
REE	Radio Engineering and Electronics *(Radiotekhnika i Elektronika)*

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GERMAN ABSTRACTS

E. Brenner

Loading of Transistor Oscillators

USE OF THE four-pole theory makes it possible to design transistor oscillators such that the conditions for oscillations are independent of the load impedance. (A similar procedure for vacuum tube oscillators was abstracted in the July 23, 1958 issue of ELECTRONIC DESIGN.)

Since the conditions for oscillations can be deduced from linear analysis, an active two-port, such as a transistor, can be described through the short circuit admittance matrix

$$I_1 = y_{11}V_1 + y_{12}V_2$$
$$I_2 = y_{21}V_1 + y_{22}V_2$$

In the case of vacuum tubes only the equation for I_2 applies since it can often be assumed that the input impedance at the grid is infinite and that the internal feedback in the tube is negligible.

In addition to the load impedance a passive four-pole is used in conjunction with the transistor, both to furnish the frequency selective network in the feedback loop and to allow adjustment for independence from load impedance. A load impedance can be connected either in series or in parallel with the passive four-pole which is obtained either by addition of the admittance matrices (parallel case) or of the open circuit impedance matrices (series case). The resulting combination can then be placed

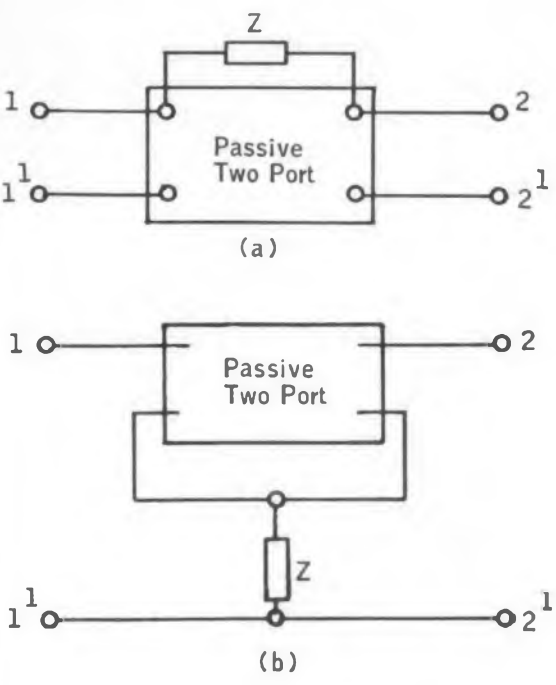


Fig. 1. (a) Parallel connection of a passive two-port and the load impedance Z; (b) Series connection of a passive two-port and the load impedance Z.

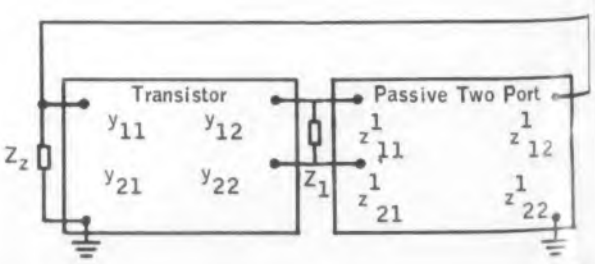


Fig. 2. Cascade connected oscillator. The impedances Z_1 and Z_2 are used to terminate the transistor so that the two driving point admittances are adjustable.

either in cascade with the transistor as in Fig. 2 or in parallel with the transistor as in Fig. 3. Algebraic manipulations then provide the condition for oscillations. These conditions generally involve the load impedance. It is possible, however, to choose the passive elements in the four-pole so that at the frequency of oscillation the load impedance is not involved in the unit loop gain condition.

For the cascade connection shown in Fig. 3 the condition for oscillation is

$$-z^1_{12}\,(y_{12}+y_{21}) \geqq 1 + z^1_{11}\,(y_{22}+Y_1) + z_{22}\,(y_{11}+Y_2) + \frac{\Delta^1}{\Delta}$$

where

z_{11}^1, z_{22}^1, z_{12}^1, are the elements of the open circuit impedance matrix of the passive four-pole and

$$\Delta^1 = z_{11}^1\, z_{22}^1 - (z_{12}^1)^2;\ 1/\Delta = (y_{22}+Y_1)(y_{11}+Y_2) - y_{12}\,y_{21};$$

where

$$Y_1 = 1/Z_1\ ;\ Y_2 = 1/Z_2.$$

It is also possible to deduce conditions under which two load impedances are used, neither of which influences the conditions for oscillations.

Abstracted from an article by W. Herzog, Nachrichtentechnische Zeitschrift, *Vol. 10, No. 11, Nov., 1957, pp 564-569.*

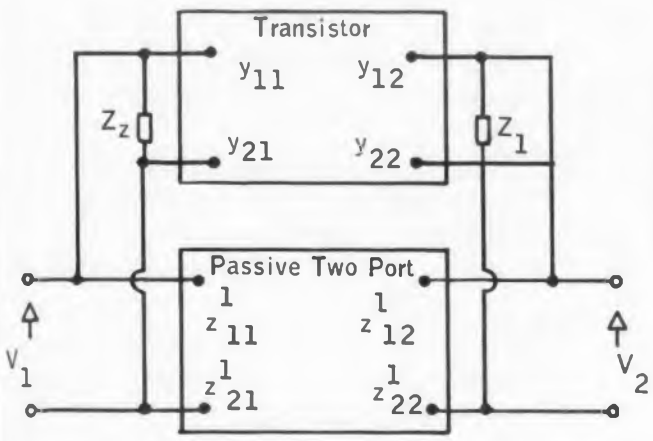


Fig. 3. Parallel connected oscillator. The condition $v_1 = v_2$ must be imposed in addition to other conditions so that a load voltage is developed, if the passive four-pole is as in Fig. 1a.

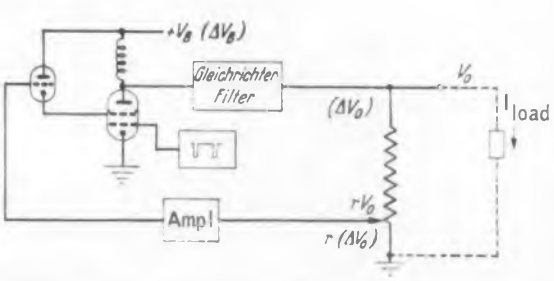
Stabilized High Voltage Supplies

IF A PENTODE is used as a switching tube in a high voltage supply it is possible to build regulated supplies with a stability in the order of 0.01 per cent. The basic schematic is shown in Fig. 1. The original voltage fluctuations which are to be compensated are due to supply voltage fluctuation, fluctuations in pulse durations which cut off the tube, and loading.

Compensation is achieved through feedback. A portion of the output voltage (rV_o) is compared to a reference and the difference is amplified and fed to the screen grid of the pentode. Variations in screen voltage change the internal resistance of the tube so that the current which charges the inductance is increased or decreased in the desired direction. Oscillations in the tank circuit, formed by the plate-ground capacitance and the inductance, then have appropriately modified amplitudes.

The author cites as examples a 4.5 kv, 5 ma supply and an 8 kv, 1 ma source. Both of these have the required stability (0.01 per cent) with 10 per cent variation in supply voltages.

Abstracted from an article by W. Mueller-Warmuth, Zeitschrift fuer Angewandte-Pkysik, *Vol. 10, No. 3, March 1958, pp 122-125.*



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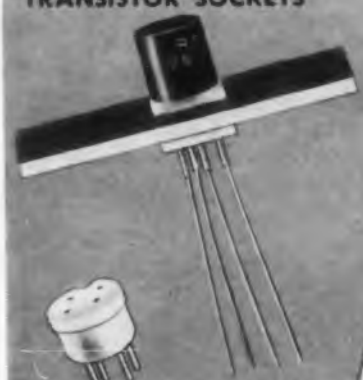

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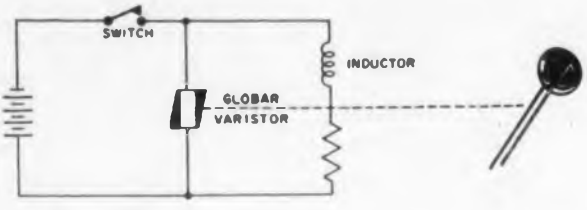

In North Electric's design, varistors also eliminate "radio interference" and assure noise-free transmission of telephone conversations in many independent, automatic telephone exchanges.

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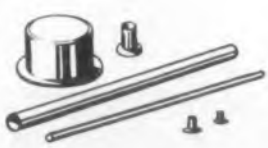

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BY APPLYING the principle of bi-periodic beam focusing a new traveling-wave tube, entirely electrostatically focused, has been achieved through the use of a pair of concentric bifilar helices and an annular gun. Experimental dc focusing results have agreed very well with theoretically calculated results. With a non-optimized gun, a beam of perveance 2 x 10^{-6} amp/volt$^{3/2}$ has been focused to 97 per cent current transmission. An rf gain of 10 db has been obtained at a power level of 100 mw at 2,970 mc.

An experimental traveling-wave tube, the sketch of which is shown, was built for testing the focusing performance and the rf performance. The outer bifilar helix is wound with 0.020 in. tungsten wire on a mean diam of 0.380 in and a pitch of 10 turns per in. To eliminate all possible undesirable rf interaction with the inner bifilar helix, the inner helices are wound with 0.020 in. resistance wire on a mean diameter of 0.200 in. and 10 turns per inch. The alignment between the gun and the helices is uniquely determined by a set of precision quartz rods.

The tube was tested first for its focusing performance. The results obtained are tabulated in Table I.

Because of the large diameter of the present tube envelope, the coupling and attenuation could not be optimized. Hence, the above results are considered particularly promising.

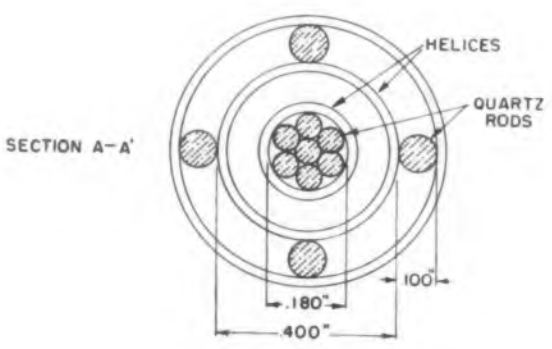
Design curves for optimum geometries of the tube for a given perveance using a minimum focusing field are presented in the paper.

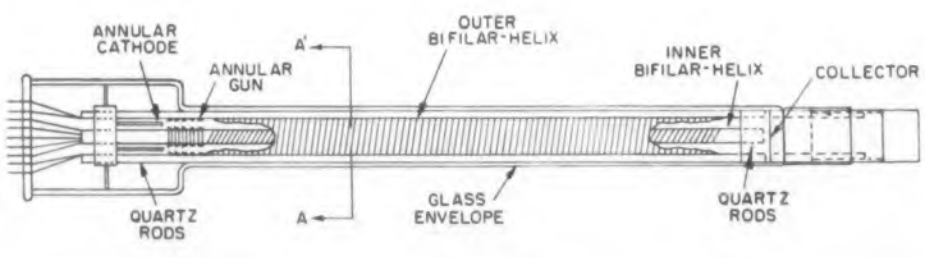
Abstracted from RCA Review Technical Journal, *Volume XIX, Mar., 1958, No. 1, by K.K.N. Chang, RCA Labs., Princeton, N.J.*

Table 1—Experimental Results

DC Performance	
Average helix voltage	200 v.
Bifilar helix voltage	100 v., 300 v.
Collector current	4 ma
Helix-intercepted current	less than .11 ma
Current transmission	97 per cent

RF Performance	
Frequency	2,970 mc
Synchronizing voltage	1,850 v.
Gain	10 db
Output power	100 mw





Assembly of the experimental traveling-wave tube.

TWT Beam Focusing

THE TRAVELING-WAVE tube has an important element located outside the glass envelope—the beam-focusing magnet—which must be precisely designed and its field accurately aligned with the tube axis to insure satisfactory operating efficiency and long life in microwave amplifiers. If the axis of the magnetic field were coincident with the mechanical axis of the magnet and the tube axis, ideal focusing conditions would prevail and the radial field components on the common axis would be zero. However, because the magnetic field builds up to its full value over a finite distance, and because this field may vary somewhat along the axis, there will be radial field components off the axis even under ideal conditions. The principal cause of these transverse field components is in homogeneities of the magnetic material.

Small errors in both positioning the magnetic center and aligning the magnetic axis of the measurement device with respect to the axis of the magnet would result in large errors of measurement. Precise determinations can be made, however, despite errors of positioning and alignment, by a method which is essentially an exploration of the field for axial symmetry. A schematic diagram of the field exploration method is shown in Fig. 1.

A test probe, or search coil, must be used to explore the air-gap field of a magnet. The coil is fixed on a non-magnetic mandrel so that the coil and the mandrel axis are mutually perpendicular. The axis of the mandrel—made coincident with the mechanical axis of the magnet—is the axis of reference. The search coil is connected to a fluxmeter which detects changes in the magnetic flux inter-linking the coil. This flux is due to radial components of the axial magnetic field and to field components resulting from errors in positioning the probe with respect to the mandrel axis.

Thus, the relative position of the probe to the axis remains fixed for all mandrel orientations. The field is axially symmetric if there is no change in flux interlinking the probe when the mandrel orientation is changed by 180 deg. This is true even for large errors of positioning and alignment of the test probe. A resultant change

in flux interlinkage, therefore, is a direct measure of the transverse field at any point on the reference axis in the plane determined by the mandrel and probe axes.

A recording fluxmeter of high accuracy and sensitivity was used in these measurements. This instrument can record field intensities of the order of a tenth of an oersted with a small probe. Originally developed for tracing magnetization curves and hysteresis loops, the fluxmeter has since been adapted to tracing transverse-field patterns.

The test probe is wound on a brass bobbin 0.25 in. in diam and 0.2-in. long with approximately 2000 turns of 1.5-mil, Formex-insulated copper wire. The probe is mounted in a transverse hole in a 3/8-in. diam bronze rod. This nonmagnetic mandrel is in turn supported in accurately fitted bushings, with its axis coincident with the mechanical axis of the magnet. The orientation of the test probe within the air-gap is read on an index head keyed to a slot in the mandrel. The mandrel is linked to a potentiometer and crank so that turning the crank produces simultaneously a longitudinal motion of the rod and a voltage output from the potentiometer. This output indicates the position of the search coil, and when applied to the X-Y recorder of the recording fluxmeter, moves the pen proportionally. The search coil is directly connected to the fluxmeter, and its output due to a change in inter-linking flux moves the paper drum in proportion to the changes in field intensity.

The recorder thus traces a curve of the variation of the resultant of the longitudinal and radial field components parallel to the probe axis. The variation for every point along this axis is recorded as the probe moves with fixed orientation from pole to pole. If the search coil makes the same traversal with a 180 deg change in mandrel orientation, the recorder traces a curve of similar field components parallel to the new probe orientation. The difference in amplitude between these two opposing curves at

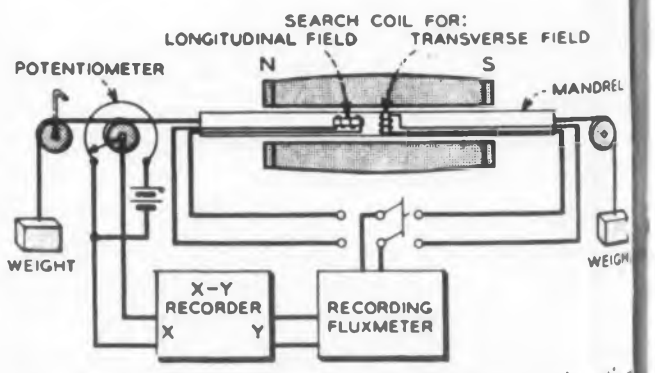


Fig. 1. Schematic diagram of the field-exploration method showing arrangement of components.

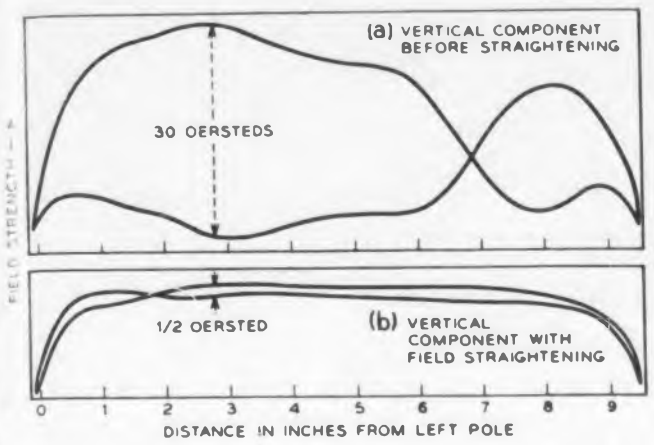


Fig. 2. Transverse-field patterns of field before straightening (top), and field after installation of field-straightener in the air-gap (bottom).

any point along the axis is a measure of the resultant radial field—defined earlier as the transverse field. If there were no transverse-field components, the two curves would coincide. To get a complete picture of the transverse-field components present in the air-gap, the distribution patterns in two right-angle planes are generally plotted for each magnet. For plotting the longitudinal field, a second coil is mounted on the mandrel with its axis coincident with the mandrel axis. Longitudinal- or transverse-field distribution curves can then be taken by simply switching the fluxmeter to the appropriate coil. Field misalignments corresponding to transverse fields of thirty oersteds are not unusual, as illustrated by the patterns in Fig. 2

Traverse components of this magnitude would cause complete interception of the electron beam by the helix of the traveling-wave tube.

Although manufactured to very strict specifications and from the best obtainable permanent-magnet materials, beam-focusing magnets cannot be used "as manufactured" because of serious field misalignment. This condition, however, can be counteracted by "field straightening." A very effective field straightening device has been developed at Bell Laboratories. This device consists of an assembly of permalloy discs and aluminum spacers. The field-straightening assembly is inserted in the air-gap along the axis of the magnet. The discs shield the space between them from transverse fields and, as plane-perpendicular, equipotential surfaces, they direct the longitudinal field parallel to the axis. The effectiveness of a permalloy-disc field-straightener is illustrated by a comparison of the transverse-field patterns before and after correction shown in Fig. 2.

Abstracted from an article by P. P. Cioffi, Bell Laboratories Record, *Vol. XXXVI, No. 5, May 1958, pp. 172-175.*

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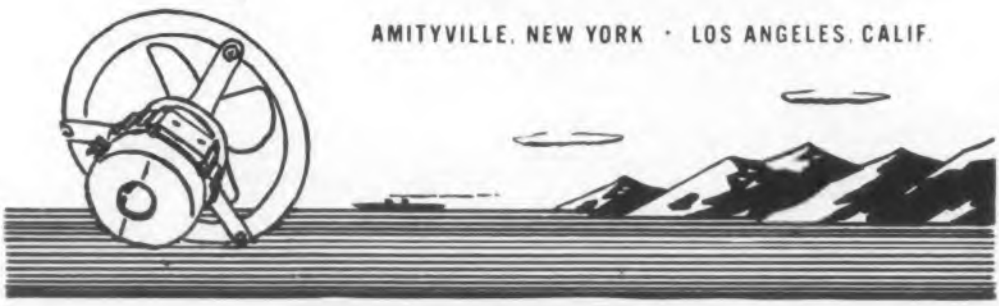

CIRCLE 505 ON READER-SERVICE CARD

ABSTRACT

Thermo-Compression Bonding

Development of high-frequency transistors has been hampered by the inability to form reliable electrical contacts between extremely fine wires and minute areas of semiconductor crystals. A promising solution to this problem has been found at Bell Laboratories using thermo-compression bonding.

WHEN structures are to be fabricated to virtually microscopic dimensions, an imposing mechanical difficulty is that of securing a bond between very thin electrical conductors and the semiconductor. The bond must be accurately positioned in a small area; it must have the least possible effect on the electrical characteristics of the semiconductor; and it must be mechanically strong and reliable. This difficulty is substantially overcome by thermo-compression bonding.

This bonding process does not involve liquid phase formation and hence avoids problems of alloy depth control, wetting and chemical contamination associated with soldering and alloying techniques. As shown in functional schematic form in Fig. 1, it merely involves the application of heat and pressure to the members being bonded. When these are applied for a few seconds, adhesion occurs.

The most important issue involved in application of thermo-compression bonds to semiconductors is the possible mechanical damage to the semiconductor. Fig. 2 relates temperature and pressure of bonding to brittle fracture and plastic stress of silicon and germanium. The shaded area represents the region of successful bonding; it encompasses all the pressure and temperature conditions used to date to bond gold, silver, aluminum and various alloys of these materials to silicon and germanium.

By noting the distance of the bonding

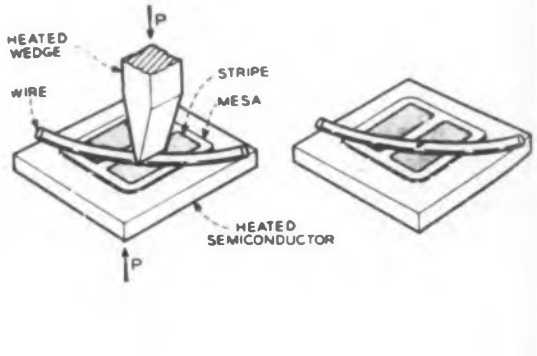

Fig. 1. Representation of the bonding process. Heat and pressure produce the bond with very little contamination of the semiconductor material.

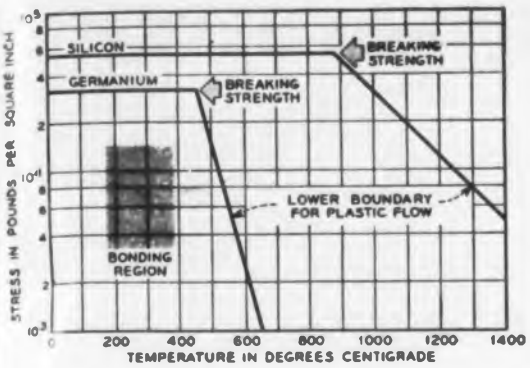

Fig. 2. Tensile-strength curves for brittle fracture (horizontal lines) and plastic yield (steep lines) for germanium and silicon. Bonding region for experiments (shaded area) is well inside these limits.

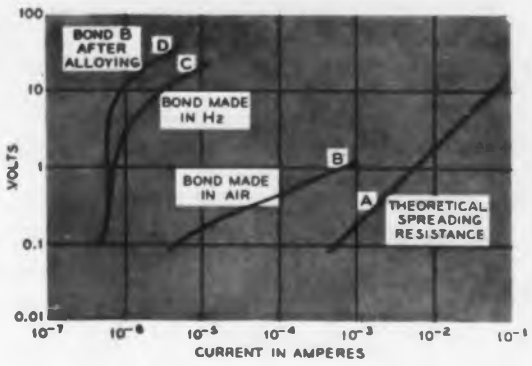

Fig. 3. Theoretical "spreading resistance" (A) compared to actual voltage-vs-current characteristic curves for bonds made by the various methods.

region from the curve for germanium, it is apparent that sufficient margins exist for both temperature and breaking strength. The curve for the onset of plastic flow in the crystal is at least 100 C from the bonding region, and along the vertical axis, breaking stress is seen to be at least double the highest stress used for bonding. It is also apparent in Fig. 2 that silicon is even better in these respects. Actually, since no compression data for silicon and germanium are available, tensile-strength values are plotted in Fig. 2, which means that the safety factors are still higher. Several thermo-compression bond areas have been studied, and no increase in density of dislocations associated with plastic flow or cracking has been found.

The electrical characteristic of a metal-to-germanium thermo-compression bond is of considerable interest, both for potential application in device technology and also for the investigation of a metal-to-semiconductor interface. When carefully formed, bonds of this sort give either rectifying or nonrectifying (ohmic) contacts in accordance with surface doping produced by the bonding wire.

Fig. 3 illustrates the conditions under which rectification is produced in a thermo-compression bonded contact of an aluminum wire to a block of n-type germanium. For the germanium under this type of bond, curve *A* shows theoretical values of spreading resistance—the resistance introduced by the crowding of flow lines of electricity in the germanium as they come to the confining area under the bond. Curve *A* is to be compared with curve *B*, which represents actual data obtained from a contact bonded in air. As can be seen, this curve is intermediate to curve *D*. Data for curve *D* were obtained after bond *B* was heated to a temperature slightly above the aluminum-germanium eutectic —the lowest temperature that gives a liquid phase when Ge and Al are heated (425 C). Curve *C* shows the effect of using a hydrogen atmosphere for bonding instead of air. In this case, we have a bond that forms a rectifier which will saturate. The difference between curves *B* and *C* is accounted for by the contamination introduced by the air ambient. Trace contamination on either the wire or the germanium surface probably accounts for the difference between curves *C* and *D* seen in Fig. 3.

One distinct possibility for application of this type of bond is the process illustrated by curve *D*. At the expense of introducing a liquid-phase eutectic into the process, we can form both an electrode and a lead in one operation. A measure of control of alloy depth is obtainable in this case because the liquid-phase eutectic forms at one or two degrees above the eutectic temperature, and wetting occurs over the bonded area. Another feature of alloy depth control is the fact that the lead wire can be of eutectic composition, so that it does not require much germanium to go into solution to form the liquid phase.

Abstracted from the article Electrical Contact with Thermo-Compression Bonds by H. Christensen, Bell Laboratories Record, *April, 1958, pp 127.*

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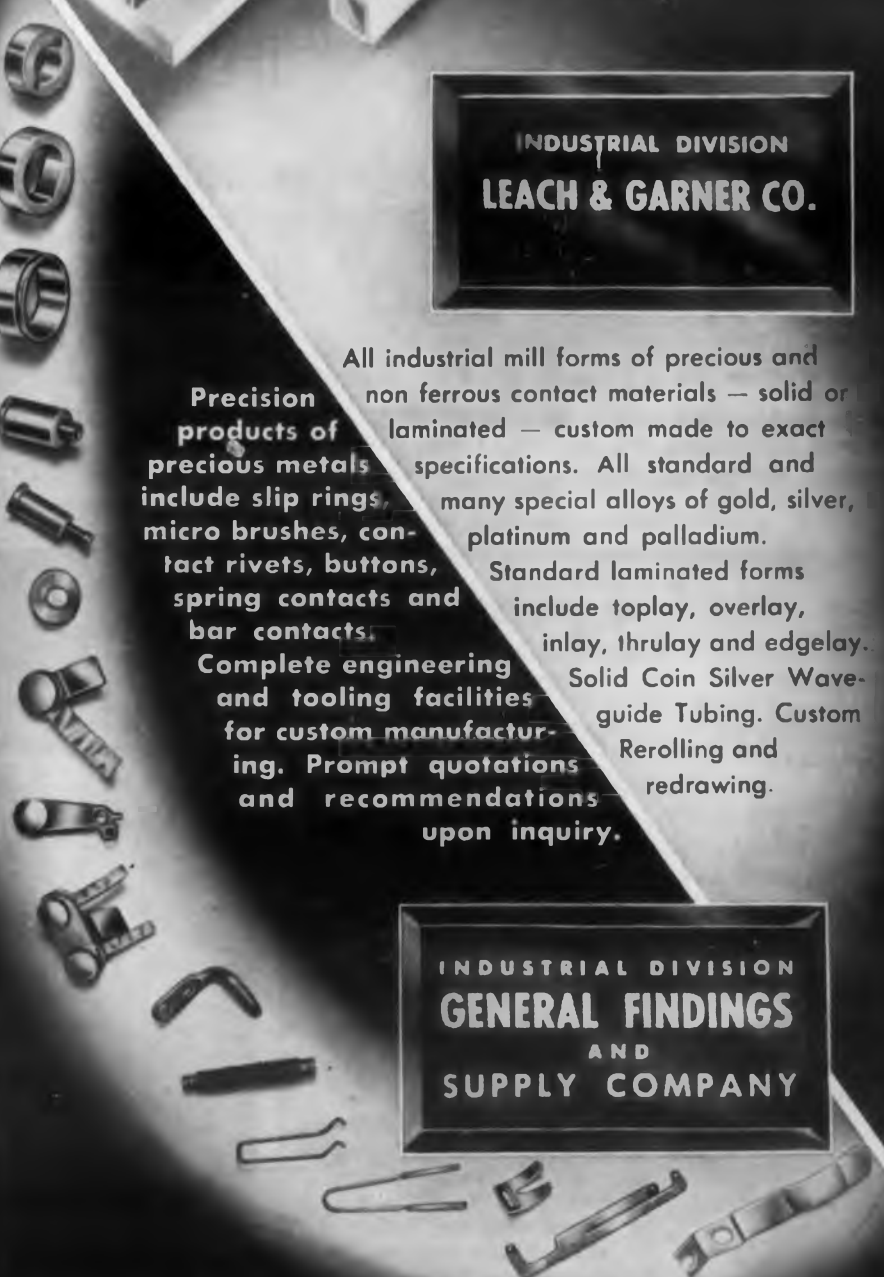

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STANDARDS AND SPECS

Sherman H. Hubelbank

Aircraft Equipment

ANA Bulletin No. 444, Design Criteria for Piloted Aircraft Electronic Equipment, 26 November 1957

This bulletin supersedes MIL-E-25647(USAF), dated September 4, 1957. Although this spec supersedes MIL-E-25647 there are few changes. One of the major changes is that the title of the spec now is directed strictly toward piloted aircraft applications. The earlier spec was directed toward all airborne electronic equipment. MIL-E-5400 is no longer referenced as an applicable spec. This bulletin now covers the philosophy of design of equipment within the scope of MIL-E-5400. Major policy as a major design factor has been deleted. Hazards to safety have been deleted as a function of reliability. Design considerations have been added to include heat transfer problems and techniques, as well as a cooling

system compatible with the aircraft in which the equipment is to be used. Definitions have been added to cover terms such as research model, breadboard model, experimental model, developmental model, service test model, prototype model, preproduction model, and production model.

Canadian Standards

CSA Code C22.1-1958 (7th Edition), Essential Requirements And Minimum Standards Covering Electrical Installation For Buildings, Structures, And Premises (All Potentials)
This code represents the result of continuous study of current Canadian practices and contemporary codes of practice dealing with electrical installations for buildings, structures, and premises. A voluntary code, it is intended to establish essential requirements and minimum standards for the installation and maintenance of electrical equipment for adoption and enforcement by electrical inspection departments throughout Canada. Copies may be ordered directly from the Canadian Standards Association, 235 Montreal Road, Ottawa 2, Canada, for $1.50 per copy.

CSA C22.2 No. 11-1957, Fractional Horsepower Electric Motors For Other Than Hazardous Locations
This standard covers fractional-horsepower electric motors for potentials up to, and including, 600 volts between conductors. These motors are designed for general domestic, commercial and industrial applications in ordinary non-hazardous locations. Copies of this standard may be obtained from the Canadian Standards Association, 235 Montreal Road, Ottawa 2, Canada for $1.00 per copy.

Resistors

MIL-R-11C, General Specification for Fixed Composition (Insulated) Resistors, 31 March 1958
Tests and requirements for acceleration, shock, and high-frequency vibration have been added. Two new styles of resistors have been added. A seal test applicable to styles RC08 and RC22 only has been added.

MIL-R-93B, General Specification for Fixed Wirewound (Accurate) Resistors, 31 March 1958
Tests and requirements for acceleration, shock, and high-frequency vibration have been added. A characteristic C specifying a maximum ambient temperature of 125°C at rated wattage has been added. Four new resistor styles have been added.

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7111	8500-9600	hand-tunable	220	0.001	200
A-1127	8500-9600	hand-tunable	280	0.001	200
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