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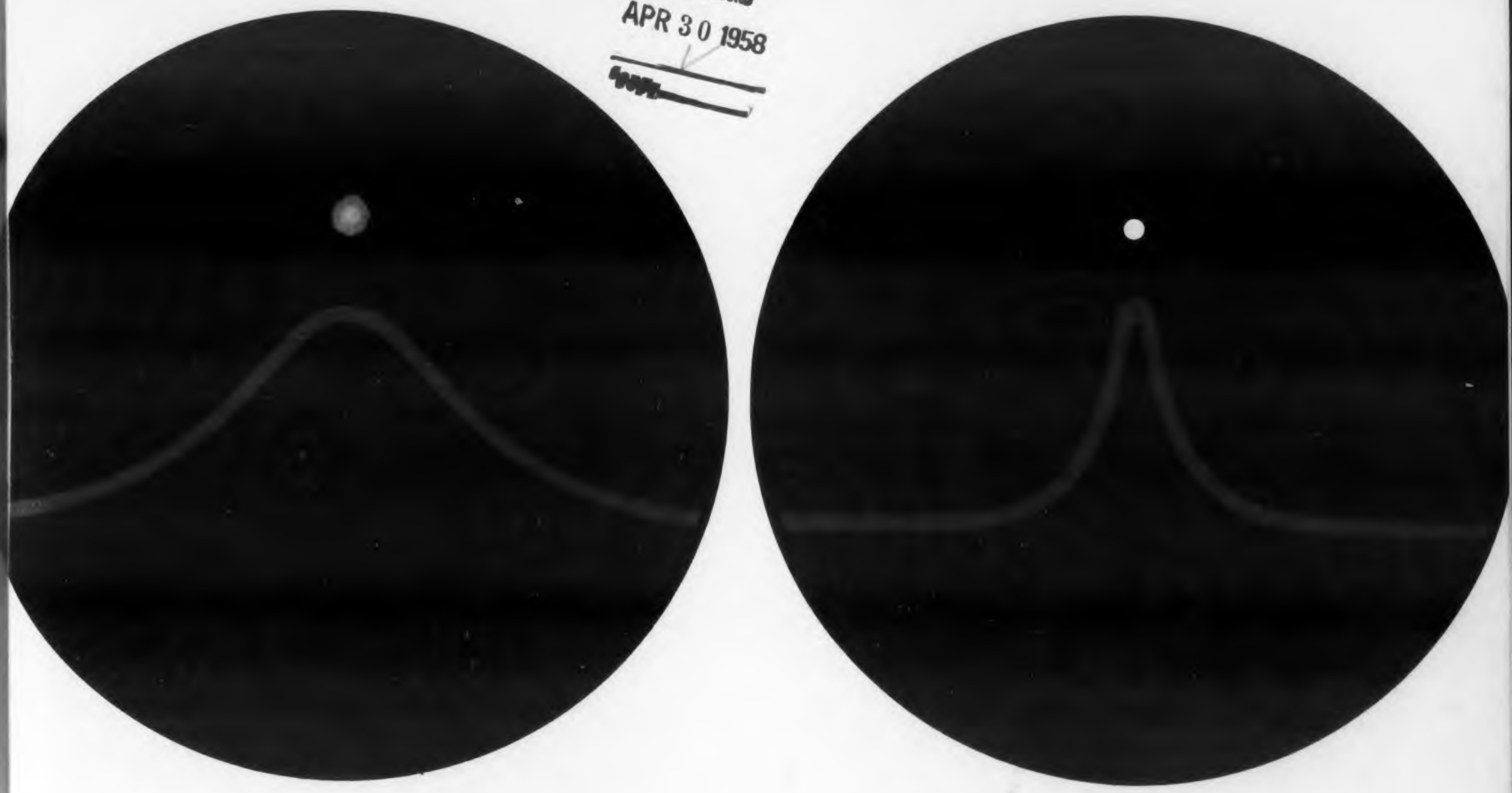
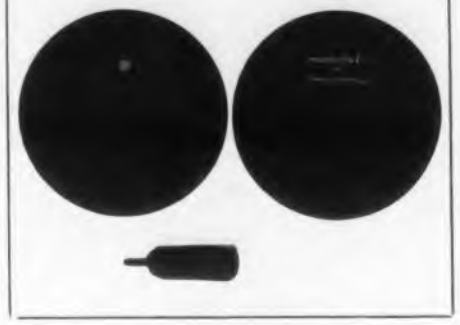


New 6000-line Resolution CRT . . . p 30

ELECTRONIC DESIGN



COVER STORY

New 6000-line Resolution CRT ..... **p 30**

Design of the electron gun and electron optics and use of new phosphors permit a resolution equal to 6000 TV lines in this cathode ray tube. The curves on the cover represent the spot profile of this tube compared to a conventional tube at the same intensity level. The high resolution tube has a sharp, well-defined spot as compared to the usual hazy image of other tubes with their tendency towards blooming. The tube is expected to be particularly useful in airborne radar photography techniques at high speed.

Optimum Design of Power Transformers and Saturable Reactors, Part 1 ..... **p 26**

Here's how to design the lightest transformer to do the job. This article, with its nomograms, can help you design your transformer with the best core configuration and wire size.

The Uniterm System of Filing ..... **p 48**

Mr. Bell presents a solution to a problem which has often plagued the design engineer: How to file away technical reference material without giving up hope of ever seeing it again. A lucid explanation of the Uniterm system is given, along with a description of how it saves a typical engineer from the throes of conventional indexing.

ELECTRONIC DESIGN

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Company

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Old Company Address

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NBP BPA

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New Speed...Versatility...Reliability...

TRANSISTORIZED DIGITAL MAGNETIC TAPE HANDLER MODEL 906

Optimum performance in virtually all tape handling applications

The advanced design of the completely transistorized Potter Model 906 Tape Handler provides improved performance in virtually any tape handling application.

Replaceable Capstan Panel permits use as Perforated Tape Reader with a remarkable new brake capable of stopping on the stop character at speeds up to 1000 characters per second. Using a small vacuum loop buffer, Model 906 features:

- Complete front accessibility—single panel construction
- Pinch rollers capable of 100 million start-stop operations
- In-line threading, end of tape sensing and tape break protection
- Speeds up to 150 ips
- As many as 4 speeds forward and reverse
- Capable of continuous cycling at any frequency from 0 to 200 cps without flutter
- Rewind or search at 400 ips
- 3 millisecond starts
- 1.5 millisecond stops
- Tape widths to 1-1/4"
- Up to 47 channels
- All functions remotely controllable

The 906 may be supplied with a transistorized Record-Playback Amplifier featuring a separate module for each channel. Electronic switching from record to playback function is available as an optional feature.

Other Potter products include Transistorized Frequency Time Counters, Magnetic Tape Handlers, Perforated Tape Readers, High Speed Printers, Record-Playback Amplifiers and Record-Playback Heads.

POTTER INSTRUMENT COMPANY, Inc.

Sunnyside Boulevard, Plainview, New York

OVerbrook 1-3200

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ENGINEERING REVIEW

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

Machine Tool Line Completely Automated

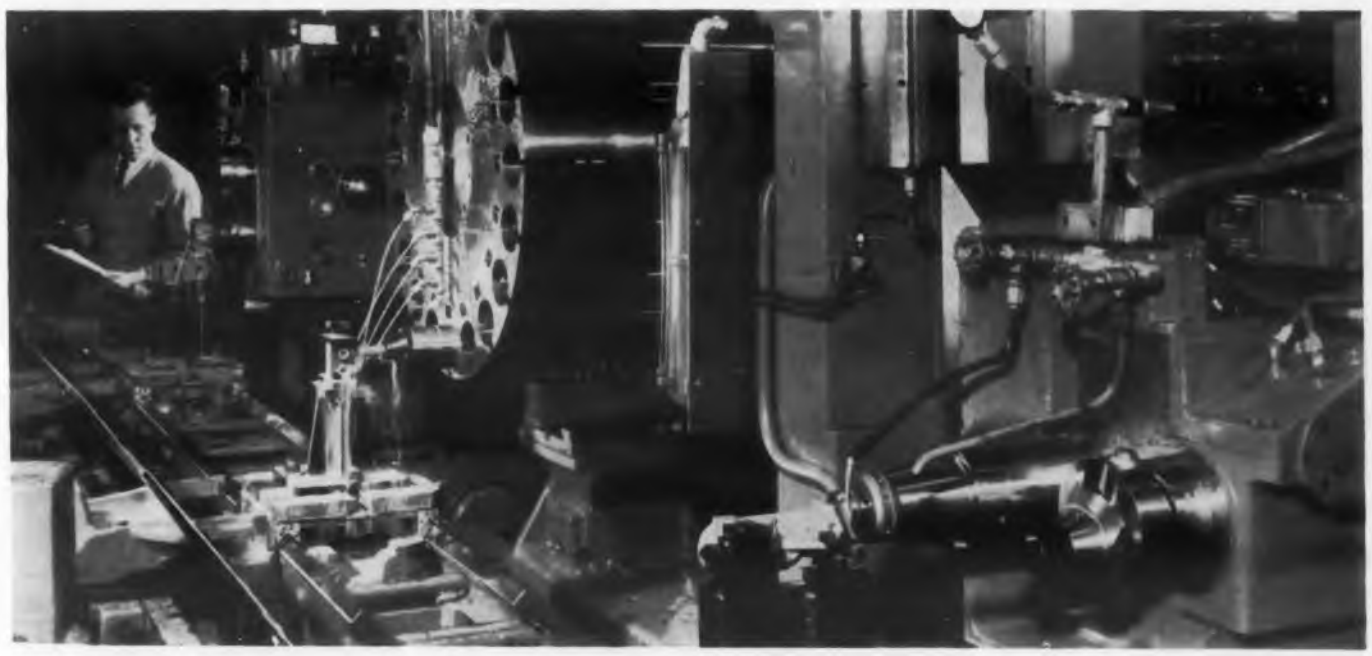
The first successful line of machine tools, controlled entirely electronically and operated from punched tapes was revealed by the Hughes Aircraft Corp., Los Angeles, Calif.

Transistorized digital computers control the information contained on the tapes including dimensions, positioning, and cutting orders, and machine sequence data. This information is obtained from blueprints, listed on a simplified planning sheet, and transcribed to the tape.

Machines can work on a series of successive operations and make a variety of parts at the same time with the Digitape System. Changes in operations may be introduced or production may be started on new parts by changing the tapes without stopping the machines.

The integrated machine line is built on the "building block" principle with both machines and controls constructed to fit together in any desired number and arrangement. The prototype demonstrated by Hughes consisted of milling, drilling and boring machines, built by Kearney & Trecker Corp., Milwaukee, Wis.

(Continued on next page)



Completely operated by Digitape electronic controls, the milling, drilling, and boring machines (above, l. to r.) pass parts along automatically. Transistorized digital computers convert information contained on tapes (at right) into operational instructions.

ENGINEERING REVIEW

The system is particularly suited for the aircraft industry since it makes available mass-production techniques for small-lot production. In addition, substantial savings are effected since tooling requirements are reduced by as much as 50 per cent and "set-up" operation time is virtually eliminated.

High Speed Airline Reservations System

An airline reservations system capable of handling more than 8,000,000 seat reservations per month is in operation. Located at Braniff International Airways, Dallas, Tex., the equipment is connected directly by 18,000 miles of teletype with 140 offices in the United States. The system maintains an inventory on 250 flights per day for 31 days ahead and the system makes it possible to sell or cancel space in less than one second.

Microfilm Eases Blueprint Filing

A photographic technique which eliminates the cumbersome problems associated with the accumulation of obsolete or duplicate specification control drawings is being utilized by Arma Corp., Hempstead, N.Y.

The method, conceived by Robert Harding, head of the Engineering Standards Section, consists of microfilming the drawings on file and processing them into individual 35 mm slides according to particular standard part categories. Upon evaluation of the prints, those which are still functional are reproduced from the slides on 8-1/2 x 11 in. sheets and included in a Parts Manual for distributions requiring component and material information. The process is reportedly far less costly than former methods.

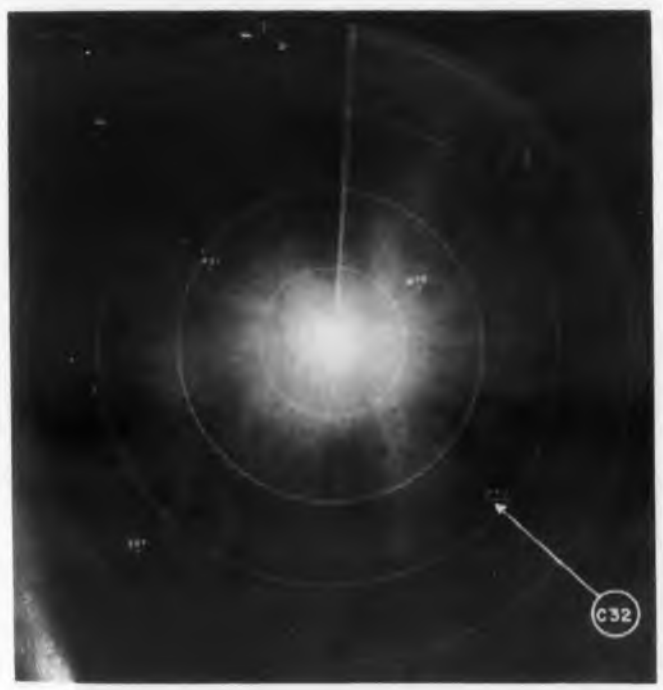
◀ CIRCLE 4 ON READER-SERVICE CARD

Radio Ruffles Rustlers

The natives need not be restless anymore, at least most of them anyway.

The high incidence of cattle stealing in the Karamoja district of Uganda has led the Police authorities to install a vhf radio network as a means of curtailing the sporadic raids of local tribes on the herds of neighboring villages. Fourteen local constabularies have been equipped with Marconi Type HX86A/HR86A fixed station transmitter/receivers working into a nearby post through a repeater station built on a 7000 ft. point within range of all the fixed stations. Both the headquarters and repeater stations are equipped with duplicate installations. The repeater station is designed to operate unmanned, but should a fault arise in the radio equipment or generating plant a warning bell is rung in the guard hut nearby and the switchover to standby equipment is carried out manually.

To their neighbours the Karamajong raiders are naturally a continual nuisance and menace but it is noticeable that those Government Officers who work among them soon tend to regard them as "naughty but in their own way pleasantly virile people."



Alphabet Radar: Help for overburdened traffic control systems is on the way with an electronic tube that identifies radar and TV images with letters, numbers, or symbols. Identified as type C19Q, this latest CHARACTRON Shaped Beam Tube, developed at Stromberg-Carlson, San Diego 12, Calif. uses the infinitesimal fraction of a second between radar pulses to form character displays. Thus, a plane image can be accompanied by symbols which show its identity, type, destination, and position. The tube can display 50,000 clear characters per second. A controller may enlarge, blink, intensify, or dim the symbols at will.

ENGINEERING REVIEW

Below-the-Horizon Navigational System Built

A navigational system accurate to within 20 ft on or above a battleground has been developed. Built originally for control of air and marine traffic the beyond-the-line-of-sight navigational system has been adapted to monitor closely-knit tactical operations of land and air forces.

The low frequency system, developed by Bendix Aviation Corp., required pairs of master and slave sending stations which transmit wave patterns occupying precisely known and stable geographical positions to form accurate position lines. These sightings are picked up by receivers in a vehicle, plane, helicopter, or fixed field unit position and automatically computed and displayed visually on standard army maps and charts.

The Currents of Time

An electronic review of outstanding historical events from 4 B.C. to the present in any of ten languages will be demonstrated in the U.S. Pavillion at the Brussels World's Fair. The automated history text is stored in an IBM 305 RAMAC computer. Any portion of the history may be located by RAMAC in less than two-thirds of a second and printed out in any one of the ten languages on a built-in IBM electric typewriter.

The memory section of the RAMAC consists of a stack of record disks which revolve on a vertical shaft at 1,200 rev per min. An electronically controlled arm moves to any location on the records to recover the historical information, which is stored on the records as magnetized spots. The unit contains up to five million alpha-numeric characters.

The history text can be printed out in English, French, Italian, Nederlands, Spanish, Swedish, Portuguese, and German, Russian and Interlingua.

◀ CIRCLE 6 ON READER-SERVICE CARD

Step Lightly

With a thickness of less than 1 millionth of an inch, this film of aluminum oxide supports itself as well as the spider moving across it. Made by chemically dissolving away everything except the rust on one surface of a piece of ordinary aluminum foil, the films are used by Westinghouse research scientists in the construction of experimental electronic tubes. The films are also of interest because they represent, essentially, two-dimensional solid matter.

Supervoltage Generator Inspects Rocket Fuel

Van De Graaf high x-ray generators are being used to inspect solid rocket and missile fuel charges surpassing the efficiency of existing methods. Internal cavities, cracks, fissures, or bits of foreign material are investigated by lowering the radiographic generating unit into the hollow core of the fuel. A special 10-foot electron tube extension for a standard supervoltage machine was devised which slips down into the propellent core. High energy x-rays are generated from the tip of the tube to concentrate x-ray intensity in one direction of a relatively acute angle.

Previously, inspection of solid propellents required radiographic film to be wrapped around the outer surface of the missile, or arranged in a flat plane. X-rays were passed diametrically through the fuel, and the film was exposed. Limitations in this technique resulted from the high loss of intensity incurred by the x-rays as they passed through the entire thickness of the missile before exposing the film. The system was developed jointly by High Voltage, Engineering Corp., Thiokol Chemical Corp., and the Friez Instrument Division of Bendix Aviation Corp.

ENGINEERING REVIEW

Explorer Tracking

Tracking of the signal from the 10 milliwatt transmitter in the Explorer Satellite for distances in excess of 2,000 miles is achieved with a tracking filter.

Working in conjunction with a conventional broadband receiver, the filter is capable of following doppler signals with low signal-to-noise ratios in the order of —40 db. The filter is, in effect, a bandpass filter with an automatically variable center frequency which tracks the frequency of the received doppler signal. The information bandwidth of the filter is easily adjusted over a wide range to accommodate known changes in the characteristics of the received signal during actual tracking.

The Model III Filter was designed and developed specifically for the Ballistic Research Lab as an essential element in their Earth Satellite Instrumentation System by Interstate Electronics Corp., 707 East Vermont Ave., Anaheim, Calif.

Power Absorption Equipment Tests Atomic Plant

Power absorbing equipment designed to test the land based atomic power plant of a large naval surface vessel is being installed at the AEC Facility, near Arco, Idaho. The equipment consists of a huge slow-speed generator which will be connected to the main shaft of the geared turbine propulsion unit. The generator will simulate loads placed on the propeller during actual operations and over a speed range generally associated with an aircraft carrier.

The power absorber generator, designed by Westinghouse Electric Corp., Pittsburgh, Pa., is 28 ft. long, 23 ft. in diameter, and weighs approximately 280 tons. High-temperature silicone insulation has been used to hold weight and size of the unit to a minimum.

◀ CIRCLE 8 ON READER-SERVICE CARD

Adapter For Single Side-Band Broadcasting

A system designed to convert any standard high-level, low-level, or Doherty type AM transmitter to a type of single-sideband operation has been announced. Transmitters can be adapted without engineering modifications, and reception is completely compatible on all existing AM receivers with the single-sideband transmitter adapter.

The unit, developed by Kahn Research Labs., Inc., 22 Pine St., Freeport, N.Y., includes a test unit permitting simple, direct measurements of desired, undesired, sidebands and associated equipment.

The adapter is presently being tested daily on WABC in New York and has been in continuous use for over a year and a half on Voice of America's megawatt station in Munich, Germany.

Technical Information Center Established

A Foreign Technical Information Center within the Department of Commerce has been established to aid in disseminating scientific knowledge according to Secretary of Commerce Sinclair Weeks.

The Center will collect, evaluate and distribute valuable foreign scientific and technical literature for the use of American scientists and engineers. Plans have been worked out for public distribution of information from such organizations as the National Science Foundation, Atomic Energy Commission, the Armed Services and the intelligence agencies.

Arrangements have been made to obtain from these and other agencies copies of abstracts and translations of foreign technical articles, monographs, and books. It is estimated that these will be supplied at an annual rate of 50,000 abstracts and 10,000 complete translations.

A staff of engineer-translators will be added to review and analyze foreign publications and select those of greatest value.

CIRCLE 9 ON READER-SERVICE CARD ➤

ENGINEERING REVIEW

Final Tests for Tester

This test stand which checks out the Ramjet Engines of the Bomarc missile, undergoes final checks before the stand is shipped to Patrick Air Force Base in Florida, from which Bomarc missiles are fired. Considered the most potent of all air-defense intercepters, the Bomarc has an estimated range of 200 to 300 miles, reaches an altitude of 60,000 ft and has a Mach 3 speed. The stand was built by Greer Hydraulic, Inc., New York International Airport, Jamaica, N.Y.

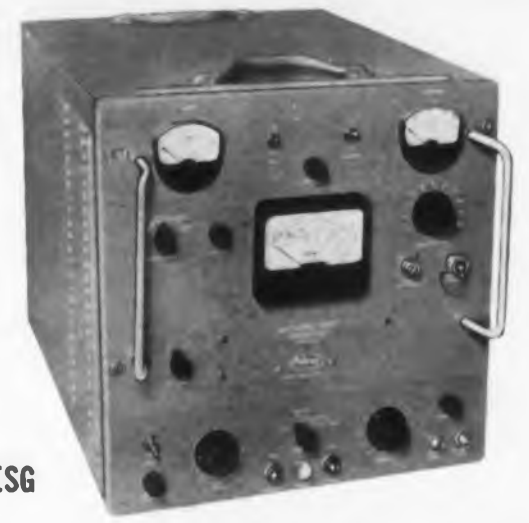
Reconnaissance Camera for Supersonic Aircraft

An aerial reconnaissance camera for taking low altitude photographs from supersonic aircraft has been developed. The initial application of this model camera will be in the nose of the McDonnell RF-101 jet.

Designed by Hycon Mfg. Co., Pasadena, Calif., the LA-11A takes 9 x 9 in. pictures using 9-1/2 in. roll film at rates up to two per sec. The camera operates at shutter speeds from 1/200 sec to 1/1600 sec utilizing a focal plane shutter making very high shutter speeds possible with a large aperture lens. It stops motion on forward oblique photographs that cannot be satisfactorily compensated for by image motion compensation.

Control of the camera is accomplished from the cockpit by use of the Universal Camera Control System (UCCS) which, by servomechanism control, sets the rate of cycling, starts and stops the camera, and changes the exposure. The focal plane shutter is internally coordinated with the lens iris. For increasing exposures, the shutter operates at top speed until the iris is fully open. The exposure control mechanism then begins to decrease the shutter speed until it reaches 1/200 of a sec. The opposite takes place when exposures are decreased.

The camera has a 12 in. focal length, fixed focus, and a maximum aperture of f/3.8. With the A-9B film magazine mounted on the camera, nearly 500 pictures can be taken on a mission.

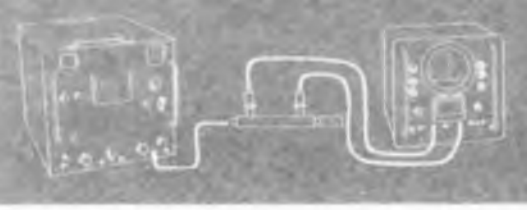


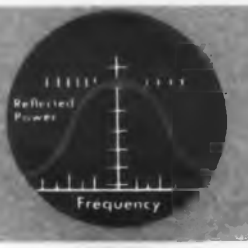
Model ESG

All Electronic MICROWAVE SWEEP GENERATOR

- **Dynamic Measurements, Rapidly**
- **High Power Source**

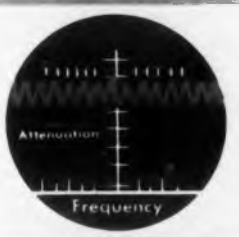
1,000 to 15,000 mc





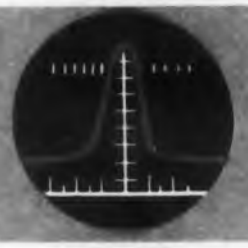
MEASUREMENT OF VSWR OR PERCENT POWER REFLECTION

By employing an ESG along with a Rapid Scan Ratio-Scope (Model VS-1) in a reflectometer system set-up, accuracies equivalent to those obtained with the use of a slotted line can be achieved, by an untrained technician, in a fraction of the time formerly required. A two-to-one frequency range is provided. 7 interchangeable microwave oscillator units enable measurements to be made at microwave frequencies of 1000 to 15,000 mc.



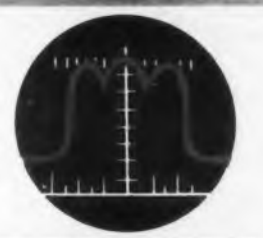
ATTENUATION MEASUREMENT

Broadband attenuation measurements are easily made with an ESG and Rapid Scan Ratio-Scope (Model VS-1). Attenuation of the unit under test is read directly on the ratio-scope indicator. Attenuation measurements can be made either at single frequency or over a band of frequencies (ESG sweeps its full frequency range).



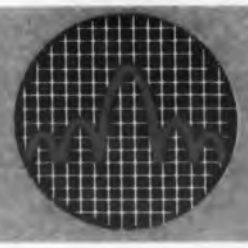
MEASUREMENTS OF Q

The use of a Model ESG enables rapid visual instantaneous measurement of high and low Q. This cuts down engineering man hours when compared with laborious point-to-point Q measurements. The diagram shows a typical set-up utilizing a standard oscilloscope.



FILTER ALIGNMENT AND BANDPASS MEASUREMENTS

Because of the ESG's rapid sweep, the complete characteristics of a filter can be observed and measured instantaneously, utilizing a standard oscilloscope. The ESG's high power output enables determination of the filter's offband response. Dynamic measurements across the entire frequency range of the filters are possible because the stable backward wave oscillator in the ESG sweeps the full frequency range of the filter.



ANTENNA PATTERN MEASUREMENTS

By using an ESG to feed an antenna under test, accurate pattern measurements can be obtained over long distances and over a wide frequency range. This because of the ESG's high stable power output from 10 milliwatts to 1 watt. Provision is made in the instrument for amplitude modulation from external source and internal 1000 cps and 456 kc square wave modulation is provided.

POLARAD *IN ACTION*
PROVEN RELIABILITY

POLARAD ELECTRONICS CORPORATION

43-20 34th Street, Long Island City 1, New York

REPRESENTATIVES: Abington, Albany, Atlanta, Baltimore, Boeing Field, Chicago, Cleveland, Dayton, Denver, Detroit, Englewood, Fort Worth, Kansas City, Los Angeles, Orlando, Portland, Rochester, St. Louis, Stamford, Sunnyvale, Syracuse, Washington, D.C., Westbury, Westwood, Wichita, Winston-Salem, Canada: Arnprior, Ontario. Resident Representatives in Principal Foreign Cities.

Polarad Model ESG Microwave Sweep Generator utilizes stable backward wave oscillators to make possible rapid dynamic tests of broadband and narrowband microwave systems and components. This instrument covers the frequency range from 1000 to 15,000 mc by use of 7 interchangeable microwave oscillator units, each of which can be purchased separately. The ESG can be externally modulated, providing a pulse rise time less than 0.15 microsecond.

Contact Polarad or your nearest Polarad representative for complete details.

Polarad Model VS-1 Rapid Scan Ratio-Scope is available to provide visual presentation of VSWR and attenuation.

SPECIFICATIONS: **Basic Unit:** Model E-B

INTERCHANGEABLE PLUG-IN UNITS

MODEL	FREQUENCY RANGE	POWER OUTPUT	MODEL	FREQUENCY RANGE	POWER OUTPUT
Model E-L1	1,000 to 2,000 mc	80 to 1,000 mw	Model E-C2	4,800 to 9,600 mc	20 to 150 mw
Model E-L2	1,600 to 3,200 mc	80 to 1,000 mw	Model E-X1	6,500 to 11,000 mc	20 to 100 mw
Model E-S1	2,000 to 4,000 mc	80 to 800 mw	Model E-X2	7,500 to 15,000 mc	15 to 40 mw
Model E-C1	3,600 to 7,200 mc	25 to 400 mw			

CODE MODULATED MULTIPLE-PULSE MICROWAVE SIGNAL GENERATOR

950-10,750 mc

An integrated mobile instrument. Generates multi-pulse modulated carrier for missiles, beacons, radar, DME, Tacan, Loran... provides 5 independently adjustable pulse channels. Variable pulse width, delay and repetition rate; and pulse time modulation.

SPECIFICATIONS:

Frequency Range:
- Band 1: 950 to 2400 mc.
- Band 2: 2150 to 4600 mc.
- Band 3: 4450 to 8000 mc
- Band 4: 7850 to 10,750 mc

Frequency Accuracy: ±1%

RF Power Output: 1 milliwatt (0 DBM)

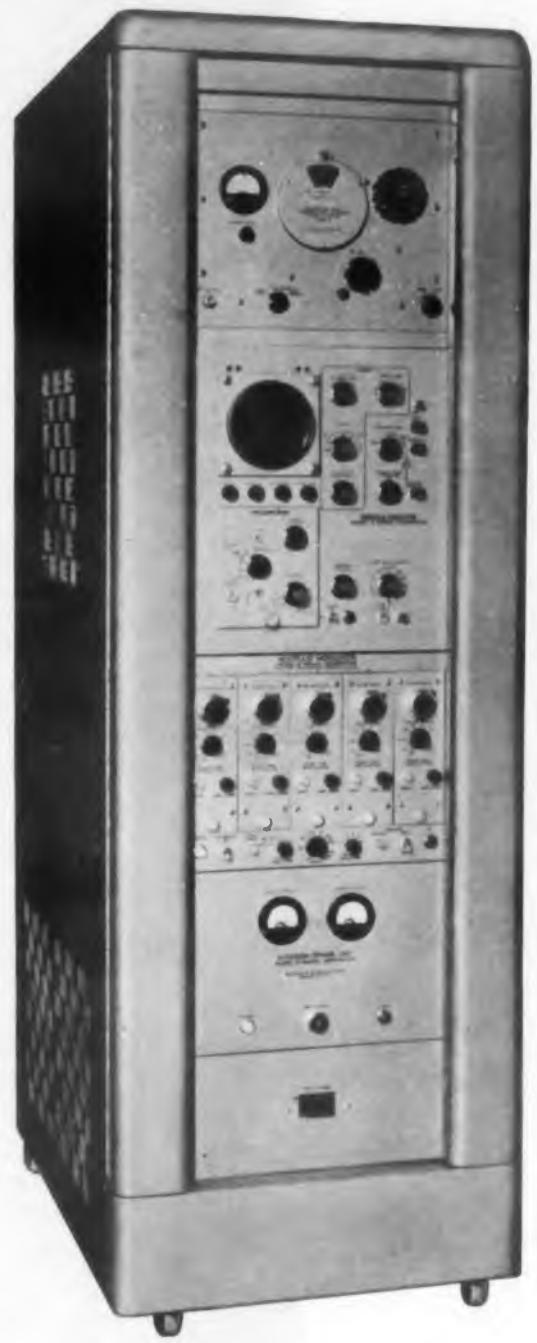
Attenuator:
- Output Range: 0 to —127 DBM
- Output Accuracy: ±2 db
- Output Impedance: 50 ohms nominal

RF Pulse Characteristics:
- a. Rise Time: Better than 0.1 microsecond as measured between 10 and 90% of maximum amplitude of the initial rise.
- b. Decay Time: Less than 0.1 microsecond as measured between 10 and 90% of maximum amplitude of the final decay.
- c. Overshoot: Less than 10% of maximum amplitude of the initial rise.

Internal Pulse Modulation:
- No. of Channels: 1 to 5 independently on or off
- Repetition Rate: 40 to 4000 cps.
- Pulse Width: 0.2 to 2.0 microseconds
- Pulse Delay: 0 to 30 microseconds
- Accuracy of Pulse Setting: 0.1 microsecond
- Minimum Pulse Separation: 0.3 microsecond
- Initial Channel Delay: 2 microseconds from sync. pulse
- Internal Square Wave: 40-4000 pps (separate output)

Pulse Time Modulation:
- Frequency: 40-400 cps any or all channels
- Required Ext. Mod.: 1 volt rms min.
- Maximum deviation: ±0.5 microsecond

Power Input (built-in power supply) 105/125 v. 60 cps 1200 watts.



FOUR INTERCHANGEABLE MICROWAVE OSCILLATOR UNITS — all stored in the instrument . . . each with UNI-DIAL control . . . precision power monitor circuit to maintain 1 mw power output reference level . . . keying circuit to assure rapid rise time of modulated r-f output . . . non-contacting chokes.

PRECISION OSCILLOSCOPE WITH BUILT-IN WIDE BAND RF DETECTOR for viewing the modulation envelope and accurately calibrating the r-f pulse width, delay, and group repetition rate. Equipped with built-in calibration markers.

FIVE INDEPENDENTLY ADJUSTABLE PULSE CHANNELS — each channel features variable pulse width and delay; has provisions for external pulse-time modulation. Repetition rate for each group of pulses can be varied.

SELF-CONTAINED POWER SUPPLIES — Model B operates directly from an AC line through an internal voltage regulator. The coded multipulse generator is equipped with an electronically regulated low voltage DC supply. Klystron power unit adjusts to proper voltage automatically for each interchangeable tuning unit.

Model B

Contact your Polarad representative or write to the factory for detailed information.

POLARAD ELECTRONICS CORPORATION

43-20 34th Street, Long Island City 1, New York

POLARAD PROVEN RELIABILITY *IN ACTION*

REPRESENTATIVES: Abington, Albany, Atlanta, Baltimore, Boeing Field, Chicago, Cleveland, Dayton, Denver, Detroit, Englewood, Fort Worth, Kansas City, Los Angeles, Portland, Rochester, St. Louis, Stamford, Sunnyvale, Syracuse, Washington, D. C., Westbury, Westwood, Wichita, Winston-Salem, Canada: Arnprior, Ontario. Resident Representatives in Principal Foreign Cities.

Circuit Sentry Isolates Damaged Power Lines

A circuit sentry has been designed to minimize damage to power-system equipment. The device utilizes the transmission of a tone signal to set in motion a series of fault-sensing relays which, in twelve thousandths of a second, actuate circuit breakers and isolate the faulty high-voltage lines.

When a relay detects a fault in a power line, it immediately transmits a tripping signal to its associated transmitter. The signal is, in turn, transmitted to all necessary receivers which cut the damaged line from the network. False tripping is prevented since the transmitted tone signal shifts from an idle frequency to a trip frequency when tripping occurs. The unit will not trip circuit-breakers unless the guard tone is present up to the instant of shift in frequency. A further safeguard against faulty tripping is provided by a special circuit which disables the tripping circuit if the guard tone should fail and operates an alarm. Designated Tru-Trip, the device was developed by RCA, New York 20, N.Y.

600-Pound Instrument Current Transformer Built

A 15-kv transformer weighing 600 lb and having a ratio of 8000:5 amp has been produced by the General Electric Instrument Dept., West Lynn, Mass. Its 16-1/2 inch window will accommodate an 11 x 11 in. bus bar.

Wire for the secondary coil alone weighs 85 lb. The bushings weigh 150 lb. The largest compound-filled transformer of this type previously built by GE weighed 160 lb, with a six in. window diameter.

Six of the units are being built for the Reynolds Metals Co., Listerhill, Ala. and will become part of the protective equipment between TVA and the Reynolds Company aluminum plant.

CIRCLE 11 ON READER-SERVICE CARD ➤

➤ CIRCLE 12 ON READER-SERVICE CARD

Overall view of profile and contour milling machine flanked by bank of magnetic, electronic, and tape transport cubicles.

Automatic Small Quantity Production Feasible

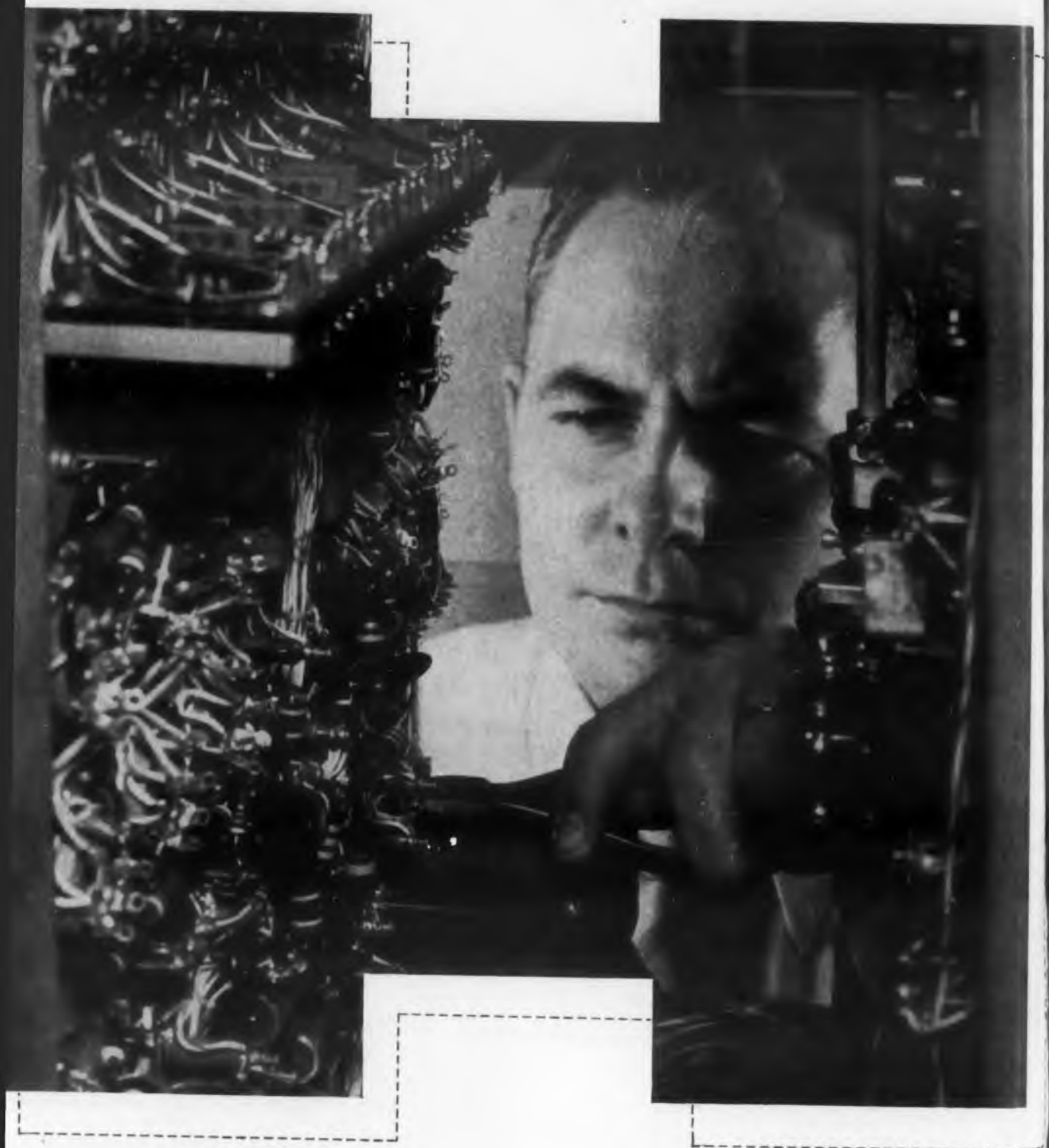
A magnetic tape-controlled profile and contour milling machine has been designed to make automation of small quantity production economically feasible. It is designed to machine precision aircraft parts from ferrous and non-ferrous metals. The three-motion magnetic tape control system directs vertical, horizontal and longitudinal milling at rates up to 100 in. per min at tolerances of .001 in. Similar tolerances are possible at traverse of 200 in. per min.

Developed by the joint efforts of Morey Machinery Co., Astoria, N.Y., and General Electric's Specialty Control Dept., Waynesboro, Va., the machine is capable of handling heat-treated tool steels as well as aluminum, magnesium, and similar metals as large as 48 x 48 x 12 in. Since feed motions of all three axes are numerically controlled from magnetic tape, the cutter can be positioned or directed along a continuous path for all types of contouring operations and parts may have regular or irregular shapes, straight lines, angles, or circles. Handwheels can be used for precision positioning of all three movements and push button controls may be employed for conventional milling operations.

Both machine and control require approximately 122 sq ft of floor space for installation. The three control cubicles are designed for easy access to front and rear equipment panels to facilitate preventive maintenance.

The Morey A50 is the smallest miller to which GE has applied this type control. A selsyn-phase magnetic-tape, contouring-control system directs the machine-feed drives so the cutting tool is continually positioned with respect to the workpiece in accordance with a predetermined recorded program. Instructions are programmed on a one-inch wide, 14-channel magnetic tape

THE JOB HE HOLDS



which can be easily stored when not in use. The need for expensive dies and large storage areas is eliminated.

Other features include: anti-friction mounting of all components; table and saddle mounting on rollers; replaceable hardened steel ways; ball bearing lead screws; and anti-backlash gear boxes with ground gears. The machine has 16 spindle speeds from 20 rpm to 3600 rpm, providing a range for machining of any material.

Dr. L. T. Rader, general manager of the Specialty Control Dept., estimated that users of this milling machine may expect manufacturing cost reductions of 35 to 69 per cent and savings in production time of at least 50 per cent.

Radar System Operates at Greater Scanning Rate

A technique in pulsed radar which permits faster scanning pulse repetition rates without resolution or range loss has been developed. Details of the classified Fastar system were discussed in a paper delivered at a symposium held at Michigan University. Designed at the W. L. Maxson Corp., New York., N.Y., Fastar uses a large antenna which scans in elevation or azimuth, or both. Long range and rapid scanning result with mechanical problems minimized. To avoid missing objects at great distances, radars other than Fastar must scan at slow rates. The short pulse duration allowed by the multiplicity of signals sent out produces good range accuracy, reduction in necessary peak power, and increase in average power.

It's Just a Matter of Money

Manned flight to the Moon and back to Earth and unmanned reconnaissance of Venus and Mars are well within the technical grasp of the aircraft industry, according to an editorial in *Planes*, official publication of the Aircraft Industries Association.

Only two key points of space flight remain unsolved—decision making and financial backing. The editorial states that about 90 per cent of the knowledge acquired in the research and development involved in the ICBM and IRBM programs can be applied to space flight.

"The inertial and celestial guidance systems, the nose cones to resist thermal heating, the exotic fuels, the manufacturing techniques, the highly skilled scientific and engineering teams, and the expert industrial management involved in the military missile programs are all of immediate, direct use in manned and unmanned space flight," the editorial continued.

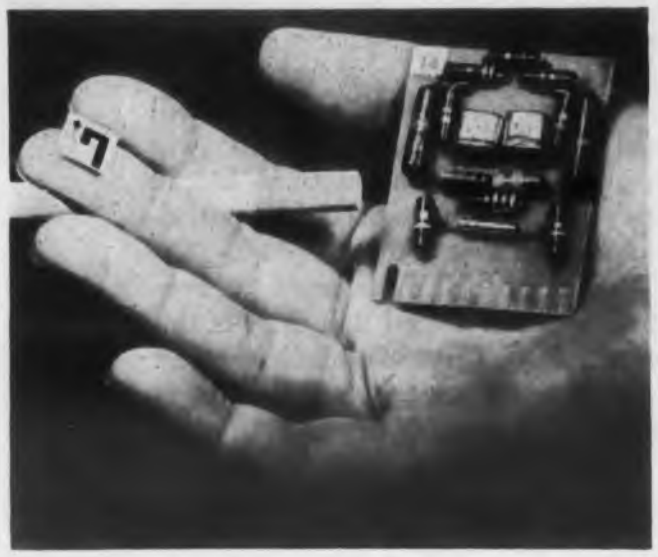


Photo illustrates the extremely small size of the award winning transistor developed through the utilization of photolithographic processes and printing techniques as compared to a present day transistor unit with its component parts. Transistor unit is on the tip of the index finger.

Award Given for Miniaturization Process

The first annual Miniaturization Award was presented last month to the Diamond Ordnance Fuze Laboratories for the development of photolithographic processes and printing techniques to form microminiature electronic subassemblies. Flip-flop counter stages, and amplifier stages which have all components including transistors, diodes, and connecting leads formed on or mounted in holes in a ceramic plate, have been constructed utilizing this technique. The subassembly is unitized through integration of the electronic parts into or on the ceramic base plate and occupying a volume not significantly greater than a conventional miniature electronic part.

ELECTRONIC DESIGN featured a detailed account of this development in the December 1, 1957 issue.

Transistorized Counting Instruments Used at Nuclear Plant

Successful use of transistors in count rate systems at a nuclear plant was reported at the 1958 Nuclear Congress in Chicago. The transistors have been used since 1956 with boron trifluoride counters, Geiger counters, and scintillation probes in monitoring process conditions at the Savannah River plant of the E. I. duPont de Nemours Co. In a paper, sponsored by the AIEE, L. E. Weisner, duPont engineer indicated that

the transistorized nuclear instruments have proven more reliable than comparable vacuum tube instruments and have operated in locations which would not accommodate conventional instruments.

Computer Link Facilitates Missile Flight Simulation

The effectiveness of digital and analog computers in simulating missile flights has been increased by the development of a multi-channel computer link. The Addaverter is essentially a translating device to link the two types of computers and make their languages compatible.

Built for the Space Technology Laboratories, a division of The Ramo-Wooldridge Corp., by Epsco, Inc., of Boston, Mass., the Addaverter is being used with an Electronic Associates PACE analog computer and a Remington-Rand Univac Scientific Model 1103A digital computer. The Laboratories have technical direction and systems engineering responsibility for the Air Force's ballistic missile program.

Both computers can now set to work on the same missile problem, with each one concerning itself with a different phase of the flight. While the digital computer plots the flight around the earth, tracing the trajectory to the eventual point of impact, the analog computer determines the flight oscillations. The Addaverter equipment responds to four distinct commands: write data from the digital computer; present data to the analog computer; sample data from the analog computer; and read data into the digital computer. In converting digital to analog and analog to digital, the Addaverter uses 30 channels. It has more than 2000 vacuum tubes and 1500 semiconductor diodes mounted on eight relay racks.

The Addaverter links an analog and digital computer so that both may simultaneously track various phases of missile flight.

ENGINEERING REVIEW

World Time Clock Measures Nuclear Phenomena

A "world time clock" which can measure the exact moment of any event, anywhere on earth, to the nearest thousandth of a second has been developed primarily to help determine the exact time of nuclear detonations.

Time signals are taken from WWV, the radio station operated by the U. S. Bureau of Standards. These signals are extremely accurate at their point of origin, but in traveling great distances around the earth, they develop inherent errors. The world time clock may be set so as to compensate for these variations and obtain an "approximate" time, correct to within a few hundredths of a second. The task of setting the time exactly is done, by means of a differential gear and precision gear train, used in conjunction with a stroboscope. The dial has the usual hour hand, minute hand and sweep second hand; but in addition it has a hand that registers tenths of a second and a milli-second hand. The latter records thousandths of a second, by virtue of rotation at a speed of 10 rps around a dial divided into one hundred parts. Strobe pulses are brought into coincidence with the time-ticks from WWV.

21 Million Watt Signals Transmitted

Microwave signals at a peak power of 21 million watts have been transmitted by the Cornell Aeronautical Laboratory, Buffalo, N.Y. The signals, reportedly the largest peak power ever radiated, are being radiated as part of the work being performed under a research contract with Army Ordnance. This development represents a significant achievement towards the design of future missile detection equipment.

WASHINGTON REPORT

Herbert H. Rosen

Delay FCC Tests of Pay-TV

The waiting game is over. It was thought many months ago that the reason the FCC delayed making any decision on pay-TV was to give Congress a chance to express its opinion. Here is what the Senate had to say in Resolution 251. "Resolved, that it is the sense of the Senate that the Federal Communications Commission should not, without specific authorization by law, authorize or permit any television licensee, or agent thereof, to impose a toll, fee, subscription, or other charge on the general public or any portion thereof, for the privilege of viewing television programs, received over television receivers located in the home, with the exception of both community antenna systems and those programs transmitted by cable or wire or both."

The House of Representatives passed a similar resolution.

To some informed sources, this is exactly what the FCC wanted Congress to do. It was a confused affair from the beginning. The House felt the FCC and the Communications Act did not allow authorization of toll-TV without special legislation. The Senate thought otherwise and provoked the FCC into issuing a call for trials of the system. Hearings were held on five proposed subscription systems. The FCC neatly sidestepped this issue by calling for applications for trial licenses without designating which of the five systems should be tested. The Commission further stated that consideration of the licenses would not begin until March, 1958. Congress passed the resolutions in February.

At this stage of the game, the FCC notes that the Congressional prohibitions would "moot the entire proceedings." Thus, says the FCC, it will not act on applications for authorization to conduct trials of pay-TV "until 20 days following the *sine die* adjournment of the Congress."

Made in Russia?

Dear Sir:

I have always been skeptical concerning Russian claims to inventions and "firsts" in the field of science. However, until I saw your issue of February 5, 1958 in which you include a Russian Translation of "Design of Multivibrator with Self-Excitation" I have not felt personally that the Russians are in fact extraordinary borrowers from American science.

The article looked quite familiar to me at first and after a closer inspection, I realized that except for some superficial changes, it was a copy of an article I wrote for *Electronics* in June 1948, entitled "Multivibrator Design by Graphic Methods."

The article was well-received at the time and was later republished in *Electronics Manual for Radio Engineers*, p 685, by Markus & Zelug. I feel now that I have reached a new height in literary endeavors since I am the author of an article which was translated from English to Russian and back into English again.

I feel that your feature "What the Russians are Writing" is worth while. However, you are taking a big chance in reproducing their work in view of their apparent custom of borrowing from American science.

E. Abbot
Government Electronics Division
Emerson Radio & Phonograph Corp.
Jersey City, N.J.

▶ We don't hold the Russians up as shining examples of literary integrity. But we should point out that Mr. Abbot's nomogram appeared in the Russian "Nomogram Collection on Radio Engineering" which made no claim to originality. The editor, Mr. V. M. Rodionov indicated that many of the nomograms were "borrowed" from foreign sources, while many were of Russian origin.

It is no secret that the Russians refer to foreign scientific literature extensively. In fact, they have a central agency for translating important technical material. Their success with Sputnik may

LETTERS

indicate that this policy hasn't hurt them a bit.

We published this material to show what Russian engineers are doing and what they are interested in. In another ten years Mr. Abbot may be doubly honored to see his nomogram printed once again by the Russians, and once again translated back to English.

Too Much To Read

Dear Sir:

At the time your magazine was first published, there were few, if any, similar magazines circulated among engineers. Due to the increased quantity of material available for publishing, it appeared reasonable to increase your issue from monthly to bi-weekly.

Today, however, there are numerous magazines with similar format, and with considerable duplication in circulation. Although the contents of the magazines complement rather than duplicate each other, an engineer usually does not have sufficient time to properly absorb the contents of five magazines (which I receive) per month. The advertisers, therefore, may not be getting their "money's worth," and many engineering articles of importance and interest are glanced over rather than read through.

I sincerely recommend that you and the publisher reconsider your original policy of a monthly publication.

George N. Krassner, Electronic Eng.
24 Elizabeth Pkwy., Eatontown, N.J.

► Too much to read is a problem we are genuinely concerned about. It's our experience that more frequent reading of small doses is better than a great deal once a month. ELECTRONIC DESIGN tries editing to present only the essential-to-know practical information. We try to organize the articles so the reader can tell after reading its first paragraph and scanning the illustrations whether or not the article will help him. Some articles should not be read by everyone. We'd like to get other readers' comments as to their reading habits, and organization of time to follow the literature.

MEETINGS

Apr. 24-26: URSI Spring Meeting

Willard Hotel, Washington, D.C. Sponsored by the PGAP, PGMT&T, PGCT, PGIT, PGI, and URSI. For information, contact John P. Hagen, Naval Research Lab., Washington 25, D.C.

Apr. 28-30: Middle Eastern District Meeting

Sheraton Park Hotel, Washington, D.C. Sponsored by AIEE. Papers, exhibits, and inspection trips will highlight the meeting. Further information about the meeting can be obtained by writing William J. Ellenberger, 6419 Barnaby St. N.W., Washington 15, D.C.

Apr. 30-May 1-2: 7th Regional Technical Conference & Trade Show

Hobbies Bldg., State Fair Grounds, Sacramento, Calif. Write Ewald W. Berger, 3421 58th St., Sacramento 20, Calif. for information.

May 4-7: 4th National Flight Test Instrumentation

Park-Sheraton Hotel, New York City. Sponsored by the Instrument Society of America. Coverage of all phases of instrumentation for aircraft testing will be offered including sessions on helicopter and power plant instrumentation. Three sessions will be specifically devoted to Missile Instrumentation. Another session will be spent on the instrumentation for ground testing of aircraft and aircraft systems. Theme of the Symposium is "More Data Per Dollar." For details write P.O. Box 113, Bethpage, N.Y.

May 5-7: AIEE Great Lakes District Meeting

Michigan State University, East Lansing, Mich.

May 5-7: PGMT&T National Symposium

Stanford University, California. The six sessions will include the following topics: ferrites; microwave physics; microwave techniques; and microwave filters. For details, write to Dr. K. Tomiyasu, GE Microwave Lab., 601 California Ave., Palo Alto, Calif.

May 6-9: Western Joint Computer Conference

Ambassador Hotel, Los Angeles, Calif. Cosponsored by IRE, ACM, and AIEE. Theme of the

conference will be "Contrasts in Computers," with panel discussions on controversial aspects of modern computers. For more information write David Parry, 6363 Wilshire Blvd., Los Angeles 48, Calif.

May 12-14: National Aeronautical and Navigational Electronics Conference

Biltmore Hotel, Dayton, Ohio. Sponsored by the Dayton Section of PGANE. For further information about the conference contact Walter Fried, 1668 Wesleyan Rd., Dayton, Ohio.

May 13-15: AIEE East Central District Meeting

Huntington, W. Va.

May 13-15: Spring Assembly Meeting of the Radio Technical Commission for the Marine Services

Benjamin Franklin Hotel, Philadelphia, Pa. Write R. T. Brown, Radio Technical Commission for Marine Services, c/o Federal Communications Commission, Washington 25, D.C.

May 21-23: AIEE, IRE, RETMA, WCEMA, Joint Electronic Components Conference

Los Angeles, Calif.

May 26-27: Engineering Refresher (Electrical Engineering)

Featured as a part of the Engineering Institute it will be held at the University of Wisconsin from January through June, 1958. This refresher will review circuits and electrical machinery for electrical engineering. Interested persons should contact Mr. Robert A. Ratner, Director Engineering Institutes, University of Wisconsin Extension Division, Department of Engineering, Madison 6, Wis.

May 27-28: 2nd EIA Conference on Maintainability of Electronic Equipment

University of Pennsylvania, Philadelphia, Pa. Technical Sessions will cover the following areas: Military Concepts and Requirements for Maintainability; Ground Environment Equipment; Missile Maintainability; and Airborne Equipment Maintainability. For more information, write J. A. Caffiaux, Staff Engineer, Electronic Engineering Dept., 650 Salmon Tower, 11 West 42nd Street, New York 36, N.Y.

MEETINGS

June 2-4: National Telemetering Conference

Lord Baltimore Hotel, Baltimore, Md. Sponsored by the AIEE, ARS, ISA, and IAS. The technical program will feature sessions in telemetering in the IGY program, telemetering overseas, rocket telemetering, industrial telemetering, and data reduction. In addition there will be the annual exhibit staged by manufacturers of telemetering equipment. For further details about the conference write W. J. Mayo-Wells, Program Chairman, 3830 Beecher St., N.W., Washington, D.C.

June 5-6: 2nd National Symposium on Production Techniques

Hotel New Yorker, New York, N.Y. Sponsored by PGPT. For information write John W. Trinkaus, Sperry Gyroscope Co., Great Neck, L.I., N.Y.

June 9-13: 6th Annual Technical Writers' Institute

Rensselaer Polytechnic Institute, Troy, N.Y. For details contact William E. Price, News Bureau, Rensselaer Institute, Troy, N.Y.

June 16-18: 2nd National Convention on Military Electronics

Sheraton Park Hotel, Washington, D.C. Sponsored by PGMIL. Contact Dr. J. McLaughlin, Naval Research Labs, Washington 25, D.C., for information.

June 22-27: AIEE Summer General Meeting

Buffalo, N.Y.

June 23-27: ASTM 61st Annual Meeting

Hotel Statler, Boston, Mass. Highlighting the meeting will be the 12th Technical Photographic Exhibit of the ASTM. Entries will be accepted from members of ASTM, employees of company members, and engineering students. For further information, contact E. W. Walsh, Chairman, ASTM Photographic Exhibit, Narragansett Electric Co., 15 Westminster St., Providence, R.I.

Paper Deadlines

May 1: Deadline for papers to be presented at the **1958 WESCON Show and Convention.** The convention is planned for August 19-22 and is to be held in Los Angeles. Prospective authors should submit 100 word abstracts and either the completed texts or detailed summaries. All material should be mailed to *Dr. Robert C. Hansen, Microwave Lab., Hughes Aircraft Co., Culver City, Calif.*

EDITORIAL

Was It Worth It?

It is safe to say that upwards of 3500 engineers daily, intent on learning something new at the 1958 IRE technical sessions, ended up puzzled, daydreaming, or dozing. Few understood fully what they heard; a fraction asked the speaker for a copy of his paper for later study. The rest wondered why they wasted their time going. Many brooded that they were too stupid to understand.

No educator would think of reading page after page of the textbook to students, but this seemed to be the rule at the Convention.

Paradoxically, the profession that invented communication theory and spends millions on equipment embodying the principles learned, ignores its application to human communications. Communication theory relates rates of transmission to chances of getting the message through. It also tells us something of the chance of a successful transmission as a function of the strangeness of the next character or word or idea being sent. On both scores most technical session speakers err badly. The concept of reading aloud a technical paper is fundamentally wrong. The rate is primarily way too slow, but it becomes too fast if the listener misses a point. The author is also prone to cover too many points in his half-hour. He taxes the best of minds, especially when his disclosures are new.

Better Ways Are These:

- Make preprints available before the convention. The AIEE and many other professional societies do this reasonably successfully;
- Have the convention record available at the door. The Dayton Aeronautical and Navigational Electronics Conference and the National Telemetering Conference are run this way;
- Have useful digests and illustrations organized into a convention notebook. This arrangement permits easier following of the papers and gives listeners something to use until a proceedings is printed. The Transistor and Solid State Circuits Conference has pioneered along these lines.

All of the above plans mean that the speaker does not have to read the full paper word for word. Ideally, the speaker should have a completely separate oral talk. The prime aim should be communicating information—and it is time we electronic communication experts learned something about human communication.

We should ask the new Professional Group on Engineering Writing and Speech to take up this project.

James C. Ryppa

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CIRCLE 21 ON READER-SERVICE CARD

Optimum Design of Power Transformers and Saturable Reactors

Part 1

T. R. Nisbet
Alto Scientific Co., Inc.
Palo Alto, Calif.

This article, in two parts, presents a general design procedure for optimizing flux density and window shape, and hence, for providing best weight economy for transformers and saturable reactors.

Free reprints will be made available at the conclusion of the second part.

HERE is a general design procedure for iron cored devices. The design effort is towards optimizing transformer or reactor weight and efficiency. Although this article was written for 400 and 800 cps applications, the approach holds good at any frequency.

For any given application—saturable reactor, magnetic amplifier, or power transformer—reduction of the cross sectional area of the core requires a related increase in the number of turns of wire to produce the same flux density. This has a number of consequences. The core window area must be increased to accommodate the larger number of turns. The weight of wire and wire losses increase while the weight of iron and core losses decrease.

The principal assumption for an initial approach is that of a square cross-sectional area of core. This is chosen since it allows the minimum length of turn of wire to enclose a given core area. Two bobbins are assumed, each containing half the primary and half the secondary. The design procedure outlined may also be applied to single bobbin windings or to three phase cores. Single bobbin winding normally yields greater overall weight.

Relationship of Terms

The number of turns per volt on an ac winding is given by

$$\frac{V}{N} = (2.865\ B\ S_c\ F\ 10^{-4})e^2 \qquad (1)$$

The numerical constant in the equation is arranged so that B represents the peak induction in kilogauss, though V is in rms volts. The frequency F is in cps. If a stacking factor S_c, of 0.9 is assumed, the bracketed portion of the equation can be solved from the nomogram of Fig. 1, giving the number of turns per volt as a constant times the core area. The constant, c, is such that

$$\frac{V}{N} = c\ e^2 \qquad (1a)$$

where e is the length in inches of one side of the core cross section.

The maximum current which the principal winding carries determines the wire diameter, and from this the number of turns per square inch, T, can be found. In the initial design, however, a different method is used for evaluating T. If the total number of turns, N, of the principal winding occupies a fraction, k, of the total winding area, it follows that V/ckT is the product of the window and the core area. The square root of this quantity is

$$M = \sqrt{\frac{V}{ckT}} = e\ f\ v^{\frac{1}{2}} \qquad (2)$$

where f is the length in inches of the shorter side of the window, v is the ratio of the sides of the core window, g/f, M is a numerical constant which is used later in the calculation, and k is the fraction of the total window area occupied by the principal winding.

In the initial stages of the design, it is best to use a theoretical rather than a practical concept of T. By using

$$T = D\ S_w/I \qquad (3)$$

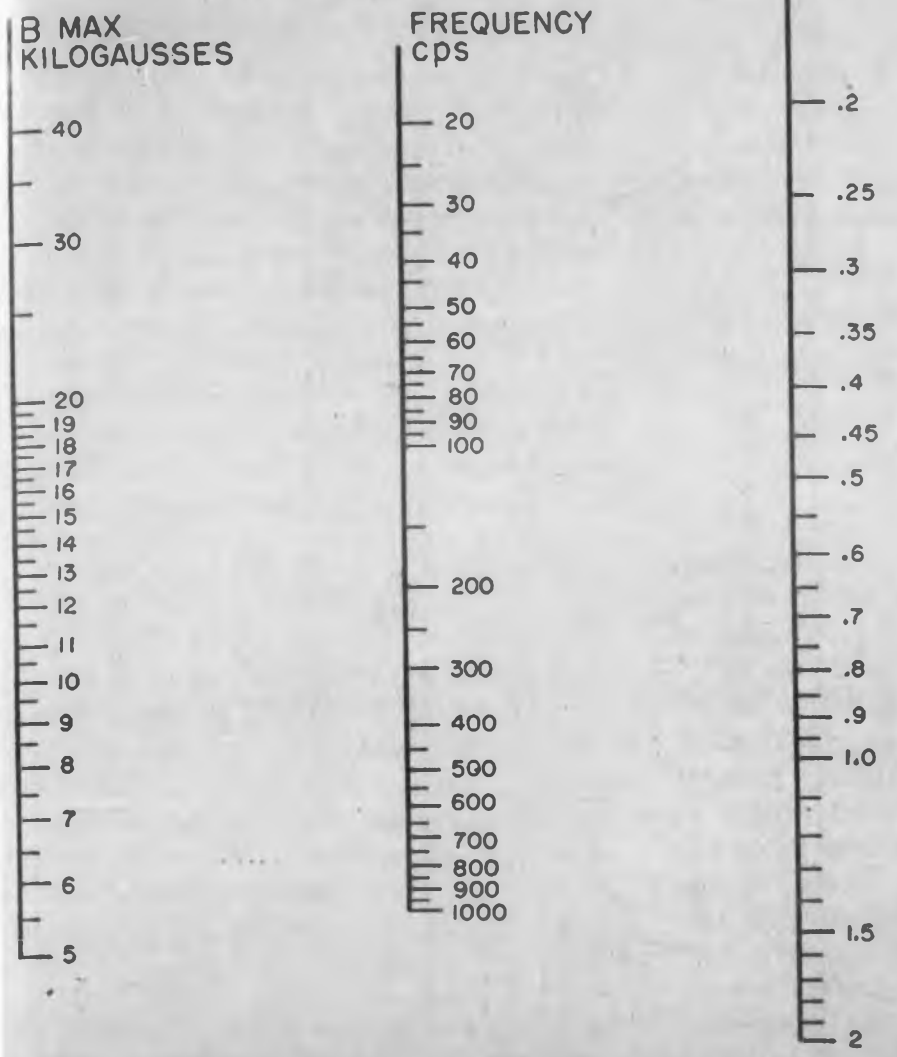


Fig. 1. Nomogram for c, assuming a core stacking factor (S_c) of .9. The number of volts per turn is c times the core area.

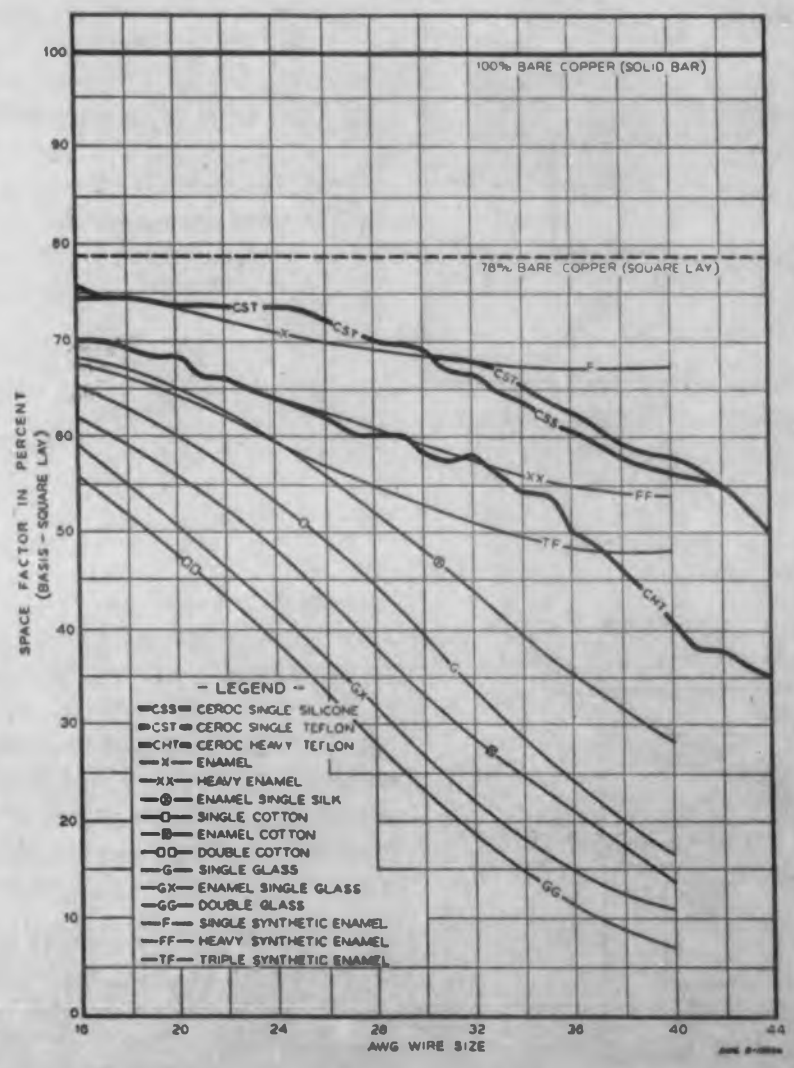


Fig. 2. Typical comparative wire space factors, on the basis of each turn being placed directly on top of the one below it (i.e. square lay), with no allowance for interleaving layers of insulation. The winding space factor (S_w) as used in this article is less than the wire space factor, since it represents the fraction of the window area filled with pure conductor. (Source—Sprague Electric Company Engineering Bulletin No. 400 A.)

where D is the current density in amperes/in.^{2} and I is the current in rms amperes, one, in effect, specifies the exact number of amperes in the principal winding. The voltage has been used in evaluating c, so that the volt-amp rating is established by the calculation of M in eq (2). Values of T should therefore include fractions where necessary. Whether or not this implies an integral number of turns per layer is unimportant, since all such consideations are allowed for in the initial design by the factor S_w, the fraction of the window area filled with conductor.

The space factor for the winding, S_w, should not be confused with that of the wire. Published space factors generally refer to the wire only, as in Fig. 2, but the winding space factor must also take into account clearance at the edges, thickness of the bobbin material, and the final wrap of insulating material and interleaving layers of insulation.

Assessment of the value of k, (eq 2), entails consideration of what other windings are to be used in addition to the principal winding of the transformer or reactor.

Minimum Weight

Core Weight

With square instead of rounded corners, the volume of a core such as that illustrated in Fig. 3 can be calculated as the difference between the volumes of two solids. The outside radius of the rounded corners is approximately 1.14 e, making

$$\text{Volume of core} = e^2\,(2f + 2g + 2.9e)\ \text{in.}^3 \quad (4)$$

Since the product of the window and core areas is M, (eq 2), this can be written

$$\text{Volume of core} = e^2\,[2M(v+1)v^{-\frac{1}{2}}\,e^{-1} + 2.9e]\ \text{in.}^3 \quad (5)$$

and by multiplying by the density of the core material ρ_c and the stacking factor, S_c

$$\text{Weight of core} = 2.9\,\rho_c\,S_c\,e^3 + 2\,\rho_c S_c(v+1)v^{-\frac{1}{2}}\,M\,e \quad \text{lb} \quad (6)$$

Wire Weight

A cross sectional view, (Fig. 4a), of two bobbins, one on each leg of the core, shows that the side area of one bobbin is $(e + f)^2$. Reference to Fig. 4b shows that the space occupied by one

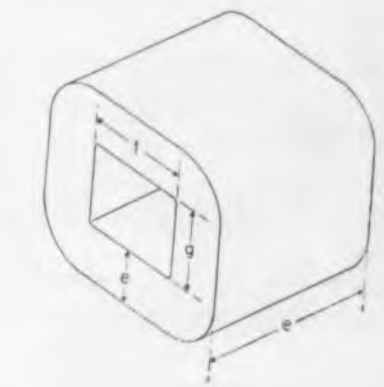


Fig. 3a. Core shape.

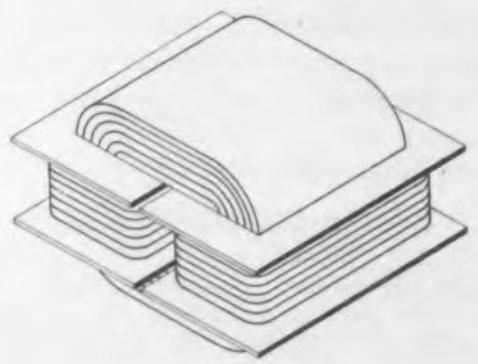


Fig. 3b. Type of core construction.

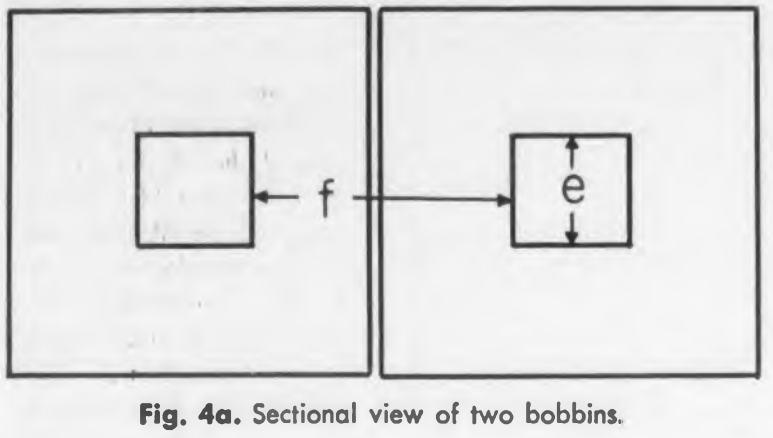
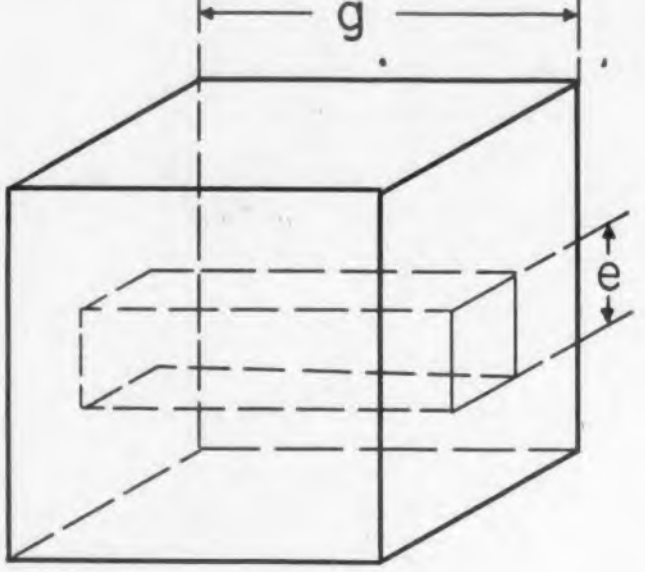


Fig. 4a. Sectional view of two bobbins.

Fig. 4b. Dimensional view of one bobbin.



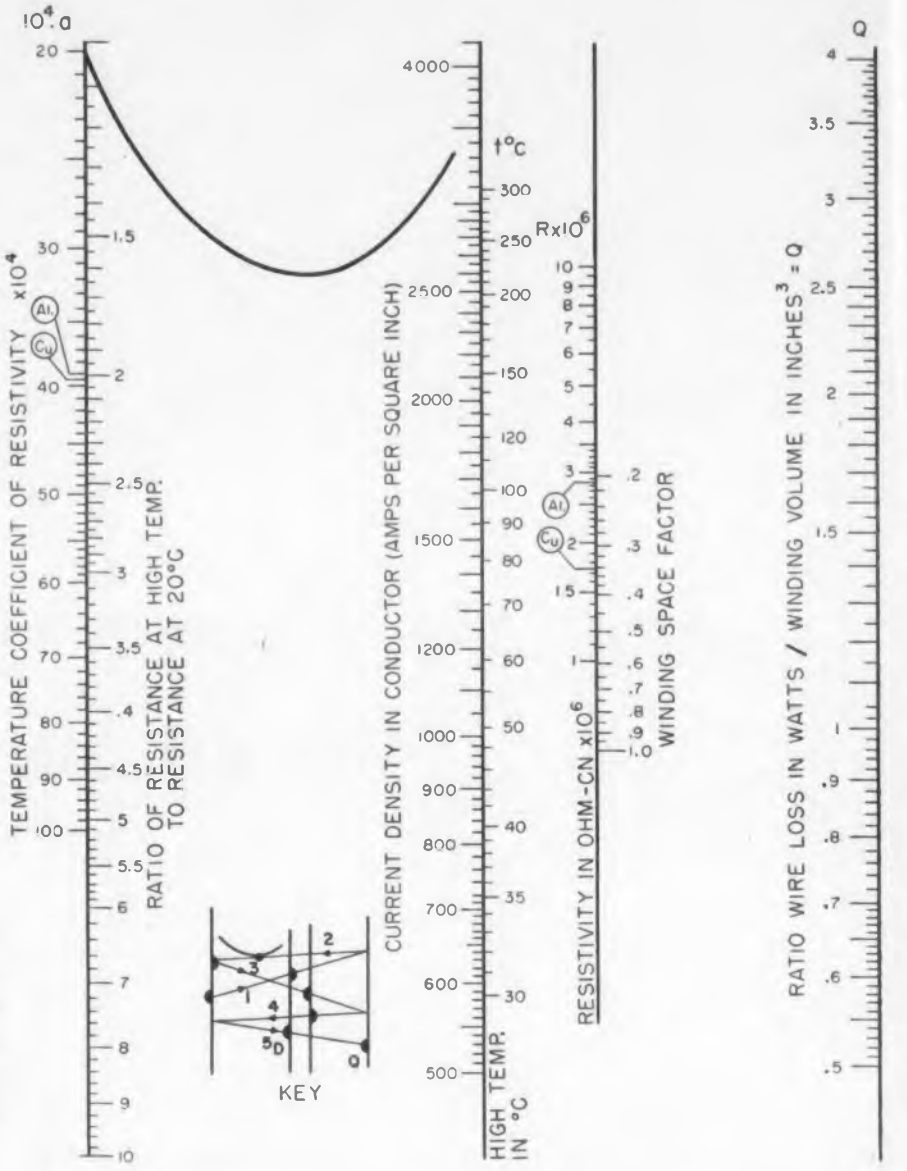


Fig. 5. Nomogram for evaluating Q. After the second traversal, the multiplying factor for resistance due to temperature may be read off (see key). The nomogram may alternately be used for evaluating the current density (*D*) when Q is known.

winding is the difference between two solids, $g(e+f)^2$ *and* e^2g, which simplifies to $fg(2e+f)$. By proper substitution, the

$$\text{Volume of two bobbins} = 4M^2 e^{-1} + 2M^3 v^{-\frac{1}{2}} e^{-3} \text{ in.}^3 \quad (7)$$

Multiplying the volume by the density of the wire material ρ_w, and applying the space factor, S_w,

$$\text{Weight of wire} = 4 \rho_w S_w M^2 e^{-1} + 2 \rho_w S_w M^3 v^{-\frac{1}{2}} e^{-3} \text{ lb} \quad (8)$$

Combined Weight

The total weight of the transformer or reactor consists of the core weight plus the wire weight. The former increases with increasing values of *e*, while the latter decreases. To find the condition for minimum weight, the differential coefficient is equated to zero, whence

$$8.7 \rho_c S_c e^6 + 2 \rho_c S_c (v+1) v^{-\frac{1}{2}} M e^4 - 4 \rho_w S_w M^2 e^2 - 6 \rho_w S_w M^3 v^{-\frac{1}{2}} = 0 \quad (9)$$

This is the general equation, the solution of which gives the value of *e*, the side of the cross section of the core, when *M* as calculated from eq (2), and *v*, (assumed or derived), are inserted. The value for *e* is inserted in the previous formulas to give core dimensions, number of turns, weight of core and weight of wire.

Maximum Efficiency

The calculation of minimum weight was arrived at by varying the dimension *e* until a point was reached where the combined core and wire weight was at a minimum. A similar procedure can be applied to find when the combined core and wire loss is at a minimum.

Wire Loss, P_w

If the volume of the windings were in the form of a cylinder with a one square in. cross section, its length would be $4M^2 e^{-1} + 2M^3 v^{-\frac{1}{2}} e^{-3}$ in.

The resistance of such a cylinder, in ohms is $r/2.54$ times its length in inches, where *r* is the resistivity of the wire material in ohm-cm. But the cross sectional area is not, in effect, pure metal. Only a fraction S_w, of the window area is filled with conductor, so that the resistance of the fictitious cylinder must be multiplied by $1/S_w$.

Since wire loss increases with resistance, which increases with temperature, the maximum loss will occur at maximum temperature. In the nomogram of Fig. 5, the first two traversals give the correction factor for resistance at temperatures above 20 C.

In estimating the wire gage of a winding on a transformer or reactor, it is normal practice to allow between 1000 and 1500 amperes per square in. of copper, or that number divided by the square root of the relative resistivity for other materials. In a saturable reactor, the maximum current density occurs when the core is fully saturated, i.e., when the control winding is also fully energized. In this case, maximum wire loss and maximum core loss do not occur simultaneously. Thus it is reasonable to take about 1200 a as the equivalent current passing through the fictitious cylinder, and to regard the wire loss as the power dissipated in the cylinder.

If *D* is the number of amperes per in.^{2} in the conductor, and $D S_w$ the amperes per in.^{2} in the

cylinder, the wire loss may be expressed

$$P_w = D^2 S_w [1 + (t - 20)a] \frac{r}{2.54} [4 M^2 e^{-1} + 2 M^3 v^{-\frac{1}{2}} e^{-3}] \text{ watts} \quad (10)$$

(The factor $1/S_w$ for resistance reduces S_w^2 to S_w.)

The part of this formula which precedes the last pair of brackets is of importance later and is styled Q. It normally has a value between 0.7 and 2, and can be evaluated by the use of the nomogram of Fig. 5. The last traversal of the nomogram cuts the D (current density) and Q scales. If either of these is known, the other is indicated.

Core Loss, P_c

The weight of the core has been calculated. The core loss is found by multiplying the weight by P, which is obtained from the manufacturer's data, using the same value of induction as was used previously. Thus

$$P_c = 2.9 P \rho_c S_c e^3 + 2 P \rho_c S_c (v + 1) v^{-\frac{1}{2}} M e \text{ watts} \quad (11)$$

where P is the number of watts per lb core loss.

Minimum Combined Loss

Equations (10) and (11) show that P_w decreases and P_c increases with increasing values of e. For maximum efficiency, the combined loss is at a minimum. Differentiating the combined weight and equating to zero, one finds

$$8.7 P \rho_c S_c e^6 + 2 P \rho_c S_c (v + 1) v^{-\frac{1}{2}} M e^4 - 4 Q M^2 e^2 - 6 Q M^3 v^{-\frac{1}{2}} = 0 \quad (12)$$

The solution of this cubic equation gives e, from which core dimensions, core and wire loss, and so on, may be calculated for the condition of minimum combined loss or maximum efficiency for the particular value of induction B, and window shape factor v, which have been assumed.

Temperature Rise

It is useful, at an early stage in the design, to be able to estimate the temperature rise. Since core and wire loss have already been dealt with, it is necessary only to examine the dissipation from exposed surfaces.

Assuming an open type of construction, the surface area can be regarded as dissipating 0.008 w per sq in. per deg C rise. As an approximation, it may be assumed that the wire material dissipates heat at the same rate as the core.

From Fig. 4, it can be seen that the perimeter of the winding exposes an area of $6g\,(e + f)$ in.^{2}, and the sides of the bobbins expose $2f\,(3e + f)$ in.^{2}, where f and g are the sides of the rectangular window. The exposed area of the core can be shown to be $11.8\,e^2 + 6\,e\,f$ in.^{2}. Writing $g = v\,f$, the total exposed area is

$$2 f^2 (2 + 3v) + 6 e f (2 + v) + 11.8 e^2 \text{ in.}^2 \quad (13)$$

The rise in temperature above ambient at the surface is

$$\Delta T = \frac{P_w + P_c}{0.008 \text{ times surface area}} \text{ deg } C \quad (14)$$

This is an approximate figure because of the approximate nature of the 0.008 component, and because of the implication that the dissipated heat does not raise the ambient temperature.

The possibility of increasing the surface area by the use of fins should not be overlooked. In theory, 660 sq in. of surface area can be provided by every pound of aluminum, but since the critical temperature is that of the hottest spot within the transformer or reactor, it is important not only to provide good thermal conductivity from core and windings to the fins, but also to allow for the manner in which the fins themselves dispose of the heat. Forced air cooling can often be provided by the addition of a fan weighing only a few ounces.

For a saturable reactor, where the total loss at any one time consists of either the wire loss or the core loss, but not both simultaneously at maximum, the temperature rise is approximately one half of that calculated from eq (14).

A reasonable assumption is that the temperature gradient within a transformer or reactor is such as to add between 10 and 20 C to the surface temperature. The class of insulation usually determines the upper limit of the permissible temperature of operation. Most of the high permeability core materials show a reduction of from 5 to 10 per cent in saturation density when the temperature is increased from 20 to 120 C.

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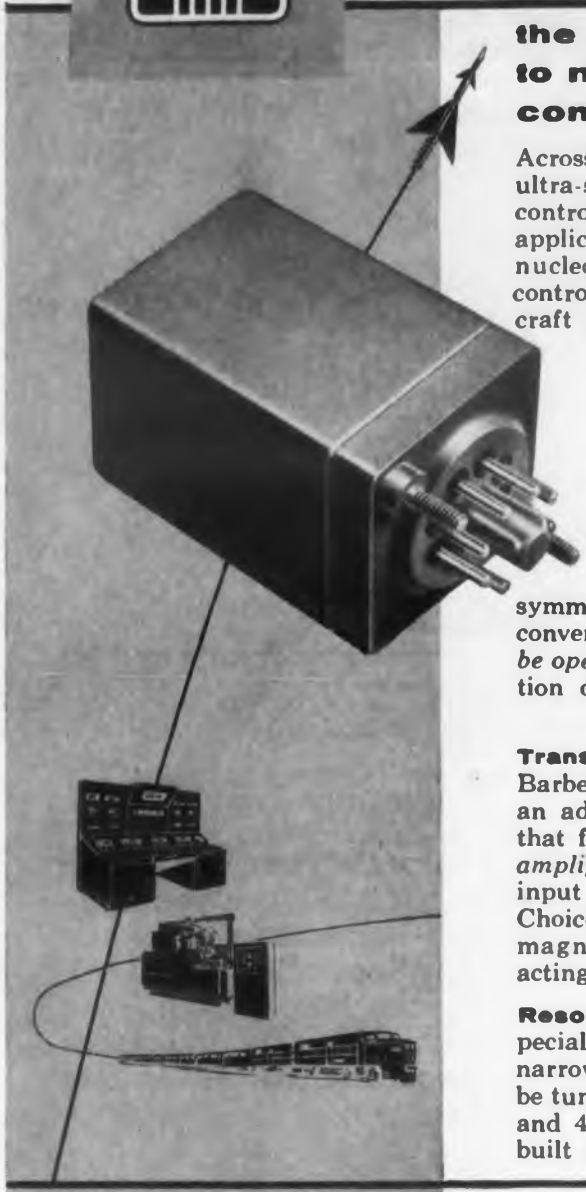

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CIRCLE 25 ON READER-SERVICE CARD

Radar Applications Broadened by this

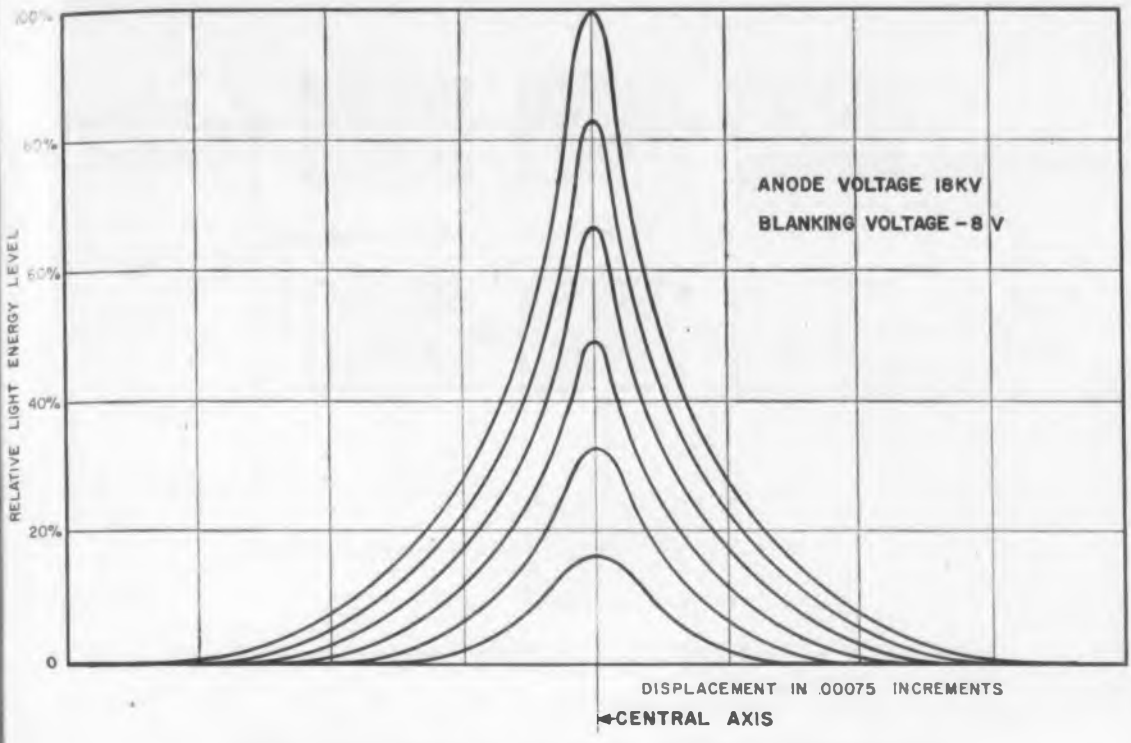
New 6000-line Resolution CRT

THE BEST conventional cathode ray tubes have often been the limiting factor in the design of present day systems. While associated circuitry has steadily improved, the CRT has remained stubbornly within a given set of performance characteristics.

Overcoming these limitations, a new cathode ray tube with a resolution equal to 6000 TV lines is being produced by CBS-Hytron, Danvers, Mass. What this high resolution means is that radar can now be improved to compensate for the rapid transition in aircraft speed;—from the World War II level of hundreds of miles per hour, to the present supersonic speeds.

The tube can be combined with photographic systems to store and transmit pictorial information. The combination permits the uninterrupted flow of information required in radar strip map-making for surveillance, navigation, and target seeking. The 6000-line tube successfully meets these requirements. For the greater speeds en-

Characteristics	Conventional 5 and 7 Inch CRT's	High Resolution CRT CBS-Hytron 5BYP5
Resolution in TV Lines	1000 Center 500 Edge	6000
Beam Size	.005-.006 Center .010-.012 Edge	Less than .001 throughout screen area
Beam Distribution	Cosine squared in center Cosine cubed at edge	Sharp edged beam
Screen Thickness in Microns	10	3 to 4
Required Focus Correction	15% Center to Edge	2% maximum
Required Anastigmatic Correction	35%	1% maximum
Beam Size, Center to Edge Ratio	1.7:1	1:1
Required Grid Drive from Cut-off	50 to 150 V	10V
Intrinsic Deflection Linearity Error	12%	Less than 1%
Beam Size vs. Drive Throughout Total Range	Minimum three-fold variation	Constant
Alternate Element Contrast Ratio (Collapsed Raster Technique)	0	3:1



TYPICAL SPOT PROFILE OF CBS HYTRON ULTRA-HIGH RESOLUTION GUN

Spot profile of the cathode ray tube at different levels of intensity. Note that at full intensity, a spot does not bloom and measures little more in diameter than at low intensities.

countered in the future, a 1200 line prototype has been readied. However, such extreme resolution is beyond temporary requirements.

The 5-in. tube, type 5BYP5, combines its resolution with high contrast and positional accuracy, fulfilling the primary requirements for good photographic reproduction. Some of the characteristics are as follows: an exceptionally flat field; a constant beam size and geometry throughout the screen area; an unusually low grid drive requirement; a large dynamic range without blooming; extreme accuracy; linear deflection; a sharp beam profile; and a very thin and finely textured screen. Data on these characteristics, as compared to a conventional tube, is listed in the accompanying table.

One of the most important achievements during development of the tube was accomplishing a concise, high intensity, electron beam source capable of modulation by available transistor video amplifiers. To best utilize this beam, electron optics were developed to extract the maximum resolution, achieved essentially through the use of a uniform field. The graph shows the very sharp profile of a spot obtained even at high beam intensities.

Concurrent with these developments, progress was made in phosphor screens. The early successful forms were very thin settled screens, but the work culminated in screens employing evaporated, actinic, very-short-persistence phosphors. Work is still continuing in this latter field.

For more information on this CRT, turn to the Reader's-Service card and circle 26.

BARBER COLMAN

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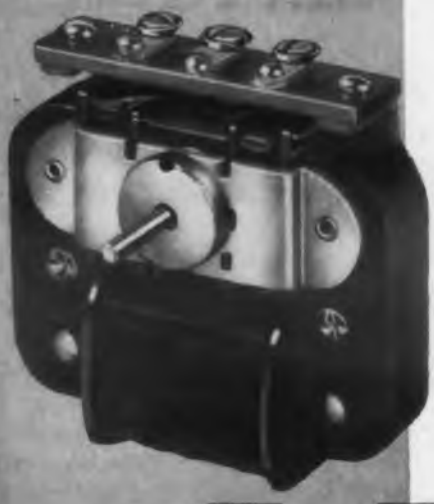

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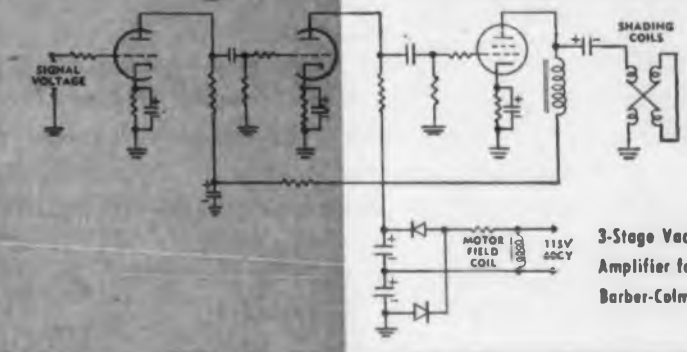

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CIRCLE 27 ON READER-SERVICE CARD

Designing An Electronic Filter Servo

J. A. Webb
Preliminary-Design
Convair-Astronautics
San Diego, Calif.

How to filter to extremely narrow bandwidths and at the same time retain good phase stability

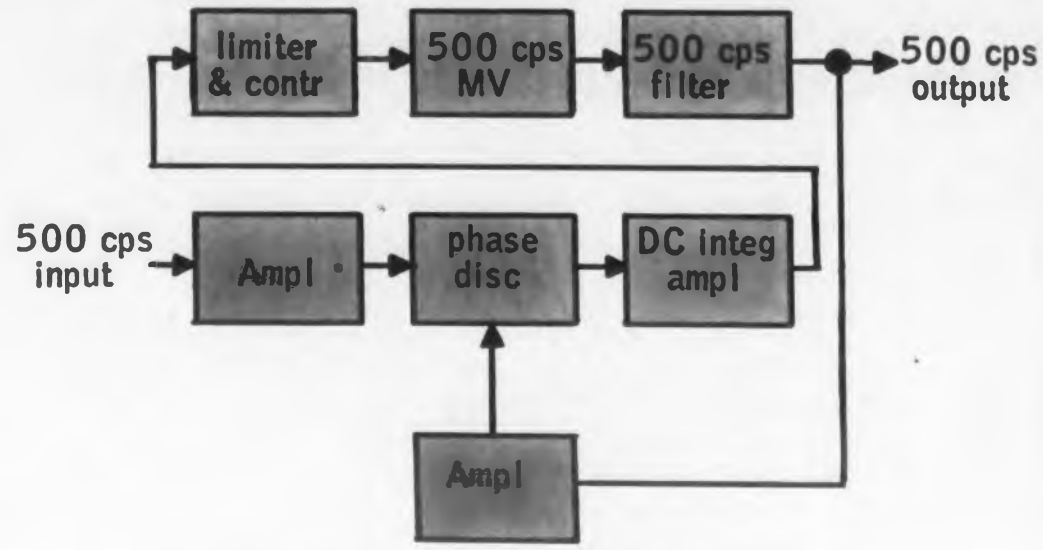

Fig. 1. Electronic filter servo.

AN APPLICATION arose where it was necessary to filter a frequency of 500 cps through a bandwidth of about 2 to 5 cps, with a resultant error due to filtering of less than one degree in phase. The maximum frequency deviation permissible was plus or minus 5 cps from center frequency. In Fig. 1 is a block diagram of the electronic filter servo which was designed to meet this requirement.

Resistance-capacitance coupled amplifiers were used to drive the phase discriminator. About 20 db of negative feedback was incorporated in each of these amplifiers from the secondary of the phase-discriminator driver transformers in order to obtain better phase stability. A slightly unorthodox phase discriminator was used to make this feedback possible with the available transformers. The only disadvantage to this discriminator is a 2-to-1 reduction in sensitivity because of the necessity of a summing network on the output. This is illustrated in the schematic diagram shown in Fig. 2.

Integrating Amplifier

Acceleration servo operation (Type 2) is approximated by the use of an electronic integrating amplifier. This procedure results in good servo following or "curve matching" while at the same time retaining narrow bandwidth. The integrating amplifier allows the use of reasonable resistor and condenser sizes for a very long time constant. As an illustration of this point, for an amplifier of gain A, the effective time constant t for this network is:

$$t = RC_{eff} = RC\,(1 + A) \qquad (1)$$

A true type 2 servo is inherently unstable due to the fact that it has 180 deg of phase shift in the loop. For this reason, it is desirable to compensate this servo with a phase lead network in order to provide sufficient phase margin in the vicinity of 0 db gain. This is accomplished in the RC integrator network shown in Fig. 3a, by the resistor R_2. For this network:

$$e_o = e_i \frac{R_2}{(R_1 + R_2)} + \frac{1}{(R_1 + R_2)C} \int (e_i - e_o)\, dt \qquad (2)$$

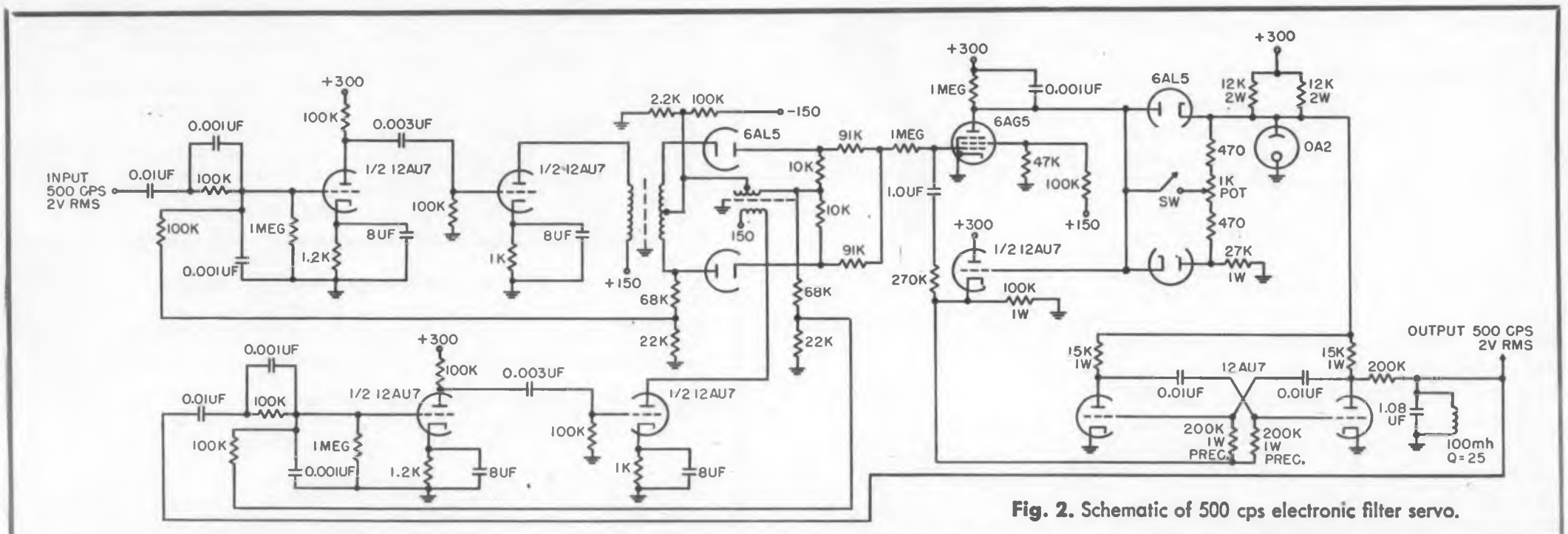

Fig. 2. Schematic of 500 cps electronic filter servo.

But, if $R_1 \gg R_2$ and $e_i \gg e_o$, then

$$e_o \simeq e_i \frac{R_2}{R_1} + \frac{1}{R_1 C} \int e_i \, dt \qquad (3)$$

For the electronic integrating network shown in Figure 3b:

$$e_o - e_g = -(e_i - e_g) \frac{R_2}{R_1} - \frac{1}{R_1 C} \int (e_i - e_g) \, dt \qquad (4)$$

But, where $A \gg 1$,

$$e_o \simeq -e_i \frac{R_2}{R_1} - \frac{1}{R_1 C} \int e_i \, dt \qquad (5)$$

The constants actually used in this design were $R_1 = 10^6$ ohms, and $C = 1\mu f$. Since $A \neq \infty$ in this case A is approximately 400), the integrator is not perfect, but will have a corner frequency where $t = R_1 C(1 + A) = 400$ sec. In other words, at frequencies below $\omega = 1/400 = 2.5 \times 10^{-3}$ radians per sec, the amplifier no longer integrates, but produces a constant gain A.

A phase lead is obtained after the second corner frequency where $t = R_2 C = 0.27$ sec, or $\omega = 3.7$ radians per sec. This second corner is the upper frequency limit for integration, thus restoring phase margin to the servo for stability purposes. A complete plot of this servo characteristics is shown in Fig. 4.

DC Amplifier Considerations

Various dc amplifier schemes were considered for use in the integrator. Most of these schemes were too complicated, requiring several stages of amplification to produce the desired results. Finally it was decided to use a single pentode stage. The screen voltage was lowered to about 50 v on this stage, and a very high resistance value was used in the plate circuit. This way a gain of about 400 was obtained in a single stage, thus greatly simplifying the problem. The high resultant output impedance of this stage was desirable from the standpoint of limiting, but undesirable for integrating purposes. It was therefore decided to follow this amplifier with a cathode-follower stage for impedance matching purposes. Limiting was accomplished on the plate at high impedance.

The capacitor in the plate of this stage was added for the purpose of suppressing oscillation only and has no importance in the circut function. The gain characteristics of this dc amplifier are shown in Fig. 5.

Oscillator Considerations

The choice of the free running multivibrator as an oscillator was greatly influenced by the simplicity and dependability of this circuit. Control of the frequency of this multivibrator is simple and easy to accomplish with the high voltage output from a dc amplifier. It is also

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CIRCLE 29 ON READER-SERVICE CARD

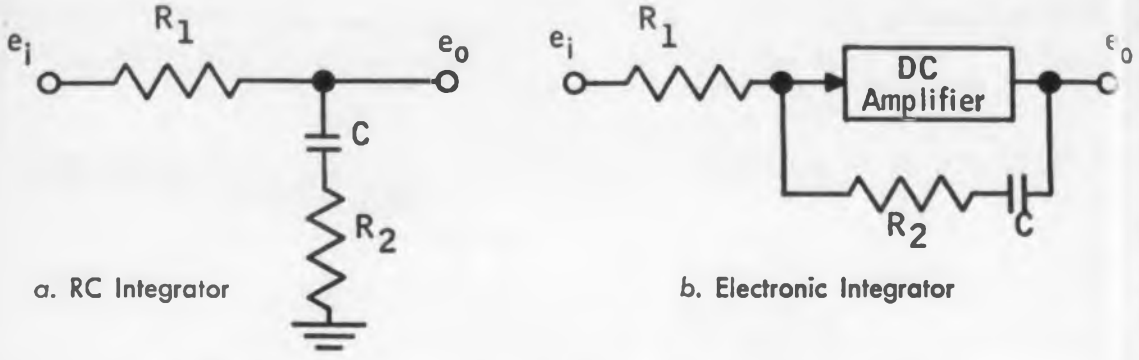

Fig. 3. Comparison of an RC Integrator with an Electronic Integrator.

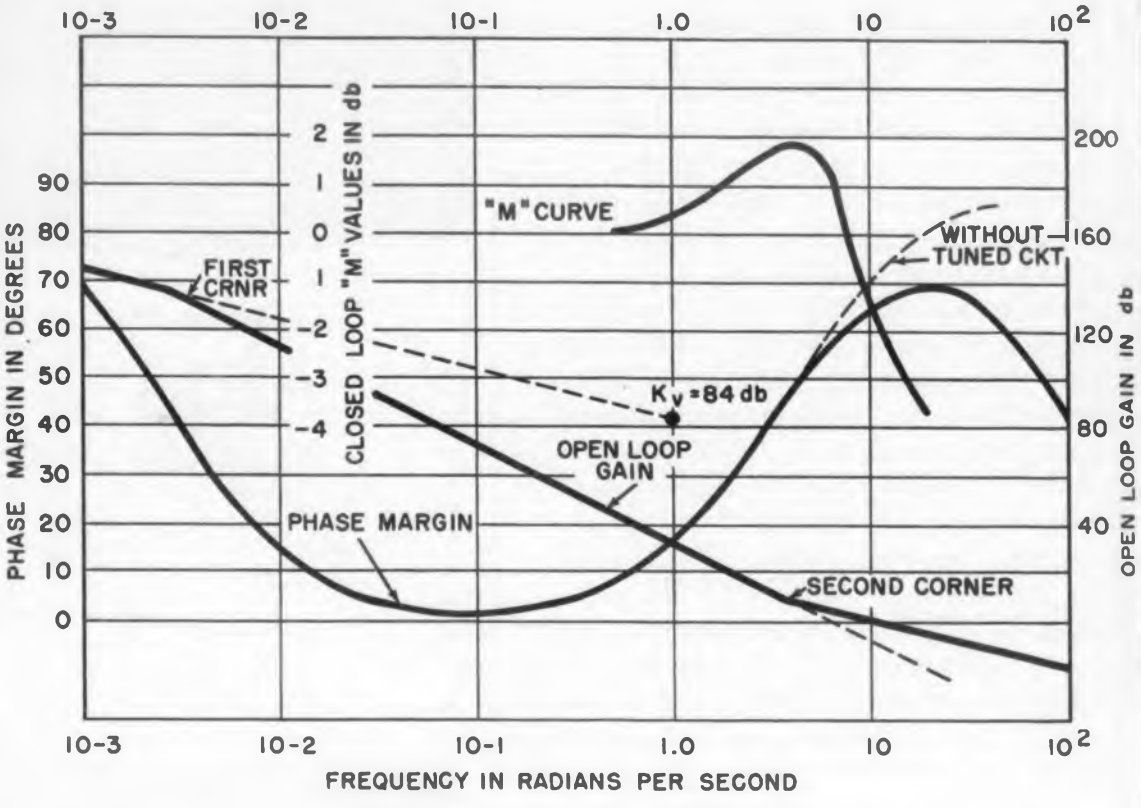

Fig. 4. Servo characteristics.

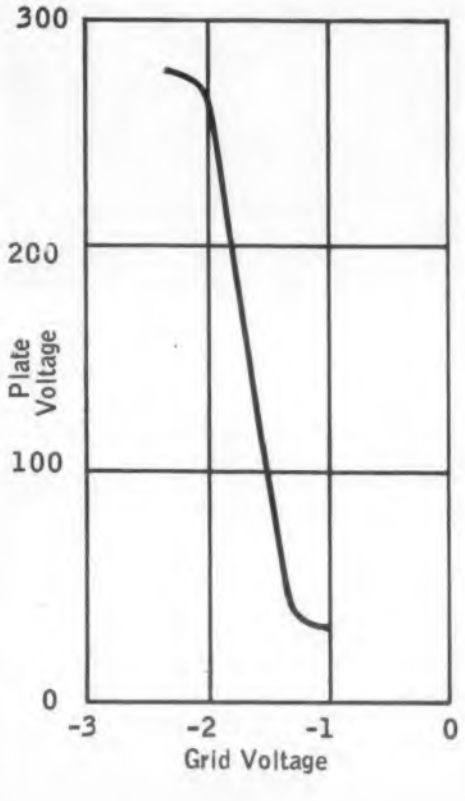

Fig. 5. (left) Gain characteristics of the DC amplifier.

relatively free from amplitude changes with frequency. Disadvantages include high sensitivity to changes in the frequency determining r-c network, and to supply voltage variations. An additional disadvantage in this application is the fact that the output is a square wave, where a sinusoid is required.

An examination of the servo bandwidth and the input frequency showed that a tuned circuit with a Q of 25 would not cause an excessive amount of phase shift in the loop when properly tuned. Placing this network inside the feedback loop would tend to greatly reduce any phase shift which it introduced, making its effect on the data negligible. The use of this network following the oscillator reduced the second harmonic by 40 db (a true square wave should have

no second harmonic anyway) and the third harmonic by 43.5 db. The output impedance of this circuit is about 8,000 ohms.

The multivibrator was designed to oscillate at 500 cps when the grid control voltage is +145 v. A deviation of ±5 v provides a frequency change of ±10 cps. Since this is more than adequate for purposes of this design, it was decided to limit the swing to this amount. This is accomplished by means of a voltage regulator tube and a voltage divider network. Diodes provide a low impedance path for plate voltages outside these limits. A potentiometer and push-button switch are provided for setting the oscillator for initial lock-on.

Stability

The narrow limits of control to be used places a severe requirement on the oscillator stability. For this reason, 1 w precision resistors are used at the multivibrator grids. A silvered-mica capacitor from plate to grid provides good temperature stability. Because of the B+ voltage coefficient of frequency of the multivibrator, the high voltage for this oscillator is regulated by the same voltage regulator tube as that used to establish the control voltage limits.

The velocity constant, K_v, of this servo is about 16,000 per sec. (If true type 2 servo operation were achieved, K_v would be infinite). The acceleration constant, K_a, is about 400 per sec^2. The total error in phase, ϵ, for such a servo can be described as a series as follows:

$$\epsilon = \frac{\phi'}{K_v} + \frac{\phi''}{K_a} + \dots \qquad (6)$$

where ϕ', ϕ'', etc. are the succesive time derivatives of the input phase.

The total velocity, or frequency, error ϵ' can be obtained by differentiating equation (6), thus:

$$\epsilon' = \frac{\phi''}{K_v} + \frac{\phi'''}{K_a} + \dots \qquad (7)$$

For the application of this design, the maximum values expected were $\phi' = 5$ cps, $\phi'' = 0.05$ cps^2, and $\phi''' = 0.0005$ cps^3. Substituting these values into equations (6) and (7) shows errors sufficiently low to warrant a look at other factors as limitations in accuracy.

Some of these factors are the discriminator errors, and random noise generated in the oscillator which is higher in frequency than that which would be compensated in the loop. Testing of this circuit to date has not been sufficiently comprehensive to justify any definite statement as to its accuracy. The filtering action of the circuit has been checked experimentally, however, and has been found to be in accordance with theoretical results.

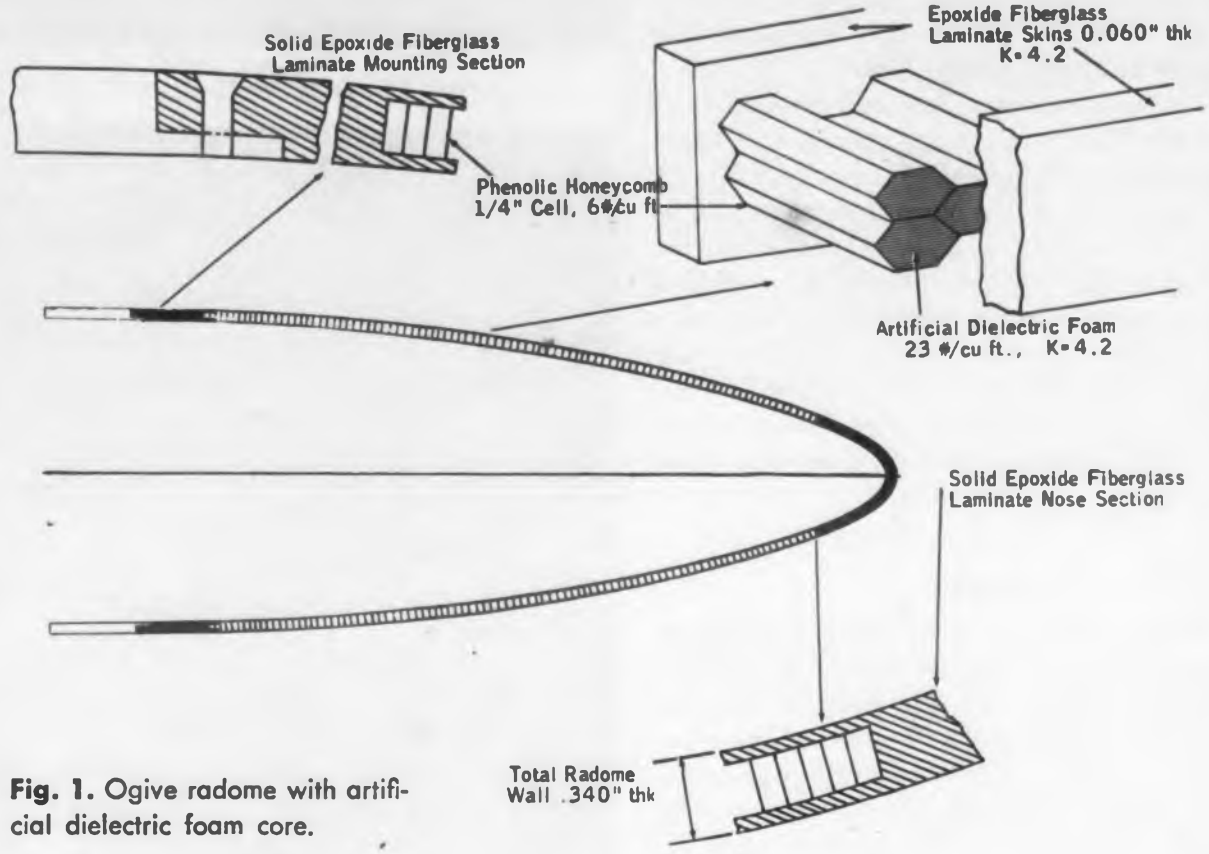

Fig. 1. Ogive radome with artificial dielectric foam core.

Radome Sandwich

Using Artificial Dielectric Foam

William R. Cuming
Emerson & Cuming, Inc.
Canton, Mass.

THE WEIGHT of an otherwise solid-wall radome can be reduced substantially by replacing the central portion of the wall with an artificial dielectric foam which has the same dielectric constant as that of the wall. Yet, electrical performance of the wall is unaffected thereby. The physical characteristics of the resulting sandwich structure can be designed to meet high performance standards by proper selection of skin thickness and suitable reinforcements. The core can be artificial dielectric foam alone, foam-filled honeycomb, or (in certain areas) solid dielectric material.

Radome Design Example

A typical radome structure is shown in Fig. 1. The inner skin is epoxide fiberglass laminate 0.02 in. thick and has a dielectric constant at microwaves of 4.2. The outer skin is the same material, 0.04 in. thick. Honeycomb is high temperature phenolic, 6 lb per cu ft. Each cell of the honeycomb is filled with epoxide "pack in place" artificial dielectric foam, 20 lb. per cu ft. density, dielectric constant 4.2. The nose cap and the mounting ring are solid epoxide laminate. The entire structure is isotropic electrically and capable of continuous operation at 500 F. Weight is 50 lb as against 90 lb for a solid wall radome of the same geometry.

Conventional "A" Sandwich vs Artificial Dielectric Sandwich

The use of an artificial dielectric foam for the core will greatly facilitate the use of sandwich type constructions where the requirement of light weight is present in a bore-sight radome. The transmission and phase delay curves for the conventional A-sandwich construction are practically normal to each other when the high angles of incidence are considered. This makes it practically impossible to meet both the transmission and boresight requirements that are imposed on

TABLE 1—Artificial Dielectric Foam (Eccofoam HiK 625D)

Strength at 70 F.

Characteristic	*Strength, psi*
Tensile Strength	520
Modulus of Elasticity in Tension	185,000
Compressive Strength	1200
Modulue of Elasticity in Compression	65,000
Shear Strength	155
Modulus of Elasticity in Shear	10,600

Flexural Strength vs Temperature

Deg F	*psi*
70	1200
100	1150
150	1250
200	1110
250	1200
300	1100
350	1260
400	1100
460	780

present day high-speed aircraft and missiles. The term "A-sandwich" refers to a radome wall construction wherein a low density, low-dielectric-constant core is used in conjunction with higher dielectric-constant skins. The core is either foam or honeycomb at dielectric constant 1.1 to 1.2; the skins are usually fiberglass laminate at dielectric constant 4.2. The use of the artificial dielectric foam to raise the dielectric constant of the core to match that of the skins permits the design of the radome to be conducted on solid wall characteristics, and thus there is a much better chance of maintaining the variation of phase delay within limits acceptable for boresight requirements over the range of required incidence angles, as well as maintaining the necessary transmission efficiency.

Selecting Artificial Dielectric Foams

An artificial dielectric foam may be defined as a dielectric foam structure which has incorporated in it discrete particles of electrically conductive material for the purpose of raising the dielectric constant. A great variety of foams can be loaded to produce artificial dielectrics. A careful study of the requirements for radome applications, however, drastically limits the number available.

Metallic Loading. A typical foam material at a bulk density of 20 lb per cu ft has a dielectric constant of 1.2. In order to substantially raise the dielectric constant without a significant increase in weight, it is necessary to load the foam with metallic particles. So long as these particles are electrically insulated from one another, the dissipation factor remains low. For a given amount of metallic loading, flake-type particles have been found to be most effective. Aluminum, copper, silver and gold particles have been found to be effective.

Since a relatively small amount of metallic loading has a large effect on the dielectric constant, it is important that dispersion of the loading throughout the foam be uniform. Moreover, the metallic particles must be randomly oriented, otherwise the material will not be isotropic from the dielectric constant standpoint. Foam density from point to point must also be uniform. In the

Fig. 2. Radome fabrication using "Pack-in-place" foam.

event that any significant inhomogenities exist in the foam, it is almost impossible to obtain reliable dielectric data.

Pack-in-Place Artificial Dielectric Foam

Artificial dielectric "pack in place" foam (such as Eccofoam HiK 625 D) is a high-temperature epoxide-based material. Only heating is required to effect cure. There is no mixing of ingredients. As received it has a form which resembles that of damp sand. In this form it is packed or tamped into the cavity to be filled. For absolute uniformity it must be packed to maximum density. Only slight pressure is needed for this; for large volumes and/or for filling honeycomb, a small air hammer is used which is fitted with a square plate on the plunger.

Although adhesion of the "pack-in-place" foam to a variety of materials is generally good, improvement can be achieved by precoating surfaces with low-viscosity resin solution which then cures simultaneously with the foam. This has been found to be particularly useful for the coating of honeycomb cell walls. The resin solution is applied by spray or dip.

Cure of the foam is complete in about eight hours (4 hours at 260 F; 4 hours at 320 F). After cure, the foam can be subjected to 500 F.

Radome Fabrication

A radome fabrication using "pack-in-place" artificial dielectric foam is shown in Fig. 2. The material as received and processed is shown in Fig. 3. The geometry of the radome lent itself to use of a female mold. For a conical or ogive radome, a male foam would probably be used.

A high temperature epoxide resin-fiberglass skin is laid up against the female foam, bag molded and cured. Preformed phenolic honeycomb strips of the proper thickness are bonded to this skin, using a thin layer of fiberglass fabric and a bag molding technique. The honeycomb cells and the laminate are coated with a high-temperature epoxide surface coating. The excess is allowed to drain. Pack-in-place foam (Eccofoam HiK 625D) is then packed into place. Excess is removed. Preliminary cure at 260 F for 4 hours is effected. The surface coating, which is only about 1 mil in thickness, makes a firm bond between the foam and honeycomb. The honeycomb-foam combination can then be machined to exact thickness. A high-temperature epoxide-fiberglass skin is next laid up, bag molded and cured. The entire assembly is then post cured. After minor finishing operations, the radome is ready for use.

Properties

Properties of the cured honeycomb are as follows:

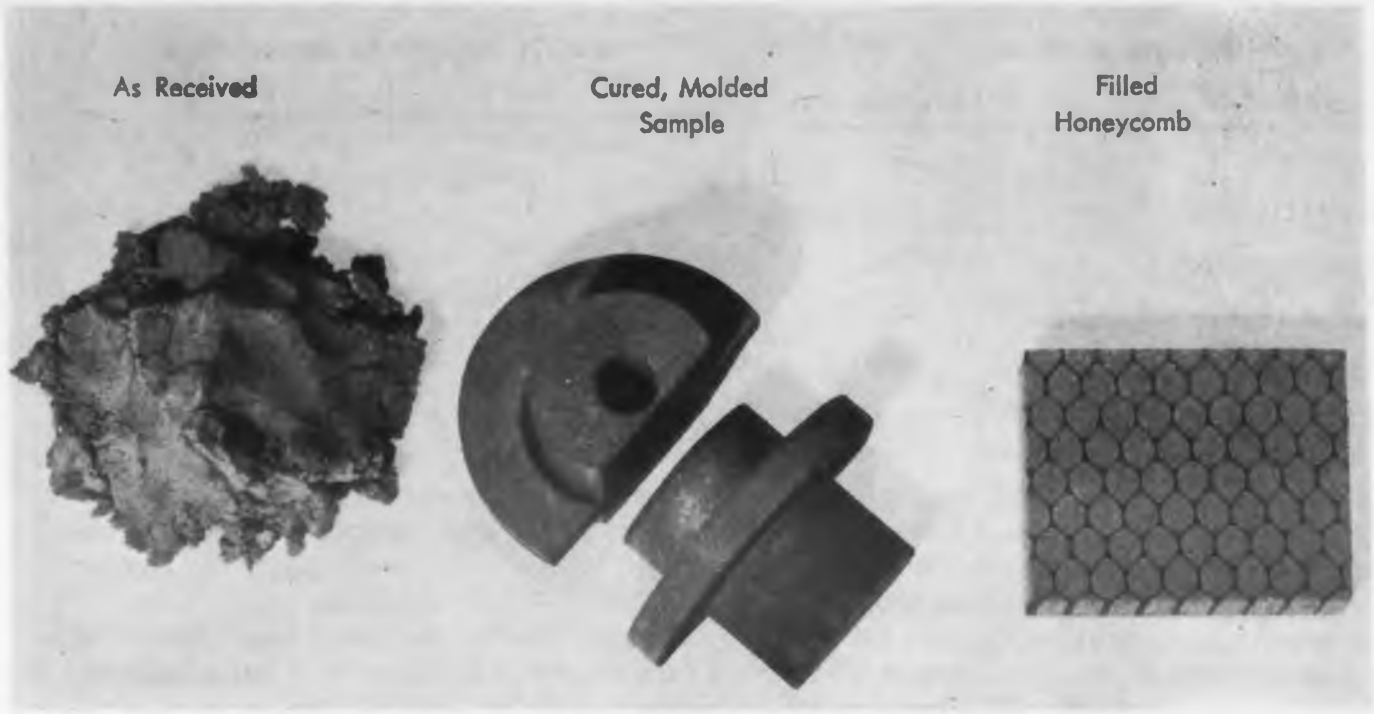

Fig. 3. Artificial dielectric "Pack-in-place" foam Eccofoam HI K 625D.

Density. Foams are produced in the density range from 20 to 25 lb per cu ft.

Dielectric Constant Range. "Pack-in-place" artificial dielectric foams have been produced from dielectric constant 1.2 to 7.0.

Dissipation Factor. A curve of dissipation factor versus dielectric constant is shown in Fig. 4.

Point-to-point variation and isotropicity. Several large blocks of foam have been made in order to obtain dielectric data of this kind. A typical block was 18 x 18 x 6 in. from which twelve samples 1 in. D x 3/4 in. long were cut. Samples were distributed throughout the block, at various orientations. Maximum variation in dielectric constant was ± 0.1 from the average value of 4.2.

Phenolic honeycomb has been filled with the foam and samples measured. The resultant material was isotropic in dielectric constant ± 0.1.

Strength. As a result of a large number of tests, significant strength data is given in Table 1.

Dielectric Constant and Dissipation Factor vs Temperature. Data for a single dielectric constant is shown in Fig. 5.

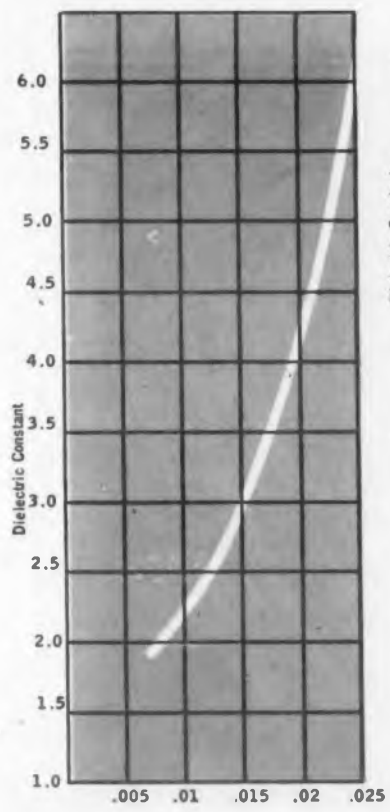

Fig. 4. (left) Dielectric Constant VS Dissipation Factor at Room Temperature for a typical epoxide Artificial Dielectric Foam at 8600 Mc.

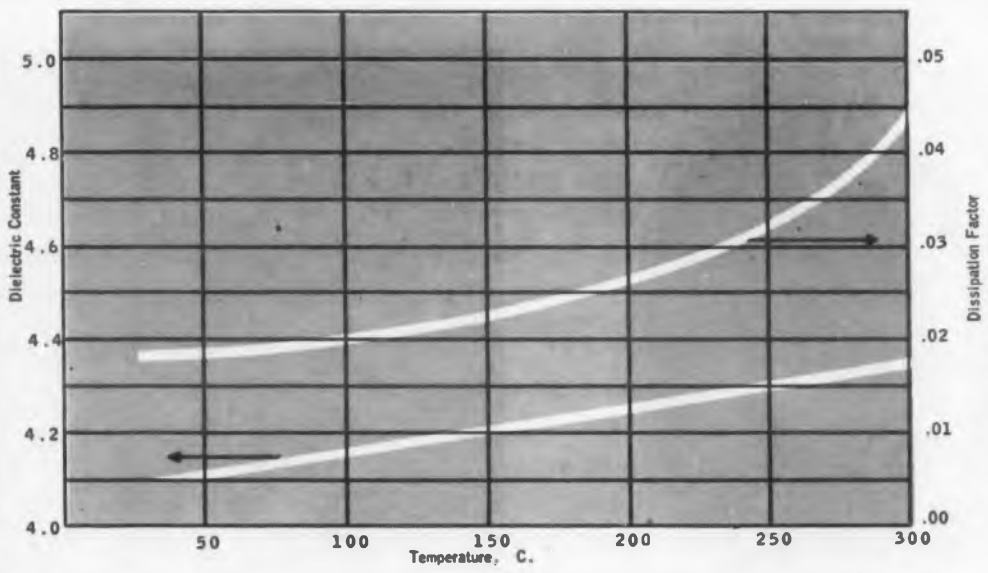

Fig. 5. (above) How dielectric constant and dissipation factor vary with temperature for a typical foam material (HiK 625D).

Moisture Absorption. This type of foam is not unicellular. It should not be exposed to liquid water without a suitable protective coating. Several such coatings have been developed.

Strength and Weight Comparison. A radome wall 0.340 in. thick made from solid fiberglass laminate weights about 3.5 lb per sq ft. A foam filled honeycomb sandwich which has 0.060 in. fiberglass laminate skins weighs 1.8 lb per sq ft. The solid laminate, when tested in flexure, will support a uniform load of 37 lb per sq in. The sandwich when tested under the same conditions will support a uniform load of 28 lb per sq in.

Use of Silicones and Inorganics for High Temperatures

Artificial dielectric foams, which make use of other resins, have been made. Silicone resins are of particular interest. Pack-in-place foams made therefrom have been subjected to 750 F for extended periods. Loss characteristics are slightly better than those of the epoxide materials, particularly at elevated temperatures, but strength characteristics are definitely inferior.

Completely inorganic artificial dielectric foams have also been made which will survive 1200 F. Electrical data is comparable, but the foams are more brittle than the organic materials.

Use in Microwave Lenses

Pack-in-place Eccofoam HiK 625D has been used successfully in several microwave lens applications. Lenses can either be molded directly to size or machined from blocks of foam. Point to point uniformity of the dielectric constant (an especially important characteristic in lenses) is comparable to that of solid homogeneous materials. In a typical case weight is one third of that of the solid material.

Other Possible Artificial Dielectrics

A variety of other artificial dielectric foams have been made. These include flexible foam sheet (both low and high loss), both liquid and powder foam-in-place resins and even low-weight casting resins. Certain artificial dielectrics have had weights as low as 2 lb per cu ft for dielectric constants up to 3.0.

With the emphasis on low weight, foam artificial dielectrics will be used to an increasing degree in a variety of microwave applications—particularly, as the electronic engineer becomes familiar with their unique properties.

The work described here was sponsored by the Radome Branch, Electronic Components Laboratory, Wright Air Development Center under Contract AF33(616)3486. Credit is due Mr. E. Luoma and Lt. J. Dickinson for assistance in furthering the program.

Typical Sonoweld applications, left to right: insulated copper wire to insulated copper wire, without stripping; aluminum foil to aluminum condenser can; aluminum foil conductor to stranded copper wire.

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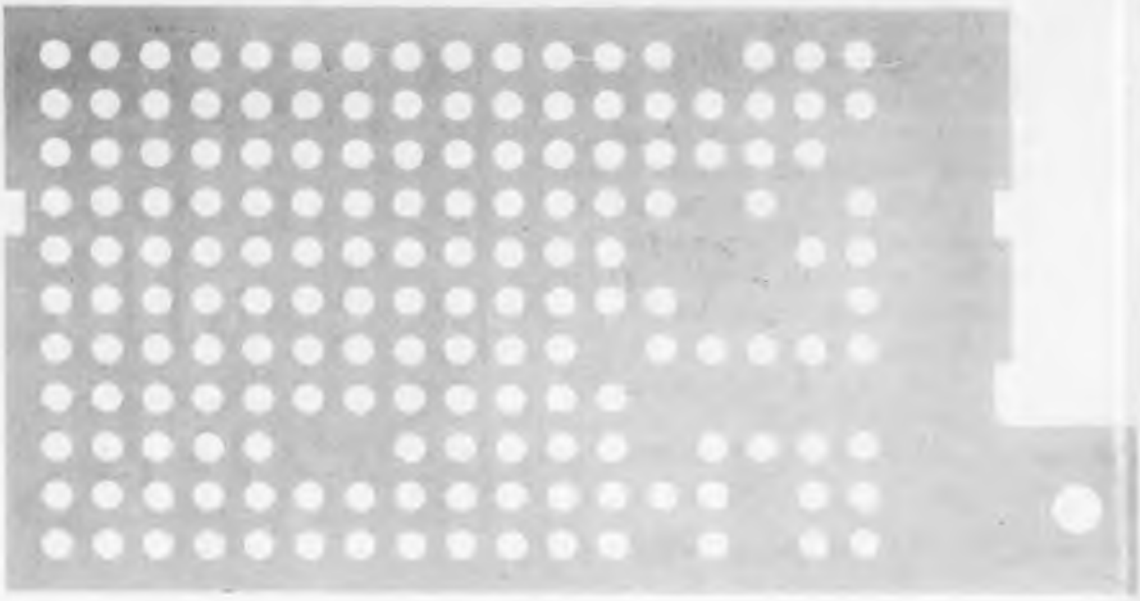
CIRCLE 34 ON READER-SERVICE CARD



Complex Switching Made Easy with

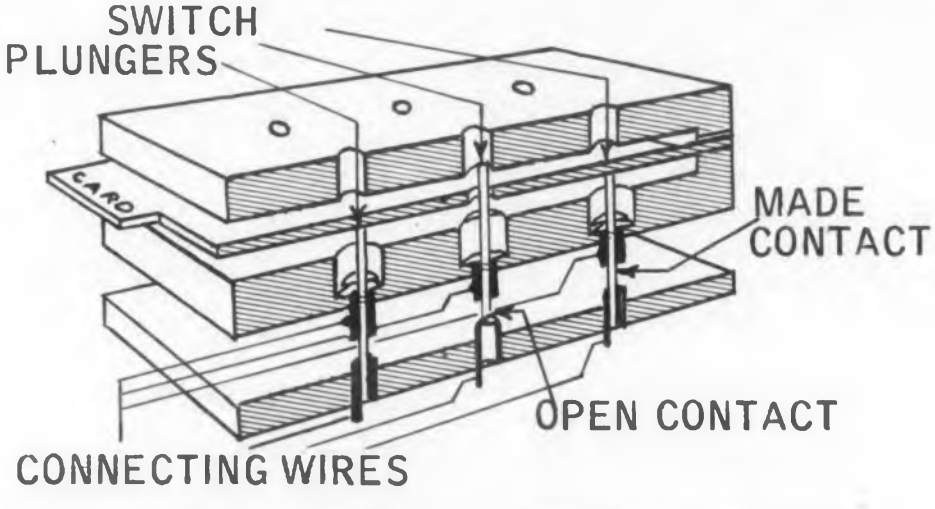
Card-Operated Switch

AUTOMATIC multiple switching operations at low cost are possible with this new punched-card actuated switch. Designed originally for use in a tube tester, the assembly has a total of 187 separate self-cleaning, wiping type switches.

Called "Cardmatic," the unit is actuated by inserting a standard 4 x 5 in. modular code card. Holes in the card determine which switch contacts close.

Contact-to-pin resistance is 0.00025 ohms nominal; current-carrying capacity is 10 amp. Thus the switch may be used in applications ranging from power switching to signal circuits.

The assembly, made by Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8,



Top portion of switch assembly down showing how plungers are pushed to close contacts.

Sliding punched card into the slot actuates the switch. Knob on the left releases it.

Ohio, weighs less than 5 lb. It measures 7-1/2 x 7-1/8 x 5 in.

Inserting the card actuates a switch at the rear of the assembly. This switch energizes an electramagnet that pulls the top half of the assembly, including the card, down. When this happens, the card forces plungers, that look like small copper nails, down into contact sleeves in the lower half of the assembly. But where the holes in the card coincide with the plungers, they are not forced down, and do not close their switch. Thus, the absence of holes in the card provides the contact actuation.

This feature has several advantages. If the switch is accidentally actuated, no contact will be made and there is no possibility of circuit damage. Also, contacts can be closed manually using a special plastic key.

Since the cards only actuate the switch, they do not require insulating properties. Cards are made of vinyl to withstand rough use, but any heavy material is suitable.

The switch is being considered for use in programming a packaging operation in which several varieties of small boxes are packed in a large box. Another firm plans to incorporate the unit into a system for production line testing of vacuum tubes. Hickok recommends the switch as the most practical method of handling complex data in programming automatic production.

For more information on this new card-operated multiple-contact switch, turn to Reader-Service card and circle **35.**

BACKGROUND FOR DESIGNERS

Simplifying Cathode Follower Circuit Design

Donald W. Moffat
General Electric Co.,
Utica, N. Y.

Experienced designers of circuits employing cathode followers will find this material generally familiar. However, the organization of cathode-circuit information as presented here should be of particular value to those engineers who have occasional use for cathode followers or related circuits and to young engineers meeting the subject in a practical way for the first time.

—The Editors

CATHODE circuits have taken on increasing importance for many applications. By careful selection and arrangement of published formulae and preparation of working curves based on design requirements, cathode-circuit development can be simplified and facilitated. Suggested procedures are described for design of amplifiers, computing circuits, multivibrations, vacuum tube voltmeters, and circuits where interface resistance is a limitation.

Cathode followers involve current feedback and cathode biasing. Equation 1 is the expression for gain as derived from the linear equivalent circuit.

$$\frac{e_o}{e_i} = \frac{\mu R_k}{r_p + R_k (1 + \mu)} \qquad (1)$$

As in any amplifier, gain is constant when voltage excursions are not large enough to change the value of g_m. This range of linear operation is extended in the cathode follower because normal characteristic curves will be considerably straightened out by the use of an unbypassed cathode resistor.

Designing with Characteristic Curves

In Fig. 1, the dotted lines are normal characteristics for a 12AU7 and the solid lines are characteristics for the same tube with a 1000 ohm cathode resistor. The modified curves are linear over a much larger region—the region where equation 1 can be applied.

If a new set of curves is required, it may be obtained by several methods. When one tube type is to be used repeatedly with one value of cathode resistor, a new set of curves, as shown in Fig. 1, should be plotted. To modify a set of standard characteristic curves, select a value of input, e_g, and a value of plate current, i_p. For this plate circuit, calculate $e_k = i_p R_k$ and $e_{kg} = e_g - e_k$. From the original tube characteristics, for a given e_c and i_p (where $e_c = e_g - e_k$) a plate voltage of e_{pk} is required. Then e_p is calculated from $e_p = e_{pk} + e_k$, and the point e_p, i_p can be plotted. When other values of i_p are selected, more points can be plotted to give the curve for one value of e_g. The process can be repeated with other values of e_g to give the family of curves.

If one tube with one value of cathode resistor will not be used often enough to warrant construction of complete characteristic curves, modified curves can be quickly approximated. A large part of each curve is a straight line; so, if the cathode resistor is medium to large, two points will describe the part of the curve where most design information is obtained. One point should be selected for as high a current as possible and one point for a medium current.

In most designs B+ is not a variable; thus, it is practical to make a simpler modification that

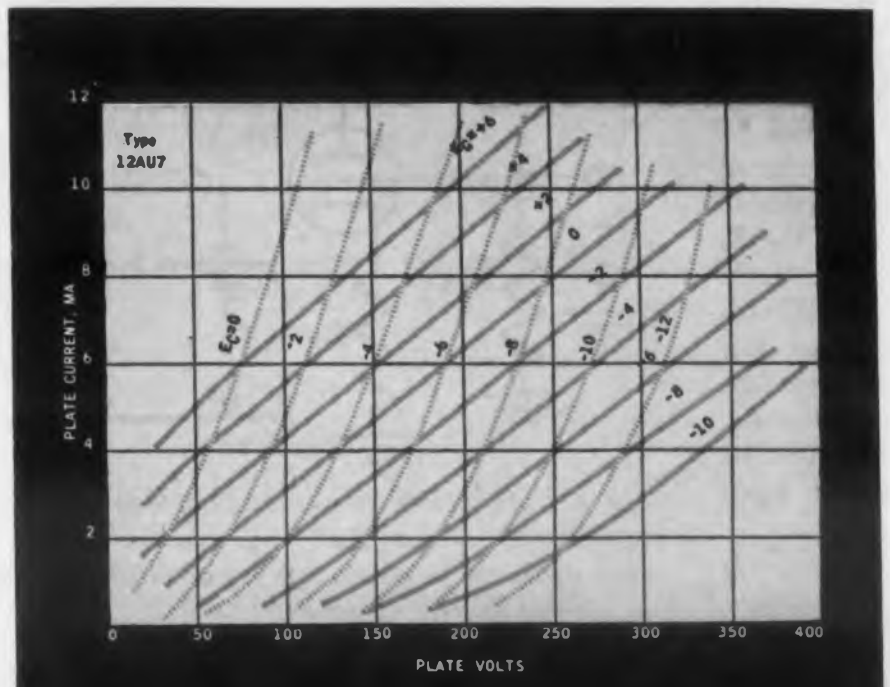


Fig. 1. How normal plate characteristics for 12AU7 (dotted lines) are modified (solid Lines) for a given (1000-ohm) cathode resistor. Note improved linearity.

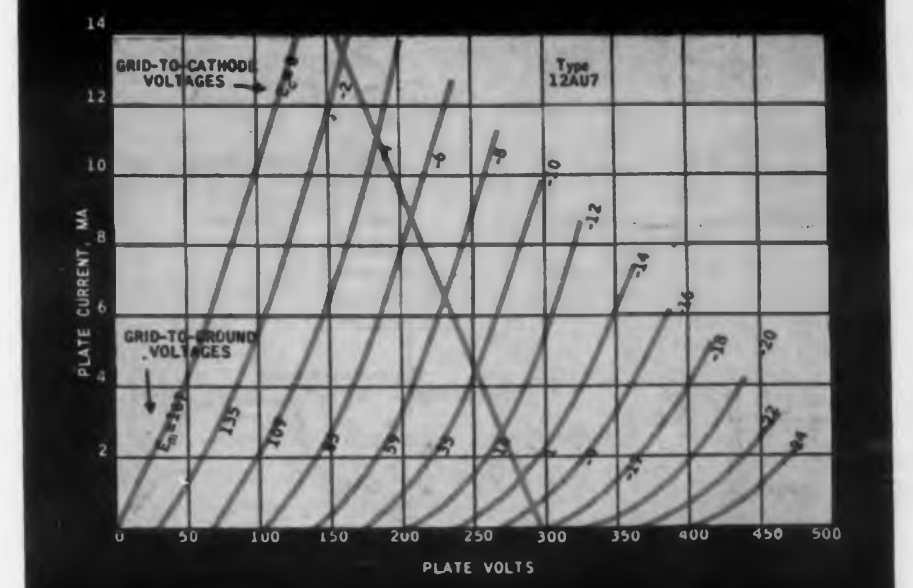


Fig. 2. Curves for use with various cathode loads. Load lines can be drawn on family of normal characteristics on which grid-to-ground voltages have been calculated.

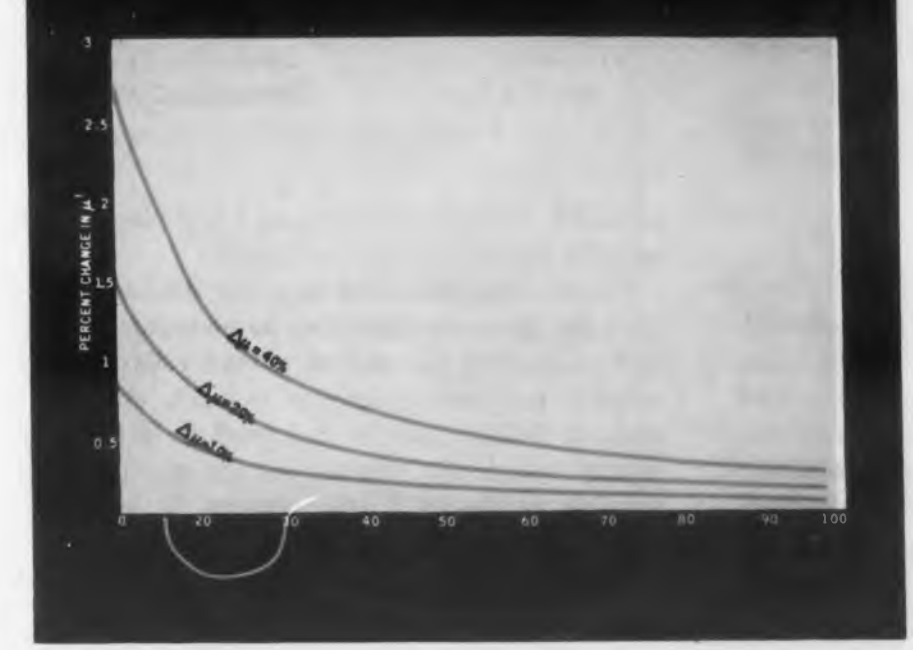


Fig. 3. How effective amplification factor (μ^1) varies with published μ. Same relationship holds for effective plate resistance (r_p^1) versus r_p.

is valid for only one tube type, one value of cathode resistor, and one value of B+. Although such a set of curves seems quite restricted, its utility is increased by the fact that it can be easily plotted and repeated for other values of resistance. In this case, the load line is drawn for the selected cathode resistor. Each of the E_c values on the original curves is a grid-to-cathode voltage, and the only unknown is the grid-to-ground (input) voltage. Where the load line crosses any E_c line, say E_{c1}, a value of plate current, such as i_{b1}, can be read. At this plate current, the cathode voltage will be $i_{b1}R_k$, so E_c and E_k can be added algebraically to obtain an input voltage of

$$e_{g1} = E_{c1} + i_{b1} R_k \qquad (2)$$

Repeating the process for each grid curve gives a value of input (grid-to-ground) voltage for every grid-to-cathode voltage, as shown in Fig. 2.

Information obtained. Considerable information can be obtained from these curves. The quiescent point can be observed at $e_g = 0$. Maximum positive grid swing before grid current is found where grid-to-cathode voltage $E_c = 0$. Gain can be determined also; if a +17 v pulse is applied, unity gain would cause the cathode voltage to increase to 17 v. The curves show that grid-to-cathode voltage changes by two volts, so gain is:

$$A = \frac{17 - 2}{17} = 0.883 \qquad (3)$$

Another way of looking at the linearizing effect of a cathode follower is to note that both μ and r_p are effectively reduced by a factor of

$$\frac{1}{\mu + 1}.$$

$$\mu^1 = \frac{\mu}{\mu + 1}\,;\, r_p{}^1 = \frac{r_p}{\mu + 1} \qquad (4)$$

Percentage change in μ^1 as μ is varied as given in Fig. 3 for a 10, 20 and 40 per cent increase in μ. It is clear that any percentage change in μ and/or r_p will be multiplied by a factor considerably less than one.

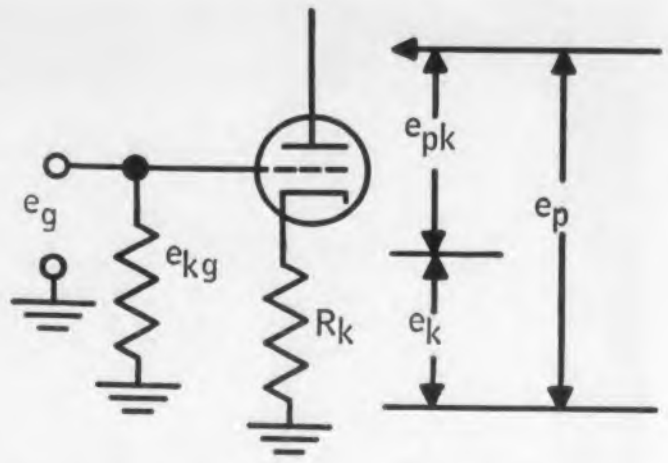
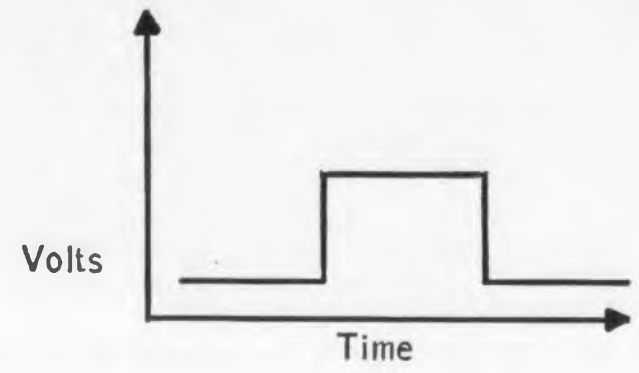
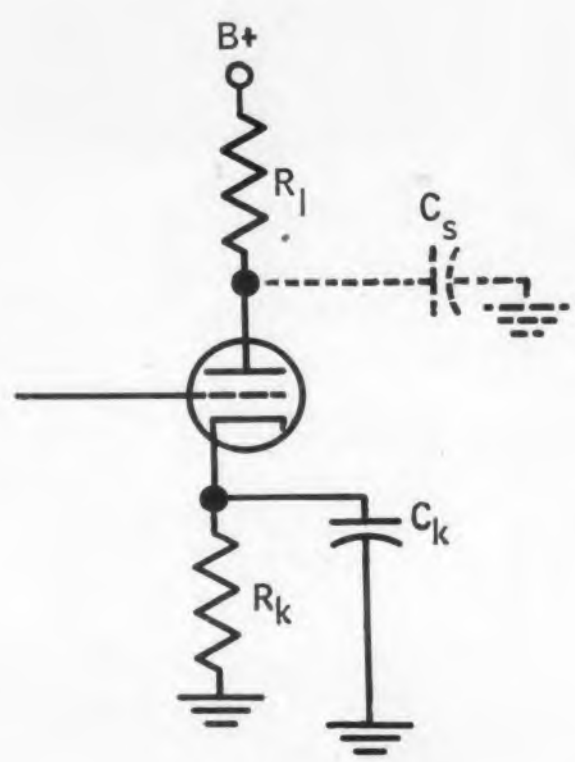


Fig. 4. Basic cathode follower circuit. If load (cathode) resistance is not too small, large positive low-duty-cycle pulses can be passed with low distortion because of inherent self-biasing feature.



Figs. 6. and 7. When rectangular pulse (Fig. 6 above) is impressed on circuit (Fig. 7 below), R_k is effectively zero for the transient rise and fall but not for the flat top. In effect, the circuit differentiates the pulse.



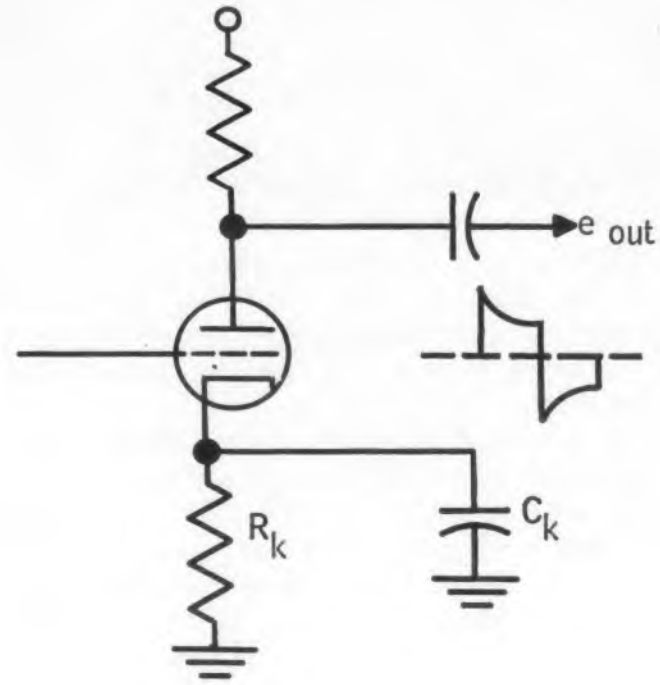


Fig. 5. For voltage-gain stabilization, this circuit can be used with unbypassed cathode; or, to extend the bandwidth, C_k can be chosen to bypass during roll-off caused by C_s.

Pulse Signal Considerations

Because self-bias is inherent in a cathode follower, special consideration must be given when handling large pulse signals. As long as the load resistor is not too small, large positive low-duty-cycle pulses are easily handled. Normal bias supplied by the cathode resistor puts the tube well on its way to cut-off so that a large negative-going pulse will be clipped. If the load resistor is made smaller to reduce the bias, the gain is reduced, but quiescent current will be limited only by the tube plate resistance.

Quite often the grid can be direct-coupled from the previous stage thus overcoming the bias and permitting the use of a load resistor large enough to limit quiescent current. Also, the cathode resistor can be returned to a negative supply which has the advantage of making it possible to design to the correct dc level and direct-couple to the next stage. Such a circuit can be used with no dc restoration if the bottoms of short negative pulses are to be lined up at O_v.

Plate Coupling—Cathode Unbypassed

Cathode degeneration results if the cathode resistor is left unbypassed and output is taken from the plate load. Some common reasons for using such a circuit are: increased fidelity, gain stabilization, self-bias in a dc amplifier, and self-bias where gain requirements do not warrant addition of a bypass capacitor. Small signal gain is given by:

$$\frac{e_o}{e_i} = -\frac{\mu R_L}{r_p + R_k (1 + \mu) + R_L} \qquad (5)$$

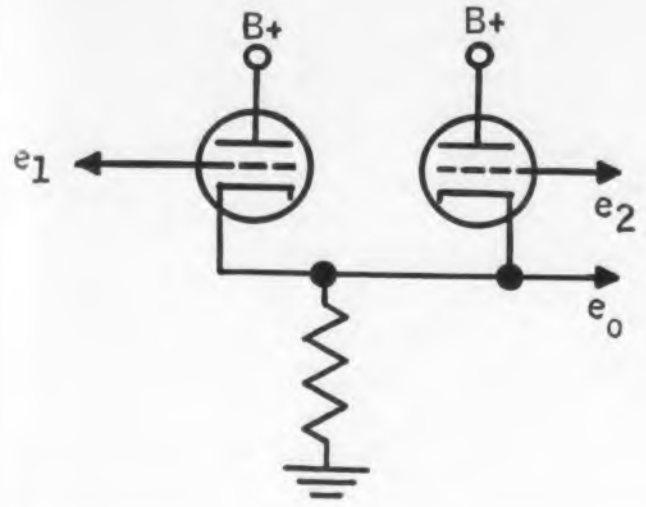


Fig. 8. Cathode-coupled summer circuit used in computers.

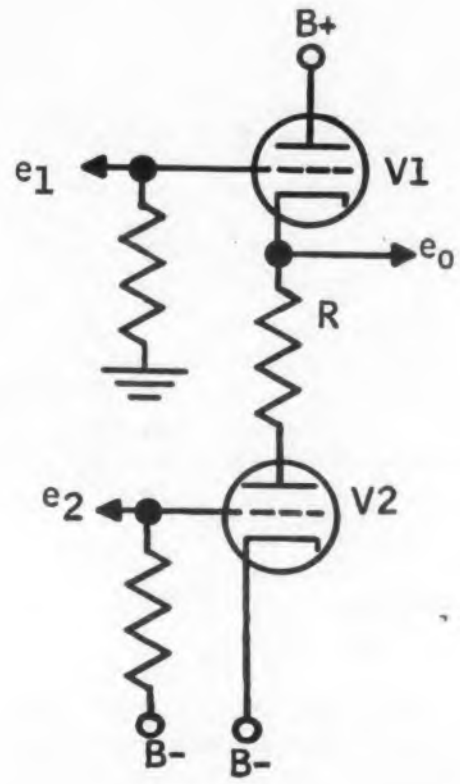


Fig. 9. Summer circuit which can be designed for any predetermined dc component in output.

The modified solid curves in Fig. 1 can be used for signals that extend into the nonlinear region if the load line is drawn for $R_k + R_L$.

To extend the bandwidth, it is convenient to compensate in the cathode circuit as in Fig. 5 by choosing C_k so that it becomes an effective bypass during the roll-off caused by C_s. Compensation is achieved when:

$$R_k C_k = R_L C_s \tag{6}$$

where: R_k = Cathode Resistor; C_k = Capacity shunted across R_k; R_L = Plate load; and C_s = Total shunt capacity.

From the equivalent circuit it can be shown that the time constant is now approximately:

$$T \approx \frac{R_L C_s}{g_m R_k + 1} \tag{7}$$

Gain is:

$$A = -\frac{g_m R_L}{g_m R_k + 1} \tag{8}$$

Bandwidth is:

$$B = \frac{g_m R_k + 1}{2\pi R_L C_s} \tag{9}$$

This means that bandwidth has been increased by a factor of $g_m R_k + 1$ and gain has been reduced by a factor of $1/(g_m R_k + 1)$.

Obviously, rise time can also be improved at the expense of gain. A pulse step with zero rise time, applied to the grid, will give a response in the plate of the form $1 - \varepsilon^{-t/RC}$. Taking gain into account, the output voltage of an uncompensated amplifier is:

$$e_o \text{ (uncompensated)} = -V g_m R_L \left(1 - \epsilon^{\frac{-t}{R_L C_s}}\right); \tag{10}$$

and output of the compensated amplifier is:

$$e_o \text{ (compensated)} = -V \frac{g_m R_L}{g_m R_k + 1} \left[1 - \epsilon \frac{t (g_m R_k + 1)}{R_L C_s}\right] \tag{11}$$

Plate Coupling—Cathode Bypassed

Consider a case where an extremely large bypass capacitor is needed. If the pulse of Fig. 6 is applied to a conventional amplifier as in Fig. 7, pulse rise time is assumed fast enough to make R_k look completely bypassed for this transient; but $R_k C_k$ sees the pulse top as a new dc level. Therefore, the stage will operate at full gain for the transient, and

$$A = g_m R_L \tag{12}$$

but will decay exponentially to that of a completely unbypassed amplifier, such that

$$A \rightarrow \frac{g_m R_L}{g_m R_k + 1} \tag{13}$$

Time constant for this decay will be increased by the same factor as in equation (7). Gain at any time is given by:

$$A\ (t) = \frac{g_m R_L}{g_m R_k + 1} \left[1 - g_m R_k - g_m R_k \left(1 - \epsilon \frac{-g_m R_k + 1}{R_k C_k}\right)\right] \tag{14}$$

(Continued on following page)

The percentage of droop can be shown to be:

$$\% \text{ droop} = \frac{g_m R_k}{g_m R_k + 1}\left(1 - \epsilon - \frac{g_m R_k + 1}{R_k C_k}\right) \quad (15)$$

If the pulse duration is much less than the amplified time constant, the droop will be so small that it can be considered a linear function of time. In that case, equation (15) is approximated by

$$\% \text{ droop} = \frac{g_m}{C_k} 100\, t \quad (16)$$

A few reference texts give numerical examples to show how ridiculously large a cathode bypass can get and why R_k is left unbypassed or the tube is biased by other means.

Summing Circuits

One of the most common active computing circuits is the cathode-coupled summer shown in Fig. 8. This circuit is described by:

$$e_o = \frac{\mu R_k}{r_p + 2 R_k (1 + \mu)} (e_1 + e_2) \quad (17)$$

or for n triodes:

$$e_o = \frac{\mu R_k}{r_p + n R_k (1 + \mu)} (e_1 + e_2 + \text{---} + e_n) \quad (18)$$

Another form of summing circuit is shown in Fig. 9. Here the design objective is to have a virtual ground about midway on resistor R so that the top half of this resistor develops bias for V_1. Then, e_1 will appear attenuated at cathode *1*, and e_2 will appear amplified and inverted at the same point. Operating points and a value for R can best be chosen by an iterative graphical method. It is possible to design the output to have any predetermined dc component.

Subtracting Circuit

A slight variation of Fig. 8 gives the cathode-coupled subtracting circuit of Fig. 10. Operation is described by:

$$e_o = \frac{\mu_1 R_1 R_k (1 + \mu_2) e_1 - \mu_2 R_1}{[r_{p1} + R_k (1 + \mu_1)][R_1 + r_{p2} + R_k (1 + \mu_2)]} \frac{[r_{p1} + R_k (1 + \mu)] e_2}{-R_k (1 + \mu_1)(R_k)(1 + \mu_2)} \quad (19)$$

If $e_2 = o$, then e_1 only will appear amplified at the output, producing e_o. The entire circuit can be considered as one stage with high input impedance and no phase reversal. With identical tubes, the output is described by:

$$e_o = e_1 \frac{\mu R_L R_k (1 + \mu)}{(1 + \mu)(2 r_p + R_L) R_k + r_p (r_p + R_L)} \quad (20)$$

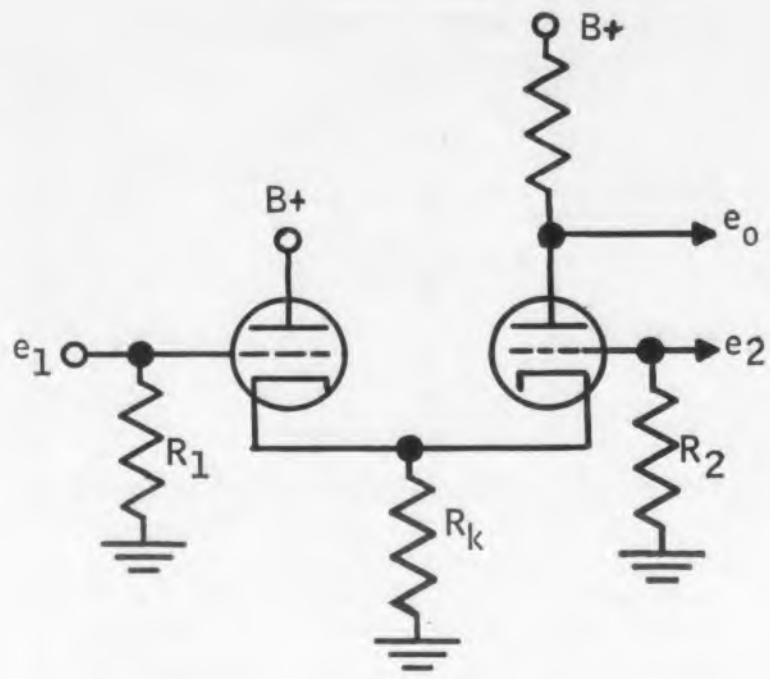


Fig. 10. Cathode-coupled subtracting circuit—a variation of Fig. 8.

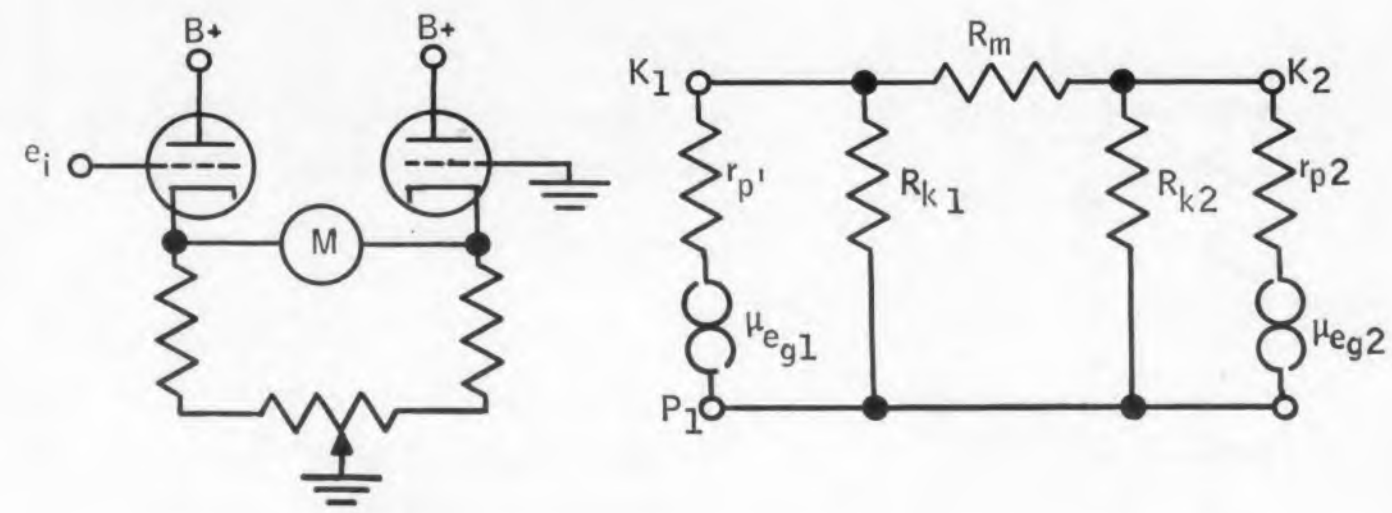


Fig. 11. Cathode-coupled vtvm circuit and equivalent.

VTVM Circuit

Cathode circuitry plays an important role in the design of vacuum tube voltmeters. In Fig. 11 is one possible configuration along with its equivalent circuit. Writing loop equations and solving by use of determinants (assuming identical tubes) gives:

$$i_m = e_1 \left[\frac{\mu R_k}{2 R_k r_p + R_m [r_p + R_k (1 + \mu)]}\right] \quad (21)$$

This circuit is for a high sensitivity meter movement with low meter resistance. If R_m is extremely small, equation (21) is approximated by:

$$i_m = e_1 \left(\frac{\mu}{2 r_p}\right) \quad (22)$$

The meter current is directly proportional to g_m. Cathode degeneration increases the area of linear tube parameters so that meter current is extremely linear. For instance, using 6J5 triodes, B + of 100 v, and 1000 ohm cathode resistors, an experimental circuit could swing 6 v and produce a meter current of 0.3 ma that is within 7 per cent of its calculated value. As cathode resistors are reduced below this value, the allowable positive swing is limited as shown in Fig. 12. This fact is sometimes used to protect sensitive meter movements against positive input surges. Another voltmeter circuit is shown in Fig. 13. Analysis of this circuit shows that it is suited for a high resistance meter movement that will indicate the amplified change in e_1 at the plates. This circuit has a disadvantage because designers do not like to run hot leads to the front panel.

Cathode Interface Impedance

Unless a tube tester is specially built for the purpose, it will not indicate cathode interface impedance. Cathode interface impedance is an effective impedance produced by a chemical

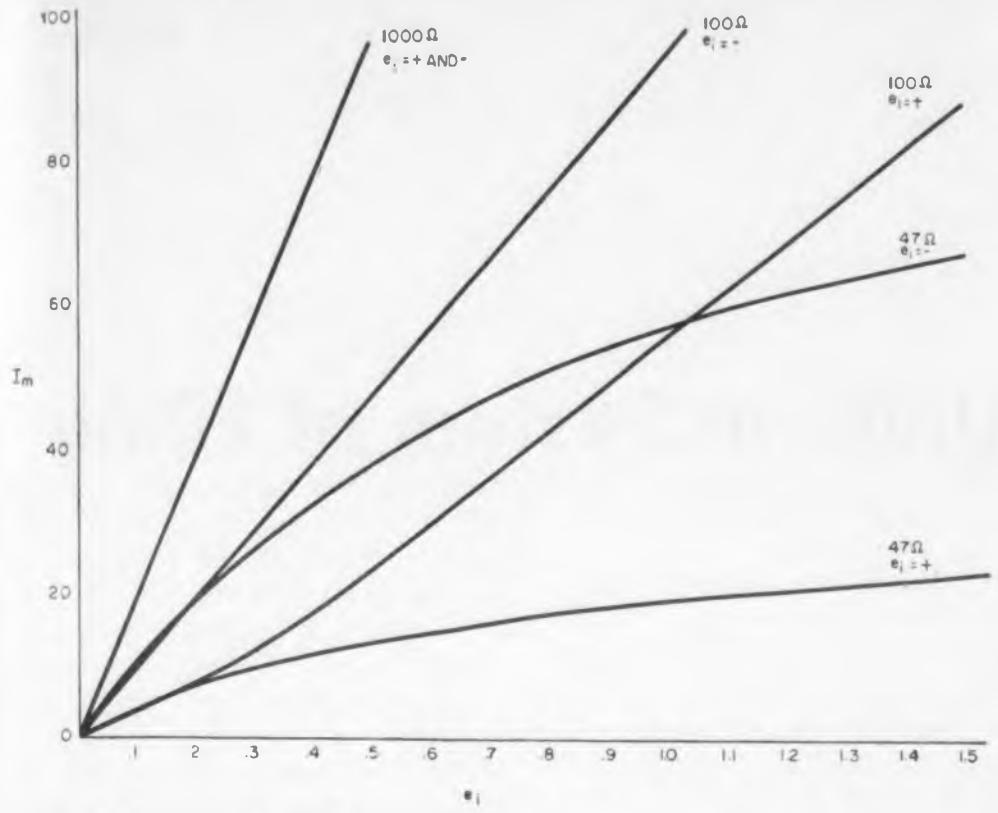


Fig. 12. Meter current in vtvm circuit versus input voltage. For lower values of cathode resistor, positive swing of meter current is limited as shown, giving protection to meter on overloads.

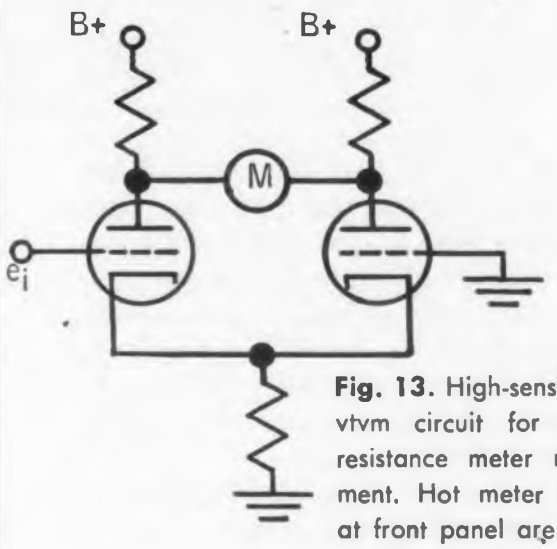


Fig. 13. High-sensitivity vtvm circuit for high-resistance meter movement. Hot meter leads at front panel are main disadvantage.

Fig. 14. Tube symbol showing cathode-interface effect, resulting from leaving heaters on standby with plate voltage removed. A "drooping" pulse output results.

action of an oxide coated cathode. It effectively places an RC circuit with approximately a 1 μsec time constant in series with the cathode as shown in Fig. 14. Maximum resistance is on the order of a thousand ohms. High filament voltage and low plate current accelerate the formation of this impedance.

Tubes that are left on standby with filament power applied are likely to develop cathode interface impedance. Keeping filament voltage medium to low and maintaining normal plate current are two methods of minimizing the impedance. The only way to completely eliminate cathode interface impedance is to use tubes with cathode materials that are not prone to develop such a layer, such as GE Five Star Tubes. Military specifications setting limits on this impedance have been written for only a few of the new tube types.

Once the layer forms, there is no way to reduce it. Since the effective circuit is similar to Fig. 7, the plate output for pulse input will be governed by equation (14) and will have a droop. Precautions must be taken to prevent formation of cathode interface impedance if this circuit is used and the flat top of the pulse is important. Low-frequency compensation is not a satisfactory solution because the value of impedance is a function of tube age as well as individual tube characteristics.

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Graphical Construction for Vacuum Tube Circuits, A. Preisman, McGraw-Hill, 1943.

A Method of Measuring Cathode Interface Impedance, W. U. Shipley, Part 3, IRE Convention Record, 1956.

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Design of Cathode Followers for Pulse Type Circuits, R. L. Whittle, *Tele-Tech*, Aug. 1953.

The Uniterm System of Filing

"The Uniterm system," the author told us from beneath a cactus near his Tucson home, "has applications everywhere." We know that the system is particularly handy in filing articles, but as Mr. Bell affirms, almost any indexing problem involving difficult-to-categorize technical material is more easily solved by Uniterming.

William Bell, who was co-founder of The Telecomputing Corp. in Los Angeles, is now in business for himself as a consultant in the computer field. He has authored a book, currently appearing on the market, entitled "A Management Guide to Electronic Computers."

ELECTRONIC DESIGNING is becoming a highly specialized profession. Just as the medical profession found that it was impossible for a single man to keep abreast of surgery, pediatrics, neurology, psychiatry, gastrology, and obstetrics, so the electronics man is finding that he, too, must limit his area of interest. Yet even though specializing in a selected field—digital or analog computer circuitry, instrumentation, servomechanisms, radar, or any one of the other innumerable fields of electronic development—the individual finds the task of keeping abreast of new developments to be an almost impossible job. This problem is a matter of concern to companies as well as individuals. If a new product is planned, what competitive equipments are already in the field, what reports, articles, and technical papers have been given that pertain to the new development? What work has the company already done that is applicable?

Consider how a typical engineer answers questions such as those posed above. Joe is supposed to design a spacistorized, demodulated, hyperdetected, quadrilateral phase shifter. Joe works at establishing his design parameters, pushes a pencil over a few preliminary design ideas. Suddenly he remembers that just three or four months ago he read an article describing a circuit idea that would exactly fit his present problem. Or was it six months ago? After some cogitating, Joe decides that he's sure (almost) that he read the article within the last year, but he's just a little uncertain as to which magazine. Was it the *ISA Journal* or the *Aeronautics Review*? Could it have been . . . no, he's certain it was not *National Geographic*. Maybe it was that excellent magazine, ELECTRONIC DESIGN? Joe digs through his own esoteric notes which he keeps in his unique filing fashion; he spends a couple of hours in the company library searching through the periodical files, and finally says to h--- with it! He'll design it himself. And so he returns to his desk, picks up his pencil and starts over.

How much redundant, repetitious design work is done within the electronics industry because of first, ignorance of the very existence of valuable reference material, and second, the inability to find the right data at the time it is needed?

Joe, as we saw above, has his own filing system. Most competent and ambitious engineers do have their own notebooks, their own methods, good and bad, of keeping track of subjects that interest them. Trying to keep such records reasonably up-to-date can take quite a chunk of Joe's working day, as well as from his evenings. Such personal records are usually worthless for any other individual. Only Joe knows what he's got in his file and how to find it. Moreover, if Joe decides to leave the company, he'll take his personal files with him, even though a major part of the time necessary to compile these data was bought and paid for by his employer.

Nor are run-of-the-mill company filing projects much better. Indexes, references and cross-references build up permutations of reference subjects that effectively disguise the hiding places of important data. To put a reference into a file is to lose it forever.

William D. Bell
Mellonics
Tucson, Ariz.

The Uniterm System

To solve the problems of organizing, storing and retrieving technical data, the Uniterm System was developed by the Armed Services Technical Information Agency (ASTIA).[1] The advantages of the system over conventional filing techniques are obvious, as will be shown. Primarily, the usual indecision of attempting to assign a principal category is eliminated. The uniterming method employs two files. The first is a material file where each item, be it a report, reference, document, or whatever, is filed under a simple serial number. The second part of the system is a small card file of "Uniterms." The Uniterms are the simplest practical word units of information into which documents can be analyzed. The serial filing numbers for reference documents are posted on the uniterm cards.

Let's see how the filing procedure actually works. ELECTRONIC DESIGN had an excellent article on analog computers. Let's assume that you tear from the magazine the pages with this article. A small paper tag is stapled to the pages. You, the interested engineer, or someone assigned to index material, list the appropriate Uniterms on the tag. But how should it be filed? In ordinary filing, the ascendancy of references complicates the operation. Do we file under *Computers, analog* or *Analog Computers*? In the Uniterm System the ordering of terms is immaterial. Also, we file under every pertinent term that we can think of. Thus, we might list as Uniterms:

computers
analog
transistor
H and G Company
correlation

This breakdown assumes the analog computer to be transistorized, built by the H and G Company and designed to calculate correlation coefficients.

The pages torn from the magazine, with the appropriate Uniterms, go to a file clerk. Her function is first to assign the next open serial number to the pages, which she writes as, say, 4523 with a heavy pencil or a numbering stamp in the upper right-hand corner. Then she pulls from her Uniterm file the appropriate cards and enters on each card the number 4523. It happens for this particular case that the file does not have a card for *correlation*, so she types a new index card to add to the Uniterm file and enters the appropriate number on it. The reference material is then put in the file in its proper sequential-number position and the Uniterm cards are returned to their file.

I can hear a protesting voice saying, "But we don't want to tear up our copy of ELECTRONIC DESIGN. These magazines are carefully kept for our company library."[2] That's quite all right, too; you don't have to tear up the magazine. In this case, the file clerk types the number, which we will assume still to be 4523, on an 8-1/2 x 11 inch piece of paper, along with the name of the magazine, the date, year, the title of the article, its authors, and the page numbers. This sheet of paper is then filed in the reference file and the magazine is kept as usual in the library.

Finding Material in the Uniterm File

Now, let's see what happens when we're searching for information. Our engineer is asked to design a transistorized operational amplifier to be used in an analog computer. If he would like to know what information is available on *computers*, a check against a single Uniterm card will give him the reference numbers of *all material* that has been filed on this subject; however, in most cases, a single card covers too much territory. The *computer* card will include data on both digital and analog computers, and our engineer has no interest in the digital equipments. Therefore, he can specify two Uniterms—*computer* and *analog*. Now, pulling the two appro-

wanted:

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General Electric's Jet Engine Dept., Cincinnati, Ohio, is now interviewing Engineers with 3 or more years experience in the following fields:

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General Electric Co., Cincinnati 15, Ohio

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CIRCLE 558 ON READER-SERVICE CARD

priate Uniterm cards from file, all like numbers posted on both cards refer to reference material that deals with the subject *analog computer.*

The engineer can get a closer and closer breakdown by specifying additional Uniterms that more accurately define his area of interest. Thus he might specify *computer, analog, operational* and *transistor.* Each of these four cards will list everything in file applicable to the particular Uniterm. But the numbers that are common to all four cards deal explicitly with material he wants (Fig. 1.)

To make correlation of numbers on different Uniterm cards easier, each card is divided into 10 columns. Reference serial numbers are posted

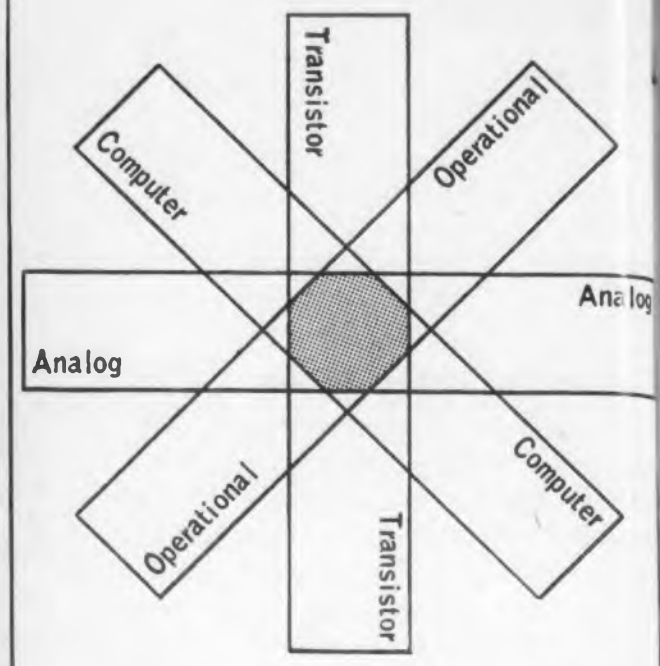

Fig. 1. Each rectangle indicates all references for the specified Uniterm. Only those references in the shaded area are common to all five rectangles and are therefore the desired reference material.

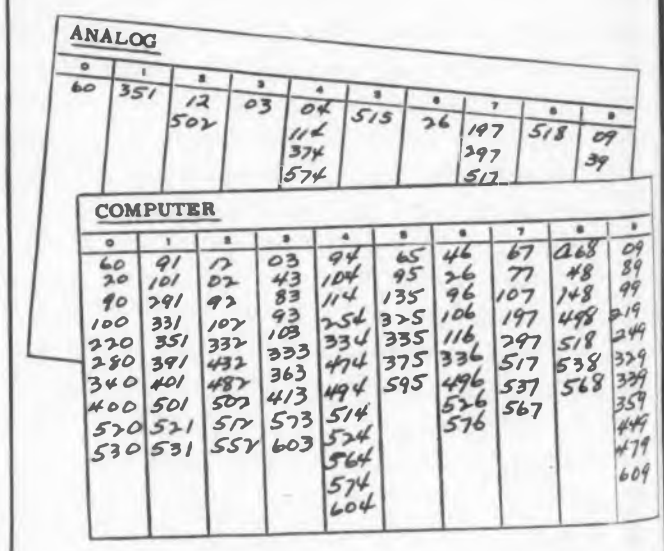

Fig. 2. Sample Uniterm cards. All numbers common to both cards are for Analog Computers.

in the appropriate columns, numbered 0 through 9, according to the last digit of the serial filing number. Fig. 2 shows typical Uniterm cards.

Let's Think Big

Can we improve the Uniterm procedure? What can be done is to eliminate the repetition of effort of different companies all expending time and dollars to do the same job of compiling reference material. What is needed is a cooperative effort to achieve really complete and superior indexing and filing of engineering materials, with the cost to be shared by participating companies. Excellent examples of the feasibility of such an idea are given by the insurance companies, who have long actively cooperated in making insurance data, such as accident claims, medical reports, etc., available to all and spreading the cost of keeping these tremendous files among the sharing companies. Clearly, this same idea could be profitably followed by electronic companies.

Why Not Use a Computer?

One other factor we, as electronics men, too seldom see is the possibilities of applying electronic equipments to our own pertinent problems. Why isn't it feasible to set up Uniterm records, not on cards, but on magnetic tapes, with the searching and auditing and filing jobs all done at high electronic speeds? Consider a service organization maintained by a number of companies. Competent researchers would scan all pertinent periodicals and keep up-to-date on all new manufacturers' catalogs and specification sheets. Company confidential reports would be added to these files on a restricted basis so that this information could only be secured by the company that supplied the data. All of this Uniterm information would be set up as magnetic-tape records. Each day participating companies could supply listings of particular categories of interest. The computer could do all the work of searching the tape records, checking the cross-correlation between numbers under different Uniterms, and preparing final output tapes to be converted to a printed report, specifically identifying pertinent references applying to each request.

Is this thinking too big? Such an ambitious program might well be supported by the government through the development period. Even without government support, a successful reference indexing and searching system, with the cost spread among a number of users, could pay a handsome dividend in reduced development costs, increased efficiency of design engineering.

References

1. The Armed Services Technical Information Agency, Installation Manual for the Uniterm System of Coordinate Indexing, October 1953.
2. Authors can cooperate.

DC Feedback Equations for Transistor Amplifiers

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FOR THE design of a reliable transistor amplifier some type of stabilizing network must be used to provide a dc operating point which will maintain the amplifier's dynamic signal handling capabilities. This is due primarily to the effects of temperature on the collector cut-off current of a transistor (I_{CBO} approximately doubles for every 10°C rise in temperature). This is further exaggerated in the common-emitter configuration since here the cutoff current (I_{CEO}) is equal to $\frac{I_{CBO}}{(1-\alpha_{fb})}$. Another factor affecting the operating point is the wide variation in alpha (α_{fb}) encountered, both initially and over the device's useful operating life.

The amount of stabilization required is dependent upon whether or not the cut-off current is an appreciable part of the total collector current. This, in fact, gives rise to a most effective method of stabilizing the dc bias point, which consists of simply swamping out the maximum cut-off current which may occur. This method, however, is extremely costly in terms of power consumption and for this reason cannot be used very often. Other methods are available which consist of the use of temperature compensating and nonlinear elements that possess the properties of an opposite temperature coefficient to the device being stabilized. This type of element usually requires careful matching and selection and may prove to be as costly as the transistor being stabilized. This paper will deal with several types of dc feedback loops which provide a changing bias current proportional to changes in output current. This type of stabilization is most effective and only requires additional resistors and in some cases bypass capacitors as well as some additional power consumption.

For the initial selection of a quiescent operating point the most accurate method is through the use of the transistor's static collector characteristic curves and the dc and ac load lines. The required stability factors can then be determined from the curves knowing the desired signal handling capacity of the amplifier and the operating temperature range. Equations have been derived for dc load line, collector current stability factor $\left(\frac{\partial I_C}{\partial I_{CBO}}\right)$, and as an aid in determining the bias point, collector current and base current.

Three configurations are considered, the effectiveness of each depending to a great extent on the magnitude of the dc load. Figs. 1, 2 and 3 illustrate the circuit configurations analyzed. Tables 1, 2 and 3 present the derived design equations.

Collector Voltage Feedback

Of the three types of bias stabilization considered, the simplest and most easily applied is collector voltage feedback. As can be seen from Fig. 1, this is accomplished by simply connecting the base bias resistor directly from collector to base. This type configuration is most effective for high dc loads. As the dc load is decreased the stability factor approaches that value obtained for fixed bias operation. Writing the branch current equations and assuming V_{BE} is negligible the following are obtained:

$$V_{CC} \simeq -I_E R_L + I_B R_F \tag{1}$$

$$V_{CE} = V_{CC} + I_E R_L \tag{2}$$

$$I_B \simeq \frac{V_{CE}}{R_F} \tag{3}$$

$$-I_E = I_B + I_C \tag{4}$$

From these equations a general expression for obtaining the dc load line may be found.

$$V_{CE} = V_{CC}\frac{R_F}{R_L + R_F} - I_C\frac{R_L R_F}{R_L + R_F} \tag{5}$$

Simplified expressions for the dc load line are shown in Table 1.

The change in collector current with respect to a change in collector cut-off current, $\frac{\partial I_C}{\partial I_{CBO}}$, may be used as an index for determining the degree of bias point stabilization achieved. Using equations (1) through (5) and the approximate relation:

$$I_C \simeq \alpha_{fe} I_B + (1 + \alpha_{fe}) I_{CBO} + \frac{V_{CE}}{r_d} \tag{6}$$

Where

$$\alpha_{fe} = \frac{\alpha_{fb}}{1 - \alpha_{fb}}$$

and

$$r_d = r_c (1 - \alpha_{fb})$$

the stability factor may be found as;

$$S_C = \frac{\partial I_C}{\partial I_{CBO}} = \frac{1 + \alpha_{fe}}{1 + \alpha_{fe}\frac{R_L}{R_L + R_F} + \frac{1}{r_d}\frac{R_F R_L}{R_F + R_L}} \tag{7}$$

Assuming $\alpha_{fe} >> 1$ and a large amount of dc voltage feedback is being used, i.e. $R_L >> R_F$

$$S_C \simeq \frac{\alpha_{fe}}{1 + \alpha_{fe} + \frac{R_F}{r_d}} \tag{8}$$

As may be seen, if r_d is also $>> R_F$ then S_C approaches one.

Equations giving I_C in terms of V_{CC} and I_{CBO} are extremely useful as an aid in determining the quiescent operating point. With the proper manipulation of equations (1) through (4):

TABLE 1. Collector Voltage Feedback

	V_{BE} Negligible,	$\alpha_{fe} >> 1$	
		$R_F >> R_L$	$R_L >> R_F$
D-C LOAD LINE V_{CE} =	$\dfrac{V_{CC} - I_C R_L}{1 + \dfrac{R_L}{R_F}}$	$V_{CC} - I_C R_L$	$V_{CC}\dfrac{R_F}{R_L} - I_C R_F$
$\dfrac{\partial I_C}{\partial I_{CBO}}$	$\dfrac{1 + \alpha_{fe}}{1 + \alpha_{fe}\dfrac{R_L}{R_L+R_F} + \dfrac{1}{r_d}\dfrac{R_F R_L}{R_L+R_F}}$	$\dfrac{\alpha_{fe}}{1 + \alpha_{fe}\dfrac{R_L}{R_F} + \dfrac{R_L}{r_d}}$	$\dfrac{\alpha_{fe}}{1 + \alpha_{fe} + \dfrac{R_F}{r_d}}$
	I_{CBO} Small	$\alpha_{fe} >> 1$	
		$R_F >> R_L$	$R_L >> R_F$
I_C	$\left(\dfrac{R_F + \alpha_{fe} r_d}{r_d (R_L + R_F)}\right) V_{CC}$	$\left(\dfrac{1}{r_d} + \dfrac{\alpha_{fe}}{R_F}\right) V_{CC}$	$\left(\dfrac{R_F + \alpha_{fe} r_d}{r_d R_L}\right) V_{CC}$
I_B	$\dfrac{V_{CC}}{(1 + \alpha_{fe}) R_L + R_F}$ $- \dfrac{V_{CE}}{r_d (1 + \alpha_{fe}) + r_d \dfrac{R_F}{R_L}}$	$\dfrac{V_{CC}}{\alpha_{fe} R_L + R_F}$ $\dfrac{- V_{CE}}{r_d \left(\alpha_{fe} + \dfrac{R_F}{R_L}\right)}$	$\dfrac{V_{CC}}{\alpha_{fe} R_L}$ $\dfrac{- V_{CE}}{r_d \alpha_{fe}}$

TABLE 2. Collector Current Feedback

	$I_C >> I_B$	$R_L >> R_E$
D-C LOAD LINE V_{CE} =	$V_{CC} - I_C (R_L + R_E)$	$V_{CC} - I_C R_L$
	V_{BE} Negligible	$\alpha_{fb} \simeq 1$
$\dfrac{\partial I_C}{\partial I_{CBO}}$	$\dfrac{1 + \dfrac{R_E}{R_1} + \dfrac{R_E}{R_2}}{1 - \alpha_{fb} + \dfrac{R_E}{R_1} + \dfrac{R_E}{R_2}}$	$1 + \dfrac{1}{R_E}\dfrac{R_1 R_2}{R_1 + R_2}$
	I_{CBO} Small	
I_C	$\dfrac{\alpha_{fe} V_{CC}}{R_1 + R_E (1 + \alpha_{fe})\left(1 + \dfrac{R_1}{R_2}\right)}$	
I_B	$\dfrac{V_{CC} - I_C R_E\left(1 + \dfrac{R_1}{R_2}\right)}{R_1 + R_E\left(1 + \dfrac{R_1}{R_2}\right)}$	

$$I_C = \frac{R_F + \alpha_{fe} r_d}{r_d (R_L + R_F)} V_{CC} \qquad (9)$$

$$+ \frac{1 + \alpha_{fe}}{1 + \alpha_{fe}\dfrac{R_L}{R_L+R_F} + \dfrac{1}{r_d}\dfrac{R_F R_L}{R_F+R_L}} I_{CBO}$$

Another useful relation is the base current, I_B, given in terms of the quiescent collector voltage, V_{CE}, and the battery supply voltage, V_{CC}. Assuming that I_{CBO} is small, I_B is given by:

$$I_B \simeq \frac{1}{(1 + \alpha_{fe}) R_L + R_F} V_{CC} \qquad (10)$$

$$- \frac{R_L}{r_d R_L (1 + \alpha_{fe}) + r_d R_F} V_{CE}$$

In using this type of stabilization, ordinarily the procedure is to select a dc load line and then using the transistor static collector characteristic curves to choose a quiescent operating point. The required I_B then may be determined from the curve intersecting the dc load line at the operating point. Then the dc load, R_L, may be chosen using one of the load line equations of Table 1. Knowing I_B, V_{CE}, R_L and the transistor parameters one of the I_B equations may be used for determining R_F. The process may be repeated using more exact equations as desired. Once R_F has been found the stability factor is fixed and may be determined using the appropriate equation. The reverse procedure may be used in an amplifier design; that is, selecting R_F to provide a certain desired stability factor and then determining whether or not the signal handling capabilities are adequate.

Fig. 4 illustrates a method of obtaining separate control of the operating point and stability factor when using collector voltage feedback. An analysis procedure similar to the above may be applied.

Should the feedback resistor R_F be too low compared to the ac load ac degeneration, resulting in a loss in gain, will occur. A method of avoiding this is to divide R_F in half and bypass the center to ground.

Collector Current Feedback

For small dc loads, such as a transformer coupled stage, a more effective stabilization technique is to provide a base bias current proportional to the collector current. This is accomplished through the use of a series emitter resistor, R_E, as shown in Fig. 2. This resistor provides a reverse bias between emitter and base which is proportional to the collector current. The voltage divider network made up of R_1 and R_2 provides a forward bias thus permitting separate control over operating point and stabilization factor. The more stabilization required the higher R_E should be made. Resistors R_1 and R_2 should be kept as small as possible for maximum stability. However, not only do these resistors consume supply power but the parallel combination effectively shunts the input to the transistor. Thus, to keep ac losses to a minimum $\dfrac{R_1 R_2}{R_1+R_2}$ should be $>>$ than the transistor input impedance. R_E should also be adequately bypassed to eliminate any ac degeneration.

Again, assuming V_{BE} is negligible the following may be written:

$$V_{CC} = V_{CE} + I_C R_L - I_E R_E \qquad (11)$$

$$- I_E \simeq I_2 \frac{R_2}{R_E} \qquad (12)$$

$$V_{CC} = I_1 R_1 + I_2 R_2 \qquad (13)$$

$$- I_E = I_B + I_C \qquad (14)$$

Using the above an equation for the dc load line may be derived:

$$V_{CE} = V_{CC} - I_C (R_L + R_E) \qquad (15)$$

Since the dc load is small the expression for I_C may be written:

$$I_C \simeq \alpha_{fe} I_B + (1 + \alpha_{fe}) I_{CBO} \qquad (16)$$

Using (11) through (16) the stability factor for this configuration may be computed:

TABLE 3. Combination Feedback Current and Voltage

	$I_C >> I_B$ V_{BE} Negligible	$R_F >> R_L$	$R_L >> R_E$
D-C LOAD LINE V_{CE} =	$\dfrac{V_{CC} - I_C (R_L + R_E)}{1 + \dfrac{R_L}{R_F}}$	$V_{CC} - I_C (R_L + R_E)$	$V_{CC} - I_C R_L$

	$I_C >> I_B$	$R_F >> R_L$
$\dfrac{\partial I_C}{\partial I_{CBO}}$	$\dfrac{1 + \dfrac{R_E R_A}{R_E + R_A} \dfrac{1}{R_L + R_F}}{1 + \dfrac{R_A}{R_L + R_F} \dfrac{R_E - \alpha_{fb} R_F}{R_E + R_A}}$	$\dfrac{1 + \dfrac{R_E R_A}{R_E + R_A} \dfrac{1}{R_F}}{1 + \dfrac{R_A}{R_F} \dfrac{R_E - \alpha_{fb} R_F}{R_E + R_A}}$

	I_{CBO} Small	$R_F >> R_L$, $R_L >> R_E$
I_C	$\dfrac{\alpha_{fe} V_{CC}}{(1 + \alpha_{fe}) \left[R_L + R_E + \dfrac{R_E}{R_A} (R_L + R_F) \right] + R_F}$	$\dfrac{\alpha_{fe} V_{CC}}{(1 + \alpha_{fe}) \left(R_L + \dfrac{R_E}{R_A} R_F \right) + R_F}$

	I_{CBO} Small
I_B	$\dfrac{V_{CC} - I_C \left[R_L + \dfrac{R_E}{R_A} (R_L + R_F) + R_E \right]}{R_L + R_F + R_E + \dfrac{R_E}{R_A} (R_L + R_F)}$

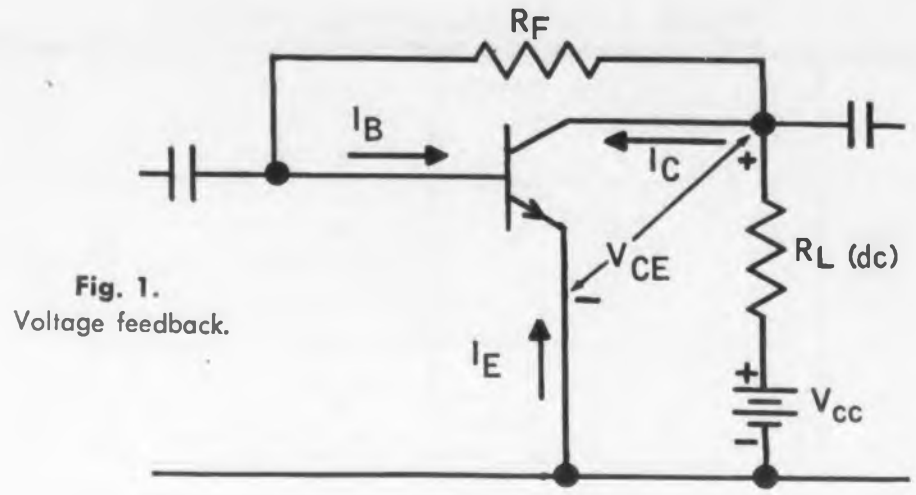

Fig. 1. Voltage feedback.

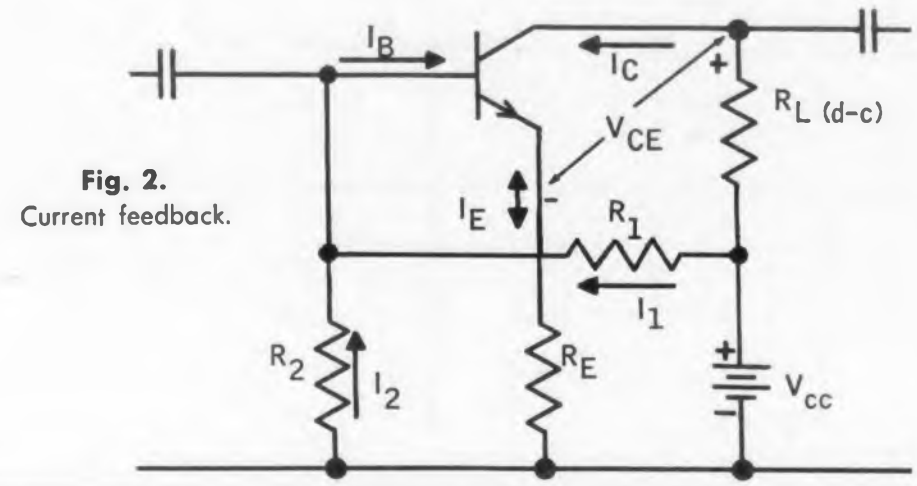

Fig. 2. Current feedback.

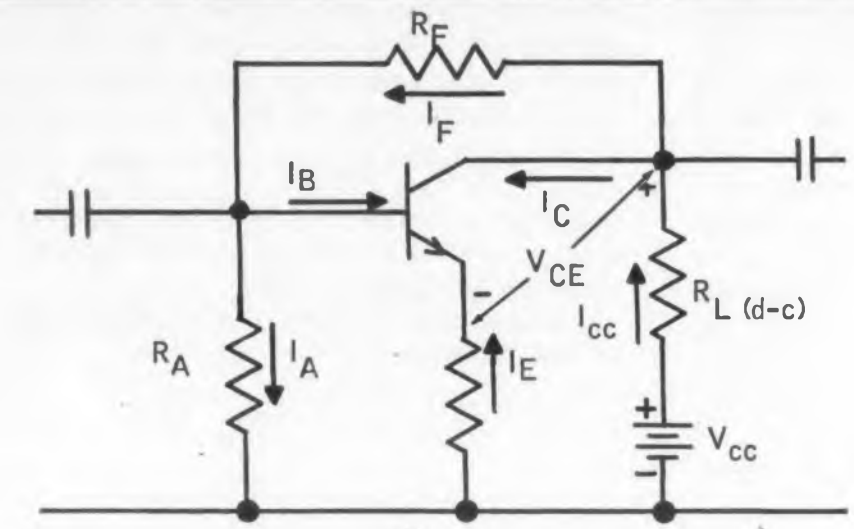

Fig. 3. Voltage and current feedback.

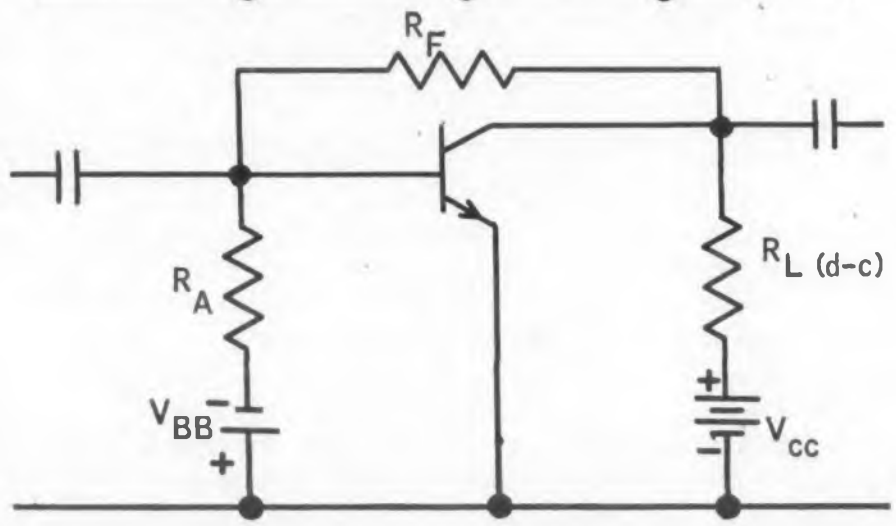

Fig. 4. Voltage feedback with separate bias control.

$$S_C = \frac{\partial I_C}{\partial I_{CBO}} = \frac{1 + \dfrac{R_E}{R_1} + \dfrac{R_E}{R_2}}{1 - \alpha_{fb} + \dfrac{R_E}{R_1} + \dfrac{R_E}{R_2}} \qquad (17)$$

Expressions for I_B and I_C may also be obtained and are presented in Table 2.

The procedure previously illustrated may be used for determining the required stability factor for this configuration. Then the desired bias point may be selected.

Combination Collector Voltage And Current Feedback

This configuration offers the advantages of both types previously discussed while diminishing the disadvantages. Both stability factor and quiescent operating point may be independently chosen. For high dc loads the reverse bias provided by R_E will enable the use of a much lower R_F thus increasing the voltage feedback. At low dc loads R_E will be most effective in providing bias stabilization. Resistor R_A allows the setting of the base bias after R_E and R_F have been chosen to provide a given stability factor. This

configuration provides a wide range of design freedom independent of the dc load. From Fig. 3 the following equations may be written:

$$V_{CC} = V_{CE} + I_{CC}R_L - I_E R_E \quad (18)$$

$$-I_E \simeq I_A \frac{R_A}{R_E} \quad (19)$$

$$V_{CE} = I_F R_F + I_A R_A + I_E R_E \quad (20)$$

Therefore from (19) and (20)

$$V_{CE} \simeq I_F R_F \quad (21)$$

Also:

$$I_{CC} = I_C + I_F \quad (22)$$

$$-I_E = I_C + I_B \quad (21)$$

$$I_B = I_F - I_A \quad (22)$$

From these equations the dc load line is given by:

$$V_{CE} = \frac{V_{CC} - I_C (R_L + R_E)}{1 + \frac{R_L}{R_F}} \quad (23)$$

Assuming I_C may be given by equation (16):

$$S_C = \frac{\partial I_C}{\partial I_{CBO}} = \frac{1 + \frac{R_E R_A}{R_E + R_A} \frac{1}{R_L + R_F}}{1 + \frac{R_A}{R_L + R_F} \frac{R_E - \alpha_{fb} R_F}{R_E + R_A}} \quad (24)$$

Assuming

$$R_A >> R_E$$

$$S_C \simeq \frac{R_L + R_F + R_E}{R_L + R_E + (1 - \alpha_{fb}) R_F} \quad (25)$$

Equations for I_C and I_B have been computed and presented in Table 3.

Conclusion

Depending upon the dc load and the simplicity desired, one of the above stabilization techniques may be chosen. Each has its particular advantages in performance, ease of design and number of components required. In many designs a shunt ac feedback loop is desired to stabilize the transistors ac parameters. In many cases resistor R_F may be chosen to supply the correct amount of ac degeneration. The desired stability factor and operating point may be achieved through the proper selection of R_E and R_A respectively. The combination method results in a saving in components and ac losses.

References

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2. Transistor Electronics, A. W. Lo, et al, pp. 131-153, Prentice-Hall, 1955.
3. For definitions of symbols used see "IRE Standards On Semiconductor Symbols," *Proceedings of the IRE*, 44, pp. 934-937, July 1956.

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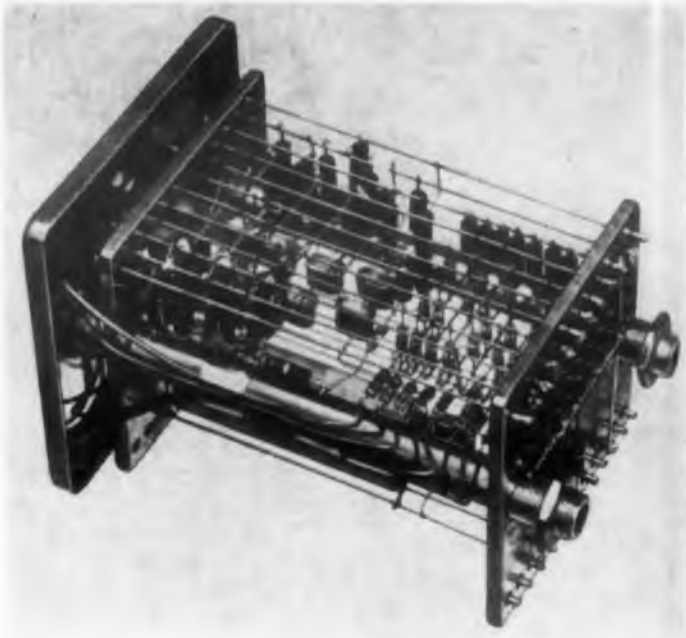

Dynamic Compression

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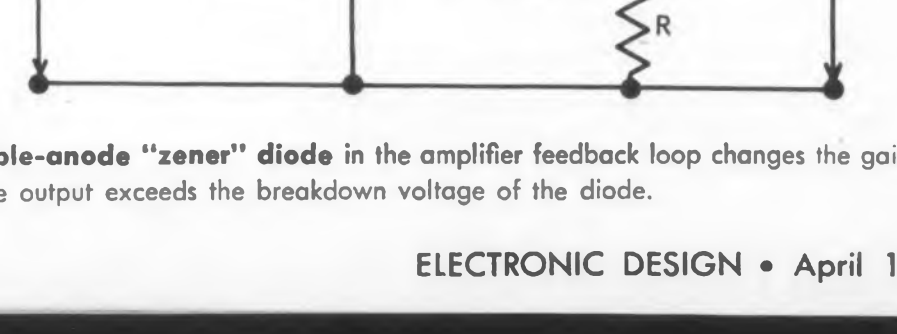


A double-anode "zener" diode in the amplifier feedback loop changes the gain whenever the output exceeds the breakdown voltage of the diode.

WHEN a wiring technique permits high production rates without extensive tooling—that's good. When the finished assembly can do its job for years, and operate under severe shock, acceleration and vibration loading—one can be sure the package includes good circuitry, good components and good assembly techniques.

The wiring technique is illustrated in the photo. It's used in an automatic scanning, alarm and control system, tagged Monitron, by Moore Associates, Inc., 2600 Spring St., Redwood City, California.

The three dimensional grid structures, used in interchangeable plug-in modules, can be encapsulated to ruggedize the assembly. It is well suited to high component densities.

Diodes and transistor leads are spotwelded to the grid wires. Harder-to-weld copper leads are soldered. A few simple jigs and fixtures hold components in place for welding.

Each module gathers alarm and control data from 8 or 16 points and transmits the data by wire or radio. Conventional pulse circuitry scans at rates from 2 to 20,000 cps. Adding simple input coding and output registering circuits enables the scanner to be used for telemetry.

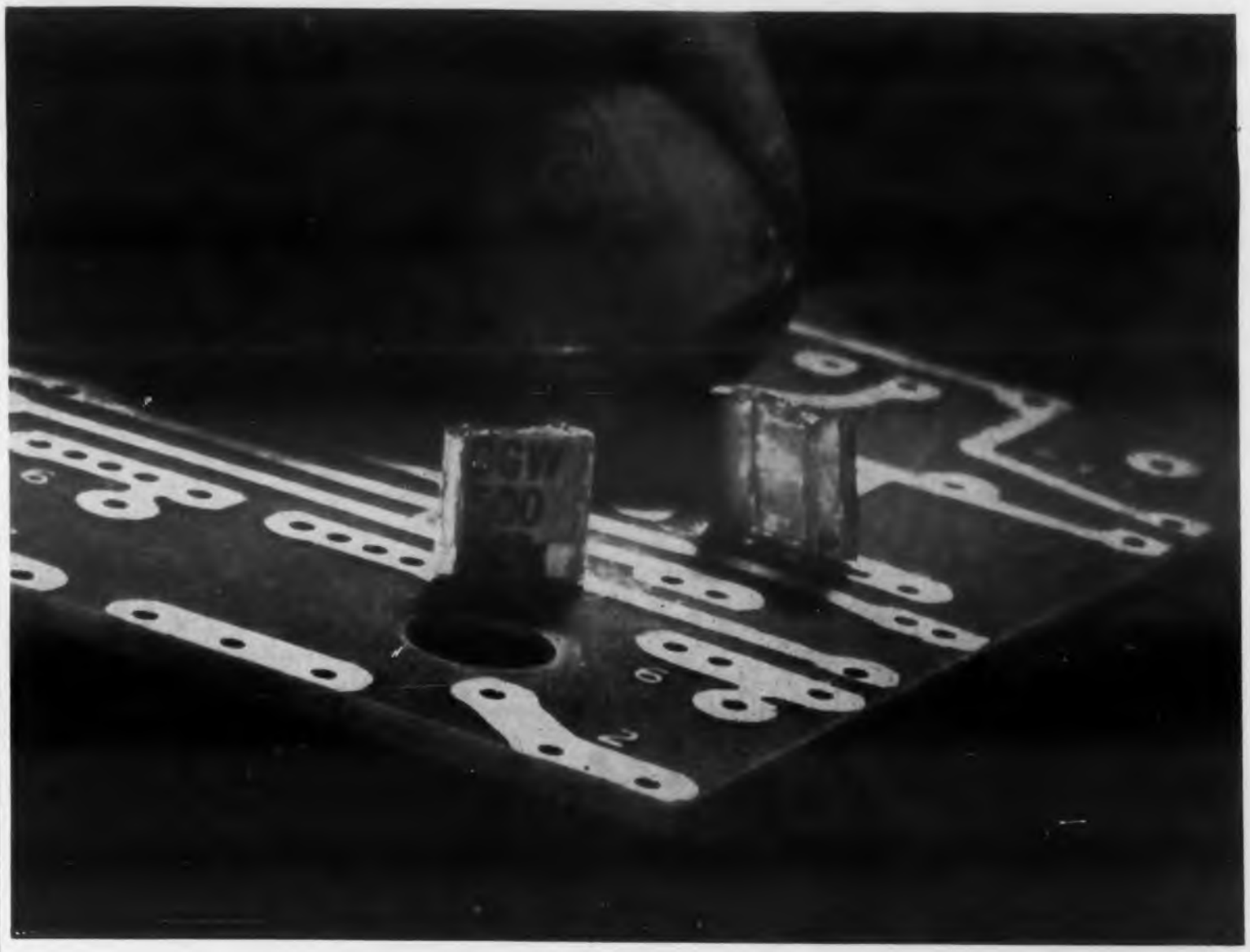
For more information, turn to the Reader's-Service card and circle 46.

OVERLOADED amplifiers can lose vital data. Dynamic compression can save the data and extend the useful signal range about ten times. Dynamic compression abruptly reduces voltage gain when the output signal reaches a positive or negative compression threshold. Below this point the amplifier has normal gain as indicated by the front panel control. Above this point, the gain is also constant, but about ten times less.

This compression feature is included in a line of dc instrumentation amplifiers made by the Dynamics Instrumentation Co. of 1118 Mission St., So. Pasadena, Calif. The amplifiers can be calibrated to read compressed data accurately.

Here's how the compression works. If an amplifier has a maximum output of 40 v, and a gain of 1000, it requires a 40 mv input to provide full output. With a 10 v compression threshold, a 10 mv input produces a 10 v output. Between 10 and 40 v at the output, the gain is knocked down 10 to 1, so 300 mv more are needed at the input to change the output from 10 to 40 v. Thus the amplifier accommodates a 310 mv input without overload, instead of 40.

For more information, turn to the Reader-Service card and circle 47.



Truly sub-miniature, these capacitors were devised especially for printed circuits and automatic assembly. Since they retain all the properties of larger, pig-tail capacitors, they are well suited to general circuitry as well.

Static inverters using high power transistors deliver large amounts of ac power with an efficiency previously considered to be unattainable. Where a typical rotary inverter might operate with an efficiency of 40 per cent, an equivalent static unit may yield 90 per cent. In airborne and missile applications, this means that less heat is liberated and fewer pounds of batteries need be carried. The units are characterized by high resistance to shock, vibration, altitude, and humidity.

Transistorized Static Inverter Design

J. F. Lohr

Supervisor Magnetics Group
Hallamore Electronics Co.
Anaheim, Calif.

STATIC inverters have been constructed over a wide range of power levels between a few milliwatts and 4 kva. Commercial availability of power transistors at this time are the principal reason for the 4 kva limitation. Larger units may be designed, but the number of transistors necessary and the complexity of the mechanical structure for mounting them makes their use inadvisable except for special requirements.

Static inverters generally produce either sine waves or square waves. If multiphase operation is desired the sine wave is recommended, because multiphase square waves cannot conveniently be passed through ordinary multiphase transformers. Most higher power units having sine wave output develop this power by a system of filters which removes the odd harmonics from a square wave. The percentage of harmonic distortion in the output is purely a matter of the effectiveness of the filter system. A design which optimizes between size and simplicity may be expected to produce sine waves with 3 to 5 per cent harmonic distortion over a variety of loads.

When determining size and weight of a static inverter for a given power output the primary factor to be considered is temperature. It is desirable to select a size that is capable of dissipating the internally generated heat at room temperature without the aid of external cooling. Where adequate external cooling can be provided, the weight may be greatly reduced. A practical unit in the 250 va power range might weigh 10 lb.

For the present, the maximum transistor junction temperature limit of +95 C must be strictly observed. This means that even with the most carefully optimized designs, a steady state ambient temperature of about +85 C is the highest that can be tolerated.

Linear Operation (Class A, AB, or B) utilizes push-pull power transistors in the output amplifier operating like vacuum tube class B amplifiers. Linear feedback can be used around the entire system for voltage regulation and harmonic content reduction.

Switching (Class D). The principle here is to drive the power amplifiers as switches at the fundamental output frequency; the transistors are driven from saturation to cutoff, producing square waves for subsequent filtering. The theoretical efficiency is very high but voltage regulation becomes difficult. Extremely high power levels may be attained.

Pulse Width Modulation. The low level driver stages in this case produce a square wave at a frequency considerably higher than the desired output. They are pulsewidth modulated by a sine wave at the desired output frequency. The signals are then amplified using class D amplification and integrated to a sine wave in the output transformer. Characteristics of this system are similar to those of the *straight switching* system except that the efficiency is not as high. However, the filter assumes almost negligible proportions in this case.

The essential characteristics of these three inverters are summarized in Table 1.

Table 1. Static Inverter System Comparison Chart

	LINEAR (CLASS B)	SWITCHING (CLASS D)	PWM SWITCHING
EFFICIENCY	78% (MAX)	97% (MAX)	50% (APPROX)
WEIGHT (APPROX)	.034 lb/WATT	.04 lb/WATT	.037 lb/WATT
REGULATION LOAD	1%	3%	1%
REGULATION LINE	1%	UNREG.	1%
DISTORTION	5%	5%	3%
OVERLOAD	NO	100%	NOT FEASIBLE
SHORT CIRCUIT PROTECTION	SPECIAL CIRCUIT REQUIRED	YES	YES
POWER LEVELS AVAILABLE FROM 1 PAIR OF OUTPUT TRANSISTORS	60 WATTS	125 WATTS	20 WATTS OR LESS

THERMAL rather than electrical considerations dictate the design of inverter systems. This is because the maximum transistor junction temperature imposes the most serious limitation on the design and use of transistorized equipment. Minimum heat is dissipated internally when the device operates at top efficiency. For a practical 250 va 3φ design, the switching method (class D) of operation proves desirable because of efficiency. An additional advantage gained by the use of class D rather than class B systems lies in the fact that in class D most of the heat-producing losses are in the output transformer, while the transistors dissipate very little. The reverse is true in classes A and B. Since high temperature transformers are readily available, this then represents the optimum situation.

Design Details

A number of oscillators are adaptable to transistor circuitry and may be used to drive static inverters. The circuit employed here is a multiphase sinusoidal oscillator that consists of one active element per phase with phase shift through the oscillator so arranged that the rotation through the system returns an in-phase signal from output to input. The phase angle across each element is 120 deg in order to satisfy these conditions.

In the phase shift oscillator shown in Fig. 1 the coupling capacitors and input impedance of the amplifier should be chosen so that a phase shift of +60 deg results. Thus with 180 deg reversal through the amplifier the phase at its output is —120 deg.

The sine wave from the oscillator is supplied to the bases of the driver transistors. They are biased in such a manner as to cause the transistors to be driven from saturation to cutoff, thus producing a square wave to drive the final amplifier. Symmetry in the square wave is important since it determines the even harmonic distortion present in the output waveform. Care should be taken to insure that the bias on the driver transistors, as well as the oscillator waveforms, are adjusted for maximum symmetry.

In designing a driver section for any group of power amplifiers, provision must be made for accommodating a wide variety of input currents. This requirement is determined by the current gain of the individual transistors in the power amplifier. The current gain may be expected to vary widely in power transistors: the power amplifier should be allowed to seek its own drive level by inserting a base resistor of about one ohm in series with each base or—in the case described here—the required resistance may be built into the drive transformers themselves. This *modified constant-voltage* drive allows the output transistors to determine their own drive as well as placing a relatively constant load on the drive transistors. Since insufficient drive will limit the power output capabilities of the unit, attention should be given to this problem. A typical case required 1.0 v at 0.5 a from the secondary of the driver transformer.

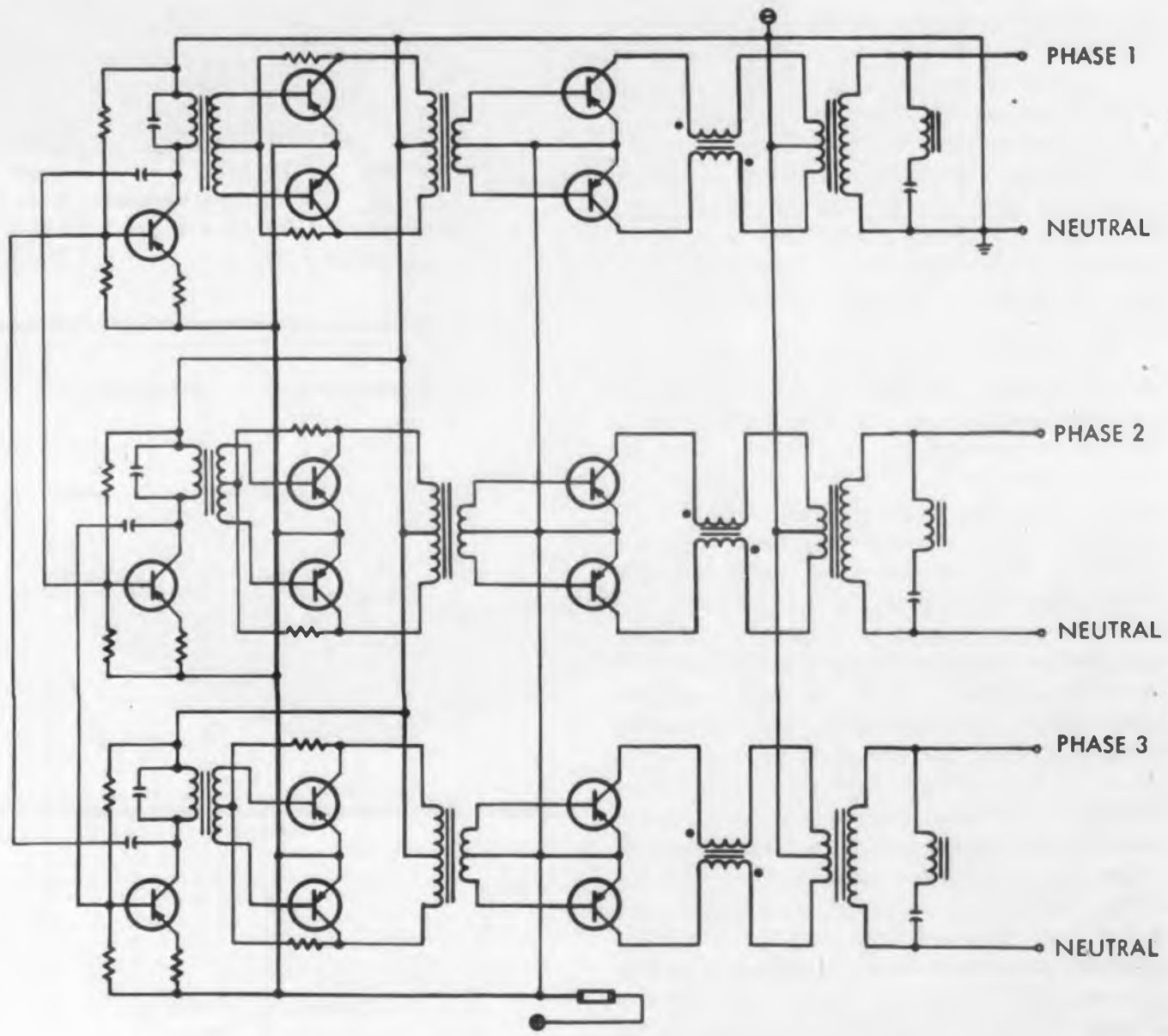


Fig. 1. Basic schematic of a static inverter. Inversion system used is switching (class D): transistors are driven from saturation to cutoff; resultant square waves are filtered at the output. Theoretical efficiency and power levels are very high.

The amplifier section consists of one pair (per phase) of power transistors in push-pull common emitter. The collectors are connected to the output transformer through a bifilar wound choke. This choke serves many purposes: it is the first section of the filter; it may be designed to provide short circuit protection; it prevents excessive voltage transients from reaching the collectors of the transistors. The selection of the output transistors must therefore include an emitter-collector voltage rating in excess of twice the dc supply to be used.

The most important consideration in these transistors is to keep the dissipation of power to an absolute minimum in order to allow for maximum operating temperature. The emitter to collector resistance in a typical germanium power transistor is about 60 milliohms when saturated. Cutoff resistance may be a hundred thousand ohms. These parameters vary somewhat with temperature. Still, it is clear that little heat is generated when the transistor is in either of these conditions. The remaining rise and fall intervals of the collector square wave constitute the main danger areas, and the highest switching speed attainable seems to be indicated.

Generally this is true. However since the transistors are used in a push-pull circuit, care must be exercised to assure that two transistors in a push-pull pair are not simultaneously turned on

and allowed to remain in that condition more than 1 or 2 μsec. Rise times in the order of 2 μsec can be realized even in the largest of power transistors if certain conditions are established: the minority carriers must be cleared rapidly to allow short fall times. Rapid rise times can be accomplished by applying the *turn on* voltage when the collector current is essentially zero. These techniques also bring about a condition of minimum *dwell time* in the high dissipation regions of the I_c-E_c transistor curves.

These conditions can be met by utilizing special filter design techniques. The voltage waveform appearing at the collector is a square wave. The current through the transistor is, however, neither square nor in phase with the voltage, but appears as a sine wave of twice the operating frequency under no load conditions and as a somewhat distorted sine wave under full load conditions as shown in Fig. 2. It will be observed that current is flowing in a reverse direction through the transistors for part of the half cycle when the inverter is in the *no load* condition. This condition does not appear to be damaging to the transistors, but care must be exercised to prevent it from being too pronounced, since the collector and emitter junctions are generally not mechanically symmetrical and would overheat.

The filter used in the static inverter depicted in Fig. 1 is basically an *m*-derived low-pass type. It has been designed such that the frequency of infinite attenuation is placed between the fifth and seventh harmonic, and the cutoff frequency at twice the operating frequency. Reasons for this choice lie in the mathematical aspects of an ideal square wave, along with the inherent rejection of the predominant third harmonic by use of a 3φ transformer. The Fourier expansion for a perfectly symmetrical square wave in a 3φ circuit is:

$$e = \frac{4E_m}{\pi}\left[\cos \omega t + \frac{\cos 5\,\omega t}{5} - \frac{\cos 7\,\omega t}{7} - \frac{\cos 11\,\omega t}{11} + \ldots\right]$$

The third, ninth, fifteenth, etc., harmonics are eliminated by the use of a 3 phase transformer in the output. Clearly the lowest harmonic to be removed by the filter is the fifth.

In practice the situation is not so simple: the flux waveforms in the output transformer core are not perfectly square and complete cancellation of the third, ninth, fifteenth, etc., harmonics does not occur. Furthermore with the cutoff frequency placed at the second harmonic, some second harmonic voltage appears in the output. As a result, most of the distortion is even harmonic instead of odd as would be expected from a filtered square wave.

Table II Specifications of the Typical Inverter, Fig. 1.

Input	26 to 29 vdc	Regulation	Better than 105 to 125v
Output	120/208 vac		
Weight	11 lb	Efficiency	85% at full load
Dimensions	10½x5x7⅝ in.	Load Power Factor	75% lag to 95% lead
Distortion	5% total harmonic	Load Balance	Insensitive to load unbalance
Frequency	390 to 410 cps.	Connection	Delta or Wye, 3 or 4 wire
Power Output	250 va	Overload	Operate continuously at 100% overload

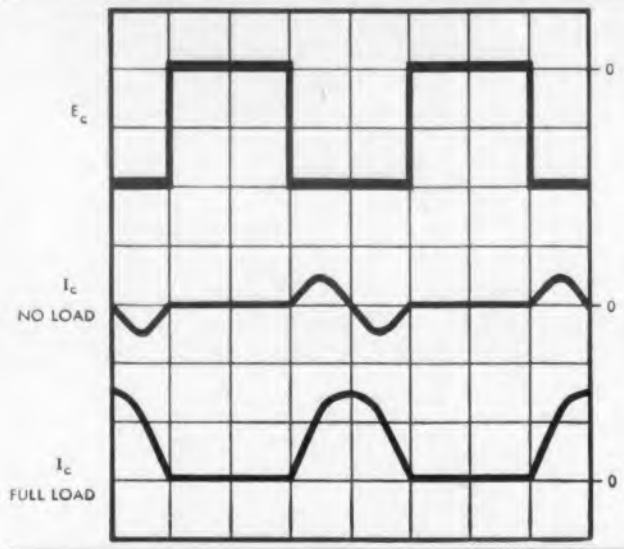


Fig. 2. Voltage and current wave forms for one transistor of a push-pull pair, no load and full load.

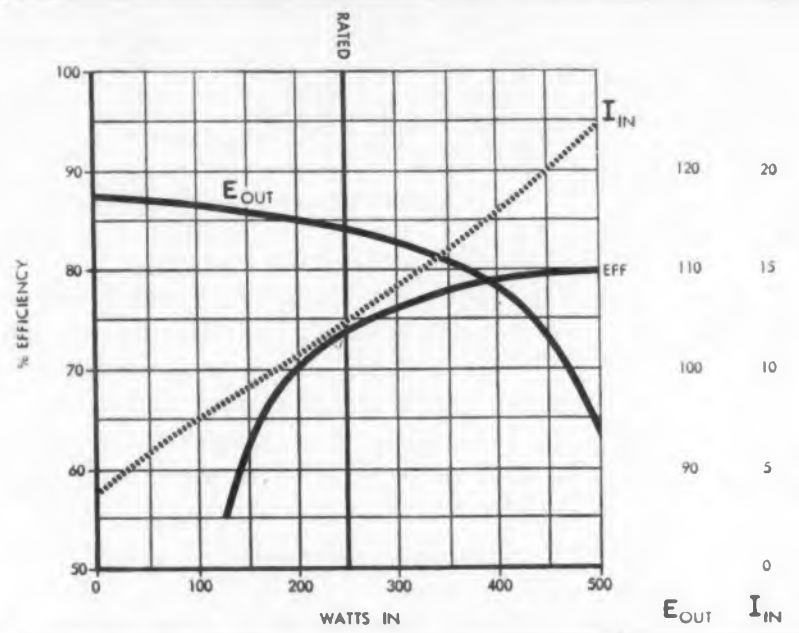


Fig. 3. Empirical performance curves of a typical static inverter. At 250w rated output efficiency is about 74 per cent.

The cutoff frequency is placed high in an effort to relieve problems attendant to maintaining voltage regulation through the filter. Attenuation vs frequency characteristics of an *m*-derived filter are well suited to this application. Maximum attenuation is provided for the predominant fifth harmonic, and somewhat less attenuation for the seventh, which is of lesser magnitude, etc. Insertion loss is low, whether the filter is loaded or not, and little change occurs from no load to full rated load. It will be noted in the schematic that the power transformer is placed between the two sections of the filter. This is done to allow use of a minimum number of components and to keep down the size of the shunt filter reactors. The cutoff frequency of the filter is chosen so that the transistor load current is essentially zero at the moment of switching. Any number of common type filters are usable.

Cooling

Since germanium transistors are used it is necessary to maintain the junction temperatures at less than 95 C, for reliable operation. Sufficient radiating surface must be made available to the transistors to ensure that all the internally liberated heat can escape, even at elevated temperatures.

RELIABILITY* INSIDE THE BLACK BOX

NEW PRODUCTS

FAIRCHILD

NEW RG-100 RATE GYRO

THE SMALLEST EVER MADE†

This is truly the mightiest tiny Rate Gyro. It was designed primarily for *missile and aircraft application* as a control and stabilization element. The Fairchild RG-100 is so small (15/16" dia. by 2" long) that it requires jewel bearings identical within 100 millionth's of an inch. ***An exclusive Fairchild feature*** is uniform damping, for any required percentage of critical within ±15% through a range of —40° to +200°F. This is accomplished by varying the damping area, using the damping medium as a sensing device which varies with temperature changes.

†with fully controlled damping.

TAKES 100 G'S OF SHOCK AND 15 G'S AT 2000 CPS VIBRATION EVEN AT VERY LOW RATES

This high resistance is due in part to another Fairchild exclusive design feature which does not require the torsion bar to act as a supporting medium. The Fairchild tiny mite Rate Gyro only weighs 3 ounces, but contains a dynamically balanced hysteresis motor which reaches an operating speed of 24,000 rpm in less than 20 seconds. It is available with a 2 or 3 phase winding, runs on 6.3V, 9V or 26V A.C. and has a power rating of 3 watts.

OTHER FAIRCHILD FEATURES:

INPUT RANGES for the standard unit are from 20° to 800° per second. Customer requirements outside of this range can be accommodated.
OUTPUT is 6 volts at maximum rate, operating on 400 cps.
LINEARITY is 0.1% to half scale and 3.5% to full scale. Total NULL varies from 15 to 40 mv depending upon maximum input rate and damping requirements of the customer.
GIMBAL BALANCE is 0.1% of full scale per G.
TEMPERATURE RANGE is —65° to +200° F. LIFE — 1000 hours.

TA-200

FAIRCHILD'S

NEW ACCELEROMETERS

FOR APPLICATION IN: Flight Control-Testing, Toss Bombing, Airborne Telemetering, Computers and other systems requiring the measuring of missile or aircraft maneuvering accelerations.

***Fairchild's Built-in SAFETY FACTORS Beyond the Specs for Reliability in Performance.**

SPECIFICATIONS

Model	TA-200	TA-300
G Range	± 1 to ± 100G	± 1 to ± 100G
Natural Frequency	7-35 cps	20-100 cps
Damping Factor	.7 @ 25° C	.7 @ 25° C

OUTSTANDING FEATURES

1. TA-200, TA-300 low cross talk units.
2. TA-200 uses a spring mass, linear motion sensing device with jewel bearings for extremely low friction.
3. TA-300 is also an extremely low friction design using a spring mass, linear motion sensing device.

Fairchild has three accelerometers for measuring accelerations in the medium G Range.

TA-100 — a low natural frequency unit *(previously announced)*

New TA-200 — a medium natural frequency unit

New TA-300 — a high natural frequency unit

These units use *special alloys* with a low temperature coefficient modulus. The use of these special alloys provide exceptionally *low hysteresis* and *excellent calibration stability* over a wide temperature range. All units use a potentiometer output (standard); can also be supplied with Fairchild's Nobl-ohm film resistance elements or AC type pickoffs.

The losses produced in a complete inverter cur in specific components in the form of heat. he major portion of this heat appears in the out- t transformer. Filter chokes and transistors are condary sources. Transformers and chokes can designed to withstand considerably higher mperatures than transistors. A mechanical de- gn that isolates the heat generating components to individual compartments therefore provides ximum cooling surface where it is most eded.

Transients

Transients are probably responsible for more nsistor failure than any other single item. Both rrent and voltage transients can be damaging. oltage transients that exceed the collector volt- e ratings can come from many sources, such the primary power supply or stored energy in e filter section. Many circuits have been de- ned for coping with these transients and are the most part beyond the scope of this article. e point is mentioned to put the design engi- er on his guard.

Performance Data

Table II tabulates specifications that can be pected from the unit that is shown in Fig. 1. pical efficiency curves for the unit shown in g. 1 are presented in Fig. 3.

Improvements

The inverter that has been shown here is a ic unit and no provisions have been shown voltage regulation, transient protection, or cise frequency control. It should, however, e the designer a sample of the basic circuits t are workable and provide him with some munition to guard against the pitfalls that are is way.

Many improvements have been made to the ic system typified in the schematic, with re- d to voltage regulation, frequency regulation, phase displacement accuracy. The incorpo- on of these improvements depends to a great nt on the specification to which the designer working. Static inverters, like their rotating nterparts, are more often than not special de- s, and must be tailored to fit the job.

Editor's **Addendum:** Since this article was tten Mr. Lohr, who is now with the Electro ds Corp. in North Hollywood, Calif., informs hat using a 3φ output transformer and filter ifications as suggested in the article, a pro- tion static inverter with somewhat over 90 cent efficiency is being built.

Acknowledgment

e efforts of F. Kelly, T. Prouty, and J. Burnette of mpore Electronics Company for their contributions in reparation of this article are gratefully acknowledged.

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Applications of Non-Linear Magnetics

Part III

Herbert F. Storm
General Engineering Laboratory
General Electric Company
Schenectady, N. Y.

Combinations of a saturable reactor with other circuit components produce extraordinary effects which usually cannot be duplicated by linear circuitry. Dr. Storm describes more of these effects in this, the third part of his article.

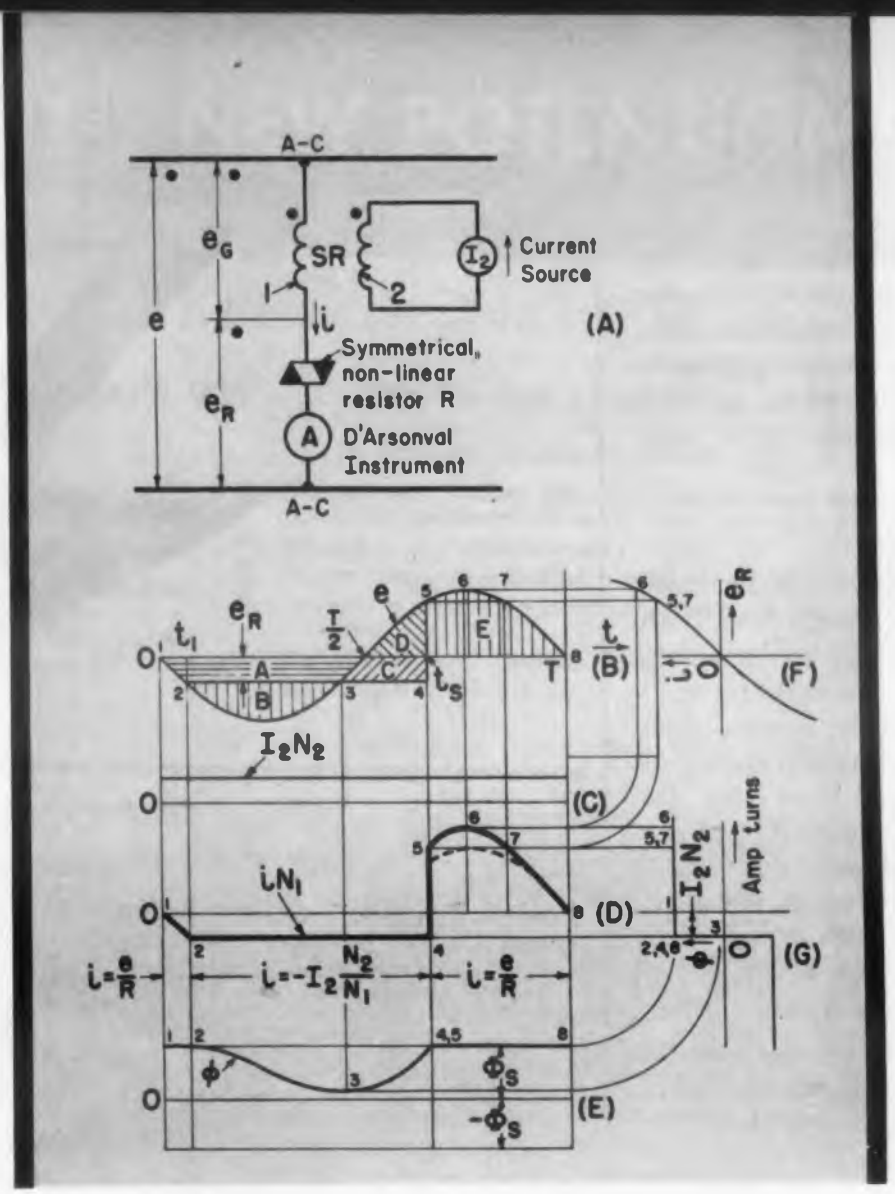

Fig. 5-1. DC without rectifiers. (A) Circuit diagram, (B) Voltage inventory, (C) Ampere-turns in winding 2, (D) Ampere-turns in winding 1, (E) Core flux, (F) Voltage-current characteristic of non-linear, symmetrical resistor R, (G) Flux-current relationship.

5 SR and Non-Linear, Symmetrical Resistor

DC Without Rectifiers

This circuit consists of an *SR* whose control circuit is energized from a direct current source I_2. (Fig. 5-1A). A symmetrical, non-linear resistor is connected in series with the gate circuit (Ref. 5-1). A suitable non-linear, symmetrical resistor can be made of carbon or silicon carbide, such as Thyrite (Ref. 5-2).

The provision of a current source, rather than a voltage source, for energizing winding 2 leads to a smooth current I_2, as shown in Fig. 5-1C. The action of load current i can be traced from Figs. 5-1D and G. (A detailed description of related circuit action can be found in chapter 8 of Ref. 1-8).

The core saturates at t_s, when the flux up-swing equals its down-swing (Fig. 5-1E). One sees from Fig. 5-1B that

$$Area\ B = C + D \qquad (5\text{-}1)$$

During the interval $t_s < t < T$, the core is saturated, so $e_R = e$. The volt-seconds acting on the non-linear, symmetrical resistor are expressed by area E:

$$E = A + B - D \qquad (5\text{-}2)$$

Thus, from eq (5-1)

$$E = A + C \qquad (5\text{-}3)$$

One concludes that the positive volt-seconds (E) from $t_s < t < T$ equal the negative volt-seconds ($A + C$) acting on the load from $O < t < t_s$. Then, for a linear load resistance, the resultant positive load ampere-seconds (dotted section to 8 of Fig. 5-1D) must equal the negative load ampere-seconds (*1,2,4*). Hence the load current is pure ac.

If, however, the load resistor is non-linear, although symmetrical, as shown by its characteristics in Fig. 5-1F, then the load resistance will be, in general, smaller during the interval from t_s to T, than from O to ts. As a result, the positive load ampere-seconds are now larger than the negative load ampere-seconds. Hence the load current contains a dc component. The d'Arsonval ammeter in Fig. 5-1A will indicate current flow. If the direction of I_2 is reversed, the dc component of the load current will also reverse.

A gradual change of I_2 causes a gradual change of the dc component of the load current, so the circuit can also be used for amplification.

In addition to the dc component, the load current also contains ac components. The ratio of dc to ac components can be greatly increased by using two *SR*s and two non-linear, symmetrical resistors feeding a common load. Among other uses, this arrangement has been applied to a magnetometer as described on page 466 of Ref. 1-8.

In those cases where the main application is in making dc without rectifiers, a separate source for current I_2 is not necessary for the two core arrangement. This current can be obtained directly from the dc output terminals of the device.

The process of making dc without rectifiers is important where present-day rectifiers introduce too much drift with temperature changes, or where high temperatures preclude the operation of solid state rectifiers. There may be other environments, such as nuclear radiation (Ref. 5-3), where the non-linear, symmetrical resistor offers advantages over conventional rectifiers.

6 SR and Capacitor C

AC Voltage Detector, Bi-stable Circuit

The circuit shown in Fig. 6-1A is a series, nonlinear resonant circuit (Refs. 6-1, 6-2). To provide some insight into the function of this circuit, the following simplified explanation is offered. (Refs. 6-3 to 6-7 provide a more rigorous approach).

First, consider the three circuit elements separately. Beginning with the *SR*, the applied voltage E_G and the current I to the *SR* are related by the curve marked *SR*, Fig. 6-1B. Current I and all voltages in Fig. 6-1B are expressed in effective (rms) values. Next, the relationship between capacitor voltage E_C and current I is shown by the straight line marked *C*. Finally, with the load assumed purely resistive, the relation between load voltage E_R and current I is shown for two different load resistances by the straight lines marked R and R'.

Next, combine the *SR* and capacitor *C*. If the *SR* were a linear inductor, E_G and E_C would be

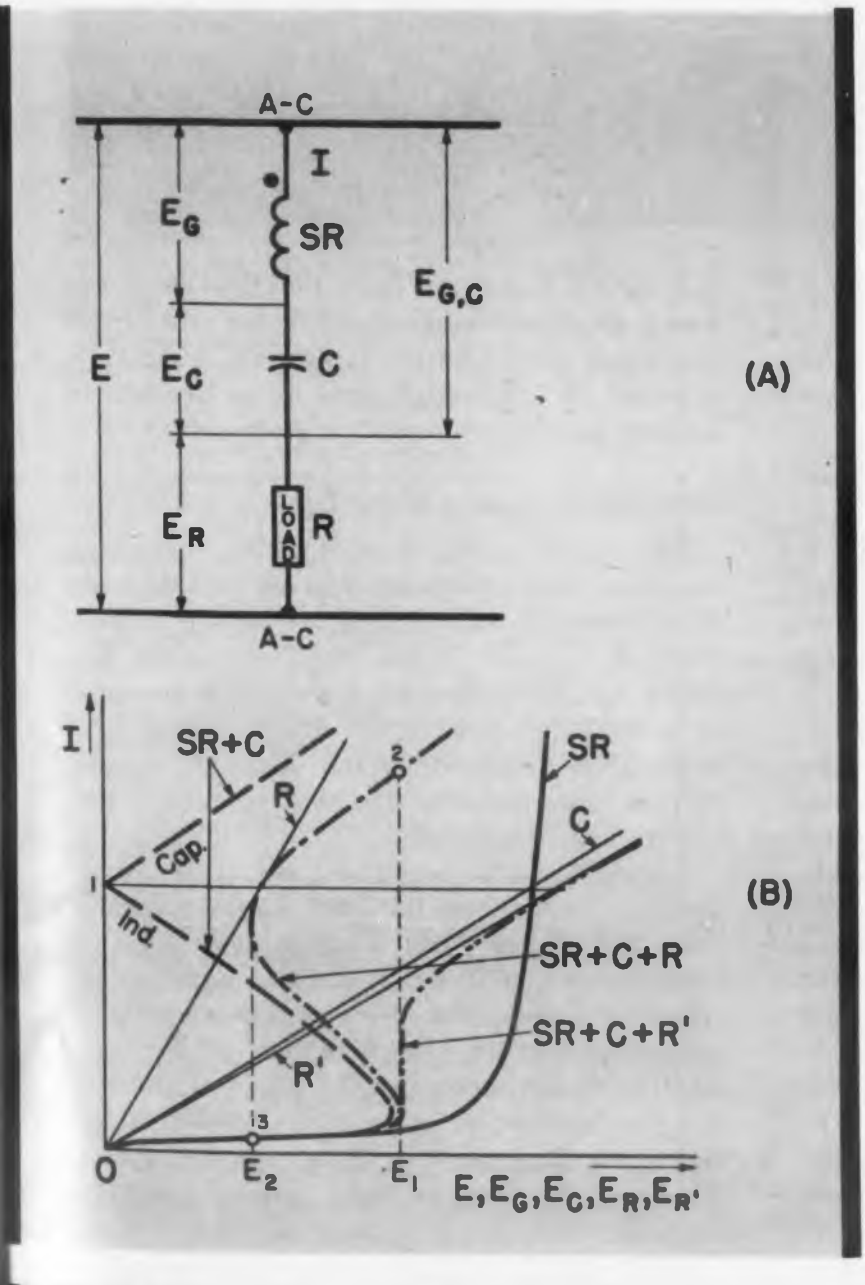

Fig. 6-1. Ferro-resonance. (A) Series, nonlinear resonant circuit. (B) Voltage and current relations. (Voltages are rms).

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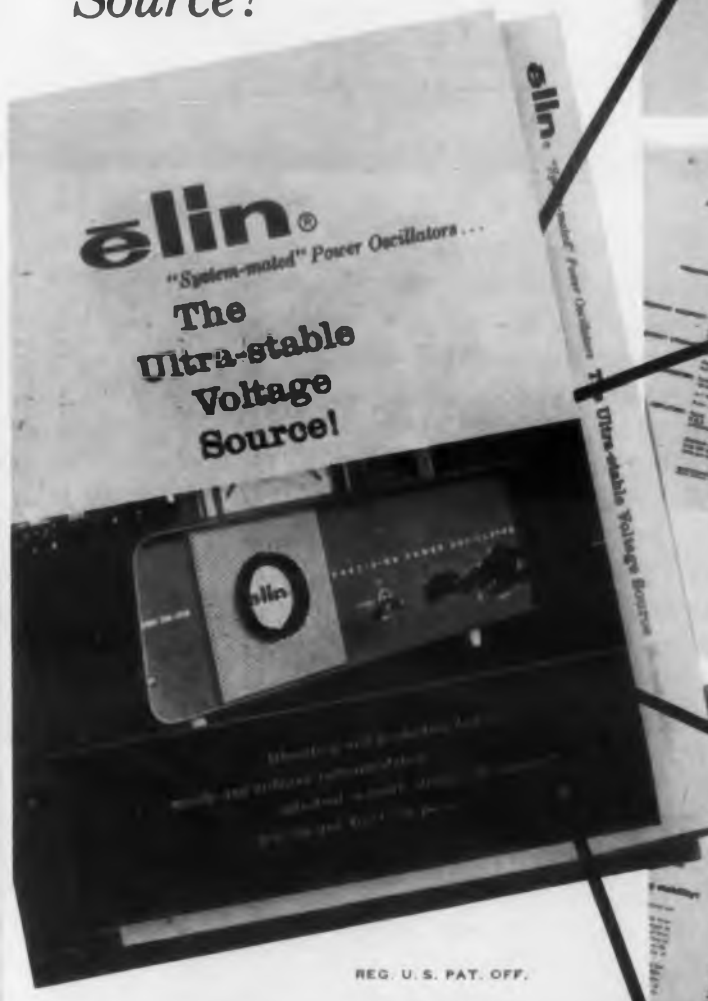

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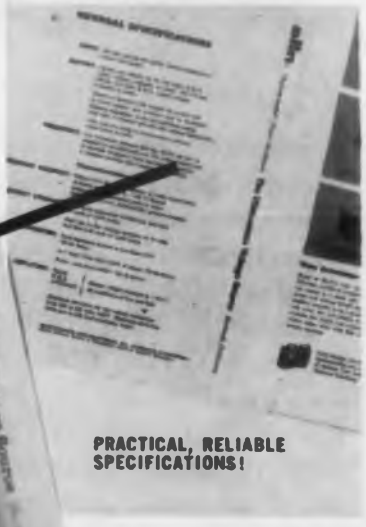

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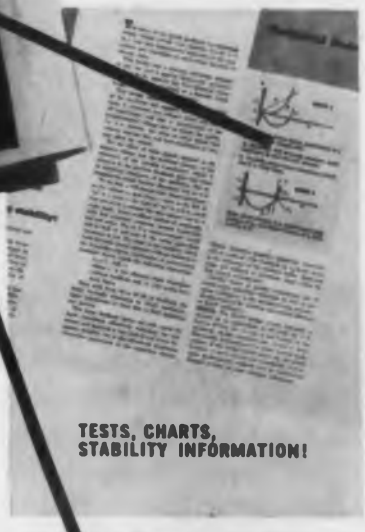

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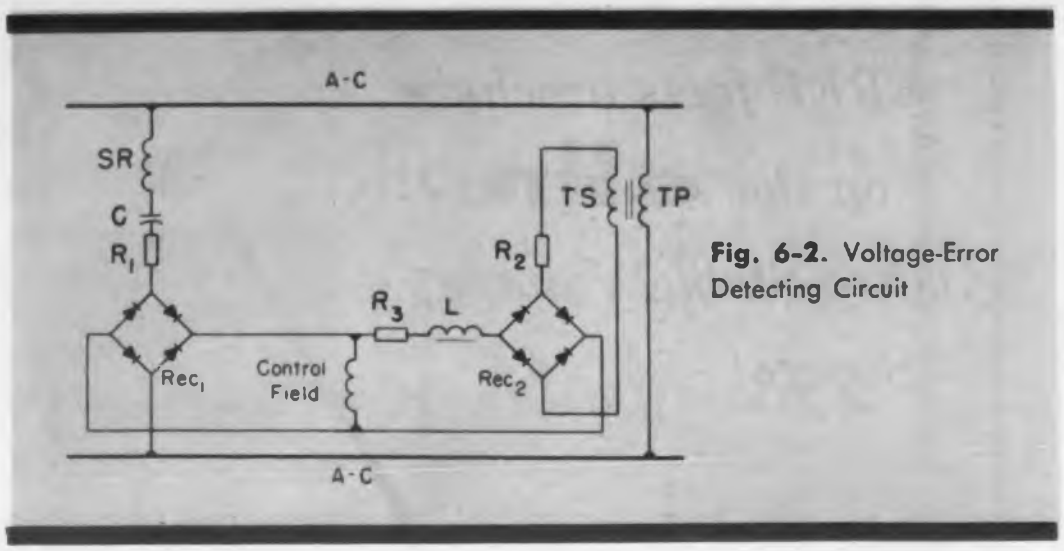

Fig. 6-2. Voltage-Error Detecting Circuit

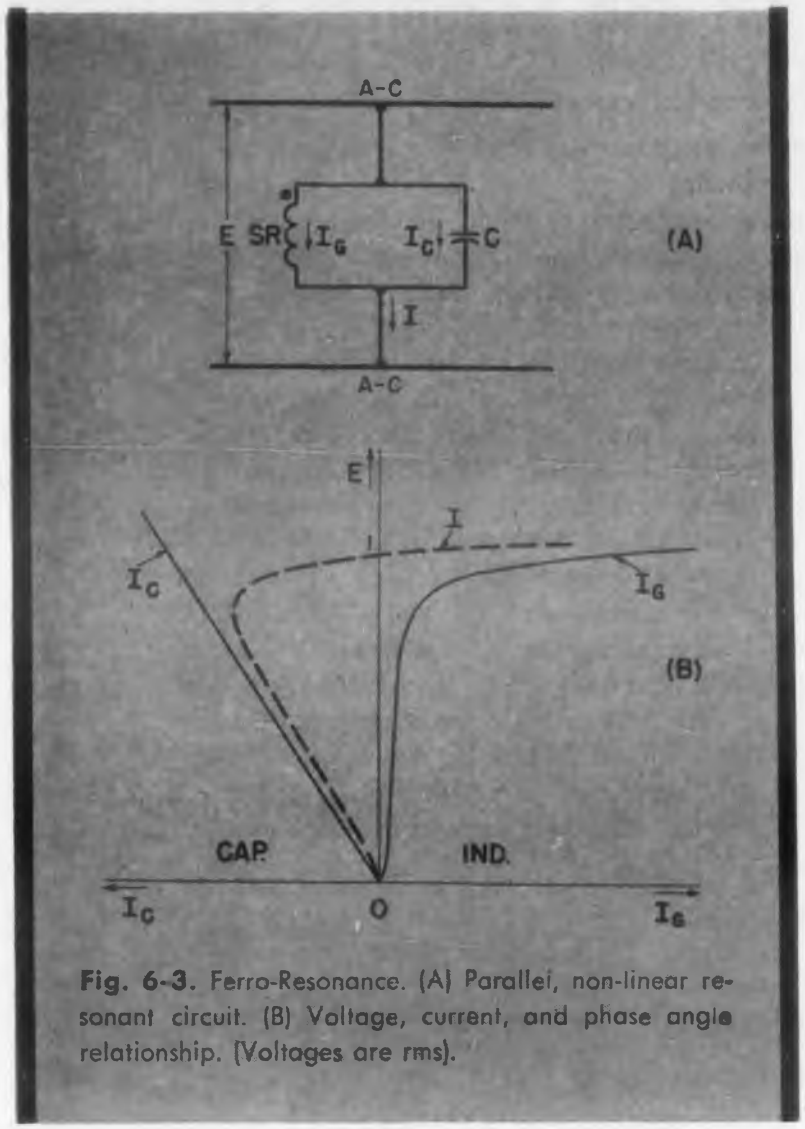

Fig. 6-3. Ferro-Resonance. (A) Parallel, non-linear resonant circuit. (B) Voltage, current, and phase angle relationship. (Voltages are rms).

sinusoidal and of opposite phase. With the *SR* actually being non-linear, E_G and E_C are no longer sinusoidal, but their fundamental components are still of essentially opposite phase.

To establish the voltage $E_{G,C}$ (Fig. 6-1A) which is across the series connection of the *SR* and the capacitor *C*, the liberty is taken of obtaining $E_{G,C}$ by subtracting E_C from E_G, resulting in the dashed characteristics labaled $SR + C$ in Fig. 6-1B. If the current is smaller than indicated by the distance *0-1*, it is inductive, if larger, it is capacitive with respect to $E_{G,C}$.

The terminal voltage *E* is approximated by the vector sum of $E_{G,C}$ and E_R, resulting in $E = (E^2_{G,C} + E^2_R)^{1/2}$. Thus, the characteristic marked $SR + C + R$ has been determined in Fig. 6-1B.

It will be noticed that the characteristic $SR + C + R$ is bi-stable. By increasing the supply voltage *E* from zero, the current increases according to the lower branch of the characteristic. If the supply voltage is increased merely a trifle beyond E_1, the load current will increase to point 2. For a further increase of supply voltage *E*, the load current follows the upper branch of the characteristic.

If the supply voltage is now decreased down to E_2, the current will decline according to the upper branch of the control characteristic. However, a minute decrease of the supply voltage *E* below E_2 will cause the load current to establish itself at point 3. For supply voltages between E_1 and E_2, two stable states for the load current are possible, hence the name bi-stable circuit. The bi-stable region is not traversed along the dashed vertical lines, but essentially along the main characteristic itself.

By increasing the resistor *R* to *R′* the width of the bi-stable region can be reduced, resulting in the border case where the loop width becomes zero and the characteristic becomes vertical (curve marked $SR + C + R'$). With a further

increase of load resistance, the characteristic remains single-valued, and its slope decreases.

The steep part of the characteristic ($SR + C + R'$) makes the circuit a useful tool for sensing deviations of the ac supply voltage. For instance, such sensing is used in voltage regulators for alternators (Refs. 6-8,1-8, p. 480).

One form of application to an alternator voltage regulator (Ref. 6-9) is shown in Fig. 6-2. The control field (to be acted upon by the non-linear, resonant circuit) may belong to a rotating exciter of a magnetic amplifier which directly or indirectly energizes the field of the alternator. The current flowing through the control field is the difference between a current proportional to the line voltage, and another current coming from the non-linear resonant circuit, which sharply varies as the supply voltage varies.

The bi-stable characteristics ($SR + C + R$, Fig. 6-1B) is utilized for handling logic in digital systems. Combined with a second circuit, identical with that of Fig. 6-1, one obtains a trigger pair, which forms the basic building block for binary counters, storage registers and other logic operations (Ref. 6-10). Triggering is usually achieved by single-logic polarity pulses which produce simultaneous mmf's in both cores.

Reversible Induction Motor Drive

The circuit of Fig. 6-3A is called a parallel, non-linear resonant circuit. The currents through the *SR* and the capacitor *C* are shown in Fig. 6-3B. On account of the phase opposition between I_G and I_C, the total current *I* is assumed to be their difference. If the supply voltage *E* is larger than indicated by the distance *1-0*, the current *I* will be inductive, if *E* is smaller, the current will be capacitive.

Reversible, induction motor drives are often used as control means for line voltage regulators; they may actuate a tap-changing mechanism of a transformer, or they may actuate an induction type voltage regulator. By connecting one field of the control motor in series with a parallel non-linear resonant circuit (SR-C_1, Fig. 6-4) and the other motor field in series with a power factor correction capacitor C_2, the motor will rotate whenever the supply voltage deviates from the set point. With proper phasing, the motor arma-

ture can be made to rotate in such a direction as to have the tap-changing transformer or induction regulator restore the supply voltage to the set point.

Flashing Lights, Sub-harmonic Oscillator

Returning to the circuit of Fig. 6-1A, and applying a dc bias to another (not shown) winding of the *SR*, one can force the circuit to break into sub-harmonic oscillations (Ref. 6-11). By varying the bias, the period of oscillation can be varied over a range from several cycles to several seconds. This tendency to break into sub-harmonic oscillations can be used to flash lights of railroad crossing signals, or for flashing beacons, and other applications requiring pulsating energy. This circuit uses exclusively static means for switching, hence its maintenance is reduced to the barest minimum.

For further study of sub-harmonic oscillators see Refs. 6-12 to 6-14.

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From a paper presented at the Winter General Meeting of the AIEE in New York City, Feb. 2-7, 1958.

NEW PRODUCTS

To provide a complete coverage of ALL new products generally specified when designing electronic original equipment, the New Product section has been extended. To include the larger number of items, products which are best suited to a brief description have been noted at the end of the section.

RELAY

Contacts close in 2 to 4 msec in this spst Glaswitch Relay. Contacts are hermetically sealed in a glass envelope containing dry nitrogen and a helium tracer. Bounce is rated at 0.25 msec. Mechanical life is given in excess of 2 billion cycles, with speeds to 400 cps or higher. Operating power is about 50 mw.

Revere Corp. of America, Dept. ED, Wallingford, Conn.

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Versatile circuits for magnetic tape applications, these amplifiers have voltage levels compatible with either transistor or vacuum tube systems of logic. The write amplifier uses logical combinations of two input voltages to provide both return-to-zero and non-return-to-zero modes. The basic read circuit is a linear amplifier with a voltage gain of approximately 2500. Liberal feedback is used to preserve pulse waveform. A variety of transitional output circuits are available.

Decisional Control Assoc., Inc., Dept. ED, 14141 Stratton Way, Santa Ana, Calif.

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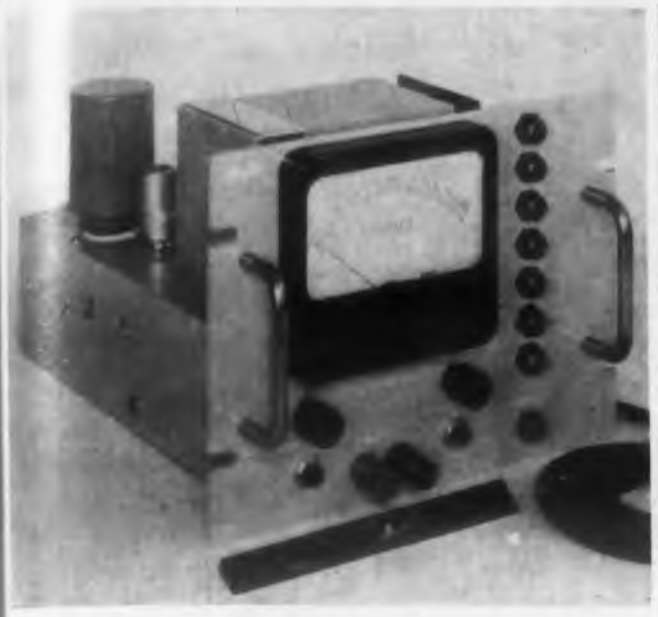

PRODUCTION OHMMETER

Automatic range switching, simple readout, and fast response are offered by the KT 427879-1 ohmmeter. Range switching is accomplished by a servo loop which selects the correct range to insure a meter indication at mid-scale for any resistance value. The selected multiplier is clearly indicated by a light located to the right of the meter.

Kearfott Co., Inc., Dept. ED, 1378 Main Ave., Clifton, N.J.

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RECTIFIERS

Potted in epoxy resin, these germanium and silicon rectifiers have octal socket tube bases for ease of equipment assembly. Other advantages include greater ruggedness than lead-mounted rectifiers, and ability to replace standard tube rectifiers directly. The rectifiers are rated from 50 to 600 v piv. The rectifier cells may be used at full free air ratings in the potted circuits.

General Electric Co., Semiconductor Products Dept. ED, Syracuse, N.Y.

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NEW PRODUCTS

DC Magnetic Amplifier

For low level applications

The 100 C series of low-level dc magnetic amplifiers weigh about six ounces and occupy about six cubic inches of space. The unit is polarity sensitive, and has stability comparable with chopper stabilized amplifier systems. The amplifier is supplied in gains of 500 and 1000 with linearity of 0.1 per cent. Gain stability with variations in line voltage of ±10 per cent and frequency of ±5 per cent is kept to ±1 per cent. Output voltage range of the instrument is plus or minus 28 vdc. Response time of the unit is 0.02 sec.

California Magnetic Control Corp., Calmag Div, Dept. ED, 11922 Valerio St., North Hollywood, Calif.

CIRCLE 58 ON READER-SERVICE CARD

Transistor Tester

Permits convenient quantity testing

Designed for unskilled operators in quantity testing, as well as for skilled technicians, model BT 5001A measures the saturation currents of diodes and transistors. Six voltage ranges (0-10; 10-50; 50-100; 100-250; 250-500; 500-750) are presetable anywhere within their range. Fourteen current ranges with keyboard selectivity permit current measurements from 10^{-9} to 10^{-3} amp full scale. The circuitry allows the zero control to balance out any leakage current in mounting jigs, cables, etc. Recorder output, regulated power supplies, and internal calibration adjustments are other features.

Trans Electronics, Inc., Dept. ED, 7349 Canoga Ave., Canoga Park, Calif.

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Delays as low as 250 msec.

Due to its low mass, the thermaline thermal time delay relay offers delays as low as 250 msec. The 1/8 in. diam silver contacts can carry 3 amp at 115 v 60 cps noninducting current, for a minimum of 250,000 operations. Operating voltages range from 6-115 v. Timing ranges, normally open or normally closed as 250 msec to 3 min. Contact recovery time is 2 sec max, timing tolerance for any range is ±10 per cent of total time. Available in glass or metal enclosures.

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Acceleration Switch

Omni-directional in one plane

Model 117 is a low-cost spst acceleration switch with omni-directional sensitivity in a single lane and adjustable acceleration setting. Small size and weight make it suitable for aircraft use in such applications as destruction of classified equipment upon crash, or arming devices on missiles.

Specifications include 2-amp dc resistive load contacts, minimum life of 10,000 operations, acceleration setting range of 1.5 to 5 g with a setting accuracy of +0.25 g, and temperature range of —50 to +190 F.

Maxson Instruments Corp., Dept. ED, 47-37 Austell Place, Long Island City 1, N.Y.

CIRCLE 61 ON READER-SERVICE CARD

CIRCLE 62 ON READER-SERVICE CARD ➤

DUPONT

TEFLON®
FLUOROCARBON RESINS
ELECTRONIC DESIGN NEWS

Low friction of TFE resin insures smooth action of punched-card sensor

Stable capacitors for missiles have high thermal,electrical ratings

CAPACITORS made of TFE-fluorocarbon resins possess outstanding stability, very low temperature coefficient, and excellent insulation resistance at high temperatures. In designing these capacitors, only bonded mica, ceramic dielectrics and TFE resins were found to meet the temperature specifications. Of these three, the TFE resins were selected as having greatly superior electrical characteristics. The capacitors are rated up to 200°C. The dielectric constant and very high sensitivity of the TFE resins remain virtually unchanged over the broadest operating ranges of frequency and temperature. The dissipation factor of the dielectric is less than 0.0003. (Manufactured by Film Capacitors, Inc., New York, New York.)

TEFLON®
is a registered trademark . . .

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including TFE (tetrafluoroethylene) resins discussed herein.

PUNCHED-CARD SENSOR depends on 540 pins molded of a TEFLON resin for smooth switching operation. The pins slide easily into the holes, because of the extremely low surface friction of the resin. The sensor is used as a programming device for automation and for multiple switching. (Manufactured by Metron Corporation, Lambertville, New Jersey.)

At the heart of this switching device are 540 pins made of a TFE-fluorocarbon resin, which translate the message on a punched card by activating complex electrical circuits. Each of the 540 positions (arranged 12 wide by 45 high) has a corresponding spring-loaded pin and a normally closed single-pole single-throw switch. The card is pressed forward onto the pins by a handle. Where there is a hole in the card, the pin slides through practically without friction. Where there is no hole, the sturdy pin is pushed forward by the card and opens a switch. Trouble-free operation of this complex sensing device is dependent on the properties of TFE-fluorocarbon resins.

TFE-fluorocarbon resins are considered almost perfect electrical insulators. Their dielectric strength ranges from 400 to 4,000 volts per mil, depending on thickness. They have virtually no moisture absorption, and retain their dimensional stability under all conditions of humidity. No other structural material has so low a coefficient of friction. TFE resins are rated for operation from close to absolute zero to 250°C. They can be molded to close dimensions and machined to tolerances of half a mil.

The properties of TFE resins might well be important in your next product. For more facts on Du Pont TEFLON TFE-fluorocarbon resins, including technical data and applications, write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., Room 184 Du Pont Building, Wilmington 98, Delaware. In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec.

CIRCLE 63 ON READER-SERVICE CARD

NEW PRODUCTS

Transmitter Power Supply
Transistorized unit supplying 130 w

Model PS-1011 transistorized transmitter power supply furnishes more than 130 w dc, occupies 62.5 in. cu, and weighs 3.2 lb. Input voltage is 28 v dc and two outputs are provided, 500 v at 250 ma and 250 volts at 25 ma. Regulation is 5 per cent from half to full load. Ripple is below 0.15 per cent on both outputs.

Power Sources, Inc., Dept. ED, Burlington, Mass.

CIRCLE 64 ON READER-SERVICE CARD

Signal Injector
Generates medium to high r-f

The Mosquito transistorized signal injector provides direct coupling as well as inductive coupling to all magnetic sensitive pick-ups and circuits without direct connection with leads. Operated by a 1.5 v battery, the unit generates from 2000 cps to high radio frequencies in harmonics. Designed primarily for testing of a-f and r-f section, hearing aid devices and similar audio systems.

Don Bosco Electronics Co., Dept. ED, 1099 S Orange Ave., Newark, N.J.

CIRCLE 65 ON READER-SERVICE CARD

Core-Transistor Shift Register
Provides up to 250,000 shifts per sec

Model CTR-250 magnetic core shift register elements can operate up to 250,000 shifts per sec

Each element utilizes one encapsulated magnetic core and one germanium transistor. The units can be cascaded into registers of any desired length. These registers may be read into or out in serial or parallel, or any combination of the two methods. Also available is a compatible transistor driver, CTSD-250, which can drive up to 16 stages or CTR-250 per driving transistor.

Mack Electronics, Div. of Mack Trucks, Dept. ED, 40 Leon St., Boston 15, Mass.

CIRCLE 66 ON READER-SERVICE CARD

Computer

Measures rate-of-change of small signals

Model 0557-1 rate-of-change computer can accurately measure slowly varying voltage changes from 10 to 5000 μv per sec superimposed upon static voltages from 0 to 100 mv. The computer readout is a dc voltage proportional to the rate of change measured and is suitable for operating any standard recording potentiometer. The computer package includes a high-gain dc differential chopper amplifier, and electronic rate unit, transistorized 400 cps power supply for the choppers, and a regulated dc supply.

Magnetic Instrument Co., Dept. ED, 546 Commerce St., Thornwood, N.Y.

CIRCLE 67 ON READER-SERVICE CARD

Indicators

Use T-2 lamps for side visibility

These units provide three degrees of side visibility in models designated 1 DH 6, 1 DH 7, and 1 DH 8, respectively. The replaceable-lamp indicators were designed expressly for the T-2 lamp which provides longer operation in 6, 12, 24, and 28 v incandescent lamp ratings and extra visibility in neon types. Lenses are butyrate; cases are aluminum, either black or aluminum-anodized.

Eldema Corp., Dept. ED, 1805 Belcroft Ave., El Monte, Calif.

CIRCLE 68 ON READER-SERVICE CARD

CIRCLE 69 ON READER-SERVICE CARD

RESISTANCE NETWORKS

Maintain Precise Voltage/Current Ratios

In missiles, computers, instruments . . . in ac or dc circuits . . . wherever voltage or current must be adjusted within close limits . . . Shallcross Networks provide accuracy and dependability.

FROM A RELIABILITY STANDPOINT, use of sealed networks is recommended in preference to individual resistors to eliminate harmful preventive maintenance. In field servicing the technician is often not aware of the precise T.C. and reactance matching of otherwise seemingly ordinary MIL resistors. In addition to special winding techniques the individual resistors in critical networks are usually stabilized. Replacement of any resistor with a standard MIL type could cause equipment malfunction, and must be prevented.

FROM A DESIGN STANDPOINT Shallcross' skill and ability assure adherence to the most exacting temperature, stability, shock, size, and weight requirements. Shallcross precision engineered networks have proven effective both in ground-based and airborne equipment.
Two typical Shallcross resistance networks are described below. Many others with specialized electrical and mechanical characteristics are regularly manufactured.

SECONDARY-STANDARD VOLTAGE REFERENCE SOURCE is built around this 24 terminal Shallcross resistance network. Using an oil-filled enclosed network of 21 matched T.C. resistors with stabilities of 0.001%, the instrument maintains an absolute accuracy of 0.01% from 0° to 50°C.

Shallcross

GROUND-SUPPORT COMPUTERS employ a number of these hermetically-sealed, standard, octal, plug-in networks. Networks have up to 10 specially wound resistors which are critically located and lead-dressed to meet specifications at 400 cycles. All units are production tested for voltage division accuracy and quadrature error using a precise 400 cycle bridge.

SHALLCROSS MANUFACTURING COMPANY • 526 Pusey Ave., Collingdale, Pa.

CIRCLE 70 ON READER-SERVICE CARD

NEW PRODUCTS

Transformer

Provided with 90 db shielding

Featuring 90 db shielding, this transformer also has a ratio accuracy of 0.01 per cent with a phase angle error not exceeding 2 min. Output voltages range from 7.2 to 230 v, and performance is maintained for any condition of loading, from open circuit to 100 w total of loads on all windings. In some combinations of loading, currents of over 2 amp may be drawn.

Osborne Electronic Corp., Dept. ED, 712 S. E. Hawthorne Blvd., Portland, Ore.

CIRCLE 71 ON READER-SERVICE CARD

Pulsed Oscillator

High power source for testing delay lines

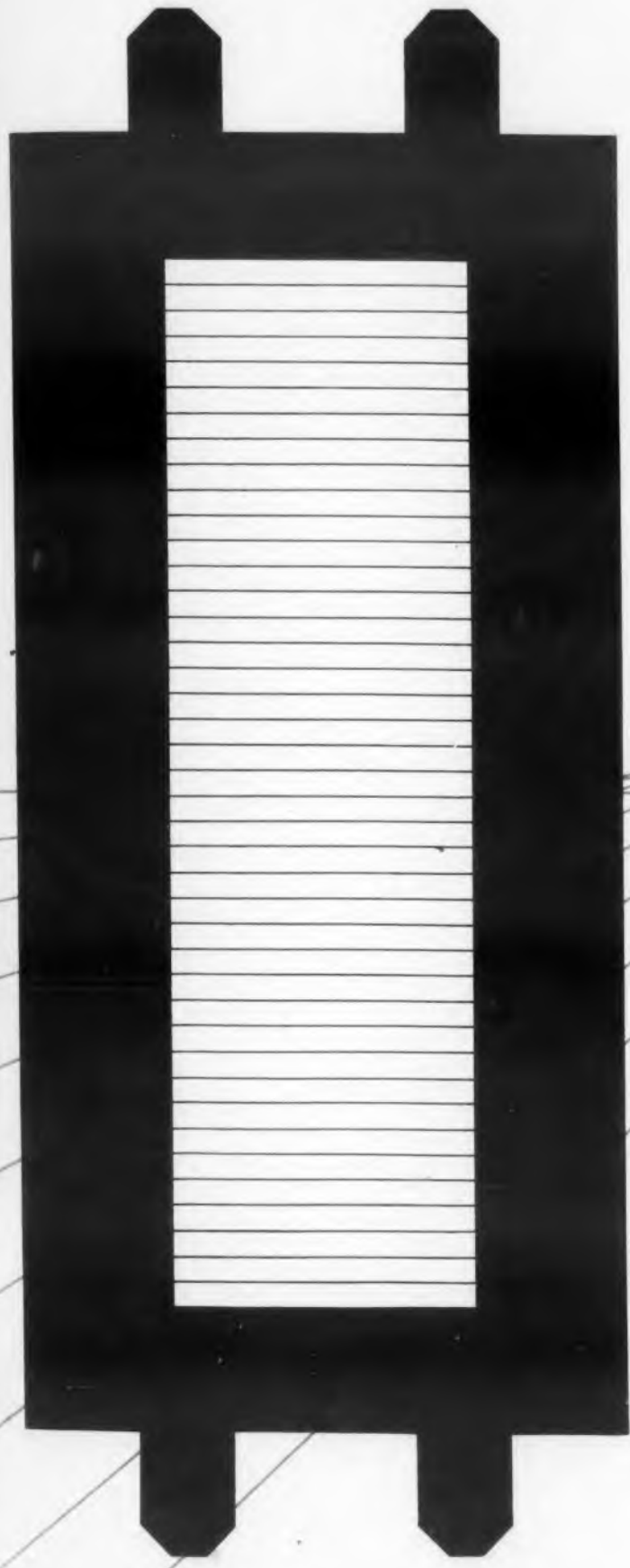
Type PG-650 oscillator is a variable frequency pulse modulated r-f source for applications requiring high power output as well as high stability. Its principal use is in measuring the parameters of ultrasonic delay lines whose high initial insertion loss and operation at low impedance levels usually present difficulties. The output of a delay line (60 db into 50 ohms) can be shown at r-f using only the vertical amplifier of an oscilloscope. Rise and fall time is as sharp as 0.5 and a minimum pulse length of less than 2 μsec has been achieved.

Specifications include an output of 0-300 v peak to peak into 93 ohms, externally terminated; internal prf of 50-2500 cps; pulse length up to 10 μsec with a flatness of less than 5 per cent droop a 10 μsec; total harmonic content of less than 10 per cent, chiefly 3rd; phase stability within pulse of less than 0.005 μsec jitter; frequency stability of 2 per cent or less than 1 dial division with output level at mid position.

Arenberg Ultrasonic Lab., Inc., Dept. ED, 94 Green St., Jamaica Plain 30, Mass.

CIRCLE 72 ON READER-SERVICE CARD

Electron Tube News
–from SYLVANIA



Announcing the Sylvania Framelok Grid

...Introducing a New Receiving Tube Era

Sylvania's revolutionary Framelok construction marks the era of mass produced "Frame Grid" Tubes

Frame grid history is a Sylvania history

Beginning with its earliest handmade frame grid, Sylvania has concentrated engineering effort on frame grid design and development. From this experience, comes the Framelok Grid, a revolutionary design which makes it possible to mass produce frame grid tubes for the first time.

First tube to incorporate the Framelok Grid is the Sylvania Type 6FH6—a beam power pentode designed for Horizontal TV Deflection.

Framelok Grid is self-aligning

In the Framelok Type 6FH6, grid alignment is accomplished with unprecedented ease and precision. Sylvania's unique construction draws grid laterals taut; grid wires are arranged in a ladder sequence, normal to the axis of the grid. Precise frame construction and close mica tolerances make perfect alignment automatic.

Higher Plate-to-Screen Current Ratios

Framelok tubes are more efficient as a result of precise grid alignment. Plate-to-screen current ratios substantially greater than those of present types can be achieved—requiring less screen power for optimum performance. Thus improved horizontal scan performance can be realized.

Higher Dissipation

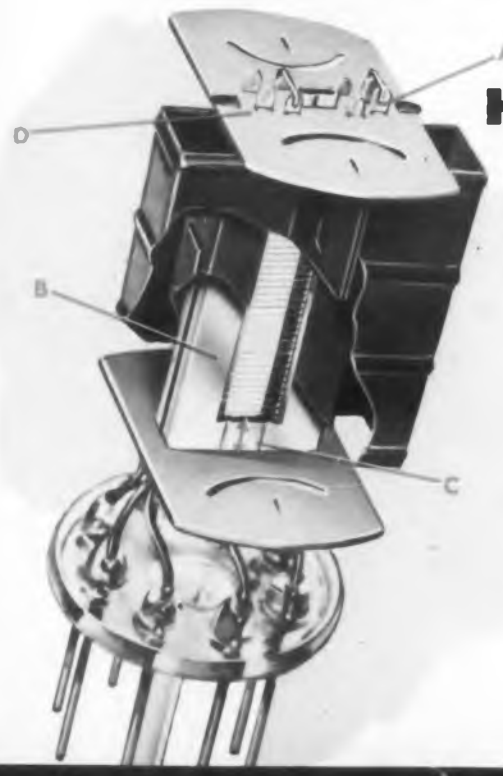
Less required screen grid power for a given plate power automatically reduces the dissipation requirements of the Framelok Grid. And since the Framelok Grid has greater mass it is more capable of dissipating heat. These factors, contributing to inherently lower grid emission, make it possible to achieve higher peak plate currents before dissipation becomes a limiting factor.

Mount is more rugged

Unlike ordinary grids, strength of the Framelok Grid comes from its rigid frame and is independent of the grid wires. This rigidity is transferred to the mount assembly, reducing life failures resulting from grid warping or bowing.

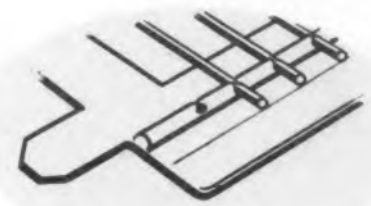
More uniform transfer characteristics

More precise grid construction, more uniform element spacings, and more rugged mount assembly,

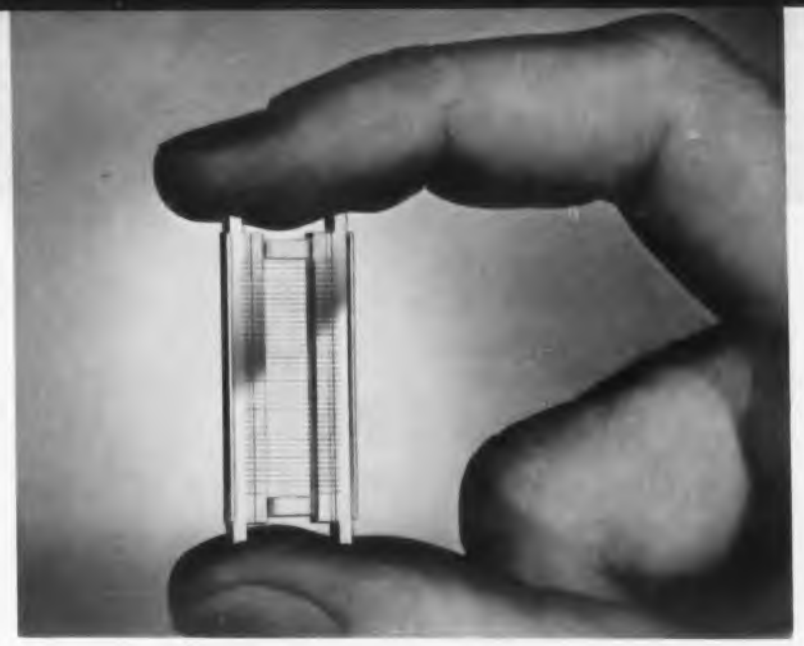


Here are a few highlights of the mechanical

A Straight line geometry of grid side-rods in present grids is considerably weaker than the double-box configuration formed by frame grids. Distortion due to mount "twist" is virtually nonexistent in the frame grid structure.



B Sylvania's new Framelok construction eliminates brazing and adapts the frame grid to automatic production. Grid halves are perfectly flat—free from thermal strains.



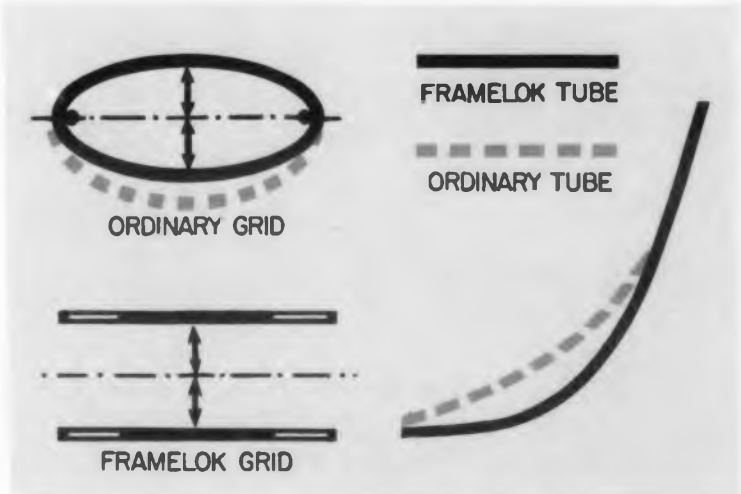
Many grids look like one! The inherent alignment capabilities of Sylvania's Framelok Grid are demonstrated by the ease with which the laterals of any number of separate grid halves can be lined up. Perfect alignment means higher efficiency—greater flexibility in the selection of grid wire diameters for optimum performance.

add up to closer control over tube transfer characteristics. Narrower control of limits of course means less critical circuitry, and a more stable and reliable performance in the end product.

Application potentials are wide

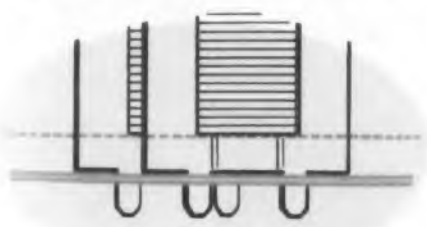
To meet the heavy operational requirements of horizontal deflection tubes, the first Framelok tube to be announced is the Horizontal Deflection Type 6FH6.

The adaptability of this grid is such that application of Framelok tubes should quickly extend to vertical TV deflection, video, audio, and a wide range of low and medium power uses in the frequency range below UHF.



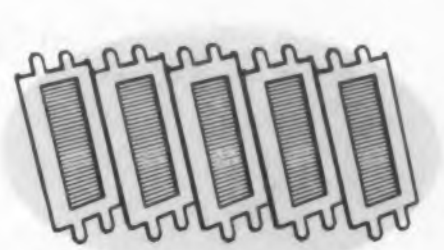
Uniform transfer characteristics of the Framelok Grid tube result largely from greater control of both major and minor dimensions of the grid. Above is a graphic representation of variations in characteristics which result from distortion of the minor dimensions in wound grids. Since both major and minor are fixed in the rigid frame grid, these variations are virtually eliminated.

superiority of the Framelok Tube



C Self-alignment is accomplished in the Framelok Grid through precise control of the distance between the mica and the first grid lateral wire. These tolerances in the frame grid are held in the order of one tenth of one thousandth of an inch—considerably tighter than ordinary grid tolerances.

D Mica slots are designed with flat alignment surface and channel index to position grids with much greater precision. Closer element spacings are possible where extra Gm is required.



Sylvania's unique technique of frame grid construction makes it possible to duplicate grid after grid. More uniform spacings produce a more uniform electrostatic field in the tube.

The SYLVANIA

FRAMELOK

TYPE 6FH6

Highly efficient horizontal deflection tube

Proved in pilot and now being planned for mass production, the Framelok Type 6FH6 is the most efficient tube ever designed for horizontal deflection service.

It provides design engineers with a new flexibility in circuit design because of the high zero-bias plate-to-screen current ratio. This permits the tube to be driven harder at a lower screen dissipation.

The 6FH6 supplies increased power output because plate voltage can swing to a very low value without encountering unduly high screen grid currents. Higher screen voltages can be maintained at lower dissipation levels resulting in higher output peak current and power.

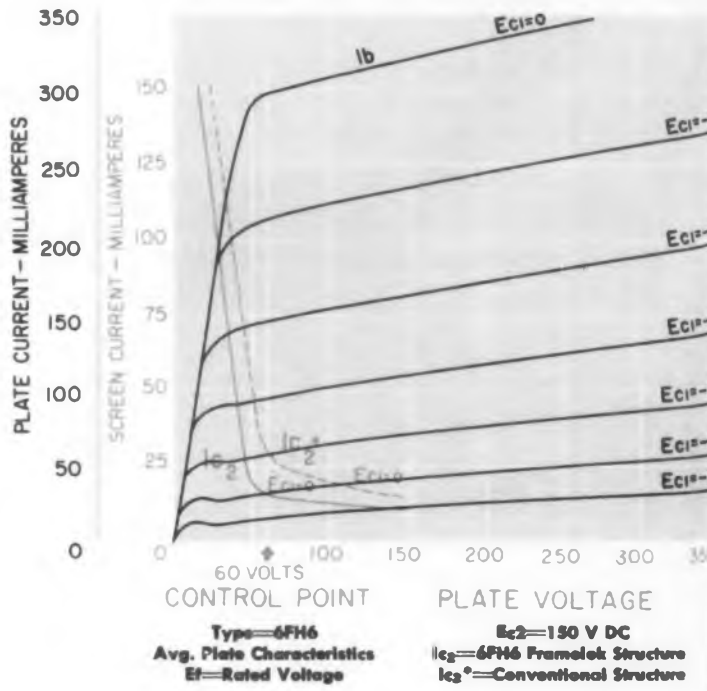
Framelok type 6FH6 plate-to-screen current ratios are compared to those of comparable existing tubes.

TYPE 6FH6
DESIGN MAXIMUM RATINGS

Maximum D. C. plate supply voltage (boost + DC power supply)	770	volts
Maximum peak positive plate voltage	6000	volts
Maximum peak negative plate voltage	1500	volts
Maximum plate dissipation	17	watts
Maximum D.C. grid #2 voltage	220	volts
Maximum peak negative grid #1 voltage	300	volts
Maximum grid #2 dissipation	3.6	watts
Maximum average cathode current	155	ma
Maximum peak cathode current	500	ma
Maximum grid #1 circuit resistance — Self-bias	1.0	megohm
Maximum bulb temperature (hottest spot)	240	°C

AVERAGE CHARACTERISTICS

Pentode operation with Eb=250 V; Ec2=150 V; Ec1= −22.5 V;		
Plate current	75	ma
Grid #2 current	1.7	ma
Transconductance	6000	umhos
Plate resistance	12,000	ohms
Zero Bias with Eb=60 V; Ec2=150 V; Ec1=0; (instantaneous values)		
Plate current	300	ma
Grid #2 current	15	ma
Cutoff: For Ib=1.0 ma with Eb=250 V; Ec2=150 V.		
Grid #1 voltage (approx.)	-53	volts
Triode Amplification Factor with Eb=Ec2=150 V and Ec1= −22.5 V	4.1	



Type=6FH6
Avg. Plate Characteristics
Ef=Rated Voltage

Ec2=150 V DC
Ic2=6FH6 Framelok Structure
Ic2°=Conventional Structure

For additional information on Framelok Tubes and the Type 6FH6 mail this coupon to:

Sylvania Electric Products Inc.
1740 Broadway
New York 17, N. Y.

Name_____

Company_____

★ Title_____

★ Street_____

★ City_____

State_____

SYLVANIA

Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.
In Canada: Sylvania Electric (Canada) Ltd., Shell Tower Bldg., Montreal

LIGHTING • TELEVISION • RADIO • ELECTRONICS
PHOTOGRAPHY • ATOMIC ENERGY • CHEMISTRY-METALLURGY

Ventilated Cabinets

Eliminate hot spots

A controlled cross ventilation system is featured in this series of modular relay rack cabinets. Air flow to cool a heat load of 2 to 3 kw input is provided. Flow is easily controlled to direct air exactly where cooling is needed. Modular construction is offered in a variety of standard units, with a 12-gage or 3/16 in. steel frame, or front and rear door with or without glass panels or cutouts.

Western Devices, Inc., Dept. ED, 600 W. Florence Ave., Inglewood, Calif.

CIRCLE 74 ON READER-SERVICE CARD

Transistorized Power Supply

For powering travelling-wave tubes

This power supply is a current regulated unit designed especially for travelling-wave tube solenoids producing 300 to 400 gauss. Specifications include a current output of 0.8 amp with output voltage variation of ±15 v centered about 100 v. Regulation is 0.5 per cent, and ripple is 0.02 per cent. Input is 115 v ac with an allowable line voltage variation of ±10 per cent. Units are available to provide current outputs from 0.5 to 1.5 amp.

Menlo Park Engineering, Dept. ED, 721 Hamilton Ave., Menlo Park, Calif.

CIRCLE 75 ON READER-SERVICE CARD

CIRCLE 76 ON READER-SERVICE CARD ➤

➤ CIRCLE 330 ON READER-SERVICE CARD

NEW PRODUCTS

Multiplexer

Converts 90 transducer signals for PDM telemetry

Type 40-101 Plexicoder commutates signals from up to 90 transducers at 112.5 samples per sec and converts them into duration-modulated pulses. Low-speed magnetic switching at the input, coupled with high-speed commutation and coding accomplished by interrupting a light beam, replaces the usual rotating wiper-arm assemblies and wide-band chopper-stabilized amplifiers. Transients in the data-channel input circuit are practically eliminated by the natural filtering characteristics of galvanometers. The Plexicoder is compatible with low-output resistive-type transducers. It will accept single- or double-ended, high- or low-level inputs.

Consolidated Electrodynamics Corp., Transducer Div., Dept. ED, 300 N. Sierra Madre Villa, Pasadena, Calif.

CIRCLE 78 ON READER-SERVICE CARD

Encapsulated Transformers

Withstand up to 175 C

Coil construction and high temperature insulation permits miniaturization in these transformers. The units have a 10,000 hr life in 125 C ambients, with temperatures to 175 C available in shorter life applications. Units have been approved to Mil-T-27A Grade 5 Class T Life specifications. The construction includes a moisture barrier which prevents moisture penetration without using bulky encapsulation. Encapsulation techniques permit complete saturation of coils.

Electro Engineering Works, Inc., Dept. ED, 401 Preda St., San Leandro, Calif.

CIRCLE 79 ON READER-SERVICE CARD

Miniature Connectors

For RG-141A/U cables or smaller

This series of miniature connectors is designed for type RG-141A/U and smaller cables. The connectors are made in gold or silver plate types. All contacts are gold for ease of assembly. Shown is a comparison between connector type UG-58A/U and the miniature connector.

Kings Electronics Co., Inc., Dept. ED, 40 Marbledale Rd., Tuckahoe, N.Y.

CIRCLE 80 ON READER-SERVICE CARD

Voltage Regulator

Supplies 24 v dc ±0.5 per cent

Model MIR-50 transistorized dc voltage regulator operates from an input of 25 to 30 v dc and supplies 24 v dc at the ouput. Regulation is ±0.5 per cent for the line variations as stated and for load variations from 500 ma to 2 amp. Response time is 5 msec for no load to full load variations, and the maximum transient overshoot as a result of load changes is held to 1 v. Size of the unit is 2-1/2 x 3-1/2 x 1-5/8 in. and it weighs 11.5 oz.

Modern Industries Inc., Dept. ED, 2601 Colorado Ave., Santa Monica, Calif.

CIRCLE 81 ON READER-SERVICE CARD

Blower

Two-inch diameter

Weighing less than four ounces, this axial blower measures 1-1/2 in. length, 2 in. diam., with a 2-1/2 in. mounting flange. It is single phase, operating on 27.5 v 400 cps or on 115 v 400 cps, and delivers 10 cfm at 0.11 in. static pressure with 5 w input.

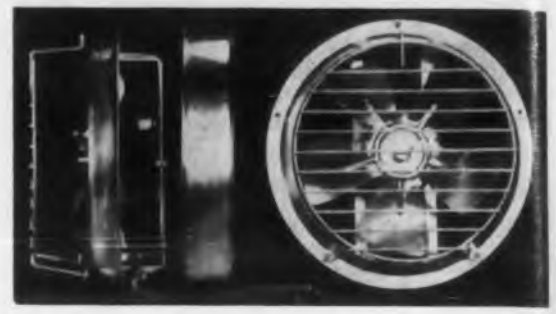
Eastern Air Devices, Inc., Dept. ED, 385 Central Ave., Dover, N.H.

CIRCLE 82 ON READER-SERVICE CARD

NEW PRODUCTS

Fan Assemblies

Down to 2-7/8 in. thin



The 6-1/2 in. diameter fan is now made in six types. In each group there is an ultra-thin model 2-7/8 in. back to front, a standard fan 3-1/4 in. overall, and a 3000 rpm model slightly deeper. A four-point shock-mounted construction is the standard method of assembly for all these fans, and is supplied at no increase in price over the previous welded frames. All fans are available with moderately-priced ball-bearing, permanently lubricated motors. The 2-7/8 in. deep model delivers 125 cfm at 0 in. static pressure.

Kooltronic Fan Co., Dept. ED, Carter Rd. at Rosedale, Princeton, N.J.

CIRCLE 85 ON READER-SERVICE CARD

Variable Transformer

1.5 amp model is first of line

Model VT1R5 variable transformer, a 1.5 amp unit, marks this company's entry into the variable transformer fields. Many of the features of the company's power rheostats are incorporated. For example, the brush arm of the VT1R5 carries no current. Other features include an internal stop and heavy rhodium plating on the brush track. A reversible, direct reading dial is calibrated to 120 on one side and 132 on the other, permitting direct setting to the desired voltage for line or overvoltage connection.

Ohmite Mfg. Co., Dept. ED, 3667 Howard St., Skokie, Ill.

CIRCLE 86 ON READER-SERVICE CARD

Selenium Rectifiers

One-half size of previous types

These Vac-u-Sel selenium rectifiers are clip assembly types which are 50 per cent smaller than other company models now available. Ratings are 2.5, 8, and 25 ma.

All three models have piv ratings of from 37 to 378 v. Peak effectiveness is possible in temperatures up to 110 C.

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

CIRCLE 87 ON READER-SERVICE CARD

Transformers

Smaller, lighter and quieter

The core and coils of series EP dry-type transformers are completely encapsulated in resin with filler, providing a sealed unit that can be installed in hazardous areas. Sealing the units in resin results in sound levels averaging 5 db below NEMA standards. At the same time, the heat transfer properties of the resin and filler make possible units averaging 55 per cent smaller and 14 per cent lighter than previous models. The transformers are available in ratings from 1/4 to 10 kva, 600 v and below.

Westinghouse Electric Corp., Dept. ED, Box 2278, Pittsburgh, Pa.

CIRCLE 88 ON READER-SERVICE CARD

Accelerometer

Differential type with 60-v output

Differential transformer accelerometers with outputs to 60 v have been added to Edcliff's line. Model 7-34 has ranges from ±1 g to ±50 g in a case measuring approximately 3.3 x 1.9 x 1.6 in. Damping is temperature compensated to 0.1 of critical and resolution is infinite. Output at full scale is a maximum 0.5 v per v-in., and at zero acceleration it is a maximum of 0.5 per cent of full scale. Standard input is 115 v 400 cps, with other inputs available. Maximum non-linearity is 1 per cent, and phase shift at 0 deg is ±5 deg.

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

CIRCLE 89 ON READER-SERVICE CARD

NEW PRODUCTS

Trigger Tube

Cold cathode type with high accuracy

The Mullard type Z803U cold cathode trigger tube has been designed with uncoated metal electrodes and sputtered envelope technique to provide stable characteristics and long life. Anode working voltage range is 170 v to 290 v. The tube has complete freedom from ambient light effects. Using this tube, it is possible to construct cold cathode tube timers with an accuracy as high as 2 per cent. The trigger breakdown voltage remains constant within 1 per cent of its initial value.

International Electronics Corp., Dept. ED, 81 Spring St., New York 12, N.Y.

CIRCLE 92 ON READER-SERVICE CARD

Symbol Generator

Provides visual display for computing systems

The SM (symbol matrix) generator and viewer translates coded data from data-processing and computing systems to a visual message for immediate viewing. Data can come from storage media, such as punched tapes or cards, or from magnetic tapes or drums. The device converts input data at any rate up to 10,000 characters per sec and displays data in blocks of 200 characters or less (20 per line in 10 lines) in alphabets or abstract symbols. The unit generates all symbols simultaneously. Thus, only one symbol generator is needed if an

application calls for many viewers. The system is essentially a two dimensional magnetic core matrix, five cores wide by seven cores high, each core representing one part of the printed symbol. Complete symbols are formed by wire threaded through the matrix in the form of various characters.

Laboratory for Electronics, Inc., Computer Prod. Div., Dept. ED, 141 Malden St., Boston 18, Mass.

CIRCLE 93 ON READER-SERVICE CARD

Standing Wave Indicator

Rotary action simplifies vswr measurement

Operating by means of a probe rotating in the plane of circular polarization of a wave-guide, this rotary standing wave indicator provides a non ambiguous read-out of the sign of reactive components. Measurement of vswr, reflection coefficient angle, hence impedance, in the low frequency range, is simplified. The unit is available in waveguide sizes from WR-650 to WR-4200. If desired, the rotating probe can be motor driven for remote operation and to provide an oscilloscopic presentation of vswr.

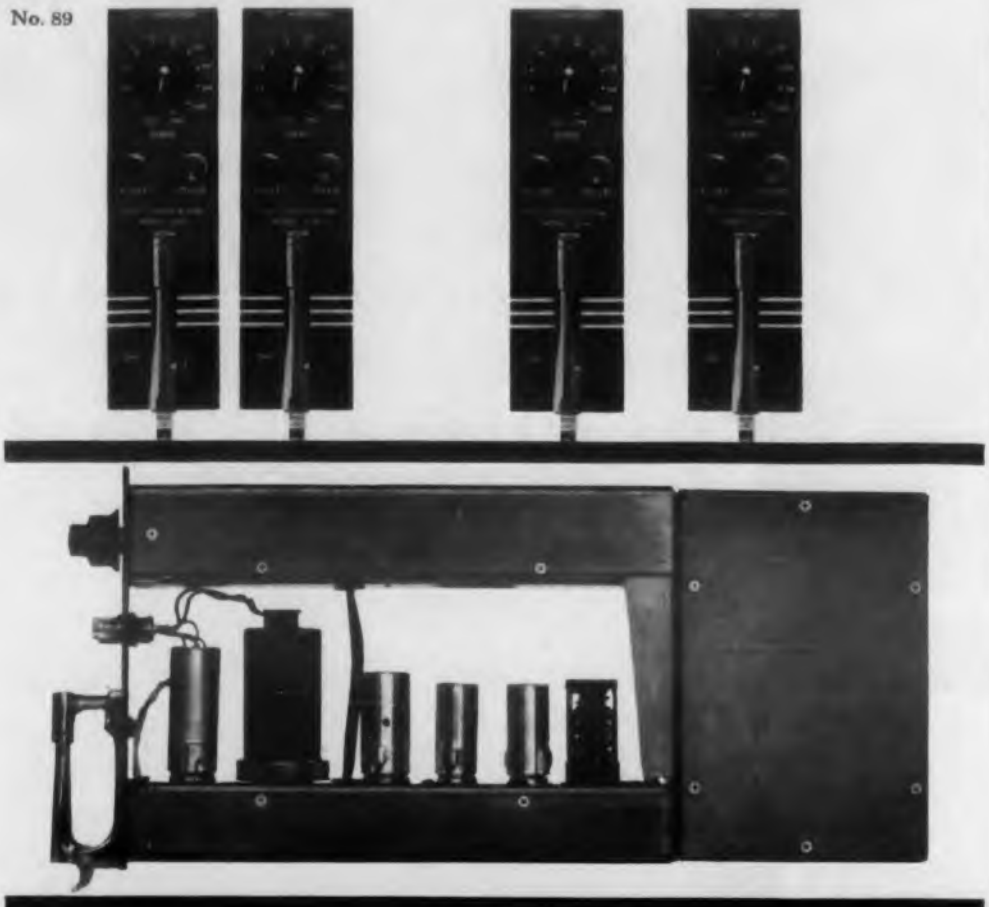
Characteristics include: an insertion length of less than 10 in.; residual vswr of less than 1.03; accuracy of ±20 deg maximum error in measurement of reflection coefficient angle with pure reactive load; and sensitivity is such that the instrument can detect 5 mv in the main wave-guide.

Polytechnic Research & Development Co., Inc., Dept. ED, 202 Tillary St., Brooklyn, N.Y.

CIRCLE 94 ON READER-SERVICE CARD

CIRCLE 95 ON READER-SERVICE CARD ➤

No. 89



"BUILDING BLOCK" APPROACH SPEEDS SYSTEM DEVELOPMENT

Based on extensive experience in system development, Hallamore has designed DC amplifier HEC-0102 for wide application in "building-block" type instrumentation systems. Combining high stability, broad bandwidth, wide line noise and drift characteristics, the amplifier, one of the series of Hallamore "building-blocks," is designed to save initial system development time, as well as to simplify functional changes or replacement of units within a system. *Write for complete specifications on HEC-0102 and the "Building-Block Instrumentation Series". Dept. 15J, 5151 Progress Avenue, Anaheim, California. TWX Calif. AH-9019.*

HALLAMORE ELECTRONICS COMPANY

a division of The Knight Corporation

CIRCLE 96 ON READER-SERVICE CARD

NEW PRODUCTS

Magnetic Latching Relay

Reduces power consumption

This dual-coil relay, model SL, operates on a 1-w, 3-msec pulse to either coil. A magnetic latch and high contact pressures hold the contacts closed under 100 g shock and 30 g vibrations to 2000 cps. The relay will switch loads up to 2 amp at 30 v dc resistive or 1 amp at 115 v ac resistive, and operates in ambient temperatures from —65 to +125 C.

Potter & Brumfield, Inc., Dept. ED, Princeton, Ind.

CIRCLE 97 ON READER-SERVICE CARD

Power Supply

36 v dc, 15 amp

Supplying up to 36 v dc and 15 amp at any voltage, model H3615 transistorized power supply has a combined line and load regulation of less than 0.5 per cent for changes of load from 0-15 amp and for line changes from 105-125 v. Output ripple is 3 mv over most of the range. The instrument measures 8-3/4 x 19 x 14 in. and weighs approximately 50 lb.

Deltron, Inc., Dept. ED, P. O. Box 192, Glenside, Pa.

CIRCLE 98 ON READER-SERVICE CARD

Solenoid Switch

Momentary or maintained contact

Type 5ETI-6 is a completely sealed momentary-action toggle switch that can be converted to a maintained-contact switch by means of a built-in solenoid. The spdt switch and a 28 v dc solenoid are contained in a unit measuring slightly over 3 in. from the top of the toggle lever to the bottom of the case. Diameter of the case is 1 in. When the toggle lever is operated and the

solenoid energized, the solenoid holds the lever in the operated position. This feature permits remote release of the lever, returning it to the unopened position. Immediate release is possible by manually over-riding the toggle lever. The switches are rated at 4 amp, 28 v dc, resistive load. They are available with either wire leads or side-facing screw terminals.

Minneapolis-Honeywell Regulator Co., Micro-Switch Div., Dept. ED, Freeport, Ill.

CIRCLE 101 ON READER-SERVICE CARD

Artificial Loads

Capacities to 70 kw

This line of standardized load banks for obtaining artificial electrical loads is available in capacities up to 70 kw per unit, 600 v max. Each load bank consists of a metal framework; prewired resistance elements; terminals for external connection and load section switching components where needed. Elements are Ribflex or Barohm ribbon type resistors.

Ward Leonard Electric Co., Dept. ED, 115 MacQuesten Pkwy. South, Mt. Vernon, N.Y.

CIRCLE 102 ON READER-SERVICE CARD

Coaxial Cable

Shielded by seamless copper tube

The seamless shield around Coaxitube prevents the stray leakage that can occur through a braided coax. Construction consists of a solid or stranded inner conductor or conductors, dielectric, and a seamless copper, or other non-ferrous metal, shield forming a coaxial pair of conductors. The seamless shielding will also prevent stray reflection that can arise if pitch of braid is some harmonic fraction of a wave length. For high frequency applications, the cable is produced in a variety of lines designed to match types including RG-8/U, RG-11/U, RG-22/U, RG-58/U, RG-59/U and RG-62/U. The conductor is stated to provide lower attenuation than that of conventional types. Outside diameter can be controlled from 0.22 in. to 0.1 in. or larger.

Precision Tube Co., Dept. C-2, Dept. ED, North Wales, Pa.

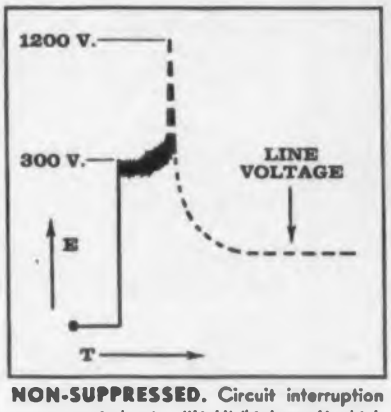
CIRCLE 103 ON READER-SERVICE CARD

SP7 SERIES moisture-sealed phenolic housing

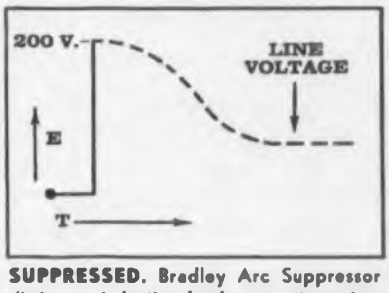
SP3 SERIES hermetically sealed metal housing

Bradley Selenium Rectifiers for Arc Suppression

PROTECT CONTACTS AGAINST ARC-INDUCED EROSION



NON-SUPPRESSED. Circuit interruption generates inductive "kick" (high peak) which creates arc across contacts.



SUPPRESSED. Bradley Arc Suppressor dissipates inductive load, prevents arcing.

When interrupted, every inductive circuit "kicks" back. Coil de-energization generates a high inductive potential which explodes in a metallic arc across contacts and sends transient surges through the circuit. Contacts erode — then lock or stick. Components operating at maximum rating break down under the voltage overload.

These conditions are eliminated by Bradley Selenium Rectifiers for Arc Suppression. Small in size, low in cost, and easily connected across any inductive element, these rectifiers block the inductive kick and prevent arcing. They perform this function without noticeably slowing circuit operation. For more information, please write for Technical Bulletin, "Bradley Selenium Rectifiers for Arc Suppression."

Bradley
LABORATORIES, INC.

BRADLEY LABORATORIES, INC., 174 Columbus Avenue, New Haven 11, Connecticut

CIRCLE 104 ON READER-SERVICE CARD

NEW PRODUCTS

Trimming Potentiometer

Two-gang unit providing 50,000 ohms per section

Type 75-M28 sealed trimming potentiometer is particularly suited for moisture or shock and vibration conditions. The aluminum housing makes possible a dissipation of 2 w when the trimmer is panel mounted. Resistance values per section of up to 50,000 ohms can be provided in a standard 1-1/8 in. housing length, with higher resistance values available with a slight increase in housing length.

Maurey Instrument Corp., Dept. ED, 7924 S. Exchange Ave., Chicago 17, Ill.

CIRCLE 106 ON READER-SERVICE CARD

Antenna Cap

Confines radiation yet simulates free space condition

These metallic housings lined on the inside with an appropriate Eccosorb product are used to cap or cover a radiating antenna. The function of the caps is to confine radiated energy and to terminate the antenna in essentially free space conditions. The caps are provided with a type N bulkhead connector so that a probe can be attached internally to monitor antenna output.

Applications include checking out an antenna-transmitter system

CIRCLE 105 ON READER-SERVICE CARD

when it is desirable that radio silence be maintained, such as with jamming equipment. The caps can be supplied to cover the frequency range from 200 to 30,000 mc. Significant broadbanding in a single cap is feasible. Power handling ability of the caps is as high as 1 kw average power. Vswr in a typical application is 1.1.

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

CIRCLE 107 ON READER-SERVICE CARD

Accelerometer

0.0017 g produces a 10 mv output

Model 24614 ac accelerometer provides a very low threshold on the order of 0.0017 g for a 10 mv output. Available in low natural frequencies, and in ranges from ±1 g to ±20 g, the instrument provides an ac output proportional to linear acceleration parallel to its mounting base. Full scale output is 6 v, with a maximum null of 0.015 v. The output can be fed directly into a relatively low impedance with little or no phase shift.

The accelerometer consists of a magnetically damped mass suspended between two disc springs. Cross-talk effect is minimum (0.003 g/g at 10 g cross acceleration on a 1 g instrument). Second order system response is achieved by magnetic eddy-current damping. The instrument is oil filled and hermetically sealed to enhance stability of output under stress.

G. M. Giannini & Co., Inc., Dept. ED, 918 E. Green St., Pasadena 1, Calif.

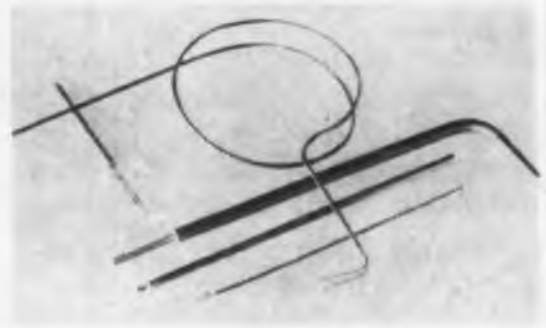
CIRCLE 108 ON READER-SERVICE CARD

CIRCLE 109 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Swaged Thermocouple

Can be bent or coiled



This assembly consists of a thermocouple or other electrical wires surrounded by a ceramic insulation and encased in a metallic sheath. The sheath is swaged in a machine, crumbling and compressing the ceramic insulation so that it forms a completely tight seal around the wires. The swaged assemblies can then be coiled or bent in any shape without damage to the insulation. The units are stated to be highly resistant to corrosion, high pressure, vibration, and temperature. The ceramic insulation in the assembly can be magnesium, aluminum, or zirconium oxide. The sheath can be supplied in Inconel, Monel, aluminum, copper, and various types of stainless as well as ordinary steel.

Advanced Dynamics, Inc., Dept. ED, 16321 Rockside Rd., Maple Heights, Ohio.

CIRCLE 111 ON READER-SERVICE CARD

Digitizer

Converts analog output of mass spectrometers

A completely unprogrammed instrument, the Mascot is designed to provide tabulated digital conversion of the analog ouput from a type 21-103C mass spectrometer. It converts the amplitude and true mass number of each mass-spectrum peak (except metastable peaks) into a signal for a parallel entry type paper-tape printer. Operating at the speed of a normally scanning mass spectrometer, the Mascot eliminates the time necessary to manually identify and measure peaks on an oscillograph record. Readout is continuously available during the mass spectrometer's run.

Consolidated Electrodynamics Corp., Dept. ED, 300 N. Sierra Madre Villa, Pasadena, Calif.

CIRCLE 112 ON READER-SERVICE CARD

FM Signal Generators

Covers mobile r-f bands

Model 1064/2 fm signal generator covers all mobile radio r-f bands and most i-f bands in a portable instrument weighing 26 lb. Frequency ranges are 450-470 mc, 118-185 mc, 30-50 mc, 290 kc-16 mc. The fm deviation is ±3.5 kc and ±10 kc, or to order. Output is calibrated .025 μv to 1 mv, up to 100 mv uncalibrated. Stability, short warm-up time, and negligible attenuator reaction and leakage are other features.

Marconi Instruments, Dept. ED, 111 Cedar Lane, Englewood, N.J.

CIRCLE 113 ON READER-SERVICE CARD

Relay

3pst 25 amp type

Model 325 3pst relay has been designed to meet airborne applications per MIL-R-6106. Temperature range is −65 to +125 C. The unit is available with up to two additional dt switches if required. The unit operates on 1/5 w, 400 cps, operation internally rectified.

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

CIRCLE 114 ON READER-SERVICE CARD

Component Ovens

Snap-action reliability

The JKO9S series of ovens retains close temperature control by eliminating the fallibility of creep-action thermostats. Suitable for housing crystals, diodes, resistors, and capacitors, the JKO9S provides operating temperatures from −55 to +105 C, with a temperature stability of ±0.5 C. Heater voltage is 12 v to 115 v.

James Knights Co., Dept. ED, Sandwich, Ill.

CIRCLE 115 ON READER-SERVICE CARD

ELECTRONIC *wire* INSULATED AGAINST MOISTURE HIGH TEMP ABRASION

***all** types conforming to* **SPECIFICATION MIL-W-16878B**

Within the wide range of insulated electronic wires . . . conforming to Specification Mil-W-16878B . . . Continental offers *every* type and size. Insulations in polyvinyl . . . Teflon . . . Silicone Rubber . . . and Nylon . . . assure a Continental wire to Mil-W-16878B specifications for practically every electronic operation where moisture, high and low temperatures, and corrosion present their problems.

Whether from stock or to *your* special order, Continental insulated wire is quality engineered to precise specifications. For help with your insulated wire requirements, write today. Be sure to give details on amperage, voltage, diameter limitations, and operating temperatures.

Direct all inquiries to CONTINENTAL WIRE, Wallingford.

continental wire *corporation*

WALLINGFORD, CONN.
YORK, PENNA.

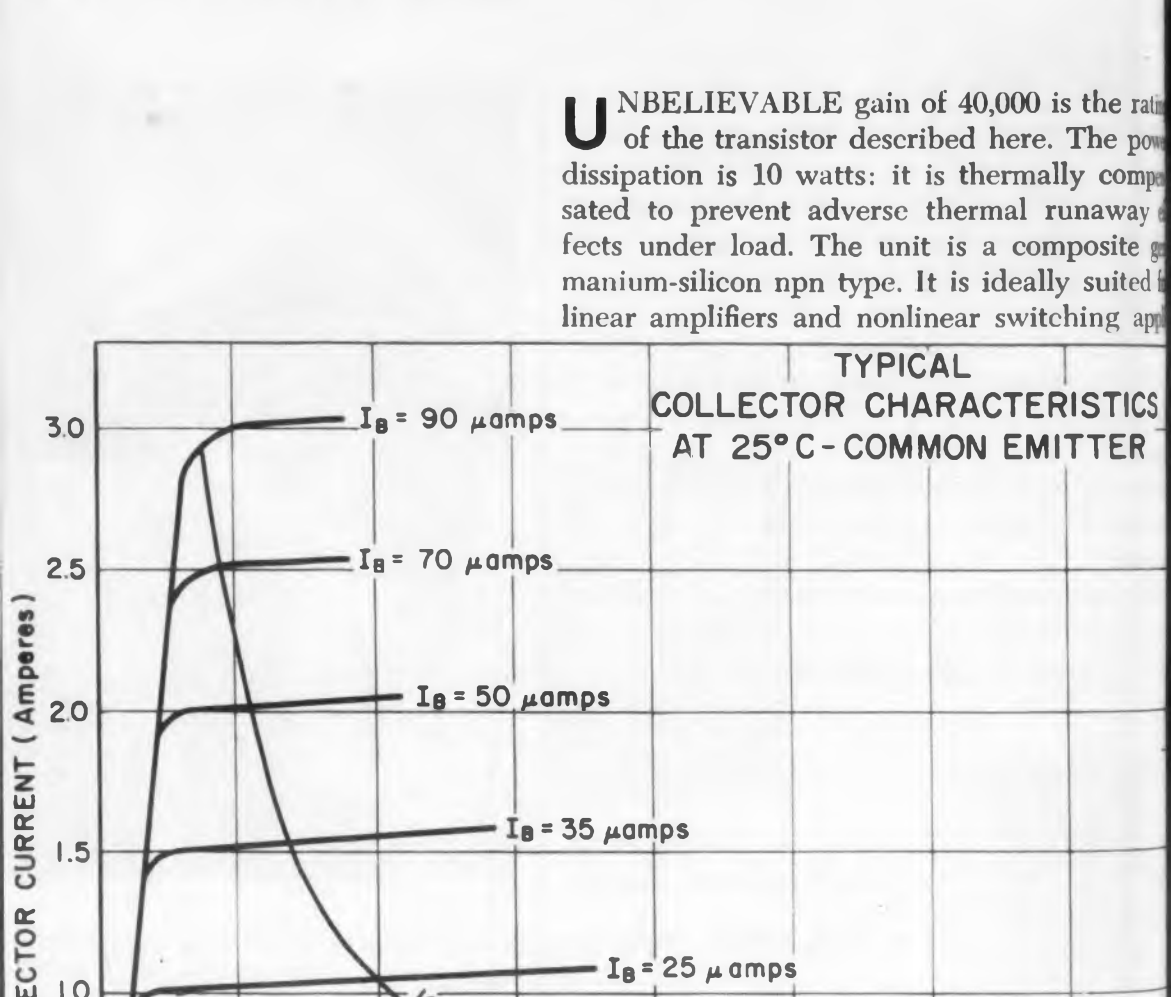
CIRCLE 117 ON READER-SERVICE CARD

Power transistor is ideal for driving a servo. No linear elements are used in the amplifier.

Stable Ultra High Gain

Composite Germanium-Silicon Power Transistor

UNBELIEVABLE gain of 40,000 is the rati of the transistor described here. The pow dissipation is 10 watts: it is thermally compe sated to prevent adverse thermal runaway e fects under load. The unit is a composite ge manium-silicon npn type. It is ideally suited f linear amplifiers and nonlinear switching app



Characteristic curve of the germanium-silicon npn power transistor.

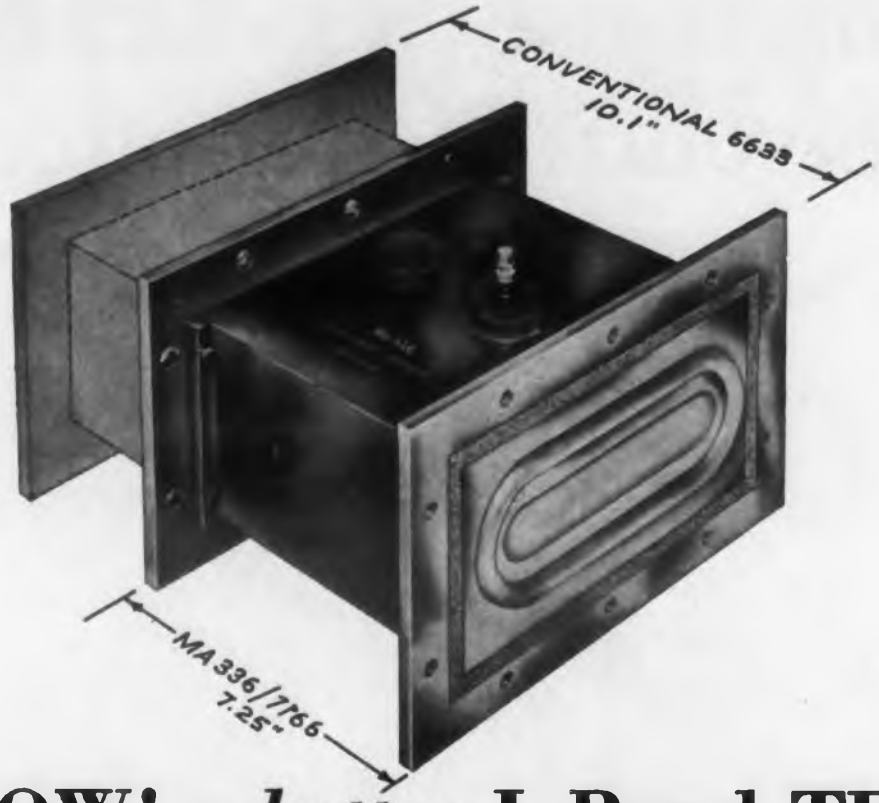
Composite high-gain, high power transistor can be used as switching device or small signal parameter amplifier. Maximum power is 10 w; undistorted class-A output is 4.

ations from dc to the alpha cutoff frequency of 00 kc. A high impedance driving source can be sed for common emitter, common base, or com- non collector. It has the general characteristics f a small-signal transistor at the input, power ransistor at the output, and over-all gain of a ascaded amplifier.

The news release announcing this device laid n your editor's desk for several days. We hought there must be a typographical error re- arding the high ratings and that a correction no- ice would be forthcoming. When no other word ame through, we called Advanced Research As- ociates, Inc., Kensington, Md. (P.O. Box 68). eneral Manager Henri Hoge said he was wait- ng for somebody to question the startling claims. s might be suspected, the device contains sev- ral independent transistor elements. But there is o resistor in the unit—transistor elements are onnected together directly. The device can prop- rly be called a transistor, though, as it has three erminals and can be treated as one high-power, igh-gain unit. The characteristic curves are il- ustrated.

Maximum ratings are as follows: collector volt- ge to base or emitter, 30 v; collector current, amp; power dissipation, 10 w. The current gain H_{fe} is 15,000 to 40,000. The input impedance h_{11e} is 2000 ohms. Output impedance for I_e is qual to 1a is 500 ohms. At 25 C I_{cbo} equals 2 ma; t 65 C, 70 ma. The maximum junction tempera- ture is 100 C.

The EIA registration number is expected to be 2N62 . The company is taking orders now. Prices are high but expected to be lowered as production is stepped up. For more information, turn to the Reader-Service card and circle 118.



NOW! a *better* L-Band TR in a *smaller* package

Crystal protection guaranteed over 500 hour minimum tube life at full rated power in Microwave Associates new TR!

NEW, FIELD-TESTED DESIGN

Designed specifically to overcome the field deficiencies of conventional 6633 tubes, the MA 336/7166 offers substantially improved performance in all characteristics. See comparison chart below.

Several hundred of these tubes have been in the field for many months and are used in early warning systems operating 24 hours a day.

The first failure has yet to be reported either from the field or from monthly production life tests!

The MA 336 is a compact, rugged tube built for maximum reliability and completely guaranteed for performance. *It is in full production and available now.*

PROGRESS IN SWITCHING DEVICES

Microwave Associates' special switching devices group under the direction of Dr. Lawrence Gould is making steady advances in the art. Available right now are high performance tubes of advanced design: high power single and dual pre-TR tubes; low level receiver protector tubes and high power ATR tubes.

If you are interested in switching high powers and in guaranteed crystal protection at any frequency write or call for full information

COMPARISON CHART

	MA 336/7166	Conventional #6633
Crystal protection	Guaranteed for 500 hrs. min. at full rated power: 2 megawatt peak	Not guaranteed
Recovery time	Short . . . less than 25μ seconds	Long 45μ seconds
Low level characteristics	VSWR 1.3 max. over full band. Insertion loss: 0.5 db (.7 db at end of life.)	VSWR 1.4 max. Insertion loss: 0.7 db (1.0 db at end of life.)
Size	7.25" long	10.1" long

MICROWAVE ASSOCIATES INC.

BURLINGTON, MASSACHUSETTS • Telephone BRowning 2-3000

CIRCLE 120 ON READER-SERVICE CARD

NEW PRODUCTS

Null Bridge

Accuracy of 0.05 per cent

Intended to indicate the percentage deviation of a sample resistor from a standard resistor, type 957 bridge offers very high accuracy over a resistance range from 1 ohm to 10 meg through the use of a chopper-stabilized feedback amplifier. Accuracy as a limit bridge is better than 0.05 per cent for resistances greater than 10 ohms.

Millitest Co., Dept. ED, 88 Madison Ave., Hempstead, N.Y.

CIRCLE 121 ON READER-SERVICE CARD

Double-Stud Tuner

50-ohm coaxial type for use in the 425 mc region

Type C6-T double stub tuner is a 6-1/8 in., 50 ohm coaxial unit designed for high power use in the 425 mc region. The tuner has two shorted coaxial stubs, spaced 3/8 wavelength apart at 425 mc. The rack and pinion short mechanisms may be optionally equipped with servo drives or may be manually adjusted with calibrated control knobs.

Continental Electronics Mfg. Co., Dept. ED, 4212 S. Buckner Blvd., Dallas 27, Tex.

CIRCLE 122 ON READER-SERVICE CARD

Accelerometer

Self calibrating

Designed primarily for control and guidance, model ADT-905 accelerometer is equipped with a self-contained calibration system which can be used to check the operation of the accelerometer

while in use. The self-calibrating system is in proportion to the electrical excitation applied. The accelerometer is stable over the temperature range of —65 to +250 F due to balanced electrical and mechanical construction. Operating at a natural frequency of approximately 30 cps, the unit maintains stable frequency response characteristics over the temperature range as a result of magnetic damping.

Gulton Industries, Inc., Dept. ED, 212 Durham Ave., Metuchen, N.J.

CIRCLE 125 ON READER-SERVICE CARD

Accelerometer

With transistorized servo amplifier

Model 4310 transistorized precision linear servo accelerometer is available in ranges from ±0.05 to ±50 g. Maximum output is ±1.5 ma. Repeatability is 0.01 per cent of full-scale and linearity is within 0.05 per cent of full-scale. The entire unit weighs 3.2 oz. The acceleration pick-up portion can be separated from the servo-amplifier part of the instrument and installed in a remote location.

Donner Scientific Co., Dept. ED, 888 Galindo St., Concord, Calif.

CIRCLE 126 ON READER-SERVICE CARD

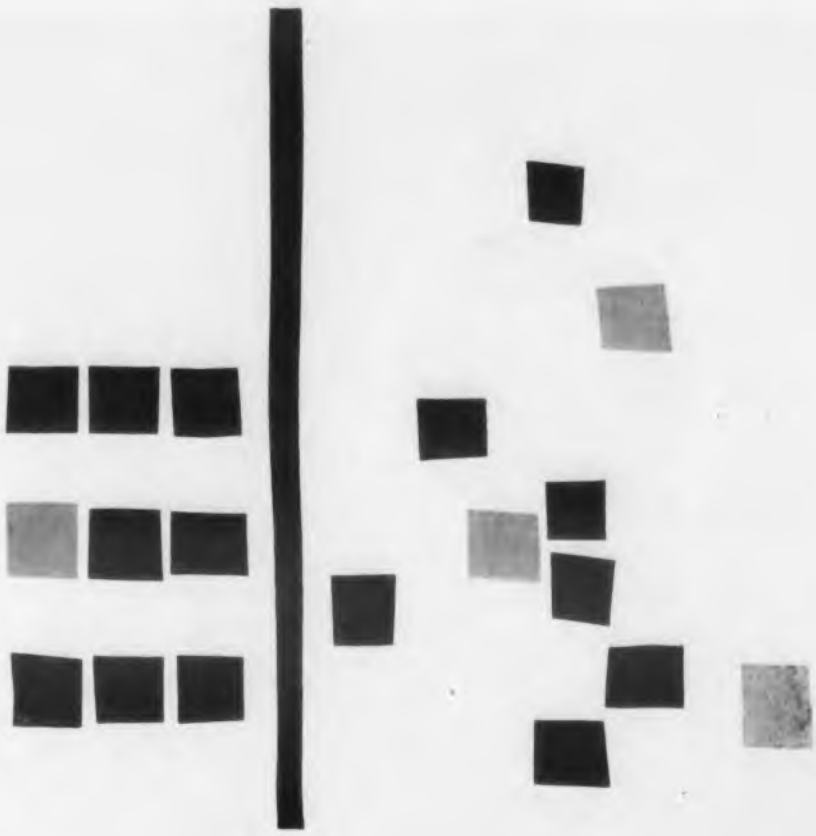
DC Amplifier

Features signal compression

Loss of data resulting from unexpected overscale input signals is avoided by a signal compression feature of the model 1250 dc amplifier. A low noise level of 3 μv rms for 30 kc bandwidth is achieved. Ground-loop and cross talk problems are minimized by a high degree of power line isolation. Specifications include voltage gain of 1000, 2 μv zero stability, and 100 k input impedance.

Dynamics Instrumentation Co., Div. of Alberhill Corp., Dept. ED, 1118 Mission St., South Pasadena, Calif.

CIRCLE 127 ON READER-SERVICE CARD



THE ELEMENT OF FREEDOM

and the Circuit Design Engineer

Freedom is doing what you like. Some Circuit Design Engineers like best to match their wits and skills against difficult technical problems. This characteristic (or idiosyncrasy) of liking complicated technical problems is one of the chief qualifications of the engineer we need.

To qualify, at least three years' experience in general circuitry design in both tubes and transistors is required. Experience should encompass areas such as video and pulse circuits, cathode ray tube displays and analog and/or digital computer techniques.

You are invited to write for more information or phone collect. Address R. W. Frost, System Development Corporation, 2432 Colorado Avenue, Santa Monica, Calif.; phone EXbrook 3-9411.

SYSTEM DEVELOPMENT CORPORATION

An independent nonprofit organization, formerly a division of the Rand Corporation

CIRCLE 552 ON READER-SERVICE CARD

NEW PRODUCTS

Bridge Balance Unit

For 1-to-4-arm transducers

Model 438-B bridge balance unit serves as a bridge between a transducer of one, two, or four-arm type strain gage and a recording oscillograph. It has provisions for completing any part of the bridge circuit not contained in the transducer, and for balancing the bridge and adjusting the sensitivity. Automatic standardization can be accomplished either by series or parallel methods.

Midwestern Instruments, Inc., Magnecord Div., Dept. ED, 41st and Sheridan, Tulsa, Okla.

CIRCLE 130 ON READER-SERVICE CARD

Power Supply

0-350 v, 0.1 per cent regulation

Model L3520A supplies from 0 to 350 v at 0 to 200 ma, and affords a regulation of 0.1 per cent for 10 per cent line or 0 to full load change. Transient response is 1 msec; ripple is 1 mv. A bias source is available at 0 to —150 v, 0 to 5 ma. There is also a filament source, 6.3 v ac, 0 to 10 amp. Line input range is from 105 to 125 v ac at 50 to 400 cps.

Universal Electronics Co., Dept. ED, 1720 Twenty-Second St., Santa Monica, Calif.

CIRCLE 131 ON READER-SERVICE CARD

Magnetic Amplifier

Controls 6 w servo motors

The CSA2A-1 magnetic servo amplifier, is designed in its original configuration to control a motor in a closed-loop servo-mechanism application for a vectoring computer system. The three-stage amplifier is used to accurately maintain the motor shaft position of a two-phase, 60 cps in-

duction motor as called for by the digital computer output. The amplifier is encapsulated in a phenolic case filled with epoxy resin and weighs approximately 10 lb. Outside dimensions are 6.5 x 7 x 2.75 in.

Magnetic Controls Co., Dept. ED, 2855 Park Ave., Minneapolis 7, Minn.

CIRCLE 134 ON READER-SERVICE CARD

Relay

Operates at ambient temperatures to 200 C

This 4PDT relay has demonstrated the following characteristics under test: operates in an ambient temperature of +200 C; withstands 55 g shock for 11 msec; withstands 25 g vibration to 2000 cps, and has a contact bounce of less than 250 μsec. The relay uses bifurcated contacts to improve contact reliability and current carrying capacity. A gold alloy is used for contact material for both low level and high level loads.

Union Switch & Signal, Div. of Westinghouse Air Brake Co., Dept. ED, Swissvale, Pa.

CIRCLE 135 ON READER-SERVICE CARD

Klystron

Low voltage X-band operation

Model SRX-92 provides low voltage operation over the 8.5-10.5 kmc band. Designed for low hysteresis and high thermal stability, applications include use as a local oscillator in microwave receivers and spectrum analyzers, signal source in radar test sets, and as a low power oscillator for microwave bench work. Using electrode voltages under 300 v, the SRX-92 produces 20 mw minimum output. Minimum bandwidth of electronic modes is 35 mc. The entire 2000 mc frequency range is covered in five turns of the tuner. Height is 3-1/8 in., weight 4-1/2 oz.

Sperry Gyroscope Co., Electronic Tube Div., Dept. ED, Great Neck, N.Y.

CIRCLE 136 ON READER-SERVICE CARD

The Lapp porcelain rod insulator shown at the top of the illustration develops 12,000 lb. strength, and is suitable for the most severe electrical and mechanical duty. It is available with rain shield and/or corona rings. All hardware is silicon aluminum alloy. Smaller insulators, in porcelain or steatite, are suited to lighter duty for strain or spreader use. Lapp engineering and production facilities are always ready for design and manufacture of units to almost any performance specification. Write for Bulletin 301, with complete description and specification data. Lapp Insulator Co., Inc., Radio Specialties Division, 105 Sumner Street, LeRoy, N. Y.

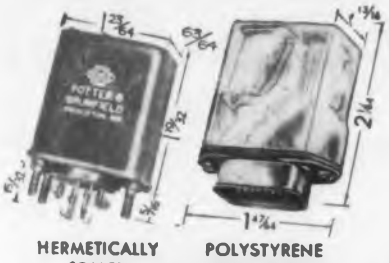
CIRCLE 137 ON READER-SERVICE CARD

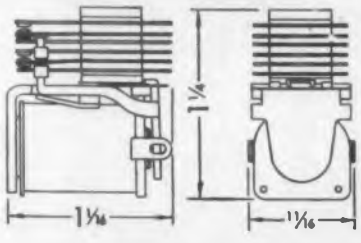
MINIATURE TELEPHONE TYPE RELAY HAS SUPERIOR SHOCK/VIBRATION RESISTANCE

Unusual for a telephone type relay, the MG Series has excellent stability under high shock and vibration conditions. Tests show this miniature, light weight (only 1.2 oz., open) relay withstands vibration of 10g 55 to 500 cycles per second and will operate under shock to 30g according to Mil-R-5757C.

The superior performance of the MG is due in part to its unique single stack construction and to an exclusive hinge design which provides zero heel gap.

Open, dust covered or hermetically sealed, the MG is available with contact arrangements up to 4 Form C (4PDT). It is rated for ambient temperatures of −55°C to +85°C. A high-temperature version with a range of −65°C to +125°C will soon be available. Write or wire today for complete specifications and delivery information.





MG RELAY

TERMINALS:
Open Relays: Pierced Solder Lugs.
Contacts: Two #18 AWG wires. Coil: Two #20 AWG wires.
Hermetically Sealed:
Miniature plug-in header with 7, 9 or 14 pins. Multiple Solder header with hook end terminals for three #20 AWG wires.
Polystyrene Dust Cover: Micro Ribbon plug-in type.
Mating receptacle: Amphenol #57-20140 or similar.
INSULATION RESISTANCE: 100 megohms min.
VIBRATION: .065" excursion 10-55 cps. 10g 55-550 cps. upon request.
SHOCK: 30g according to Mil-R-5757C upon request.
TEMPERATURE RANGE: −55°C to +85°C.
WEIGHT: 1.2 ozs. (open) 2.0 ozs. (sealed).
PULL-IN SPEED: Approximately 15 ms at nominal voltage.
DROP-OUT SPEED: Approximately 10 ms at nominal voltage.
CONTACTS: 3/32 silver.
CONTACT ARRANGEMENT: 4 pole, double throw (4 Form C).
COIL POWER: 3 watts max. DC @ 25°C. Continuous duty.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC, ELECTRICAL AND REFRIGERATION DISTRIBUTORS

Potter & Brumfield, inc.

PRINCETON, INDIANA

SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

CIRCLE 138 ON READER-SERVICE CARD

NEW PRODUCTS

Compression-Mounted

Simply pressed into chassis hole

This Teflon miniature tube socket requires no mounting hardware thus saving space and assembly time. The socket is pressed into a single chassis hole, slightly smaller than the Teflon body of the socket.

United States Gasket Co., Fluorocarbon Products Inc. Div., Camden, N. J.

CIRCLE 139 ON READER-SERVICE CARD

Digital VTVM Line

Accurate rack-mounted instruments

This rack-mounted digital vtvm line can be used by unskilled personnel to provide a wide range of ac and dc voltage and resistance readings for production, incoming inspection, and quality control purposes. The instruments have a direct reading 3-digit display with an illuminated decimal point.

Hycon Electronic, Inc., Dept. ED, 321 S. Arroyo Parkway, Pasadena, Calif.

CIRCLE 140 ON READER-SERVICE CARD

Timing and Recording System

Measures missile flight-times

The Model 5710-41 timing and recording system was designed to measure and record the travel time of a missile between points on its trajectory. The pulses generated by movements of the missile are sent to two single and two dual channel time interval meters (TIM's) where they are counted and registered as digital data. A 100 kc crystal-controlled oscillator furnishes the clock pulses used to measure the time intervals.

A digital scanner scans the counters of all the TIM's and sends the information to a printer.

The scanner contains the scanning switches for all the counters, two stepping switches to provide identification numbers, and reset circuitry for the entire system. Each time the system is reset and a new series of data is sent through the TIM's, the stepping switches will step one decimal number, starting with 01 through 00, so that time intervals of 100 different missiles can be identified.

The eight chassis required for the system are housed in one six-foot high cabinet. The system operates on 117 volts ±10 per cent, 60 cps power.

Beckman Instruments, Inc., Systems Div., Dept. ED, 325 N. Muller Ave., Anaheim, Calif.

CIRCLE 143 ON READER-SERVICE CARD

Magnet Wire

Diameters down to 50 AWG

Miniature diameters down to 50 AWG are featured in these film insulated magnet wires. Thermester-L magnet wire has a maximum operating temperature of 155 C, and good electrical and mechanical properties. Also available in the same gauges is Temprite (Teflon) magnet wire. Temprite has a temperature range as high as 250 C, and exhibits low dielectric constant and power factor.

Hitemp Wires, Inc., Dept. ED, Westbury, N.Y.

CIRCLE 144 ON READER-SERVICE CARD

Noise Source

Gas type for shf measurements

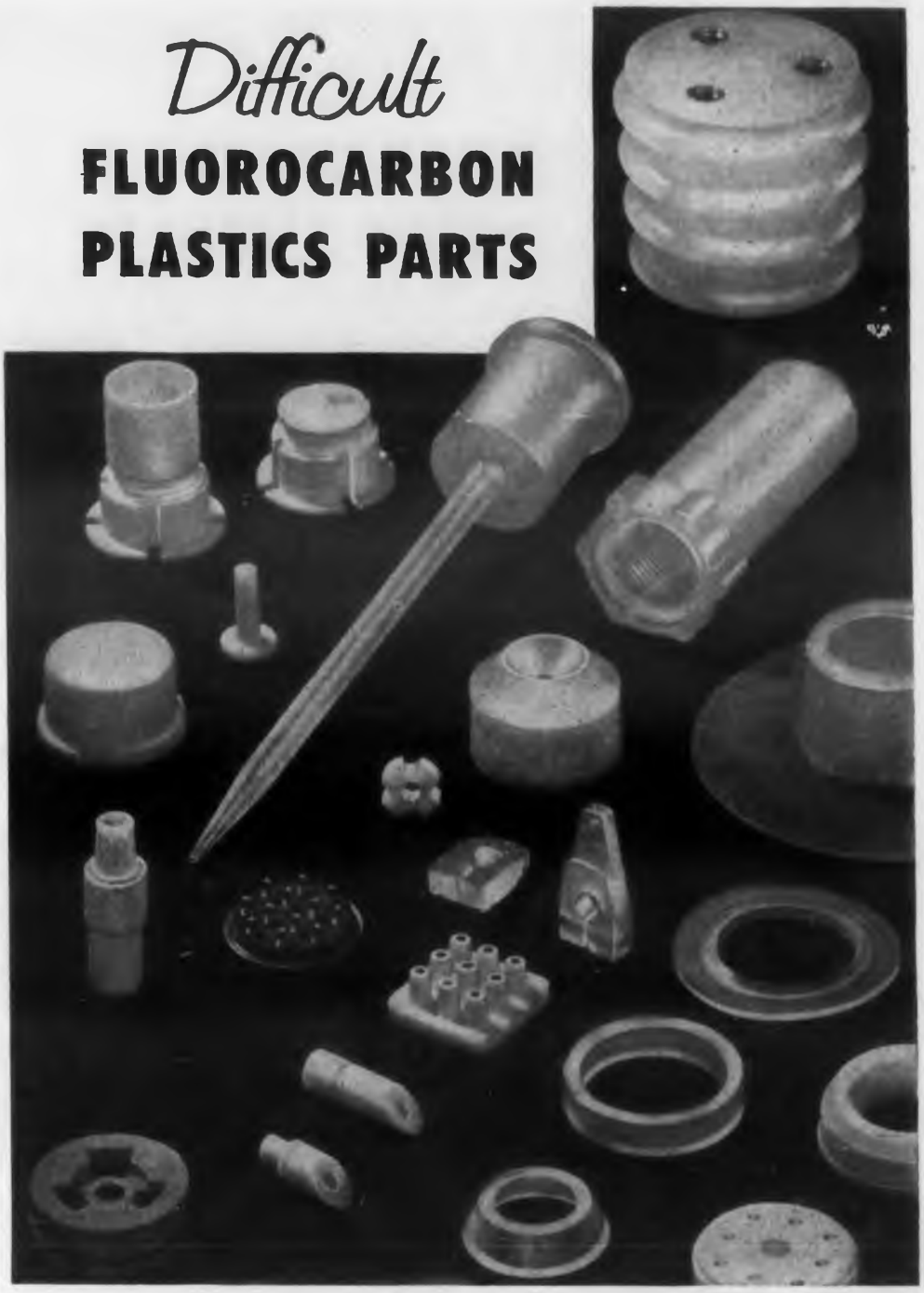
Type TD-22 gas tube is designed for use as a noise source in shf measurements. It is constructed for use with a 90 deg H-plane mount in RG/48U waveguide to provide noise in the 7.6-11.5 cm waveband. When used in the suggested mount assembly it functions essentially as an untuned noise generator over the recommended transmission bandwidth of the mount.

Typical applications for the tube are: radio receiver calibration; radiometer; micro-wave radio relay; radio telescope reference; and as a noise measurement standard.

Bendix Aviation Corp., Red Bank Div., Dept. ED, Eatontown, N.J.

CIRCLE 145 ON READER-SERVICE CARD

Difficult FLUOROCARBON PLASTICS PARTS



■ Gain greater design freedom without penalty in production costs.

Send us your difficult TEFLON* and KEL-F† part problems for quotations. Intricate shapes, inserts, thin sections, molding around metallic structures, threaded parts, precision tolerances—all are routine to U.S.G. production.

Unmatched experience and facilities for cold molding and sintering, injection molding and high speed machining—guarantee the best parts made by the right methods and at the right price, when you come to the pioneers and world leaders in fluorocarbon plastics fabrication.

du Pont Trademark

†*M.M.&M. Trademark*

For prompt service, contact one of The Garlock Packing Company's 30 sales offices and warehouses throughout the U.S. and Canada, or write

United States Gasket Company
Camden 1, New Jersey

United States Gasket *Plastics Division of* **GARLOCK**

CIRCLE 146 ON READER-SERVICE CARD

This typical application of the Hupp "Data-Tab", lighted by 2,300 G-E 2-pin lamps, posts wheat prices. It can easily be adapted to deliver practically any message—instantly.

WHEAT PRICES, TEAM SCORES OR TRAIN SCHEDULES, G-E 2-PIN LAMPS CAN ANNOUNCE THEM ALL!

Actual size

By arranging more than 2,300 tiny G-E 2-pin lamps in rectangular patterns, or modules, and then flashing combinations of the lamps, Hupp Electronics Company's* new data tabulator can spell out any message—instantly! Designed for push-pull sockets, G-E 2-pin lamps are used because they're so easy to install and maintain. Simplified construction of lamps and socket takes less space.

For many applications, the G-E 2-pin lamp offers special advantages. It weighs about half as much as conventional lamps with the metal base. You get positive electrical contact, and because there's no solder to soften, G-E 2-pin lamps give good performance up to 600°F.

Two-pin lamps "live" longer because there's no glass bead needed to hold the heavy-duty lead-in wires. (This means no resonant frequency differential that helps break filaments in other lamps.) Discover how they can give your products improved design and operation—and more sales appeal. For further information on G-E 2-pin lamps write: General Electric Co., Miniature Lamp Dept. ED-48, Nela Park, Cleveland 12, Ohio.

**743 Circle Avenue, Forest Park, Illinois.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

CIRCLE 147 ON READER-SERVICE CARD

NEW PRODUCTS

Frequency Meter

Direct reading from 5100 to 5900 mc

A direct-reading meter, Type 590-A allows quick determination and reading of frequencies between 5100 and 5900 mc. The unit consists of a mode cavity resonator tuned by a non-contacting plunger whose position is variable along the axis of the cavity. The reaction-type meter insures a symmetrical dip over the entire frequency range and therefore eliminates ambiguities.

Polytechnic Research & Development Co. Inc., Dept. ED, 202 Tillary St., Brooklyn, N. Y.

CIRCLE 148 ON READER-SERVICE CARD

Counter-Timer

In-line readout of counts up to 1 mc

Model 1031 Counter-Timer measures frequency to 1 mc, time and period in 1 μsec increments, phase angles in 0.1 deg increments, events to 7 digits, and ratio of 2 frequencies. Features include in-line indication and the use of beam switching tubes for the counting decades.

Systron Corp., Dept. ED, 2055 Concord Blvd., Concord, Calif.

CIRCLE 149 ON READER-SERVICE CARD

Pressure Switch

With 0.5 psi accuracy from −85 to +200 F

Designed to hold ±0.5 psi accuracy from −85 to +200 F, model RR-30 pressure switch comes in nominal pressure settings from 5-1/2 psia to

23-1/2 psia and has a 2 psi differential between On and Off. A design feature is that the switch will not chatter at the operating points and meets applicable sections of MIL-E-5272A. The switch may be used under 1000 cps, 7 g vibration. Weight, 2 oz; 2-7/32 in. long x 1-5/32 in. od; 28 v dc, 100 v ac, 5 amp, non-inductive, spst or spdt.

Newark Controls Co., Dept. ED, 15 Ward St., Bloomfield, N.J.

CIRCLE 152 ON READER-SERVICE CARD

Rate Switch

Has external adjustment for flexibility

Since this rate switch is externally adjustable, it is possible to stock units and set them for the desired rate as projects require them. Typical ranges supplied are 1 to 10 deg per sec, 5 to 50 deg per sec, and 10 to 500 deg per sec. Model no. RSO3-0101-1, now in production, has a rate range from 10 to 200 deg per sec, and a natural frequency greater than 30 cps.

Humphrey, Inc., Dept. ED, 2805 Canon St., San Diego, Calif.

CIRCLE 153 ON READER-SERVICE CARD

Spectrometer

Has highly regulated power supply

Model C-2910, spectrometer is designed to count only those pulses lying within a selected channel defined by front panel controls, and can provide from 750 to 2000 volts with a regulation of 0.01 per cent of the ac line voltage. Maximum counting rate is 10,000 counts per sec. Five different ranges are provided for both count rate and integral methods of operation.

NRD Instrument Co., Dept. ED, 9842 Manchester, St. Louis 19, Mo.

CIRCLE 154 ON READER-SERVICE CARD

NEW All-American!

Spir-O-line®

SEMI-FLEXIBLE ALUMINUM TRANSMISSION LINE

Compressed and profiled high strength 100°C polyethylene or 250°C teflon dielectric structure providing the highest transmission efficiencies for any impedance desired.

UNIQUE! ADVANTAGES of SOLID and AIR DIELECTRIC LINE COMBINED by Prodelin

in revolutionary All-Aluminum Cable and Connector

*Spir-O-line** — Prodelin's latest contribution to air-dielectric transmission — combines the low loss of air dielectric with the high power of solid dielectric lines by using dielectric tubes compressed and profiled into a symmetrical supporting structure. *Spir-O-line* is available in continuous lengths up to 1000' with reliably low VSWR and 50, 70, 75 ohm, and other impedances; the 50 ohm line usable up to these cut-off frequencies: ⅜" - 15.0 Kmc; ½" - 10.0 Kmc; ⅞" - 5.0 Kmc; 1⅝" - 2.8 Kmc; 3⅛" - 1.5 Kmc. The normally non-corroding aluminum-alloy outer conductor is available with a non-contaminating polyethylene jacket for caustic environments.

FEATURES

- No special techniques or tools required to make up cable-connector assembly
- No metallic welds or dielectric splices are used regardless of cable length
- Continuous high-conductivity aluminum sheath assures maximum pressure tightness and weather protection
- Uniform straight lay tubular support throughout keeps inner conductor smoothly centered on bends
- Pressure-tight and high tensile cable-connector assembly can be made with only hand-tightening
- Dielectric structure makes continuous and intimate line contact with both conductors without spiraling — yielding best broadband performance, highest power handling capacity, lowest attenuations, and VSWR smoothness
- Both cable and connector available for —90°C to +250°C operation
- Terminates in standard EIA (RETMA) dimensions

PLUS

Spir-O-line Connector

Amazing Prodelin development! Adequately pressure-tight for lab use when hand-tightened . . . ready for field service when wrench-tightened. Specifically designed for use with soft aluminum tubing to provide highest tensile strengths without tube distortion. No special techniques, bulky fixtures, or non-standard tools required. *May be used again and again without redressing tubing or replacing connector parts!* Saves time and money! RETMA dimensioned.

Specify Spir-O-line HI-TEMP with Teflon for 250°C operation

ANTENNAS and TRANSMISSION LINES

Prodelin Inc

KEARNY, NEW JERSEY, U.S.A.

Reconsider your cable requirements now and ask how Spir-O-line can provide new life with added economies in your service! WRITE FOR TECHNICAL BULLETIN TODAY

DEPT. ED-4, 307 BERGEN AVE., KEARNY, N. J.

*PATENTS PENDING

See us at the NAB Show Apr. 26 - May 1
Room 2234, Hotel Biltmore, Los Angeles, California

CIRCLE 156 ON READER-SERVICE CARD

NEW PRODUCTS

Silicon Rectifiers

Range of 1500 to 16,000 v at 150 C

This line of high voltage cartridge type silicon rectifiers has a voltage range from 1500 to 16,000 v at temperatures to 150 C. The 18 types in the line meet or exceed EIA specifications for the 1N1133 to 1N149 series. The units are ruggedized with all connections between component diodes bonded within a high impact sealed sleeve. The units are stated to be vibration-safe and shock-resistant as a result of the junction bonding method of assembly.

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

CIRCLE 157 ON READER-SERVICE CARD

Temperature Bridge

Reads directly in centigrade

Essentially a Wheatstone bridge designed to read temperature change directly in deg C, Model TB101-5 may be calibrated to operate with resistors of platinum, nickel, copper, or other materials having a linear resistance vs temperature characteristics.

Dynamic Development Co., Dept. ED, 59 New York Ave., Westbury, N.Y.

CIRCLE 158 ON READER-SERVICE CARD

D.C. Amplifier

Features low drift

Chopper stabilized dc amplifier model 512 features low drift of ±2 μv, and a noise level of

μv. The amplifier unit is coupled to a separate power supply, allowing a single power supply to be used with six channels of amplification in one 19-in. rack. Input impedance is 100,000 ohms; linearity, better than 0.1 per cent; frequency response, dc to 10 kc; gain, 0-1000 in ten steps; size with single-channel power unit, 6-1/2 in. high, 17/8 in. wide, 19 in. deep.

Allegany Instrument Co., Inc., Dept. ED, 1091 Hills Mountain, Cumberland, Md.

CIRCLE 160 ON READER-SERVICE CARD

Angular Position Encoders

Easily adapted to analog instruments

Designed for converting positional analog data into digital form, series 31 can be readily fitted to most instruments from which analog data is available. These encoders are constructed of a glass fiber insulation disc with segmented conducting tracks and a set of pick-up brushes. The encoder disc is mounted on a hollow shaft which can be slipped on and coupled rigidly to the instrument to be digitized.

Wang Labs., Inc., Dept. ED, 37 Hurley St., Cambridge 41, Mass.

CIRCLE 161 ON READER-SERVICE CARD

Radar Pulse Program

For target simulation

Model RP175 radar pulse programmer realistically simulates radar target characteristics over a range of 30 nautical miles at velocities from 0 to 5000 fps. It will accelerate target speed at constant accelerations up to 30 g. It may be externally triggered or operated internally over a pulse range of 400 to 2000 pps. Pulse width is adjustable from 0.2 to 1.0 μsec. Target pulse may be mixed with radar i-f noise and amplitude modulated up to 1000 cps.

Kittleson Co., Dept. ED, 416 N. La Brea Ave., Los Angeles 36, Calif.

CIRCLE 162 ON READER-SERVICE CARD

Nonlinear ACEPOT shown actual size.

ACEPOT®

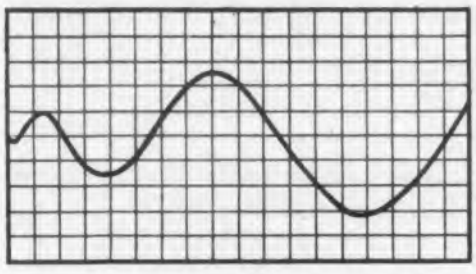
PRECISION, WIRE-WOUND

NONLINEAR POTENTIOMETERS

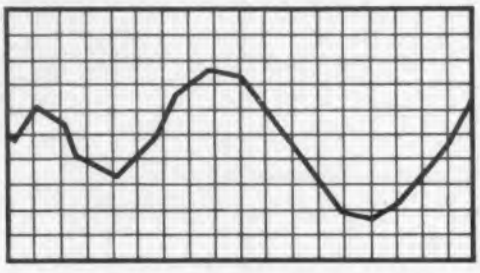
0.25% terminal conformity *without padding resistors*

A potentiometer without padding resistors produces a smooth output function curve as opposed to a stepped function curve when padding resistors are used. With the addition of padding resistors there is also a corresponding decrease in reliability and accuracy since each padding adds a pair of critical tap-offs to the delicate wire windings.

ACEPOT nonlinear potentiometers have terminal conformity to 0.25% without padding resistors. Desired output function is achieved by use of unique winding equipment of microscopic accuracy plus newly developed manufacturing techniques for precision, miniaturized parts. Dependability is guaranteed with ACE quality control. A tabulation of check points showing voltage ratio versus rotation is supplied for each unit.



ACEPOT WITHOUT PADDING RESISTORS achieves output function within 0.25% with *smooth* curve that follows application requirements exactly.



SAME FUNCTION WITH PADDING RESISTORS follows *stepped* curve which impairs accuracy and introduces "tap-offs" that decrease reliability.

To meet the exact requirements for your particular applications, ACEPOTS can be custom designed and mass produced with short lead time. ACEPOTS in AIA sizes are immediately available in sine, cosine, square law and logarithmic functions that meet applicable sections of MIL specs. Call, wire or teletype Dept. G at ACE ELECTRONICS ASSOCIATES, INC., 99 Dover Street, Somerville, Mass. SOmerset 6-5130. TWX SMVL 181.

ACEPOT®
ACETRIM®
ACESET®
ACEOHM®

ACE ELECTRONICS ASSOCIATES, INC.

CIRCLE 164 ON READER-SERVICE CARD

NEW PRODUCTS

DC Power Supply

High regulation of 25 ma load

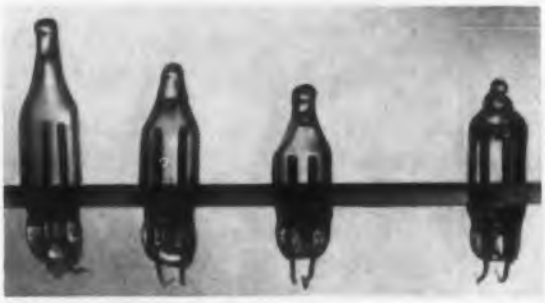
A 0.006 per cent regulation of a 0 to 25 ma load is provided by the model 218A dc power supply. The unit provides 175 to 3500 v at 0 to 25 ma. Voltage is adjusted with a 10-turn potentiometer and is resettable to $\pm 1/2$ per cent. Line regulation is 0.003 per cent and full load regulation is 0.006 per cent of full scale. Drift specification is 0.1 v or 0.01 per cent (whichever is greater) per hr and 0.02 per cent for eight hours. Ripple voltage is less than 20 mv pk to pk. Also available with similar voltage and operating characteristics are 50 ma, 100 ma and 150 ma supplies.

Alfred Electronics, Dept. ED, 897 Commercial St., Palo Alto, Calif.

CIRCLE 165 ON READER-SERVICE CARD

Glow Lamps

Longer electrodes for better performance



Designated as the NE-2E, the glow lamp shown on the right is expected to replace the NE-2, NE-2A, and the NE-2B glow lamps in indicator light applications. The NE-2E features the better performance of the 1-1/16 in. long NE-2, while having the shorter 3/4-in. overall length of the NE-2B. The molded tip construction permits the use of longer electrodes for better end-on and side viewing, and the uniformly centered tip offers improved appearance both lighted and unlighted. The new lamp can be used effectively in all applications where NE-2 and NE-2A glow lamps are now being used.

General Electric, Dept. ED, Cleveland 12, Ohio.

CIRCLE 166 ON READER-SERVICE CARD

Potentiometer Series

Ratings to 5 w

Available in power ratings of .5, 2.5, 3.5, and 5 w, all six types of this series of potentiometers are designed to operate within an ambient temperature range from −55 to +125 C. Life expectancy is given as 2,000,000 revolutions. The potentiometers have all-aluminum cases, and are manufactured in AIA sizes to close standard resistance and linearity tolerances.

Osborne Electronic Corp., Dept. ED, 712 S. E. Hawthorne Blvd, Portland, Ore.

CIRCLE 168 ON READER-SERVICE CARD

Bi-Directional Counter

Provides algebraic sum of input pulses

Model 7108 Digi-tally totalizes positive or negative pulses from computer systems or similar equipment, and provides a visual as well as electrical readout with either potentiometers or contacts opposite each number wheel. This mechanical counter provides continuous voltage outputs from each number wheel proportional to the number indicated in the counter window. Potentiometer output from each wheel gives a convenient means of telemetering digital data for controller recording. Size is 1.75 x 3 x 3 in.

The Digitran Co., Dept. ED, 45 West Union St., Pasadena, Calif.

CIRCLE 169 ON READER-SERVICE CARD

CIRCLE 170 ON READER-SERVICE CARD ➤

to lap the servo field

Fast getaway wins at 200°C

Beckman Rotating Components shade the field in the first heat . . . or any heat up to 200°C . . . by accelerating, braking and reversing, instantly and precisely. Stall them, even at full wattage input. Then step on the gas. They'll rev up to full power immediately. Stock models are: Servomotor and Servomotor Rate Generator . . . available in sizes 8, 11, 15 and 18 Inertia Damped Servomotor . . . and Velocity Damped Servomotor in sizes 8, 11 and 15

Beckman Inertia-Damped Servomotors are modified to produce the mechanical equivalent of an AC notching filter network. Consistently cool performers, they are inherently stable and insensitive to carrier frequency variations, thereby stabilizing the servo system.

For all the facts about Beckman Rotating Components, cut down for quick reading, write for data file 43C.

Beckman® Helipot

1250

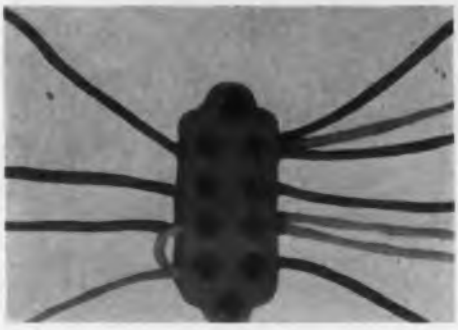
Helipot Corporation
Newport Beach, California
a division of
Beckman Instruments, Inc.
Engineering representatives in principal cities

CIRCLE 171 ON READER-SERVICE CARD

NEW PRODUCTS

Terminal Block

Wires are quickly inserted, locked firmly



This terminal block saves production expense by eliminating the need for lugs, soldering, or screws. Employing a patented V cam action, a quarter turn opens the block for insertion of wire and a reverse quarter turn locks it into place. The harder the wire is pulled, the tigher it becomes. Each station can hold three No. 14 wires.

Willor Mfg. Corp., Dept. ED, 825 Bronx River Drive, Bronx 72, N.Y.

CIRCLE 172 ON READER-SERVICE CARD

Recorder

Multi-range 5-in. strip type

This 5-in. strip chart recorder is available with a variety of ranges by means of plug-in resistors, for thermocouple, resistance bulb and linear millivolt spans. Chart speeds are from 1 in. per hr to 2 in per sec. Total panel space required is 9-5/8 in. wide by 8-1/2 in. high.

Westronics Incorporated, Dept. ED, 3605 McCart St., Fort Worth, Texas.

CIRCLE 173 ON READER-SERVICE CARD

Synchro Test Set

Easily operated

Featuring a complete test of all synchro and resolver parameters in five minutes by an un-

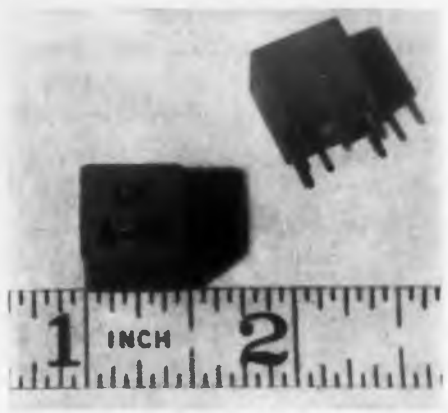
killed operator, this equipment tests parameters such as electrical error, total null, fundamental null, input current, phase shift, and transformation ratio to an accuracy of at least one tenth of the allowable synchro and resolver tolerance. Types of units tested, CX, CT, CDX, and resolvers, size of units, 8 through 37; error method used in proportional voltage bridges testing at 5 deg intervals; transformation ratio range, 0 through infinity; phase shift range through 360 deg.

Theta Instrument Corp., Dept. ED, 48 Pine St., Paterson, N.J.

CIRCLE 175 ON READER-SERVICE CARD

Magnetic Shift Register

Miniature size



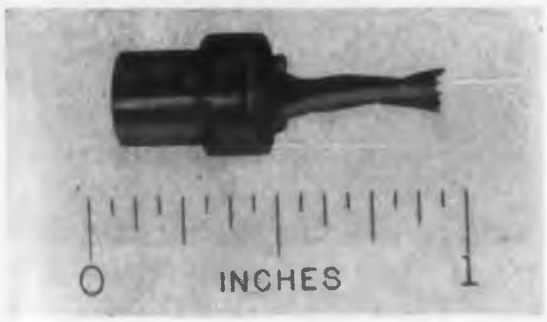
Measuring 1/2 inch on each side, the A-66 magnetic shift registers can be obtained in production quantities. The units range from 0 to 5 kc, and feature low peak power and wide tolerance on the width and amplitude of the advance pulse.

C K Components Inc., Dept. ED, 101 Morse St., Newton 58, Mass.

CIRCLE 176 ON READER-SERVICE CARD

Pressure Transducer

Miniature unit measuring 1/2 in. long



The P222 flush diaphragm pressure transducer has a diameter of 0.25 in., measures 0.47 in. long and weighs three grams.

The unit employs the company's unbounded strain gage principle, which consists of resistance wire in the form of a complete bridge. In this unit, the bridge has a nominal resistance of 200 ohms.

Statham Instruments, Inc., Dept. ED, 12401 W. Olympic Blvd., Los Angeles 64, Calif.

CIRCLE 177 ON READER-SERVICE CARD

NEW PRODUCTS

Variable Load

Permits constant current to be drawn from a powe supply over a wide voltage range

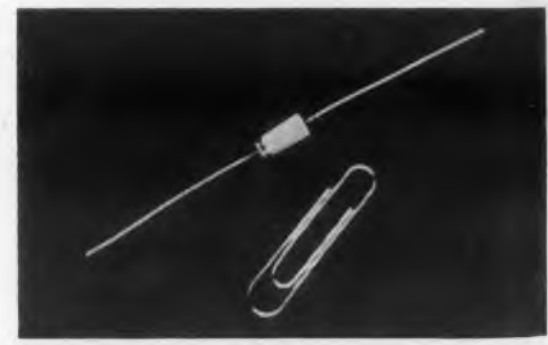
For the precise testing of power supplie model 910B is essentially a vacuum tube loa The impedance of the load may be varied to pr from 0-600 ma for any voltage in the range 0-600 v by varying the grid bias of the tub For any particular setting of load current, t grids of the vacuum tube load are controlled b an amplifier which maintains the current draw from the power supply under test, essentiall constant over the entire voltage range of 0-600

Kepco Labs., Inc., Dept. ED, 131-38 Sanfo Ave., Flushing 55, N.Y.

CIRCLE 180 ON READER-SERVICE CARD

Copper Oxide Diode

For low voltage applications



Model CX7A1H copper oxide diode is for u in low voltage, low current applications. The u is insulated by nylon tube housing, 3/8-in. lo by 3/16-in. od, through which the leads are i serted. Specifications for instrument use are: cu rent rating of 2 ma continuous duty, ac inp 6 v rms max, peak inverse of 8-1/2 v max. F other applications, the current value can be i creased 5 times and voltage value doubled. Ma mum temperature rating is 85 C.

Bradley Labs., Inc., Dept. ED, New Have Conn.

CIRCLE 181 ON READER-SERVICE CARD

Printed Circuit Relay

Measures 3/4-in. square

The LR-1301 relay, for printed circuit mounting, has palladium inlay contacts to assure good contact in dry circuit switching. Coil resistances up to 10 K can be had in either treated or un-treated coils. The terminal mounting block can be furnished in either glass epoxy, glass silicone, or phenolic. Overall dimensions are 3/4 in. square by 7/8 in. high; weight, 13 grams.

American Monarch Corp., American Electronics Div., Dept. ED, 11 N.E. Lowry Ave., Minneapolis, Minn.

CIRCLE 182 ON READER-SERVICE CARD

Servo-Amplifier

Operates in both 400 and 60 cps systems

Operating equally well in 400 cps and 60 cps systems, the SA101 servo amplifier is designed primarily for general experimental work in instrument servomechanisms. Several popular servomotor types may be driven from the appropriate output tap points. Approximately zero phase-shift, low output impedance, high gain, and exceptionally low noise are other features.

Dynamic Development Co., Dept. ED, 59 New York Ave., Westbury, N.Y.

CIRCLE 183 ON READER-SERVICE CARD

CIRCLE 184 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Hysteresis Motors

Incorporates virtues of an induction motor

The Hyspersyn synchronous motor combines the characteristics of an induction motor and a salient pole dc excited synchronous motor with the smooth torque of the Hysteresis motor.

Starting with the vigorous torque of an induction motor and using ceramic permanent magnets for synchronous operation, the motor has a 90 per cent efficiency and a good damping against step loads. The torque angle is quite stiff and not influenced by line voltage variations.

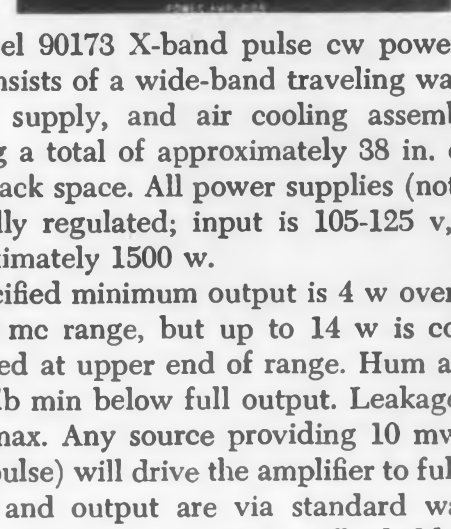
An Hyspersyn can be built in sizes from 1/10 to 1 hp, for all frequencies, voltages, phases and speeds.

Bekey Electric Co., Inc., Dept. ED, Los Angeles, Calif.

CIRCLE 186 ON READER-SERVICE CARD

X-Band Power Amplifier

10 watts, 8 to 10 kmc



Model 90173 X-band pulse cw power amplifier consists of a wide-band traveling wave tube, power supply, and air cooling assemblies requiring a total of approximately 38 in. of 19 in. relay rack space. All power supplies (not shown) are fully regulated; input is 105-125 v, 60 cps, approximately 1500 w.

Specified minimum output is 4 w over 8000 to 10,000 mc range, but up to 14 w is commonly obtained at upper end of range. Hum and noise is 30 db min below full output. Leakage is −90 dbm max. Any source providing 10 mw (cw or peak pulse) will drive the amplifier to full output. Input and output are via standard waveguide flanges. Full twt protection is afforded by special thermal and electrical overload circuits.

Applications include testing of antennas, filters, attenuators; the power rating of small components; and the simulation of jamming signals. Optional features include calibrated output attenuator, ferrite modulator with less than one msec rise/decay times, video and power monitoring, and others.

Resdel Engineering Corp., Dept. ED, 330 S. Fair Oaks Ave., Pasadena, Calif.

CIRCLE 187 ON READER-SERVICE CARD

Variable Toroid

Completely encapsulated versions offered

This variable toroid is equivalent lectrically to the type AT-11 and T-12 Ajustoroids; however, the roid is completely hermetically ealed as there is no physical con- ct between the adjusting screw nd the toroid itself. Stepless ad- stment of inductance over a 10 er cent range is provided and rque adjustment is such as to reclude possible strain on printed rcuit mounting. Weighing ap- roximately one-half an ounce, the nits are designated models ATE- 1 and ATE-12.

Burnell & Co., Inc., Dept. ED, 0 Pelham Pkwy., Pelham, N.Y.

CIRCLE 188 ON READER-SERVICE CARD

Switch Light

Control panel assembly

This switch has a 1 x 1 in. lens ith two independent light circuits. nits now in production are red nd green, but can be supplied in ny two colors. Similar units are ade incorporating any prescribed umber of independent light cir- uits. The light is evenly distrib- ted over the entire lens surface.

Switch-Lock, Inc., Dept. ED, 31 Vineland Ave., North Holly- ood, Calif.

CIRCLE 189 ON READER-SERVICE CARD

CIRCLE 190 ON READER-SERVICE CARD ➤

X *and* C band

RADAR TEST SET

in one complete unit!

Now... *one compact test unit* to check radar system performance in both "X" Band (8.5 KMC to 10. KMC) and "C" Band (5.2 KMC to 5.9 KMC). Identical with standard "single band" models except unique stacking arrangement permits "X-C" Band testing from *one unit*. Provides *all four* master functions: *Spectrum Analyser*, *Power Monitor*, *Signal Generator* and *Direct Reading Frequency Meter*. Ideal for service organizations and manufacturers working with *both* "X" and "C" Band systems. Price $6,250.00.

OTHER KEARFOTT *products include: Printed Circuit Strip-Line Assemblies, Ferrite Isolators and Duplexers in a wide range of sizes and band widths with facilities to produce special configurations if desired. Our engineers are at your service.*

Kearfott

GENERAL PRECISION EQUIPMENT CORPORATION GPE

KEARFOTT COMPANY, INC.
MICROWAVE DIVISION
DEPT. 10D, 14844 OXNARD ST.
VAN NUYS, CALIF.

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Clifton N. J.

Midwest Office:
23 W. Calendar Avenue
La Grange, Ill.

South Central Office:
6211 Denton Drive
Dallas, Texas

Northwest Area Office:
530 University Avenue
Palo Alto, California

CIRCLE 191 ON READER-SERVICE CARD

NEW PRODUCTS

PHOTOTRANSISTOR.—For use in readout systems, the 2N469 is an improved version of the type 2N318 phototransistor, being smaller and having greater optical sensitivity. The device is a head-on pnp type.

General Transistor Corp., Dept. ED, Jamaica, N.Y.

CIRCLE 192 ON READER-SERVICE CARD

COAXIAL ADAPTERS.—More compact and more modern in design than previous units, these waveguide to coaxial adapters have a vswr of less than 1.25.

Narda Microwave Corp., Dept. ED, Mineola, N. Y.

CIRCLE 193 ON READER-SERVICE CARD

RADIATION SOURCE.—The Gammalab, a portable cobalt irradiation unit, stands less than two ft high and holds 62 curies of cobalt-60.

Radiation Applications Inc., Dept. ED, 342 Madison Ave., New York, N.Y.

CIRCLE 194 ON READER-SERVICE CARD

CONTACT SOCKET.—The molded neoprene insert and the gasket are one integral part, providing a completely sealed and pressurized type of receptacle.

Whitney Blake Co., Dept. ED, New Haven 14, Conn.

CIRCLE 195 ON READER-SERVICE CARD

VINYL TUBING.—Used for applications requiring a clear, low temperature tubing, No. 3022 is fungus resistant, flame retardant, with no discoloration.

Minnesota Mining & Mfg. Co., Irvington Div., Dept. ED, Irvington, N.J.

CIRCLE 196 ON READER-SERVICE CARD

TOGGLE SWITCH.—Extremely small in size, this environment-proof momentary action unit can be converted to a maintained contact switch by means of a built-in solenoid.

Microswitch, Div. of Minneapolis-Honeywell Regulator Co., Dept. ED, Freeport, Ill.

CIRCLE 197 ON READER-SERVICE CARD

RADIOGRAPHY UNIT.—Designed for industrial use, MG 100 provides sharp radiographic detail and is powerful enough for tasks involving steel welds and opaque materials.

Philips Electronics, Inc., Instruments Div., Dept. ED, 750 S. Fulton Ave., Mount Vernon, N.Y.

CIRCLE 198 ON READER-SERVICE CARD

FIBERGLASS PULLEY.—A larger, self-lubricating pulley for fhp motors with 1/2 in. and 3/8 in. V-belt drives.

Rampe Mfg. Co., Dept. ED, 14915 Woodworth Ave., Cleveland 10, Ohio.

CIRCLE 199 ON READER-SERVICE CARD

VOMS.—Types 630-Pl and 630-APL have been added to the company's line of VOMs. The models stress easier reading and feature instant accurate vision of longer, wider spread scales.

Triplett Electrical Instrument Co., Dept. ED, Bluffton, Ohio.

CIRCLE 202 ON READER-SERVICE CARD

PUNCH PRESS CONTROL.—Designed to protect against damage to presses and dies, the unit is equipped with an indicating pointer activated by a current transformer. Control action is initiated when the press is overloaded.

Tipptronic, Inc., Dept. ED, Chagrin Falls, Ohio.

CIRCLE 203 ON READER-SERVICE CARD

FILM-TAPE HEAD.—Used in synchronous recordings employing film as the medium, Model 204 is primarily designed for high impedance systems in the range of 1-1/2 to 2 h.

Lipps Engineering, Dept. ED, 1511 Colorado Ave., Santa Monica, Calif.

CIRCLE 204 ON READER-SERVICE CARD

PASSIVE REFLECTOR.—Permitting control from remote location, this unit is practical and reliable, and can be driven in azimuth and elevation under load conditions.

The Gabriel Co., Gabriel Electronics Div., Dept. ED, 135 Crescent Road, Needham Heights 94, Mass.

CIRCLE 205 ON READER-SERVICE CARD

POTENTIOMETERS.—These nonlinear, precision, wire-wound Acepots are designed with terminal conformity to 0.25 per cent without padding resistors.

Ace Electronics Associates, Inc., Dept. ED, 99 Dover St., Somerville, Mass.

CIRCLE 206 ON READER-SERVICE CARD

GAS ANALYZER.—Model 7C is designed for continuous monitoring of one constituent in a variety of combination gases, and utilizes ultra sensitive thermal conductivity filaments as detecting elements.

Beckman/Process Instruments Div., Dept. ED, 2500 Fullerton Rd., Fullerton, Calif.

CIRCLE 207 ON READER-SERVICE CARD

O AND V RINGS.—Featuring square, round, and oval cross-sections, these Teflon rings are limited to a maximum od of 15/16 in., 3/4 in. id. Some are as small as 3/32 in. od.

Tri-Point Plastics, Inc., Dept. ED, 175 I.U. Willets Rd., Albertson, N.Y.

CIRCLE 208 ON READER-SERVICE CARD

CONTACT TAPES.—Silver-cadmium oxide clad electrical contact material, formed as a continuous coil of tape, makes possible automatic assembly providing savings in assembly costs.

Metals & Controls Corp., General Plate Div., Dept. ED, Attleboro, Mass.

CIRCLE 209 ON READER-SERVICE CARD

Key Openings for Electronics Engineers

Electronics activities are broad and fast-growing at Chance Vought. Projects involve advanced guidance and control and fire control systems for missiles and high-performance manned aircraft. They begin with investigations and theory and progress through systemization and packaging to detailed hardware design. Key responsibilities await additional men who are qualified in these areas. Advanced degrees are preferred.

Stability and Control Engineer. E.E., M.E., or A.E. with emphasis on flight stability and control problems or dynamics. (Special consideration given graduate study or extensive experience in transients or closed loop stability analysis.) To assist in design of autopilot and control systems for high-performance missiles and aircraft.

Antenna Design Engineer. E.E. or Physics Degree with demonstrated aptitude for antenna design. To join active projects involving design of flush-mounted, recessed and external antennas at all frequencies for very high-performance aircraft and missiles.

Fire Control and Microwave Systems Engineer. Requires E.E. or Physics Degree; at least 2 years experience in radar, data link, or fire control systems; and strong ability in this work.

Test Equipment Engineer. Requires E.E. or Physics Degree and at least 2 years experience in this or related field. (Desirable: broad background in electronics design with emphasis on digital computers or microwave systems.) To join in the design of complete checkout systems for missiles and associated subsystems.

Guidance Design Engineer. E. E. or Physics Degree, plus 2 or more years experience. To design various active and self-contained missile guidance systems, and to design and develop radar beacons.

Reliability Analyst. Requires M.E., Physics, E.E., or Math Degree; broad knowledge of electronic and mechanical systems; experience in operations research or reliability. Helpful: statistical methods experience.

Electronic Packaging Engineer. M.E., E.E., or equivalent packaging design experience. To help design ground, airborne and shipboard electronic equipment for use in severe environments. Involves consideration of heat transfer, shock, vibration and other factors.

To arrange for a personal interview, or for more information on these or other current openings, return coupon to:

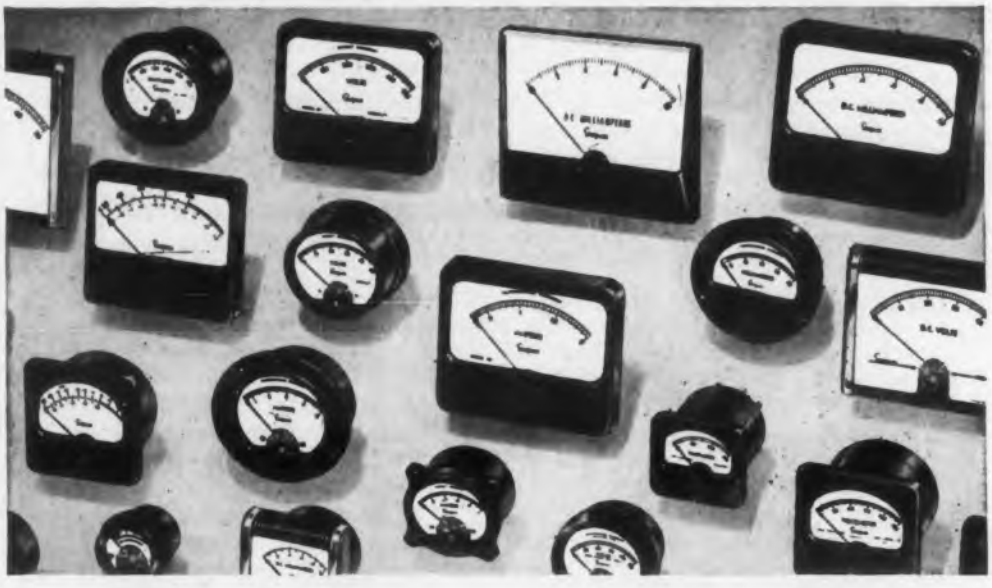
C. A. Besio
Supervisor, Engineering Personnel
CHANCE VOUGHT AIRCRAFT, Dept. W-1
Dallas, Texas

I am a_____ Engineer,
interested in the opening for_____
Name_____
Address_____
City_____ State_____

CIRCLE 559 ON READER-SERVICE CARD

Simpson

meters for every need...



Custom-built or Stock, Simpson Offers a Complete Line—To meet your special requirements, Simpson can build electrical panel meters in many combinations of size, range, type, and style. For units in small quantities, you can select from 60,000 stock models (over 900 sizes and types) available for *immediate delivery* through your Electronic Distributor. Many stock meters now have the *self shielded* Core Magnet Meter Movement which is not affected by stray magnetic fields.

These fine panel instruments are known throughout industry for their ruggedness and long-lived accuracy. Write today for Technical Manual No. 17 which describes them.

SIMPSON ELECTRIC COMPANY
5200 West Kinzie Street, Chicago 44, Illinois
Phone: EStebrook 9-1121
In Canada: Bach-Simpson Ltd., London, Ontario

instruments that stay accurate

CIRCLE 211 ON READER-SERVICE CARD

NEW MATERIALS

Microwave Absorbing Material

High Frequency Range

A microwave absorbing material, type AF20, has been made available for operation over high frequency ranges. AF20 is a light rigid material having a frequency range of 2500 to 70,000 mc with improved performance at high angles of incidence. Designed for permanent radar darkrooms for use in radar measurements and as temporary test bays, the material is a highly expanded polystyrene treated to give a specific attenuation. The material is supplied in rigid blocks, 15 in. sq and 4 in. thick.

Gulton Industries, Inc., Dept. ED, 212 Durham Ave., Metuchen, N.J.

CIRCLE 212 ON READER-SERVICE CARD

Urethane Potting

Solid and Cellular Types

Both solid and cellular type urethane has been announced for potting and encapsulation. Solid urethane potting compounds are characterized by high dielectric strength, low dielectric constant, and low moisture absorption. Corrosion resistance of this type is such that it can be employed in environments involving exposure to strong acids, alkalies, oils and gasoline, and aliphatic solvents. Cellular urethane potting is particularly useful where savings in weight are desired. This compound weighs about 2 lb per cu. ft. A second characteristic of the latter type is the short cure-time required.

Allied Chemical & Dye Corp., Dept. ED, 40 Rector St., New York, N.Y.

CIRCLE 213 ON READER-SERVICE CARD

Silicone Sponge

Close Tolerances

Two compounds, the first of which makes possible the production of silicone rubber sponge components to close tolerances, have been announced. Designed SE-546 and SE-547, both are usable from —120 to +500 F. SE-546 meets the requirements of AMS 3196 for firm, closed cell sponge; SE-547 the requirements of AMS 3195 for medium, closed cell sponge. Electrical, thermal, and physical properties permit their use in high temperatures for low pressure seals and the absorption of sound and shock.

General Electric, Silicone Products Dept., Dept. ED, Waterford, N.Y.

CIRCLE 214 ON READER-SERVICE CARD

Ferromagnetic Material

Unaffected by High Temperatures

Called Ferrotron, this ferromagnetic material is a powdered iron filled plastic. It has a constant permeability and high Q relatively unaffected by long time exposure to temperatures of 200 C, high relative humidities, or aging at high ambient temperature conditions. It has high impact strength and ductility and is machinable by conventional methods. In addition to rigid cores, it is available in flexible rod and tape.

The Polymer Corp. of Pennsylvania, Dept. ED, 2140 Fairmont Ave., Reading, Pa.

CIRCLE 217 ON READER-SERVICE CARD

Microwave Absorbents

Machined by conventional tools

Called Radite 75, this microwave absorbent material is obtainable in standard rod form or to specially molded shapes. Intended primarily for use is microwave circuitry, the material is rigid, moisture repellent and is worked with conventional machine tools. Applications include waveguide and coaxial matched terminations, spurious mode absorbers, microwave attenuators, and others.

Radar Design Corp., Syracuse Custom Div., Dept. ED, 2360 James St., Syracuse, N.Y.

CIRCLE 218 ON READER-SERVICE CARD

Magnet Wire

Two Improved Types

Daglas (Dacron-glass) insulated magnet wire is a smoother and tougher wire, for use at class B or higher temperatures where a positive inorganic spacing is desired. Another magnet wire, called Polyvar (polyurethane enamel) is a magnet wire that solders directly without insulation removal. Polyvar claims properties equal to those of Formvar for wire insulation, easy solderability, greater thermal stability, lower moisture absorption.

The Acme Wire Co., Dept. ED, 1255 Dixwell Ave., New Haven, Conn.

CIRCLE 219 ON READER-SERVICE CARD

45
TO
600
CPS

ROTRON

Dual Frequency
Without Switching

FANS AND BLOWERS

Specifically for instruments and test consoles which must operate on 50-60 cps in the lab and on aircraft 400 cps power supply. Continuous operation over a frequency range from 45-600 cps without the use of switching components or duplicate power connectors. Long operational life. Meets both military and federal specifications.

Model	Type	Capacitor MFD Series	Rated 220 vac	CFM 60 cps	400 cps	Total Net Pounds	Approximate Dimensions
DF	KRS-301	433A	0.25	28	41	1.1	3"x3"x3"
DFE	KRS-401	434A	0.5	82	102	1.7	4"x4"x3½"
DFE	KRS-4501	435A	1.0	115	160	2.7	4½"x4½"x5"
DRPP	KRS-1504	433A	0.25	9	14	1.2	3"x3"x3½"
DR	KRS-202	434A	0.5	20	25	1.7	4"x3½"x4"
DR	KRS-2501	435A	1.0	33	40	3.0	5"x4½"x5"

Write today for detailed technical information to . . .

ROTRON mfg. co., inc.

WOODSTOCK • NEW YORK

CIRCLE 220 ON READER-SERVICE CARD

New Subminiature

Modular Design *Precision* POTENTIOMETER

by

Type PVR-05 features:

- Extraordinary High Precision in ½ inch size.
- High Temperature Operation to +145°C.
- Low-torque, Ball-bearing Construction.
- Linear or Non-Linear Functions.
- Independent Linearity of ±0.3%.

New, modular design provides extreme flexibility in adapting or customizing the unit to the particular requirements of application. Depth of cup, mounting, resistance, linear or non-linear function are all variable as needed. Up to 9 cups may be ganged to the front servo cup without external clamp rings. Each cup may be individually phased at the factory.

The new PVR-05 provides the greatest precision in the industry for its ½ inch size. Gold alumilite finish, machined aluminum base and cover, precious metal contacts and slip rings, spring-loaded ball-bearings assembled under quality controlled procedures provide optimum performance characteristics.

Reliability is insured under severe environmental conditions of missile and airborne applications.

SPECIFICATIONS

Resistance Range:	50, 100, 200, 500, 1K, 2K, 5K, 10K, 20K.
Taps:	Maximum of 3 taps to specification.
Temp. Coeff. of Res. Wire:	0.002%/°C above 50 ohms.
Terminals:	Gold plated, forked lug type std., other types available.
Torque:	.1 in. oz. per cup.

Where space is at a premium and precision a must, PVR-05 is the answer.

Bulletin of full details on request.

TECHNOLOGY INSTRUMENT CORPORATION

555 Main St., Acton, Mass. COlonial 3-7711 • P.O. Box 3941 No. Hollywood, Calif. POplar 5-8620

CIRCLE 221 ON READER-SERVICE CARD

NEW MATERIALS

Epoxy Resins

For high temperatures

Three epoxy resins have been added to the Scotchcast brand line. Resin No. 250 is a two part, rigid unfilled electrical type for production run casting. No. 251 is a filled version of No. 250 for structural strength. No. 252 is formulated specifically for dipping applications. All three resins have an ASTM heat distortion point at 125 C and a weight loss after heat aging of 3.5 per cent after 1000 hours at 220 C. They have a dielectric strength of 525 v per mil (1/8 in. thickness) and a surface arc resistance of 77 sec. Water absorption for the three resins is 0.25 per cent after 240 hr at room temperature.

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

CIRCLE 222 ON READER-SERVICE CARD

Teflon Coated Wire

Thickness of 0.02 to 0.225 in.

Wire insulated with Teflon in wall-thickness from 0.02 to 0.225 in. is available in a broad range of sizes. Employing conventional granular Teflon, the coating process provides a high degree on concentricity, controlled tightness of coating to wire, and high density.

Chemplast, Inc., Dept. ED, 3 Central Avenue, East Newark, N.J.

CIRCLE 223 ON READER-SERVICE CARD

Flexible Etched Cable

Copper-clad glass supported Teflon

Glass-supported Teflon tape with copper foil bonded to one or both sides is available for use as etched flexible cable harnesses or as flexible connectors in multiple-array printed circuit stacks. The material can now be supplied on a developmental basis in lengths up to 30 ft and widths up to 6 in. The company expects within 30 or 60 days to manufacture it on a production basis in lengths of 100 ft or longer. In this material, electrolytic copper foil in weights of either 1 or 2 oz per sq ft is applied to one or both sides of cementable glass supported Teflon tape grades GB-108T, GB-116T, or GB-128T. Depending on the weight of copper foil and the Teflon tape grade, the over-all thicknesses run from 0.006 to 0.016 in.

Continental-Diamond Fibre Corp., Dept, ED, Newark 107, Del.

CIRCLE 224 ON READER-SERVICE CARD

Epoxy Preforms

Bind Dissimilar Metals

Epoxweld 100 is an unpolymerized epoxide sin available in pressed shapes allowing fabrictors to introduce a definite shape and amount the bonding material. As a bonding material, e material has the advantage of low melting int, quick cure cycle, and the ability to be apied at low temperatures without damaging mponents or finishes.

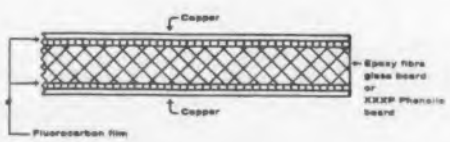
Typical applications include bonding metal rts to all types of ceramics, glass, quartz, and rrites; bonding tough-to-solder materials such aluminum, magnesium, zirconium, titanium, d stainless steel. Other uses include hermetic aling of components, fabrication of low cost rmetic seal headers, and immobilizing thin ire pigtail leads.

Technion Design & Mfg. Co., Inc., Duramic oducts Div., Dept. ED, 262-72 Mott St., New rk 12, N.Y.

CIRCLE 226 ON READER-SERVICE CARD

Printed Circuit Laminate

High Band Strength



Fluoroply laminate Type F for printed circuits ovides high bond strengths of copper foil to astic base without the use of adhesives. The orocarbon plastic base eliminates the problems water absorption and humidity surface leakage. mong the electrical properties are high surface d volume resistivities, high dielectric strength d good high frequency characteristics. Fluoroly can be cold-punched, drilled or machined.

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

CIRCLE 227 ON READER-SERVICE CARD

Modified Selenium Glass

Transmits 25 μ Infrared

Type 80-20 arsenic modified selenium glass ansmits infrared radiation to 25 μ and permits mmersion of infrared detectors to boost overll sensitivity. With a refractive index of 2.45 lus, the material acts as an effective IR focusg element when infrared detectors are adhered the glass to form an infrared optical system.

Eastman Kodak Co., Dept. ED, Apparatus and ptical Div., Rochester 4, N.Y.

CIRCLE 228 ON READER-SERVICE CARD

NEW MATERIALS

High Voltage Laminate

Exceeds values of XXXP phenolic types

A plastic laminate which combines excellent electrical characteristics with flame and arc resistance has been developed. Designated Insurok grade XT-901, electrical characteristics of the material exceed the published NEMA values for XXXP phenolic laminates. The material is suited for high voltage applications such as flyback transformer terminal boards. Low cold flow provides retention of spacing in riveted assemblies, such as jack spacers and relays. Wear and abrasion resistance coupled with high arc resistance make possible applications involving sliding contacts. Other features include low water absorption and low edge and center expansion.

The Richardson Co., Dept. ED, Melrose Park, Ill.

CIRCLE 232 ON READER-SERVICE CARD

Adhesive

For Transducer Applications

Ceramad M-50, an organic-inorganic blend, has several applications, but in its present formulation was engineered specifically as an adhesive for fibrous-glass to stainless steel for transducer application. Modifications can be made for sealants or coatings to withstand 700 F for 100 hr.

L. H. Butcher Co., Chemical Div., Dept. ED, 3628 E. Olympic Blvd., Los Angeles 23, Calif.

CIRCLE 233 ON READER-SERVICE CARD

Silicone Varnish

Coats and bonds class H materials

Developed especially for coating and bonding class H insulation components, type R-610 silicone exhibits retention of flexibility and retains 90 per cent of its original dielectric strength after seven days exposure at 275 C. Low viscosity accounts for two of the varnish's outstanding properties: penetration and wettability. Type R-610 silicone varnish can be used to bond mica splittings in many mica tape combinations, including: glass backing on one side, glass backing on both sides, or glass backing on one side with Mylar film backing on the other. R-610 can also be used to coat glass cloth on conventional coating towers. The high solids, low viscosity characteristics make it easy to saturate or wick through fibrous materials as asbestos or glass paper.

Union Carbide Corp., Silicones Div., Dept. ED, 30 E. 42nd St., New York 17, N.Y.

CIRCLE 234 ON READER-SERVICE CARD

Epoxy Compounds

Require no hardeners or mixing

These single package fluid thermosetting epoxy compounds do not require either the addition of hardeners or other mixing. They eliminate the inclusion of air bubbles in mixing and the hazard of working with toxic hardeners. The compounds are cured by application of heat and have a long shelf life.

Ellanar Chemical Co., Dept. ED, 2308 Oakton St., Evanston, Ill.

CIRCLE 236 ON READER-SERVICE CARD

Tantalum

High Purity for Capacitor Use

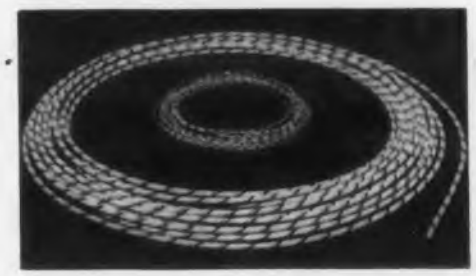
Bars, sheets, foil, and wire made from high purity tantalum have been made available in production volume particularly for use in capacitors. In addition to these forms, tantalum metal granules of the same purity are also available.

Kennametal, Inc., Dept. ED, Latrobe, Pa.

CIRCLE 237 ON READER-SERVICE CARD

Teflon Tape

With Color Stripes



This striped Teflon tape, available in widths of 1/4 to 1 in. can be provided in any specified color. Uniformity of the laminated stripes is precisely controlled. The tape is currently being used as a wire insulating material which is applied to the wire in one operation.

Bonny Mfg. Corp., Dept. ED, 339 Auburn St., Auburndale 66, Mass.

CIRCLE 238 ON READER-SERVICE CARD

Plastic Laminates

Flame-retardant types

Comprising nine different grades of varying characteristics, this line of laminates combines flame-retardant properties with the other qualities inherent in laminated plastics. Included in the line are the paper-base phenolic resin laminates, glass-mat polyester resin laminates, and glass-base epoxy resin laminates.

Continental-Diamond Fibre Corp., Dept. ED, Newark, Del.

CIRCLE 239 ON READER-SERVICE CARD

NEW LITERATURE

Electronic Cooling

A 4-page brochure covers a line of custom air conditioning units for trailer and airborne electronic systems. The folder contains photographs and drawings and a table of specifications. Application and other data are presented. Ellis and Watts Products, Inc., P.O. Box 33, Cincinnati, Ohio.

Precision Ball Bearings

A 12-page booklet, "Ball Bearing Yield and System Isoelasticity," is now available. The booklet is designed to assist users in the application of precision instrument bearings. It offers comprehensive background data on radial and axial play, axial take-up and pre-loading, as well as isoelastic bearings and achievement of system isoelasticity. The Barden Corp., Danbury, Conn.

Molding Compounds

A paper-bound, 40-page catalog describing Thermaflow reinforced polyester molding compounds is now available. The catalog suggests that these compounds can replace metals and other plastics in many applications. It features detailed data sheets on each of seven compounds. Characteristics such as form and shelf life are given, as well as the physical, chemical, mechanical, heat, and flame resistant properties of the molded part under certain procedures. A selector chart facilitates selection of the proper compound for given end use conditions. Other sections instruct on the storage and handling of the compounds, and offer suggestions on design selection and design. Atlas Powder Co., Chemicals Div., Wilmington 99, Del.

ELECTRONIC DESIGN Article Index

Reprints of ELECTRONIC DESIGN's Index of Articles for July 1 through December 15, 19[illegible] are ready. A short summary accompanies each title and articles are categorized in a subject cross reference. The 8-page booklets are 8-1/2 by 11 inches. ELECTRONIC DESIGN, 830 Third Ave., New York 22, N.Y.

Silicone Dielectrics

A 12-page, illustrated brochure has been published, outlining the properties of silicones as dielectric materials. The report also discusses the use of silicone rubbers, fluids, resins, and compounds in applications ranging from motor insulation to electronic systems. Dow Corning Corp., Midland, Mich.

ectrothermal Heat-by-the-Yard 247

Electrical heating tapes that can be cut with ssors are described in a 6-page bulletin. Illus- ted and pocket size, the folder explains how e tapes are used with glass and metal equip- ent. Arthur S. LaPine & Co., 6001 S. Knox Ave., hicago 29, Ill.

958 Technical Convention Guide

Technical meetings—over 250 of them—are ronologically listed in the 1958 "Engineering d Technical Conventions." Compiled by eutsch & Shea, Inc., the list gives the time and ace of national, state, and regional conven- ns from Feb. 1 through Dec. 31, 1958. Spon- ring organizations are arranged alphabetically a separate list along with persons to whom quests for information should be directed. A pplement will be issued in the fall to cover eetings from September through January for hich information was not available at press me. *The price for the guide and the supple- ent is $3.00. They may be obtained from Indus- al Relations News, Inc., Dept. ED, 230 W. st St., New York 36, N.Y.*

wer Supplies 248

A file drawer folder, 12 pages, containing cata- sheets on a standard line of regulated labor- ry power supplies, giving specifications, mensions, and other characteristics has been ued. The folder contains power supply re- irement sheets to facilitate setting down on per complete and vital information in ordering ecial power supply units. Trans Electronics, c., 7349 Canoga Ave., Canoga Park, Calif.

ils and Transformers 280

Catalog No. 5811 contains 56 pages and in- des technical and non-technical cross-refer- ces and illustrations listing more than 900 items the company line.

The catalog contains six cross-indexed sections voted to horizontal output flybacks, power nsformers, chokes, i-f transformers and coils, kes, audio transformers and rf transformers, ils and chokes. Each section features a table exact replacement by manufacturer's part mber, the company's part number and sug- ted list price, and each item is illustrated for ntification alongside a simplified schematic awing with specifications and applications.

Large cutaway illustrations of each type of oduct identify all of its features and point out physical and electrical characteristics. Merit il & Transformer Corp., 4427 N. Clark St., hicago 40, Ill.

NEW LITERATURE

Potentiometer Data Sheet 253

Data Sheet 54-15 concerns a 3-turn precision potentiometer with a total resistance range from 100 to 195,000 ohms. Its 4 pages show standard specifications and special modifications. Standard coil information, dimensional drawings, and a photograph are included. Helipot Corp., Newport Beach, Calif.

PC Laminates 254

A set of catalog pages on thermosetting laminated-plastic sheets for printed-circuits and similar uses may be had in a loose-leaf notebook. The catalog has a complete materials list for quick identification of each product by NEMA grade, resin and base, and significant characteristics. It also contains technical data and prices for epoxy-glass, epoxy-paper cold-punching phenolic-paper, and other laminates. The sheets may also be ordered separately. New England Laminates Co., Inc., 481 Canal St., Stamford, Conn.

Rectifiers Derating Curve 255

Bulletin Sheet No. 257, giving high temperature derating curves of vacuum-processed, high current density, selenium rectifiers has been issued. The data supplements the specifications in Bulletin 248A. Having an estimated life of 100,000 hours and low forward voltage drop these rectifiers are much smaller than conventional cells of comparable ratings. Radio Receptor Co., Inc., Brooklyn, N. Y.

Toggle Switch 256

This is a data sheet describing an environment-proof momentary action toggle switch which can be converted to a maintained contact switch by means of a built-in solenoid. A photograph, dimension drawing, electrical data, and price information are included to give the main features of the switch. Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Crystal Filters 257

A two-color, four-page brochure outlining a product line of stock and special miniaturized quartz crystal filters is available. The report includes technical data, typical, and representative curves of crystal filters. The brochure is entitled XT-455. Burnell & Co., Inc., 10 Pelham Parkway, Pelham Manor, N. Y.

6

Slip Ring Assemblies 259

Over 50 slip rings, brushes, commutators, and drums are pictured in this six-page brochure. The nine methods of manufacturing these units are disclosed along with the different materials and end uses of the product. Each slip ring is described in detail. Slip Ring Company of America, 3612 West Jefferson Blvd., Los Angeles 16, Calif.

Time Delay Relays 260

Bulletin No. 1357, a four-page, illustrated brochure describes a line of electronic time delay relays. These relays are of subminiature design and employ transistor circuits. All moving parts except relay contacts have been eliminated. The brochure includes a complete description of the units' electronic and mechanical design, along with performance curves for voltage and temperature variation tests. Also included are detailed specifications, mounting styles and dimensions, typical applications, and ordering information. Tempo Instrument, Inc., 240 Old Country Road, Hicksville, N.Y.

Facilities 261

Details of the company's design, engineering, and manufacturing facilities are set forth in this 46-page, 6-color brochure. The bulletin shows electro-mechanical and electronic products and systems in the fields of power supplies, actuators, blowers, timing devices, and inverters as used in the manufacture of aircraft and missiles. U.S. Industries, Inc., Western Design & Mfg. Corp. Div., Santa Barbara Airport, Goleta, Calif.

Level Controls 262

"Level and Control Systems" is a 16-page booklet about techniques and equipment for measuring and controlling level. With pictures, it covers applications of capacitance-type devices in quantitative measurement and control of granular solids, liquids, powders, and interface. Robertshaw-Fulton Controls Co., Instrument Div., 2920 N. 4th St., Philadelphia 33, Pa.

Heat Dissipating Lubricant 263

Bulletin PP102-3-1-57 describes a dry lubricant finish for heat-dissipating tube shields. The characteristics, applications, and effectiveness of the finish, as well as its protective qualities, salt spray and corrosion resistance, and heat radiation and electrical conduction properties are included in the bulletin. International Electronic Research Corp., 145 W. Magnolia Blvd., Burbank, Calif.

NEW LITERATURE

Cap and Set Screws 267

Microsize socket head cap and set screws with self-locking feature are subjects of this bulletin.

This four-page, illustrated literature shows in text and drawings how a resilient nylon pellet, seated into the threaded portion of the tiny fasteners, presses against the mating thread of a tapped hole or nut to prevent the loosening caused by shock and vibration. In addition to describing how the insert increases frictional gripping power of the tiny fasteners, the bulletin reviews design and processing features which result in an increase of as much as 80 per cent in tensile strength of these fasteners. Standard Pressed Steel Co., Box 202, Jenkintown, Pa.

Semiconductor Rectifiers 268

Bulletin GEA-6375A, containing 12 illustrated pages, discusses silicon and germanium power rectifiers for use in electrochemical processes, aluminum and copper production, electroplating, anodizing, and steel process lines. It explains how high efficiency conversion can be obtained at relatively low cost with semiconductor rectifiers. Features and applications of water-cooled and air-cooled designs are also included in the bulletin. General Electric Co., Schnectady 5, N.Y.

Facilities 274

A facilities brochure for engineering, research, design and production of electronic and electromechanical products and assemblies is now made available. This brochure outlines resources, physical facilities, experience and reputation for quality of service and production in the electronics field. It gives an illustrated description of facilities from laboratory to final assembly and testing, and illustrated examples of typical products, both technical and commercial. Gray Mfg. Co., Industrial Div., 16 Arbor St., Hartford, Conn.

Thermocouple Systems 275

Catalog G100-8 describes a line of thermocouple accessories for measuring temperature. This issue includes new Meg-O-Pak assemblies and new insulated extension wire. The illustrated catalog is divided into eight sections: general information; base metal thermocouples; small mass, sensitive thermocouples; noble metal thermocouples; special purpose thermocouples; mounting attachments; thermocouple components; and charts, inks, and quantity discounts. Minneapolis Honeywell Regulator Co., Industrial Div., Wayne and Windrim Avenues, Philadelphia 44, Pa.

Industrial Heating Units 276

Catalog 27-620 describes strip heaters, oven heaters, immersion heaters, bolt heaters, industrial hot plates, and other heating equipment. Called "Industrial Electric Heating Units and Devices," the 24-page illustrated booklet also covers a line of compatible heater control equipment. With the aid of charts and graphs, it discusses heating problems and solutions. Westinghouse Electric Corp., P.O. Box 2099, Pittsburgh 30, Pa.

Gamma Rays 277

A 6-page technical report, "Production of Gamma Radiation with a Linear Electron Accelerator," is offered free. Written by Malcolm H. MacGregor, the paper discusses the generation of gamma rays for experimental measurement of radiation effect and for commercial radiation processing. It summarizes the properties of gamma ray beams and gives the information necessary to calculate shielding requirements. It also covers the neutron intensities obtainable when gamma radiation is used to produce neutrons. Designated AM-100, the report is accompanied by nine full-page graphs. Applied Radiation Corp., Walnut Creek, Calif.

Television tube being sprayed with "dag" colloidal graphite. For exterior use the graphite is dispersed in lacquer, providing a smooth, black, adherent, conductive coating on any type of glass.

Copper oxide rectifier discs being painted with "Aquadag," a colloidal graphite. The dispersion fills the cavities in the relatively rough, crystalline surface, producing a smooth surface with large contact area.

Colloidal Graphite

Has Many Applications in Electronic Equipment Design

BECAUSE high-purity, electric-furnace graphite can be processed down to colloidal size and dispersed in a variety of fluid carriers, it has many applications in electronic component and instrument manufacture.

In Vacuum Tubes

By coating the envelope of a vacuum tube and connecting the coating to grid potential, surface charge effects are avoided.

Graphite is ideal as electrode material for light-sensitive selenium-tellurium phototubes since it is non-metallic and does not react with selenium to form selenides. Colloidal graphite has a marked physical affinity for cesium and, therefore, finds application in photocells and half-wave rectifiers made of this material. In the production of some tubes, baking at high temperatures to remove excessive cesium is avoided by inclusion of a metal plate coated with colloidal graphite. The surplus cesium is adsorbed by the graphite coating. In multiplier phototubes, colloidal graphite is used to form an electrostatic shield to offset the inherent sensitivity of these tubes to stray fields.

A conductive coating on thin-window geiger tubes is used to avoid field distortion, and, in glass geiger tubes, colloidal graphite is used for the cathodes. In a Mueller-type projection tube, halation was minimized by reducing the optical contact of the phosphor with the glass by use of relatively large phosphor crystals. By coating the glass-air surface with a colloidal suspension of graphite in glycerine, internal reflection of light was minimized.

Colloidal graphite is employed in vacuum-tube manufacture to increase thermal radiation as well as for decreasing secondary emission, "back" emission, and other undesirable photoelectric effects. The ideal form of graphite for this purpose is an adherent dry film produced by applying dispersions of colloidal electric-furnace graphite. Excellent thermal-radiation properties of graphite help keep grids cool enough to prevent undesired primary emission. The low photoelectric properties of graphite render properly coated parts practically free from the effects of such electro-magnetic radiations as light, X-rays, etc. Applied to grids (and frequently to plates) of thermionic tubes, a graphite coating offers protection from the impact of primary particles since it is resistant to electron bombardment. This greatly reduces or entirely eliminates emission of secondary electrons.

On Cathode-Ray Tubes

Special dispersions of colloidal graphite in ion-free water are applied to the inside surfaces of cathode-ray tubes. These graphite films serve as ray-focusing anode materials to prevent stray electrons from reflecting back into the electron beam and distorting the image. A dispersion of colloidal graphite in lacquer is often sprayed onto the outside of a TV picture tube to produce

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a smooth, black, adherent, conductive coating on any type of glass. The film thus applied resists scratching and is not loosened by immersion in water.

In Meter Design

Windows in low-torque instrument meters are made conductive and protected from the accumulation of static charges by thin, buffed films formed from diluted colloidal graphite. As a conductive coating on very thin windows of ionization chambers and radiation detection instruments, colloidal graphite avoids distortion of the electrical field in the ionization chamber. Another interesting application is in a bolometer. When heat radiation falls on a thin sheet of cellophane painted on each side with a colloidal graphite dispersion, the electrical conductivity measured through the sheet changes sufficiently so that the coating can be used as the sensitive element in the bolometer.

For Nuclear Targets

While investigating nuclear reactions, Indiana University made use of a 22 Mev external alpha particle beam. To obtain carbon targets, an atomizer was used to spray a thin suspension of "Aquadag" in alcohol onto a very thin backing foil. A fairly uniform film of surface density (about 0.1 *mg/cm²*) was produced in this manner and served satisfactorily as a target.

Other Uses

Since cuprous oxide used in copper-oxide rectifiers produces a relatively rough, crystalline finish, it is advantageous to paint colloidal graphite on the oxide to fill the cavities between crystals and produce a smooth surface with a large contact area.

Graphite films (colloidal graphite dispersed in water or alcohol) are used as shields in TV cabinets, hearing-aid cases, and tape-recorder cases. For the "atomic" battery, a dispersion of colloidal graphite in water was found to be suitable as the positive electrode in preference to gold, because graphite is beyond gold in the electromotive series. Colloidal graphite has been used to provide a conductive coating on the face of piezoelectric crystals. A dispersion of colloidal graphite in petroleum oil is used for lubricating automatic tuning mechanisms of radio receivers. Colloidal graphite is also used in the manufacture of deposited-carbon resistors and for high temperature tape resistors.

Acheson Colloids Co., Port Huron, Mich.

REPORT BRIEFS

Demodulation Systems

Four different methods of extracting the intelligence from an amplitude-modulated carrier in the presence of noise are analyzed on a mean-square error basis. Assumed is band-limited white gaussian noise and a noise-like modulating intelligence of uniform power spectrum ranging from dc to an upper limiting frequency equal to two-thirds of the carrier frequency. Included in the analysis are the square-law, autocorrelation, two-amplifiers, and crosscorrelation demodulator. *Mean-Square Error Analysis of Several Demodulation Systems, by Bruno F. Ludovici, Stanford University, Electronics Research Lab., Stanford, Calif., Jan., 1956, 54 pp, microfilm $3.60, photocopy $9.30. Order PB 125880 from Library of Congress, Washington 25, D.C.*

Magnetic Amplifier and Reactor Design

This report discusses the comments made by the Magnetic Research Corp. in their evaluation studies of the final engineering report on this contract. Studies were also conducted on the influence of series line resistor, use of four cores, and importance of a quality ratio upon the performance of half wave magnetic amplifiers. Various core materials and sizes were checked to specify a sensitivity factor utilized in a simplified design procedure for full-wave amplifiers. Simplified methods of design for half-wave amplifiers were also considered. *Design Methods for Magnetic Amplifiers and Able Reactors, James R. Walker and Max Frank, Wayne University, Wayne Engineering Research Institute, Detroit, Mich. May, 1957, 64 pp, diagrams, graphs, tables, $1.75. Order from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.*

Thermoelectric Effects in Halides

Measurements of the electrical conductivity and the thermoelectric power as a function of temperature in the range of 30 C to 300 C were made for silver chloride and silver bromide single crystals. Variations of these properties from past history were examined for annealed and quenched states. An appendix gives the details of a scale expander for a recording potentiometer used in this study. *Thermoelectric Effects in Silver Halides, Walter Grattidge, Massachusetts Institute of Technology. Research Lab of Electronics. May, 1954, 17 pp, diagrams, graphs, table, microfilm $2.40, photocopy $3.30. Order from Library of Congress, Washington 25, D. C.*

Network Synthesis

Although the investigation has not yielded a completely general solution of the problem, a powerful synthesis method has been developed by which the designer may obtain a network realization of a given immittance matrix provided such a realization exists. That is, even though one lacks a formal statement of the sufficient conditions on a thermal immitance matrix, one may proceed with the synthesis with the assurance that, if the terminal matrix has a network realization, it may be obtained by this synthesis method. *Synthesis of Multiterminal Two-Element-Kind Network, by F. S. Boxall, Stanford University, Electronics Research Lab., Stanford, Calif. Nov. 1955, 128 pp, microfilm $6.30, photocopy $19.80. Order PB 125070 from Library of Congress, Washington 25, D.C.*

Bibliography of Grid-Controlled Rectifiers

This bibliography was compiled after a search of the literature uncovered no comprehensive reference to grid-controlled rectifiers and their application in radio transmitters. Entries refer to literature published between 1923 and early 1957. Books, periodical articles, and unclassified research reports are included. References are listed chronologically by author. An author index and a subject index are also included. *Grid-Controlled Rectifiers: An Annotated Bibliography, M. Benton, Naval Research Lab. July, 1957, 95 pp, $2.75. Order PB 131126 from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

Theory of Switching

Contents: I. Tables for Irreducible Series, Parallel Networks, by Robert Ashenhurst and Gustav Tollett; II. Use of Indeterminate Binary Boolean Functions in the Synthesis of Single Impulse Switching Networks (Translation from the Czech); III. Chart for Unate Functions, by Warren Semon and Roderick Gould; IV. Switching Applications of Silicon Carbide Crystal Agglomerates, by Albert Hopkins; V. Properties of Some Special Classes of Subsets of the 2^n Argument Combinations of N Variables, by Chan Ping Yang; VI. Circuit Synthesis for Network Switching Functions, by Roderick Gould; VII. Method for the Synthesis of Minimal Series-Parallel Switching Circuits, by William Wright. *Theory of Switching, Bell Laboratories Report No. 13, Covering the Period 1 July-1 Nov., 1955, Harvard University, Computation Laboratory, Cambridge, Mass. Nov., 1955, 277 pp, microfilm $11.10, photocopy $42.60. Order PB 128023 from Library of Congress, Washington 25, D.C.*

REPORT BRIEFS

Accelerometer Signal Transistor Amplification

Transistor amplifier circuits are proposed to reduce microphonism, a serious problem when vacuum tube amplifiers are used in telemetering shock and vibration data with barium titanate accelerometers. The microphonic noise output caused by vibration of elements in the vacuum tube amplifier may, under some conditions, be as large as the output of the accelerometer. Reduction of microphonism was attempted through use of 2N77 transistors in the amplifier. Of three configurations analyzed, a grounded emitter with added emitter resistance appeared to give the best signal-to-noise ratio. The circuit did not meet specifications, however, because of low frequency noise (excess noise below 1 kc. The collector noise generator was the main noise source. Other circuits studied were a grounded emitter with added base resistance and a grounded collector stage. *Application of Transistors to Amplification of Barium Titanate Accelerometer Signals, by R. C. Carter, Diamond Ordnance Fuze Labs., Ordnance Corps, U.S. Army. Mar., 1956, 39 pp, $1.00. Order PB 131277 from OTS, U.S. Department of Commerce, Washington 25, D.C.*

Ultrasonics For Cleaning Precision Parts

Accessible soils of all kinds are shown to be easily removed from small precision parts by the ultrasonic systems studied. Inaccessible soils, such as steel particles in bearings and grease in blind holes, require high sonic intensities and a coupling fluid with optimum cavitating and solubility or dispersability properties for the particular soil. Low frequency systems appeared more effective than high frequency systems for removing most soils investigated. Those included greases, burnt-on carbon, lapping and buffing compounds, steel particles, and a synthetic soil. It was further observed that bearing damage resulting from ultrasonic treatment is insignificant for the short cleaning times normally required. Processes are recommended for cleaning precision parts and bearings. A coupling fluid—trichloroethylene—is shown to be best for removal of soils. The steel-removal and probe methods, two new processes for evaluating ultrasonic systems and factors, are described. *Investigation of the Applicability of High Frequency Sound Waves (Ultrasonics) for Cleaning of Precision Parts, by O. E. Mattiat and P. P. Zapponi, Clevite Research Center for Wright Air Development Center. June, 1957, 76 pp, $2.00. Order PB 131361 from OTS, U.S. Department of Commerce, Washington 25, D.C.*

Power Arcing Protection

Fault diverters, or crowbars, have proven very effective in protecting against transient-induced power arcs in oscillator tubes used at the University of California's Radiation Lab. The device short circuits the oscillator-plate power supply in the event of an over-current. Ignitrons, thyratrons, and triggered spark gaps are used for short circuiting. The power supply is protected from the short circuit either by a current-limiting device or a high-speed contactor which removes the system from the power lines. *The Fault Diverter—A Protective Device For High-Power Electron Tubes, B. H. Smith, Radiation Lab., University of Calif., for Atomic Energy Comm. Aug., 1957, 21 pp., $0.75. Order UCRL 3701 (Revised) from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

Printed Circuitry Research

Various methods of in-place fabrication of electronic circuits have been examined to find means of improvement and extension of the basic practice. Only materials which can yield circuits operative above 200 deg C are considered for use. The fabrication of condensers, resistors, and inductors as well as conductive lines and mounting means are included in evaluating the methods. The scope of fabricating means are not limited but particular attention is given to exploitation of xerographic techniques. *Performing Research on New Approaches to Printed Circuitry, Haloid Company. July, 1956, 22 pp, microfilm $2.70, photocopy $4.80. Order PB 126122 from Library of Congress, Washington 25, D.C.*

Satellite-Tracking System

A guide to construction of the Mark II Minitrack, the tracking system with which the Navy hopes to enlist the aid of many serious amateur radio groups in plotting the course of its Vanguard earth satellite, has been published. The volume describes two relatively inexpensive designs for the Mark II. One is a simple system which merely records passage of the satellite. A more complicated version contains tracking and data-recording modifications. The Mark II is based on the interferometer principle, which is discussed in the illustrated guide together with all other aspects of design, construction, and calibration of the system. *Project Vanguard Report No. w1, Minitrack Report No. 2—The Mark II Minitrack System, R. L. Easton, Naval Research Lab. Sept., 1957, 32 pp, $1.00. Order PB 131330 from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

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PATENTS

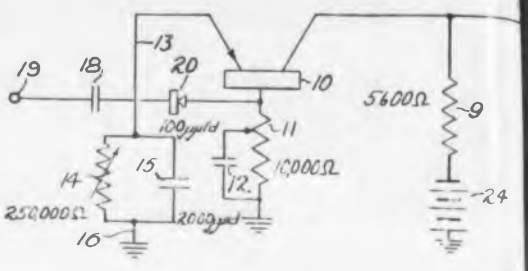
Transistor Pulse Delay Circuit

Patent No. 2,787,717. B. Kasmir. (Assigned to Emerson Radio and Phonograph Corp.)

The pulse delay circuit illustrated was designed to provide a device involving very simple circuitry and utilizing a single transistor. These variable delay circuits find many applications and the circuit of the figure is designed particularly as the delay circuit for a radio altimeter. In an altimeter, a pulse is sent from the aircraft which pulse is reflected and the time interval elapsed between transmission and return gives a factor from which the altitude of the aircraft may be determined.

In the normal operation of the circuit, a negative potential is applied to the collector of the transistor 10 from potential source 24. Current will then flow through the emitter circuit 13 which current charges the condenser 15. When the condenser has been charged to a potential below cut-off for the emitter, the emitter current ceases whereupon the condenser 15 discharges through the resistor 14. When the condenser has discharged to the potential at which the emitter electrode again becomes positive enough to again pass emitter current, the condenser 15 begins to recharge. A saw-tooth form of wave is thus generated in the emitter circuit. It is during the period of current flow in the emitter circuit that a pulse is generated in the collector circuit and appears at the output terminal 17. The pulses appearing in the output under the normal operation described are uniformly spaced and of uniform amplitude.

If now a trigger pulse such as a reflected pulse is applied at the terminal 19 and transmitted to the base through the condenser 18 and diode 20, a potential condition is established which again triggers current flow through the emitter circuit so that the condenser 15 again charges until its potential reaches emitter cut-off. The emitter current results in a pulse in the collector circuit and at the output. When the circuit is used in an altimeter, the received pulses operate a servo mechanism which adjusts the variable resistance 14 and alters the time delayed characteristic of the circuit so that the period of discharge of the capacitor is changed.

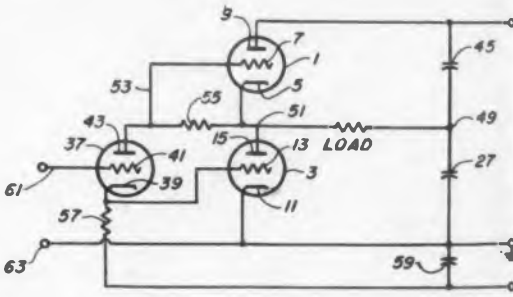


The patent points out that the time interval for the trigger pulses must be greater than the time interval of the saw tooth wave of the emitter circuit and must be less than twice this time interval. With the values shown on the figure the delayed pulse may be varied between 160 and 320 microseconds.

Magnetic Amplifier Circuits With Feedback

Patent No. 2,812,449. Richard W. Spencer and Theodore H. Bonn. (Assigned to Sperry Rand Corporation)

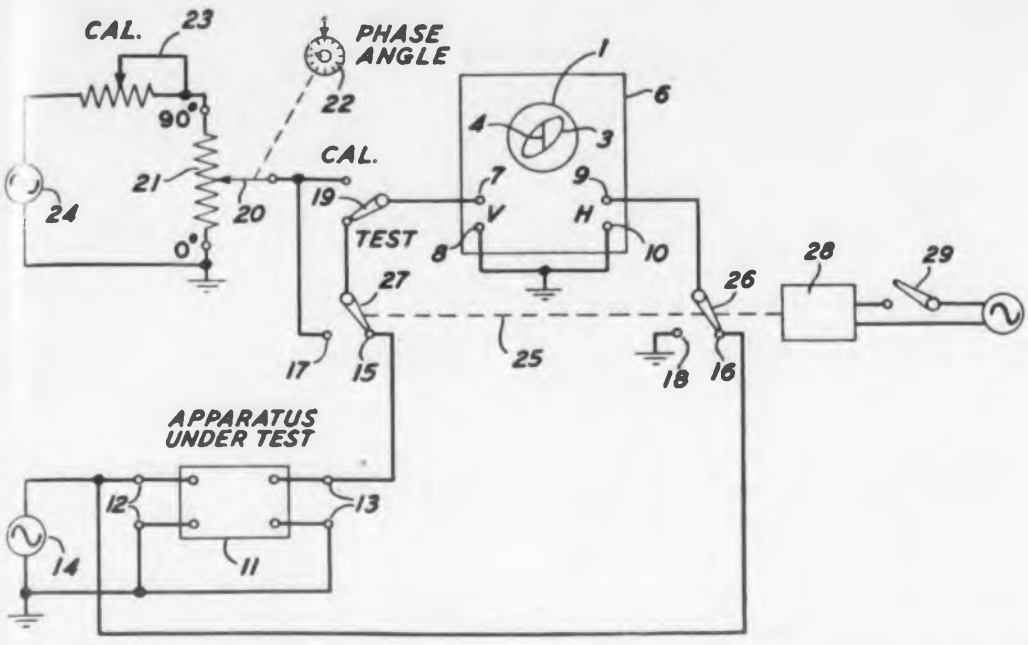
The amplifier uses one or more magnetic cores and a source of carrier potential. The source and core are coupled together to produce a flux in the core in response to the signal. A potential appears across a load impedance which is coupled to the core, in response to the signal. A feedback flux is produced in the core in opposition to flux produced in the core by the signal potential.



Phase Indicator

Patent No. 2,816,266. P. M. Nadolski. (Assigned to Bell Telephone Laboratories.)

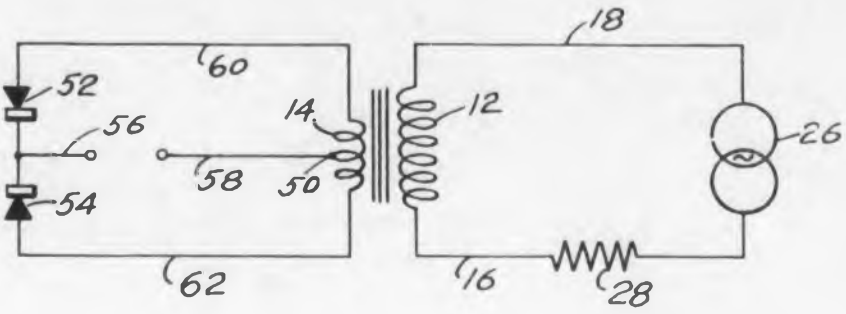
The phase angle between two voltages



the same frequency is measured by pidly switching the cathode ray tube display sequentially the elliptical Lisjous figure and a vertical line which st reaches the intercept points of the llipse on the vertical axis. The vertical ne is generated by an ac voltage from source which is calibrated in terms of hase angle. A mercury relay may be sed to switch the signals to a high perstence oscilloscope.

The ellipse is generated on the screen when relay *28* connects horizontal input *9* to contact *16* and vertical input *7* to contact *15*. A vertical line is displayed when relay *28* grounds horizontal input *9* and connects vertical input *7* to the calibrated a-c source *21*. The length of the line is varied by sliding contact *20* until the vertical line at either end just touches the ellipse. Phase angle is read on the calibrated dial.

PATENTS



Resistive Reactor

Patent No. 2,817,057. Hans E. Hollmann. (Granted under Title 35, U. S. Code (1952) sec. 266.)

A non-linear reactor is used to control currents over a wide frequency range where hysteresis phenomena of saturable reactors are at a disadvantage.

When the secondary winding of a transformer is loaded with a non-linear resistor, i.e., a crystal or vacuum diode, the non-linear resistance is transformed in the primary circuit making the reactor non-linear. The primary impedance may be controlled by introducing a control voltage into the secondary circuit and changes in the primary current appear as voltage variations across a load resistor inserted into the primary circuit. Since the voltage across this resistor is proportional to the transformer turns ratio high amplifications is possible.

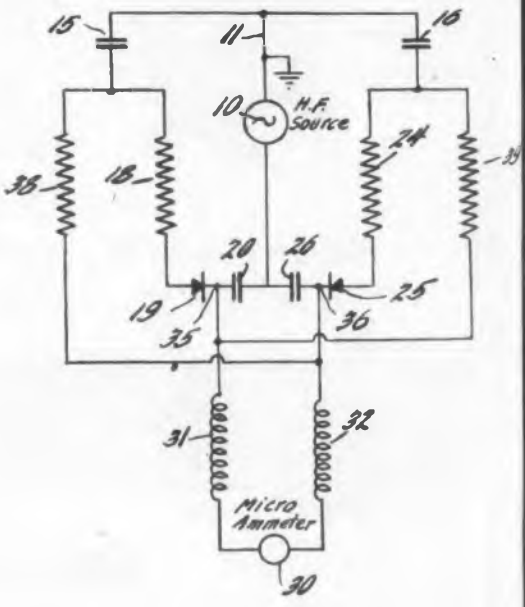
The balanced resistive reactor with a center-tapped secondary circuit is in the form of an ac bridge and the control voltage is introduced into the balanced configuration through leads *56* and *58*. Non-linear resistors *52* and *54*, shown as crystal diodes, are connected in series opposition. The ac source *26* is connected in series with the load resistor *28* in the transformer primary. The balanced arrangement is analogous to a push-pull magnetic amplifier of the type with a three-legged iron core structure.

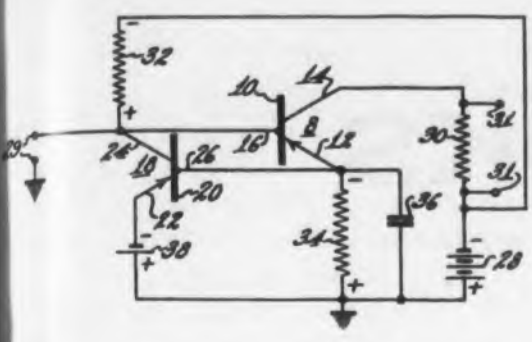
Apparatus for Measuring Electrical Characteristics

Patent No. 2,820,194. John L. Reinartz. (Assigned to Eitel-McCullough, Inc.)

Since it is essential to determine whether the value of a manufactured component falls within a range of values which can be employed effectively, a means is provided to measure the deviation of the significant value of the element from the optimum value at a frequency at which it will be used.

The circuit illustrates how the unknown capacitor *16* is compared to the standard capacitor *15*. At the chosen frequency, the oscillator *10* is the current source in series with standard capacitor *15*, resistor *18*, germanium diode *19*, microammeter *30*, and the dc return resistor *38*. The oscillator simultaneously is connected through the unknown capacitor *16* in a similar manner. Resistors *18* and *24* and resistors *38* and *39* are of equal values. Microammeter *30* measures the difference in potential between points *35* and *36*. Precise conformity of the unknown capacitor *16* with the standard capacitor *15* exists when the microammeter reading is zero. The microammeter may also be calibrated in terms higher and lower than optimum values so that an unknown condenser may be selected within tolerable limits.





Stabilizing Means For Semi-Conductor Circuits

Patent No. 2,816,964. Lawrence J. Giacoletto. (Assigned to Radio Corporation of America)

The circuit uses a pair of transistors. The signal output is derived from the collector of the first. The second transistor provides a substantially constant emitter current. Bias is applied to the collector of the first transistor and to the emitter of the second transistor. The emitter of the second transistor is initially biased in the reverse direction. A resistor is provided between the emitter of the first transistor and the point of reference potential in order to provide a voltage variation in response to the current variation of the first transistor. A dc connection is made between the emitter of the first transistor and the base of the second transistor to vary the current conducting condition of the second transistor in response to voltage variations across the first resistor. A second resistor is provided between the collector of the second transistor and the other terminal of the potential source in order to provide a voltage variation in response to current variations of the second transistor. A dc connection is made between the collector of the second transistor and the base of the first transistor to apply the voltage variations across the second resistor to this base. The operation of the first transistor is then stabilized.

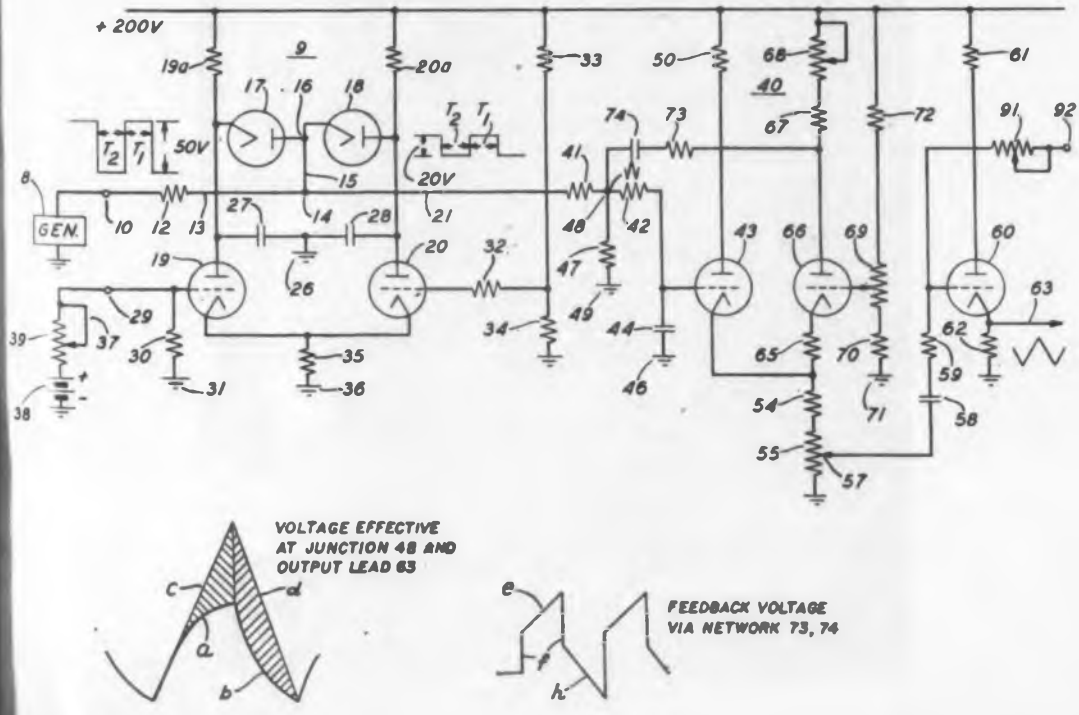
Triangular Wave Generator

Patent No. 2,817,016. Charles J. Custer. (Assigned to Bell Telephone Laboratories, Inc.)

An isosceles triangular waveform is generated in order to wobble linearly the voltage on the reactance tube of a frequency modulator.

The waveform generator essentially consists of capacitor *44* which is charged and discharged by the square wave generator *8* through resistor *42*. Linearity of the triangular waveform is obtained by feedback from the plate of triode *66* which maintains the charging and discharging currents constant.

Diode *17* clamps the amplitude of the positive portion of the square wave and diode *18* clamps the amplitude of the negative portion of the square wave. Therefore, a convenient means is provided to vary the amplitude of the triangular waveform by means of rheostat *39*. The common cathode voltage across resistor *35* follows the setting of the grid voltage on triode *19*, resulting in equal and opposite voltage changes at the plates of triodes *19* and *20*. Since diodes *17* and *18* are in series across the plates of the triodes, the square wave is clamped symmetrically for any setting of rheostat *39*.



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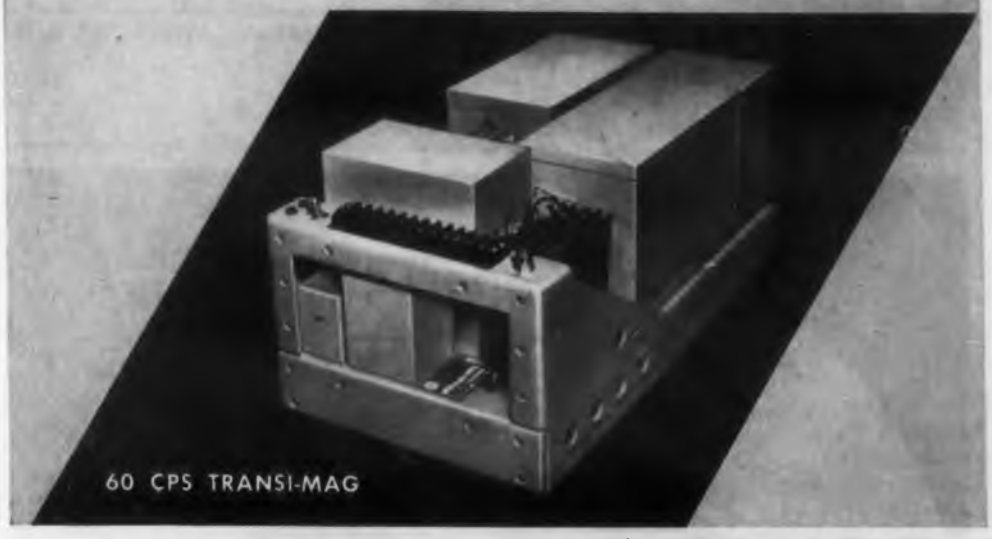

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MAX. POWER OUTPUT WATTS	50	100	120	175	650	1900	2800
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SENSITIVITY	A.C. Input — 0.3 volts A.C. for full power output D.C. Input — 0.15 volts D.C. for full power output						
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BOOKS

Electron-Tube Circuits

Samuel Seely, McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York, N.Y., 695 pp, $10.50.

Extensively rewritten, this second edition contains new material to strengthen and broaden the study of electron tube circuits. This additional material includes: anaylsis of RC feedback amplifiers; f-m discriminators; electronic computing circuits and devices; and the theory of clamping. The treatment of the principles of feedback has been expanded. There is new material on solid state electronics.

Approximately one-half of the content is of a radio-engineering character. The remainder explores radar, television, electronic control and instrumentation, and computers. Wherever possible analysis proceeds in two stages. First an effort is made to present a physical explanation of the operation of the circuit. Then, if feasible, a mathematical analysis of the operation of the circuit is given.

Scientific Encyclopedia, 3rd Ed.

D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N.J., 1839 pp, $26.85.

This third edition of the one-volume scientific and engineering encyclopedia contains: over 100,000 definitions; 2,000,000 words; 14,000 separate articles; and 1,400 illustrations with 12 pages in full color. Each term which is significantly used in the article from another term is bold-faced, making for an effective system of cross-reference. The areas covered range from aeronautics to zoology.

A Second Survey of Domestic Electronic Digital Computing Systems

Martin H. Weik, Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., 453 pp, $7.00.

Based on the results of a survey conducted from October, 1956 through January, 1958, the engineering and programming characteristics of one hundred and three different electronic digital computing systems are given. The data are presented from the point of view of application, numerical and arithmetic characteristics, input, output, storage systems, physical requirements, personnel requirements, and production records. Cost and rental rates, sale and lease policy, reliability and operating experience, engineering modifications and improvements are also included. In addition, an analysis of the survey data, fifteen comparative tables, a discussion of trends, a bibliography, and a complete glossary of computer engineering and programming terminology are offered.

Among the items not covered by this report are analog computing systems, foreign systems or separate computing system components, such as analog-digital converters, storage units, arithmetic units, input-output units, and data recording units, except when these are associated with specific complete systems.

The report, PB 111996 R, supersedes BRL Report No. 971.

Installing Electronic Data Processing Systems

Richard G. Canning, John Wiley and Sons, Inc., 440 Fourth Ave., N. Y. 16, N.Y., 193 pp, $6.00.

This book deals with the various aspects of installing electronic data processing systems beginning with the placement of the equipment order. It covers the significant problems of fitting EDP into the organization, selecting and training EDP personnel, programming, physical installation of the system, and the early phases of operation.

Discussion is offered indicating the important and expensive factors of EDP installation. Suggestions are made for effective cost control based on actual cases. Studies of a number of companies in dissimilar fields have been synthesized into a single case history. Written in non-technical language, the author has assumed that the reader is relatively unacquainted with electronic computers.

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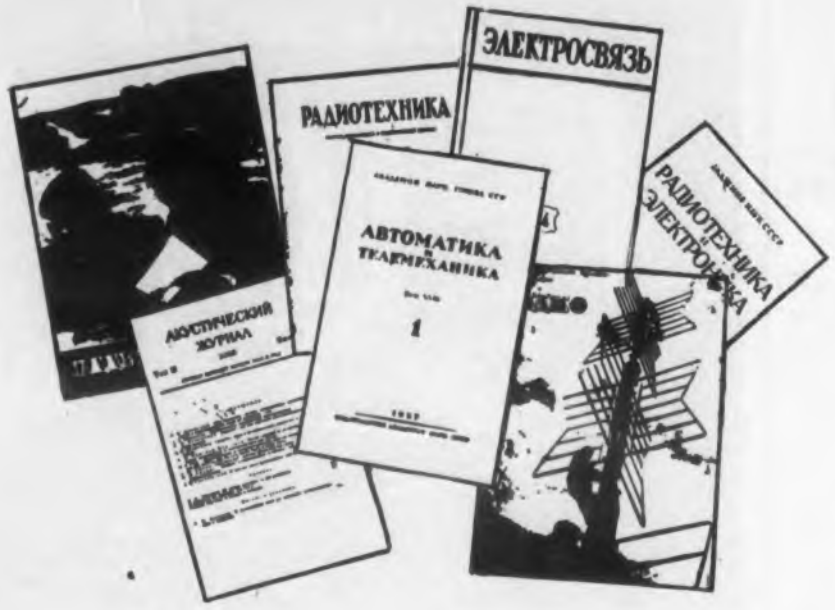

What The Russians Are Writing

J. George Adashko

CIRCUITS

Three-Phase Magnetic Amplifier by V. V. Gorskiy. AT 7/57, pp 681-685, 9 figs.

A new circuit, for which a Russian patent was applied for, is described. This amplifier is claimed to be more compact and to have higher power gain, inasmuch as a single control winding, having the same dimensions as the control winding in an ordinary single phase amplifier, acts in this system on all three phases. The amplifier uses 20-30 per cent less material than systems consisting of three single phase amplifiers. A shortcoming of the new amplifier is that the voltage drop is not the same in all three phases, but in the case of symmetrical loading this does not affect the symmetry of the line and phase voltages at the terminals of the load.

Features in the Design of Multistage Magnetic Amplifiers by N. P. Vasil'yeva and M. A. Boyarchenkov. AT 7/57, pp 660-688, 6 figs.

The authors published articles on this subject in the October 1956 and in the January 1957 issue of Avtomatika i Telemekhanika, *ED* 6/15/57 and 8/15/57. This article shows certain unique features in the design of low power magnetic amplifiers for a specified time constant.

The "Rubin" Television Set by V. Khakharev. R 7/57, pp 35-59, 5 figs.

Description of the latest model television set produced by the Moscow Plant for Television Apparatus. It has higher audio fidelity and better video qualities than its predecessors.

Keying Circuit for Automatic Gain Control in Television Sets by D. Kheifets. R 9/57, pp 43-44, 2 figs.

Unlike AGC in which a voltage proportional to the input signal is applied to the grids of the rf and if tubes, this system employs a special peak detector to obtain a control voltage, and the regulating voltage output from the peak detector varies only with the field intensity at the reception point.

What is New in Television Circuits by S. Khazan. R 10/57, pp 55-60, 8 figs.

Describes in detail certain innovations in Russian television sets.

Cold Thyratron Relaxation Oscillators by A. Klopov, Yu. Polyakov. R 5/57, pp 56-58.

Thyratrons with "cold" cathodes are discussed in a variety of relaxation oscillators (multivibrators) with lower power consumption than circuits employing tubes with filaments. This is due not only to the absence of a filament circuit, but also to the low internal resistance of the thyratron in the conducting state. For example, a typical vacuum-tube multivibrator consumes a supply power on the order of 2-3 watts, while one employing "cold" thyratrons consumes only 0.1 w.

The article analyzes a variety of multivibrator circuits employing this type of tube.

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 (*Elektrosvyaz*)
IET	Instruments and Experimental Techniques (*Pribori i Tekhnika Eksperimenta*)
R	Radio
RE	Radio Engineering (*Radiotekhnika*)
REE	Radio Engineering and Electronics (*Radiotekhnika i Elektronika*)

TRANSLATIONS AVAILABLE

ELECTRONIC DESIGN is gratified to learn of the growing availability of full translations of important Russian electronics journals.

Consultants Bureau, Inc. of 227 W. 17th St., New York 11, N.Y. translates *Automation and Telemechanics* regularly.

Pergamon Press of 155 E. 55th St., New York 22, N.Y. is preparing translations of *Radio Engineering, Radio Engineering and Electronics, and Electrical Communications.*

Readers interested in specific Russian journals can obtain more information by writing directly to one of these publishers.

Transistor Amplifier by Z. Kromachevskaya, V. Munin, V. Sokolov. R 5/57, pp 53-55, 5 figs.

This amplifier is intended primarily for portable phonographs and radios with relatively poor frequency and distortion characteristics.

High Quality Low Frequency Amplifier by A. Kuz'menko. R 5/57, pp 51-52, 6 figs.

This is about a small amplifier, using miniature tubes, and employing approximately 10 db of feedback. Its power is up to 8 watts; the nonlinear distortion down to 5 per cent, and the hum level is -50 db.

Shortwave Transmitter by V. Lomanovich. R 5/57, pp 26-30, 6 figs.

Description of an amateur 100 watt transmitter for the 160, 80, 40 and 20 meter bands. Several automatic switching and duplexing provisions are incorporated.

Stabilized Rectifiers by A. Dol'nik. R 7/57, pp. 48-50, 6 figs.

Description of three rectifiers for radio apparatus consuming 1-3 watts, employing voltage stabilizers operating satisfactorily over a range of 90-230 volts. Such apparatus can be connected to any standard electric line without range switching. Two of these circuits are intended for circuits employing tubes with 300 ma filament current, and the third is designed for 60 ma filament current and employs a power transformer.

Certain Problems of Simplified Analysis of Transients Excited in Linear Networks by Frequency Modulation of the Input Signal by V. G. Segalin. REE 7/57, pp 856-859, 7 figs.

A method is given for a simplified investigation of the transients excited in linear networks by frequency modulation of the input signal. The concept of the frequency transfer coefficient is introduced, and the mechanism of the established function dependence of the time constant of the frequency transient on the frequency is explained. This topic is not treated extensively in the literature.

Wave Matrices of a Four-Terminal Network by L. R. Yavich. REE 7/57, pp 870-882, 3 figs, 8 tables.

Tables are given for the transient relationship between the wave matrices of a four-terminal network (scattering and transmission) and the matrices of the classical theory of linear networks. On the basis of these relationships, the most important properties of the elements of wave matrices are determined. The use of wave matrices is illustrated by a practical example. Refers to many articles on scattering matrices published in the American literature.

Automatic Tuning of High Frequency Stages in Shortwave Transmitter by P. A. Karavaev. CJ 6/57, pp 10-11.

The method employed here is based on the fact that the phase shift between the plate and grid voltages is 180 degrees at exact tuning. A diagram of the circuit, intended for use at 3-20 mc, is given.

UHF FM Receiver with Frequency Feedback by L. Ya. Kantor. CJ 6/57, pp 12-15.

Further detailed description of a receiver used for a wired-broadcast reception unit in which frequency feedback is used to reduce the nonlinear distortion and increase the selectivity. A complete diagram and coil-winding data are given.

Automatization of Control of the Operation of a Broadcast Channel by V. A. Nyurenberg. CJ 8/57, pp 7-9.

This project deals primarily with automatic lever control in wired-broadcast networks such as are extensively used in Russia. The control method is based on comparison of signals on both ends of the channel.

CONFERENCES

Second Technical Conference of the Government Radio Trust by A. Kaganeva. R 8/57, pp 23-24.

No date is given for this conference. It dealt primarily with problems in producing commercial radio and television equipment in the U.S.S.R. Thirty papers were delivered. They will be described in detail in an information-technical bulletin to be published in the future.

Conference on Ultrasonics by V. Mikhaylov. R 8/57, pp 25-26.

This conference, which was held in Moscow, was attended by more than 1,000 delegates. They came from various cities of the Soviet Union. This article gives only a brief mention of each paper presented. The date of the conference was not given.

(Continued on following page)

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MICROWAVES

Round Waveguide, Partially Filled with Ferri... as a Decelerating System by R. G. Mirima... and Yu. G. Anisimova. REE 7/57, pp 843-85... 7 figs.

R. G. Mirimanov, together with L. G. Lomi... published an earlier article on an infinite gy... tropic cylindrical waveguide in Radiotekhnika... Elektronika, September 1956, vol. 1, page 11... see *ED* 11/1/56. The present article treats t... theory of a waveguide with perfectly conducti... walls, covered on the inside with a layer of gy... magnetic substance of arbitrary thickness.

The waveguide theory developed makes it p... sible to investigate with sufficient detail t... physical properties of the waveguide as a ... celerating system and to determine various i... portant technical characteristics of such a s... tem. Reference is made to the article by M. ... Kales, "Modes in Waveguide Containing F... rites," Journal of Applied Physics, 1953, 24, ... 604, and by Bruck and Wicher, Slow Transve... Magnetic Waves in Cylindrical Guides, Jour... of Applied Physics, 1947, 18, 8, 766.

Calculation of Phase Shifts of Gyrotropic Irreg... larities in a Waveguide by the Perturbati... Method by V. V. Nikol'skiy. REE 7/57, pp 83... 842, 6 figs.

The author has previously published ext... sively on this subject (see Radiotekhnika i El... tronika, 1956, vol. 1, pages 447 and 638; vol. ... page 157, *ED* 11/1/56 and 11/15/56). In t... article he employs the perturbation method ... the problem of the arbitrary gyrotropic reg... in a waveguide. The phase of the transfer ... efficient of various gyrotropic irregularities, s... as rods, diaphragms, and disks, is calculated. R... erence is also made to the article by Suhl a... Walker, "Topics in Guided Wave Propagati... Through Gyromagnetic Media" BSTJ, 1954, v... 33, p 1133.

COMPONENTS

Electronic Model of a Wire Wound Potentiom... eter by M. A. Shnaydman. AT 7/57, pp 669-67... 13 figs.

A practical wire wound potentiometer is ... from a linear device. Its characteristic is mo... accurately represented by a staircase curve a... furthermore is subject to hysteresis so that t... values obtained in one direction are not nece... sarily the same in the other direction. The artic... discusses an analog of a device producing th... type of staircase function, an analog with hig... accuracy, large input and low output impedanc... and with a wide range of variation of the inp... and output voltages. In addition, provision ... made for varying the height of each step in th... output voltage over a wide range. The anal...

ploys standard operational amplifiers d in electronic analog computers.

PROPAGATION

estigation of the Inhomogeneous ucture of the F-Layer of the Iono- ere by Ye. G. Proshkin and B. L. shcheyev. REE 7/57, pp 819-825, 8 , 4 tables.

Report on observations of the inhomo- eities of the F-layer of the ionosphere. observations were carried out in r'kov from July 1954 through May 6 by vertical sounding of the iono- ere. It is shown that there is no regu- variation in the change of the degree nhomogeneity of the F-layer. In 90 cent of the cases, the reflection from F-layer has a random character. ers to "The Fading of Radio Waves Medium and High Frequencies" by Nicol, Proceedings IRE, 1949 Part vol. 96, p 571.

gularities in the Refraction of Radio ves and Great Inhomogeneities in Ionosphere by V. V. Vitkevich and L. Kokurin. REE 7/57, pp 826-832, gs, 1 table.

Description of a procedure and of the lts of measurement of vertical refrac- of 4-meter radio waves in the iono- ere. It is shown that the vertical action is frequently subject to irregu- variations, and that the irregularity he refraction is due to electronic in- ogeneities measuring approximately km in the F-layer of the ionosphere. ain models of the inhomogeneous sphere are considered. The daily rse of the irregularities is analyzed it is shown that the appearance of nogeneities in the ionosphere is nected with the activity of the sun. fers to various investigations by Ross amley (Nature, 1947, vol. 159, p. 132; re, 1949, vol. 164, p 355), Maxwell Little (Nature, 1952, vol. 169, p. Philosophical Magazine, 1951, vol. 267) and other British and Ameri- observers.

Forgotten Radio Wave Band by V. provskiy. R 7/57, pp 33-34, 4 figs.

A "plug" for the real long waves, cor- nding to 7-35 kc, which have good distance propagation properties, but which have been all but forgotten owing to the great attention paid to the short and ultra short waves. Oscillograms and curves illustrate some of the advantages claimed for these waves.

New Medium Wave Radio Broadcasting Antennas on Low Towers by B. S. Nadenenko. L. P. Pozdnyakov. CJ 5/57, pp 11-14, 12 figs.

Description of slot antenna for long and medium waves. It is shown that the use of slot vibrators at these wave lengths does not call for high supporting structures.

Modern Trends in the Development of Shortwave Radio Communication by L. A. Kopytin. CU 5/57, pp 8-11.

Brief discussion of the fundamental trends followed in the design of modern shortwave radio stations and in the development of new types of equipment for telephony and telegraphy. Comparison between Soviet and western equipment is frequently indicated.

RADIO ASTRONOMY

Concerning the Thermal Calibration of Radio Astronomical Apparatus, by V. S. Troitskiy. REE 7/57, pp 935-944, 1 fig.

Represents extension of Diecke's method (Review of Scientific Instruments, 1946, vol. 7, p 268) to the calibration of radio meters against thermal radiation from a sufficiently hot matched load acting as a standard, to the radiation from cosmic sources.

Radio Astronomy by S. Khaykin. R 11/57, pp 25-27, 4 figs.

A popular article, mentioning the names of many Soviet scientists engaged in this activity and the several institutions that carry out research in radio astronomy.

TELEPHONY

Type R-60/120 Radio Relay Apparatus by S. V. Borodich. CJ 9/57, pp 3-7.

Description of new apparatus intended for multi-channel telephone communication and for the transmission of television signals. The apparatus in the repeater stations is fully automatized and requires no attending personnel. The block diagrams of the equipment, the specifications, and several photographs of various racks are given. This equipment was developed by the experimental plant of the Ministry of Communications, U.S.S.R.

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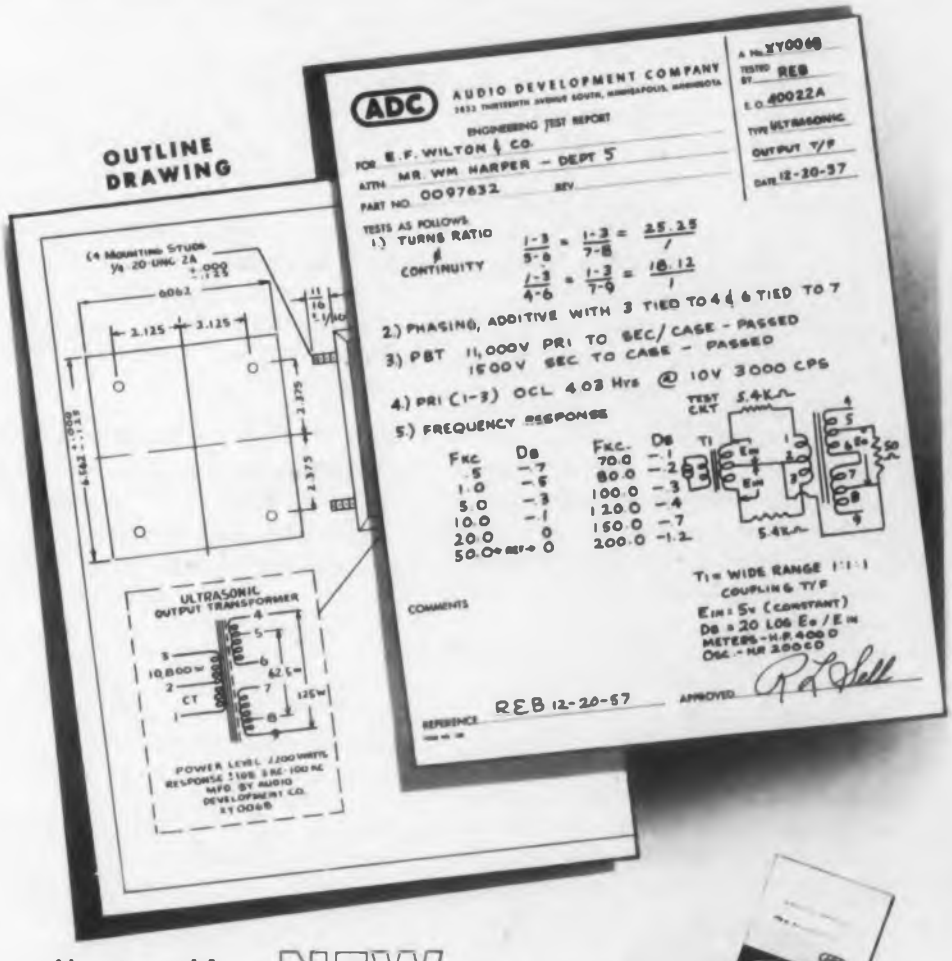

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ABSTRACT

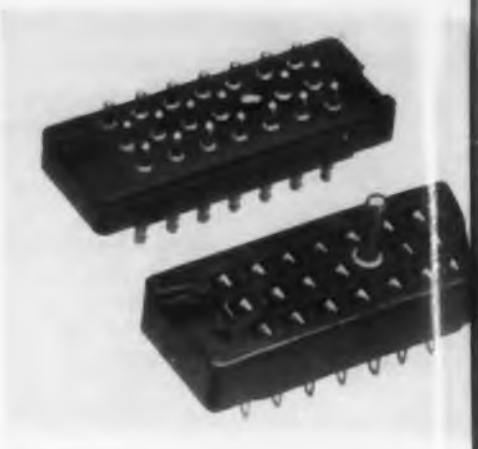

Fig. 1. New multiple-contact connecto ploying two-petal contacts and longer pin.

Improved Multiple-Contact Connector

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The redesigned connector is sho Fig. 1. It is similar in general appea to the earlier connector, but it w noted in Fig. 2 that the jack ar ments are quite different. The new signed jack employs a two-petal co This contact is oriented so that the pins move in a sidewise directio proximately parallel to the petals. no petal edge falls within the p the pins. The slight motion of the pins, resulting from rotation abo

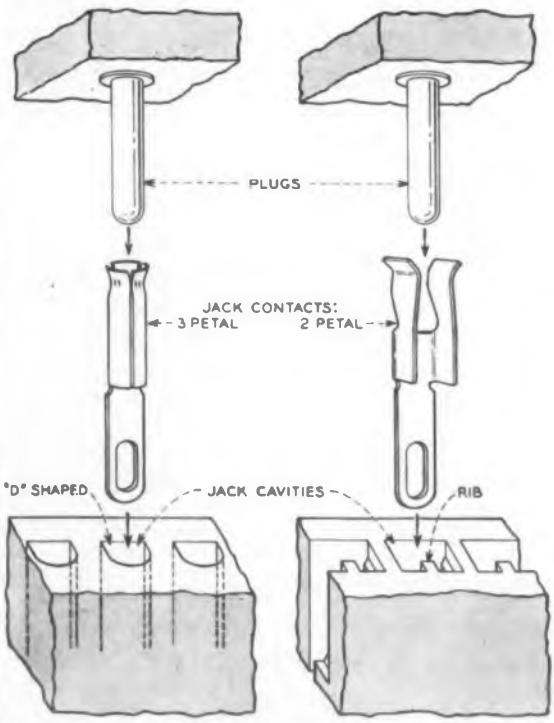

Fig. 2. Large-scale drawing showing details of jack contacts and jack cavity structures for old and new types of multiple-contact connectors.

guide pin, is restricted by the introduction of a rib in the jack cavity and by the off-center location of the cavity with respect to the plug pins. In addition, the rib restricts the float of the jack contact, but allows sufficient movement to absorb the maximum possible misalignment between the plug pin and the jack cavity in the longitudinal axis of the connector. This structure assures the same deflection in each petal during insertion of the plug pin. When the connectors are manufactured, the two-petal contacts are automatically inserted into the cavities of the connector block. The innermost portion of the rib is sloped as in Fig. 3 to act as a guide so that the terminal or soldering end of each contact slides easily through a slot at the rear of the block.

After the contact is inserted into the cavity, the rearward-projecting terminal is twisted. The twist serves to retain the contact in its proper position in the cavity; it also prevents damage to the contact if a force is applied to the terminal that would otherwise tend to deform the contact petals. If there is an excessive sidewise pull on the wires soldered to the terminals, the terminal ends will deflect without impairing the action of the contacts.

The increased length of the jack prevents insertion of the contact pins until the plug and jack are angled into a position that assures satisfactory registration between the pins and their associated contacts.

In the three-petal construction, a jack contact can float to one side of its cavity, and the associated plug pin can move toward the opposite side of the cavity because of rotation about the guide pin. Occasionally, these misalignments may be large enough that the pin could snag or butt against a petal edge of the jack contact. Upon insertion, the plug pin would bend or collapse the petal.

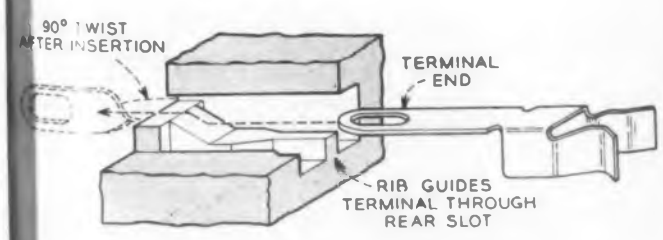

Fig. 3. Sloped rib in jack cavity guides terminal during automatic insertion process of manufacture.

CAREERS

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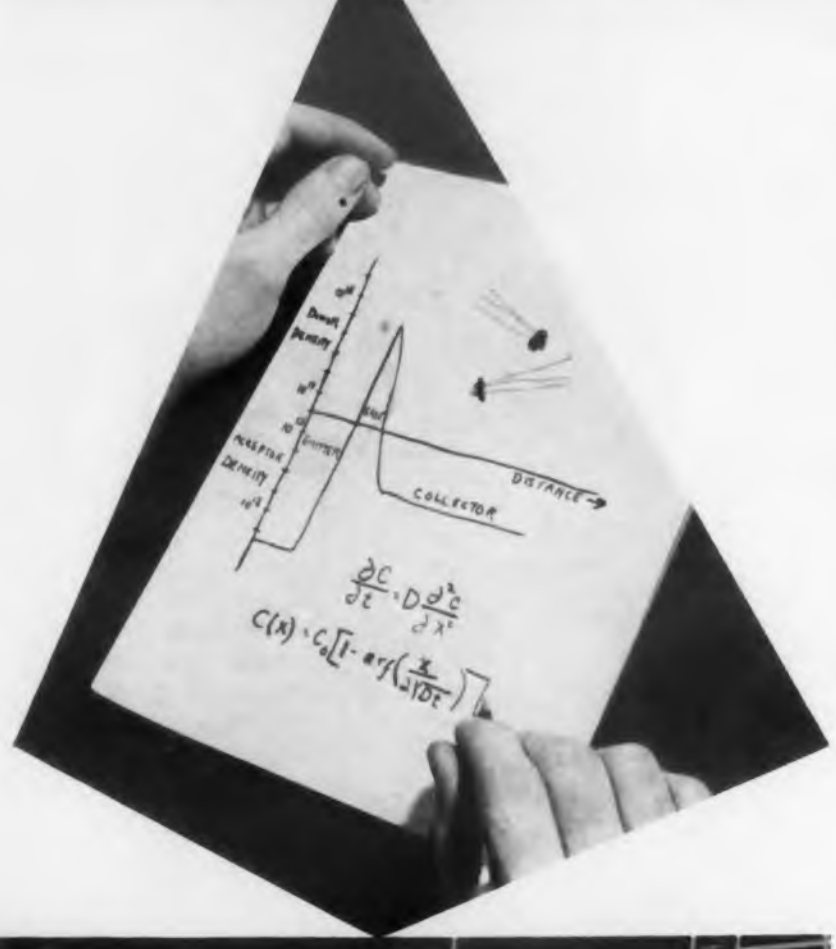

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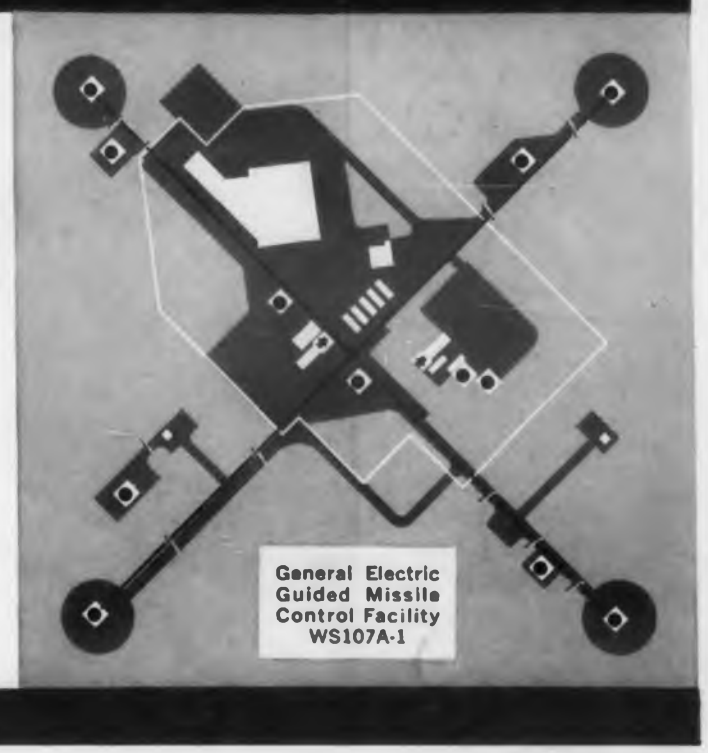
Electronic and communication products for home, industry and defense

CIRCLE 550 ON READER-SERVICE CARD

GRADUATE EE'S: GENERAL ELECTRIC DISCLOSES HIGH PRIORITY PROGRAM FOR ATLAS GUIDANCE SYSTEM. MANY POSITIONS OPEN IN ELECTRONIC MISSILE TECHNIQUES=

ACCURACIES ON ORDER OF 1 PART IN 10 MILLION

required for portions of G.E.'s ICBM ATLAS Guidance System



Delivering an ICBM over a > 5000 mile trajectory into the target area demands a guidance system of unprecedented accuracy — and this is the calibre of the electronic system General Electric engineers are creating for ATLAS.

But achieving designated accuracies and reliabilities in the laboratory is not enough. *These high standards must be maintained in actual operational environments, with virtually no interruption or degradation.*

CAREERS IN STEP WITH THE FUTURE

Engineers who join the Missile Guidance Product Section of G.E. are doing more than hastening development of one of the nation's most urgent programs — guidance for ATLAS. As Manager of the Section Richard L. Shetler states: *"With this job behind us, there will remain no significant obstacle to the practical guidance and navigation of other space vehicles."*

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If you feel that your special skills and interests fit you to work in any of the above areas, why not write us in detail? Qualified candidates will be invited to visit our facilities to meet with technical managers and gain first hand knowledge of the living advantages of our locations at Syracuse and Utica, N. Y.

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STANDARDS AND SPECS

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Simplified Drafting

FUNCTIONAL DRAFTING

Functional drafting can save time and money by the use of streamlined drawings produced by modern techniques tailored to the needs of the user. This pamphlet is intended to help the draftsman overcome costly drafting habits in preparing working drawings. Copies of this 24-page publication are available from the Government Printing Office, Washington 25, D.C., for 15 cents each. Request Catalog No. D211.6:D78.

Recommended Wiring Practices

HANDBOOK INSTALLATION PRACTICES FOR AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

This handbook gathers together under one cover the recommended practices and techniques to be used for installing, repairing, and maintaining aircraft wiring. Standard techniques are described that enable installations to be done in a uniform manner. Failures which may result from poor workmanship are also included. Safety is also described by pointing out unsafe practices. Copies of this 174-page publication are available from the Government Printing Office, Washington 25, D.C. for $1.25 per copy. Request catalog No. D202.6W74.

Copper-clad Laminates

MIL-P-13949A, PLASTIC SHEET, LAMINATED, COPPER-CLAD PAPER-BASE PHENOLIC, 4 SEPTEMBER 1957

The requirements for paper-base phenolic laminated plastic sheet having copper foil bonded to one or both surfaces are covered in this spec. These sheets are to be used primarily for the fabrication of etched conductor patterns for electronic circuits. The material covered by this spec is not intended for use above 105°C. A typical type designation for material conforming to this spec is FL-PP2C14/28.

Switches

MIL-S-3950A, TOGGLE SWITCHES, 25 NOVEMBER 1957

This spec covers military service requirements for toggle-type switches for use in ac and dc applications. Switches furnished under this spec shall be a product which has passed the specified qualification tests.

ADVERTISERS' INDEX

April 16, 1958

These 3 New RCA Low-Cost Computer Transistors Can Open New Markets For You!

RCA now makes available low-cost high-quality transistors for reliable performance in electronic computer applications!

- Can low-priced, highly-reliable computer transistors help you expand into new markets?
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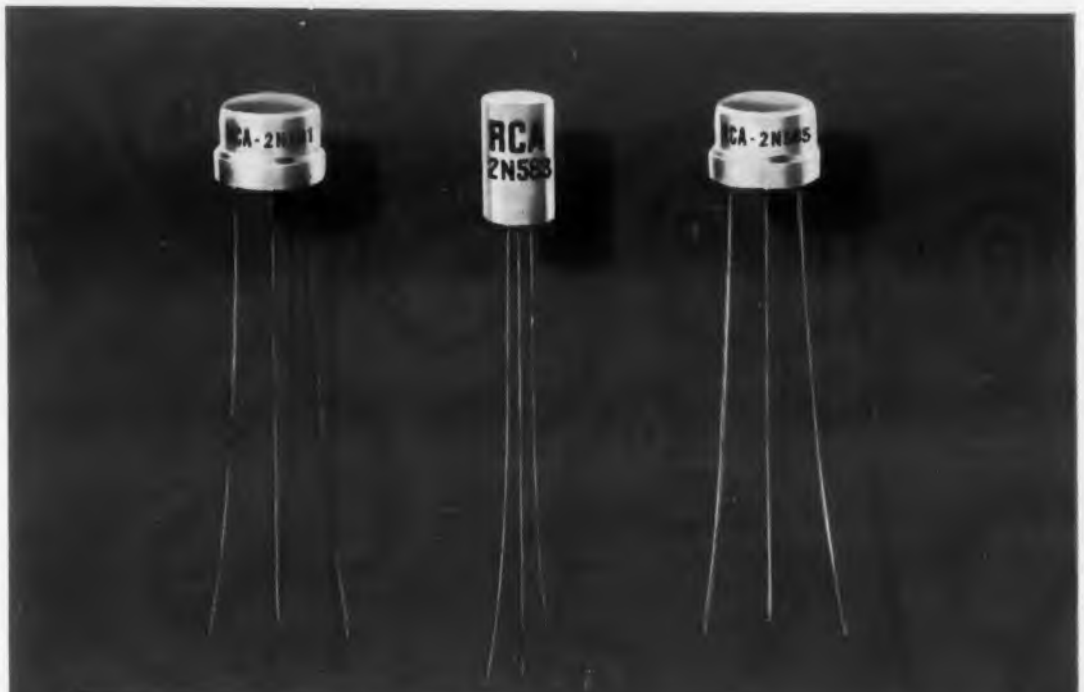
If the highly desirable combination of *reliable performance* and *low cost* have been difficult for you to find, investigate these three new RCA units: RCA-2N581, RCA-2N583, and RCA-2N585. They are specifically designed, produced and controlled for computer applications; life-tested for dependable service; electrically uniform; available in commercial quantities; and are unusually low in price.

In addition to these three new types, RCA offers a comprehensive line of transistors for your most critical computer designs. For additional information on RCA Transistors, contact your local authorized RCA Distributor or your RCA Field Representative at the office nearest you.

For technical data on RCA Transistors, write RCA Commercial Engineering, Section D-18-NN-2, Somerville, New Jersey.



NEW GERMANIUM ALLOY-JUNCTION TRANSISTORS FOR MEDIUM-CURRENT SWITCHING SERVICE IN COMPUTER APPLICATIONS

RCA Type	Typical Alpha-Cutoff Frequency Mc	Typical DC-Current Transfer Ratio Value at Collector Ma.	Maximum Collector Ma.
2N581* (p-n-p)	8	30 at −20	−100
2N583** (p-n-p)	8	30 at −20	−100
2N585* (n-p-n)	5	40 at +20	+200

*Jetec TO-9 Outline (formerly referred to as Jetec Size-Group 30 Case)
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